ISBN No. : 978-81-956864-4-5

ISTE 1st STUDENT'S CONVENTION

BIHAR & JHARKHAND SECTION

HACKATHON

"IDEA GENERATION AND START-UPS - A KEY TO SUCCESS"

On

22nd & 23rd March 2025

In Association with :

Jharkhand University of Technology
Ranchi, Jharkhand

Organised by:

GGSESTC
GURU GOBIND SINGH EDUCATIONAL SOCIETY'S TECHNICAL CAMPUS
GGSESTC, KANDRA (V),
CHAS, BOKARO,
JHARKHAND - 827013

Host :

ISTE
(Bihar & Jharkhand Section)

GGSESTC

GURU GOBIND SINGH EDUCATIONAL SOCIETY'S TECHNICAL CAMPUS

You are cordially invited to participate in

1st ISTE BIHAR & JHARKHAND STUDENT'S CONVENTION

HACKATHON

"IDEA GENERATION AND START-UPS - A KEY TO SUCCESS"

On

22nd & 23rd March 2025

Host : ISTE (Bihar & Jharkhand Section)

Venue :

GGSESTC, Bokaro

IMPORTANT DATES :

Last date of receipt of abstract	15st February, 2025
Intimation of acceptance	24th February, 2025
Last date of Registration	28th February, 2025

EVENTS

» Paper/Poster Presentation
» Projects/Model/Prototype Exhibition
» CAD Competition (only individual participation)
» Quiz Competition

REGISTRATION FEE :

Event Name		
Paper/Poster Presentation/ Projects/Model/ Prototype Exhibition	ISTE Student Member (Without Publication)	Rs 300/
	Non-ISTE Student Member (Without Publication)	Rs 500/
CAD Competition/ Quiz Competition	ISTE Student Member	Rs 150/
	Non ISTE Members	Rs 200/

RSVP :

Prof. (Dr.) Priyadarshi Jaruhar
(Principal Convener : 9822732264)

Prof. Apurba Sinha
(Convener : 9330551682)

Phone No.: 06542 - 265 398 **Toll Free No.:** 18003455398

Google form Link:
https://forms.gle/NzXvBDFqSPZjqL7B9

Proceedings

of

ISTE 1st Student's Convention

Bihar and Jharkhand Section

Hackathon

"Idea Generation and Start-ups - a Key to Success"

22nd -23rd March, 2025

Organized by

Guru Gobind Singh Educational Society's Technical Campus,
Kandra, Chas, Bokaro –827013, Jharkhand.

In association with

Jharkhand University of Technology
Namkum, Ranchi-834010, Jharkhand,
India

Title: **Proceedings of ISTE 1st Student's Convention (Bihar and Jharkhand Section)**

Hackathon: "Idea Generation and Start-ups - a Key to Success"

Author: **Dr. Priyadarshi Jaruhar**

Published by: **Guru Gobind Singh Educational Society's Technical Campus**

Publisher's Address: **Kandra, Chas, Bokaro, Jharkhand, Pin: 827013**

Printed by:

Shivam Printers

Chas, Bokaro

Jharkhand–827013

India

First Impression: **2025**

Published on: **20th March, 2025**

ISBN: **978-81-956864-4-5**

Convention Organization

Hon'ble Chief Patrons

Dr. Pratapsinh Kakasaheb Desai, President, ISTE, New Delhi

Prof. (Dr.) D. K. Singh, VC, JUT, Ranchi, Jharkhand

Prof. S.K. Verma, VC, Bihar Engineering University, Patna

Shri Tarsem Singh, President, GGES, Bokaro, Jharkhand

Hon'ble Patrons

Shri Udayan Mishra, IAS, Director cum Special Secretary, DSTTE, Patna

Prof. (Dr.) Mithilesh Kumar Jha, Principal, M.I.T Muzaffarpur

Prof. (Dr.) Pankaj Rai, Director, BIT Sindri, Dhanbad

Shri S.P. Singh, Secretary, GGES, Bokaro, Jharkhand

Principal Convener

Prof. (Dr.) Priyadarshi Jaruhar, Director, GGSESTC, Bokaro

Co-Convener

Prof. Apurba Sinha, Asst. Prof., CSE, GGSESTC, Bokaro

Chief Editor

Dr. Deepak Kumar, Asst. Prof., BSH, GGSESTC, Bokaro

Editor(s)

Ms. Pallavi Prasad, Administrative Officer, GGSESTC, Bokaro

Dr. Vaibhav Gupta, Assistant Professor, FT, GGSESTC, Bokaro

Technical Committee

- Prof. (Dr.) Sanjay Kr. Singh, Principal, Govt. Engg. College, Palamu, Jharkhand
- Dr. S.C. Dutta, Assoc. Prof., CSE, BIT Sindri, Dhanbad
- Shri Rajesh K. Singh, CGM, BSL, Bokaro, Jharkhand
- Prof. (Dr.) A B Marathe, Director, Shri Shivaji Education Society's Amravati's College of Engineering & Technology, Akola, Maharashtra
- Prof. Gautam Kumar, Asst. Prof., ECE, GGSESTC, Bokaro, Jharkhand
- Dr. Sabita Kumari, HR & Training Head, Twintech, ACI, Autodesk, Bhubaneswar

- Dr. Manojit De, IQAC Co-ordinator & Asst. Prof., BSH, GGSESTC, Bokaro, Jharkhand
- Dr. Vaibhav Gupta, Asst. Prof., FT, GGSESTC, Bokaro, Jharkhand
- Dr. Sarfaraz Karim, Assoc. Prof., MBA, GGSESTC, Bokaro, Jharkhand

Organizing Committee

- Dr. Rajesh Kumar Tiwari, Principal, RVSCET, Jamshedpur
- Prof. (Dr.) L. Ranganathan, Principal, CIT, Ranchi
- Prof. Rohi Prasad, Asst. Prof., ME, GGSESTC, Bokaro
- Prof. Mahmood Alam, Asst. Prof., ME, GGSESTC, Bokaro
- Prof. Sumit K. Pandey, Asst. Prof., ME, GGSESTC, Bokaro
- Dr. Deepak Kumar, Asst. Prof., BSH, GGSESTC, Bokaro
- Prof. Manoj Kumar, Asst. Prof., ME, GGSESTC, Bokaro
- Adv. Pallavi Prasad, Administrative Officer, GGSESTC, Bokaro
- Mr. Anil Kumar Singh, System Administrator, GGSESTC, Bokaro
- Prof. Mahavir Prasad, Asst. Prof., MBA, GGSESTC, Bokaro

Reception & Hospitality

- Prof. Kumar Ashish, Assistant Professor ME,GGSESTC
- Prof. Mukesh Kumar Sinha, Assistant Professor, BSH,GGSESTC
- Prof. Salim Ahmed, Assistant Professor, ECE, GGSESTC

National Advisory Board

- Prof. Mani Kant Paswan, Director, SLIET, Sangrur, Punjab
- Prof. Anil Kumar, National Executive Council Member, ISTE, New Delhi
- Prof. Nishant Kumar, Registrar (I/C), JUT, Ranchi
- Prof. (Dr.) Bhagwan Singh, Dean (Business Admin.),CUJ, Ranchi
- Shri. Sneh Kumar, Director (Curriculum Development),JUT, Ranchi
- Prof. (Dr.) A.W. Kharche, Director, Padmashri Dr. V. B. Kolte College of Engg, Buldhana, MS
- Prof. (Dr.) Anupam Kumar, Professor & Dean, Textile Engg. MRSPTU, Bhatinda
- Prof. (Dr.) Maya Rajnarayan Ray, Assoc. Prof., CE, BIT Sindri
- Prof. (Dr.) Manoj Kumar, Dean (Academic Affairs), Gaya College of Engg, Gaya
- Dr. P. A. Khatwani, Professor, Textile Engg., Sarvajanik College of Engg & Tech, Surat
- Prof. J.K. Pandey, Chief Scientist, CSIR-CIMFR, Dhanbad.
- Dr. Vinod Kumar, Principal Technical Officer, CSIR-NML, Jamshedpur
- Prof. (Dr.) Pradip Kumar Sadhu, IIT (ISM), Dhanbad.
- Prof.(Dr.) Sanjay, Professor & Head, Dept. of ME, NIT Jamshedpur

Contents

List of Papers for Oral Presentation

List of Abstracts for Poster Presentation

SANTOSH KUMAR GANGWAR
GOVERNOR OF JHARKHAND

सत्यमेव जयते

RAJ BHAVAN, RANCHI-834001
JHARKHAND
Phone : 0651-2283465

Message

I am pleased to learn that Guru Gobind Singh Educational Society's Technical Campus (GGSESTC), Bokaro is organizing the 1st ISTE Student's Convention on the theme "Hackathon, Idea Generation and Start-ups – A Key to Success."

This convention will undoubtedly serve as a significant initiative toward fostering innovation, entrepreneurship, and youth empowerment. Today's era is defined by innovation and start-ups, where creative thinking, determination, and technical proficiency are the keys to success. Young minds, inovative ideas, and an entrepreneurial spirit play a vital role in shaping society and driving national progress. Events like this will not only inspire students but also strengthen their contribution to the vision of "Viksit Bharat."

I am confident that this event will provide students with an excellent platform to transform their ideas into reality, explore new possibilities, and promote innovation.

I extend my best wishes for the success of this program and convey my greetings to the organizers, faculty, and students.

(Santosh Kumar Gangwar)

भारतीय तकनीकी शिक्षा संस्था
INDIAN SOCIETY FOR TECHNICAL EDUCATION

(Under the Societies' Registration Act XXI of 1860)

DR. PRATAPSINH K. DESAI
President

MESSAGE

I am extremely happy to know that ISTE Bihar & Jharkhand Section is organizing its 1st Student's Convention at Guru Gobind Singh Educational Society's Technical Camus (An Engineering & Management College), Bokaro (Jharkhand) with the theme "**Hackathon, Idea Generation and Start-ups – a Key to Success**" during 22nd & 23rd March, 2025.

I am sure that this Convention will provide a platform for showcasing innovative research and projects and explore the latest advancement in Science and Technology on a global scale. I hope this initiative will bring students closer to technology by introducing them to a novel way of approaching familiar topics.

On this occasion, I extend my greetings and felicitations to the participants and organizers and wish the Convention a grand success.

11/03/2025 **(DR. PRATAPSINH K. DESAI)**

SHAHEED JEET SINGH MARG, NEAR KATWARIA SARAI, NEW DELHI - 110016
☎ - 91 11 2651 3542, 2651 4234, ✉ : istedhq@isteonline.org, : www. isteonline.in
: www.facebook.com/indian society for technical education

Message from VC, JUT Ranchi

Prof. (Dr.) D.K. Singh, Hon'ble VC, JUT, Ranchi

Guru Gobind Singh Educational Society's Technical Campus (GGSESTC), Bokaro in association with Jharkhand University of Technology (JUT), Ranchi is organising ISTE First Student's Convention (Bihar & Jharkhand Section) on Hackathon: **'Idea Generation and Start-ups - a Key to Success'** on 22nd and 23rd March, 2025. I welcome academicians, faculty members, scholars, participants and students to this convention for sharing their learning on a single stage. JUT is an autonomous body intended to impart higher technical education and skill development and other such programs in the state of Jharkhand, India. Through the present ISTE Convention, GGSESTC Bokaro and JUT Ranchi aim to bring together leading scientists, researchers, research scholars and students to exchange and share their experiences and research results about all aspects of Engineering, Applied Sciences & Management.

JUT appreciates GGSESTC for their on-going dedication for preparing their students for the professional world. The Indian Society for Technical Education (ISTE) aims to empower students by fostering their development into skilled professionals through technical education, promoting lifelong learning and cultivating a strong sense of ethics and responsibility.

The ISTE Convention will provide an interdisciplinary platform in hybrid mode to share latest research and innovation experiences and facilitate the development of cutting-edge applications. This event is poised to enhance collaboration and knowledge exchange for the betterment of all involved. I am looking forward to the ISTE First Student's Convention 2025 and I extend my best wishes for its success.

Prof. (Dr.) D.K. Singh

प्रो. सुकुमार मिश्रा
निदेशक
Prof. Sukumar Mishra
FIEEE, FNASc, FNAE, FIET, FIETE, FIE
Director

भारतीय प्रौद्योगिकी संस्थान (भारतीय खनि विद्यापीठ) धनबाद
धनबाद–826004, झारखण्ड, भारत
Indian Institute of Technology (Indian School of Mines) Dhanbad
Dhanbad-826004, Jharkhand, India

Message

It is with immense pleasure and pride that I extend my warmest congratulations to the organizers and participants of the 1st Student Convention Program of the Indian Society for Technical Education (ISTE) with the theme **"Hackathon, Idea Generation and Start-ups – A Key to Success"** at **Guru Gobind Singh Educational Society's Technical Campus, Bokaro.** This milestone event is a testament to the spirit of academic excellence, innovation, and collaboration that ISTE embodies.

In today's dynamic world, technology and education are evolving at an unprecedented pace. Platforms like this convention play a pivotal role in shaping young minds by fostering interdisciplinary learning, critical thinking, and leadership. It is heartening to see our students engaging in discussions, competitions, and knowledge-sharing sessions that will not only enrich their academic pursuits but also empower them as future leaders and problem-solvers.

The ISTE Student Convention provides a unique opportunity for aspiring engineers, technologists, and researchers to interact with experts, explore new frontiers in science and technology, and develop solutions that address real-world challenges. Such initiatives cultivate innovation-driven mind-sets and prepare students to contribute meaningfully to the nation's progress and global advancements.

I commend the efforts of the organizing committee, faculty mentors, and student participants who have worked diligently to bring this event to fruition. May this convention be an inspiring journey that ignites curiosity, fosters creativity, and strengthens professional and personal growth.

Wishing the 1st ISTE Student Convention Program grand success and hoping it becomes a legacy of learning and excellence in the years to come.

(Sukumar Mishra)

भारतीय तकनीकी शिक्षा संस्था
INDIAN SOCIETY FOR TECHNICAL EDUCATION

(Under the Societies' Registration Act XXI of 1860)

Dr. S.M. Ali
Executive Secretary

MESSAGE

It gives me immense pleasure to note that ISTE Bihar & Jharkhand Section is organizing its 1st Student's Convention at Guru Gobind Singh Educational Society's Technical Camus (An Engineering & Management College), Bokaro (Jharkhand) during 22nd & 23rd March, 2025 with the theme "**Hackathon, Idea Generation and Start-ups – a Key to Success**".

I believe that this Convention will surely pave way for the participants to exhibit their talents and enable them to enhance their knowledge in their respective field of interest.

I wish the Convention a grand success.

Dr. S.M. Ali
Executive Secretary

11/03/2025

SHAHEED JEET SINGH MARG, NEAR KATWARIA SARAI, NEW DELHI - 110016
☎ - 91 11 2651 3542, 2651 4234, ✉ : istedhq@isteonline.org, : www. isteonline.in
: www.facebook.com/indian society for technical education

Message from Principal, M.I.T Muzaffarpur, Bihar & Chairman ISTE, (Bihar and Jharkhand Section)

Prof. (Dr.) Mithilesh Kumar Jha, Principal, M.I.T Muzaffarpur, Bihar

ISTE First Student's Convention (Bihar & Jharkhand Section) on Hackathon: **'Idea Generation and Start-ups - a Key to Success'** on 22nd and 23rd March, 2025, represents a significant milestone in our collective journey to impart ethical values and professional standards in our students. Hackathons provide a platform to the students for innovation and collaboration with the different companies. Students participating in hackathons and idea generation workshops can develop innovative thinking in research and societal development. These initiatives can help develop critical thinking, creativity, and problem-solving skills, preparing students for the challenges of the 21st century. It's not just another step forward in automation and manufacturing; it's a revolution that revolves around the central tenet of human-centricity. By fostering a culture of innovation, creativity, and experimentation, these elements can help individuals and teams turn their ideas into successful businesses, driving economic growth and social impact.

Throughout this convention, we will delve into the critical dimensions of human-technology interaction, the integration of AI, Internet of Things, and Advanced Robotics. We'll discuss the ethical implications and the responsibilities that come with these advancements. Most importantly, we'll strive to find the right balance between human ethics and technological prowess. We must ensure that our technological pursuits remain ethical, inclusive, and sustainable, benefiting not just a privileged few but the society as a whole.

Prof. (Dr.) Mithilesh Kumar Jha

Message from Professor, NITTTR Kolkata & National Executive Council Member, ISTE

Prof. Anil Kumar

Dear Students, Faculty, Researchers and Innovators,

It is with great enthusiasm that I extend my warm wishes to all participants of the ISTE Bihar & Jharkhand First Student's Convention on Hackathon: **'Idea Generation and Start-ups – a Key to Success'**, scheduled to be held on March 22nd-23rd, 2025 at Guru Gobind Singh Educational Society's Technical Campus, Bokaro, Jharkhand. This convention serves as a dynamic platform to ignite creativity, foster innovation, and empower young minds to explore cutting-edge solutions through hackathons, start-up ideas, and emerging technologies. As we step into an era driven by digital transformation, artificial intelligence, and sustainable solutions, it is imperative for students to embrace problem-solving, entrepreneurship, and interdisciplinary collaboration to drive impactful change.

The event is designed to nurture innovative ideas, encourage knowledge sharing, and inspire students to transform their vision into reality. Engaging in hackathons and start-up discussions will enhance your critical thinking, technical expertise, and leadership skills, equipping you to navigate challenges in the evolving global landscape. I encourage all students, researchers, and academicians to actively participate in paper presentations, prototype exhibitions, CAD competitions, and quiz contests. This is an excellent opportunity to network with industry experts, academic leaders and fellow innovators while contributing to the technological advancements that shape our future.

I extend my gratitude to ISTE Bihar & Jharkhand Section, GGSESTC Bokaro, and the organizing committee for their commendable efforts in orchestrating this convention. Let us join hands in fostering a culture of innovation and entrepreneurship and making this event a grand success.

Wishing all participants a rewarding and enriching experience.

Prof. Anil Kumar

Message from President, GGES

Shri Tarsem Singh
Hon'ble President, GGES, Bokaro, Jharkhand

It is with great pleasure that I welcome you to ISTE First Student's Convention (Bihar & Jharkhand Section) on Hackathon: **'Idea Generation and Start-ups - a Key to Success'** organized by GGSESTC, Bokaro in association with Jharkhand University of Technology, Ranchi on 22nd and 23rd March, 2025.

The main objective of this event is to explore the latest advancements in science and technology on a global scale. ISTE Student's Convention 2025 provides a platform to the students for showcasing innovative research projects and encourage discussions on addressing global challenges through collaborative efforts. In this convention we explore the pivotal role of Artificial Intelligence, Internet of Things, and Advanced Robotics in shaping our future. I encourage all students to participate in ISTE First Student's Convention (Bihar & Jharkhand Section) on Hackathon: **'Idea Generation and Start-ups - a Key to Success'** to unlock their potential, creativity, and showcase their talents to take the first step towards becoming successful entrepreneurs.

I congratulate the Director, all students and faculty members for organising this convention. I am sure that their endeavours will be widely discussed and the participants will gain interaction and learning during this convention. I wish them a grand success.

Shri Tarsem Singh

Message from Secretary, GGES

Shri Surendra Pal Singh
Hon'ble Secretary, GGES, Bokaro, Jharkhand

It brings me immense joy to extend a warm welcome to all of you for the two-day ISTE First Student's Convention on 22nd and 23rd March, 2025. This event is a hackathon centred on the theme of **'Idea Generation and Start-ups - a Key to Success'.** It is organized by GGSESTC, Kandra, and hosted by ISTE (Bihar & Jharkhand Section).

In 2011, Guru Gobind Singh Educational Society's Technical Campus (GGSESTC) embarked on its journey towards academic excellence under the aegis of Guru Gobind Singh Educational Society, which runs educational institutions across the nation. The vision and mission of GGSESTC is to provide world class education, training and research opportunities in fields of Technology, Management and other disciplines and be a centre of academic excellence and an ecosystem vehicle for aspiring technologists and entrepreneurs.

I commend the dedicated efforts and hard work put forth by the organizing committee for this significant ISTE First Student's Convention (Bihar & Jharkhand Section) 2025, which promises to bring great benefits to all participants and stakeholders. My best wishes for its success.

Shri Surendra Pal Singh

Message from Director, GGSESTC Bokaro & Principal Convenor

Prof. (Dr.) Priyadarshi Jaruhar, Director,
Guru Gobind Singh Educational Society's Technical Campus, Kandra, Bokaro

On behalf of the organising committee of ISTE 1st Student Convention under ISTE Bihar & Jharkhand Section on Hackathon: '**Idea Generation and Start-ups- a Key to Success'** (an initiative of IQAC, GGSESTC, Bokaro) - I have great pleasure in welcoming all the delegates to the Convention during 22nd–23rd March, 2025 at Shri Guru Tegh Bahadur Auditorium, GGSESTC, Kandra, Bokaro. It is the first time that this student convention is being organised in Jharkhand. I am thankful to Hon'ble President ISTE, New Delhi, Dr. Pratapsinh Kakasaheb Desai; Hon'ble Vice Chancellor, JUT Ranchi, Prof. (Dr.) D K Singh; Executive Secretary, ISTE, Dr S. M. Ali; ISTE Chairman (Bihar & Jharkhand Section) & Principal, MIT Muzaffarpur, Bihar Prof (Dr.) M K Jha, who have given the required permission and sanction for organising this convention. I am thankful to Prof. (Dr.) A. W. Kharche, Director, Padmashri Dr. V. B. Kolte College of Engineering Malkapur -Buldana, Guest Of honour, for providing valuable suggestions and assistance time to time. The mission of Viksit Bharat will be complete when nascent young minds will join in the scientific, digital and entrepreneurial development development of the country because technical students are the future of the nation.
The two days' convention will cover the entire scope of ISTE on 22nd–23rd, March 2025. There are 32 research papers for presentation in 6 technical sessions and 10 abstracts for poster presentation and quiz sessions. Besides, there are two eminent personalities invited for expert lectures. At the end of the convention, a comprehensive panel discussion has been organised upon the topic "Fifth Generation Engineering & Management College". During the panel discussion, experts from the Government Agencies, Academic Institutes, Public Sector Undertakings and Private Sector will directly interact with the participants. A technical science & innovation exhibition has been organised during the convention. More than 15 groups will be exhibiting their projects. Delegates & participants can interact and be informed about the start-ups, hackathon etc.

I extend my sincere thanks to all the esteemed representatives of ISTE, New Delhi, Bihar & Jharkhand Government, GGES Management - Hon'ble President Shri Tarsem Singh, Hon'ble Secretary Shri Surendra Pal Singh, Public Sector Undertakings, Private Industries, Academic Institutes and Individuals for their support in this first student convention.

Prof. (Dr.) Priyadarshi Jaruhar

Message from Assistant Professor, CSE & Convenor

Apurba Sinha

It is with great enthusiasm that I welcome you all to the ISTE First Student's Convention (Bihar & Jharkhand Section) on Hackathon: **'Idea Generation and Start-ups - a Key to Success'** on 22nd and 23rd March, 2025. This prestigious event will provide a platform for students to showcase their knowledge, creativity, and technical expertise through various competitions, including: Paper/Poster Presentation, Projects/Model/Prototype Exhibition, CAD Competition, Quiz Competition

I am delighted to share that we have received an overwhelming response, with over 400 registrations and more than 350 participants expected to actively engage in the event. Out of 50 technical paper submissions, 32 have been accepted for presentation and 10 for poster presentation. A proceedings with ISBN no. has been published. Additionally, a Project and Model Exhibition has been organized, offering an excellent opportunity for participants to exhibit their innovative ideas.

This initiative is a testament to our commitment to fostering innovation, creativity, and entrepreneurship among young minds. Hackathons and idea-generation platforms serve as the breeding ground for ground breaking solutions to real-world challenges. They provide a dynamic space where collaboration meets technology, and ideas transform into actionable ventures. In today's rapidly evolving world, start-ups play a crucial role in driving economic growth and technological advancement. The journey from an idea to a successful venture requires perseverance, teamwork, and a willingness to embrace challenges. Through this event, we aim to inspire our students to think beyond boundaries, develop problem-solving skills, and build solutions that can make a meaningful impact. I extend my sincere gratitude to our mentors, speakers, and participants for their valuable contributions. I also heartily welcome media persons to cover this historic event.

Apurba Sinha

Acknowledgement

We acknowledge the compliments from the following dignitaries –

1. **Dr. AW Kharche**
   Principal – Padmashri Dr. V. B. Kolte College of Engineering
   Malkapur, Maharashtra

2. **Prof. (Dr.) Pankaj Rai**
   Director - B.I.T, Sindri, Dhanbad
   Jharkhand

3. **Dr. Nikhil Kant**
   Deputy Director -All India Council of Technical Education (AICTE)
   & Environmentalist & Poet Climatologist
   New Delhi

4. **Dr. Sunil Kumar Jha**
   Principal - Sityog Engineering College, Aurangabad
   Bihar

5. **Smt. Neeta Baa**
   General Manager (HRD) - Steel Authority of India Limited (SAIL)
   Bokaro Steel Plant, Bokaro Steel City
   Jharkhand

6. **Dr. Amaresh Kumar Rai**
   Associate Professor & HOD, Civil Engg.
   MIT, Muzaffarpur
   Bihar

7. **Dr. Ramesh Kumar**
   Principal - Government Women's Polytechnic, Bokaro
   Jharkhand

8. **Dr. Bal Krishna Sahai**
   MC Member – Indian Society for Technical Education (ISTE)
   Bihar & Jharkhand Section, Patna
   Bihar

Adoption of IoT in e-Learning in Higher Educational Institutes: A Review

[1]Dr. Sunil Kumar Jha, [2]Mr.Aman Kr Dubey

[1]Principal, Associate Professor ,Dept CSESityog Institute Of Technology , Aurangabad
[2] B.Tech ,Sem : 4 DeptCoputer science

Abstract : IoT is a fundamental enabling technology for creating smart spaces which can assist the effective online education system. The transition to smart education is appealing which has a concrete impact on learners engagement , motivation, attendance and deep learning. With technology evolving, IoT has enhanced the learning experience for students, teachers and university operations. From smart classrooms to connected devices, the role of IoT in education has opened up various opportunities. While capabilities are increasing day by day, there are still many limitations and challenges to utilizing these technologies within E-Learning in higher educational institutes (HEIs). In this article, we will explore the ways IoT is transforming higher education. We'll also cover the benefits and challenges that come with its implementation. This research aims to examine the factors influencing IoT adoption for E-Learning to be utilized in HEIs. The paper also focuses to investigate new strategies in context of IoT to integrate the recent ICT trends with educational system. Further, an adoption model is proposed for IoT-based E-Learning and provides recommendations for enhancing the IoT adoption for E-Learning in HEIs. This study describes (i) addresses the problems in the traditional education system with possible solutions (ii) the transition towards smart education (iii) increasing the understanding and competence of human resources in of Higher Educational Institutes.

Keywords : Education, IoT, e-learning, software system, learning process

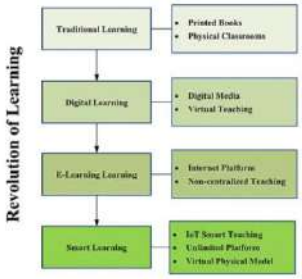
I. Introduction

The Internet of Things (IoT) describes the internet of physical objects "things" that are embedded with sensors, software and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. The term "Internet of Things" refers to the three types of online interactions that occur between people, between machines and things, and between machine and other things. IoT can deliver unique services in a variety of domains including education manufacturing, health care, home automation, retail, medical and agriculture. Smarter and smaller devices are included . The IoT is already attracting a slew of academic and businesss of academic and business interests.

IoT technology has an important impact on educationwhich has not only changed the traditional teaching practices but also has brought significant changes in the infrastructure of education institutions. IoT based e-Learning system is a method of teaching adopted in modern education system where virtual pedagogy of teaching is implemented. The integration of the Internet of things (IoT) in education has brought a revolution the way we teach and learn..IoT applications in education have grown exponentially, making learning more interactive, efficient and personalized. E-Learning systems have reached their peak with the revolution of smart technologies. IoT. Academic institutions are currently including IoT in their educational activities, however, there are still few review studies available that do a comprehensive sweep on the acceptance and adoption of IoT in higher education. Therefore, this research was developed with the aim of filling this research gap as well as exploring existing scenarios for their inclusion and implementation in higher education through a systematic review of the literature. The results obtained will be useful for use by researchers or practitioners in higher education in the future.

The Internet of things is a new actor in learning environments. It plays a significant role in bringing interactivity, improved learning, and understanding between academic staff and learners via virtual and physical objects within the HEIs environment. Also, there is more focus on smart education and the use of IoTtechnology to bring improvement to learners in a class. Hence, with the increasing rate of utilizing online teaching by HEIs, assessment of the adoption of IoT is becoming dominant among academics and researchers. Internet of things supports the changes in the HEIs environment in education, including teaching, learning, management, experiment, training, school, campus building, etc. This creates a new opportunity where innovative learning options result from the change in concepts from ubiquitous computing and technologies.

The educational system has been transformed in most of the developing countries. At the same time, new specifications are required to establish teaching and learning methods for success within their setups and the boundaries that may entail. Technology is progressively essential in answering and allowing for innovative outcomes in terms of teaching and learning, such as the inverted classroom, massive open online courses (MOOCs), and smart learning.Till now, the revolution of learning is divided into four groups including traditional, digital, E-Learning, and smart learning.Currently, we are living in the era of Smart learning. In simple words, Smart learning is the combination of E-Learning and IoT, or it is also known as IoT based E-Learning (Verma and Singh, 2021; Verma et al., 2021)



II. Background

A. e-Learning Overview

e-Learning is a part of smart education teaching, learning and managing paradigm encompasses smart technologies such as IoT, Artificial Intelligence and 5G which make it more effective , comprehensive and attractive. Smart education provides a digital environment to facilitates learners, teachers and administrators
where more comprehension, interaction, transparency and motivation. With the recent development smart technology , educational institutions need to be transformed into smart institution rather than continue with the traditional institution.The points mentioned below highlights how the Smart Education dominates over the Traditional education system –[5]

- The traditional Education System focuses basically on the bookish theoretical pattern of education

while the Smart Education System focuses on the practical learning and critical thinking .

- Traditional Education is not flexible and the student has to go to the classes, while the Smart Education

is scientific in nature which allows the student to study in their own space.

- Tradition Education is based on firm policies which is time and place dependent while Smart Education

not confined to the place and time rather student can interact anywhere and any time.
Some of the drawbacks of traditional e-Learning systems include limitations in expanding and distributing computing power as well as exchanging information among system users which has encouraged the development of new technologies to overcome these obstacles and motivate the learning process.

E-learning is a type of online education, training, and knowledge sharing through electronic technologies that is conducted through Internet. Application of software in the learning process make teaching processes more effective , result oriented and dynamic. It involves delivering learning content and experiences through digital platforms, allowing for a flexible and comfortable learning environment that enables learners to study at their own pace and location. It can be utilized in various settings, such as academic education, corporate training, continuing professional development, and skill development courses.Although, IoT has been in process of e-Leraning from years, but the growth of e-Learning or online method of learning got momentum by the COVID-19 pandemic during which all the learning processes have had to migrate totally to e-Learning processes resulting the widespread adoption of computers and internet technology. Consequently the demand for online learning became the solutions of teaching and learning. [18]

Due to the launch of 5G mobile network that introduces real time communication and this superfast connectivity accompanied by the latest smart supportive devices brought revolution in launching the Smart Education vis-a-vise-Learning. E-learning offers benefits such as flexibility, accessibility, and scalability, making it a popular choice for both personal learning and corporate training. It is increasingly used in various fields, including academia, professional development, and corporate education. E-Learning is prime for betterment of education from primary to higher and it is the main method to enhance skill of teacher as well as the comprehension of the students as it developed scientific methodology in pedagogy. The use of techniques in e-Learning like virtual class rooms, channels like Zoom, Google meet and Skype has contribute better impulse to the knowledge of learners and transforms the educational process into a universal one. E-learning can take place through various platforms such as websites, mobile apps, and Learning Management Systems (LMS). [24]
e-Learning follows two kinds of technology - namely first is infrastructure based and the second is software based. The infrastructure is categorized into on-premises and on-cloud. E-Learning infrastructure includes mobile phones, computers, networking devices, servers and other devices which communicate data from one end to other end. On –premises infrastructure needs skilled man power for help while cloud based educational technology has some flexibility and it is comparatively less cost effective. The software category of learning may be Synchronous type an Asynchronous type . Synchronous type of learning include audio and video learning using conferences , live chat and application sharing while Asynchronous support learning resources management systems.[17]

IoT is one of the best technologies which has strong influence in various forums, education is considered one of these which plays a key role in the amelioration of quality of education and its development. The IoT enabled transformation from Teacher-centric education to Student –centric education in which student built their knowledge by enabling them to explore the reality around them.

Integrating IoT smart objects, traditional e-Learning is converted into intelligent and interactive e-Learning It creates an appropriate and comfortable learning environment in addition to increasing performance.[9]

B. **Types of E-Learning**

1.Online Courses: It is Synchronous and Asynchronous and courses offered by educational institutions in any mode. Synchronous mode of learning is instructor led in which participants are required physically while Asynchronous mode of learning is self directed need not participant present at the same time. be synchronous (live sessions) or asynchronous (pre-recorded lessons).[24]

2.Virtual Classrooms: Interactive, real-time sessions where students and instructors communicate through video conferencing, chat, or other collaborative tools.

3.Mobile Learning : Allows learners to access through smart phones or laptop. It allows users to access course content on the go.

4.Blended Learning:A hybrid approach that combines online learning with face to face

5.Microlearning: Provides short bite-sized modules of information for just a few minutes. It is useful for skill-building or quick knowledge acquisition.

6.Webinars and Video Lectures: Live or recorded sessions that provide an opportunity for learners to engage with instructors, often with the ability to ask questions and participate in discussions.

7.Massive Open Online Courses (MOOCs): Massive Open Online are large scale Courses accessible and affordable online to any one providing distance learning opportunities

8. AR and VR learning: Augmented reality (AR) adds something virtual on top of the real world, while virtual reality (VR) involves a virtual world

C **.Key Features of E-Learning:**

E-learning or electronic learning implements digital technologies to educate learners. Some key features of e-learning include:

1. Accessibility :E-learning is available to anyone without consideration of geographical limitations through Internet connection.

2. Flexibility : Learners can access content at any time and from any place.

3. Interactivity :E-learning can be interactive, allowing learners to engage with content through quizzes, discussions, simulations, and more.

4. Multimedia : E-learning can incorporate multimedia elements like videos, animations, and graphics to make learning more engaging.

5. Individualized learning :E-learning can provide customized material recommendations based on users' interests, abilities, and progress.

6. Collaboration tools : Learners can access content on their own schedule, making it easier to balance with personal or professional commitments.

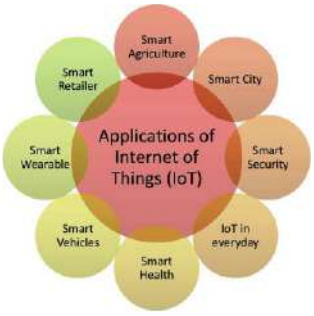
7. Cloud hosting : Cloud-based platforms ensure scalability, security, and accessibility.

8. Add-ons :E-learning platforms can have add-ons applications as per needed that can help with things like generating reports, translating content into multiple languages, and hosting live online classes.

D. **Internet of Things Overview**

The Internet of Things (IoT) technology comprises of interconnection of devices, vehicles, appliances and other objects embedded with sensors, software and connectivity , enabling to gather and exchange of data over the network. The significant property of IoT to have good control over objects and transform in to smart object. In this way it generates smart environment. It is ubiquitous since communication and association between physical and virtual object is established. In this way IoT has brought smart systems by connecting smart gadgets.

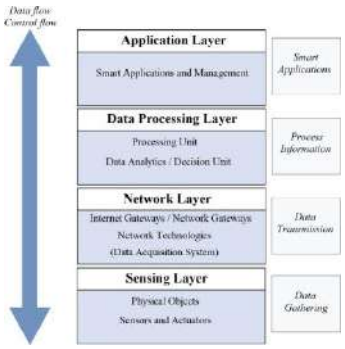
IoT technology is increasing by leaps and bounds and offering benefits to all the domains. The educational sector is not untouched. The teaching process is progressing towards digitization. Patton investigated digitization and discussed the key impact and challenges in the process. In due course not only students and teachers but also curriculum and institution would take benefit of digitization applied in education. BidyaNandetal discussed smart education to solve traditional deficiencies in the prevalent traditional education system. Zhu et al discussed smart education to solve traditional educational issues. He focused on personalized and seamless learning.



E. **Technologies behind IoT**

While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies such as standard protocols and networking has made it practical. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, LTE-A, and WiFi-Direct. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.[8]

- **Access to low-cost , low-power sensor technology :** Affordable and reliable sensors are making IoT technology possible for more manufacturers . These devices are at the heart of IoT, as they allow machines and devices to interact with the physical world
- **Connectivity :** Connectivity is significant that facilitates availability of IoT infrastructure . Any where , any time it can be connected .In order to data transmission across the cloud from sensors and actuators, IoT devices need to be connected to the internet. There are several connectivity technologies that are used in IoT, including wifi, Bluetooth, cellular, Zigbee, and LoRaWAN.
- **Automation :** Integration of Sensors and Actuators allow machines and devices to interact with the physical world. Automation is possible when sensors and actuators work to resolve issues without human intervention.
- **Cloud computing platform :** The increase in the availability of cloud platform enables IoT devices to stored, process, and analyze the data.as well as to build and deploy IoT applications.
- **Big data analytics**: Extraction of knowledge from generated data by IoT devices, businesses need to use advanced analytics tools to extract insights and identify patterns. These tools can include machine learning algorithms, data visualization tools and predictive analytics models.
- **Interoperability :** Regardless of their manufacturer or operating system, IoT systems can work seamlessly with other systems and devices. As a result, a variety of devices and systems can be integrated into IoT systems.
- **Scalability** :The number of elements connected to the IoT zone is increasing day by day. Hence, an IoT setup should be capable of handling the massive expansion. The data generated as an outcome is enormous, and it should be handled appropriately.
- **Security and privacy technologies:** As IoT deployments become more widespread, IoT security and privacy become increasingly important. Technologies such as encryption, access controls and intrusion detection systems are used to protect IoT devices and the data they generate from cyberthreat
- **Distributed Real-time architecture:**IoT systems often have a distributed architecture, with devices and sensors located at the edge of the network, rather than centrally located [35]. This decentralized architecture allows for the Real-time collection and processing of data from many devices and sensors.



F. **Benefits ofIoT in education**

Smart devices brought significant changes in education sector. It has affected the method of teaching ,learning , administration in respect of students as well as teachers and improved communication and collaboration.

- **Smart Administration :** Monitoring teachers and learners progress is critical. In an institution, the most important is to monitor and getting feedback . With the proper evaluation of teachers and institution the performance can be improved to a significant extent as well. The smart system can transparently manage all the issues as the excess workload can be alleviated. For example the IoTmanagement solution in schools can track the availability of material s like number of books in the library , alerting the concerned person when supplies need replenishment. In addition , IoT technology can monitor and manage school resources and help optimize these resources use and ensure these are efficient and effective and also make cost effective.[28]
- **Smart Classroom engagement :**With IoT devices , classes can be interesting as well as interactive a teachers can create more engaging and interactive lessons that keep student interested and motivated. Using interactive smart whiteboard, the teacher can present lecture in audio video media . Specially , in the technical institution IoT devices are key to present design, models, graphics and such topics that can not be discussed in traditional chalk board can be discussed very effectively in lucid style. Overall , using IoT system, in education sector can bring improvement in the resource management, leading to cost saving and more efficient and effective use of resources.[3]
- **Smart attendance :**Manual or Biometric attendance is time taking and sometimes lead some boring. RFID Smart cards may be used to automate the attendance system of the schools . This mark the learners and teacher's attendance as they enter the class. This smart system notifies the head of the institution data of the present students and staffs instantly.[38]
- **Smart reports :**Latest technology based IoT devices and artificial intelligence based software Sheet+, AjeLix represents very effective report Microsoft Text Analytics for Excel add-in enables to analyze text data within Excel using AI-powered sentiment analysis and key phrase extraction. Power Query incorporates AI-driven capabilities for data cleaning, transformation, and enrichment. It utilizes machine learning algorithms to detect patterns, recognize data types, and suggest transformations based on user input. Azure Machine Learning provides a comprehensive platform for building, training, and deploying machine learning models enabling seamless access to AI-powered capabilities within your spreadsheets. The introduction of smart system minimizes corruption andcurves illegal practices.
- **Smart Security :**With IoT devices safety and security can be ensured in the campus of the institution. The intelligent system pays a major role in security by installing cameras and sensors.
- **Smart Engagement :**e-Learning solutions through IoT technologies can enhance collaboration allowing collaborative approach on projects and share ideas and resources in real time. It can help create more dynamic and engagement learning environment conducive to active learning and problem solving. To optimize the quality of education , learners engagement must be enhanced and it can be done using IoT which keeps learners motivated and engaged in a particular domain.
- **Personalized Learning :**IoT based solutions can also be used to provide personalized learning to the students. The idea is to use IoT devices and sensors to gather data, track performance, and provide real-time feedback to both students and educators. By gathering data of student's preferences and learning style and needs, these systems can create tailored curriculum.
- **Real-Time Data Analytics :**IoT-enabled devices can track student engagement, attention, and performance in real time. Wearables, smart glasses, or biometric devices can monitor how students are responding to lessons. This data can be analyzed to adjust the pace of the class, the type of content being delivered, and the level of difficulty, providing a highly personalized learning path for each student.
- **Smart Activities:** Learning by doing increases the retention and understanding of the learners. A case study survey has concluded that students retain 10% from reading, 20% from listening from a teacher, 30%from watching , 50% from watching and listening at a time, 70% from participating , in discussion and continuing practical or workshop, and more than 90% of information remains in memory from teaching to others. Smart objects are helpful in apprehension , retaining , recalling.
- **Smart Marking and Question Bank :** During preparation of questions, the answer is loaded in the database and while answering , the suitable an answer is verified through databases. Smart testing services are used to assess students as well as to evaluate teachers and then store the result on fog servers.
- **Smart Classrooms :** Smart class rooms are becoming increasingly popular in educational institutions. Unlike traditional classroom teaching pedagogy, flipped classroom teaching pedagogy is emerging in many leading universities of the world. In flipped classroom teaching pedagogy, this content is recorded in the form of video lectures. These video lectures are made available to students using some platform/technology. Students are expected to see the video lectures before coming to class. Now, based upon this content, the students will do the problems/numerical/questions in class with instructor offering more personalized guidance and interaction with students.
- **Gamification and Learning through IoT :**IoT can enable gamified learning experiences, where students use connected devices to participate in interactive and engaging lessons. Sensors could track a student's progress in real time, allowing the system to provide rewards or level-ups based on the student's performance, making learning more enjoyable and tailored to the individual.

G. **IoT application in e-Learning :**In the context of e-learning, smart devices powered by the Internet of Things (IoT) enhance and personalize the learning experience by gathering data and provide feedback. It creates an interactive environment that supports various learning needs. Following are smart devices contributing qualitative approach in e-learning to optimize the educational process.[12][17]

- **MCU** – MCU is a single board computer, working as a hub to connect all devices and make decisions as per the sensors input. A number of MCU models are available which are selected as per requirements. In educational institutions , they may be used to collect data from different sensors and smart devices.
- **RFID**- RFID chip is embedded in the card which is identified through the radio frequency. They can help in the automatic attendance of the teacher as well as of the students automatically. It will improve the efficiency and performance of learners and teachers.
- **Interactive boards** – Through Interactive Smart board , the learner scan learn practical aspects of the lessons other than only the theoretical education. It gives deep and almost permanent impact on the brain of the learners.
- **Smartphone**–It helps to manage Flip class rooms where students, teachers and parents can easily communicate.
- **Sensors and Actuators** - These are the core component of IoT infrastructure
- **VR and AR** -VR and AR is becoming a part of teaching and learning. This helps the teachers to teach the concept in a three-dimensional environment just like real physical objects. ‘is simulates the real environment for learners.
- **Smart Speakers and Smart Microphones** - Smart speakers have di,erent connectivity options. They may be connected by Wi-Fi, Bluetooth, or direct IP access. ‘is may be used for announcement and timetable management. ‘e smart microphone may be used in classes with VR capabilities to automatically update the home assignment.
- **Alexia** -Alexia is a smart voice assistant. It uses AI and Voice Recognition (VR) to interpret voice commands. This put great eort into educational institution automation. Instead of using notification systems, Alexia may verbally explain the situation.
- **Biometrics and Face Detection** -Manual attendance is an issue and time-consuming. It is also not secure. Biometric and face detection technologies may be used in the a endance system. This can help to keep the exact arrival and departure information.
- **Scan Marker** - Scan marker is a device which scans the text and converts it into different languages. This may be used in reading other languages and converting text into audio. Scan marker is also called a digital highlighter.

III. Related Work

In terms of education, IoT is dignified to play the role of a big game-changer as this technology is now utilized by many educational institutions. Along with that, connected smart devices are used by many institutions for supporting the even now available e-learning and smart board infrastructure. The value of the IoT was demonstrated by [6] by developing and enhancing education, as well as the scope of their significance in higher education institutions via smart coursework utilizing the latest methods in the classroom setting, smart labs to run tests more efficiently and enable tests, including the use of gadgets to enhance student communication with their classmates and teachers, and also scientific content.

S.Gul.et.al investigated the role of emergent technology, such as smart materials, artificial intelligence, and augmented reality, in the future of e-learning. In Zhang and Zhou , the importance of locality, interaction, intelligence, openness, and cloud computing were analyzed from the standpoint of e-learning‟s future vision. The use of smartphones in e-learning was emphasized by Mohammed and Isa [25] emphasized the significance of IoT in enhancing human-machine connection, which contributes to people's social isolation .Mountec. These gadgets must be integrated into distance learning systems. These gadgets became more widely available and easier to operate as time went on. The authors suggest a platform that has an intelligent agent on a student's smartphone. The necessary information about the students' obsessions, participation in the course, and other factors is collected and sent to the artificial intelligence system for evaluation. The artificial intelligence algorithms look at student data, comments, and ratings of course materials to figure out what course content is suitable. The authors suggested analyzing student behavior with smartphones to make sure that the course content was customized correctly. Tobarra, et al. put the app of the virtual laboratory to the test to see how well it worked. The learners' acceptance was evaluated using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, as well as time allocation, learner‟s behavior in relation to evaluation items, and material sources. The main result of this research is that the suggested lab has a high level of student acceptability, as measured by several factors (ease of use, perceived usefulness, attitude, intention to use, social influence, and estimated effort).

In the same way, IT expertise is required when dealing with IoT apps or devices. Individuals prefer to interact personally with another person rather than with a machine. Others may believe that revealing medical details to the machine will compromise their privacy. Such factors represent considerable obstacles to the use of IoT applications to control the virus‟s spread [25]. Dodero, et al. look at what needs to be done to make the e-learning future a reality. Issues related to IoT and elearning integration, including CPU and storage limitations, throughput, and bandwidth constraints, should be addressed for successful integration. Accordingly, the trade-off between data-collection efficiency and interoperability may be considered to enhance this integration. In their work, Chituclooked at standards interoperability and pointed out the problems with interoperability that need to be fixed for the IoT and e-learning visions of the future to come true. Perales, et al. demonstrated an online system utilized by the International University of La Rioja. The online service is a remote online lab that delivers experiential learning using engineering experimental tools. The teacher might move from one online workspace to another to help students with their lab instructions. Even though this method is used to offer online labs, it doesn't consider how and why the students interact with each other. In the work of, the authors recommended using a context-aware system to capture a vast amount of data about the learner's surroundings. The system automatically adjusts to the customer's wishes based on these facts. Contextawareness

incorporation into an e-learning system would be an effective strategy for improving learning. Zaguia, et al. [24] showed learners a new way to use synchronous e-learning for intelligent e-learning. The paradigm is a new way of thinking about distance learning in which the teacher has more control over the students. Tools for artificial intelligence, IoT, and virtual reality are put together to make a more powerful system that helps the teacher keep an eye on the students during lessons and tests. Most of the changes we will make to our systems in the future will involve adding more computer-aided services to help teachers see and respond to how students are acting. In the work of , the authors proposed that artificial intelligence approaches such as data mining and fuzzy logic be used to smarten up e-learning tactics and augment students' learning. Most of these systems are limited by the time to finish the assessment exam, the learner's evaluation criteria, history, and so on [24]. Similarly, Leahy, et al. investigated the role of emergent technology, such as smart materials, artificial intelligence, and augmented reality, in the future of e-learning. In Zhang and Zhou , the importance of locality, interaction, intelligence, openness, and cloud computing were analyzed from the standpoint of e-learning‟s future vision. The use of smart phones in e-learning was emphasized by. These gadgets must be integrated into distance learning systems. These gadgets became more widely available and easier to operate as time went on. The authors suggest a platform that has an intelligent agent on a student's smartphone. The necessary information about the students' obsessions, participation in the course, and other factors is collected and sent to the artificial intelligence system for evaluation. The artificial intelligence algorithms look at student data, comments, and ratings of course materials to figure out what course content is suitable. The authors suggested analyzing student behavior with smart phones to make sure that the course content was customized correctly. Tobarra, et al. put the app of the virtual laboratory to the test to see how well it worked. The learners' acceptance was evaluated using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, as well as time allocation, learner‟s behavior in relation to evaluation items, and material sources. The main result of this research is that the suggested lab has a high level of student acceptability, as measured by several factors (ease of use, perceived usefulness, attitude, intention to use, social influence, and estimated effort).

According to Marquez, Villanueva, Solarte , Garcia in " IOT in education: Integration of objects with virtual academic communities" the students, teachers, and physical and virtual things can interact effectively and via efficiently using IOT. Due to the significance of IOT, the Open University in the UK presented a course and named it "My Digital Life" that depends on IOT basics for undergraduate students in the computer science department. The students learned in this course how to deal with IOT for understanding the world and know their role. Melissa Burns, journalist says Smart learning environments are equipped with digital components that create better, more efficient, and smoother learning process. Ideally, they produce an ideal action between physical and digital realities, permitting students to absorb data from their surroundings and making opportunities for seamless transitions between a spread of learning approaches. Individual and group learning, formal and informal settings, in analogue and digital formats. IOT can track whether homework was done and collect data about how much time a student needed to complete an assignment. This data can help teachers better understand whether their methods are working, which students need additional help, and which tasks they struggle with the most. Literature review shows that almost all of the recent studies propose completely different models for classroom. Several advanced and innovative ideas square measure being projected or introduced in education like introducing IOT technology with crowdsourcing in e-education may be helpful for up learning and teaching processes.

IV . E-Learning-based IoT adoption model for Higher Educational Institutes

Adoption of the IoT is vital for effective E-Learning. Individuals and organizations must work in a technological environment where specific processes must be followed in order for learning to be successful and effective. For this purpose, E-Learning influencing factors of the IoT adoption model in HEIs are classified into four groups:

- Individuals, Organizational, Technological, Environmental,

Individuals are based on instructors and students, organizations depend on institutes and universities, technology is based on devices and tools, and the environment depends on classrooms and homes. Furthermore, details are described given below.[49]

Individual : Individuals consist of instructors or students who must possess specific IoT-based E-Learning skills to function successfully. Individuals must have computing abilities, and it is recommended that they remain self-motivated by realizing and learning a lot from IoT based E-Learning approaches. They must be cautious in their actions, attitudes, and everyone must maintain a high level of morality. In order to learn effectively, students and instructors must engage in interactive learning sessions. Instructors may obtain feedback from students on how the learning process is going on and if they understand the learning materialcorrectly or need clarification. Instructors can also automatically use the IoT-based E-Learning sign-in record to automatically save attendance. (Agrawal et al., 2020)

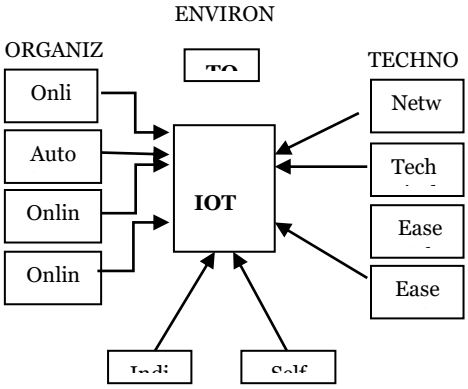


Fig : E-Learning-based IoT adoption model for HEI

Organizational : Organizations consist of institutes and universities. On the other hand, organizations must keep a few things in mind, such as designing the course before publishing it and making the website user-friendly. They should also examine if they are financially ready to publish a course and can meet all the requirements in the future before doing so. Also, they should make sure that the website is infrastructure-ready so that an online exam/test/quiz can be taken and monitored if all goes as planned.(Ahmad et al., 2021)

Technological : Technical devices or tools are one of the essential considerations when it comes to implementing IoT-based E-Learning. Instructors and students must know how to utilize technology, and IoT-based devices and platforms must be simple for them to access and use. IoT-based E-Learning systems should have a solid framework and have the ability to add any needed content easily and quickly. They must also have sufficient IoT resources to make effective use of it.(Razzaque and Hamdan, 2020a)

Environmental : The learning environment is based on classrooms and homes. Furthermore, it should be preferable to teach their students and instructors before publishing the course to understand the IoT-based E-Learning system entirely. Again, several particular problems, such as privacy and ethical issues, should be considered while operating an online classroom. Moreover, the meeting or conference room, class capacity, and internet speed must be considered.(Amasha et al., 2020).

V .Proposed e-Learning Entity Model integrating IoT

The proposed model describes the communication system in via network using IoT devices utilizing IoT devices sensors and actuators. End user teacher and learner both connects themselves with various apps residin cloud through IoT gateways. Sensors detect a physical entity's feature and transform them into digital data that can be interpreted by humans. Actuators use digital instructions to operate on or affect the attributes of physical things.[42]

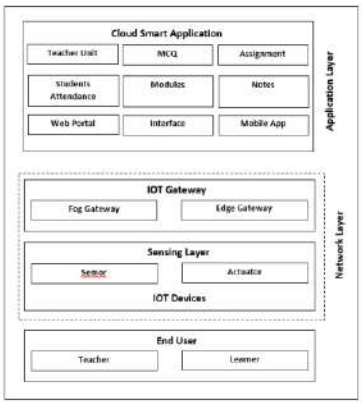


Fig : e-Learning Entity Model integrating IoT

Application Layer : Application Layer is cloud layer which includes business application like e-Learning system. This layer will include all the services that can be provided to learners and teachers. All the information is available in this area.

Gateway Layer and Networking : Data generated through by IoT devices is disseminated through this layer. It includes data storage as well as device management applications. The main task network components is to establish communication link with IoT devices.
Sensor Layer : This layer consists of sensor and actuator. Teacher and student interact with e-Learning system using smart phones, computers, tablets and more specialized devices.

V . Challenges and Future Directions

The research study examines the influencing factors that are significant for the IoT adoption of E-Learning in HLIs by proposed designing an E-Learning-based IoT adoption Model and e-Learning Entity Model integrating IoT. The research study stands on two categories of challenges 1)computational challenges and 2)Social challenges. As the area and dimension of Higher Institutional systems are growing ,it is exigent to find out the remedies to cope up with such a growth regarding IoT adoption.
1. Computational Challenges ;Computational challenges run parallel to the installation and integration of smart system. Major challenges in the part of smart education in Internet connectivity, privacy issue, compatibility and interoperability, data pollution, artificial intelligence,
2. Social Challenges : Despite the countless benefits, the smart system faces many challenges from the social side. The most general one is the use of modern technologies because the new person and non technical persons are not friendly with smart devices. Another major challenge is the lack of funds. Generally students are addicted to mobile phones. Therefore , one of the challenges with digitization is that students may addict to different applications instead of giving time to learning. It is the primary concern for the students for overcoming such a kind of attitude.

VI . Conclusion

This article explored the IoT and smartdevices integration in education and proposed a possible framework for smart education. This further explored the issues related to the traditional educational system and how the Information and Communication Technology (ICT) with smart devices can change the academy into digitized methodology. Smart devices convert the traditional activities of the higher educational institution to smart activities such as smart attendance , smart reporting, smart lesson planning , smart pedagogy and smart learner engagement.IoT technology removes presence of teachers and learners physical presence and expands the access perimeter of teachers, tools facilitating the E-learning efficiently anywhere and any time. IoT promises a significant impact on the process of learning in higher education by offering access to the international resources and possibilities for students and teachers. Therefore, one of the major impacts of the IoT-based learning environments is that the conventional student and instructors' tasks can be changed considerably. Students and teachers can retain didactic materials and/or laboratory virtually at any time, from anywhere they can connect. The Internet of things is projected to promote the large number of investigation opportunities for educators, students and researchers around the world.Cloud computing is an innovative technology that can provide huge benefits to universities to improve their teaching and learning processes. While it has been widely adopted for e-Learning across universities in developed countries, its adoption in developing countries is very low and there is a lack of empirical studies that investigate the factors that influence its adoption by university students.

VII. References

[1] Y. I. Alzoubi, V. H. Osmanaj, A. Jaradat, and A. Al-Ahmad, "Fog computing security and privacy for the Internet of Thing applications: State-of-the-art," Security and Privacy, vol. 4, no. 2, p. e145, 2021.
[2] Y. I. Alzoubi, A. Al-Ahmad, A. Jaradat, and V. Osmanaj, "Fog computing architecture, security, and privacy, for the internet of thing applications: An overview," Journal of Theoretical and Applied Information Technology, vol. 99, no. 2, 2021.
[3] N. B. Salehudin, H. Kahtan, H. Al-bashiri, and M. A. Abdulgabber, "A Proposed Course Recommender Model based on Collaborative Filtering for Course Registration," International Journal of Advanced Computer Science and Applications, (IJACSA), vol. 10, no. 11, pp. 162-168, 2019, doi: 10.14569/IJACSA.2019.0101122.
[4] H. M. Truong, "Integrating learning styles and adaptive e-learning system: Current developments,
problems and opportunities," Computers in human behavior, vol. 55, pp. 1185-1193, 2016.
[5] H. Al-bashiri, H. Kahtan, M. A. Abdulgabber, A. Romli, and M. A. I. Fakhreldin, "Memory-based Collaborative Filtering: Impacting of Common Items on the Quality of Recommendation," International Journal of Advanced Computer Science and Applications, vol. 10, no. 12, 2019, doi: 0.14569/IJACSA.2019.0101218.
[6]S. Kummar, F. S. Al-Aani, H. Kahtan, M. J. Darr, and H. Al-Bashiri, "Data Visualisation for SmartFarming Using Mobile Application," International Journal of Computer Science and NetworkSecurity, vol. 19, no. 11, pp. 1-7, NOV 30 2019. [Online].
[7] W. N. A. W. A. Fatthi, M. H. M. Haris, and H. Kahtan, "Application of Travelling SalesmanProblem for Minimizing Travel Distance of a Two- Day Trip in Kuala Lumpur via Go KL City Bus," in Advances in Intelligent Systems and Computing. Switzerland AG: Springer, 2018, pp. 277-284.
[8] H. Kahtan, W. N. Ashikin, W. A. Fatthi, A. Azma, A. Mansoor, and R. Noor Aishah, "Application of Fuzzy Logic Controller for Safe BrakingSystem: An Anti-Theft Tracking," Advanced ScienceLetters, vol. 24, no. 10, pp. 7317-7321, October 2018 2017, doi: 10.1166/asl.2018.12935.

[9] H. Kahtan, K. Z. Zamli, W. N. A. W. A. Fatthi, A. Abdullah, M. Abdulleteef, and N. S.Kamarulzaman, "Heart Disease Diagnosis System Using Fuzzy Logic," presented at the 7th International Conference on Software and Computer Applications, Kuantan, Malaysia, 2018.
[10] M. Bayani, K. Leiton, and M. Loaiza, "Internet of Things (IoT) Advantages on E-learning in the Smart Cities," International Journal of Development Research, vol. 7, no. 12, pp. 17747-17753,2017.
[11] Z. AjazMoharkan, T. Choudhury, S. C. Gupta, and G. Raj, "Internet of Things and its applications in E-learning," in Proceedings of the 3rd International Conference on Computational Intelligence & Communication Technology (CICT), Ghaziabad, India, 2017: IEEE, pp. 1-5.
[12] S. Gautam and M. K. Tiwari, "Components and benefits of E-learning system," International Research Journal of Computer Science (IRJCS) vol. 3, no. 1, pp. 14-17, 2016.
[13] I. Kamar, P. Chatterjee, and A. Hamie, "Internet of Things in Learning Systems-A Perspective of Platforms," International Journal of Advanced Research in Computer Science, vol. 7, no. 2, 2016.
[14] M. Abdel-Basset, G. Manogaran, M. Mohamed, and E. Rushdy, "Internet of things in smart education environment: Supportive framework in the decision-making process," Concurrencyand Computation: Practice and Experience, vol. 31, no. 10, p. e4515, 2019.
[15] O. Said and Y. Albagory, "Internet of things-based free learning system: performance evaluationand communication perspective," IETE Journal of Research, vol. 63, no. 1, pp. 31-44, 2017.
[16] S. Kusuma and D. K. Viswanath, "IOT and big data analytics in e-learning: a technological perspective and review," International Journal of Engineering and Technology, vol. 7, no. 18,
[17] A. Elsaadany and M. Soliman, "Experimental evaluation of Internet of Things in the educational environment,"International Journal of Engineering Pedagogy, vol. 7, no. 3, pp. 50-60, 2017.
[18] M. Maksimović, "Transforming educational environment through Green Internet of Things (G-IoT)," Trend 2017, vol.23, pp. 32-35, 2017.
[19] M. Veeramanickam, N. M. Sundaram, L. Raja, S. A. Kale, and U. P. Mithapalli, "„i-Campus‟: Internet of Things Based Learning Technologies for E-Learning," in Proceedings of theInternational Conference on Intelligent Data Communication Technologies and Internet of Things(ICICI).
[20] A. Magalhães, A. Andrade, and J. M. Alves, "SOLL: Smart Objects Linked to Learning Educational Platform with the Internet of Things," in Proceedings of the 14th Iberian Conferenceon Information Systems and Technologies (CISTI), Coimbra, Portugal, 2019: IEEE, pp. 1-6.
[21] M. B. Abbasy and E. V. Quesada, "Predictable influence of IoT (Internet of Things) in the higher education," International Journal of Information and Education Technology, vol. 7, no. 12, pp.914-920, 2017.
[22] S. Charmonman, P. Mongkhonvanit, V. N. Dieu, and N. Linden, "Applications of internet of things in e-learning," International Journal of the Computer, the Internet and Management, vol. 23, no. 3, pp. 1-4, 2015.
[23] W. Khan, Q. A. Nisar, S. Sohail, and S. Shehzadi, "The Role of Digital Innovation in E-LearningSystem for Higher Education during COVID 19: A New Insight from Pedagogical Digital Competence," in Innovative Education Technologies for 21st Century Teaching and Learning: CRC Press, 2021, pp. 75-100.
[24] A. Zaguia, D. Ameyed, M. Haddar, O. Cheikhrouhou, and H. Hamam, "Cognitive IoT-Based e-
Learning System: Enabling Context-Aware Remote Schooling during the Pandemic," Journal of Healthcare Engineering, vol. 2021, 2021.
[25] I. B. Mohammed and S. M. Isa, "The role of internet of things (IoT) in the containment and spread of the novel COVID-19 pandemic," in Computational Intelligence Methods in COVID-19: Surveillance, Prevention, Prediction and Diagnosis, vol. 923, K. Reza Ed. Singapore: Springer2021, pp. 109-119.
[26] M. Mehrtash, K. Ghalkhani, and I. Singh, "IoT-based Experiential E-Learning Platform (EELP)for Online and Blended Courses," in Proceedings of the 2021 International Symposium on Educational Technology (ISET), Tokai, Nagoya, Japan, 2021: IEEE, pp. 252-255,
[27] N. Parsazadeh, N. M. MohdZainuddin, R. Ali, and M. Rezaei, "An Empirical Study of Students' Perceptions on the Technological Aspects of the E-Learning System," Journal of Computing and Security, vol. 4, no. 1, pp. 25-38, 2017.
[28] K. Dahdouh, L. Oughdir, A. Dakkak, and A. Ibriz, "Building an e-learning recommender system using Association Rules techniques and R environment," International Journal of InformationScience and Technology, vol. 3,
[29]A. N. Islam, "E-learning system use and its outcomes: Moderating role of perceived compatibility," Telematics and Informatics, vol. 33, no. 1, pp. 48-55, 2016.
[30] D. A. Elneel, A. S. Fakharudin, E. M. Ahmed, H. Kahtan, and M. Abdullateef, "Stakeholder Identification Overview and Challenges in Requirements Engineering Prospective," in 2022 2nd International Conference on Computing and Information Technology (ICCIT), Tabuk, Saudi rabia, 2022: IEEE, pp. 314-319
[31] H. E. DuhaAwad, K. Hasan, F. Abdul Sahli, A. Mansoor, A.-A. Ahmad Salah, and A. YehiaIbrahim, "The Factors Influenced by Stakeholder Identification in E-learning Systems: A Survey," Journal of King Saud University –Science, vol. 35, no. 3, p. 102566, 2023,
[32] E. Borgia, "The Internet of Things vision: Key features, applications and open issues," Computer Communications, vol. 54, pp. 1-31, 2014.
[33] D. K. Chu et al., "Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis,"

[34] B. B. Zarpelão, R. S. Miani, C. T. Kawakani, and S. C. de Alvarenga, "A survey of intrusion detection in Internet of Things," Journal of Network and Computer Applications, vol. 84
[35] M. Murtaza, Y. Ahmed, J. A. Shamsi, F. Sherwani, and M. Usman, "AI-based personalized e-learning systems: Issues, challenges, and solutions," IEEE Access, 2022.
[36] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications," IEEE internet of things journal, vol. 4, no. 5, pp. 1125-1142, [37] K. Mershad and P. Wakim, "A Learning Management System Enhanced with Internet of Things Applications,"
Journal of Education and Learning, vol. 7, no. 3, pp. 23-40, 2018.
[38] B. Pauget and A. Dammak, "The implementation of the Internet of Things: What impact on organizations?,"Technological Forecasting and Social Change, vol. 140, pp. 140-146, 2019.
[39] S. Gul et al., "A survey on role of internet of things in education," International Journal of Computer Science andNetwork Security, vol. 17, no. 5, pp. 159-165, 2017.
[40] C. Gomez, S. Chessa, A. Fleury, G. Roussos, and D. Preuveneers, "Internet of Things for enabling smart environments: A technology-centric perspective," Journal of Ambient Intelligence andSmart Environments, vol. 11, [41] H. Aldowah, S. U. Rehman, S. Ghazal, and I. N. Umar, "Internet of Things in higher education: astudy on future learning," Journal of Physics: Conference Series, vol. 892, no. 1, 892,
[42] H. H. Nasereddin and M. FAQIR, "The impact of internet of things on customer service: A preliminary study,"Periodicals of Engineering and Natural Sciences (PEN), vol. 7, no. 1, pp.148-155, 2019.
[43] P. Asghari, A. M. Rahmani, and H. H. S. Javadi, "Internet of Things applications: A systematic review," ComputerNetworks, vol. 148, pp. 241-261, 2019.
[44] A. S. Al-Ahmad, H. Kahtan, and Y. I. Alzoubi, "Overview on Case Study Penetration Testing Models Evaluation,"Emerging Science Journal, vol. 7, no. 3, pp. 1019-1036, 2023,
[45] H. Kahtan, M. Abdulhak, A. S. Al-Ahmad, and Y. I. Alzoubi, "A model for developing dependable systems using acomponent-based software development approach (MDDS-CBSD)," IET Software, vol. 17, no. 1, pp. 76-92, 2023,
[46] B. Al Kurdi, M. Alshurideh, and S. A. Salloum, "Investigating a theoretical framework for e-learning technology acceptance," International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 6, pp. 6484-6496, [47] A. Karasan and M. Erdogan, "Prioritization of Influence Factors for Selecting E–Learning Systems," in Proceedings of the International Conference on Intelligent and Fuzzy Systems, Cham, C. Kahraman, S. C. Onar, B. Oztaysi, I. Sari, S. Cebi, and A. Tolga, Eds., 2020: Springer
, [48] R. F. E. Encarnacion, A. A. D. Galang, and B. J. A. Hallar, "The impact and effectiveness of e-learning on teachingand learning," International Journal of Computing Sciences Research, vol. 5, no. 1, pp. 383-397, 2021.
[49] K. H. Abbasi, G. Shams Mourkani, F. Seraji, M. Rezaeizadeh, and H. Abedi, "E-Learning Challenges in Iran: A Research Synthesis," International Review of Research in Open and Distributed Learning, vol. 21, no. 4, pp. 96-116,
[50] N. A. Al-Husban, "Critical Thinking Skills in Asynchronous Discussion Forums: A Case Study," International Journal of Technology in Education, vol. 3, no. 2, pp. 82-91, 2020.

Survey on Different Wireless Network Technologies

Mahendra Kumar 1, A. K. Jain 2
1.Associate Professor, Deptt. of Electrical Engg., Sant Baba Bhag Singh University, Jalandhar
2. Ex-Professor Deptt. of ICE, Dr BR Ambedkar NIT, Jalandhar

Abstract-Wireless technologies are being widely used in lot many applications such as communications, entertainment, medical, battle fields and institutes etc. This paper discusses on three prominent wireless technologies like IEEE 802.11, IEEE802.16 and Bluetooth. In the end comparative study has been provided.

Key words: Bluetooth, IEEE 802.11, IEEE 802.16,

I. INTRODUCTION

The great advent of wireless technology reduced the human effort for accessing data at various locations by replacing wired infrastructure with wireless infrastructure and also providing access to devices having mobility. The three major wireless technologies commonly used are- Bluetooth for low range applications, IEEE 802.11 for medium range applications and IEEE 802.16 for high range applications. Bluetooth is a technology for personal area networks, where device battery power is limited. Most current Bluetooth devices offer the modest range of 10 m using the (low) power class 2. Bluetooth has received a considerable amount of attention, being vigorously marketed by the Special Interest Group, who promise a technology to ''seamlessly connect all your mobile devices'' [1]. Bluetooth is unique in offering the front-end Radio Frequency processing integrated with the baseband module. On-chip integration lowers the cost of the network interface, and the small size makes it easy to embed Bluetooth chips in devices such as cell phones and Personal Digital Assistants (PDA). A Bluetooth chip can be connected to its host processor using Universal Serial Bus (USB), Universal Asynchronous Receiver Transmitter (UART), or Personal Computer (PC) -card interfaces [2]. The convenience of wireless networking has led IEEE 802.11 to emerge from the individual home to large-scale deployments in environments covering medium to large

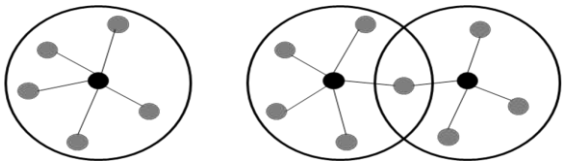
1. Research Scholar, Instrumentation and Control EngineeringDepartment., Dr. B R Ambedkar National Institute of Technology Jalandhar, Punjab-144011, India (e-mail: dei.mahendra@gmail.com).
2. M-Tech student, Instrumentation and Control Engineering Department., Dr. B R Ambedkar National Institute of Technology Jalandhar, Punjab-144011, India (e-mail: venchitin@gmail.com).
3. Professor and Head, Instrumentation and Control Engineering Department. Dr. B R Ambedkar National Institute of Technology Jalandhar, Punjab-144011, India (e-mail:jainak@nitj.ac.in)

enterprises, apartment complexes and housing Developments, and public area hot-spots [3]. IEEE 802.16 broadband wireless access air interface standard is a Wireless Protocol intended to supply broadband data and voice services.It is the basis of Worldwide Interoperability for Microwave Access (WiMAX) technology, which is a broadband wireless network [4].

The remaining paper is structured as follows. In section II, the overview of Bluetooth technology is given. In section III, information regarding architecture of 802.11 is provided, 802.16(WiMAX) is discussed in section IV and a conclusion in section V.

II. BLUETOOTH

The prefatory use of Bluetooth technology has lead to various portable devices, which operates using the concept of a piconet. Piconet is the collection of Bluetooth devices in a specified radio range. Devices such as laptops, Mobile phones, PDAs are currently the main proponents of the technology, and it is likely to remain this way in the short term. Many technological developments, scatternets may precede concrete applications. However, high levels of market penetration will increase the density of Bluetooth enabled devices, thereby increasing the potential for scatternet based applications. Bluetooth has a much more powerful business model associated with it, based on two key points [5]. Firstly, the scatternet functionality is important to allow flexible formation of Bluetooth personal area networks and also used to improve the performance of a group of nodes that are either already part of a scatternet, or part of separate piconets [6]. The roles of devices in such nodes may be rearranged to adapt to a new traffic distribution. Bluetooth Wireless Local Area Networks are already in service for large scale commercial IP applications, such as conference scenarios [7].Bluetooth is designed for a myriad of Wireless Personal Area Network applications. Secondly, the cost and size of the technology means that it is being included in equipment by default. Figures 1(a and b) gives the general scenario of piconet and scatternet formation in which black spot represents master and grey spots represents slaves. The current Bluetooth device Tiny Bluetooth 2.0 Wireless Adapter Dongle (Vista Supported) costs 2.84 US dollars [8].



(a) Piconet (b) Scatternet

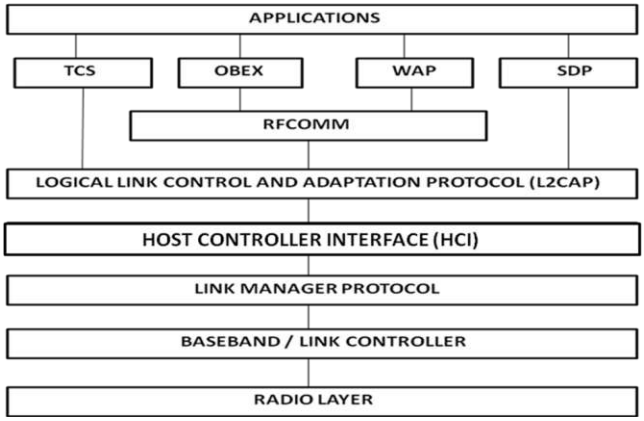
Fig.1: Configurations available in Bluetooth

A. The Bluetooth specification

The Bluetooth radio system is delineated to resolve the following fundamental issues in an ad hoc communication scenario such as concerning application of the radio spectrum, discovery of devices, connection establishment, channel allocation, medium access control, interference and power consumption. On December 17, 2009, the Bluetooth Special Interest Group (SIG) adopted Bluetooth low energy technology as the hallmark feature of the version 4.0 [9]. On April 21, 2010, the Bluetooth SIG completed the Bluetooth Core Specification version 4.0, which includes Classic Bluetooth, Bluetooth high speed and Bluetooth low energy protocols. Bluetooth low energy is an alternative to the Bluetooth standard that was introduced in Bluetooth v4.0, and is aimed at very low power applications running off a coin cell. It allows two types of implementation, dual-mode and single-mode. In a dual-mode implementation, Bluetooth low energy functionality is integrated into an existing Classic Bluetooth controller. The resulting architecture shares much of Classic Bluetooth's existing radio and functionality resulting in a negligible cost increase compared to Classic Bluetooth.

B. Radio Layer

The organization of Bluetooth stack is presented in Fig 2.The radio layer is the lowest layer. Its interface specification defines the characteristics of the radio front end, frequency bands, channel arrangements, permissible transmit power levels, and receiver sensitivity level. The Spread spectrum frequency-hopping occurs in the 2.4 GHz Industrial Scientific Medical band using either 79 or 23 radio frequencies in countries with restrictions in the Industrial Scientific Medical(ISM) band. A fast hopping rate of 1600 hops per second occurs, using pseudo-random hopping sequences, which provide an automatic method for controlling interference from other sources in the unregulated ISM band. These frequencies are located at (2402 + a) MHz, for a = 0,1, . . . ,78.The modulation technique is Gaussian Frequency Shift Keying (GFSK) which enables a simple low cost radio chip design and a transmission speed of up to 1 Mbps.The baud rate is 1Msymbols per second. Three power classes are defined for transmission, 20dBm (100mW), 4dBm (2.5mW) and 0dBm (1mW)[10].



TCS: Telephony Control protocol Specification
OBEX: Object Exchange
WAP: Wireless Application Protocol
SDP: Service Discovery Protocol
RFCOMM: Radio Frequency Communication

Fig.2: Bluetooth protocol stack

C. Baseband

Baseband layer defines the concept of a piconet. At this level, homogeneous devices are recognized by their Bluetooth device address which is a unique 48-bit address, hard-coded into the Bluetooth chip. Additionally, each device holds a free-running clock which ticks every half time-slot for a hopping rate of 1600 hops per second. Exchange of clocks and Bluetooth addresses is central to the formation of a piconet. Each piconet consists of exactly one device whose role is the master, and at most seven other active devices whose roles are slaves. The first device to initiate the formation of a piconet becomes the master. Every other device in range is assigned a locally unique active member address. These take up the role of the slave within the master's piconet. At most seven active slaves participate in each piconet, but additional slaves can be registered with the master and sustain the Parked mode. Devices outside of any piconet sustain the stand-by mode. To determine the frequency hopping sequence in a piconet, slaves maintain the offset time between their clock and that of the master, using a slot dwell time of 625 μs, and apply pseudo-random sequencing of frequencies. Multi-slot packets requiring three or five slots are also permitted. When these are transmitted, the transmit frequency remains constant. Uplink and downlink between master and slave occurs using time division duplex, with the master only communicating in even numbered slots, and slaves in odd numbered slots. A device cannot be a master in two piconets simultaneously, since this would result in two piconets having the same communication channel, resulting in significant co-channel interference between piconets.

D. Link Manager

The baseband state machine is manipulated by the Bluetooth link manager. This layer is equipped with the link control hardware, and handles link setup, security and control. Its job includes control of paging, changing slave modes, and handling required changes in master/slave roles. It also supervises the link and controls handling of multi-slot packets. Link managers of various devices communicate with each other using the Link Management Protocol (LMP). This is organized by LMP packets which are sent in the payload of packets on asynchronous connectionless links and are flagged by a bit in the Access Control List (ACL) header. Some link controller hardware may include a Host Controller Interface (HCI) layer above the link manager. This layer is used to separate the Bluetooth baseband and link manager from a transport protocol.

E. Host Controller Interface (HCI)

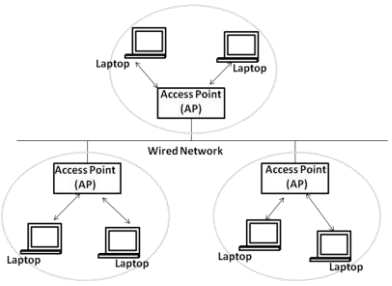
The HCI provides Bluetooth application for accessing Bluetooth hardware in the absence of the transport layer or other hardware implementation details. The HCI layer is a constituent of the Bluetooth stack, but it doesn't constitute a peer-to-peer communication layer since the HCI command and response messages do not flow over the air link.

F. Logical Link Control and Adaptation Protocol (L2CAP)

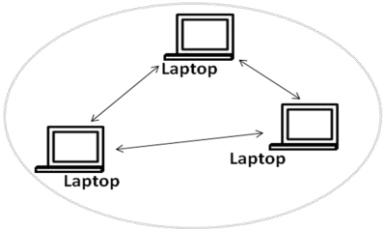
Bluetooth protocols over the link manager and HCI are software based. Logical Link Control and Adaptation Protocol (L2CAP) specification is the first layer, which is effectively a Bluetooth link layer. The L2CAP delivers packets received at higher layers to the other end of the link. It is required because baseband packet size is too small for transporting higher layer packets. The L2CAP resolves this, and operates over an ACL link provided by the baseband. It performs segmentation, re-assembly and multiplexing of high level applications above the HCI. The L2CAP supports the multiplexing of several logical channels over the devices ACL links. A single ACL link is always available between the master and any active slave. This provides a point-to-multi-point link supporting data transfer [11].

G. The Service Discovery Protocol (SDP)

The Service Discovery Protocol (SDP) is used to reveal Bluetooth services available on a particular device. Each Bluetooth device can act as a client or server in discovering services with SDP. The SDP only provides information about the different services which are available. Further protocols (either from Bluetooth or elsewhere) must be usedIn order to use a service. In order to uphold the efficiency of the process and to reduce the amount of information which needs to be carried across the Bluetooth



(a) Infrastructure mode



(b) Adhoc mode

Fig.3: IEEE 802.11 modes

link between devices, Universally Unique Identifiers are used.

H. Profile Specification

The Profile specifications function is to organize fundamental range of operations for supporting interpretability for range of applications. These define usage for generic access, service delivery, mobile telephony interconnection, intercom, serial ports, headsets, dial-up networking, fax services, Local Area Network(LAN) access, and usage models for generic object exchange, object push, file transfer and synchronization. Out of all, the arrangements for serial port and LAN access are the most prominent. The former case is eased by adopting the Radio Frequency Communication protocol. This competes the signals on Recommended Standard (RS-232) interconnection cable. This permits the emulation and multiplexing of several serial ports over a single channel.

.

III. IEEE 802.11

IEEE 802.11 standard was first introduced in 1997. It was envisioned for home and office environments for wireless local area connectivity and supports three types of transmission technologies namely i)Infrared Radiation(IR),ii)Frequency Hopping Spread Spectrum (FHSS), iii) Direct Sequence Spread Spectrum (DSSS). In 1999 two other transmission technologies were included Orthogonal Frequency Division Multiplexing (OFDM) and High Rate-Direct Sequence Spread Spectrum (HR-DSSS). The second OFDM modulation scheme was introduced in2001 for high data rates [12]. The standard introduces two operating modes as fig. 3. each other [13, 14].

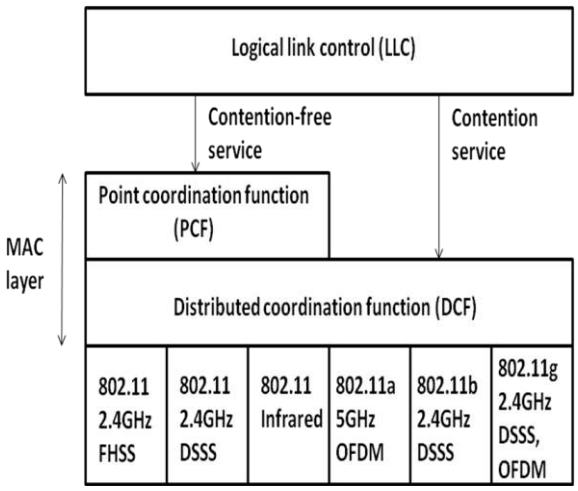


Fig.4: IEEE 802.11 Protocol Architecture

A. Physical Layer

The initial standard includes three Physical layers, FHSS, DSSS and Infrared. Later on two other transmission technologies were included OFDM and HR-DSSS. FHSS uses a technique in which the transmission channels are divided into sub channels, which are then time division multiplexed; users simultaneously hop pseudo-randomly from frequency to frequency within the transmission spectrum. FHSS is thus a unique combination of Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM). In DSSS communication system, the pseudo-noise (PN) code sequence is used to spread the transmitted signal in frequency at the modulator and to dispread the received signal at the demodulator [15].Infrared is a light-based wireless transmission technology. The frequencies of light used are below the visible spectrum, so it is not a light we can see with our eyes. However, it has all of the characteristics of light. It can propagate through clear objects (e.g., glass, clear plastic) but it cannot propagate through opaque objects. It can, however, reflect very well off some objects, like mirrors and white surfaces. This means the transmitter and receiver have to be within Line of Sight (LOS), either direct or reflected. IEEE 802.11b standard uses a new Physical layer, HR-DSSS, based on DSSS [16, 17]. IEEE 802.11a and IEEE 802.11g use OFDM Physical layer that greatly increases the overall throughput at the AP. OFDM has been around for some time under the name discrete multi-tone modulation (DMT). It is based on traditional frequency division multiplexing (FDM), but it is used as a digital modulation scheme. OFDM operates on a bit stream that has been divided into several lower-bit rate streams. The available spectrum is divided into a number of sub-channels and these low-bit rate data streams are on modulated onto sub-carriers in each of these channels. The modulated carriers are combined into a single signal using an inverse Fast Fourier Transform. The signal is sent onto the receiver, which repeats the process in reverse to recover the original stream. Since the entire low-bit rate channels are transmitted simultaneously, the aggregate data rate is the sum of the low-bit rate channels. In the upcoming IEEE 802.11n standard, the use of OFDM modulation coupled with a Multiple Input Multiple Output (MIMO) mechanism is planned. Most of the IEEE 802.11 Physical layers work in the 2.4GHz frequency band (2.414–2.484GHz) with 14 distinct channels. The availability of these 14 channels varies from country to country [18].

B. Medium Access Control Layer (MAC)

Medium access control (MAC) layer of IEEE 802.11 utilizes a contention based scheme called Distributed Coordination Function (DCF) where Stations associated with the AP sense the air interface for channel availability. If the interface is idle, the source Station sends its data to the destination through the AP. If more than one Station tries to access the air interface simultaneously, a collision occurs. The standard uses Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) mechanism to avoid collisions. IEEE 802.11 also defines a centralized MAC technique, the Point Coordination Function (PCF), which is partially contention-based and partially centralized [19].

1. Distributed Coordination Function (DCF)

Fig. 5 shows a sender accessing the medium and sending its data. But now, the receiver answers directly with an acknowledgement (ACK). The receiver accesses the medium after for duration of Short Interframe Spacing (SIFS) so no other station can access the medium in the meantime and cause a collision. The stations have to wait for DCF Interframe Spacing (DIFS) plus their backoff time. The acknowledgement ensures the correct repetition of a frame on the MAC layer, which is especially important in error-prone environments such as wireless connections. If no acknowledgement is returned, the sender automatically retransmits the frame. But now sender has to wait again and complete for the access right. There are no special rules for retransmissions. The number of retransmissions is limited, and final failure is reported to the higher layer.

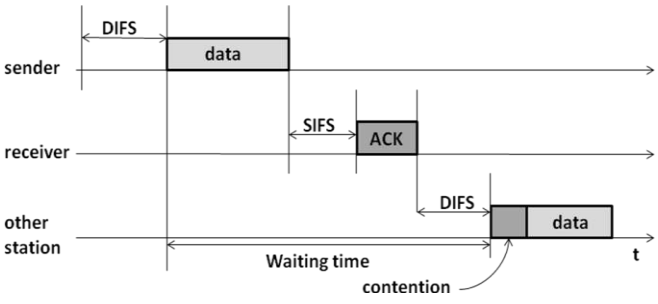


Fig.5: IEEE 802.11 unicast data transfer

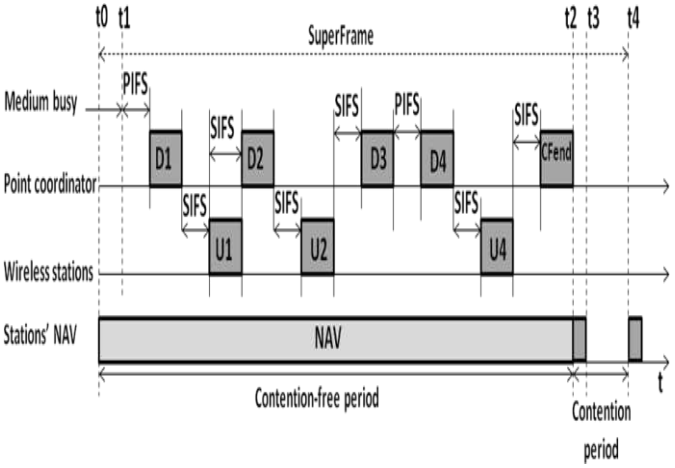
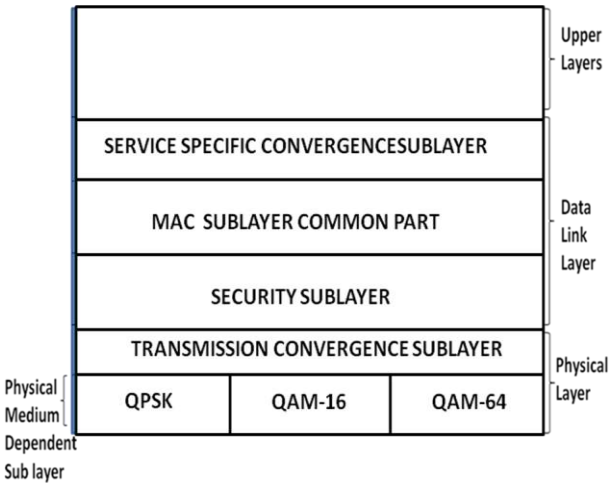


Fig.6: Contention-free access using polling mechanisms (PCF)



QPSK: Quadrature Phase Shift Keying
QAM: Quadrature amplitude Modulation

Fig.7: IEEE 802.16 protocol stack

2. Point Coordination Function (PCF)

The point coordinator in access point splits the access time into superframe periods as shown in Fig. 6. A superframe comprises a Contention Free Period (CFP) and a Contention Period (CP). At time t0 the CFP of the superframe should theoretically start, but another station is still transmitting data. After the medium has been idle until t1, the point coordinator has to wait for PCF Interframe Spacing (PIFS) before accessing the medium. As PIFS is smaller than DIFS, no other station can start sending earlier. The point coordinator now sends data D1 downstream to the first wireless station. This station can answer at once after SIFS. After waiting for SIFS again, the point coordinator can poll the second station by sending D2. This station may answer upstream to the coordinator with data U2. Polling continues with the third node. This time the node has nothing to answer and the point coordinator will not receive a packet after SIFS. After waiting for PIFS, the coordinator can resume polling the stations. Finally, the point coordinator can issue an end marker (CFend), indicating that the contention period may start again. Using PCF automatically sets the Net Allocation Vector (NAV), preventing other stations from sending [20].

IV. WiMAX (IEEE 802.16)

IEEE 802.16 also represented by acronym Worldwide Interoperability for Microwave Access (WiMAX) .The architecture of IEEE 802.16 is given in Fig 7. Its radio coverage is about 5miles with a bandwidth of up to 70Mbps is offered without requiring deployment of expensive base stations.WiMAX supports working in both licensed and unlicensed portions of the frequency spectrum. The first Version of 802.16 was approved in December 2001 to make data rates available to users having Line of Sight connectivity. WiMAX, with its mesh mode support, provides broadband Connections in wider areas even to users with Non-Line- of-Sight connections. IEEE 802.16 operates in the licensed spectrum between 10 and 66GHz employing single carrier scheme in the physical layer. In order to enable Non-Line of Sight (NLOS) communication, IEEE 802.16a was completed in 2003 as an amendment to the previous standard offering Orthogonal Frequency Division Multiple Access (OFDMA) physical layer and supports for Orthogonal Frequency Division Multiple Accesses in the MAC layer [21]. By the end of 2004, IEEE 802.16(d) - 2004 replaced previous versions and it was called the Fixed WiMAX [22]. With this revision, mesh topologies are supported via enhancements to the MAC layer in addition to point-to multipoint topologies, and the supported frequencies are set to be within 2 and 11 GHz. As of Dec 7th 2005, IEEE802.16e-2005 standard is approved and became the Official standard for Mobile Wireless Metropolitan Area Network [23]. IEEE 802.16e is published as an amendment to 802.16d.Through this revision, mobility is allowed via modifications in the MAC layer and Scalable OFDMA is specified for the physical layer.

A. Physical Layer

IEEE 802.16 employs three different modulation schemes, depending on how far the subscriber station is from the base station. For close-in subscribers, Quadrature amplitude Modulation (QAM)-64 is used, with 6 bits/baud. For medium-distance subscribers, QAM-16 is used, with 4 bits/baud. For distant subscribers, Quadrature Phase Shift Keying (QPSK) is used, with 2 bits/baud .The WiMAX physical layer is based on OFDM which is a digital encoding and modulation technique used by many broadband systems. 802.16d supports both OFDM with 256

Fast Fourier Transform (FFT) and OFDMA with 2048 FFT. OFDM uses multicarrier modulation in which the given data stream is divided into several lower bit rate streams that are modulated and transmitted simultaneously on separate sub channels. As a result, the data throughput is increased enabling high-speed data and multimedia communications along with resilience to interference and low multipath distortion. OFDM allows one user at a time on the channel. On the other hand, OFDMA is the multi-user version of OFDM which allows multiple users access the channel at the same time. Subsets of sub-carriers are assigned to individual users allowing simultaneous transmissions from several users. Different from the 802.16d standard, 802.16e WiMAX employs Scalable OFDMA (SOFDMA) where FFT sizes can vary from 128 to 2048 according to the channel bandwidth in order to keep the carrier spacing constant across different bandwidth channels. Scalable bandwidth opportunity and sub channelization techniques on 802.16e OFDMA results in better network performance management meeting specific capacity and coverage requirements[24].

B. Medium Access Control Layer

In WiMAX, MAC protocol consists of three sub layers namely, Convergence Sub layer, Common Part Sub layer and Privacy Sub layer .WiMAX MAC is connection oriented and each link is recognized by a unidirectional Connection Identifier. In convergence sub layer, higher layer protocol addresses such as IP addresses are mapped onto Connection Identifier and Service Flow Identifier. With this, every transmission is inserted to a queue associated with its service type. In the standard, convergence sub layer for Asynchronous Transfer Mode (ATM) and packet networks are defined, however, only convergence sub layers for Internet Protocol (IP) and Ethernet are decided to be implemented by WiMAX Forum. Furthermore Payload Header Suppression is another functionality of convergence sub layer defined in the standard as optional. The functionalities of ranging, scheduling, bandwidth management, construction and transmission of MAC Payload header suppression. The last sub layer of 802.16 MAC's security sub layer is responsible for providing private access to the subscribers across a fixed wireless network through encryption.

V. CONCLUSION

Bluetooth, WLAN, and WiMAX networks represent an increasingly important segment of networking research as a whole, driven by the explosive growth of portable computing, communication and embedded devices connected to the Internet. Table 1 gives the basic differences between the three technologies. Mobile agents appear to be an interesting way to exploit synergies between current researches on network management and agent-related research. While network management looks for new ways to overcome the limitations of current client-server technology, mobile agents and peer computing provide technologies and architectures to enable de-central peer- to-peer communication. In future, all cell phones will be full-fledged Internet devices, implying inevitable changes both in applications and network infrastructure to support mobility, location-awareness and processing/bandwidth limitations associated with this class of end-user terminals. Wireless technology will be a greater progress and widely used in the world.

Table1: Comparison of salient features of Bluetooth, IEEE 802.11 and WIMAX technologies

	Bluetooth	802.11	WiMAX
Coverage (up to)	10 meters	300 meters	10kilometers
Frequency Band	2.4GHz	2.4Ghz - 5GHz	2GHz -11Ghz
Data rate (up to)	1Mbps	54Mbps	70Mbps
Multiplexing	FH-CDMA	CSMA/CA	Burst TDM/TDMA /OFDMA
Modulation	GFSK (Gaussian Frequency Shift Keying)	GFSK, DBPSK (Differential Binary Phase Shift Keying)	QAM-16,QAM-64,QPSK
Network Topologies	Piconet and Scatternet	Infrastructure and Adhoc	Infrastructure
Power Transmission	4dBm(20m) Class2 20dBm(100 m) Class1	18dBm	43dBm
Applications	Mouse, Keyboard, Printer, Bar Code Scanners, Traffic Control Devices, GPS Receivers, Medical Equipments.	Wireless LAN, Internet	Metro Area Broadband Internet Connectivity

VI. REFERENCES

[1] Roger M. Whitaker a, Leigh Hodge a,1, Imrich Chlamtac , "Bluetooth Scatternet formation: A survey", Ad Hoc Networks 3 (2005) 403–450

[2] Pravin Bhagwat • Reefedge Inc, "Bluetooth: Technology for Short-Wireless Apps", May - June 2001

[3] Emilio Ancillotti, Raffaele Bruno, "Design and Performance Evaluation of Throughput-aware rate Adaptation protocols for IEEE 802.11

Wireless Networks" , June 12, 1999
[4] Hyung Seok Kim, "Tiny MAP: An efficient MAP in IEEE 802.16/WiMAX broadband wireless access systems", May 10, 2007
[5] S. Buttery, A. Sago, Future applications of Bluetooth, BT Technology Journal 21 (3) (2003) 48–55.
[6] P. Johansson, M. Kazantzidis, R. Kapoor, M. Gerla, "Bluetooth and Enabler for personal area networking", IEEE Network 15 (5) (2001) 28–37.
[7] R. Kraemer, Personal Communication with ceo of Lesswire Available From <http://www.lesswire.com>, 2003.
[8] Tiny Bluetooth 2.0 Wireless Adapter Dongle (Vista Supported), http://www.dealextreme.com/p/tiny-bluetooth-2-0-wireless-adapter-Dongle-vista-supported-14255
[9] Bellevue, WA, USA "sig introduces Bluetooth Low Energy Wireless Technology, the next generation of Bluetooth Wireless Technology", December 17, 2009.
[10] J.C. Haartsen, S. Mattisson, "Bluetooth—A New Low Power Radio Interference providing short-range connectivity, Proceedings of the IEEE 88 (10) (2000) 1651–1661.
[11] K.V.S.S.S.S. Sairam, N. Gunasekaran, S.R. Redd, Bluetooth in Wireless Communication, IEEE Communications Magazine 40 (6) (2002) 90–96.
[12] IEEE 802.11-1999, IEEE Standard for Local and Metropolitan Area Networks Specific Requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, June 12, 1999.
[13]Mehmet S. Kuran, Tuna Tugcu, "A Survey on Emerging Broadband Wireless Access Technologies", Computer Networks 51 (2007) 3013–3046
[14]IEEE 802.11e-2005, IEEE Standard for Local and Metropolitan Area Networks Specific Requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications MAC Enhancements for QoS, 2005.
[15]Xiao Liping ; Xu Chengqian ; Zhong Wenguang, Performance Analysis of the DSSS System Based on Sequence Pairs, 10 April 2007.
[16]IEEE 802.11i-2004, IEEE Standard for Local and Metropolitan Area Networks Specific Requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Medium Access Control (MAC) Security Enhancements, July 23, 2004.
[17] Atheros Communication, Super G Maximizing Wireless Performance, www.super g.com/Atheros_Superg_Whitepaper. pdf, 2004.
[18] U.S. Robotics, 802.11g Speed Acceleration How We Do It, www.usr.com/download/whitepapers/125mbps- wp.pdf 2004.
[19] J. Zyren, W.Wise Coalition, The W.Wise Proposal for The 802.11n Standard, www.analogzone.com/col_0920.htm 2005
[20] Chhaya, H.S.Gupta, S, "Performance of Asynchronous Data Transfer Methods of IEEE 802.11 MAC protocol", wireless network 3, 1997.
[21] B. Fong, N. Ansari, A.C.M. Fong, G.Y. Hong, P.B. Rapajic, On the Scalability of fixed Broadband Wireless Access Network Deployment, IEEE Radio Communications 42 (9) (2004) s12–s18.
[22] IEEE 802.16-2004, IEEE Standard for Local and Metropolitan Area Networks – Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 2004
[23] X. Li, P. Wan, Y. Wang, O. Frieder, Sparse Power Efficient Topology for Wireless Networks, in: Proceedings of the 35th Annual Hawaii International Conference on System Sciences (HICSS _02), pp. 3871–3880.
[24]S.G. Glisic, Advanced Wireless Networks: 4G Technologies, Wiley Publishing, 2005.

Employability Skill-Sets among Engineering Students in the Perspective of State of Jharkhand

Prof. (Dr.) Priyadarshi Jaruhar [1*] and Nikita Saw[1]

[*]Director, Guru Gobind Singh Educational Society's Technical Campus, Chas, Bokaro, Jharkhand

Corresponding Author: pjaruhar@yahoo.co.in

Abstract:

At Present scenario ,the National Employability Report of Engineering Graduates, 2019 by Aspiring Minds (AI-powered Talent Evaluation), just 20% engineers in India are employable, only 18.43 % are employable for software Engineer-IT services role. For core engineering jobs in Mechanical, Electronics/Electrical Engineering Civil Engineering only a mere7.49 % is employable. The same report recognizes Jharkhand among list of best employable engineers producing states of India. Employability is a set of achievements, skills, understandings and personal attributes that makes graduates more likely to gain employment and be successful in their chosen occupations. The American Society for training and development (ASTD) emphasized 6 skill groups across all job families: Basic competency skills of reading, writing, computation, communication skills, speaking, listening; Adaptability skills of problem solving, thinking creatively; Developmental skills of self-esteem, motivation and goal-setting, career planning; Group effectiveness Skills of interpersonal skills, teamwork, negotiation; Influencing Skills of understanding organizational culture and sharing leadership. Employers are often looking for skills that go beyond qualifications and experience. Employers before hiring the candidate usually want to see his/her hybrid skills - a combination of hard and soft skillsbefore hiring.Secondly, there is a large mismatch in the aspirations of graduating engineer's readiness. Preference for startups by Engineers are less while most of the engineers want jobs either in software or core engineering. Around 3% engineers possess new-age skills in areas such as artificial Intelligence (AI) Machine learning, Data engineering and mobile technologies. Internship and project beyond course work may enhance employability. Jharkhand state has its own leverage of being one of the most industrialized zones of India. The largelytribal state has culture and tradition which inculcate equity, equality, self-reliance, conflict resolution, and team work and adaptability skills. There is a need to improve the quality of education in our institutions. New faculty development for new program and resources need to strengthen connections between academia and industry.Bloom's Taxonomy modelrecommendations and outcome based education are some of the measures which may prove to solve theemployability among engineering graduates. The present study has attempted to find out the opportunities and challenges related to quality of engineering students and their employability skill sets in Jharkhand.

Key words: Skillsets, Hybrid skills, Adaptability skills, Employability, Internship, Bloom's taxonomy

1. Introduction:

In past' personnel management has focused on the Human Resource potentially contributes to the bottom line just not through other resources but by going through a self- management. An organization's business goal is being assessed through stock value which in turn is highly dependent on its own value of human resources. Earlier high population of India was looked at as a negative parameter but today it is internationally viewed as a major strength. Of course, this strength can be derived only when the valued human resource is properly channelized and contribution used fully for constructive purposes. With specific reference to India, an overview of human resources would be incomplete without taking into account of the Engineering discipline and its strength. Firstly, our engineers in India and abroad are making big name and fame through intellectual and financial contribution. The Government and the knowledge commission have encouraged growth of engineering college's multifold segmentation. Secondly, engineering institutions under JUT have been churning out thousands of engineering graduates year after year, but the industry experts are not truly happy with the quality of engineers being produced from the states of Jharkhand due to their poor knowledge related with employability. The author has made an attempt to study this scenario with the tripod approach of Industry's perspective, Students' perspective and the engineering graduate's perspective. In this article, the focus is on the perception of the faculty who motivates the engineering graduates into potential engineers as related to employability skills enhancement as required by today's engineering graduates in different prospective in the Jharkhand region taken by the Jharkhand University of Technology Ranchi.

2. Research back ground:

We the researcher has highly encouraged and motivated to wards to write this conceptual Paper as desired by the Jharkhand University of Technology (JUT) because it is a well though and plan taken by university to know the basic problems of engineering graduates in different colleges under this university so that we interest to do our extensive research work for knowing the root cause and pit falls which are becomes the major obstacles for emplobilities skill development of engineering graduates in the state of Jharkhand and recommend to university for further Prosecution of perspective Development.

3. Literature Review:

In this Section we the researcher has taken the aforesaid research title as a challenge for finding out the realistic Problems behind the employability skill why under developed than other states in India Tina she Harry et.al. (2018) [1], the study explores the factors influencing employability among thecollege student in the rural areas of Jharkhand university. The study use exploratory research design to explore the students' perception and concerns of employability. The study has conducted focus group interview technique to collect the data through Secondary Sources. The findings of the analysis said that there were the five type of factors which influence the employability such a curriculum issues, poor education system, poor social and economic status and social connections which the students belongs to and perception around the higher education. The study suggested that by understanding the perception of

employability factors and perceptions, policy makers should develop such policies which can furnish the students need. Bassou El Mansour, Jason C. Dean(2016),[2] the study focuses on employability skills perceived by engineering graduates of human resource development (HRD)and management and employers for entry level graduate jobs.The result indicates that with the use of technology and the exception of communication skill, human resource development faculty in India and abroad provides the skills required by the employers. The study has used one-way ANOVA for the analysis of variable and to evaluate the relationship among employees and faculties of various Institutes of Jharkhand state .The research was conducted in Ranchi, Bokaro Steel city and Jamshedpur, an emergent city in Jharkhand through the on line questionnaire and over telephone . The study found out that there is a significant relationship between the variable investigated as related with the engineering graduate employability development.

4. Basic Characteristics for Developing Employability Skills:

The potentiality of engineering graduates under Jharkhand University of Technology will be enhancing if the following characteristics will be focused by the state Govt. of Jharkhand as well as University

- To improve Communication Skills in all engineering Colleges under JUT
- To focus on Teamwork Skills
- To emphasize on Self-Motivated/Ability to work with little or no supervision
- To focus on Problem-Solving/Decision-Making, Reasoning/Creativity skills
- To focuses on dedication/hardworking/work Ethic and positive attitude based of learning
- To motivate the young graduates for making a systematic Planning/Organizing Skills as per the availability resources
- To develop Computer/Technical Skills/Skill of AI /Interpersonal abilities and Self- Presentation Skills
- To develop Multi-Tasking Skills
- To develop positive attitude/motivation/energetic-self-confidence
- To develop Leadership quality and Management Skills and multicultural sensitivity/awareness
- To becomes loyalty towards your Institute and authority
- To develop your Professionalism rather than profession and show willingness for Learning
- To focus on Customer Service Skills and use your common sense and knowledge at Present

5. Research Methodology:

In this invited paper, we the researcher have taken the research methods as followed by other researchers the paper has discussed the gap between degree outcomes and enhancement of employability skills in various engineering colleges, in Jharkhand State. The paper is based on both the primary and empirical study through the primary and secondary sources of information. The data has been collected from the direct questionnaire to the engineering graduates from the different cities and Towns of Jharkhand state as well as various resources of published papers, internet sources and newspapers.

6. Objectives of the Study:

- To review the challenges that leads the gap of Employability skills in Jharkhand state as compare to other states in India
- To review the literature of bridging the employability gap in various engineering Colleges under Jharkhand University of Technology (JUT), Jharkhand.
- To know the pitfalls /Obstacles for preventing the employability skills of Young graduates in various engineering /General/Professional colleges in Jharkhand state.

7. Meaning and Concept of Employability skills:

As the word Employability Skills are concerned, these may be defined as the transferable skills needed by an individual /student to make them 'employable' at present, In simple, employability depends on your knowledge, skills and attitudes, perception and individual behavior, how you use those assets, and how you present them in front of employers while you attend an Interview .Hence, it may refers about the knowledgebased in a specific career of student.

For Examples:

- An electrician knows wiring and its defects while its dis function.
- An engineer of mechanical engineering knows how to operate machine andits repair.

8. How to develop EmployabilitySkills:

- Having and using your life skills and abilities to be hired and stay hired.
- (Truth) Most people change careers at least 5-7 times in their lives. Skills developed in one job can be used in different lines of work or industries.
- Present positive qualities
- Communicate effectively with all employers, co-workers, and consumers (i.e. customers, clients, patients, users, etc.)
- Meet your responsibilities at work

*[*Employability Skill Development by Team work in engineering Colleges of Jharkhand State figure-1.]

9. Importance of Employability Skills in Student Life

- ❖ Decision Making - Shows you know how to evaluate options.
- ❖ Problem Solving - Shows leadership role to find a positive solution.
- ❖ Goal Setting - Shows you know how to set up a plan to achieve specific goals.
- ❖ Critical Thinking - Shows you know how to be objective and think logically
- ❖ Communicating Effectively - Shows you know how to work with others.

10. How to build Employability Skills:

The employability skill can be building up if the student focused on his/her career plan and prospective such as:

- **Conflict Resolution:** It looking for various ways to reduce conflict with siblings and communicate more effectively with parents.
- **Set Academic Goals:**To create a plan to achieve the career goal.
- **Be Active in a Club:** Join and involve yourself inDECA, Cyber Security, Team Sports, 4-H, Student Cabinet, and more.
- **Participate In Some Form of Community Service:To** dedicate your time and energy toward improving the community.

11. Factors/determinants affecting Employability skills in Jharkhand:

In this section, we the researcher has observed that the following causes are sole responsible for prevent the employability development in the state Jharkhand.

- Poor employability education system in Jharkhand in comparison to other states of India
- Lack of meticulous Plan and action by the state Govt.
- Lack of Infrastructure development
- Lack of Industries and enterprise in Jharkhand
- Lack of Political support for enhancing employability skills in various schools and colleges

12. Why employability is needed?

The Employability Skill-Sets in the Perspective of State of Jharkhand, India is highly necessary because of poor employability opportunity at present context. So that it needs employability as per the following prospective

- For getting good Job description and job
- For taking the responsibilities of Industries/institutions/Organizations
- For different kinds of education or training is required?
- For knowing the pay package and what is the pay range?
- For knowing the work environment?
- For knowing the job position and where is the job?

13. Outcome based employability in Jharkhand

For a sustainable employability skill development in the states of Jharkhand it needs an outcome based of employability in different engineering colleges and institutions under JUT University, Ranchi like

- A systematic and meticulous planning is needed for development of infrastructure in different skill based disciplines such as agriculture- engineering, , Pc culture, manufacturing, refreezing, animal Diary, establishment of incubation centers, Centre of excellence etc, at various colleges under JUT by one can be plan for and actually achieve this by his/her own potency of employability skills.
- Searching the opportunities and have the resources to accomplish their desires goals.
- Having opportunities for using their skills and abilities.
- Should be flexible in norms specific in NAAC Accreditation
- State exactly what the young engineering graduates wants to accomplish
- Motivate the young graduates to believe himself/herself in order to build self- confidence which could achieve the goal
- Trained them in work oriented and outcome based learning where they hope to live and work
- Should be more flexible in the process of admission for giving the opportunities to 1st and Second year students of Jharkhand state.

- Should be conduct own entrance test like Jharkhand Engineering Entrance (JEE), so that many students getting the opportunities for taking admission in engineering and management education

14. How to make a good career Plan?

Each and every graduate needed a good career plan and prospective in order to achieving an employment, here some of career plan prospective are given below

- To focus your aim and set goals accordingly for academic achievement
- To set goals for volunteering in different non-curriculum based skills
- To set goals for researching different types of careers by your own choice
- To set goals for building skills and abilities
- A map that can show you a way to reach your goals.
- To write a statement describing your ultimate career goal.
- To set goals for earning and saving money for future life.

15. Employability Models:

For a sustainable employability skill development the Govt.of Jharkhand trying a lot for development of employability byorganizing various workshops and training session with number of employability models .The Jharkhand Skill Development Mission Society (JSDMS) is set to impart skill development training in four colleges on a pilot basis next month under the EXCEL (Employability Excellence with College Education and Learning) Programme.

<table>
<tr>
<td>  </td>
<td> 
</td>
</tr>
<tr>
<td>Govt. Of Jharkhand, TISS Sign An MOU To Make College Students Employable</td>
<td>Ajay Kumar Singh, secretary of state higher education and skill development department, at the workshop in Ranchi on Wednesday. Picture by Prashant Mitra</td>
</tr>
</table>

**[*Figure –II Refers about The Jharkhand Skill Development Mission Society (JSDMS) is set to impart skill development training in four colleges in Jharkhand in the year 2018*

"EXCEL was being run by central funds since 2013 and is now being taken up by JSDMS on a large scale," Ajay Kumar Singh, secretary in state higher and technical education and skill development department, told the representatives of colleges and training providers in Ranchi on Wednesday. Initially, the programme will be rolled out in four colleges, but will be extended to 35 colleges by March 2018. JSDMS, which targets to hand over job letters to 20,000 skilled youths on International Youth Day on January 12, plans to introduce EXCEL in 100 colleges of five universities of the state in a phased manner. "The colleges will be selected carefully," Singh said, adding that they need to have proper infrastructure and adequate models the employability skill will be enhancing a bench mark of development. (See figure -3)

16. Models of Employability

[Figure -3 Refers about the Career EDGE Model of Engineering Graduate Employability]

Research Findings: (Suggestion and Recommendations to JUT)

From the aforesaid research work taken by the researcher related with the research problem, we the researcher have like to recommend the suggestions to the authorities of Jharkhand University of Technology (JUT) would implement the followings for better employability such as :

- Introduce more job oriented syllabus and course structure will be implement rather than traditional and old curriculum pattern.
- Be flexible in admission of Diploma engineering student in both first and second year of admission
- Conduct joint Engineering entrance in Jharkhand state every Year
- Inviting many national and registered company to the colleges for providing better employability opportunities
- Focused on NAAC accreditation first rather than NBA so, the quality of teaching and training facility will be increased, then go for NBA
- Organize seminar/Work shop by experts from Industry so that proper training and Placement will be achieved.

17. Conclusion

In sum, the summations are summarizing that for enhancing the employability skill is not a bench mark at the present scenario of Jharkhand state, it needs to improve by a sustainable planning by the both state and central Govt. in association with number of industries , Enterprises as well as training Institutes of the state as related with various employability Models. Therefore, student s is highly motivated for having better opportunities of learning and placement in their near future.

References:

[1] Bianca Kubler and Peter Forbes (2004) Student Employability Profiles Engineering, Enhancing Student Employability Coordination Team (ESECT), the Higher Education Academy

[2] Chithra.R (2013) Employability Skills A Study on the Perception of the Engineering Students and their Prospective Employers, Global Journal of Management and Business Studies Volume 3, Number 5, 525-534.

[3] Gandhi Meenaksdhi (2013) Employability Skills in Management Students- An Industry Perspective, Asian Journal of Multidimensional Research, Feb 2013, 85-97

[4] Kaushal, Urvashi (2016) Empowering Engineering Students through Employability Skills, Higher Learning Research Communications, 6. 10.18870/hlrc.v6i4.358.

[5] Mohapatra Manolisa et al. (2019) Impact of Information and Communication Technology (ICT) on Employability, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-9 Issue-2, 4477-4480

[6] National Employability Report Engineers 2019, https://www.aspiringminds.com/research-reports/national-employability-report-for-engineers-2019/. 9)

[7] Talent shortage survey. Mckinsey-NASSCOM. (2005).

[8] Tinashe Harry et.al.(2018) Perceptions of factors that affect employability amongst a sample of final-year students at a rural South African university, SA Journal of Industrial Psychology 44(6):101

[9][Employability Skill Development by Team work in engineering Colleges of Jharkhand State figure-1.

[10] Tina she Harry et.al. (2018), Engineering graduate employability in States of Texas, USA in year 34. (7)

ROLE OF AI IN EFFICACY ENHANCEMENT AND MANAGEMENT OF SOCIAL ENTERPRISES

Pallavi Prasad[1*], Shabnam Ara[1], Manish Bharadwaj[1]

[1*]Corresponding Author
Prof. Pallavi Prasad
Asst. Prof. Department of Management
GGSESTC, Kandra, Bokaro,

Abstract
This paper studies the role of Artificial Intelligence in strategizingCompensation/HR/Performance/Output subject to Indian legislations to effectively manage resources employed in social entrepreneurship sector, in a way that balances enhancement of living standards as well as maintaining cost competitiveness; to improve lives and sustain economic viability and growth of social enterprises.

Keywords: Digitalization, Data-base, Artificial Intelligence, Compensation, Outreach, Strategize

Introduction
In the past one and a half decade India has undergone mass scale digitalization. The Indian population has been put on roll by Aadhar, Voter Id, PAN, Jan Dhan Bank accounts, Digilockers, BPL schemes and various, never before subsidies, social and health security schemes of the Central and various State Governments in India. Moreover, India turned the most populous nation of the world in 2022. The role of AI is important for management and finance strategies for enhancing the outreach and sustenance and viability of social entrepreneurship projects. Digitalization has created a reservoir of data-base. This paper studies the potential of Artificial Intelligence for the effective administration of public and welfare services through social entrepreneurship, to the Indian populace.

Literature
Social enterprises engaged in environment, health, education, technology, etc. sectors functionupon corporate, government and other sources' funding. They recruit human resources, train/up- skill and motivate and compensate them which involves strategizing as laws and other factors in India may vary state-wise. Application of AI tools in social enterprises enables enhancement of outreach, higher visibility, increased impact, increased transactions, social penetration, removing of disparities, speed and time efficiency with greater output and empowerment to the people.

Potential Role of AI

- Analyzing data and making predictions Using AI to study vast databases to detect needs, habits, inclinations, trend and patterns
- Personalized facilitation – creating virtual assistants for support to beneficiaries, enhanced engagement and execution of initiatives.
- Making models and predictions –forecasting trends and outcomes to facilitate fashioning future business models, effective resource allocation, managing wastage, etc.
- Identifying growth opportunities and optimizing operations.
- Creating future models upon predicting risks, costs and returns.
- Automating routine tasks as far as possible
- Increasing inclusivity through mass-engagement
- Ease and accessibility
- Creating platforms for collaborations and associations/partnerships among the stakeholders.

Table 1.

Sr. no.	Sectors/Areas	Artificial Intelligence Tools
1	Health	AI Chatbots
2	Education	AI Education platforms
3	Environment	AI Environment Monitors
4	Rural Development	AI Chatbots
5	Data Analysis	Machine Learning Algorithms
6	Public Accessibilty	Virtual Assistants

Table 2.

Sr.no.	Name of AI Tool	Application
1	Hirevue	Hiring/Recruiting
	Entelo	
	LinkedIn Recruiter	
2	SuccessFactors	Training and Output Management
	Workday	
	Cornerstone OnDemand	
3	Lighthouse	Employee Feedback and Management
	Glint	
	Culture Amp	
4	Google Analytics 360	HR Projection and Reporting
	SAP SuccessFactors Analytics	
	Tableau	
5	Lattice	Feedback and Performance Management
	15Five	
	Reflektive	
6	ServiceNow Virtual Agent	HR Self Service
	IBM Watson Assistant	
	Microsoft Bot Framework	

Benefits of applying AI in social entrepreneurship

- Improved lives
- Cost cuts
- Automated decisions and sped efficacy
- Personalized experiences/earning/development
- Expansive engagement
- Equity
- Inclusion of diversity

Challenges

- Displacement of jobs
- Lack of discretion
- Security and Privacy concerns
- Ethical considerations

Examples Piramal Foundation, Micro Finance Institutions, BRAC, d.light,Aravind Eye Hospital, KIVA, Grameen Shakti, TOMS Footwear, Warby Parker, etc.

Table 3.Global Trends in State Initiatives for Innovation and AI in Social Entrepreneurship

Sr.no.	Government of the Nation	Name of the Initiative
1	India	Atal Innovation Mission (AIM)
2	USA	Social Entrepreneurship Fund (SEF)
3	Australia	Social Enterprise Development Fund
4	United Kingdom	Big Society Capital

Conclusion

Industry 5.0 is on the anvil and there's an unprecedented stress upon developing sustainable ecosystems. Social enterprises are here to revolutionize the socio-economic scenario especially in India which has the highest population in the world. To singlehandedly cater to the needs of the population of such volume and diversity is difficult for the State. However, with the help of social enterprises, not only the Indian Government but the governments of nations around the world are achieving economic and social development targets. This cannot be possible without technology and its ever growing innovations of using Artificial Intelligence, as studied above.

Reference

1. Concepts in Strategic Management and Business Policy – Thomas L. Wheelen, J. David Hunger
2. Compensation Management – Tapomoy Deb
3. The World Economic Forum – https://initiatives.weforum.org

A critical review on Fifth Generation Engineering & Management College with special reference to GGSESTC, Kandra

Ms Sahiba Akram[1], Puja Kumari[2], Prof. Dr. Priyadarshi Jaruhar[3#], Prof. Rashmi Thakur[4*].
#Director, GGSESTC, Bokaro
*Corresponding Author,
Asstt. Professor, BBA & OSD (HR), GGSESTC, Bokaro.
Email: rashmithakur0483@yahoo.com

Abstract

The term 'fifth generation' indicates exceptionally advanced in attributes. Fifth generation computers have enhanced performance which facilitate Artificial Intelligence, IoT, Big Data processing with the utilisation of massive numbers of CPUs instead of integrated circuits or microprocessors. A fifth-generation type fighter aircraft must have stealth, low probability of intercept radar (LPIR), agile air frames, 3 Cs etc. In the same way 5G is the fifth generation known for wireless cellular technology with more reliability, offering higher uploading, more consistent connections and improved capacity than previous networks.

This study is aimed to find out necessary features of fifth generation engineering colleges and its synchronization with GGSESTC, Bokaro. After research and survey considering the factors viz. happiness index, human centric, excellence in entrepreneurial skill, digital, high level multi-disciplinary setup, problem solving laboratory, students faculty from developed countries, personal mentorship like classical gurukul, the cutting edge and globally influential nature of research focus on practical application of their research, plenty of green space, cultural and other leisure activities and regular symposia and conferences, performance of music, theatre, visual arts, film, documentaries, community industry & Governance connect and sustainability influencing empirical equation.

Key words: Fifth generation, global influence, entrepreneurship, sustainability, empirical equation.

Email: rashmithakur0483@yahoo.com

1. Introduction:

The world is progressing in a rapid speed since industrial revolution. If one count one or first phase of revolution and pragmatic change after some decades invention and requirements changes. Now we have industry 5.0, 5 G mobile, 5th generation computers 5th generation stealth aircrafts. In the line the engineering education must move in the same space. The various requirements in engineering education to meet challenges and opportunities of future economy environment are to reinvent, human physical and psychological interactions, future skills, happiness index, human centric, entrepreneurial skills, students faculty from developed countries, personal mentorship like classical gurukul, globally influential nature of research, problem solving, capacity building for SDGs, , plenty of green space, cultural and other leisure activities and regular symposia and conferences, performance of music, theatre, visual arts, film, documentaries, community industry & Governance connect and sustainability influencing empirical equation.

Through cyberethnography we can explore how digital technologies help to support the needs, abilities, aspirations and the mass use of technology in teaching and learning can be further evidenced in the literature which refers to the global phenomena of 'emergence' - the internet domination of interactive, self-evolving non-hierarchical structures (Johnson, 2001). Such structures develop self-sustaining intelligence through user contributions. Examples of this include Wikipedia, Google, E-bay, Facebook, Myspace, You-Tube and Amazon. According to Johnson (ibid), the import of such sites has not been lead but is more the result of user-generated interactions and creativity such as in the formation of special interest groups and user feedback. Furthermore, user-designed free open-source software such as Mozilla Firefox and OpenOffice are competing with traditional commercial approaches for design authoring and control.

With rapid advancements in technology and evolving business landscapes, the education system must adapt to meet the demands of Industry 5.0. A 5th Generation Engineering and Management College (5GEMC) integrates student centric environment, sustainability and social responsibility, A I powered career and placement support to prepare graduates for the future.

Student centric environment- Traditional grading systems primarily rely on exams and theoretical assessments, often failing to capture a student's practical abilities, problem-solving skills, and real-world application of knowledge. A skill-based grading system powered by AI transforms the evaluation process by focusing on competency, performance, and personalized learning progress rather than just memorization. AI-driven grading systems analyze multiple parameters such as practical project performance, real-time coding skills, critical thinking, teamwork, and leadership qualities. Through AI-powered assessments, simulations, and automated analytics, students

receive personalized feedback that helps them understand their strengths and areas for improvement. AI can track student progress over time, ensuring a holistic and fair evaluation rather than relying on a single exam.

Sustainability and social responsibility- In the era of Industry 5.0, education is not just about technical knowledge and business acumen; it must also in still sustainability and ethical responsibility in students. A 5th Generation Engineering and Management College (5GEMC) integrates green technologies, ethical business practices, and social responsibility to shape future professionals who contribute to both economic growth and environmental well-being. A 5GEMC adopts eco-friendly infrastructure with solar energy, smart buildings, rainwater harvesting, and waste recycling systems to minimize its environmental footprint. IoT-enabled smart grids and energy-efficient buildings reduce resource consumption, setting an example for students on sustainable living and engineering solutions.

AI- Powered career and placement support- For a 5th Generation Engineering and Management College (5GEMC), traditional placement cells are evolving into AI-driven career and placement support systems, ensuring personalized, data-driven, and efficient job-matching for students. AI enhances career guidance, skill assessment, industry connections, and recruitment processes, making placements more effective and aligned with individual strengths.

AI-Driven Personalized Career Mapping- AI analyzes students' academic performance, skills, interests, and industry trends to provide tailored career recommendations. By assessing their strengths in engineering, management, analytics, or entrepreneurship, AI suggests the best career paths, whether in tech firms, business consulting, research, or startups.AI-powered tools help students create optimized resumes by identifying keywords, achievements, and skills that match industry requirements. AI job-matching platforms then connect students with relevant job opportunities, aligning their skill sets with employer demands.

2. Methodology:

Cyber-ethnology is a recent addition to our research tools located within an interpretive paradigm gaining momentum in use and credibility in reputation. With its roots in ‘ethnography’, as part of the social science branch of anthropology, its focus is on the study of mankind and cultures. Traditionalists surprised to see ethnography used this way should remember that ethnography has been adaptive and explored myriad cultural connections although this fact is often forgotten by modern ethnographers who deplore the use of their art to study the virtual world Cyber–ethnography, as a research methodology, involves becoming immersed in virtual culture.

The overall aim of cyber-ethnographic studies is to immerse oneself in the virtual world that the participants have created, in order to understand how they experience social interaction and devise ways of regulating social order.

cyber-ethnography methods were adopted for this with help of computer service providers. The survey was conducted through computer at GGSESTC location with following, Cyber-ethnography permits the exploration of the conditions of the environments most likely to improve productivity of practitioner and learner time, thus revealing how collaborative and individually based communications in the learning environment can best be utilized. It provided evidence-informed analysis of the benefits and roots of personalized learning through technology across the life course.

This study focused on the use of a Virtual Learning Environment, earners could develop both individual responsibility and social learning skills from which a vibrant, interactive and reflective learning community would emerge. modern education functions and to think differently about the processes involved in learning and teaching. Finally, through learner participation, the intention was to enable learners (who were all teachers) to evaluate whether the adopted Virtual Learning Environment could benefit their learners.

Questionnaires:
Q. What are the stark difference factors between conventional and 5 generation engineering & management colleges and weightages?
Factors-
a) Core subject knowledge with Virtual Classroom management
b) Human Centric
c) Artificial Intelligence uses
d) Cutting edge and globally influential nature of research
e) Problem solving learning
g) Gurukul system
h) Future Skills Prime is an innovative and evolutionary ecosystem designed to equip learners with cutting-edge skills essential in today's rapidly evolving digital landscape.
i) Teaching experts from developed countries
j) Employability
k) core teaching learning
l) plenty of green space
m) cultural and other leisure activities
n) social learning skills
o) Curiosity & research skills

p) Digital Curator
q) Size of Institutes (measurement 1000 students)
r) 80 %Salary component is supported by other than consultancy revenue
s) Academia stuck in the past

3. Results & Discussion

After detailed study and analysis of processed data

MODEL

"What is the conceptual paradigm of the fifth-generation Engineering & Management Colleges model?

Fifth Generation University Model Conditions: Causal conditions are the factors that impact the core category. Based on the conducted interviews, axial codes were identified and linked to a broader selective code known as causal conditions. These codes include knowledge development. Modern social needs; intra-organizational factors; extra-organizational factors; first-generation university mechanisms; second generation university mechanisms; third generation university mechanisms; fourth generation Engineering College mechanisms. After placing the survey quotient data. Factors a to pare directly proportional to 5GEMC quotient and q to s are inversely proportional to the quotient.

This research was conducted to propose a data-oriented model for fifth-generation universities in engineering & management colleges. The administrators of GGSESTC, Kandra should take the necessary steps to achieve the goals outlined in the Vision Document through data-driven decision making. For this purpose, it is necessary to utilize the educational data mining process to effectively navigate this path and overcome the challenges that lie ahead. Today's academic system must continuously adapt to the scientific and social environments through data-oriented strategies and maintain a dynamic balance with the ever-changing society.

4 Conclusion:

In conclusion, a 5th Generation Engineering and Management College redefines education by integrating technology, skill development, sustainability, and student well-being. By embracing AI, interdisciplinary learning, and global opportunities, such institutions prepare students not just for jobs but for leadership, innovation, and entrepreneurship in a rapidly evolving world. If the GGSESTC, Kandra**,** take necessary steps in the direction ofthe cutting edge and globally influential nature of research focus on practical application of their research, globally influential nature of research and teaching faculty recruitment from developed countries, it can reach to 8.3 numeric value. The strength observed during research which made college a fifth generation one is, happiness index, gurukul system (Indian ancient teaching system), entrepreneurship and employability skill sets, plenty of green space, problem solving abilities, sustainability, conferences, seminars, FDPs, workshops, films, Institute-Industry-Governance Research (IIGR) interface. For the meaningful survival of any engineering and management college it is necessary to achieve 5th Generation attributes.

5 Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The data and quotient will be shared directly in next research paper.

6 Reference:

1. Paul Hodkinson's study of Goth: Identity, Style and Subculture (2002)
2. Nicholas Pleace *et al.* an alcoholics' support group (Sociological Research Online, 2000)
3. Nasim Bakhshaei, Mohammad Reza Bagherzadeh, , Yusuf Gholipourkanani , Mohammad Reza Dalvi, International Journal of Knowledge Processing Studies,(June 2023)
4. Richard, A. Levine, P. E. Rivera, L. He, J. Marilee J. Bresciani L A learning analytics case study: On class sizes in undergraduate writing courses, Stat, https://doi.org/10.1002/sta4.527, . (2023).
5. Etuk, G. K. (2015). Innovations in Nigerian Universities: Perspectives of an Insider from a" Fourth Generation" University. International journal of higher education, 4(3), 218-232. https://doi.org/10.5430/ijhe.v4n3p218
6. Mei, W., &Symaco, L. University-wide entrepreneurship education in China's higher education institutions: issues and challenges. Studies in Higher Education, 47(1), Knowledge Processing Studies. 2024, 4(1): 79-91. 90 177-193. doi.org/10.1080/03075079.2020.1735330, (2022).
7. AbhyjithK.Ashokan , 'IIT academia stuck in the past' : Hotmail-founder Sabeer Bhatia says innovation comes from doing, not just studying', The Hindustan Times, (March 07, 2025).

Performance Characteristics of a Four Cylinder Four Stroke ISUZU Petrol Engine

Hrishabha Kumar Shani[1], Vikrant Kumar[2] and Dr. Bikash Ghoshal[3]
[1& 2] Student,Mechanical Engineering, GGSESTC, Kandra, Chas, Bokaro
[3]Professor, Mechanical Engineering, GGSESTC, Kandra, Chas, Bokaro

Abstract: Modern civilization utilizes I.C. Engines in different areas such as aircraft, automobile, motorcycle engine, marine propulsion, railway locomotive engine, spacecraft propulsion such as rocket engine, traction engine etc.I.C. Engines are also used in industry for manufacturing products in various forms. Efficient running of engines are very much required for better utilization of fuels and lesser pollution. Thus, aim of this paper is to know the principle of operation of multi cylinder engine and to study the best performance condition of practical ISUZU Engine. Detailed calculations regarding engine performance have been made and based on analysis of the test results maximum efficiency of 31.26 % was observed at 16.2:1 air:fuel ratio which is slightly lean mixture. This is the most economical running condition when other parameter like rpm is 1574 and BHP is 9.84. Maximum power was observed to be 12 HP at the A:F ratio of 12.2:1 which is slightly richer than the stoichiometric mixture while rpm was 1236.

***Key words*:** engine performance; efficiency; power

1. Introduction

Heat Engine is defined as any engine that converts thermal energy to mechanical work output. Examples of heat engines include: steam engine, diesel engine, and gasoline (petrol) engine. The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine the expansion of the high-temperature and pressure gases produced by combustion applies direct force to some component of the engine, such as pistons. This force moves the component over a distance, generating useful mechanical energy. The effect of water injection on a spark ignition engine thermal balance and performance has been experimentally investigated on a four stroke four cylinder engine with LPG (liquid petroleum gas) as fuel [1]. The results showed that as the water injection level to the engine increased, the percentage of useful work increased, while the losses other than unaccounted losses decreased. Moreover, the specific fuel consumption decreased, while the engine thermal efficiency increased. A theoretical study of different strategies for waste heat recovery in an internal combustion engine run by internal combustion and electric motor was conducted to reduce specific fuel consumption [2]. The important applications of I.C. engines are road vehicles, locomotives, ships and aircraft, portable standby units for power generation in case of scarcity of electric power, extensively used in farm tractors, lawn movers, concrete mixing devices and motor boats etc. Thus, aim of this paper is to know the principle of operation of multi cylinder engine and to study the best performance condition of practical ISUZU Engine.

2. Principle parts of petrol engine

Fig 1 shows the major internal combustion engine components:

Combustion chamber: The end of the cylinder between the head and the piston face where combustion occurs. I.C. Engine components shown in figure are defined as follows:

Block: Body of the engine containing cylinders, made of cast iron or aluminum.

Cylinder: The circular cylinders in the engine block in which the pistons reciprocate back and forth.

Crankshaft: Rotating shaft through which engine work output is supplied to external systems. The crankshaft is connected to the engine block with the main bearings.

Connecting rod: Rod connecting the piston with the rotating crankshaft, usually made of steel or alloy forging in most engines but may be aluminum in some small engines.

Inlet and Exhaust valves: Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the product of combustion (exhaust valve) from the cylinder.

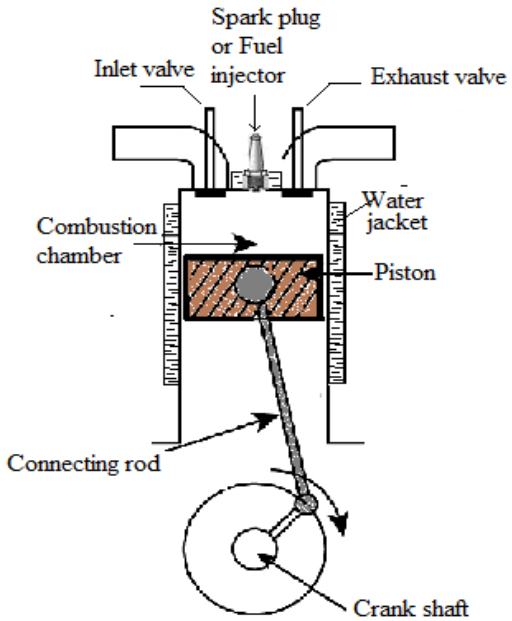


Fig 1 Basic engine components

Piston: It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits perfectly into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft
Camshaft: Rotating shaft used to push open valves at the proper time in the engine cycle, either directly or through mechanical or hydraulic linkage (push rods, rocker arms, tappets).
Gudgeon Pin: It links the small end of the connecting rod and the piston
Cam: These are made as integral parts of the camshaft and are so designed to open the valves at the correct timing and to keep them open for the necessary duration.
Crankcase: Part of the engine block surrounding the crankshaft.
Exhaust manifold: Piping system which carries exhaust gases away from the engine cylinders, usually made of cast iron.
Intake manifold: Piping system which delivers incoming air to the cylinders usually made of cast metal, plastic, or composite material.
Carburetor: A device which meters the proper amount of fuel into the air flow by means of pressure differential.
Spark plug: Electrical device used to initiate combustion in an SI engine by creating high voltage discharge across an electrode gap.
Flywheel: Rotating mass with a large moment of inertia connected to the crank shaft of the engine. The purpose of the flywheel is to store energy and furnish large angular momentum that keeps the engine rotation.
Piston Rings: Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases.

Fig 2 Experimental set up (ISUZU Engine)

3. Performance testing of petrol engine

Engine performance is an indication of the degree of success of the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. For the evaluation of an engine performance few more

parameters are chosen and the effect of various operating conditions, design concepts and modifications on these parameters is studied. The basic performance parameters are as follows:

3.1 Performance parameters:-

Power and Mechanical Efficiency

The power developed by an engine and measured at the output shaft is called the brake power (*BP*) and is given by,

$$BP = \frac{2\pi NT}{60}$$

Volumetric Efficiency

It is defined as the ratio of the mass of air inducted into the engine cylinder during the suction stroke to the mass of the air corresponding to the swept volume of the engine at atmospheric pressure and temperature.

Volumetric efficiency,

$$\eta_v = \frac{Mass\ of\ charge\ actually\ sucked\ in}{Mass\ of\ charge\ corresponding\ to\ the\ cylinder\ intake\ P\ and\ T\ conditions}$$

Fuel-Air Ratio (*F*/*A*)

Fuel-air ratio of the mixture affects the combustion phenomenon in that it determines the flame propagation velocity, the heat release in the combustion chamber, the maximum temperature and the completeness of combustion.

Specific Fuel Consumption

Specific fuel consumption is defined as the amount of fuel consumed for each unit of power developed per hour. It is a clear indication of the efficiency with which the engine develops power from fuel.

Specific fuel consumption (*sfc*) = $\frac{Fuel\ consumption\ per\ hour}{Power}$

3.2 Engine specification:-

Brake Horse Power : 10 HP
No of cylinder : 4
Compression ratio : 8.5:1
Bore Diameter : 84 mm
Stroke length : 82 mm
Types of cooling : water cooling
Air drum orifice diameter : 24 mm
Load arm : 320 mm
Maker : ISUZU

Table1: Experimental and calculated data

No of observation	(RPM)	Manometric head (mm)	Load (Kg)	BHP	Mass of fuel (Kg)	η_{Bth}	Actual vol m3/hr	Swept vol m3/hr	$\eta_{vol(\%)}$	A:F
1	690	35	6.5	2	1.4	8.83	24.35	37.61	64.74	21.03
2	930	42	8.5	3.53	1.6	13.05	26.67	50.69	52.62	19.32
3	1170	40	15	7.84	3.2	14.63	26.03	63.77	40.81	9.52
4	1574	40	14	9.84	1.9	31.26	26.03	85.79	30.34	16.2
5	1236	55	21.5	11.87	2.9	24.24	30.52	67.37	45.3	12.21

3.3 Analysis of engine performance

Experiments were performed on the set up shown in Fig. 2. The engine performance is indicated by the term efficiency η. The heat energy which is converted to power is called indicated power, ip it is utilized to drive the piston. The useful energy available at the shaft is called brake power bp. The fuel consumption characteristics of an engine are generally expressed in terms of specific consumption in kg of fuel per kilowatt-hour. It is an important parameter that reflects how good the engine performance is. The relationship between speed, power developed and specific fuel consumption determines the performance of an engine.

3.3.1 Variation of efficiency with variation of air fuel ratio

The Fig 3 describes the variation of efficiency(η) with the variation of air fuel ratio(A: F). Initially efficiency increases linearly as the A:F ratio increases and maximum efficiency of 29.26 % was observed at 16.2:1 (A:F) which is slightly lean mixture. This Air : Fuel ratio (16.2:1) is very important from point of fuel economy and also, less pollution. Complete combustion of fuel is possible at this air fuel ratio when other parameter like rpm is 1574 and BHP is 9.84.

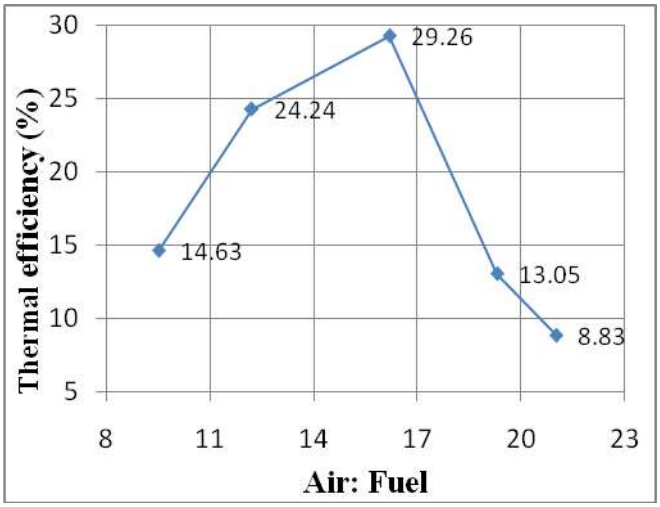


Fig 3 Variation of efficiency(η) with the variation of air fuel ratio

3.3.2 Variation of power output with variation of air fuel ratio :

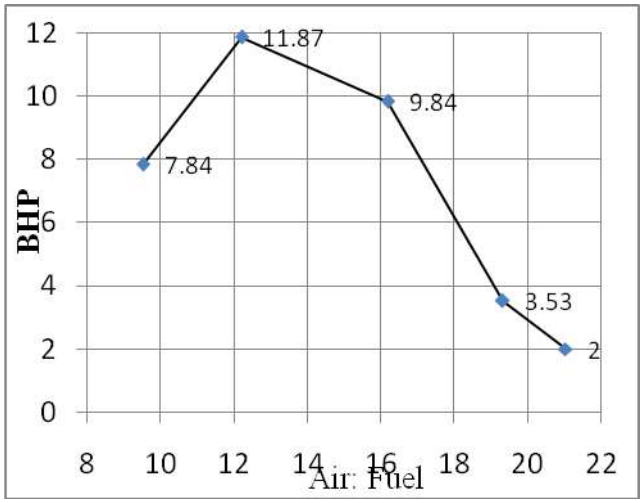


Fig 4 Variation of power output (HP) with the variation of air fuel ratio(A:F)

The Fig 4 describes the variation of power output(HP) with the variation of air fuel ratio (A:F). The A:F ratio at which an engine operates has a considerable influence on its power output. Initially when A:F mixture is rich i.e. Air is less compared to stoichiometric Air:Fuel ratio very less oxygen is available for sufficient combustion and hence, engine produces less power. After that power output increases with increases in A:F ratio due to availability of more oxygen for burning. Maximum power was observed to be 12 HP at the A:F ratio 12.2:1 which is slightly richer than the stochiometric mixture. The oxygen available in the limited air inside the cylinder is fully utilized for combustion. Dissociation is less as CO is already present in the product of combustion and thereby, power is highest at rich mixture. Therefore to get maximum power from the engine it should be run at 12:1 A:F ratio.

3.3.3 Variation of volumetric efficiency with variation of Power output

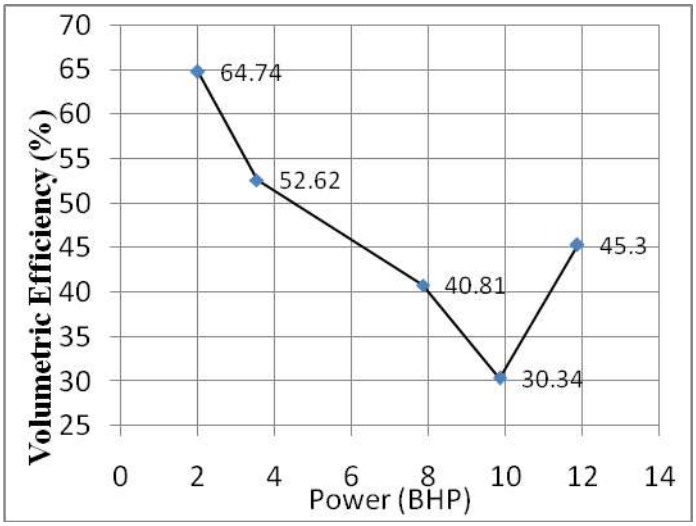


Fig 5 Volumetric efficiency versus power

Volumetric efficiency is a very important parameter for longevity and overall health of the engine. It also indicates the breathing ability of the engine. Here volumetric efficiency is maximum at brake power of 2 HP when rpm of engine is very low due to the fact that number of opening and closing of vlaves per unit time is less and hence, time involved in opening and closing is less. Operation of valves need some time to fully open the inlet. With increase in speed, the cycle time decreases and within the short span opening of valves are disturbed and cylinders are not fully filled with outside air and thereby, volumetric efficiency decreases. Moreover, at higher speed throttle valve of carburetor is fully open and hence at maximum power of 12 HP more air enter due to inertia of velocity and volumetric efficiency is medium (45 %). Therefore to get longevity of engine running at lower power is necessary and at urgency, maximum power is suitable.

Variation of Power output with variation of RPM

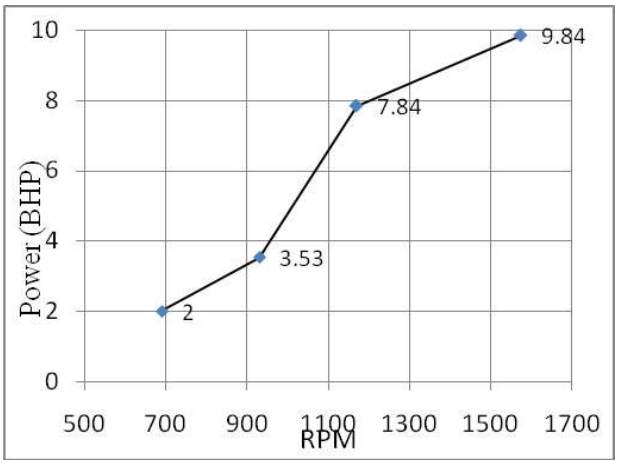


Fig 6 Power output with the variation of speeed (RPM)

The Fig 6 describes variation of power output with the variation of speeed (RPM). Brake power output of the engine is almost linearly proportional to speed of the engine. Number of cycles per unit time increases with increase in RPM. Hence, power output increases with the increase in rpm. Here we observed that highest brake power output (9.84HP) obtained when engine running at speed of 1574 RPM. Although, all engine have certain limit, where it gives highest power at a perticular speed. So, always engine should run within its speed limit. Otherwise it may damage any time.

4 Conclusion

Performance testing of four cylinder practical engine (ISUZU make) has been performed. Detailed calculations regarding engine performance have been made and based on analysis of the test results, following conclusions can be made:

(i) Maximum efficiency of 31.26 % was observed at 16.2:1 (A:F) which is slightly lean mixture. This is the most

economical running condition when other parameter like rpm is 1574 and BHP is 9.84.

(ii) Maximum power was observed to be 12 HP at the A:F ratio 12.2:1 which is slightly richer than the stochiometric mixture. The oxygen available in the limited air inside the cylinder is fully utilized for combustion. Dissociation is less as CO is already present in the product of combustion and thereby, power is highest at rich mixture.

(iii) Volumetric efficiency is a very important parameter for longevity and overall health of the engine. Volumetric efficiency decreases linearly with increase in rpm. Operation of valves need some time to fully open the inlet. With increase in speed, the cycle time decreases and within the short span opening of valves are disturbed and cylinders are not fully filled with outside air and thereby, volumetric efficiency decreases. At higher speed throttle valve of carburetor is fully open and hence at maximum power of 12 HP more air enter due to inertia of velocity and volumetric efficiency is medium (45 %).

(iv) The BHP increases linearly with the increase in rpm. Number of cycles per unit time increases with increase in RPM. Hence, power increases with the increase in rpm.

REFERENCES:

[1] HakanÖzcan, M.S. Söylemez, "Thermal balance of a LPG fuelled, four stroke SI engine with water addition," Energy Conversion and Management 47 (5) (2006) 570-581.

[2] Diego A. Arias, Timothy A. Shedd, Ryan K. Jester, "Theoretical analysis of waste heat recovery from an internal combustion engine in a hybrid vehicle," SAE paper 2006-01-1605.

[3] VGaneshan, "Internal Combustion Engine," Tata McGraw Hill Publishing Company Limited, Second Edition, pp 35, 606-670.

The safety of pedestrian roads in connection with the type of urban roads and traffic patterns.

[1]Dr. Rajendra Prasad Verma*, [2]Mr. Sidhlal Hembram, [3]Mr.Santosh Mandal, [4]Md..Tanveer Ansari
Department of Civil Engg, GGSESTC.
Correspondence Author's Email Id dr.rpverma28@gmail.com

Abstract
The analysis of the connection between traffic flow for motor cars, urban roads type, and pedestrian road safety. We have studied six different kinds of urban streets in Jharkhand. For every road section of the streets under examination, we gathered information on the flow of pedestrian traffic and whether or not they were walking legally. Additionally, we gathered information on the flow of traffic for drivers in the same road segments of the streets inside the research area. When those statistics are combined with each road's administrative ranking, it is possible to determine the walk ability level of a street or a particular route under study as well as the mobility and safety concerns of pedestrians. This study confirms that different road types have different walking habits. Local streets had the lowest rate of law-abiding pedestrians, while major thoroughfares had the highest rate [1]. The low volume of motorized traffic combined with challenges with pedestrian infrastructure mobility and maintenance encourages people to walk on the street, which understates their safety concerns. Promoting pedestrian mobility with a focus on safety issues can improve the quality of life for local residents, raise an urban area's sustainability index, and shift the modal split in favor of vulnerable road users.
Keywords: Pedestrian, Safety, Accident, Sustainability, Urban.

1. Introduction: A high number of pedestrian fatalities in India are caused by inadequate infrastructure, such as sidewalks and pedestrian crossings, as well as lax traffic enforcement. Some important strategies to increase pedestrian safety include: always using designated crosswalks, walking on the sidewalk when possible, crossing roads only when there is a safe gap in traffic, being aware of turning vehicles, and dressing reflectively at night to be visible to drivers. To stay safe from traffic hazards, pedestrians should develop the practice of using road infrastructure appropriately. To cross the road, use foot over bridges, zebra crossings, or subways. Paying attention is the most crucial safety strategy to lower pedestrian fatalities and injuries. Following traffic laws can greatly lower your risk of getting involved in an accident with a motor vehicle. If at all possible, look drivers in the eye and make sure they can see you.

Everyone is a pedestrian at some point during the day. Sadly, there are still a lot of pedestrian fatalities and injuries. In 2023, 8,421 pedestrians were killed and more than 69,000 pedestrians were injured nationwide. Government raises awareness of the dangers to pedestrians and provides tips to keep pedestrians safe.

2. Literature review
In order to comprehend the peculiarities of pedestrians in mixed traffic situations, Oeding (1963) carried out a study. Older (1968) illustrates the walking habits of British consumers. Even though walkers move more slowly than cars, the flow diagrams for pedestrians and cars are similar in appearance. According to Moral (1991), pedestrian speeds in Asian nations are substantially slower than those in Western nations. When pedestrians encounter heavy or fast motorized traffic, they are exposed to a heightened risk level, making them vulnerable road users. Research on the severity of pedestrian accidents is extensive globally. The most frequent elements that affect pedestrian accidents are the kind of vehicle, age and gender, and alcohol consumption. To examine the impact of contributing factors on the likelihood of death and serious injury, Sze and Wong (2007) used logistic regression. Pedestrians under the age of 19 and those over 60 are more likely than other age groups to be involved in fatal pedestrian-vehicle collisions (Al-Ghamdi, 2002). The following factors have a major impact on the severity of pedestrian injuries: vehicle type; the presence of alcohol by drivers or pedestrians; and age (over 65) (Zajac and Ivan, 2003). Elderly people are more susceptible, accidents at signalized junctions are less serious, injuries are more severe in the dark, and speed limits increase the severity of injuries (Eluru et al., 2008). The severity of pedestrian-vehicle collisions is also influenced by environmental and personal factors. Urban design should take environmental circumstances into account and conduct a more thorough analysis of them (Clifton et al., 2009) [2]. The level of road safety can be raised by walking in a group and by having a high volume of pedestrian traffic on the roadway. According to Jacobsen (2003), doubling the number of pedestrians reduces traffic crashes that cause injuries by 32%. This can be explained by the fact that drivers modify their driving habits when they are aware of pedestrians. Increased vehicle speeds raise the risk of a pedestrian being hit by a car and the seriousness of the injuries sustained (Rosen and Sander, 2009). The majority of pedestrian fatalities happen at night, in metropolitan areas, and outside of intersections (NHTSA, 2015). In the United States, 4,735 pedestrians lost their lives in road accidents in 2013. This equates to one pedestrian fatality from a collision every two hours on average (NHTSA, 2015). Furthermore, in 2013, over 150.000 pedestrians received treatment in emergency rooms for injuries sustained in non-fatal collisions (CDC, 2015). According to Beck et al. (2007), pedestrians had a 1.5-fold higher risk of dying in an automobile accident on each journey than passengers in passenger vehicles. 5,712 pedestrians, or 22% of all fatalities, were killed in traffic accidents in the EU in 2013. Pedestrian fatalities decreased by 37% in the European Union during the past ten years, while overall fatalities decreased by nearly 45% (ERSO, 2015). People want to live in a place where they can stroll around conveniently and safely. Road and personal safety, convenience, proximity to destinations, multimodal transit, and improved health are just a few advantages that residents of walkable cities enjoy. Although there is no universally accepted definition of walkability, it can be defined as the degree to which the urban road environment is suitable for pedestrians (Lund, 2003; Southworth,1997;Saelens et al., 2003).

3. Methodology
i. Pedestrian Traffic Flow: This describes how pedestrians move through a specific location and is impacted by things like walking speed, density, and the existence of impediments. Designing safe and effective pedestrian infrastructure requires an understanding of pedestrian traffic.

ii. Walking Behavior: This relates to the behaviors and patterns that pedestrians display when they are on the move, such as their reaction to environmental signals, group dynamics, and compliance with traffic laws. The safety of pedestrians and the general effectiveness of pedestrian infrastructure are greatly impacted by walking behavior.
iii. Motorized Traffic Flow: Metrics like speed, density, and traffic volume define this, which involves the movement of automobiles. Road capacity evaluation, congestion point identification, and traffic management strategy improvement are all aided by motorized traffic flow analysis.
By examining these factors, we want to obtain a thorough grasp of how cars and pedestrians interact, which is crucial for improving traffic control and road safety.

3.1. MAJOR PROBLEMS IDENTIFIED FROM FIELD SURVEY
A number of problems have been identified from the field investigation in study area regarding the pedestrians' convenience. Some of them are:
3.1.1. Ineffective Pedestrian Crossing Control Devices: According to field research, pedestrian traffic signals are present at 61% of signalized junctions in the DMP region (at least at one approach to the intersections). However, their use is ineffective. Consequently, pedestrians cross intersections at random. Once more, there are crosswalk markings at about 28% of signalized intersections. However, they lack advance crossing signs. With faded markings, the majority of the crosswalks are zebra crossings. As a result, the crossing marks are invisible to drivers at a distance.
3.1.2. Vehicles Occupied Crosswalks: Additionally, field research demonstrates that cars do not stop at intersections past the stop line. They try to occupy the crosswalks and travel as far as they can in the intersections' leg. The pedestrian's ability to cross the street is impeded by this circumstance.
3.1.3 Manual Operation of Intersections: The traffic police in Jharkhand manually run the majority of the signal-controlled crossings. Consequently, cars that arrive late frequently try to avoid the police and speed through intersections. This mindset raises the probability of pedestrian fatalities at junctions.
3.1.4. Raised Crosswalks at Exits: Despite the fact that raised crosswalks ought to be placed at intersection approaches, certain crossings (like Shahbag) have them placed at the exits. They are not functioning efficiently as a result of their failure to meet installation requirements.
3.1.5. Lack of Authorized Bus Stops: Because there aren't enough approved bus stations in Jharkhand , most buses stop close to intersections. Consequently, pedestrians are put in greater danger at junctions due to rivalry among automobiles for pedestrian loading and unloading.
3.1.6. Competition among Drivers: There is a greater chance of accidents due to chaotic intersection crossings caused by rushing and competitiveness among pedestrians to reach the bus.
3.1.7. Teenager's Unconsciousness: Teenagers in particular are known to cross streets while wearing headphones.
3.1.8. Illegally Occupied Footpath: Hawkers, little tea stalls, and other vendors unlawfully occupied the sidewalks and footpaths close to the crossroads, forcing people to cross the carriageway and putting them in danger from cars. Consequently, the likelihood of accidents rises[3].
3.1.9. Lack of Uses of Overpass: A few crossings in Jharkhand, such as the Science Laboratory intersection, feature overpass facilities. However, in the majority of situations, they are inhabited by hawkers and do not draw people. Consequently, there are major safety risks when pedestrians cross the road.
3.1.10 Illegal On-street Parking: On-street parking close to crossings and illegal parking on sidewalks make it difficult for pedestrians to observe cars when crossing the street. They also encourage pedestrians to cross the street, exposing them to cars.
3.1.11. Garbage Stock: Pedestrians are forced to cross the carriageway of the roadways when trash or an open dustbin is thrown near junctions, increasing their risk.
3.1.12. Poor Construction Materials: During the rainy season (monsoon), the use of subpar construction materials frequently results in muddy conditions and water logging on the sidewalks, which discourages people from utilizing the sidewalks and instead encourages them to use the carriageways.
3.1.13. Absent of Footpath Barrier: In regions with heavy pedestrian activity, such as Farmgate crossroads, and close to intersections, there are typically barriers to pathways. However, this feature is absent from a significant section of the walkway. Consequently, the efficacy of the walkways close to the junctions is significantly diminished.

3.1.14 Drivers' Perceptions: The results of the survey indicate that the majority of drivers do not wish to assume responsibility for pedestrian injuries. bad traffic control, bad traffic management, and haphazard pedestrian crossings from any part of the roads at intersections are the things they blame. Another factor that drivers acknowledge as contributing to these fatalities is the failure to use crosswalks. They rarely acknowledge, however, that speeding is a major contributing factor in the incidents.

3.1.15 Pedestrians' Perceptions: Pedestrians, on the other hand, state that the primary cause of accidents is vehicles traveling too fast. Once more, unlawful vendors on sidewalks and in on-street parking force people to utilize carriages, which raises the risk of collisions. Fading crosswalk markings, inadequate flyover facilities, and poor pedestrian traffic signal management are also recognized as contributing factors to the accidents.

3.3.1 Design and Layout of Pathways
Wide vs. Narrow Paths: Narrow places can cause congestion, but wider walkways facilitate smoother mobility.
Intersection Design: Signage, signals, and pedestrian crossings are essential for preserving flow where paths converge.
Space Segmentation: Accidents and confusion can be avoided in places where walking zones are clearly marked off (e.g., sidewalks vs. roadways).
Density and Volume of Pedestrians

City centers and other high-density locations need to pay close attention to managing pedestrian movement in order to avoid bottlenecks. Temporary infrastructure or crowd control techniques may be necessary for events like concerts or protests that result in an increase in foot traffic.

3.4.1 Pedestrian Behavior

Walking speed: People usually walk at varying rates, and slower pedestrians have a propensity to gather in particular spots, which slows down traffic flow.

Group walking: Groups of people can impede traffic, particularly on small roads.

Environmental Factors: Rain or snow can have an impact on how swiftly and comfortably people can move.

3.5.1 Technological Solutions

Smart Traffic Systems: Some cities allow for more efficient movement by synchronizing pedestrian signals and traffic lights with real-time traffic flow data.

Data Analytics: Through the analysis of pedestrian movement data (from sensors or cameras, for example), city planners can pinpoint possible areas of congestion and implement solutions.

3.6.1 Safety Considerations

It's crucial to make sure that pedestrian walkways are clear of obstructions, such as shoddy building materials or incorrectly parked vehicles. Particularly in locations with heavy traffic, pedestrian safety can be maintained by installing features like elevated crosswalks, pedestrian bridges, or underpasses. Would you like to go into further depth about any one of the specific ways to improve pedestrian traffic flow? The patterns and traits of how people move on foot in different situations are referred to as pedestrian walking behavior. Numerous elements, including as personal traits, the environment, and societal or cultural influences, all have an impact on this behavior.

3.7.1 Speed and Walking Patterns:

Average Walking Speed: Pedestrians typically move between 1.2 and 1.4 meters per second, or 4 and 5 feet per second. Depending on variables including age, health, and surroundings, this can change.

Walking Styles: People can walk in a variety of ways, such as briskly, leisurely, or aimlessly. The pedestrian's destination, time constraints, or mood can all influence the style and speed.

3.8.1 Personal Characteristics:

Age: In general, older persons move more slowly than younger ones. Youngsters also walk at a distinct tempo, which may be more irregular or slower.

Physical Condition: A person's walking pace and endurance might be influenced by their level of fitness.

Disabilities: Individuals with mobility problems may require assistive devices such as walkers or wheelchairs, or they may walk more slowly.

3.9.1 Social and Group Behavior:

Group Walking: Due to the coordination needed, pedestrians may form a line or cluster when walking in groups, which frequently results in slower movement. Social elements like connection and conversation can also influence how they move.

Pedestrian Interactions: To prevent collisions with other people, pedestrians may alter their walking route, slow down, or accelerate in busy areas. They frequently convey their intentions through body language or eye contact.

3.10.1 Environmental Factors:

Infrastructure: The way pedestrian areas, such sidewalks, crossings, or pathways, are designed has a big impact on how people travel. While pedestrians may move more slowly on narrow or badly built walkways, wide, clear paths promote speedier travel.

Weather: Rain, snow, and intense heat are examples of weather conditions that can impact walking comfort and pace.

Urban vs. Rural Settings: People may walk more slowly and deliberately in urban locations with more traffic, but they may walk more leisurely and slowly in rural areas.

3.11.1 Cognitive Factors:

Attention: The actual surroundings, their mobile gadgets (such as texting or utilizing maps), and other activities like socializing or shopping frequently receive different amounts of the attention of pedestrians. Distractions might cause risky behavior or slow down walking.

Way finding: In order to find their way around, pedestrians usually rely on signs, landmarks, or their local knowledge. On the other hand, walking more slowly and cautiously could be the result of unfamiliar surroundings.

3.12.1 Safety and Risk Behavior:

Crosswalk Usage: For safety, pedestrians typically use designated crosswalks and crossings. However, depending on their sense of urgency or safety, individuals occasionally may take shortcuts or jaywalk.

Awareness of Surroundings: Safety concerns cause pedestrians to alter their behavior, such as avoiding busy locations, keeping an eye out for cars, or crossing at slower times.

3.12.1 Pedestrian Flow in Crowded Spaces:

Density and Flow: People tend to follow the lead of others and move in a smooth, flowing manner in crowded areas like malls, transportation stations, and busy streets. The crowd's density can influence this movement; slower walkers tend to be passed by faster ones, resulting in a natural flow pattern.

Congestion: Congestion can result in slower walking speeds, delays caused by the congestion, or even jams when the density reaches a specific threshold, particularly in small areas.

3.12.2 Cultural Influences:

Walking Etiquette: There are various cultural standards about pedestrian behavior, such as which side of the sidewalk one should use or when one should stop for another.

Walking and Transportation Systems: Walking to train or bus stations is one example of a pattern that may influence pedestrian behavior in cities with robust public transportation systems. In contrast, the reliance on cars in rural regions may make walking less necessary. Urban planning, transit design, and public safety all benefit from an understanding of pedestrian walking behavior since it makes walking environments safer, more effective, and more enjoyable. The term "motorized traffic flow" describes how automobiles,

trucks, buses, and motorcyclists go along roads and highways. It deals with the safe and effective flow of these cars, making sure that traffic is controlled and that there are as little delays, accidents, or congestion as possible.

3.12.3 Key factors that affect motorized traffic flow include:

Road design: Traffic flow is significantly influenced by the design and construction of roadways, including the number of lanes, intersections, and road conditions.

Traffic signals and signs: Traffic control devices, like stoplights, yield signs, and speed limits, are used to regulate the flow of vehicles and prevent accidents.

Traffic density: The number of vehicles on the road at any given time influences how easily traffic can move. High density leads to congestion, while low density typically allows smoother flow.

Vehicle types: The types of vehicles on the road (e.g., light cars vs. heavy trucks) can affect traffic flow, as heavier vehicles might slow down or take up more space.

Driving behavior: The actions of individual drivers, such as speeding, lane changes, and aggressive driving, can influence the overall flow of traffic.

Traffic management systems: Advanced systems like adaptive traffic signals, road sensors, and real-time traffic monitoring can help optimize the flow and reduce bottlenecks.

External factors: Weather conditions, accidents, roadwork, and special events can all disrupt traffic flow. Efficient motorized traffic flow is essential for reducing travel time, improving safety, and enhancing the overall experience of commuting.

4. Research area

Given the high number of traffic accidents in Jharkhand, pedestrian safety is an urgent issue. Jharkhand saw 5,175 traffic incidents in 2022, which led to 3,898 fatalities and 3,747 injuries. This represents a 9.5% increase in accidents over 2021. Pedestrians are especially at risk, accounting for 19.5% of all fatalities in traffic accidents in the country[4]. Although there is little precise data on pedestrian accidents in Jharkhand, reports from nearby states such as Odisha indicate that two-wheelers account for 31.8% of pedestrian fatalities, with trucks and lorries coming in second at 21.4%.

To address these challenges, Jharkhand has initiated several road safety measures:

Bokaro District Initiatives: Bokaro's District Level Road Safety Committee has started a number of comprehensive initiatives, such as clearing up encroachments, enforcing parking laws, and fixing areas that are prone to accidents. The goal of these initiatives is to improve traffic flow and road safety.

Awareness Campaigns: To encourage safe driving habits, the District Commissioner of Jamshedpur has launched a road safety awareness vehicle. The program involves putting up road safety signboards, handing out posters, and stressing the importance of wearing seat belts and helmets. It also emphasizes preventing underage driving, excessive speeding, and drunk driving. The Jharkhand Police advise pedestrians to safely cross roadways by using the available traffic infrastructure, such as foot over bridges, zebra crossings, and subways. The likelihood of accidents can be considerably decreased by developing the habit of using these facilities. Notwithstanding these initiatives, the ongoing increase in traffic accidents emphasizes the necessity of ongoing and improved road safety protocols. Improving pedestrian safety in Jharkhand requires persistent efforts, increased public awareness, and rigorous enforcement of traffic laws.

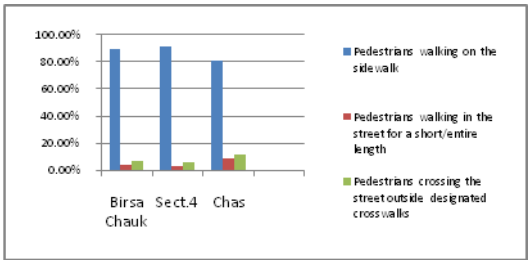
Overall Road Accident Statistics in Jharkhand: About 5,175 traffic incidents were reported in Jharkhand in 2022, with 3,898 people killed and 3,747 injured. The most common cause of these collisions was found to be excessive speeding, with two-wheelers playing a major role.

Pedestrian-Involved Accident Data: In accidents where pedestrians were victims, two-wheelers caused the greatest casualties, accounting for 23.19% of such instances. Trucks and lorries followed closely, contributing to 22.18% of pedestrian casualties. According to specific statistics, two-wheelers were responsible for 115 pedestrian fatalities, and trucks and lorries were responsible for 110. In addition, 61 pedestrians were hurt and 83 pedestrians died in the Ranchi district in 2022 after being hit by cars. **Contributing Factors:** Over speeding, drunk driving, driver distraction, red light jumping, and disregard for safety precautions like seat belts and helmets are common behaviors that result in accidents. These figures highlight how urgently Jharkhand has to improve pedestrian safety measures and enforce traffic laws more strictly. the movement of bikers and motorized vehicles (private cars, buses, trucks, and power two vehicles) in each road section across the street for the same 15-minute period. Passenger Car Units (PCU) were used to determine the traffic flow based on the kind of vehicle (private vehicle = 1.00, bus = 3, truck = 3, power two vehicle = 0.5, bicycle = 1.5).

5. Result and Analysis

Table-1 Detail of Pedestrians walking

Particular/Location	Birsa Chowk	Sect.4	Chas
Pedestrians walking on the sidewalk	89.60%	91.50%	80.70%
Pedestrians walking in the street for a short/entire length	3.50%	2.40%	8.10%
Pedestrians crossing the street outside designated crosswalks	6.90%	6.10%	11.20%



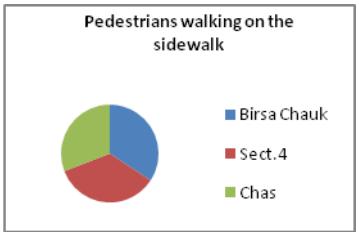


Figure 1. Pedestrian walking behavior

Table 2. Motorized traffic flow (road segments, duration 15min).

Street	Birsa Chauk	Sect.4	Chas	Birsa Chauk	Sect.4	Chas
Duration 15min	Mean value (Side A, B)			Passenger Car Units (Side A, B)		
Private vehicle	110.1	80.2	96.2	110.1	80.2	96.2
Bus	7.1	7.8	0	21.3	23.4	0
Truck	0.2	0.1	0.1	0.6	0.3	0.3
Power two vehicle	10.8	37.5	32	5.4	18.75	16
Bicycle	7	6.3	10.5	10.5	9.45	15.75
Traffic flow (PCU)				147.9	132.1	128.25

Table 3. Pedestrian flow for 30 minute duration

Location	Pedestrian flow (side A+B)
Birsa Chowk	122.4
Sect.4	98
Chas	112.2

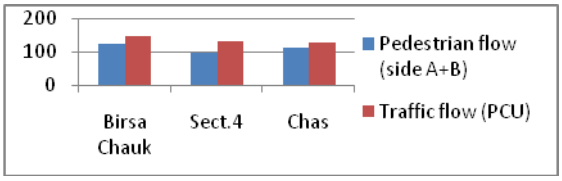


Figure 3. Pedestrian and motorized traffic flow (in PCU).

Conclusion: To enhance pedestrian safety on urban roads, several strategies can be implemented such as Infrastructure Improvement, Traffic Calming Measures, and Community Engagement etc. Additionally, pedestrian safety in urban settings can be improved by traffic calming techniques including speed bumps, reduced lanes, and improved enforcement of traffic regulations. In order to safeguard vulnerable road users and promote walking as a sustainable form of transportation, future urban design should place a high priority on developing pedestrian-friendly roads by including safety measures, lowering vehicle speeds, and encouraging effective traffic management. [5]

7. References:

[1] Bayes, A. (2012). Traffic Accident Study in Dhaka City (2007-2011). Implemented by "Clean Air and Sustainable Environment (case) Project, Dhaka South City Corporation and Dhaka North City Corporation.
[2] Shahrior Pervaz Accident Research Institute (ARI), "Pedestrian safety at intersections in dhaka metropolitan city".
[3] Athanasios Galanis at all(2016) "Pedestrian road safety in relation to urban road type and traffic flow" 3rd Conference on Sustainable Urban Mobility, 3rd CSUM 2016, 26 – 27 May 2016, Volos, Greece.
[4] Chattaraj, U. (2011). Understanding Pedestrian Motion: Experiments and Modelling. Ph.D. Thesis. IIT Kanpur, India.
[5] Navin, F.P.D. and Wheeler, R.J. (1969). Pedestrian Flow Characteristics. Traffic Engineering, 39 (9), pp. 30–36

Sustainable Solutions in Cybersecurity: A Technical Exploration

[1]Slok Kumar Goyal*
Student, Department of Computer Science and Engineering, GGSESTC, Bokaro
[2]A.P. Burnwal
Professor, Department of Basic Sciences & Humanities, GGSESTC, Bokaro
Email ID:apburnwal08@gmail.com
*Corresponding Author

Abstract
The evolving digital landscape necessitates robust and adaptive cybersecurity frameworks. Sustainable solutions in cybersecurity integrate energy-efficient protocols, adaptive security systems, equitable access, responsible data management, and cloud-based security solutions. A sustainable cybersecurity system ensures digital safety not only for the present but also for future generations. This paper investigates the application of sustainable cybersecurity practices, analyzing their technical implications and the benefits they provide across organizational levels. It also compares traditional systems with innovative cloud-based solutions, focusing on scalability, cost-efficiency, **and overall sustainability.**

Keywords: Sustainable, Cybersecurity, Cloud based solutions

Introduction
Sustainable solutions encompass strategies, practices, and innovations designed to meet present needs without jeopardizing the ability of future generations to fulfill their own. These solutions simultaneously address economic, environmental, and social challenges, promoting long-term viability over short-term gains. By balancing environmental protection, economic growth, and social equity, sustainability ensures the well-being of both people and the planet through responsible resource use, minimized environmental impact, and resilient, inclusive systems. In the digital age, this concept extends to cybersecurity, where sustainable practices focus on ensuring the long-term safety, integrity, and privacy of digital systems. As cyber threats become increasingly sophisticated and organizational dependence on digital infrastructure grows, traditional security measures often fall short in addressing resource efficiency, equitable access, and adaptability. Sustainable cybersecurity bridges this gap by integrating energy-efficient technologies, fostering resilience, and promoting global accessibility—all while reducing environmental impact and ensuring a secure digital future for generations to come.

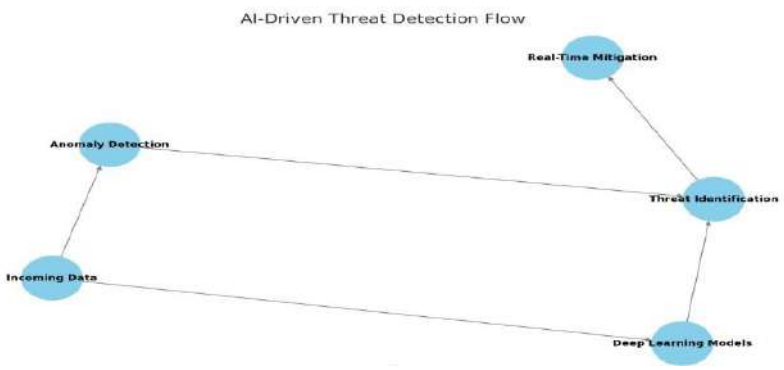
1. Applications of Sustainable Solutions in Different Areas
Sustainable solutions are applied across various sectors to promote environmental protection, economic growth, and social equity:

- **Energy:** Adoption of renewable energy sources such as solar, wind, and hydropower reduces reliance on fossil fuels and lowers carbon emissions.
- **Agriculture:** Practices like organic farming, crop rotation, and precision agriculture enhance food security while preserving soil health and biodiversity.
- **Industry:** Implementation of energy-efficient technologies and circular economy models minimizes waste and resource consumption.
- **Urban Development:** Green infrastructure, sustainable transportation, and smart city initiatives improve resource efficiency and reduce environmental impact.
- **Water Management:** Techniques such as rainwater harvesting and wastewater recycling ensure the sustainable use of water resources.

These applications contribute to long-term environmental stability, economic resilience, and social well-being.

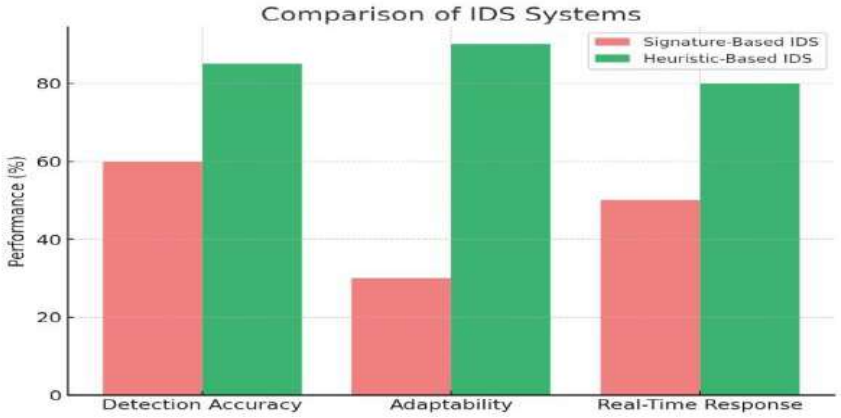
2. Adaptive Security Systems
Adaptive security systems are designed to dynamically adjust to new and evolving threats, enabling organizations to maintain continuous protection. These systems leverage advanced technologies like artificial intelligence (AI), machine learning (ML), and automation to proactively address vulnerabilities and respond to cyberattacks in real time.

2.1 AI-Driven Threat Detection
AI-driven threat detection utilizes machine learning algorithms to identify and mitigate sophisticated cyber threats. Techniques such as anomaly detection allow systems to recognize deviations from normal behaviour patterns, which may indicate a security breach. Deep learning models, trained on large datasets of known attack vectors, enhance this capability by detecting complex attack patterns, including zero-day exploits and advanced persistent threats (APTs). This approach ensures that even previously unknown threats can be identified and neutralized in real time, significantly reducing the window of exposure.



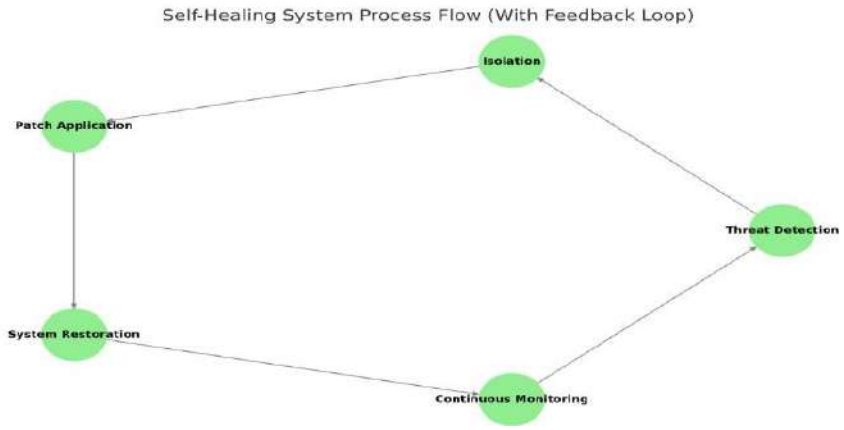
2.2 Intrusion Detection Systems (IDS)

Intrusion Detection Systems (IDS) monitor network traffic for malicious activities and policy violations. Adaptive, heuristic-based IDS solutions like Snort and Suricata go beyond traditional signature-based detection by using behavioral analysis to identify new or modified threats. These systems update their detection rules dynamically, allowing real-time protection against emerging cyberattacks. They can detect unusual patterns, such as unexpected data transfers or unauthorized access attempts, and trigger alerts or automated countermeasures to contain potential breaches.



2.3 Self-Healing Systems

Self-healing systems are automated cybersecurity frameworks capable of responding proactively to security breaches without human intervention. When an intrusion is detected, these systems isolate the affected components, apply necessary patches, and restore operations autonomously. For example, if malware is detected on a specific endpoint, the self-healing system can quarantine the device, remove the malicious code, and re-establish normal functions. This minimizes downtime and reduces the risk of damage spreading across the network, ensuring business continuity and operational resilience.



3. Sustainable Data Management

3.1 Data Minimization Principles

Reducing unnecessary data collection lowers storage requirements and reduces potential vulnerabilities.

3.2 Secure Data Deletion

Cryptographic erasure and secure overwriting techniques ensure irrecoverable data deletion, minimizing long-term storage costs.

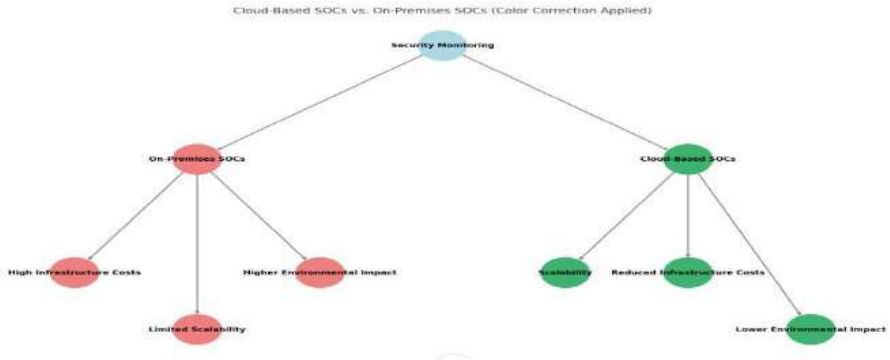
3.3 Efficient Data Encryption

Encryption modes like Galois/Counter Mode (GCM) enhance processing speed and minimize energy consumption through parallel encryption operations.

4. Cloud-Based Security Solutions

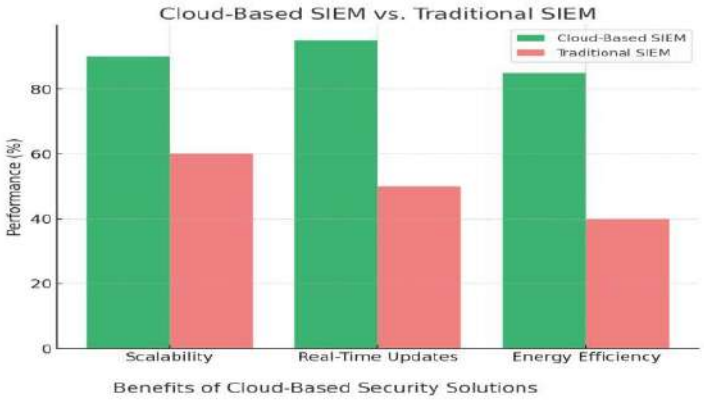
4.1 Cloud-Based Security Monitoring vs. On-Premises SOCs

Cloud-based Security Operations Centers (SOCs) provide scalable, real-time monitoring with reduced infrastructure costs, offering enhanced flexibility over traditional on-premises SOCs. Additionally, they reduce the need for manufacturing, shipping, and maintaining physical servers, contributing to environmental sustainability.



4.2 Cloud-Based SIEM vs. Traditional On-Premises SIEM

Cloud-hosted Security Information and Event Management (SIEM) systems offer flexible deployment, real-time updates, and AI-powered analytics, outperforming traditional on-premises systems in scalability and energy efficiency. They also reduce the need for physical infrastructure maintenance.



4.3 Cloud-Based Firewalls vs. Physical Firewalls

Cloud-based firewalls offer scalable, remotely managed security controls that reduce hardware-related maintenance costs and energy usage while eliminating the need for physical firewall devices.

4.4 Multi-Factor Authentication (MFA) vs. USB Security Tokens

MFA solutions, incorporating biometrics and app-based verification, provide more scalable and accessible protection than physical USB tokens.

4.5 Benefits of Cloud-Based Security

- **Scalability:** Adapts dynamically to organizational growth.
- **Cost Efficiency:** Reduces capital expenditures on physical infrastructure.
- **Accessibility:** Enables global remote monitoring.
- **Resource Optimization:** Decreases energy consumption by minimizing reliance on on-premises data centers.
- **Reduced Environmental Impact:** Less need for manufacturing, shipping, and maintaining servers, contributing to overall sustainability.

5. Types of Cloud computing models

Public Cloud

A **public cloud** is a cloud computing model where services such as storage, computing power, and applications are provided by third-party vendors over the internet and shared among multiple users (tenants). It offers scalability, cost-efficiency, and ease of access, as users pay only for the resources they use. Public clouds are suitable for businesses seeking flexibility and lower infrastructure costs. Popular examples include **Amazon Web Services (AWS)**, **Microsoft Azure**, and **Google Cloud Platform (GCP)**.

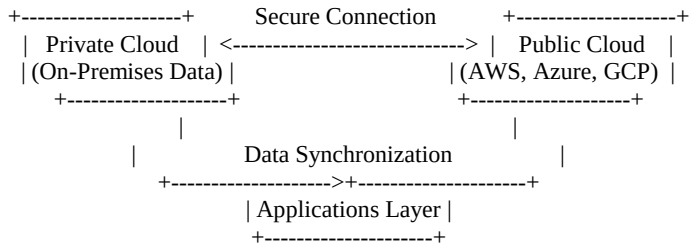
Private Cloud

A **private cloud** is a dedicated cloud computing environment designed exclusively for a single organization. It offers enhanced security, control, and customization, making it ideal for businesses with strict data privacy and compliance requirements. Private clouds can be hosted on-premises or managed by third-party providers. Although they involve higher setup costs, they provide greater flexibility, scalability, and performance for sensitive workloads.

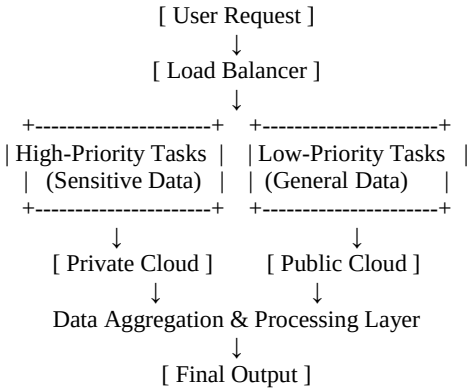
Hybrid Cloud

A **hybrid cloud** combines both **private** and **public cloud** environments, allowing data and applications to move between them seamlessly. This model offers the flexibility and cost-efficiency of public clouds while maintaining the security and control of private clouds. It is ideal for businesses that need to balance sensitive data handling with scalable computing resources for less critical tasks.

Hybrid Cloud Architecture



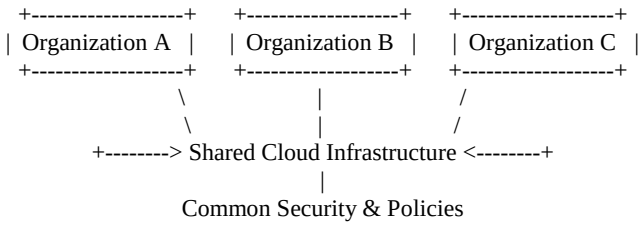
Hybrid Cloud Data Workflow



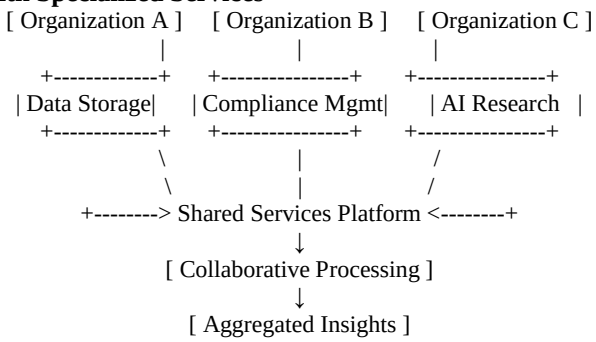
Community Cloud

A **community cloud** is a shared cloud infrastructure designed for a specific group of organizations with common goals, security requirements, or compliance needs. It offers the benefits of a private cloud but is jointly managed and used by multiple organizations, often from the same industry or sector. This model enhances collaboration while reducing costs through shared resources.

Community Cloud Architecture



Community Cloud Workflow with Specialized Services



6. Conclusion

Sustainable cybersecurity solutions prioritize long-term resilience, equity, and energy efficiency. By incorporating adaptive protocols, promoting equitable access, and leveraging scalable cloud technologies, organizations can ensure robust and cost-effective cybersecurity infrastructures. Future research should focus on enhancing AI-driven defenses, fostering global cybersecurity collaboration, and integrating advanced cloud-based protection systems for sustainability. In the present scenario, a sustainable step for cybersecurity requires a balance among current technological advancements, regulatory frameworks, as well as ethical considerations.

7. References

[1] Biryukov, A., et al. (2007). "PRESENT: An Ultra-Lightweight Block Cipher." CHES 2007.
[2] National Institute of Standards and Technology (NIST). (2020). "Guidelines for Lightweight Cryptography."
[3] MITRE ATT&CK Framework. (2024). https://attack.mitre.org/
[4] Cloud Security Alliance. (2023). "The Benefits of Cloud Security Solutions."
[5] Ranjithkumar S and M. Mohankumar (2023)"Security Information and Event Management (SIEM) Performance in On-Premises and Cloud-Based SIEM.

[6] M. A. P. Chamikara et al. (2023)"Comparative Analysis of On-Premises and Cloud Hosting Solutions".
[7] S. K. Dash et al. (2023)"On-Premises versus Cloud Computing: A Comparative Analysis of Energy Consumption"
[8] Smith, J., & Kumar, R. (2021). Hybrid Cloud: A New Paradigm in Cloud Computing. Journal of Cloud Computing Research, 12(3), 213-230.
[9] Patel, A., & Thompson, L. (2020). A Hybrid Cloud Architecture for Social Science Research Computing. International Journal of Advanced Computer Science, 18(4), 455-472.
[10] Johnson, M., & Singh, P. (2019). Hybrid Cloud Computing: Security Aspects and Challenges. Cloud Security Journal, 5(2), 112-129.
[11] Gupta, R., & Zhao, Y. (2020). Community Cloud Architecture to Improve Use Accessibility. International Journal of Collaborative Computing, 9(1), 35-50.
[12] Ahmed, S., & Walker, T. (2018). Community Cloud: Concept, Model, Attacks, and Solution. Journal of Network Security, 7(4), 221-239.
[13] Li, X., & Martin, J. (2022). Descriptive Literature Review and Classification of Community Cloud Computing Research. Wiley Journal of Cloud Systems, 15(6), 678-694.
[14] Prajwal K, Sumaiya M.N. (2023) "An overview of cloud computing and cloud cryptography" J.C.S.P.I.C, Vol. 02, Issue-01, PP. 20-25.
[15] Bhargav A.J.S. and Manhar A. (2020) "A review on cryptography in cloud computing" IJSRCSEIT, 6(6), PP. 225-230.
[16] Yash Tembhare et al. (2023)"Cloud computing security issues and threats"Vol. 2, Issue 2, PP. 1-9.
[17] Arun Prasad Bunnwal et al. (2024) "Sustainable solutions in cybersecurity and mining activities" IJAAR, Vol. 5, No. 39, PP. 51-52.
[18] Scarfone, K., & Mell, P. (2007). Guide to Intrusion Detection and Prevention Systems (IDPS). National Institute of Standards and Technology (NIST). https://doi.org/10.6028/NIST.SP.800-94
[19] Gartner. (2023). SIEM Market Guide: Cloud vs. On-Premises Performance.
[20] National Institute of Standards and Technology (NIST). (2020). Guidelines for Cloud-Based Security Implementations.

Smart Home Energy Management System: Future of Energy Efficiency

Anshu Mishra[1], Ashna Kashyap[1], Sapan Kumar Dutta[1#] and Deepak Kumar[1*]

[1]Guru Gobind Singh Educational Society's Technical Campus, Bokaro, Jharkhand-827013

Prof. Sapan Kumar Dutta
Assistant Professor,
Department of Mechanical Engineering
GGSESTC, Kandra, Bokaro, Jharkhand-827013

***Corresponding Author**
Dr. Deepak Kumar
Associate Professor
Department of Basic Science and Humanities
GGSESTC, Kandra, Bokaro, Jharkhand-827013
Email: j.m.krdeepak@gmail.com

Abstract:

A Smart Home Energy Management System (SHEMS) is like a smart helper for your house that makes sure you use electricity wisely. It connects to things like lights, fans, air conditioners, and other devices to turn them on or off at the right time. SHEMS helps save money by using less electricity when it's not needed. It also protects the environment by reducing waste. Some SHEMS can even learn your habits, like when you wake up or go to bed, and adjust things automatically to keep your home comfortable. By using SHEMS, people can have smarter, greener, and more efficient homes, making life easier and better for the planet.

Introduction

Smart Home Energy Management System (SHEMS) have emerged as a promising solution to address the growing challenges of energy consumption in residential buildings. Thanks to rapid advances in Internet of Things (IOT) Technology. Smart homes can how use connected devices, sensors and data analysis to optimize energy consumption, increase energy efficiency and promote sustainable living.

Background

Residential buildings contribute significantly to overall energy consumption and carbon emission, Traditional homes often lack efficient energy management mechanisms, leading to unnecessary energy waste, increased utility bills and a larger ecological footprint. The scenario requires innovation approaches to monitor, control and optimize energy consumption in households.

Motivation:

The motivation for Smart Home Management Systems comes from the urgent need to reduce energy consumption increases energy efficiency and mitigate the environmental impacts associated with residential buildings. By integrating IOT technology, Smart Homes can use real-time data automation and intelligent data, automation and intelligent decision -making to achieve these goals. Smart Homes Energy Management Systems allows homeowners to track energy usage. Identify energy – intensive devices, and monitor consumption patterns. With the access to this information users can make informed decisions about their energy use, identify areas for improvement and take energy -saving measure. In addition, these systems allow for the integration of renewable energy sources such as solar panels to further reduce dependence on conventional energy grids. By automating energy- related processes, such as adjusting thermostat settings or controlling lighting, residents can enjoy a personalized and comfortable environment without compromising energy conservation efforts. In this article, we aim to explore the architecture, key components, features and benefits of smart home energy management system. We will also present a case study that demonstrates the effectiveness of such systems in a residential setting. In this way, we hope to contribute to the development of energy – efficient technologies for smart homes and encourage the adoption of sustainable particles in the residential sector.

What is a Smart Home Energy Management System (SHEMS)?

THE ENERGY STAR Smart Home Energy Management Systems (SHEMS) program recognizes smart home systems that help you simplify, reduce and manage your energy consumption. An ENERGY STAR SHEMS package requires at minimum, an ENERGY STAR certified smart thermostat, lighting and monitor / control plug loads. However, other products and services, such as ENERGY STAR appliances, EV charges, and smart security can be added. Beyond the minimum devices. the package can be definitely customizable to fit your lifestyle.

Through SHEMS energy consumption is simplified by:

- Facilitating a schedule for your smart devices to operate.

- ❖ Suggesting energy saving actions based on usage patterns.
- ❖ Automatically controlling smart home devices based on room or home occupancy.

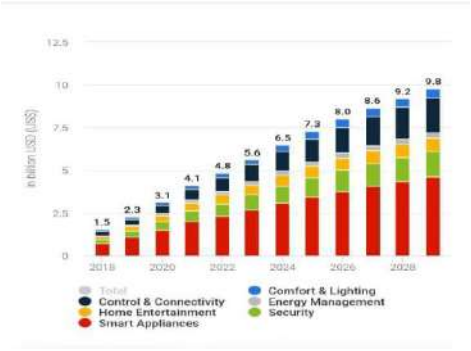


Fig 1: Graph Showing the year wise increase in the smart appliances (Aliero et al 2021)

Components of Shems:

1.Smart Energy Monitoring: Enhancing Efficiency and Sustainability.

Smart Energy Monitoring is a modern approach to managing electricity consumption using advanced digital tools like smart meters, IoT sensors, and real time analytics. This system provide detailed insights into energy usage, allowing users to track and optimize their consumption efficiently. By identifying patterns and inefficiencies, individuals and businesses can take proactive measures to reduce energy waste and lower costs.

One of the biggest advantages of smart energy monitoring is its contribution to sustainability. By minimizing unnecessary energy usage, these systems help reduce carbon footprints and promote eco-friendly practices. Additionally, many smart monitoring solutions offer remote accessibility through mobile apps, enabling users to control their energy consumption from anywhere. As technology continues to evolve, smart energy monitoring is expected to integrate with artificial intelligence and automation, making energy management even more efficient and seamless in the future.

Smart Thermostats: Revolutionizing Home Climate Control

Smart thermostats are advanced devices that help homeowners manage their heating and cooling systems efficiently. Unlike traditional thermostats, these smart devices use sensors, Wi-Fi connectivity, and learning algorithms to automatically adjust temperatures based on user preferences and habits. With real-time monitoring and remote access through smartphone apps, users can optimize their energy consumption, leading to lower utility bills and a more comfortable living environment.

One of the key benefits of smart thermostats is their ability to enhance energy efficiency. By learning a household's routine and adjusting temperatures accordingly, they prevent unnecessary energy usage. Some models even integrate with smart home systems, allowing voice control and compatibility with other devices. As energy conservation becomes a priority worldwide, smart thermostats are playing a crucial role in reducing carbon footprints and promoting sustainable living.

Smart Plugs and Switches: Enhancing Convenience and Energy Efficiency

Smart plugs and switches are innovative devices that transform ordinary electrical outlets and switches into smart, automated systems. These devices allow users to control their appliances remotely using smartphone apps or voice assistants like Alexa and Google Assistant. With features like scheduling, automation, and real-time energy monitoring, smart plugs and switches help improve convenience and reduce unnecessary energy consumption.

One of the biggest advantages of these smart devices is their ability to enhance energy efficiency. Users can set schedules to turn off appliances when not in use, preventing energy waste and lowering electricity bills. Additionally, many smart plugs provide insights into energy usage, allowing homeowners to track and optimize their power consumption. As smart home technology continues to advance, smart plugs and switches are becoming essential tools for creating more energy-efficient and automated living spaces.

Benefits of Shems:

Cost Savings on Electricity Bill:

A Smart Home Energy Management System (SHEMS) helps reduce electricity bills by optimizing energy consumption. It automates the operation of appliances, ensuring they run during off-peak hours when electricity rates are lower. Smart thermostats adjust heating and cooling based on occupancy, preventing unnecessary energy use. Additionally, SHEMS prevents "phantom loads" by cutting power to idle devices, reducing waste. By integrating with solar panels and battery storage, it maximizes self-generated energy use, minimizing reliance on expensive grid power. Another major cost-saving feature of SHEMS is demand response participation, where the system adjusts power usage based on electricity price fluctuations, allowing homeowners to benefit from lower rates and potential utility

incentives. Real-time monitoring provides insights into energy consumption, helping users make informed decisions. AI-driven automation learns household habits and continuously optimizes energy use. These features collectively lead to significant savings, with households potentially reducing electricity bills by 10% to 30% annually.

Convenience and Smart Automation:

A Smart Home Energy Management System (SHEMS) enhances convenience by automating household energy use, reducing the need for manual adjustments. Smart thermostats learn user preferences and adjust heating or cooling automatically, maintaining comfort while minimizing energy waste. Lighting systems can be programmed to turn on or off based on occupancy, ensuring efficiency without user intervention. Additionally, smart plugs and outlets allow remote control of appliances, making it easy to manage devices from anywhere via a smartphone app.

Advanced AI-driven automation takes convenience further by analyzing energy usage patterns and optimizing settings without user input. For example, SHEMS can schedule high-energy appliances like washing machines or water heaters to run during off-peak hours for cost savings. Voice control integration with assistants like Alexa or Google Home allows effortless adjustments with simple commands. By seamlessly managing energy consumption while enhancing comfort, SHEMS provides a smarter, more convenient living experience.

Environmental Sustainability:

A Smart Home Energy Management System (SHEMS) promotes environmental sustainability by reducing overall energy consumption and encouraging the use of renewable energy. By optimizing energy use, SHEMS lowers electricity demand, decreasing reliance on fossil fuel-based power plants and reducing greenhouse gas emissions. Smart thermostats, automated lighting, and intelligent scheduling of appliances help eliminate energy waste, ensuring that only the necessary amount of electricity is used. Additionally, SHEMS integrates with solar panels and battery storage, maximizing the use of clean energy and further cutting down the carbon footprint of a household. By participating in demand response programs, SHEMS helps stabilize the power grid, reducing the need for additional energy production from non-renewable sources. This not only benefits the environment but also supports a more sustainable and resilient energy infrastructure for the future.

Increased Home Value:

A Smart Home Energy Management System (SHEMS) can significantly increase a home's value by enhancing energy efficiency, convenience, and sustainability. Homes equipped with smart energy systems are more attractive to buyers, as they offer lower utility costs, modern automation, and better control over energy consumption. Features like smart thermostats, automated lighting, and integrated renewable energy solutions appeal to eco-conscious and tech-savvy buyers, making the property more desirable in the real estate market. Additionally, homes with energy-efficient certifications or smart energy management systems often command higher resale prices. As the demand for sustainable and smart homes continues to grow, properties with SHEMS are likely to see increased marketability and a faster selling process, providing homeowners with both financial and lifestyle benefits.

Improved Grid Reliability:

A Smart Home Energy Management System (SHEMS) contributes to improved grid reliability by optimizing energy consumption and reducing peak demand stress. By intelligently managing when and how electricity is used, SHEMS helps prevent sudden surges in demand that can lead to power outages or grid instability. Features like smart scheduling, demand response participation, and load balancing allow homes to use energy more efficiently, reducing strain on the power grid, especially during high-demand periods. Additionally, SHEMS integrates with renewable energy sources and battery storage, allowing homes to generate and store their own power. This reduces dependence on the grid during peak times, stabilizing overall energy distribution. As more households adopt smart energy solutions, the grid becomes more resilient, ensuring a more reliable and sustainable energy infrastructure for the future.

Challenges And Future of Shems:

Challenges

Initial Cost:

The initial cost of a Smart Home Energy Management System (SHEMS) varies based on several factors, including system complexity, brand, and installation requirements. Here’s a general breakdown:

1. Basic SHEMS (DIY setups, smart plugs, and thermostats): $100 – $500
2. Mid-range SHEMS (integrated systems with energy monitoring, automation, and control features): $500 – $2,000
3. Advanced SHEMS (full home automation, AI-driven energy optimization, solar + battery integration): $2,000 – $10,000+

Additional costs may include installation fees, software subscriptions, and smart device upgrades. Let me know if you're looking for specific SHEMS brands or cost details!

Compatibility Issues:

Compatibility issues with Smart Home Energy Management Systems (SHEMS) often arise due to differences in communication protocols, device limitations, and software restrictions. Many SHEMS rely on Wi-Fi, Zigbee, Z-Wave, or Bluetooth, but not all smart devices support the same protocol, leading to connectivity problems. Some systems require a central hub, while others work independently, making integration challenging. Additionally, certain brands, like Apple HomeKit or Google Nest, may have closed ecosystems, restricting compatibility with third-party devices. Older appliances and energy meters may also lack the necessary technology to connect with SHEMS, limiting their functionality.Software-related issues can further complicate SHEMS integration, as some platforms have proprietary APIs that prevent smooth data exchange between different systems. Frequent firmware or app updates may temporarily disrupt compatibility, requiring manual adjustments. Energy meter integration can also be problematic since some utility providers limit access to real-time consumption data. Moreover, cloud-dependent SHEMS may become unusable during internet outages, and privacy concerns over data sharing may prevent systems from accessing essential energy usage insights. To minimize these issues, users should choose SHEMS that support multiple protocols, offer open-source compatibility, and integrate with major smart home platforms like Alexa, Google Home, or Matter.

Privacy concerns:

Data privacy concerns with Smart Home Energy Management Systems (SHEMS) stem from the collection, storage, and sharing of personal energy usage data. Many SHEMS rely on cloud-based platforms, which can expose users to risks such as unauthorized access, data breaches, or third-party sharing without consent. Some systems continuously monitor household activities, raising concerns about surveillance and profiling by service providers or hackers. Additionally, unclear privacy policies may allow companies to sell or share data with advertisers or utility companies. To protect privacy, users should choose SHEMS with strong encryption, local data processing options, and transparent privacy policies, while also regularly updating firmware and using secure network settings.

Future Trends:

AI and IoT Advancements:

AI and IoT advancements have enhanced Smart Home Energy Management Systems (SHEMS) by enabling real-time monitoring, automation, and energy optimization. AI analyzes usage patterns, while IoT devices communicate via Wi-Fi, Zigbee, and Z-Wave. Smart grids, edge computing, and anomaly detection improve efficiency, reduce costs, and enhance privacy, making SHEMS essential for sustainable energy management in modern homes.

Integration with smart grids:

AI and IoT advancements have enhanced Smart Home Energy Management Systems (SHEMS) by enabling real-time monitoring, automation, and energy optimization. AI analyzes usage patterns, while IoT devices communicate via Wi-Fi, Zigbee, and Z-Wave. Smart grids, edge computing, and anomaly detection improve efficiency, reduce costs, and enhance privacy, making SHEMS essential for sustainable energy management in modern homes.

Conclusions:

A smart home management system makes our homes more comfortable, safe, and energy-efficient. It allows us to control things like lights, fans, air conditioners, and security cameras using our phones or voice commands. This system helps save time and energy by doing tasks automatically, like turning off lights when no one is in the room or locking doors. With smart technology, our homes become smarter and make life easier for everyone!

References:

[1] Aliero, M. S., Qureshi, K. N., Pasha, M. F., & Jeon, G. (2021).Smart home energy management systems in internet ofthings networks for green cities demands and services.Environmental Technology & Innovation, 22, 101443.https://doi.org/10.1016/j.eti.2021.101443

[2] Alimi, O., & Ouahada, K. (2018). Smart home appliancesscheduling to manage energy usage. In 2018 IEEE 7thInternational Conference on Adaptive Science &Technology (ICAST) (pp. 1–5). IEEE.

[3] Asare-Bediako, B., Kling, W. L., & Ribeiro, P. F. (2013).Integrated agent based home energy management sys-tem for smart grids applications. In IEEE PES ISGT Europe2013 (pp. 1–5). IEEE.

[4] Chen, S. J., Chiu, W. Y., & Liu, W. J. (2021). User preference-based demand response for smart home energy man-agement using multiobjective reinforcement learning.IEEE Access, 9, 161627–161637. https://doi.org/10.1109/ACCESS.2021.3132962

[5] Fioretto, F., Yeoh, W., & Pontelli, E. (2017). A multiagent sys-tem approach to scheduling devices in smart homes. InProceedings of the 16th Conference on Autonomous Agentsand MultiAgent Systems (pp. 981–989). I

[6] InternationalFoundation for Autonomous Agents and MultiagentSystems.Fiorini, L., & Aiello, M. (2022). Automatic optimal multi-energy management of smart homes. EnergyInformatics, 5(1), 1–20. https://doi.org/10.1186/s42162-022-00253-0Hartono,

[7] B. S., Mursid, S. P., & Prajogo, S. (2018). Homeenergy management system in a Smart Grid scheme toimprove reliability of power systems. IOP ConferenceSeries: Earth and Environmental Science, 105, 012081.https://doi.org/10.1088/1755-1315/105/1/012081

[8] Hosseinian, H., & Damghani, H. (2019, February). Smarthome energy management, using IoT system. In 20195th Conference on Knowledge Based Engineering andInnovation (KBEI) (pp. 905–910). IEEE. https://doi.org/10.1109/KBEI.2019.8734979Lin,
[9] Y.-H. (2018). Design and implementation of an IoT-oriented energy management system based on non-14 K. G ET AL.intrusive and self-organizing neuro-fuzzy classification asan electrical energy audit in smart homes. AppliedSciences, 8(12), 2337. https://doi.org/10.3390/app8122337Lin,
[10] Y. H., Tang, H. S., Shen, T. Y., & Hsia, C. H. (2022). Asmart home energy management system utilizing neu-rocomputing-based time-series load modeling and fore-casting facilitated by energy decomposition for smarthome automation. IEEE Access, 10, 116747–116765.https://doi.org/10.1109/ACCESS.2022.3219068
[11] Ma, Y., Chen, X., Wang, L., & Yang, J. (2021). Study onsmart home energy management system based on arti-ficial intelligence. Journal of Sensors, 2021(1), 1–9.https://doi.org/10.1155/2021/9101453Mathur,
[12] P. (2020). Using machine learning and the IoT intelecom, energy, and agriculture. In IoT MachineLearning Applications in Telecom, Energy, and Agriculture.Apress.Metering, A. S., Visalatchi, S., & Sandeep, K. K. (2017).
[13] Smart energy metering and power theft control usingarduino & GSM. In 2017 2nd International Conference forConvergence in Technology (I2CT) (858–961). IEEE

Green Computing: A Review on its Past; Present and Future Research

Snehal Mondal[1], Shristi Gupta[1], Rohi Prasad[1#] and Deepak Kumar[1*]

[1]Guru Gobind Singh Educational Society's Technical Campus, Bokaro, Jharkhand-827013

Prof. Rohi Prasad
Assistant Professor,
Department of Mechanical Engineering
GGSESTC, Kandra, Bokaro, Jharkhand-827013

***Corresponding Author**
Dr. Deepak Kumar
Associate Professor
Department of Basic Science and Humanities
GGSESTC, Kandra, Bokaro, Jharkhand-827013
Email: j.m.krdeepak@gmail.com

Abstract:

Artificial Intelligence (AI) has made significant strides over the past few decades, with applications in areas like computer vision, natural language processing, and speech synthesis. The rise of deep learning, particularly Large Language Models (LLMs), has driven a focus on achieving state-of-the-art results, leading to larger models and greater computational demands. However, this need for high computing power results in higher carbon footprint and limits access for smaller institutions and companies with fewer resources. To address these challenges, Green Computing has become a key research focus. Through a comprehensive review of recent literature, case studies, and industry reports published between 2009 and 2024, the study explores the core principles of green computing, tracing its evolution and highlighting key advancements in the field. The main objective of this article is to analyze the design, manufacture, and usage of computer systems to reduce energy consumption, enhance resource efficiency, and support environmental sustainability and thus promoting the technologies and practices that contribute to energy efficiency, waste reduction.Furthermore, it discusses how green computing can not only improve our daily lives by reducing operational costs and energy demands but also plays a critical role in mitigating the adverse effects of electronic waste and global warming. Ultimately, it concludes by highlighting the necessity of integration of green computing practices for building a sustainable future, enhancing both the performance of technology and its environmental benefits.

Introduction:

As technology continues to advance at an unprecedented pace, the environmental implications of computing have become a critical area of study. The rapid expansion of data centers, widespread use of personal electronic devices, and the ever-growing need for computational power have resulted in significant energy consumption and escalating levels of electronic waste. According to the International Energy Agency (IEA), data centers alone account for nearly 1% of global electricity demand, with this number expected to rise in the coming years. Green computing, also referred to as sustainable computing, seeks to mitigate these environmental challenges through the implementation of energy-efficient technologies and eco-friendly practices in hardware design, software development, and IT operations. This discipline encompasses various strategies, including power management, virtualization, cloud computing, and responsible e-waste disposal. By integrating green computing principles into technological development, businesses, educational institutions, and individuals can contribute to reducing the overall carbon footprint of information technology (IT) while maintaining optimal efficiency and performance. Educating future generations about the importance of sustainable computing is vital for fostering an environmentally responsible digital ecosystem. As the demand for IT infrastructure grows, so does the need for innovative solutions that balance technological progress with ecological stewardship. By embracing green computing, we can work towards a more sustainable and energy-conscious future.

Measures of Green Computing:

Key factors:

Model size, parameter tuning, and training data are key factors influencing the computational resources required for AI model training and inference. Larger models, with more parameters, demand more resources and energy, leading to higher carbon emissions. Smaller models, in contrast, have a lesser environmental impact. Parameter tuning, a process involving various experiments to optimize model performance, is also resource-intensive. For instance, in Facebook's ML research cluster, half of training experiments require up to 1.5 GPU days, while nearly all complete within 24 GPU days [1]. Finally, the scale and quality of training data play a significant role; large or low-quality datasets can increase storage needs, computation time, and energy consumption. Thus, selecting optimal datasets and refining data processing can help reduce a model's environmental footprint.

Measurements:

The ways to measure “greenness” in computing as follows: Running time, model size, FPO/FLOPS, hardware power consumption, energy consumption, and carbon emissions are all key factors in evaluating the environmental impact of AI. Running time refers to the total time taken for model training and inference, easily measured by adding a timer to the program. However, comparing running times across different infrastructures is challenging, and using running time alone to assess "greenness" lacks accuracy. Model size, particularly the number of parameters, significantly affects energy consumption but doesn't account for other factors like data volume or the number of training iterations. While it provides some insight into a model's environmental footprint, it doesn't fully reflect the overall impact. Floating Point Operations (FLOPS) measure the number of operations needed to run a model, providing a hardware and software-agnostic metric for computational efficiency. FLOPS allow fair comparisons between models but don't reflect the actual runtime due to varying degrees of parallelism across different algorithms. Hardware power consumption is another concern, but it is often higher than the actual energy consumed by the model, as it also includes overheads. Energy consumption refers to the total energy used by the facility [2], which is calculated as: $e_{total}=PUE\times e_{hardware}$ where PUE (Power Usage Effectiveness) represents additional energy used for purposes like cooling. The global average PUE ratio is reported as 1.59[3], but it varies significantly across companies. For example, Google reports a PUE ratio of 1.11[4], while Amazon (AWS) and Aliyun report 1.2[5] and 1.3[6], respectively. Finally, carbon emissions (CE) provide the most direct assessment of environmental impact, typically estimated using the formula: $CE=CI\times e_{total}$ where CI (carbon intensity) represents the amount of carbon emitted per kilowatt-hour of energy consumed, varying across regions based on the energy sources used for power generation.

Strategies of Implementing Green Computing:

Implementing green computing requires a multi-faceted approach that addresses various aspects of technology use and infrastructure. The following strategies provide actionable methods for reducing the environmental impact of IT systems:

1. Energy-Efficient Hardware: Adopting hardware components designed for low power consumption is fundamental to green computing. Modern processors, solid-state drives (SSDs), and energy-efficient monitors contribute to reduced energy usage. According to a report by the U.S. Department of Energy, energy-efficient servers can reduce power consumption by up to 30%. The NCAR-Wyoming Supercomputing Center utilizes energy-efficient designs, making it 89% more efficient than typical data centers.

2. Virtualization and Cloud Computing: Implementing virtualization technologies allows multiple virtual machines to operate on a single physical server, optimizing resource utilization and decreasing the number of physical servers required. A study by the International Data Corporation (IDC) found that virtualization can reduce IT energy costs by up to 50%. Cloud computing further enhances this by providing scalable resources on demand, reducing the need for extensive on-premises infrastructure. This approach not only conserves energy but also minimizes physical space requirements.

3. Sustainable Software Development: Developing software with a focus on energy efficiency can lead to significant reductions in power consumption. Efficient coding practices, optimized algorithms, and minimizing resource-intensive processes contribute to lower energy usage. Research by the Software Improvement Group suggests that optimizing code can reduce CPU energy consumption by 20-50%, making software sustainability a crucial component of green computing.

4. Green Data Centers: Designing data centers with sustainability in mind involves utilizing renewable energy sources, implementing advanced cooling techniques, and optimizing power distribution. According to the IEA, the use of advanced cooling technologies can lower energy consumption in data centers by up to 40%. The NCAR-Wyoming Supercomputing Center, for example, uses Wyoming’s cool climate for natural cooling and integrates local wind energy, achieving a facility that is 89% more efficient than typical data centers.

5. E-Waste Management: Proper disposal and recycling of electronic waste are crucial components of green computing. Establishing programs for refurbishing and recycling outdated equipment helps reduce the environmental impact of discarded electronics. According to the Global E-Waste Monitor, around 53.6 million metric tons of electronic waste were generated in 2019, with only 17.4% properly recycled. Companies like ASML have implemented refurbishment centers to maintain high reuse rates, significantly cutting down on e-waste.

Key drivers and enablers of Green Computing:

Recent literature highlights several key drivers and enablers of green computing. The first is the growing awareness of digital technologies' environmental impact. With the ICT sector responsible for an estimated 3.7% of global greenhouse gas emissions in 2020 [7], businesses, governments, and individuals are aligning digital transformation with sustainability goals. This awareness is fueled by scientific evidence, media coverage, and grassroots activism. Regulatory pressures also play a crucial role [7]. Governments worldwide have introduced policies to curb energy consumption and environmental harm. For instance, the EU’s Eco-design Directive mandates energy efficiency standards, while the WEEE Directive enforces e-waste recycling [8]. Such regulations drive businesses toward sustainable practices and technological innovation. Economic factors further incentivize green computing [7]. As data centers and digital infrastructure consume more electricity, businesses seek ways to cut costs. Techniques like server virtualization, dynamic power management, and renewable energy integration lower both energy use and operational expenses while enhancing environmental

performance. Technological advancements also enable green computing [9]. Energy-efficient hardware, such as low-power processors and solid-state drives, reduces power consumption. Software optimization—through algorithmic efficiency and green coding—minimizes computational overhead. Innovations in data center design, like liquid cooling and renewable energy adoption, further improve sustainability. Lastly, corporate social responsibility and sustainable investing are creating market incentives for green computing [10]. Consumers and investors increasingly prioritize sustainability, pushing companies to adopt eco-friendly initiatives like renewable energy procurement, e-waste recycling, and carbon footprint reporting to gain a competitive edge.

Advancements in Energy-Efficient Computing

Energy-efficient hardware and software are central to green computing. Low-power processors, such as Intel's Core i9 12900HK and ARM's big.LITTLE architecture, optimize power consumption by dynamically switching between high-performance and energy-efficient cores [12][11]. The transition from HDDs to SSDs has also reduced power usage while enhancing speed and efficiency [11]. Software optimization is equally critical. Algorithmic efficiency minimizes computational complexity, reducing energy demands [9]. Green coding practices, such as optimized memory use and reduced redundant computations, further decrease software energy footprints [13]. System-level power management techniques like dynamic voltage and frequency scaling (DVFS) adjust processor speed based on workload, leading to significant power savings [11]. Power gating selectively disables unused components, reducing static power consumption [9]. Energy-efficient frameworks, such as the Green Computing Framework (GCF) and PowerAPI, help developers optimize energy usage [14][9]. Looking ahead, AI and ML will enhance energy-efficient computing by predicting energy consumption patterns and optimizing power management dynamically [11][14]. These technologies will further drive sustainable computing practices.

Sustainable IT Through Data Centers and Cloud Computing

Data centers and cloud computing are essential to modern digital infrastructure but also contribute significantly to global energy consumption, accounting for 1% of electricity use and 0.3% of carbon emissions [15]. Improving their energy efficiency is a major focus of green computing. Server virtualization and consolidation reduce energy consumption by running multiple virtual machines on a single server, optimizing resource use [9]. Dynamic workload balancing further enhances efficiency [14]. Renewable energy adoption has also grown, with companies like Google achieving 100% renewable energy usage since 2017 [16]. Cloud providers such as AWS and Microsoft Azure are setting ambitious carbon neutrality targets. Innovative data center designs, including liquid cooling, free air cooling, and waste heat recovery, further improve efficiency [9][14]. Cloud computing enhances sustainability by centralizing resources, optimizing utilization, and reducing overall energy waste compared to traditional IT setups [15]. However, the sustainability benefits of cloud computing depend on data center efficiency, electricity sources, and workload optimization [15]. Standardized environmental performance metrics are needed for better transparency [14]. AI and ML will play an increasing role in optimizing resource allocation and energy consumption, driving more sustainable data center operations [11][13].

Tackling the E-Waste Challenges

The rise of digital technology has led to a surge in electronic waste (e-waste), containing valuable materials like gold and rare earth elements, as well as hazardous substances like lead and mercury [17]. Improper disposal contaminates soil and water, posing environmental and health risks. Developing countries face significant challenges due to inadequate infrastructure and regulations [17]. Informal recycling methods, such as open burning and acid leaching, expose workers and communities to toxic materials [18]. A circular economy approach is key to sustainable e-waste management. This shift moves from a linear "take-make-dispose" model to one that emphasizes durability, reuse, repair, and recycling [9]. Extended Producer Responsibility (EPR) policies require manufacturers to manage their products' end-of-life, encouraging sustainable design and internalizing environmental costs [17]. Formal e-waste collection and recycling systems, particularly in developing countries, need support through regulations, infrastructure, and public awareness campaigns [18]. Technological advancements are improving e-waste recycling. Hydrometallurgical and pyrometallurgical techniques recover more materials, while robotics and automation enhance efficiency and safety [17][9]. Consumer awareness and behavior changes are also critical. Many individuals remain unaware of e-waste hazards and proper disposal methods [18]. Education campaigns and incentives for participation in recycling programs can drive better e-waste management. Looking forward, integrating circular economy principles into product design and production will be crucial. Collaboration among manufacturers, governments, and consumers is necessary to develop more responsible approaches to electronic product life cycles.

Results from Implementation:

Implementing green computing strategies has led to innovative breakthroughs and measurable benefits across industries. The following key outcomes have emerged from adopting sustainable IT practices:

AI-Driven Energy Optimization:

Companies utilizing artificial intelligence to manage energy consumption in data centers have reported up to a 40% reduction in cooling costs and an overall 15% increase in energy efficiency. Predictive analytics help adjust power distribution dynamically, reducing waste and ensuring optimal performance.

Carbon-Neutral Cloud Computing:
Major cloud service providers have achieved carbon neutrality by integrating renewable energy sources and improving hardware efficiency. Studies indicate that shifting traditional IT infrastructure to cloud-based solutions can reduce an organization's carbon footprint by up to 84%.

Circular Economy in IT:
The concept of a circular economy, where electronic components are repurposed or refurbished rather than discarded, has gained traction. Companies embracing this model have seen a 30% reduction in e-waste generation while cutting costs on new hardware procurement.

Eco-Friendly Software Development:
Developers focusing on energy-efficient coding practices have created applications that require 20-50% less computational power. This shift has not only enhanced system performance but also extended the battery life of portable devices, reducing the need for frequent charging.

Smart Workplaces and Green IT Policies:
Businesses adopting green IT policies, such as remote work and smart office automation, have observed a 25% reduction in operational costs. By optimizing energy use in work environments and minimizing unnecessary hardware usage, organizations are significantly lowering their environmental impact.

Adopting green computing strategies yields numerous benefits:
Environmental Impact:
Reducing energy consumption and promoting the use of renewable energy sources directly decrease greenhouse gas emissions. Efficient data centers and sustainable practices contribute to a lower carbon footprint. For example, deploying a single data center-enabled High Altitude Platform can save up to 12% of electricity costs, highlighting the potential for significant environmental benefits. A study by the Carbon Trust shows that shifting to energy-efficient computing practices can reduce global carbon emissions from IT by up to 20%.

Cost Savings:
Energy-efficient hardware and optimized software lead to lower operational costs. Businesses can achieve financial savings through reduced energy bills and less frequent hardware upgrades. A report from Gartner states that enterprises implementing green IT strategies can save up to 30% on their annual IT budgets.

Regulatory Compliance and Corporate Reputation:
As governments enforce stricter environmental regulations, companies adopting green computing practices ensure compliance and avoid potential penalties. Moreover, demonstrating a commitment to sustainability enhances corporate reputation, appealing to environmentally conscious consumers and stakeholders. A survey by Nielsen found that 81% of global consumers feel strongly that companies should help improve the environment, reinforcing the importance of sustainability-driven business practices.

Conclusions:
This paper presents a comprehensive and up-to-date review of recent advancements in green computing research. We discuss methods for measuring green computing, techniques for improving efficiency in model training and inference—especially for large language models—and strategies for designing sustainable systems. Additionally, we highlight various use cases where green computing technologies contribute to environmental sustainability and engineering efficiency. As computationally intensive technologies like large language models and blockchain continue to evolve, computing resources remain a bottleneck for industry growth. Despite progress in energy efficiency and carbon reduction, green computing still demands further investment and innovation to overcome these challenges. We outline several key directions for future research in this field.

1. AI-Driven Carbon-Aware Computing Future computing systems can leverage AI to make real-time decisions about where and when to run computational tasks based on the availability of renewable energy sources. By integrating carbon intensity forecasts from smart grids, these systems can dynamically shift workloads between data centers powered by solar, wind, or hydro energy. For example, non-urgent cloud computing tasks can be scheduled for times when renewable energy production is at its peak. Research in this area could focus on optimizing scheduling algorithms, integrating carbon-aware APIs into cloud infrastructure, and ensuring minimal impact on latency and performance.

2. Bio-Inspired Computing for Energy Efficiency Neuromorphic computing, inspired by the human brain's efficiency, can lead to major breakthroughs in green computing. Unlike traditional CPUs and GPUs, neuromorphic processors operate using event-driven, parallel computing that mimics neural networks, drastically reducing power consumption. Future research could explore how these bio-inspired

architectures can be optimized for AI training and inference, edge computing, and real-time data processing while maintaining energy efficiency. Additionally, investigating hybrid models that combine neuromorphic chips with conventional architectures could help balance performance and sustainability.

3. Self-Sustaining Edge Computing Nodes With the rapid expansion of IoT devices, there is a growing need for energy-efficient edge computing. A promising direction is developing edge nodes that operate autonomously using renewable energy sources such as solar panels, piezoelectric generators (which harvest energy from movement), or ambient radio frequency energy. These nodes could power AI-driven applications in remote locations, such as wildlife monitoring, precision agriculture, and disaster response, without relying on power-hungry centralized cloud services. Research in this area could explore energy-harvesting techniques, low-power AI models, and adaptive task offloading between edge and cloud systems.

4. Green Blockchain for Sustainable Digital Transactions While blockchain technology is revolutionizing industries like finance, supply chain, and digital identity, its energy consumption remains a major concern. Future research can focus on designing next-generation blockchain protocols that significantly reduce energy use while maintaining security and decentralization. This could involve hybrid consensus mechanisms that combine Proof of Stake with AI-driven trust models, lightweight block validation techniques, and energy-adaptive block mining. Another direction is exploring how blockchain can enhance sustainability itself, such as by tracking carbon credits, optimizing supply chains, or verifying eco-friendly business practices.

5. Circular Economy for Computing Hardware A major challenge in green computing is electronic waste (e-waste), as obsolete or broken devices often end up in landfills. Future research can explore modular, upgradable, and recyclable computing hardware to promote a circular economy. For example, laptops with swappable components (such as CPUs, GPUs, and batteries) could extend device lifespans, reducing the need for frequent replacements. Biodegradable or bioengineered circuit boards could minimize toxic waste. Additionally, AI-driven predictive maintenance can be developed to monitor hardware health, alert users about necessary repairs, and optimize component reuse, ultimately reducing overall e-waste generation.

6. Quantum Computing for Energy-Intensive Problems Quantum computing has the potential to solve complex optimization problems with far greater efficiency than classical computers, using significantly less energy. Future research could explore applications of quantum algorithms in areas such as AI model training, supply chain logistics, and climate modeling, where traditional high-performance computing consumes massive amounts of energy. Additionally, hybrid quantum-classical computing systems could be developed to selectively offload computations to quantum processors only when it results in energy savings. The challenge lies in making quantum hardware more stable and scalable while integrating it into real-world computing infrastructures.

References:

[1] C.-J. Wu, R. Raghavendra, U. Gupta, B. Acun, N. Ardalani, K. Maeng, G. Chang, F. A. Behram, J. Huang, C. Bai, M. Gschwind, A. Gupta, M. Ott, A. Melnikov, S. Candido, D. Brooks, G. Chauhan, B. Lee, H.-H. S. Lee, B. Akyildiz, M. Balandat, J. Spisak, R. Jain, M. Rabbat, and K. Hazelwood, "Sustainable ai: Environmental implications, challenges and opportunities," 2022.
[2] T. Parcollet and M. Ravanelli, "The energy and carbon footprint of training end-to-end speech recognizers," in Interspeech, 2021. [Online].
[3] UptimeInstitue, "2019 data center industry survey results," https://uptimeinstitute.com/ 2019-data-center-industry-survey-results/, 2019.
[4] Google, "Efficiency-data centres," https://www.google.co.uk/about/datacenters/efficiency/, 2020.
[5] AWS, "Aws and sustainability," https://aws.amazon.com/about-aws/sustainability, 2020.
[6] aliyun, "Alibaba Cloud is the first to meet the national green data center standard, with an average PUE of less than 1.3," https://developer.aliyun.com/article/ 691750, 2019.
[7] Afwande, Margaret & Wabwoba, Franklin & Ongare, Roselida. (2024). IT as a Green Enabler to Save the World for the Future of Life on Earth: A Review.. International Journal of Research and Innovation in Applied Science. IX. 67-72. 10.51584/IJRIAS.2024.909007.
[8] European Commission. (2021). The new ecodesign for sustainable products regulation. European Commission Technical Report, Brussels, Belgium.
[9] Kharel J, Sinha R, Sanchez-Caballero S and Vu T. (2022). A review of green computing for sustainable smart cities: Challenges and solutions. Sustainable Cities and Society, 83, 103916.
[10] Bose K and Luo X. (2019). Green computing and sustainability in information technology. Sustainable Computing: Informatics and Systems, 23, 77-82.
[11] Bravo-Sánchez M, Valencia-García R, García-Sánchez F and Pujara J. (2021). Sustainability in artificial intelligence: A survey of trends and future paths. Sustainable Computing: Informatics and Systems, 30, 100572.
[12] Intel. (2022). 12th Gen Intel® Core™ mobile processors: Breakthrough performance for what's next. Intel Technical Documentation, Santa Clara, USA.
[13] Capra E, Francalanci C and Slaughter SA. (2019). Is software "green"? Insights into the environmental implications of software development. IEEE Software, 36(6), 62-68.
[14] Noureddine A, Rouvoy R and Seinturier L. (2019). Software techniques for optimizing the power consumption of computing systems: A survey. ACM Computing Surveys, 52(2), 1-39.

[15] Masanet E, Shehabi A, Lei N, Smith S and Koomey J. (2020). Recalibrating global data center energy-use estimates. Science, 367(6481), 984-986.
[16] Google. (2021). Our data centers now work harder when the sun shines and wind blows. Google Technical White Paper, Mountain View, USA.
[17] Awasthi AK, Hasan M, Mishra YK, Pandey AK, Tiwary BN, Kuhad RC and Thakur VK. (2019). Environmentally sound system for E-waste: Biotechnological perspectives. Current Research in Biotechnology, 1, 58-64.
[18] Osibanjo O and Nnorom IC. (2019). The challenge of electronic waste (e-waste) management in developing countries. Waste Management & Research, 37(10), 963-974.
[19.] International Energy Agency (IEA): Global Electricity Demand for Data Centers - https://www.iea.org
[20.] U.S. Department of Energy: Energy-Efficient Servers Report - https://www.energy.gov
[21.] International Data Corporation (IDC): Virtualization and Energy Savings - https://www.idc.com
[22.] Global E-Waste Monitor: Electronic Waste Statistics - https://globalewaste.org
[23.] Gartner: Green IT Strategies and Cost Savings - https://www.gartner.com
[24.] Nielsen: Consumer Sentiment on Sustainability - https://www.nielsen.com

Adsorption of Cr (VI) by using low cost agricultural wastes *Saccharum Officinarumas* an adsorbent from waste water.

[1]Aashi Bhardwaz, [2*]BinuKumari,[2]M.Yadav, [3]R.K.Tiwary
[2]Department of Chemistry and Chemical Biology, Indian Institute of Technology (ISM), Dhanbad,
[3]Department of Natural Resource Environmental Managment, CSIR- Central Institute of Mining & Fuel Research, Dhanbad,
*[2]Corresponding Author: Dr. BinuKumari, [1]Department of Chemistry and Chemical Biology IIT(ISM) Dhanbad,
Email: binukumaribit@gmai.com, binunikkisingh@gmail.com

Abstract

In this study, a low cost agricultural waste material Saccharumofficinarum (SO)was used to remove toxic Cr(VI) from water.For this purpose batch experiment was conducted in the laboratory by taking 100 ml of desired concentrationof Cr(VI) solution in 250 ml Erlenmeyer flask with different dose, different contact time (15 to 100 min) at different pH, and shake whole solution well in water bath shaker machine with 150 rpm speed at 303 K temperature.The concentration of Cr (VI) was determined by using spectrophotometer following di-phenyl carbazide method. Result shows that 97% Cr(VI) was removed from aqueous solution at pH 2. The adsorption of Cr(VI) on SO adsorbent followed Langmuir adsorption isotherm as well as pseudo-second-order kinetic model. Temperature study confirm the endothermic nature of adsorption of Cr(VI). When temperature of solution is increases from 303 to 323 K percentage of Cr(VI)removal increases from 97.0 to 99.1 %. Surface characterization studies such as Field emission scanning electron microscopy, Fourier transform infrared, illustrated adsorption mechanism of the adsorbent. Adsorbent used in this study is novel because in other research paper author modified the SOby the addition of different chemical and by boiling the adsorbent to remove remaining pulp/sugar from SO but in this study adsorbent used as such as raw adsorbent and we didn't add any chemical to SOfor adsorption study.
Key words: Chromium (VI); Adsorption;SaccharumOfficinarum;

1. Introduction

At present, environmental pollution due to hexavalent chromium becomes the main concern due to its carcinogenic nature and health hazard [1]. The main source of Cr (VI) contamination in waste water are industrial effluents discharged from mining industry, electroplating industry, metallurgical process, battery manufacturing, leather and tanning process, steel fabrication, textile and ceramic industries etc [2,3]. The main cause of release of chromium into the environment is the result of poor storage, leakage, and improper disposal practices related with industrial processes. As per literature [4–6], chromium exists in two oxidation state i.e., hexavalent chromium [Cr(VI)] and trivalent chromium [Cr(III)] in waste water, natural water and in soil. Among two oxidation states, Cr(VI) is found 1000 times more toxic than Cr(III) [7].In sukinda chromite mining area, (Odisha) ground water and surface water contains higher Cr(VI) concentration which is greater than the Indian standard drinking water guidelines (A/C to IS;10500 and WHO, Cr(VI) concentration in water should be 0.05 mgL^{-1})as reported by [8] Some mines at Sukinda chromite valley releasing untreated effluent water directly into the ground and surface water of nearer village of mining area which increase the concentration of Cr(VI) inwater of the area. The contaminated and toxic water is used by people and animalsand suffered from different diseases like diarrhea, skin irritation, lungs cancer, ulcer etc. This polluted water has very bad impact on environment and it also destroys the quality of soil and water on which living beings depend. The concentration of Cr (VI) more than the permissible limit in aqueous solution causes various health hazards to human beings such as skin irritation, vomiting, nausea, diarrhea, kidney failure, lungs cancer, stomach ulcer, haemorrhage and respiration problem [9–11]. Hence removal of Cr (VI) from water before its discharge into environment has become important. Different technology like adsorption [12, 13], membrane separation [14,15], ion exchange [16,17], chemical reduction & precipitation, reverse osmosis and photocatalysis [18,19] have been employed for Cr (VI) removal. Among these the most acceptable technologies for Cr (VI) removal is adsorption due to its low cost, greater removal efficiency, easy operation, economically viable, reusability property of adsorbent [20,21] and low secondary pollution [22–24]. Due to toxic and carcinogenic nature of hexavalent chromium it is in public concern for mitigation from waste water now a day. In this study we used easily available agricultural wastesSO (sugarcane bagasse)after the extraction of juice for mitigation ofCr (VI). It is fibrous in nature and it composes 40% cellulose, 24% hemicelluloses and 25% lignin[25]. This waste is found in abundant in the environment so it can be used in industrial level for removal purpose. It is useful not only in deductionof toxic heavy metals from environment but also in minimizing the generation of sludge after adsorption. It has the potential to appropriate metals from solutions. It (SO) is best adsorbent for waste remediation and treatment of contaminated water because it has high adsorption capacity, easy availability, found in abundant in environment, very cheap or cost effective. Similar work was done by Osvaldo et al. for removal of Cr(VI) using SO adsorbent but they modified sugarcane by succinic anahydride [26]. These make our work different from another.

2. Materials and Methods

Sugarcane bagasses werecollected from fruits seller shops of Dhanbad, Jharkhand, India. It was washed with tap water to remove dust particles from SO and finally rinsed with distilled water. Then it was spread on trays and exposed to sunfor five days (total 60 hrs dry sun exposure) so that adsorbent was completely dry in natural way rather than artificial like oven. After that it is crushed with mortar pestle and then grounded to fine dust particles by mixer grinder. Powdered adsorbent sieved through 10 IS siever to obtain 105 microns (10 IS) uniform particle size. To remove moisture fromsieved material itis placed in an oven for 60 minutes at 80 ^{0}C andstored in airtight glass container for further use.

2.1 Batch adsorption experiments

For batch studies stock solutions of Cr (VI) were prepared by dissolving 2.829 g of $K_2Cr_2O_7$ in 1L of doubled distilled water. To obtain the different concentration of Cr (VI) (2 to 6 mgL^{-1}) distilled water is added to stock solution. Before proceed to batch process pH of Cr (VI) solution was adjusted (pH 2 to 5) by using known concentration of H_2SO_4 or NaOHin solution by the help of pH meter ATI Orion model Ion Analyzer. After pH adjustment batch experiments were carried out by taking 100 ml solution of Cr (VI) with concentration 2 mgL^{-1} in 250 ml Erlenmeyer flask and then add 0.5g adsorbent dose. Now shake whole solution in thermostated water bath shaker machine with 151 rpm speed for 2h contact time at different temperature of 303 to 323 K. After shaking, the entire solution was separated using whatman filter paper number 42. Cr (VI) of filtrate was determined by the addition of 2ml phosphoric acid, 2ml of 0.2N H_2SO_4 and 2ml 1,5- di phenylcarbazide in filtrate using Thermo Scientific Genesys 20 visible spectrophotometer at 540 nm wavelength by developing purple-violet colored.
Quantity adsorbed and percentage removal efficiency of SOwas calculated using Eq. (1) and Eq. (2):

$$q_e = \frac{(C_0 - C_e)}{W} \times V \quad (1)$$

$$\% \text{ Removal} = \frac{(C_0 - C_t)}{W} \times 100 \quad (2)$$

Where $C_0$is initial and C_e (mgL^{-1}) is the equilibrium concentrations of Cr(VI), V is the volume of the solution (L) and W is the weight of dry adsorbent (g).

3.0 Results and discussion

3.1. Effect of pH

pH is an essential factor for the mitigation of Cr (VI) from an aqueous solution. To show the pH effect on the mitigation of Cr (VI), batch experiment was conducted at different pH (2–6) for 2 mg/L Cr (VI) concentration with 0.5 g dose for 120 min at 303K and the results are shown in Fig. 1(a). It was observed that with the rise in pH of solution, % removal of Cr (VI) decreases. In this study, maximum removal of Cr (VI) was found as 97.5% at pH 2, so the pH 2 was taken as optimum pH for further study.

3.2.Effect of adsorbent dose

The optimization of adsorbent dose was studied by taking the adsorbent dose from 0.1 g to 0.6g in100 mL Cr (VI) solution of 2 mgL^{-1} concentration at pH 2, time 120 min at 303K. The variation of % removal at different adsorbent dose is represented in Fig. 1 (b). It is clear from Fig. 1(b) that on increasing the adsorbent dose from 0.1 to 0.6 g, the percentage removal of Cr (VI) increases from 50 to 96% and become almost constant at 0.5g. So 0.5 g of adsorbent was taken as optimum dose for further study. The increase in percentage removal with increasing the adsorbent dosage is due to increase in adsorbent surface area and the availability of more binding sites on the surface which are ready for metal ion uptake.

3.3. Effect of contact time

For optimization of contact time, batch experiments were carried out by placing 0.5 g SO adsorbent in 100 mL of 2 mgL^{-1}Cr(VI) concentration solution in a 250 mL Erlenmeyer flask and then agitate the reaction mixtures at shaker for different contact time (15 min–150 min) at 303K. The effect of contact time on % removal of Cr (VI) and adsorption capacity is shown in Fig. 1 (c). From Fig. 1 (c) it is visible that the adsorption of Cr (VI) on SO was fast for first 30 min and became abate with the increase in time and then, the equilibrium was achieved in 90 min. So, the optimum contact time to obtain the maximum adsorption of Cr (VI) was taken as 60 min. The fast adsorption at the initial stage is probably due to large number of vacant sites available in the beginning.

3.4. Effect of initial concentration

For optimization of concentration of Cr(VI), batch experiment was performed at Cr(VI) concentration ranging from 2 to 6 mg L^{-1} at optimized pH, dose, and time. It was observed that with increase in initial Cr(VI) concentration from 2 to 6 mg L^{-1}, % removal decreased from 97% to 88 % up to 5 ppm and after this concentration; % removal became almost constant as depicted in Fig. 1 (d). The reason behind this is the saturation of sorption sites of adsorbent surface as reported in the literature [27]. At higher concentration the active sites of adsorbent (SO) are surrounded by more Cr(VI) ions in solution for fixed adsorbent dose result in increased adsorption capacity and decreased % removal. It is clear from Fig. 1(d) that maximum removal efficiency was observed at 2 mg L^{-1} Cr (VI) concentration, so the optimum concentration of Cr (VI) solution was taken as 2 mg L^{-1}.

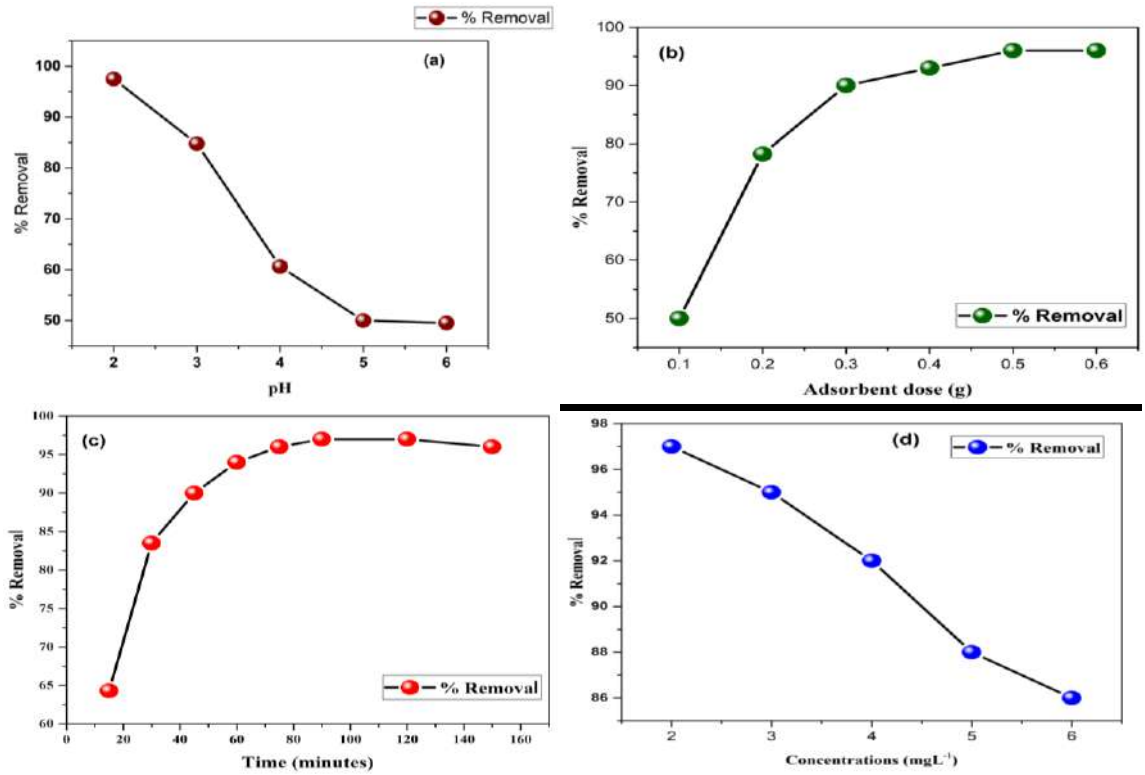


Fig. 1.Effect of pH, (b) dose, (c) contact time and (d) initial Cr (VI) concentration on Cr (VI) removal.

3.5 Adsorbents characterization

3.5.1SEM studies

SEM imagesof raw adsorbent and Cr adsorbed adsorbent are shown in Fig. 2 (a). Fig. 2 (a) shows the adsorbent surface is very rough and it has different pores with different size and Fig. 2 (b) shows adsorbent surface is homogenous due to some metal is adsorbent in the pores. Therefore when metal is adsorbed in this pore we observe very smooth surface area of adsorbent.

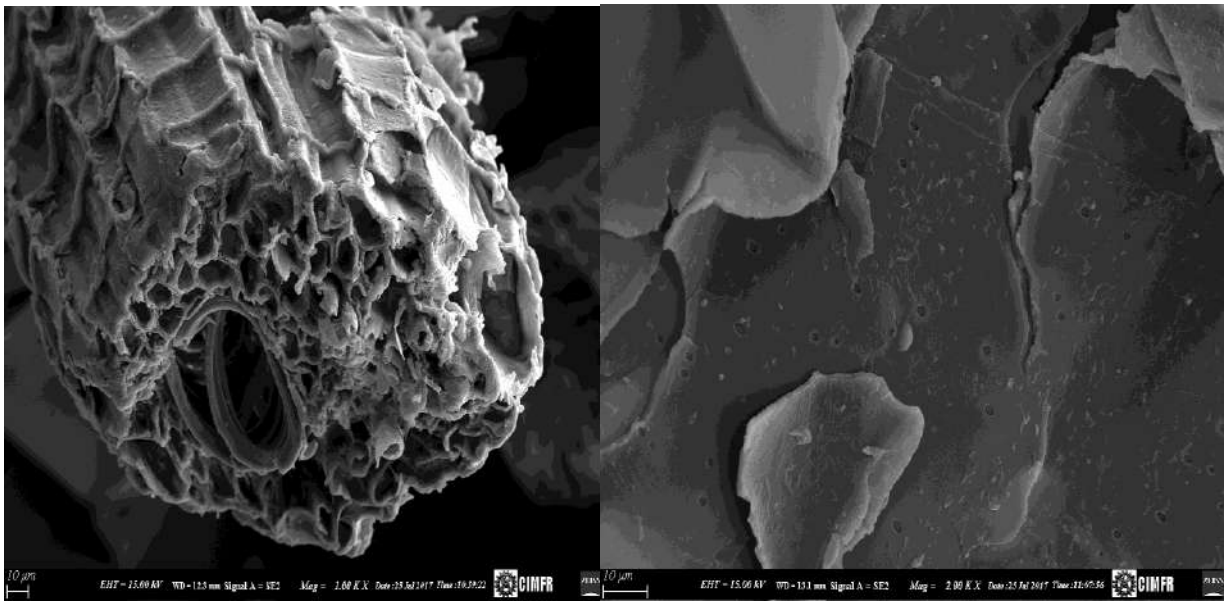


Fig 2: SEM Image of SO before and after Cr (VI) adsorption

3.5.2Fourier transforms infrared spectroscopy (FTIR)

The spectra of raw SOand Cradsorbed SO were measured by an FTIR spectrometer in 400 to 4000 cm^{-1} range and shown in Fig.3. FTIR adsorption band before adsorption occurs at 3412.58, 2932.7, 1633.1, 1050.3 and 607.5 cm^{-1} and FTIR functional group after adsorption occurs at 3412.5, 2913.1, 1642.4, 1050.3 and 598.2 cm^{-1}.

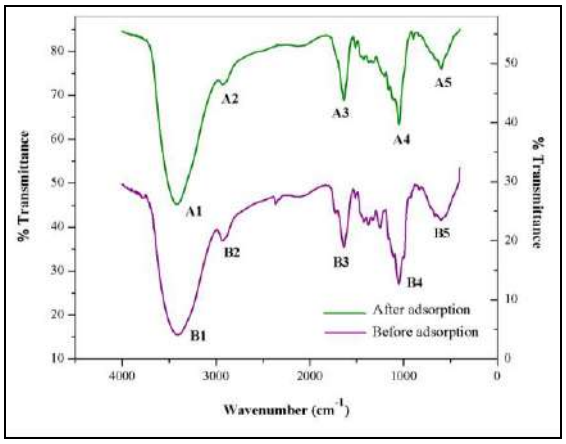


Fig 3: FTIR spectrum plot of Sugarcane bagasses before and after adsorption

4.0 Conclusions:

Cr(VI) removal from water using SO adsorbent depends on solution pH, dose, shaking period, adsorbateinitial concentration and temperature. Isotherm and kinetic studies showed that adsorption of Cr (VI) on SO followed Langmuir isotherm and pseudo-second-order kinetic model respectively. Batch study shows that maximum the adsorption capacity of 1.075 mg/g and percentage removal of 97.0 % was observed at 303 K temperature by using 0.5g SO dose, at pH 2, and contact time of 90 minutes which shows good performance of Saccharumofficinarumfor removal of Cr (VI) in low concentration range. As the adsorbent used in this research is afibrous waste plant material and useful for treatment of aqueous solution (effluent water) containing chromium (VI) or can be used on industrial scale.

Acknowledgements:

The authors thankfully acknowledge CSIR-CIMFR, Dhanbad, CRF, IIT(ISM), Dhanbad for the facilities provided for research work and funding agencies Department of Science and Technology (DST), New Delhi, India.

References:

[1] Z. Peng, H. Zhao, H. Lyu, L. Wang, H. Huang, Q. Nan, J. Tang, UV modification of biochar for enhanced hexavalent chromium removal from aqueous solution, Environ. Sci. Pollut. Res. Int. 25 (2018) 10808–10819.

[2] S.S. Kerur, S. Bandekar, M.S. Hanagadakar, S.S. Nandi, G.M. Ratnamala, P. G. Hegde, Removal of hexavalent chromium Industry treated water and Wastewater: a review, Mater. Today Proc. 42 (2021) 1112–1121.

[3] N. Kazakis, N. Kantiranis, K. Kalaitzidou, E. Kaprara, M. Mitrakas, R. Frei, G. Vargemezis, D. Vogiatzis, A. Zouboulis, A. Filippidis, Environmentally available hexavalent chromium in soils and sediments impacted by dispersed fly ash in Sarigkiol basin (Northern Greece), Environ. Pollut. 235 (2018) 632–641.

[4] Y. Tang, J. Zhao, J. Zhou, Y. Zeng, W. Zhang, B. Shi, B, Highly efficient removal of Cr(III)-poly(acrylic acid) complex by coprecipitation with polyvalent metal ions: performance, mechanism, and validation, Water Res. 178 (2020), 115807.

[5] J. Li, G. Xu, K. Wang, B. Han, L. Li, Y. Wang, D. Ju, M. Chai, D. Zhang, W. Zhou, Study on fabrication and electrochemical performances of Fe7S8@C composite materials, Electrochemistry 88 (5) (2020) 380–386.

[6] C. Zheng, Z. Yang, M. Si, F. Zhu, W. Yang, F. Zhao, Y. Shi, Application of biochars in the remediation of chromium contamination: fabrication, mechanisms, and interfering species, J. Hazard Mater. 407 (2021), 124376.

[7] H. Lyu, H. Zhao, J. Tang, Y. Gong, Y. Huang, Q. Wu, B. Gao, Immobilization of hexavalent chromium in contaminated soils using biochar supported nanoscale iron sulfide composite, Chemosphere 194 (2018) 360–369.

[8] Kumari B, Tiwary RK, Srivastava KK. Physico-Chemical Analysis and Correlation Study of Water Resources of the Sukinda Chromite Mining Area, Odisha, India, Mine water and Environment. 2017; 36:356-362.

[9] J. Bayuo, An extensive review on chromium (VI) removal using natural and agricultural wastes materials as alternative biosorbents, J. Environ. Health Sci. Eng. 19 (1) (2021) 1193–1207.

[10] H. Znad, M.R. Awual, S. Martini, The Utilization of algae and seaweed biomass for bioremediation of heavy metal-contaminated wastewater, Molecules 27 (2022) 1275.

[11] W. Lu, J. Li, Y. Sheng, X. Zhang, J. You, L. Chen, One-pot synthesis of magnetic iron oxide nanoparticle-multiwalled carbon nanotube composites for enhanced removal of Cr (VI) from aqueous solution, J. Colloid Interface Sci. 505 (2017) 1134–1146.

[12] W. Cai, W. Jiahao, Z. Li, L. Yan, J. Zhou, B. Han, Preparation of amino-functionalized magnetic biochar with excellent adsorption performance for Cr (VI) by a mild one-step hydrothermal method from the peanut hull, Colloids Surf., A 563 (2019) 102–111.

[13] Z. Feng, N. Chen, C. Feng, Y. Gao, Mechanisms of Cr(VI) removal by FeCl3- modified lotus stem-based biochar (FeCl3@LS-BC) using mass-balance and functional group expressions, Colloids Surf., A 551 (2018) 17–24.

[14] Z. Yao, S. Du, Y. Zhang, B. Zhu, L. Zhu, A.E. John, Positively charged membrane for removing low concentration Cr(VI) in ultrafiltration process, J. Water Proc. Eng. 8 (2015) 99–107.

[15] U. Habiba, T.A. Siddique, S. Talebian, J.J.L. Lee, A. Salleh, B.C. Ang, A.M. Afifi, Effect of deacetylation on property of electrospun chitosan/PVA nanofibrous membrane and removal of methyl orange, Fe (III) and Cr (VI) ions Carbohydr, Polymer 177 (2017) 32–39.

[16] H. Gu, H. Zhang, C. Gao, C. Liang, J. Gu, Z. Guo, Z, New functions of polyaniline, ES Mater. Manuf. 1 (2018) 3–12.

[17] P. Santander, D. Morales, B.L. Rivas, N. Kabay, I. Yilmaz, O. Kus¸ku, M. Yuksel, M. Bryjak, Removal of Cr(VI) from aqueous solution by a highly efficient chelating resin, Polym. Bull. 74 (2016) 2033–2044.

[18] J.C. Wang, C.X. Cui, Y. Li, L. Liu, Y.P. Zhang, W. Shi, W, Porous Mn doped g-C3N4 photocatalysts for enhanced synergetic degradation under visible-light illumination, J. Hazard Mater. 339 (2017) 43–53.

[19] Q. Cheng, C. Wang, K. Doudrick, C.K. Chan, Hexavalent chromium removal using metal oxide photocatalysts, Appl. Catal., B 176–177 (2015) 740–748.

[20] Y. Xu, J. Chen, R. Chen, P. Yu, S. Guo, X. Wang, Adsorption and reduction of chromium(VI) from aqueous solution using polypyrrole/calcium rectorite composite adsorbent, Water Res. 160 (1) (2019) 148–157.

[21] V.E. Pakade, N.T. Tavengwa, L.M. Madikizela, Recent advances in hexavalent chromium removal from aqueous solutions by adsorptive methods, RSC Adv. 9 (2019) 26142–26164.

[22] W.Q. Cai, Z.L. Li, J.H. Wei, Y. Liu, Synthesis of peanut shell based magnetic activated carbon with excellent adsorption performance towards electroplating wastewater, Chem. Eng. Res. Des. 140 (2018) 23–32.

[23] L. Lonappan, T. Rouissi, B.S. Kaur, M. Verma, R.Y. Surampalli, An insight into the adsorption of diclofenac on different biochars: mechanisms, surface chemistry, and thermodynamics Bioresour, Technol. 249 (2018) 386–394.

[24] J.-H. Park, J.J. Wang, S.-H. Kim, J.-S. Cho, S.-W. Kang, R.D. Delaune, K.-J. Han, D.-C. Seo, Recycling of rice straw through pyrolysis and its adsorption behaviors for Cu and Zn ions in aqueous solution, Colloids Surf. A Physicochem. Eng. Asp. 533 (2017) 330–337.

[25] Lee YJ, Chung CH., Day DF. Sugarcane bagasse oxidation using a combination of hypochlorite and peroxide, Bioresour. Technol. 2009;100: 935–941.

[26] Osvaldo KJr , Leandro VAG, Melo JCP, Botaro VR, Melo TMS, Gil RPF, Gil LF. Adsorption of heavy metal ion from aqueous single metal solution by chemically modified sugarcane bagasse. Bioresource Technology.2007; 98:1291-1297.

[27] R. Karthik, S. Meenakshi, Removal of hexavalent chromium ions from aqueous solution using chitosan/polypyrrole composite, Desalination Water Treat. 56 (2015) 1587–1600.

The Impact of Pandemic on Fashion Retailing and its Future Trends

Mahi Kumari[1], Dr. Vaibhav Gupta[2]*
[1]Student, Department of Bachelor of Business Administration (BBA), GGSESTC, Kandra, Bokaro
[2]Assistant Professor, Department of Fashion Technology, GGSESTC, Kandra, Bokaro
*Corresponding author e-mail id: gpt.1729@gmail.com

Abstract: Fashion retailing is the business of buying clothing and accessories from manufacturers and selling them to customers. Fashion retailing consists of various activities such as Buying, Storing, Selling, Sorting and Marketing. Fashion retail theory examines the intersection of fashion, business, and consumer behavior, covering concepts like consumer experience, merchandising, marketing strategies, and the dynamics of the fashion industry. Moreover, in the post-pandemic world, the evolution of the fashion retail landscape holds important significance due to significant changes in consumer preferences, advancements in technology etc. The adoption of e-commerce, reinvented physical retail spaces and increasing consumer consciousness towards the environment also contributes to changes in fashion retailing. This paper discusses changes in the fashion retail landscape in the post-pandemic era and its future trends, which will ultimately shape the future of fashion retail.

Keywords: Fashion, retailing, pandemic, post-pandemic, future trends.

1. Introduction:

Fashion retail (Fig. 1) describes businesses that sell clothes and accessories directly to customers in store. There are four main types of fashion retail businesses including highstreet chain stores, department stores, luxury brands and independent boutiques. It helps brands share their vision and connect with customers via in store experiences, services and products. Fashion retail not only provides products but also creates a platform where brands can engage with customers, building loyalty through immersive and memorable shopping experiences. This connection between brands and consumers makes fashion retail an essential part of the global economy, which was significantly disrupted during the COVID-19 pandemic.

Figure 1: A view of fashion retail store

2. Impact of COVID on Fashion Retailing:

a) **Supply Chain Disruption:** China is one of the important suppliers of fashion goods.The COVID-19 outbreak led to lockdowns in China and subsequently worldwide, disrupting the global value chain. With plummeting demand, retailers canceled orders, and countries imposed trade restrictions. Unsold inventory remained in warehouses due to uncertain future demand. As a result, the apparel industry's revenue declined by 27–30% in 2020 compared to 2019, according to a joint report by Business of Fashion and McKinsey &Company[1].

b) **Market Shift:** With restrictions in place, consumers shifted to e-commerce, prompting retailers to adapt. Those with an established online presence had an advantage, while others expanded their reach through virtual community-building. Nike, for example, saw an 80% surge in fitness app users in Q1, driving a 30% increase in digital sales. Meanwhile, fashion brands with integrated digital and physical channels benefited as shoppers opted for in-store pickup of online orders[1].

c) **Work from Home Wear:** The pandemic boosted sales of comfortable leisurewear as people worked, lived, and socialized from home. The 'work-from-home' apparel category emerged during this time and is expected to remain relevant for the foreseeable future[1].

d) **Economic Impact:** The fashion industry, a $2.5 trillion global market, was projected to face a 90% sales decline due to the pandemic. In the U.S. alone, it supports over 1.8 million jobs. With malls shut and stores closed, smart retailers pivoted to digital retail early, while departmental stores and small businesses struggled to adapt, leading to job losses, store closures, and bankruptcies. Major players like JC Penney filed for bankruptcy, Zara shut 1,200 stores, Canada Goose laid off 125 workers, and Gucci reduced its fashion shows from five to two in 2020[1,2].

e) **Shift in Consumer Behavior:** Financial uncertainty during the pandemic led to a significant decrease in spending on fashion apparel. Consumers prioritized essential goods over discretionary items like clothing, resulting in decreased demand for new fashion products[3].

f) **Financial Crisis & Store Closures:** The pandemic caused a complete absence of revenue from physical stores, leading to a deep drop in revenue for fashion retailers. This resulted in a reconfiguration of stocks for fashion brands and a subsequent drop in orders for garment manufacturers. Many fashion retailers filed for bankruptcy in the aftermath of the pandemic [4,5].

3. Fashion Retail in the Post-Pandemic World:

With the spread of the Coronavirus in 2020 and 2021 came physical, psychological and logistical changes that impacted all industries across the globe. As many countries begin to ease restrictions and return to normal, the impact of the pandemic can still be felt today and will be affecting how businesses remain competitive. The significant changes in fashion retail landscape are discussed below:

a) **Digital-First Strategies (Adoption of e-commerce):**

- **Zara** (Fig. 3a) incorporates the latest technology from Zara's platform of integrated physical and online stores, offering customers the option to browse the store of their choice online, consult available stock, shop online and collect their purchases in just two hours.
- **H&M** (Fig. 3b) uses AI to optimize inventory and provide personalized recommendations.

Figure 3(a)

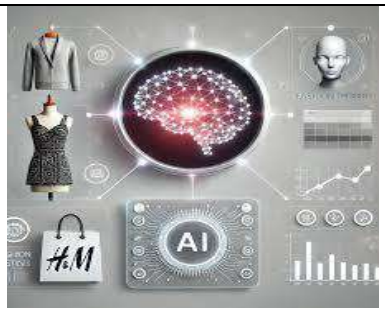


Figure 3(b)

b) **Reinvention of Brick -and Mortar Stores:**

- **Nike Live** (Fig.3c) stores feature personalized services and exclusive products tailored to local communities.
- **Lululemon** (Fig. 3d) combines retail with wellness by offering yoga classes and meditation spaces.

Figure 3(c)

Figure 3(d)

c) **Technological Advancements in Personalization:**

Personalization has become the key to customer retention. Advanced technologies like artificial intelligence (AI) and machine learning (ML) are enabling brands to deliver tailored experiences.

- **Stitch Fix** (Fig. 3e) uses AI to curate personalized outfit recommendations for its customers.
- **Uniqlo** (Fig. 3f) utilizes heat-mapping technology in stores to optimize product placement.

Figure 3(e)

Figure 3(f)

d) Sustainable Fashion:

- **Sustainability** (Fig. 3g) has shifted from being a trend to a necessity. Consumers are increasingly conscious of the environmental and social impact of their purchases, pushing brands to adopt ethical practices.
- **Levi's** (Fig. 3h) promotes sustainable production through water-saving technologies and recycled fabrics.

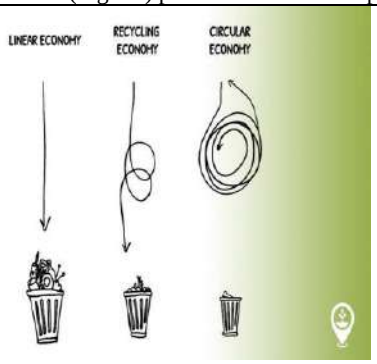


Figure 3(g)

Figure 3(h)

e) Vocal for Local: The pandemic's impact on imports has created opportunities for local designers, brands, and artisans, promoting Indian fabrics and boosting the economy.

- **Fabindia's** (Fig. 3i) focus on promoting Indian fabrics and empowering rural artisans thrived post-pandemic, aligning with the growing preference for sustainable, locally sourced products.
- **Raymond's** (Fig. 3j)Khadi initiative post-pandemic revived Indian handloom, empowered rural artisans, and promoted sustainable, locally sourced fabrics.

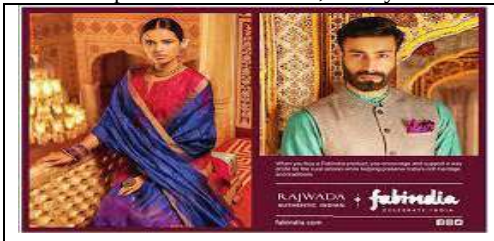


Figure 3(i)

Figure 3(j)

4. Future Trends of Fashion Retailing

a) Social Shopping(Fig. 4a)**:** According to McKinsey and Business of Fashion, the pandemic has accelerated reliance on social media , with more and more people are influenced to shop through these channels.

b) Metaverse (Fig. 4b)**:** Gen Z consumers are expressing a strong interest in the metaverse, spending on digital garments is likely to increase. Many brands are exploring this trend and are partnering with leading video game developers to bring their garments to the digital world.

Figure 4(a)

Figure 4(b)

c) **Authentic Influencers** (Fig. 4c): More and more consumers are attracted towards authentic influencers as compared to celebrity status or aspirational lifestyle..

d) **Experiential Retail** (Fig. 4d)**:** It is also known as "Personalized Retail Experiences", and its demand is increasing at a rapid rate. For better and enhanced customer experience, more and more brands are turning towards technology. AI (Artificial Intelligence), in particular, is playing a leading role. Eg: Chatbots asks customers about their clothing preferences and in turn provides personalized recommendations.

Figure 4(c)

Figure 4(d)

e) **Fit Technology** (Fig. 4e)**:** It is the incorporation of AR (Augmented Reality) into the customer journey. It allows customers to visualize garments on their bodies without getting undressed.

f) **Channel Diversification** (Fig. 4f): Based on emerging future trends in fashion, retailers are reconsidering their channel strategies and diversifying their mix. To enhance the customer's in-store experience, digitization is necessary for the customers who desire something different. Eg: Using a combination of NFC and RFID technology, shoppers can tap and scan their body through their smartphone as they browse in-store.

Figure 4(e)

Figure 4(f)

g) **Circular Textiles** (Fig. 4g)**:** With the circular economy nowadays being the buzz word, the demand for sustainable and circular manufacturing processes is inevitable.

h) **Fast Fashion** (Fig. 4h): Fast fashion retailers move, well, faster than their traditional counterparts do. This means that they compress production cycles and turn out up-to-the-minute designs, enabling shoppers to not only expand their wardrobes but also refresh them quickly—and cheaply. The term has become more prominent in conversations surrounding fashion, sustainability, and environmental consciousness.

Figure 4(g)

Figure 4(h)

5. Conclusion:

The future seems to be driven by technology and sustainability. Virtual reality might redefine the concept of in-store experiences, blurring the lines between physical and digital realms. Sustainable practices are expected to become the norm, with consumers increasingly demanding transparency and eco-consciousness from brands. Since adaptability will be key to all of this, brands should identify the threats to their businesses and prepare strategic responses across multiple scenarios to counter uncertainty and facilitate fast decision-making. Building cross-functional teams that are informed by judicious priorities will give brands more smartness to respond quickly and capture market opportunities.

6. References:

[1] Balchandani, Anita; Young, Robb; Kent, Sarah; Amed, Imran, and Berg, Achim (2020). The State of Fashion 2021.Report on Business of Fashion & McKinsey & Company.
(https://www.mckinsey.com/~/media/McKinsey/Industries/Retail/Our%20Insights/State%20of%20fashion/2021/The-State-of-Fashion-2021-vF.pdf)

[2]Patil, Kavita (2021).Scenario of Fashion Industry & Fashion Trends: Post Covid-19. Journal of Research in Humanities & Social Sciences, Vol.9, Issue 1, pp 38-43.

[3] York, Kandace (2020).Dressing in a COVID world.A pandemic's impact on the multi-billion dollar fashion industry.
(https://www.bgsu.edu/news/2020/07/dressing-in-a-covid-world--a-pandemic-s-impact-on-the-multi-bill.html?)

[4] Ilchi, Lyla (2020). How the Coronavirus Is Impacting the Fashion, Beauty and Retail Industries.
(https://wwd.com/fashion-news/fashion-scoops/coronavirus-impact-fashion-beauty-retail-fashion-week-store-closures)

[5] Law, Tara (2020). How the Coronavirus' Effect on the Fashion Industry Reveals Flaws in the Global Economy.
(https://time.com/5794928/coronavirus-fashion-economy/)

Reinterpreting the Speed of Light: A Proposal to reassess the constant in Relation to Space-Time Structure

Rashad Ahmad Khan[1], Manojit De[2*]
[1]Department of Computer Science (Data Science), Guru Gobind Singh Educational Society's Technical Campus, Kandra, Bokaro, Jharkhand
[2]Department of Physics (BSH), Guru Gobind Singh Educational Society's Technical Campus, Kandra, Bokaro, Jharkhand
***Email of the corresponding author:** (Manojit De) manojit.de@ggsestc.ac.in

Abstract: The speed of light in a vacuum, commonly denoted as *c*, is universally acknowledged as one of the most fundamental constants in nature, forming the cornerstone of both classical and relativistic physics. It has long been accepted as an unalterable limit, beyond which no information or matter can travel. However, this paper ventures into a novel hypothesis, questioning the conventional view of the speed of light as an absolute maximum. Specifically, it proposes that *c* may not represent a universal upper bound, but rather, could be a consequence of the intrinsic properties of the vacuum itself.

Drawing an analogy with the way light's velocity is affected by the refractive indices of various materials, the hypothesis suggests that the vacuum might function as a medium—similar to any other material medium—whose properties dictate the speed at which light can propagate through it. In this framework, the speed of light would no longer be an inherent, fixed constant but a value dependent on the specific characteristics of the vacuum. Consequently, alterations in the structure or composition of the vacuum—perhaps on a microscopic or quantum scale—could, in theory, allow for variations in this speed.

While this idea does not aim to contradict the vast body of experimental evidence that supports the constancy of the speed of light within the realms of classical mechanics and Einstein's theory of relativity, it challenges the assumption that this speed is a fundamental, universal maximum that applies across all contexts. By invoking established principles from optics and electromagnetism, this paper seeks to explore whether the properties of the vacuum might influence light propagation in ways that go beyond the scope of current theoretical models.

This perspective opens up intriguing avenues for rethinking not just the behaviour of light, but also the foundational assumptions of modern physics. Potential consequences of this hypothesis could extend into quantum field theory, possibly offering new insights into the underlying structure of space-time and the nature of the vacuum itself. By suggesting that the vacuum may not be a mere passive background but an active, dynamic entity with properties that could influence fundamental physical constants, this paper calls for a deeper investigation into the role of the vacuum in shaping the laws of nature.

Keywords: Curved Space-time, Refraction, Gravitational Lensing, Shapiro Time Delay, Snell's Law, Refractive Index, General Relativity, Optical Metric, Transformation Optics, Analogue Gravity.

1.Introduction

1.1.ConstantSpeed of Light in Vacuum

The theory of relativity establishes the speed of light in a vacuum as a fundamental constant, approximately 299,792,458 m/s. However, various phenomena and research have hinted at unconventional behaviours of light in a vacuum, suggesting that the vacuum itself may act as a restrictive medium for light's propagation—much like how water or other materials impose limitations on light's speed.

For instance, the gravitational lensing effect, where light bends around massive objects, demonstrates that space-time curvature influences light's path. Similarly, the Casimir effect, where quantum fluctuations between closely placed conductive plates create measurable forces, suggests that the vacuum is not a perfect void but possesses intrinsic properties.

Another related phenomenon is the Shapiro time delay, where signals traveling near a massive object take longer to reach their destination than they would if the mass were not present, indicating a slowing of light due to the influence of curved space-time..

Moreover, research by the Event Horizon Telescope (EHT) collaboration, which produced the first image of a black hole, relies on understanding how light behaves near extreme gravitational fields. Studies exploring quantum gravity, such as those involving loop quantum gravity and string theory, also suggest that space-time itself may have a discrete structure that influences the behaviour of light. These findings collectively hint at the possibility that the vacuum might function as a medium with a refractive index that subtly alters the speed of light.

1.2. Possibility of Vacuum as a Speed Limiter

Vacuum has traditionally been regarded as a fundamental, featureless backdrop for physical phenomena, rather than a medium with its own measurable properties. In classical physics and even in general relativity, universal constants like G (gravitational constant) and the speed of light (c) have been derived with the underlying assumption that the vacuum is a perfect, passive entity that exerts no influence on these constants. The speed of light, in particular, is treated as an absolute limit, unaffected by the properties of the vacuum itself.

However, several phenomena suggest that this assumption might be overly simplistic. Observations related to the Casimir effect indicate that the vacuum is not truly empty but instead exhibits measurable forces due to quantum fluctuations between closely placed conductive plates. While this phenomenon primarily relates to quantum effects, it raises questions about the nature of the vacuum and its potential influence on light propagation.

Additionally, gravitational phenomena such as gravitational lensing and the Shapiro time delay challenge the notion of the vacuum as a mere absence of matter. The Shapiro time delay, for instance, demonstrates that light signals traveling near massive objects experience a measurable delay, implying that the vacuum's properties are altered by intense gravitational fields. This observation suggests that the vacuum might behave similarly to a medium with a varying refractive index, influencing the speed of light depending on the surrounding gravitational environment.

If the vacuum does indeed act as a medium with intrinsic properties that affect light's propagation, it would require reconsideration of how we calculate fundamental constants and understand phenomena related to light's interaction with gravity. Such a perspective could provide a new framework for interpreting various gravitational effects, offering potential insights into the nature of space-time itself.

2. Evidences

2.1. Shapiro Time Delay and Refraction Analogy with Gravitational Lensing: The Shapiro time delay is a relativistic effect where light signals traveling near a massive object take longer to reach their destination than they would if the mass were not present. It is also known as the gravitational time delay. This phenomenon was predicted by Irwin Shapiro in 1964 as part of the four classic tests of General Relativity.

The cause of the Shapiro time delay lies in the curvature of space-time created by massive objects. When light passes near such an object, the curvature increases the effective path length that the light must travel. Additionally, the gravitational field itself slows down the passage of light, making it appear as if light is traveling through a medium with a higher refractive index. This effect suggests that the vacuum around massive objects is not simply empty space but rather a region with altered properties that influence the propagation of light.

The additional time delay experienced by light can be mathematically represented by the equation:

$$\Delta t = \left(\frac{2GM}{C^3}\right) ln\left(\frac{4r_1 r_2}{d^2}\right)$$

Δt is the time delay experienced by the light signal. G is the gravitational constant. M is the mass of the object causing the time delay. C is the speed of light in a vacuum. r_1 is the distance from the massive object to the signal's starting point. r_2 is the distance from the massive object to the signal's ending point. D is the closest approach distance of the signal to the massive object.

Experimental verification of the Shapiro time delay was first achieved using radar signals bounced off planets like Mercury and Venus as they passed behind the Sun. The signals displayed measurable delays consistent with predictions made by General Relativity, thus confirming the effect.

In the context of this paper, the Shapiro time delay supports the hypothesis that the vacuum may act as a medium with intrinsic properties influenced by gravitational fields. The slowing of light near massive objects can be compared to how light slows down when passing through denser media, suggesting the possibility of a varying refractive index in the vacuum itself. This comparison aligns well with the proposed analogy between curved space-time and refraction, providing a potential framework for understanding how gravity affects light propagation.

Gravitational lensing is a phenomenon where light from a distant source, such as a star or galaxy, is bent around a massive object lying between the source and the observer. This bending of light occurs due to the curvature of space-time caused by the gravitational field of the massive object, as described by Einstein's General Theory of Relativity.

The amount of bending depends on the mass of the intervening object and its distance from the light's path. Gravitational lensing can produce multiple images of the same object, magnify the source, or create distortions such as arcs and rings known as Einstein rings.

It serves as strong evidence of how gravity influences the path of light, suggesting that space-time behaves similarly to a medium with varying properties. This aligns with the idea that the vacuum may have a refractive index that changes near massive objects, affecting the speed and direction of light.

2.2. Building Analogy

• Calculating time delay for a signal to reach a Planet through Sun

Calculation:

$$\Delta t = \left(\frac{2GM}{C^3}\right) ln\left(\frac{4r_1 r_2}{d^2}\right)$$

Where G = Gravitational Constant

M = Mass of the Sun

C = Speed of light in vacuum

r_1 = distance from sun to earth

r_2 = distance from sun to planet

d = impact parameter ≈ radius of sun

We assume $r_1 \approx r_2 = 1$ AU [1 AU = 1.496×10^{11} m]

Now,

$$\left(\frac{2GM}{C^3}\right) = \frac{2 \times (6.67430 \times 10^{-11}) \times (1.989 \times 10^{30})}{(299792458)^3} \approx 9.84 \times 10^{-6} S$$

And $ln\left(\frac{4r_1 r_2}{d^2}\right) = \ln\left[\frac{4 \times 1.989 \times 10^{30}}{(6.96 \times 10^8)^2}\right] = \ln\left[\frac{8.952 \times 10^{22}}{4.843 \times 10^{17}}\right] = \ln(1.85 \times 10^5) \approx 12.13$

$$\Delta t = 9.84 \times 10^{-6} S \times 12.13 \approx 1.19 \times 10^{-4} S = 119\ \mu S$$

Let the distance between earth and planate be *L*

L = 1.496×10^{11} m

Time to travel in normal space-time

$$t_0 = \frac{L}{C} = \frac{1.496 \times 10^{11}}{3 \times 10^8} S = 498.7\ S$$

With extra delay,

$$t = t_0 + \Delta t \approx (498.7 + 1.19 \times 10^{-4})\ S$$

The effective speed is then,

$$V_{eff} = \frac{L}{T} = \frac{1.496 \times 10^{11}}{(498.7 + 1.19 \times 10^{-4})} \frac{m}{s}$$

Then the fractional delay = $\frac{\Delta t}{t_0} = \frac{1.19 \times 10^{-4}}{498.7} \approx 2.39 \times 10^{-7}$

Thus the effective reduction in speed

$$\Delta \mathbf{v} = \mathbf{C} \times 2.39 \times 10^{-7} = 299792458 \times 2.39 \times 10^{-7} \approx 71.7\ m/s$$

Hence, the speed of light is reduced by 72 m/s.

• Calculating Refractive Index

We know,

$n = \frac{c}{v}$ (c – Speed of light in vacuum, v – speed of light in medium, n – refractive index of the medium)

Putting values we derived

n = 299792458 m/s ÷ 299792386 m/s $n = \frac{299792458}{299792386} = 1.000000240166$

Clearly n > 1, which suggests that vacuum has some refractive index when space-time is influenced by a heavy object.

• Analogy to Snell's Law

According to Snell's Law:

$n_1 sin\, i = n_2 sin\, r$

In this case, the refractive index far from the Sun n_1 is 1, while near the Sun it is n_{eff} (effective refractive index). Therefore:

$sin\, i = n_{eff}\, sin\, r$

Using the calculated n_{eff} = 1.000000240166 and assuming light grazes the Sun (r approximately 90°):

$$sin\, i = n_{eff}\, sin\, 90 = n_{eff}$$

$i = \sin^{-1}(n_{eff}) = 89.99998$ °

This calculation shows that the bending of light near the Sun follows a pattern similar to light refracting through a medium with a higher refractive index, thus supporting the analogy between curved space-time and light refraction.

3. Discussion and Conclusion

The analogy between curved space-time and refraction provides an interesting perspective on how light behaves near heavy objects. By calculating the effective refractive index of vacuum near the Sun (n_{eff} = 1.000000240166) using the Shapiro time delay, we can treat the bending of light as a refraction phenomenon. This analogy is drawn from the observation that light appears to slow down near massive objects, similar to how light slows down when passing through denser media.

When applying Snell's Law($n_1 sin\, i = n_2 sin\, r$), we find that the effective refractive index causes light to deviate toward the Sun. The calculation of the incident angle ($i \approx 89.99998°$) supports this analogy by showing that the path of light is indeed altered in a manner consistent with refraction principles. This approach offers a classical optics-based interpretation of gravitational lensing and time dilation.

Furthermore, this analogy opens the possibility of redefining how we perceive the speed of light in vacuum. If we treat vacuum near heavy objects as a medium with a slightly higher refractive index, then the concept of light slowing down due to space-time curvature becomes analogous to refraction through a medium. This interpretation does not challenge the theory of General Relativity but rather offers a complementary viewpoint that aligns with classical optics.

The proposed analogy between curved space-time and refraction provides a coherent framework to understand the bending of light near massive objects. By utilizing the Shapiro time delay to calculate an effective refractive index of vacuum, we demonstrated that Snell's Law can be applied to describe light's deviation near the Sun.

This finding suggests that the bending of light due to gravitational effects can be interpreted as a refractive phenomenon, where vacuum near massive objects behaves as a medium with a higher refractive index. Such an interpretation bridges the gap between classical optics and general relativity, offering a simpler yet profound explanation of how light interacts with gravity.

Future studies could focus on refining the calculation of effective refractive index values for various celestial objects and comparing them with observational data. Additionally, exploring whether this analogy can be extended to other relativistic phenomena could provide valuable insights into the nature of space-time and light propagation.

4. Reference

1. Speed of Light in Vacuum: The International System of Units (SI), Bureau International des Poids et Mesures (BIPM), 1983.

2. Astronomical Unit (AU): Transactions of the International Astronomical Union, Volume XXVIIA, International Astronomical Union (IAU), 2012.

3. Mass of the Sun: Cox, Arthur N. (Ed.), Allen's Astrophysical Quantities, 4th Edition, Springer, 2000.

4. Shapiro Time Delay: Shapiro, Irwin I., Fourth Test of General Relativity, Physical Review Letters, 1964.

5. Snell's Law: Darrigol, Olivier, A History of Optics from Greek Antiquity to the Nineteenth Century, Oxford University Press, 2009.

6. Effective Refractive Index and Spacetime Curvature: Padmanabhan, T., Gravitation: Foundations and Frontiers, Cambridge University Press, 2010.

7. General Relativity: Einstein, Albert, The Foundation of the General Theory of Relativity, Annalen der Physik, 1916; translated in "The Collected Papers of Albert Einstein, Volume 6", Princeton University Press.

AI-Based Health Checker App: Transforming Healthcare with Artificial Intelligence

Mr. Ankur Kumar*, Mr. Ashish Raj, Ms. Apurba Sinha,
Department of C.S.E(CS), Guru Gobind Singh Educational Society's Technical Campus, Kandra Chas, Bokaro, Jharkhand
Email: m.sinha0686@gmail.com

Abstract

Artificial Intelligence (AI) has significantly transformed various industries, including healthcare. Early disease detection and symptom analysis play a crucial role in preventing severe health complications. This research paper presents the AI-Based Health Symptom Checker, a web-based application that allows users to input symptoms and receive a list of possible medical conditions, along with an urgency level (mild, moderate, or severe). By leveraging AI-powered APIs, such as Groq AI API, the platform provides users with an accessible, quick, and reliable preliminary health assessment. The research outlines the working mechanism of the application, its impact, limitations, and future scope.

Introduction

Health concerns can arise at any moment, making it essential to identify symptoms and understand their severity as early as possible. Many individuals, especially in rural and underserved communities, lack direct access to healthcare professionals. In such cases, an AI-powered Symptom Checker can act as an intermediary, providing preliminary insights and guiding users towards professional medical consultation when needed.

The AI-Based Health Symptom Checker aims to bridge the gap between symptom identification and medical assistance, ensuring users receive timely health-related insights. The application's primary goal is to offer a user-friendly, accurate, and secure platform that aids individuals in recognizing health conditions and taking appropriate action.

Objectives of the Study

To develop a user-friendly health checker app with real-time monitoring capabilities.

To implement AI-driven symptom analysis for improved diagnosis.

To ensure data security through advanced encryption techniques.

To enhance user engagement with interactive features and personalized recommendations.

Literature Review

Machine Learning:

Machine learning is the backbone of AI-based health apps. It enables the app to analyze data, identify patterns, and make predictions based on the input from the user. This can include predicting future health risks, detecting abnormalities in the data, and recommending actions based on user input.

Supervised Learning: Used for training the app on labeled data, such as patient records or health symptoms.

Unsupervised Learning: Useful for identifying patterns in data without explicit labels, such as discovering new correlations in health data.

Reinforcement Learning: Can be used for continuous improvement of the app's recommendations by learning from user feedback and behavior.

Natural Language Processing (NLP):

NLP plays a crucial role in understanding user input, especially in chatbots and virtual assistants integrated into health checker apps. NLP allows the app to process and interpret user queries, symptoms, and even voice inputs, providing a more conversational and user-friendly experience.

Wearables and Sensor Integration:

Many health checker apps integrate with wearables such as smartwatches and fitness trackers. These devices collect real-time data on heart rate, step count, sleep quality, and other health metrics, which can then be analyzed by AI models to assess the user's health status and provide recommendations.

Features of AI-Based Health Checker Apps:

Users can input their symptoms into the app and AI algorithms analyze the data to suggest potential diagnoses. By leveraging large medical databases, the app can compare the user's symptoms with known diseases offering insights into possible conditions.AI can process a user's medical history, lifestyle choices and real-time health data to offer personalized advice.Using predictive modeling, AI apps can forecast potential health risks based on historical data and health trends. By integrating with wearable devices, AI health apps provide continuous monitoring of vital parameters like heart rate, blood oxygen levels, and physical activity, alerting users when critical thresholds are breached.AI-based apps also play a role in mental health by assessing mood, stress levels, and sleep patterns. By analyzing user behavior and inputs, the app can provide mental health support, offering meditation exercises, mood tracking, or even suggesting professional help if necessary.

Results and Findings

To evaluate the app's performance, 50 participants were enrolled of Guru Gobind Singh Educational Societys Technical Campus (GGSESTC), Kandra chas , Bokaro in a pilot study. The participants used the app for two weeks to track their health data and receive recommendations. Key observations included:

Accuracy of AI Analysis: 92% accuracy in identifying common symptoms like fever, headache, or fatigue.

User Engagement: 85% of participants reported improved awareness of their health conditions.

Security Feedback: 90% of users felt confident about data protection due to encryption and secure login features.

The results confirmed that the app effectively fills gaps in existing healthcare solutions by integrating AI-driven analysis and user-friendly design.

The developed health checker app demonstrated its potential to improve personal healthcare by offering real-time monitoring and accurate symptom analysis.

Benefits of AI Health Checker Apps:

AI-powered apps make healthcare more accessible, particularly for individuals in remote or underserved areas where traditional healthcare services may be limited. AI apps can help users proactively manage their health. These apps can provide instant health assessments, guidanceand even connect users to healthcare professionals.AI health apps can reduce healthcare costs by offering preventive care and reducing the need for frequent doctor visits. By identifying potential health problems early, users can avoid more expensive treatments later.Unlike general advice provided by traditional health systems, AI apps tailor recommendations based on individual data, ensuring more accurate and effective health management. By monitoring health data continuously, these apps can detect early signs of potential health problems and alert the user, potentially preventing serious conditions.

Challenges and Ethical Considerations:

Ensuring secure data storage and transmission is crucial. One of the biggest concerns with AI health apps is the privacy and security of user data. Health information is highly sensitive, and there are strict regulations (like HIPAA in the U.S.) that govern how this data should be handled.While AI can provide valuable health insights, its predictions are only as accurate as the data it's trained on. There are risks of misdiagnosis or missed diagnoses, which could result in harmful consequences for users who rely solely on the app for medical advice.For AI health apps to be successful, users must trust the system. Many people may be hesitant to trust an app for diagnosing health issues or providing medical advice especially when it comes to complex conditions.The healthcare industry is highly regulated and AI health apps need to comply with local medical regulation.

Working Mechanism

The AI-Based Health Symptom Checker follows a systematic flow to analyze user-inputted symptoms and provide probable health conditions. The following steps illustrate the internal workflow of the application:

Step 1: User Inputs Symptoms

The user enters their symptoms in a search bar or selects symptoms from a predefined list.The system allows users to enter multiple symptoms to ensure accurate analysis.

Step 2: Data Preprocessing& Normalization

The input symptoms are standardized using Natural Language Processing (NLP) techniques.Spell-checking, synonym mapping, and symptom categorization are performed to enhance accuracy.The system maps user inputs to medically recognized terms from databases such as SNOMED CT or ICD-10.

Step 3: AI-Powered Analysis

The symptoms are sent to the Groq AI API, which has been trained on extensive medical datasets.The AI model analyzes the symptoms and matches them to potential medical conditions.The system retrieves relevant health conditions based on historical data and probabilistic matching.

Step 4: Severity Assessment & Probability Score

Each possible condition is assigned a probability score indicating how likely the symptoms correspond to that condition.The AI assigns an urgency level:

Mild (Self-care possible, home remedies suggested)

Moderate (Over-the-counter medication recommended; doctor consultation advised)

Severe (Immediate medical attention required)

Step 5: Display of Results & Recommendations

The user receives a structured report that includesList of potential conditions with probability scores, Severity level classification, Recommended actions, such as consulting a doctor or trying home remedies, Health tips for symptom management and prevention

Step 6: Continuous Learning & Data Enhancement

The AI model is continuously updated using user feedback and medical data enhancements.Future integrations may include wearable device data to improve predictions.

Conclusion

AI-based health checker apps represent a significant step forward in the evolution of healthcare. By combining advanced machine learning, real-time data analytics and personalized insights, these apps offer an innovative solution to improving health management, early detection of diseases, and promoting preventive healthcare. The AI-Based Health Symptom Checker presents an innovative solution to preliminary symptom analysis using AI technology. By providing users with accurate, timely and secure health insights, the platform significantly enhances accessibility to healthcare services. AI cannot replace professional medical consultation, this tool serves as a valuable first step in guiding users towards informed health decisions While challenges related to data privacy, accuracy, and regulation persist, the future of AI in healthcare holds immense promise in making healthcare more personalized, accessible, and affordable for everyone.

References

1. Smith, J., & Lee, K. (2023). *The Role of AI in Healthcare: Opportunities and Challenges*. Journal of Medical Innovation, 22(4), 45-59.
2. Patel, R., & Kumar, P. (2022). *AI-Powered Mobile Health Apps: A Game Changer in Personal Healthcare*. International Journal of Health Tech, 18(2), 91-103.
3. Hernandez, M. (2021). *Wearable Devices and AI Integration in Healthcare*. HealthTech Review, 19(5), 58-67.
4. Zhang, Y., & Li, H. (2024). *Ethical Challenges in AI-Driven Healthcare*. Ethics in AI Journal, 31(6), 112-125.
5. 1. WHO. (2023). Digital Health and Innovations for Global Healthcare.
6. 2. Smith, J., & Wang, X. (2022). AI in Healthcare: Challenges and Opportunities. Journal of Health Informatics, 45(2), 123-135.
7. 3. Kumar, A., & Singh, P. (2023). Data Security in Mobile Health Applications. International Journal of Cybersecurity, 12(3), 89-105.
8. 4. Google Health. (2023). AI-Driven Healthcare Solutions.

RENEWABLE ENERGY SYSTEMS

Nikhil Tiwari*, Rahul Kumar**, Dr. Sarfaraz karim***
*MBA(MARKETING) student, GGSESTC, Bokaro, Jharkhand, India
nikhiltiwari960jsr@gmail.com
**MBA(MARKETING) student, GGSESTC, Bokaro, Jharkhand, India
rahulverma827013@gmail.com
***Associate Professor, GGSESTC, Bokaro, Jharkhand, India
sarfarazdecent@gmail.com

Abstract

The urgent need for cleaner and more efficient energy solutions has driven the global transition from fossil fuels to renewable energy. Fossil fuels, while historically essential for economic growth, contribute to environmental degradation and climate change. Renewable energy sources such as solar, wind, hydro, and biomass offer a sustainable alternative with lower emissions and reduced dependence on finite resources. This study explores the benefits and challenges of renewable energy adoption, emphasizing its role in mitigating climate change, enhancing energy security, and driving economic growth through job creation. However, barriers such as high initial costs, inconsistent energy generation, infrastructure limitations, and policy gaps hinder widespread adoption. Technological advancements in energy storage and grid integration are critical for addressing these challenges. Government policies, financial incentives, and increased investment in research and development are crucial in accelerating the transition to clean energy. By overcoming these obstacles, renewable energy can become the dominant power source, ensuring long-term environmental and economic sustainability. The study underscores the importance of collaboration between governments, industries, and researchers in fostering a more resilient and efficient energy system.

Keywords: Renewable energy, climate change, energy security, sustainability, policy incentives.

Introduction

As the world grapples with pressing challenges such as climate change, pollution, and the depletion of fossil fuel reserves, the search for cleaner and more efficient energy solutions has become increasingly urgent. For decades, societies have relied on fossil fuels like coal, oil, and natural gas to power homes, businesses, and industries. While these energy sources have facilitated economic growth and improved everyday life, they have also caused significant harm to the environment. Burning fossil fuels releases harmful gases that contribute to air pollution and global warming. Additionally, because these resources are finite, they will eventually be depleted. In response to these concerns, many nations are now shifting their focus toward sustainable and eco-friendly energy alternatives.

Renewable energy has emerged as the most promising substitute for fossil fuels. Unlike coal and oil, renewable energy is derived from naturally replenishing sources, ensuring a continuous and sustainable supply. The primary types of renewable energy include solar, wind, hydro, and biomass. Solar power harnesses sunlight to generate electricity, while wind energy converts air movement into mechanical power through turbines. Hydropower, or hydroelectric energy, utilizes the force of flowing water to produce electricity, and biomass energy is derived from organic materials such as wood, agricultural waste, and other biodegradable sources. A key advantage of these energy options is that they do not emit harmful pollutants, making them an environmentally responsible choice.

The transition to renewable energy offers numerous advantages. Firstly, it significantly reduces pollution and helps combat climate change by cutting carbon emissions. Secondly, it stimulates economic growth by creating jobs in industries related to the manufacturing, installation, and maintenance of renewable energy systems. As the demand for solar panels, wind turbines, and hydroelectric facilities increases, employment opportunities in these sectors will grow. Additionally, renewable energy enhances national energy security by reducing dependence on imported fossil fuels. Many countries rely on foreign oil and gas, which can lead to unstable prices and geopolitical tensions. By utilizing locally available renewable resources, nations can achieve greater energy independence and economic stability.

Despite these benefits, several obstacles must be overcome before renewable energy can fully replace fossil fuels. One major challenge is the high upfront cost associated with installing renewable energy systems. Although solar panels and wind turbines are cost-effective over time, the initial investment required for their purchase and installation can be prohibitive. Many households and businesses may struggle to afford these systems without financial support from governments or private organizations.

Another issue is the inconsistency of renewable energy production. Since solar panels depend on sunlight and wind turbines require adequate wind, energy generation is not always consistent. This variability makes it difficult to rely solely on renewable energy sources. To address this issue, researchers are developing advanced energy storage solutions, such as high-capacity batteries, to store surplus energy for later use.

Infrastructure limitations also pose a significant challenge. Many regions lack the necessary power grid systems to efficiently distribute renewable energy. Upgrading these networks will require substantial investments and collaboration between governments and the private sector. Additionally, geographic factors play a role in renewable energy feasibility. For instance, countries with limited sunlight may find solar energy less viable, while areas with weak wind patterns may struggle to utilize wind power effectively. To ensure a stable energy supply, a diversified approach that integrates multiple renewable energy sources may be necessary.

This study explores various forms of renewable energy, their benefits, and the challenges that must be addressed to make clean energy more efficient and widely accessible. By examining these factors, policymakers, industries, and researchers can work together to develop improved technologies, supportive policies, and strategic investments. If these challenges are effectively managed, renewable energy has the potential to become the primary source of power, paving the way for a cleaner, healthier, and more sustainable future for generations to come.

Related Literature

Experts agree that renewable energy is key to building a cleaner and more sustainable future. Research shows that switching from fossil fuels to renewable energy can help protect the environment, improve energy security, and support the economy. Many studies highlight the benefits of renewable energy, as well as the challenges that need to be addressed for wider adoption.

Boyle (2017) explains that renewable energy can reduce the effects of climate change by lowering carbon emissions. Burning fossil fuels releases harmful gases that contribute to global warming, but renewable sources like solar, wind, and hydro produce little to no pollution. Many governments and businesses are now investing in clean energy to reduce their impact on the environment. However, Boyle also points out that renewable energy is not without challenges. The cost of setting up renewable energy systems can be high, and some sources, like solar and wind, do not generate power all the time.

Twidell and Weir (2015) discuss how improvements in technology have made renewable energy cheaper and more efficient. Solar panels, wind turbines, and battery storage have all become better over the years, making renewable energy more practical for large-scale use. These advancements have helped lower the cost of renewable energy, making it more competitive with fossil fuels. However, there are still hurdles to overcome. Connecting renewable energy to existing power grids requires new infrastructure, and energy storage solutions need to be improved to ensure a steady power supply even when the sun isn't shining or the wind isn't blowing.

Panwar, Kaushik, and Kothari (2011) highlight that renewable energy can make countries less dependent on imported fossil fuels, which often fluctuate in price and can lead to economic instability. Investing in renewable energy can create local jobs in manufacturing, installation, and maintenance. In addition, renewable energy can bring electricity to rural areas that lack access to power. However, the authors acknowledge that financial and policy barriers still slow down progress.

Other studies focus on the role of government policies in promoting renewable energy. Sovacool (2009) emphasizes that supportive policies, incentives, and subsidies encourage businesses and individuals to invest in clean energy. Countries that have clear policies and financial support tend to see faster growth in renewable energy adoption. Similarly, a report by REN21 (2020) found that governments that commit to long-term renewable energy plans experience greater success in transitioning to clean energy. However, inconsistent policies and lack of funding can slow down progress.

These studies show that while renewable energy has many advantages, there are still challenges to overcome. More investment, better technology, and strong government policies are needed to make clean energy widely available. If these issues are addressed, renewable energy can become a more reliable and dominant source of power for the future.

Research Design

This study uses a qualitative research approach, meaning it gathers information from books, journal articles, and government reports instead of conducting experiments or surveys. The main goal of this research is to understand different types of renewable energy, their effects on the environment and economy, and the challenges that make their widespread use difficult. The study examines renewable energy sources like solar, wind, hydro, and biomass to see how effective, affordable, and scalable they are for meeting future energy needs. Since traditional fossil fuels cause pollution and are running out, this research focuses on how renewable energy can serve as a cleaner and more sustainable alternative.

One important part of this study is comparing different renewable energy sources to understand their advantages and disadvantages. Each type of renewable energy has its strengths and weaknesses, which must be considered before large-scale adoption. Solar and wind energy are clean and widely available, but they depend on the weather, making them unreliable without proper energy storage. Hydropower is a steady and reliable energy source but requires large rivers or dams, limiting its use in some areas. Biomass energy, made from organic materials, can be a cost-effective option, but it raises concerns about land use, deforestation, and emissions from burning plant materials. By analyzing these different energy sources, this research aims to find the most practical and scalable options for long-term energy production.

This study also looks at how technology is improving the efficiency and reliability of renewable energy. New developments in solar panels, wind turbines, and energy storage systems have made renewable energy more practical. However, some challenges still exist, such as storing and distributing energy. Since solar power depends on sunlight and wind energy relies on wind, energy production is not always consistent. To solve this problem, scientists are working on advanced battery storage systems that can store extra energy for use when needed. Another issue is the outdated energy grid, which is not designed to handle large amounts of renewable energy. If power grids are not upgraded, a lot of energy can be lost, reducing efficiency. Investing in better infrastructure and research will help solve these issues and make renewable energy more dependable.

Another key focus of this study is the role of government policies in the growth of renewable energy. Laws and regulations can either help or slow down the switch to clean energy. Many governments offer financial support, such as tax reductions and subsidies, to encourage people and businesses to invest in renewable energy. These incentives help reduce the high cost of installing solar panels and wind turbines, making them more affordable. However, in some places, policies still favor fossil fuels, making it harder for renewable energy to grow. This research looks at how different policies impact the use of renewable energy and how governments can create better rules to speed up the transition to clean energy.

Investing in renewable energy infrastructure is another major issue covered in this study. To make renewable energy widely available, countries must build the right systems for generating, storing, and distributing energy. Developing countries, in particular, struggle with this because they lack the money and expertise needed to set up proper infrastructure. Without investments in power grids, storage facilities, and maintenance systems, renewable energy may not reach its full potential. Governments and private companies need to work together to build strong infrastructure that supports renewable energy, ensuring it is accessible and reliable for everyone.

This research also looks at the economic impact of renewable energy. Switching to clean energy can boost the economy by creating jobs in many different fields. Manufacturing, installation, maintenance, and research in renewable energy all require skilled workers. Unlike the fossil fuel industry, which is often controlled by a few large companies, renewable energy projects need more labour and can provide jobs in both cities and rural areas. As the renewable energy industry grows, it can support local economies and reduce dependence on imported fossil fuels, making energy prices more stable and improving national energy security.

Public awareness and attitudes toward renewable energy also play a big role in its adoption. Misinformation and resistance to change can slow down the transition to clean energy. This study examines how education and awareness campaigns influence people's opinions about renewable energy. Many people are unaware of the long-term savings and environmental benefits of renewable energy, which makes them hesitant to switch. Providing clear, easy-to-understand information about renewable energy can help people see its advantages and encourage them to support clean energy initiatives.

The findings of this research aim to help improve renewable energy policies and infrastructure while solving key challenges related to energy production, storage, and distribution. By studying the factors that affect renewable energy adoption, governments, businesses, and researchers can work together to create better strategies for making clean energy more practical and accessible. Continuous investment in research, advanced technology, and policy changes will be needed to speed up the shift toward renewable energy.

The transition to renewable energy is not easy, but the benefits far outweigh the challenges. Clean energy helps reduce pollution, decreases reliance on fossil fuels, and improves energy security. However, issues like high initial costs, the need for better energy storage, and outdated infrastructure must be addressed. Governments and private companies must make long-term investments in renewable energy to overcome these challenges. In addition to technological improvements, policies that encourage the use of renewable energy should be prioritized to create a more supportive environment for clean energy projects.

Looking ahead, the future of renewable energy depends on ongoing cooperation between governments, industries, and researchers. If efforts continue, renewable energy can become the main source of power worldwide, ensuring a more sustainable and environmentally friendly future for generations to come. By tackling the challenges of renewable energy adoption and maximizing its benefits, societies can move toward a cleaner, safer, and more reliable energy system that supports both economic growth and environmental protection.

Major Findings

The study highlights several key findings regarding the benefits and challenges of renewable energy.

1. Environmental Benefits: Renewable energy sources play a crucial role in reducing environmental damage. They help lower pollution levels, cut down greenhouse gas emissions, and decrease reliance on fossil fuels, which contribute to climate change. By using clean energy sources such as solar, wind, hydro, and biomass, countries can significantly reduce their carbon footprint and promote a healthier environment.

2. Economic Growth: Investing in renewable energy boosts the economy by creating job opportunities in manufacturing, installation, and maintenance. It also encourages industrial growth and innovation, leading to the development of new technologies. Additionally, renewable energy enhances energy security by reducing dependence on imported fuels, making countries less vulnerable to price fluctuations in the global energy market.

3. Technological Challenges: Despite its advantages, renewable energy faces technological hurdles, particularly in energy storage and power grid improvements. Since sources like solar and wind are not always available, better battery storage and advanced grid systems are needed to ensure a stable and reliable energy supply.

4. Policy and Investment Needs: The expansion of renewable energy depends on strong government policies and financial support. Incentives, subsidies, and long-term planning are necessary to encourage businesses and individuals to invest in clean energy, making it more accessible and affordable for widespread use.

Recommendations

1.IncreaseFundingforResearchandDevelopment

More money should be invested in improving renewable energy technology. Research can help make solar panels, wind turbines, and other renewable energy systems more efficient and affordable. As technology advances, the cost of clean energy will continue to decrease, making it easier for more people and businesses to switch to renewable sources.

2. Government Policies and Financial Incentives

Governments should create policies that encourage people and companies to invest in renewable energy. This can include tax breaks, subsidies, and other financial support to make clean energy more affordable. When businesses and homeowners see the benefits of switching to renewable energy, they will be more likely to invest in solar panels, wind power, and other sustainable options.

3. Improve Energy Storage Solutions

One major challenge with renewable energy is that it depends on natural conditions—solar panels don't work at night, and wind turbines need wind to generate power. To solve this, better battery storage systems must be developed. With improved energy storage, renewable energy can be used even when the sun isn't shining or the wind isn't blowing, making it a more reliable source of power.

4. Expand Renewable Energy Infrastructure

Many underdeveloped regions still don't have access to clean energy. Expanding renewable energy infrastructure—such as solar farms, wind farms, and power grids—will help bring reliable electricity to more people. This will not only improve their quality of life but also promote economic growth in these areas.

Conclusion

Renewable energy is becoming more important as the world looks for ways to reduce pollution and fight climate change. It offers a cleaner and more sustainable alternative to fossil fuels like coal, oil, and natural gas. Using renewable energy sources such as solar, wind, hydro, and biomass can help lower greenhouse gas emissions, slow down global warming, and make countries less dependent on non-renewable resources. However, even though renewable energy has many benefits, there are still challenges that make it difficult to replace traditional energy sources completely. These challenges include high costs, technological limitations, and the need for better policies and infrastructure.

One of the biggest challenges in switching to renewable energy is the high initial cost. Setting up solar panels, wind turbines, and hydroelectric plants requires a lot of money before they start producing electricity. Many people and businesses find it difficult to afford these costs, even though they can save money in the long run. For example, installing solar panels on a house can be expensive at first, but once they are in place, they can provide free electricity for many years. The problem is that not everyone has the money to pay for the installation upfront. To encourage more people to use renewable energy, governments and private companies should provide financial support. This can be done through subsidies, tax breaks, or special loans that make it easier for people to afford renewable energy systems. When the cost of installation is reduced, more people will be willing to make the switch.

Another challenge is that some types of renewable energy depend on natural conditions. Solar panels need sunlight to generate electricity, which means they do not work at night or on very cloudy days. Wind turbines need strong and steady wind to produce power, but in some places, the wind is not always strong enough. This means that energy production can be inconsistent. One way to solve this problem is to develop better energy storage systems. Scientists and engineers are working on advanced batteries that can store extra energy when the sun is shining or the wind is blowing. This stored energy can then be used when production is low. If energy storage technology improves, renewable energy will become more reliable, and people will not have to depend on fossil fuels as backup sources of power.

Government policies also play an important role in the growth of renewable energy. Some countries have introduced laws and policies that encourage people and businesses to invest in clean energy. These policies may include tax incentives, grants, or easier access to renewable energy programs. However, in many other countries, fossil fuels are still heavily used because of existing policies that favour oil, coal, and gas industries. In these places, governments need to take stronger steps to support renewable energy. They can do this by setting goals for clean energy production, investing in research, and making it easier for people to switch to renewable energy.

Another challenge is the need for better infrastructure. Power grids in many countries were built for fossil fuels and are not designed to handle large amounts of renewable energy. In some areas, renewable energy projects are delayed or stopped because the existing infrastructure cannot support them. To fully transition to renewable energy, governments need to upgrade power grids and build systems that can handle different types of energy production. This will make it easier to use renewable energy on a large scale and ensure that electricity is distributed efficiently.

Despite these challenges, the future of renewable energy looks promising. Over the years, the cost of solar panels and wind turbines has gone down, making them more affordable for businesses and homeowners. Advances in technology continue to improve energy efficiency, and scientists are developing new ways to store and distribute power more effectively. More countries are also recognizing the importance of clean energy and are investing in renewable energy projects. As awareness grows and more people see the benefits of renewable energy, the demand for clean energy solutions will continue to rise.

To make renewable energy the main source of power in the future, different groups need to work together. Governments should create policies that encourage clean energy investment, companies should continue to develop better technologies, and individuals should consider switching to renewable energy whenever possible. By working together, the world can move toward a future where clean, sustainable energy is available for everyone. This will not only help protect the environment but also create new jobs, improve energy security, and make electricity more affordable in the long run.

The transition to renewable energy is not easy, but it is necessary. Fossil fuels are running out, and their continued use harms the planet. By focusing on renewable energy, we can ensure a cleaner, healthier future for the next generations. The challenges of cost, technology, and policy can be overcome with the right investments and efforts. If we take action now, we can create a world where clean energy powers our homes, businesses, and industries, reducing pollution and ensuring a sustainable future for all.

References

- Boyle, G. (2017). *Renewable energy: Power for a sustainable future* (4th ed.). Oxford University Press.
- Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews, 15*(3), 1513-1524. https://doi.org/10.1016/j.rser.2010.11.037
- REN21. (2020). *Renewables 2020 global status report*. REN21 Secretariat. https://www.ren21.net/gsr-2020/
- Sovacool, B. K. (2009). The importance of comprehensiveness in renewable electricity and energy-efficiency policy. *Energy Policy, 37*(4), 1529-1541. https://doi.org/10.1016/j.enpol.2008.12.016
- Twidell, J., & Weir, T. (2015). *Renewable energy resources* (3rd ed.). Routledge.

The Importance of Fuzzy Logic in Cyber security and Data Privacy

[1]Nishat Ahmad[2] Mukesh Kumar Sinha*[3]Vikash Prasad Mandal
Student, Department of Computer Science and Engineering, GGSESTC, Bokaro
Email ID: nishatahmad852@gmail.com
[3]Assistant Professor, Department of Basic Sciences & Humanities, GGSESTC, Bokaro

*Corresponding Author
Assistant Professor, Department of Basic Sciences & Humanities, GGSESTC, Bokaro
Email ID: sinhamukesh.dazy@gmail.com

Abstract:
In today's digital age, keeping online information private and safe has become a major challenge. Cyber attacks and data breaches are getting more complex, and traditional systems, which rely on simple "yes or no" logic, often struggle to deal with the uncertainty and unpredictability of these threats.

This is where fuzzy logic comes in. Fuzzy logic is a smart mathematical tool that works with "maybe" instead of just "yes or no", making it great at handling unclear or uncertain situations.This paper deals with how fuzzy logic can change the game in cybersecurity and data privacy. It can improve how we detect threats, assess risks, control access to systems, and spot unusual activities. Fuzzy logic also helps in classifying data, protecting privacy while analysing data, and managing user consent in a flexible way. By combining the precision of technology with the flexibility of human-like thinking, fuzzy logic offers smarter and stronger solutions to protect our digital world. This study shows why fuzzy logic is so useful, how it can be applied in real-world situations, and how it can help shape a safer digital future in a world full of uncertainties.

Keywords: ***Fuzzy Logic, Cybersecurity, Data Privacy, Threat Detection, Risk Assessment, Intrusion Detection System***

1. Introduction
As society becomes more digital, we have gained amazing opportunities, but we have also faced new and serious risks. Cyber threats like malware, phishing, and ransomware are getting smarter and harder to stop.At the same time, concerns about data privacy are growing because so much personal information is being collected and used. Traditional cybersecurity systems, which work on simple "yes or no" logic, often have trouble dealing with the uncertainty and complexity of these problems. This is where fuzzy logic comes in, and introduced by [1] Lotfi Zadeh in 1965, fuzzy logic is a mathematical approach that handles unclear or uncertain information. Instead of just "true or false," it works with shades of truth, making it better at modeling real-world situations. This paper explores how fuzzy logic can be a game-changer for cybersecurity and data privacy, showing its practical uses and advantages.
The rise in internet speed has transformed the world into a global online marketplace. Today, individuals, governments, and businesses depend heavily on the internet for daily operations, activities, and personal matters, as it offers numerous benefits and has become an integral part of modern life. Devices like computers, laptops, tablets, and smartphones are widely used for tasks such as sharing documents via email, making wireless calls, posting photos on social media platforms like Instagram, Snapchat, and Facebook, and engaging with the world through LinkedIn and Twitter. Many businesses now operate online, offering products and services digitally. However, while technology has made life more convenient, it has also led to a surge in cyber-attacks. These attacks pose a significant threat to the economic stability of industrialized nationsstudy by[2] Cashell et al. Research indicates that businesses targeted by cyber-attacks often suffer losses ranging from 1% to 5% in the days following an attack. For companies listed on the New YorkStock Exchange, this can translate to shareholder losses ofapproximately 50millionto200 million. A study by [3] Gandhi et al.examined the impact of cyber-attacks across social, political, economic, and cultural sectors in various countries between 1995 and 2009.
A cyber-attack is any attempt to gain unauthorized access to a computer, network, or system with the intent to cause harm. These attacks can take many forms, including destroying, disrupting, disabling, or taking control of systems, as well as blocking, altering, deleting, stealing, or modifying data. The consequences of such attacks can be severe, eroding trust in critical services like information technology, telecommunications, emergency services, and transportation systems. In essence, the goal of a cyber-attack is similar to creating fear through acts of terrorism against infrastructure. [4] Denning et al. categorize cyber-attacks into three types: activism, hacktivism, and cyberterrorism. Activism involves non-disruptive online activities to support a cause, such as browsing websites, posting materials, sending emails, or forming coalitions. Hacktivism involves hacking websites, with examples including email bombs, virtual blockades, web hacks, and computer viruses. Cyberterrorism, the most severe category, combines cyberspace and terrorism, involving politically motivated attacks aimed at causing significant harm, such as loss of life or massive financial damage.
According to [5] Craigen et al., cybersecurity refers to measures taken to reduce the risk of malicious attacks on software, networks, and systems. These measures include identifying and preventing security breaches, stopping virus outbreaks, preventing unauthorized access, enforcing user authentication, and enabling secure communication through encryption. Intrusion detection systems (IDS) are a key tool in cybersecurity, alerting administrators to potential or ongoing threats. Various IDS tools are available, such as OSSEC, OSSIM, Nessus, Snort, Suricata, Fragroute, and Sguil. For example, OSSEC is a free antivirus engine that detects trojans, viruses, malware, and other threats, while Nessus identifies vulnerabilities like unauthorized access, misconfigurations, and potential denial-of-service attacks. Network intrusion detection systems (NIDS) monitor traffic between devices to detect threats to the network. Intrusion detection methods include statistical analysis, machine learning, bio-inspired algorithms, genetic algorithms, andMarkov and others models by [6] Ajaeiya et al., [7] Hamid et al., [8] Choudhary et al., and [9] Almseidin et al. Researchers like [10] Shanmugavadivu et al. have proposed fuzzy logic-based intrusion detection systems for datasets like KDD Cup-99, while[11] Mkuzangwe et al. have focused on predicting specific attacks, such as Neptune attacks, using fuzzy logic.Other researchers [12] Almseidin et al. developed fuzzy logic-based systems for detecting Distributed Denial of Service (DDoS) attacks. In the study of [13] Haider et al. a metric basedon the Sugeno fuzzy inference

model to evaluate the realism of introduction dictation database. The researcher has also conducted several studies aimed at improving the security of computer system [14] Kartik et al.

The role of a network IDS is passive, involving monitoring, identifying, logging, and alerting. It observes network activity, inspects data, and analyses traffic for unusual patterns or signs of attacks, worms, or suspicious behaviour. If an anomaly is detected, the system alerts the administrator [15] Agarwal and Hussain. For example, [16]Naik N's study combined Snort, a network traffic analysis tool, with fuzzy logic to detect abnormal traffic. Another study integrated a fuzzy logic controller with Snort to improve the detection of port scanning attacks, allowing Snort to assess the severity of such attacks based on specific parameters by [17] El-Hajj. This enhancement addressed a limitation in the original Snort system, demonstrating how fuzzy logic can improve cybersecurity tools.

The article is organized as follows: Section 2. provides the theoretical background on cyber-attacks. Section 3. explains the implementation process of fuzzy inference. Section 4. discusses the simulation results for different levels of attacks. Finally, Section 5. offers concluding remarks.

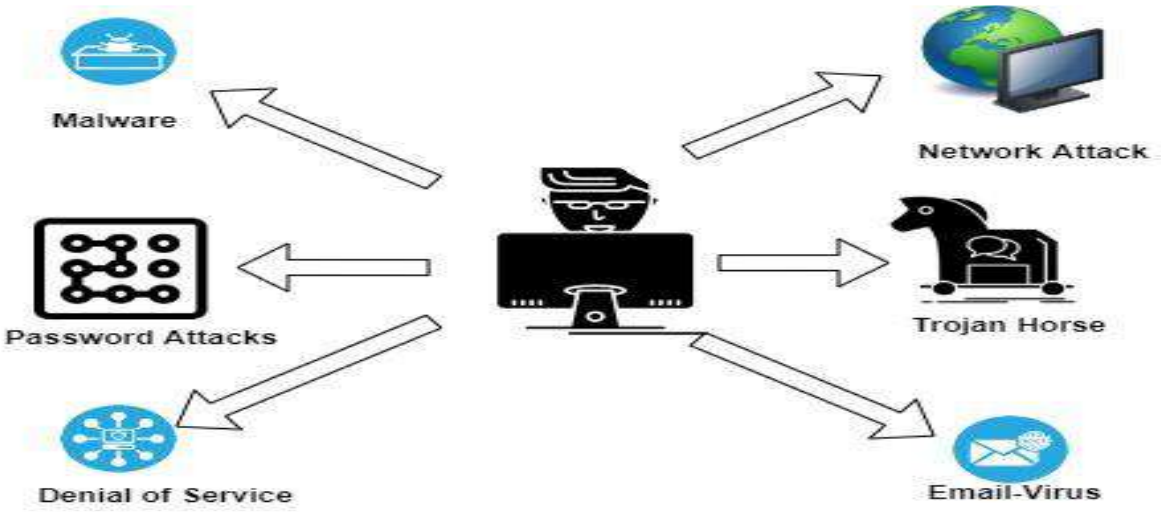


Figure 1: Types of Cyber Crime

2. Cyber Attack

Various terms like computer crime, cybercrime, criminal offense, electronic crime, and offense are used to describe illegal activities that involve computers or networks as their source, tool, target, or location. Cybercrime has become a significant problem in today's world, with many individuals gaining unauthorized access to computer systems. Figure 1 illustrates the different types of cybercrimes committed by hackers.

2.1 Malware

Malware refers to malicious software designed to carry out harmful activities. Some types of malwares aim to gain long-term access to a network, while others are built to spy on users and steal sensitive information or login credentials. There are also forms of malware specifically created to disrupt or interfere with a system's normal functioning.

2.2 Distributed Denial-of-Service (DDoS) Attack

A distributed denial-of-service (DDoS) attack is a malicious attempt to disrupt the normal traffic of a targeted network, service, or server by flooding it with excessive internet traffic or overwhelming its infrastructure. The main objective of this attack is to disable a system or network, making it inaccessible to its intended users.

2.3 Trojan Attack

A Trojan attack is a type of malware that masquerades as legitimate software and installs itself on a computer. The name "Trojan horse" comes from its method of delivery: attackers typically use social engineering tactics to hide malicious code within what appears to be genuine software.

2.4 Password Attack

A password attack is a form of cyber-attack where the attacker attempts to guess or crack a user's password. There are several techniques used to achieve this, including Brute-Force attacks, Dictionary attacks, Rainbow Table attacks, Credential Stuffing, Password Spraying, and Keylogger attacks. In a brute-force attack, the attacker systematically tries numerous password combinations until the correct one is found. To speed up the process, attackers often use automated software to test a vast number of combinations in a short amount of time.

2.5 Network Attack

Network attacks refer to unauthorized actions carried out on digital systems within an organization's network. These attacks often involve the use of malicious code to alter, destroy, or steal sensitive information. Attackers typically target network perimeters to infiltrate internal systems. Network attacks are broadly categorized into two types: passive and active. In passive attacks, malicious individuals gain unauthorized access to networks and secretly monitor or steal private data without altering it. In contrast, active attacks involve modifying, encrypting, or destroying data.

2.6 Email Virus

An email virus is a malicious code embedded in an email message, which spreads when a user interacts with the infected email, such as by opening an attachment or clicking on a link. Hackers often disguise these malicious emails to appear as if they are from trusted sources, such as search engines, social media platforms, banks, or even friends and colleagues. The primary aim of these attacks is to

deceive users into disclosing personal information, including their full names, addresses, usernames, passwords, credit card details, or Social Security numbers.

2.7 Capture Confidential Information

Cybercriminals break into devices or websites to steal personal information, which they then use to commit crimes like theft. With so many people using the internet for shopping, banking, and paying bills, sensitive financial details such as credit card numbers and bank account information are often stored on devices. Even if a hacker only manages to access one account or device, they can still cause serious damage. Hackers use spyware to secretly collect data from internet-connected devices, sending it to others without the victim's knowledge or permission. They often trick people into installing spyware by getting them to open spam emails, click on attachments, or follow links in emails, instant messages, or pop-ups. Once installed, spyware can track keystrokes or take screenshots, allowing hackers to steal account numbers, passwords, and other private information.

2.8 Seize of Websites

SQL injection is a method used by hackers to take control of a website by targeting its SQL databases. SQL statements are used to interact with and manage data in these databases, often through an HTML form on a webpage. If the database permissions are not set up properly, attackers can manipulate the HTML form to run unauthorized queries. This allows them to create, read, modify, or even delete data from the database.

3. System Design

A network intrusion detection system (NIDS) is designed to collect, identify, log, and alert, but it does not take active steps to prevent threats. Its primary function is to monitor auditing data and network traffic, analyzing it to identify unusual patterns, protocol anomalies, or packet payload signatures that may indicate potential attacks, suspicious activities, or worms. When such activities are detected, the system alerts the network or system administrator for further action.

3.1 Fuzzy Input and Output

In this paper, we use three input parameters and three output parameters for the fuzzy logic system. Each input and output are divided into subsets. As outlined in [18] Prichard et al., cybercrime is categorized into four areas: cyber terrorism, hacking, infrastructure targeting, and attack techniques. Different departments manage various infrastructures; for example, the Department of Homeland Security oversees information systems, transportation, emergency systems, and more [19]Moteff et al. We use these variables as inputs, which are grouped into three categories: the techniques used by cyber attackers, the purpose of the attackers, and the targets of the attacks. Cyber attackers employ multiple methods to carry out successful attacks on systems. The tables and figures below illustrate the input and output variables for each category, along with their corresponding membership functions.

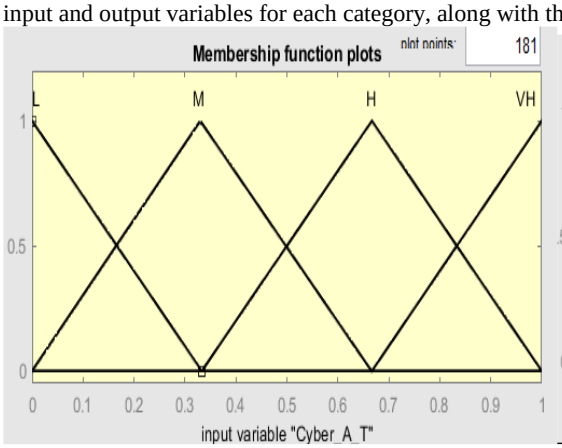


Figure 2: Membership for Cyber Attacker's Target

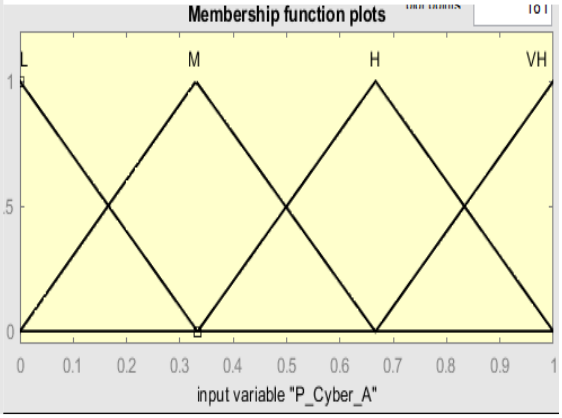


Figure 3: Membership for P_ Cyber_ A

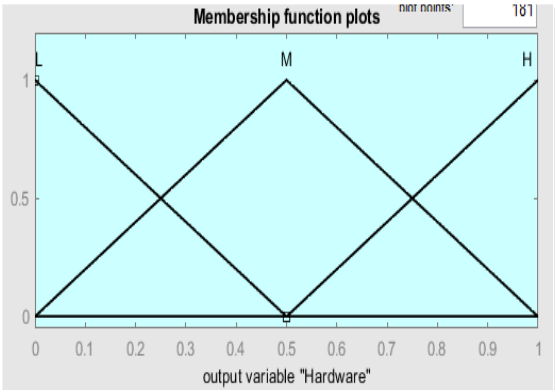


Figure 4: Membership of Hardware

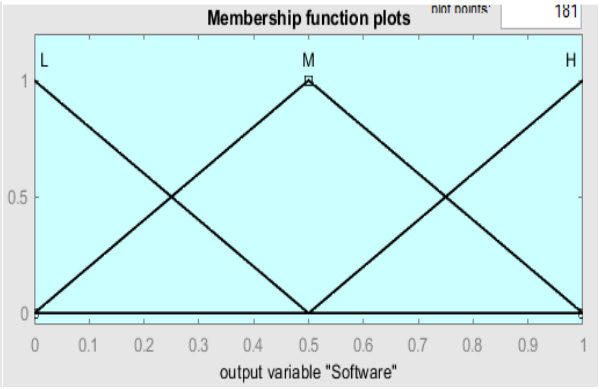


Figure 5: Membership of Software

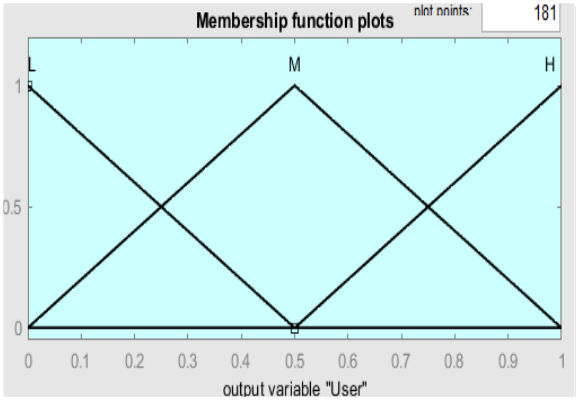


Figure 6: Membership of User

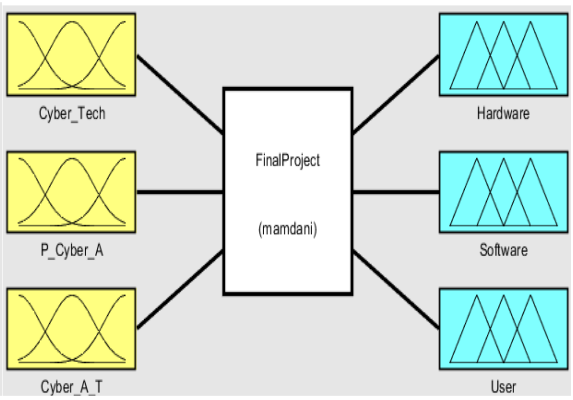


Figure 7: Structure of the System Using Mamdani Method

3.2 Fuzzy Inference

A fuzzy inference system (FIS) uses fuzzy set theory to connect inputs (like features in fuzzy classification) with outputs (such as classes in fuzzy classification). A fuzzy set is a mathematical way to represent vague or uncertain qualitative or quantitative data, often expressed in natural language terms. The process of a fuzzy inference system involves the following steps:

1. Defining a set of fuzzy rules
2. Fuzzifying the inputs using input membership functions
3. Combining the fuzzified inputs based on the fuzzy rules to determine the rule strength
4. Determining the rule's consequence by combining the rule strength with the output membership function
5. Aggregating the consequences to create an output distribution
6. Defuzzifying the output distribution (this step is only necessary if a precise output or class is required).

Fuzzy rules are typically expressed using simple "If-Then" statements, which capture rule-of-thumb knowledge. Fuzzy inference is the process of deriving logical conclusions from a set of these fuzzy rules. In the context of an intrusion detection system (IDS), a fuzzy inference system generates alerts for system administrators based on the scanning parameter values. By improving the accuracy of security alerts and minimizing false positives and false negatives, a fuzzy inference system enhances the overall security of the system.

3.3 Fuzzy sets and Rules

The fuzzy rules are created using input and output fuzzy variables. Three input fuzzy variables are used, corresponding to the three parameters discussed earlier. Each variable is described using five linguistic fuzzy sets: very low (VL), low (L), medium (M), high (H), and very high (VH). For simplicity, these fuzzy sets are represented using a triangular membership function. Fuzzy rules are conditional statements written in a basic "If-Then" format. These rules are used in fuzzy logic systems to determine the output based on the input variables. The structure of fuzzy rules follows the "IF-THEN" format. Below is an example of fuzzy rules.

- Rule 1: If x_1 is Low and $x_2$is High then y_0 is low
- Rule 2: If x_1 is Medium and x_2 is medium then y_0 isMedium

Here y_0 is output

Table I: Cyber Attacker's Technique

Network Attack	VL
Denial of Service	L
Email Virus	M
Trojan Attack	H
Malware	VH

Table II: Cyber Attacker's Target

Telecommunication Information	L
Transportation System	M
Emergency Service	H
Technology	VH

Table III:

Purpose Cyber attacker's Target

Out of Service	L
Seizing Webpage	M
Control of the System	H
Capture Confidential Information	VH

Bellow shows our system design rules based on input andoutput variables. Cyber Attacker's Technique (Cyber_Tech),Cyber attacker's Target (Cyber_A_T), Purpose Cyber attacker'sTarget(P_Cyber_A), refer to Table I, Table II, TableIII respectively.

1. If (Cyber_Tech is VL) and (P_Cyber_A is L) and (Cyber_A_T is L) then (Hardware is H)
2. If (Cyber_Tech is M) then (Hardware is M)(Software isM)(User is L)
3. If (Cyber_Tech is VL) and (P_Cyber_A is H) and (Cyber_A_T is L) then (Hardware isH)(Software is M)
4. If (Cyber_Tech is VH) and (P_Cyber_A is VH) and(Cyber_A_T is M) then (Hardware is M)(Software isM)(User is L)

5. If (Cyber_Tech is L) and (P_Cyber_A is L) and (Cyber_A_T is VH) then (Hardware is H)(Software isH)(User is L)
6. If (P_Cyber_A is H) and (Cyber_A_T is M) then (Softwareis L)
7. If (P_Cyber_A is VH) and (Cyber_A_T is H) then(Hardware is L)(Software is H)(User is M)
8. If (P_Cyber_A is M) and (Cyber_A_T is L) then (Hardwareis H) (Software is L)(User is H)
9. If (Cyber_A_T is VH) then (Hardware is M)(Software isL)(User is H)
10. If (Cyber_Tech is VL) then (Software is M)
11. If (Cyber_Tech is L) then (Hardware is H)
12. If (Cyber_Tech is VH) then (Software is M)(User is M)
13. If (P_Cyber_A is L) then (Hardware is H)(Software isL)(User is L)
14. If (P_Cyber_A is H) then (Hardware is H)(User is H)
15. If (P_Cyber_A is VH) then (User is H)
16. If (P_Cyber_A is M) then (Hardware is M)(Software isH)(User is H)

4. Result and Discussions

In this study, we utilize MATLAB's Fuzzy Logic Toolbox to develop a system model with three input variables and three output variables. The input variable, Cyber Attacker Techniques, is a fuzzy variable that includes various methods such as malware, Trojan attacks, email viruses, denial of service, and more. Similarly, the other input and output variables are also fuzzy in nature. Figure 8 displays a sample simulation result where Cyber Tech = 0.297, P_Cyber_A = 0.5, and Cyber_A_T= 0.5, with the corresponding outputs being Hardware = 0.602, Software = 0.5, and User = 0.626. Here, Hardware = 0.602 indicates that the system requires specialized computer hardware, Software = 0.5 suggests the need for updated or specialized software, and User = 0.626 emphasizes the importance of user awareness and control.

Figure 6 illustrates different alert levels based on varying input variables. The Cyber Tech criteria are plotted on the x-axis, P_Cyber_A criteria on the y-axis, and the Software solution criteria on the z-axis (as shown in Figure 9). An output of Software = 0.5 signifies that the system requires software updates, Hardware = 0.602 indicates the need for technical hardware support, and User = 0.626 highlights the critical role of user control and awareness. MATLAB-generated images of the solution set for the output criteria Software are provided in Figures 9 and 10, where Cyber_Tech = 0.297, P_Cyber_A = 0.5, and Cyber_A = 0.5.

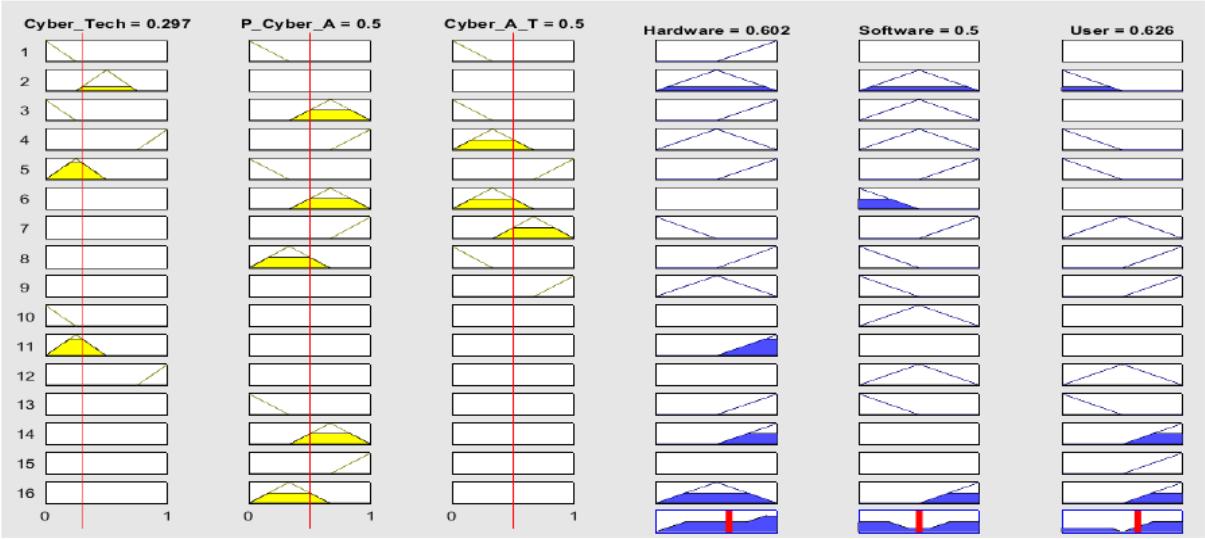


Figure 8: Simulation result for different input variables (Level of alert, Hardware = 0.602, Software = 0.5, User = 0.626).

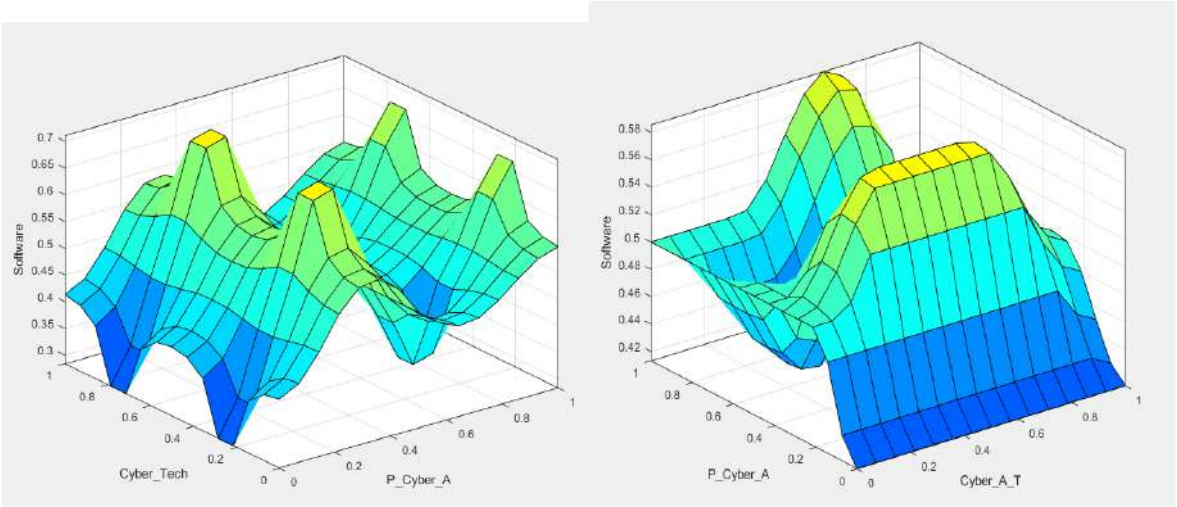


Figure 9: Sample solution set for P_Cyber_A, Cyber_Tech **Figure 10**: Sample solution set for P_Cyber_A, Cyber_A_T and Software

Table IV: Output

Hardware	Software	User
Physical Control (L)	System Update (L)	User Training (L)
Special Computer (M)	Special Software (M)	Awareness (M)
Technical Support (H)	National Data Bank (H)	User Control (H)

5. Conclusion

This paper introduces a cybersecurity warning system powered by fuzzy logic. The system works by using an Intrusion Detection System (IDS) to measure the severity of cyberattacks, which are then fed into a fuzzy logic model. These measurements are categorized as low, medium, high, or very high, and the fuzzy system translates them into actionable warning signals.

The goal is to help system administrators understand the urgency of threats and determine appropriate responses. Importantly, the model does not directly prevent attacks but instead focuses on generating alerts based on predefined fuzzy rules.

The strength of this approach lies in its flexibility and rapid response to evolving cyberthreats. Administrators can use the warnings to identify the nature of attacks, such as those from cyberterrorists, and prioritize countermeasures. This system can be adopted by businesses, government agencies, or other institutions to strengthen their cybersecurity frameworks and foster safer digital environments.

6. References:

[1] Zadeh, L. A. (1965). Fuzzy Sets. **Information and Control*, 8(3),* 338-353.

[2] B. Cashell, W. D. Jackson, M. Jickling, and B. Webel, (2004). "The economicimpact of cyber-attacks," *Congressional research service documents,CRS RL32331 (Washington DC), vol. 2,* 2004.

[3] R. Gandhi, A. Sharma,W. Mahoney,W. Sousan, Q. Zhu, and P. Laplante, (2011)."Dimensions of cyber-attacks: Cultural, social, economic, and political,"*IEEE Technology and Society Magazine, vol. 30, no. 1*, pp. 28–38.

[4] D. E. Denning, (2001). "Activism, hacktivism, and cyberterrorism: The internetas a tool for influencing foreign policy," *Networks and netwars: Thefuture of terror, crime, and militancy, vol. 239,* p. 288.

[5] D. Craigen, N. Diakun-Thibault, and R. Purse (2014). "Defining cybersecurity,"*TechnologyInnovation Management Review, vol. 4,* no. 10.

[6] G. A. Ajaeiya, N. Adalian, I. H. Elhajj, A. Kayssi, and A. Chehab (2017)."Flow-based intrusion detection system for sdn". *IEEE Symposiumon Computers and Communications (ISCC),* pp. 787–793.

[7] Y. Hamid, M. Sugumaran, and L. Journaux (2016). "Machine learning techniquesfor intrusion detection: a comparative analysis,"*Proceedingsof the International Conference on Informatics and Analytics,* pp. 1–6.

[8] A. Chaudhary and G. Shrimal (2019). "Intrusion detection system based ongenetic algorithm for detection of distribution denial of service attacksin manets," *Proceedings of International Conference on SustainableComputing in Science, Technology and Management (SUSCOM), AmityUniversity Rajasthan, Jaipur-India*.

[9] M. Almseidin, J. Al-Sawwa, and M. Alkasassbeh (2011). "Anomaly-basedintrusion detection system using fuzzy logic," *InternationalConference on Information Technology (ICIT), IEEE*, pp. 290–295.

[10] R. Shanmugavadivu and N. Nagarajan (2011). "Network intrusion detection system using fuzzy logic," *Indian Journal of Computer Science and Engineering (IJCSE), vol. 2, no. 1,* pp. 101–111.

[11] N. N. P. Mkuzangwe and F. V. Nelwamondo (2017). "A fuzzy logic-basednetwork intrusiondetection system for predicting the tcp syn floodingattack,"*Intelligent Information and Database Systems: 9th AsianConference*.

[12] M. Almseidin, J. Al-Sawwa, M. Alkasassbeh, and M. Alweshah (2023). "Ondetecting distributed denial of service attacks using fuzzy inferencesystem," *Cluster Computing, vol. 26, no. 2,* pp. 1337–1351.

[13] W. Haider, J. Hu, J. Slay, B. P. Turnbull, and Y. Xie (2017). "Generating realisticintrusion detection system dataset based on fuzzy qualitative modeling,"*Journal of Network and Computer Applications, vol. 87,* pp. 185–192.

[14] P. Karthik, P. Shanthibala, A. Bhardwaj, S. Bharany, H. Yu, and Y. B.Zikria (2023). "A novel subset-based polynomial design for enhancing thesecurity of short message-digest with inflated avalanche and randomresponses," *Journal of King Saud University-Computer and InformationSciences*.

[15] N. Agarwal and S. Z. Hussain (2018). "A closer look at intrusion detectionsystem for web applications," *Security and Communication Networks,vol. 2018,* https://doi.org/10.1155/2018/9601357.

[16] N. Naik (2015). "Fuzzy inference-based intrusion detection system: Fi-snort,"*IEEE International Conference on Computer and InformationTechnology; Ubiquitous Computing and Communications; Dependable,Autonomic and Secure Computing; Pervasive Intelligence and Computing,*pp. 2062–2067.

[17] W. El-Hajj, F. Aloul, Z. Trabelsi, and N. Zaki (2008). "On detecting port scanningusing fuzzy based intrusion detection system," *IEEE InternationalWireless Communications and Mobile Computing Conference*.

[18] J. J. Prichard and L. E. MacDonald (2004). "Cyber terrorism: a study ofthe extent of coverage in computer science textbooks," *Journal ofInformation Technology Education: Research, vol. 3, no. 1*, pp. 279–289.

[19] J. Moteff and P. Parfomak (2004). "Critical infrastructure and key assets:definition and identification," *Library of Congress Washington DCCongressional Research Service*.

SOCIAL ENTREPRENEURSHIP AND INNOVATION: To Foster Societal Progress And Well-Being

Shahnaaz Farhin[1], Rudrani[2], Mahavir prasad[3]
[1]Student, Department of Master of Business Administration (MBA), GGSESTC, Kandra, Bokaro, Jharkhand[1]
e-mail id :Shahnaazfarhin04@gmail.com
[2]Student, Department of Master of Business Administration (MBA), GGSESTC, Kandra, Bokaro, Jharkhand[2]
[3]Assistant Professor, Department of Master of Business Administration (MBA) GGSESTC, Kandra, Bokaro, Jharkhand[3],
Corresponding author e-mail id:mahavir0091@gmail.com

ABSTRACT:

Social entrepreneurship is a growing field that combines business strategies with social responsibility to solve various social and economic problems. This study explores how social entrepreneurship contributes to society by creating both financial sustainability and positive social impact. It discusses the challenges faced by social entrepreneurs, such as limited funding, lack of government support, and difficulties in expanding their businesses while maintaining their social mission. The study also highlights the role of innovation in helping social enterprises find creative solutions to social issues. Findings suggest that strong policy support, financial assistance, and community involvement are essential for the success of social enterprises. Despite their potential to bring meaningful change, many social enterprises struggle to scale up due to a lack of proper funding and regulatory support. Additionally, the study identifies research gaps in measuring the impact of social entrepreneurship and understanding long-term challenges. Future research is needed to develop effective strategies to help social enterprises grow and sustain their impact over time. This research provides valuable insights into how social entrepreneurship can drive sustainable development and economic progress. It also encourages further discussions on how governments, businesses, and society can work together to support social enterprises and maximize their positive imp

Keywords: Entrepreneurship, Finance, Management, Business

1. INTRODUCTION

1.1. Understanding Social Entrepreneurship

Social entrepreneurship is an approach adopted by individuals, groups, startups, or business leaders to develop, finance, and implement solutions for social, cultural, or environmental challenges. This concept is applied across various organizations, differing in size, objectives, and beliefs. Unlike traditional businesses that prioritize financial performance indicators like revenue and profit, social entrepreneurs measure success through their societal impact. They often operate as non-profits or use hybrid models that balance financial sustainability with social welfare. Their efforts are usually aligned with objectives such as poverty alleviation, healthcare improvement, and community development.Some social enterprises generate profits but direct them towards achieving their core mission rather than simply maximizing wealth. For instance, an organization supporting the homeless might run a restaurant, both to generate income and to provide employment opportunities for those in need.

1.2. The Role of Technology in Social Entrepreneurship

The rise of the internet and social media platforms has significantly influenced social entrepreneurship, especially since 2010. These platforms enable social entrepreneurs to connect with like-minded individuals across different locations, fostering collaboration, knowledge sharing, and fundraising through crowdfunding. Digital networking enhances the reach and impact of social ventures, allowing them to mobilize resources effectively.

1.3. The Growing Research on Social Entrepreneurship

In recent years, researchers have emphasized the need to better understand the environment in which social enterprises operate. A deeper comprehension of these ecosystems can help entrepreneurs formulate effective strategies and achieve their dual objectives of financial sustainability and social impact.

1.4. Defining Social Entrepreneurship

The term "social entrepreneurship" has existed since the 1950s but has gained more prominence in recent decades. Despite numerous attempts to define it clearly, no universal agreement has been reached. The concept remains complex due to the diverse perspectives used by researchers. Some scholars compare social entrepreneurship to a "mythological beast" due to its dynamic nature and varied interpretations. Additionally, different political and economic ideologies influence how it is perceived.

Academics often categorize social entrepreneurship into five broad areas based on different conceptual approaches. The most widely accepted definition highlights the entrepreneur’s role as a creative and innovative leader. According to J.G. Dees, social entrepreneurship thrives on individuals who develop novel solutions for pressing social issues.

2. WHO CAN BE A SOCIAL ENTREPRENEUR?

People from various professional backgrounds, including social work, environmental science, and business, can become social entrepreneurs. Due to their diverse expertise, defining who qualifies as a social entrepreneur remains challenging. David Bornstein even uses "social innovator" as an interchangeable term to emphasize the unconventional and creative methods employed in this field. To distinguish social entrepreneurship from traditional non-profit activities, some scholars argue that the term should apply only to organizations that generate income primarily through commercial activities rather than relying on donations or grants. Others extend this definition to include organizations funded through public-sector contracts.

2.1. The Importance of Social Entrepreneurship in Modern Society

Social entrepreneurship provides a form of business that prioritizes societal well-being. It transforms social capital in ways that benefit communities, emphasizing altruism and concern for the welfare of others. Since social enterprises prioritize impact over profit, they tackle urgent problems while considering the broader societal context. Their approach enables them to mobilize resources innovatively and implement sustainable solutions.

Unlike conventional businesses, social enterprises focus on maximizing social good rather than financial returns. Governments, private firms, and public agencies worldwide invest billions of dollars in initiatives to empower marginalized communities. This support encourages social entrepreneurs to develop scalable solutions that reach a larger audience.

2.2 Notable Social Entrepreneurs

Several influential figures have made significant contributions to social entrepreneurship. Muhammad Yunus, founder of Grameen Bank, pioneered microcredit, which has empowered underprivileged individuals in Asia, Africa, and Latin America. His efforts earned him a Nobel Peace Prize. Similarly, Akhter Hameed Khan played a crucial role in advancing community-based social initiatives in Pakistan.
On a local level, former Indianapolis mayor Stephen Goldsmith applied social entrepreneurship principles to city governance, using private-sector partnerships to improve public services. These examples highlight the diverse ways in which social entrepreneurs can create meaningful and lasting change.

2.3. Related literature

Exploring social entrepreneurship (SE) offers valuable insights into its evolving nature and helps identify research gaps for future studies. SE is an interdisciplinary field that integrates business strategies with social impact.

Although entrepreneurial initiatives that generate both social and economic value are not new, academic research in this domain has gained momentum only in the past decade (Saebi et al., 2019). However, the term **"social entrepreneurship"** lacks a universally accepted definition, encompassing diverse initiatives aimed at social welfare. Cherrier et al. (2018) define SE as **"entrepreneurial activity with an embedded social purpose,"** while others describe it as the fusion of economic and social objectives (Chell et al., 2016; Saebi et al., 2019). Despite these definitional variations, the literature consistently emphasizes SE's dual purpose of generating social and economic benefits (Doherty et al., 2014; Saebi et al., 2019; Santos, 2012; Wu et al., 2020).

Gupta et al. (2020) highlight the need to synthesize existing SE research, arguing that consolidating diverse studies not only bridges fragmented knowledge but also provides a broader understanding of the field. Such an approach helps address practical challenges by drawing insights from past research. However, despite the growing academic focus on SE, gaps remain in understanding its long-term impact, sustainability, and the role of policy interventions in fostering social enterprises.

This study builds on existing literature by examining social entrepreneurship and innovationcontributing to a deeper understanding of how SE can be leveraged for greater social impact.

3. RESEARCH DESIGN

This study uses a **qualitative approach** to understand how social entrepreneurship helps society. Since social entrepreneurship is a broad and developing field, a qualitative method allows for a deeper understanding of the challenges and impact of social enterprises. The nature and sources of data collection are secondary by the use of published and unpublished content and textual analysis from textbook, magazine, newspapers, internet, government official publications.

4. MAJOR FINDINGS

1. **Social and Economic Impact** – Social entrepreneurship plays a crucial role in addressing social issues while also contributing to economic development. Many social enterprises focus on creating employment opportunities, improving education, and promoting sustainable business practices.
2. **Challenges Faced by Social Entrepreneurs** – The study found that social entrepreneurs struggle with limited funding, lack of government support, and difficulty in scaling their businesses while maintaining their social mission.
3. **Role of Innovation** – Innovation is a key factor in the success of social enterprises. Many entrepreneurs use creative business models and technology to address social problems more effectively.

4. **Need for Policy Support** – Government policies and financial assistance are essential for the growth of social entrepreneurship. Many participants suggested that better funding opportunities and regulatory support could help social enterprises expand their impact.
5. **Community Engagement and Sustainability** – Successful social enterprises actively involve local communities in their initiatives. Long-term sustainability is achieved when businesses align their goals with the needs of the people they serve.
6. **Bridging Research Gaps** – The findings highlight the need for more academic research on social entrepreneurship, particularly in areas like measuring impact, understanding long-term challenges, and exploring ways to make social enterprises more sustainable.

5. CONCLUSIONS

This study highlights the significant role of social entrepreneurship in addressing social and economic challenges. Social enterprises not only create employment opportunities but also contribute to sustainable development through innovative business models. However, entrepreneurs face challenges such as limited funding, lack of government support, and difficulties in scaling their businesses while maintaining their social mission.

The findings suggest that **policy support, financial assistance, and community engagement** are essential for the success of social enterprises. Encouraging innovation and providing better funding opportunities can help social entrepreneurship grow and create a lasting impact.

Additionally, there is a need for further research to explore **effective ways to measure the impact of social enterprises, identify long-term challenges, and develop strategies for sustainability**. By bridging these research gaps, policymakers, researchers, and entrepreneurs can work together to strengthen the field of social entrepreneurship and maximize its benefits for society.

REFERENCES

[1.] Chell, E., Spence, L. J., Perrini, F., & Harris, J. D. (2016). Social entrepreneurship and business ethics: Does social equal ethical? *Journal of Business Ethics, 133*(4), 619-625.

[2.] Cherrier, H., Goswami, P., & Ray, S. (2018). Social entrepreneurship: Creating value in the context of institutional voids. *Business & Society, 57*(7), 1350-1377.

[3.] Doherty, B., Haugh, H., & Lyon, F. (2014). Social enterprises as hybrid organizations: A review and research agenda. *International Journal of Management Reviews, 16*(4), 417-436.

[4.] Gupta, P., Chauhan, S., Paul, J., & Jaiswal, M. (2020). Social entrepreneurship research: A review and future research agenda. *Journal of Business Research, 113*, 209-229.

[5.] Saebi, T., Foss, N. J., & Linder, S. (2019). Social entrepreneurship research: Past achievements and future promises. *Journal of Management, 45*(1), 70-95.

[6.] Santos, F. M. (2012). A positive theory of social entrepreneurship. *Journal of Business Ethics, 111*(3), 335-351.

HR APPROACHES FOR MINIMIZING WORKPLACE STRESS AND ENHANCING MENTAL WELL-BEING

Anisha Kumari[1] Komal Agarwal[2], Md Asif Faizi[3]
[1]Student, Department of Master of Business Administration (MBA), GGSESTC, Kandra, Bokaro, Jharkhand[1]
e-mail id :anniekri2024@gmail.com
[2]Student, Department of Master of Business Administration (MBA), GGSESTC, Kandra, Bokaro, Jharkhand[2]
[3]Assistant Professor, Department of Master of Business Administration (MBA) GGSESTC, Kandra, Bokaro, Jharkhand[3]
Corresponding author e-mail id:asif.faizi111@gmail.com

Abstract

In today's dynamic and fast-paced professional landscape, workplace stress and mental health concerns have emerged as significant challenges, affecting employee well-being, productivity, and overall job satisfaction. The growing prevalence of stress-related issues in the workplace necessitates the adoption of effective Human Resource (HR) strategies to create a supportive and mentally healthy work environment. This study explores various HR-driven initiatives aimed at mitigating workplace stress, such as flexible work arrangements, Employee Assistance Programs (EAPs), wellness programs, mental health awareness training, stress management workshops, and supportive leadership. These strategies are designed to foster a balanced and positive work culture, reducing burnout and enhancing job engagement.

The findings highlight that a proactive HR approach, emphasizing open communication, work-life balance, and comprehensive psychological support, significantly improves employee morale and organizational performance. Additionally, this research underscores the importance of a holistic strategy that integrates mental health policies with organizational goals. The study also discusses future research opportunities and strategic recommendations to help organizations effectively prioritize mental health and overall employee well-being, ensuring a more resilient and engaged workforce.

Keywords: Human Resource Strategies, Workplace Stress, Employee Well-being, Mental Health, Work-Life Balance, Employee Assistance Programs (EAPs), Workplace Wellness

1. Introduction

1.1 Background of the Study

Stress in the workplace is a growing issue that affects employee productivity, engagement, and job satisfaction. Rapid technological advancements, high performance expectations, and increasing workloads have contributed to rising stress levels among employees. Organizations globally are now recognizing the need for HR strategies that support mental well-being. Recent research in 2024 highlights the significance of hybrid work models and AI-powered mental health solutions in reducing stress and enhancing employee satisfaction (Anderson & Patel, 2024).

1.2 Problem Statement

Despite increasing awareness of mental health challenges in the workplace, many organizations struggle to implement effective HR strategies to manage stress. Employees often experience burnout, job dissatisfaction, and declining mental health, which negatively impact organizational performance. A structured HR approach is necessary to foster a healthy and supportive work environment.

1.3 Significance of the Study

This research is essential as it investigates HR-led approaches to workplace stress management, emphasizing strategies that enhance employee well-being and job performance. The findings provide valuable insights for HR professionals and business leaders in developing policies that promote a mentally resilient workforce.

2. Literature Review

2.1 Workplace Stress and Its Impacts

Research indicates that workplace stress is one of the primary contributors to employee disengagement, absenteeism, and reduced productivity (Smith & Jones, 2020). High-stress levels have been associated with burnout, anxiety, and decreased job satisfaction. A 2024 study by Harrison et al. found that organizations utilizing AI-driven wellness platforms experienced a 25% decrease in stress-related absences.

2.2 HR Strategies for Managing Workplace Stress

Several HR interventions have been identified to reduce stress and enhance employee well-being, including:

- **Flexible Work Arrangements**: Studies reveal that remote work, compressed workweeks, and flexible hours significantly lower stress and enhance work-life balance (Johnson et al., 2021). A 2024 Deloitte report indicates that employees in hybrid work settings experience greater job satisfaction and reduced burnout.
- **Employee Assistance Programs (EAPs)**: Research highlights the role of EAPs in offering psychological support and boosting employee resilience (Lee & Kim, 2019).
- **Wellness Initiatives**: Programs focused on mindfulness and physical health have demonstrated significant benefits in stress management (Miller et al., 2020).
- **Mental Health Awareness Training**: Such training equips managers with the skills to recognize stress symptoms and provide necessary support (Clark, 2022).
- **Supportive Leadership**: Leadership styles that prioritize empathy and transparent communication contribute to a less stressful work environment (Garcia & Roberts, 2020).

3. Methodology

3.1 Research Design

A mixed-method approach was adopted, integrating qualitative and quantitative research techniques. Data collection was conducted through surveys, interviews, and case studies of various organizations.

3.2 Data Collection Methods

- **Survey**: A structured questionnaire was administered to 250 employees across different industries to evaluate stress levels and workplace support mechanisms.
- **Interviews**: HR professionals and employees participated in semi-structured interviews to offer insights into HR-led stress management strategies.
- **Case Studies**: Organizations with successful stress management programs were analyzed.

3.3 Data Analysis

Survey responses were evaluated using statistical analysis, while qualitative data from interviews were thematically analyzed to identify emerging trends.

4. Results

4.1 Key Findings

- **Flexible Work Arrangements**: 80% of employees reported reduced stress levels when offered flexible work schedules.
- **Effectiveness of EAPs**: 70% of respondents who accessed EAPs experienced improved mental well-being.
- **Workplace Wellness Initiatives**: 65% of participants stated that mindfulness and physical wellness programs positively influenced their stress levels.
- **AI in Mental Health Support**: Studies in 2024 found that AI-based mental health tools increased productivity by 18% and reduced burnout symptoms by 30%.
- **Leadership Support**: Employees with empathetic leaders reported higher job satisfaction and lower stress levels.

4.2 Statistical Analysis

Regression analysis demonstrated a strong positive correlation between HR-led stress management strategies and employee well-being ($R^2 = 0.78$).

5. Discussion

The study's findings confirm that HR-driven initiatives, such as EAPs, flexible work arrangements, and wellness programs, effectively minimize workplace stress. Organizations that integrate mental health policies into their strategic framework witness increased employee engagement and productivity.

The results align with past studies, reinforcing the importance of leadership in fostering a stress-free work culture. Companies prioritizing mental health report improved employee retention and workplace morale. The rising use of AI-based well-being platforms in 2024 indicates that technology can play a pivotal role in mental health support, providing real-time insights and personalized interventions.

6. Summary and Conclusion

6.1 Restating the Problem and Findings

Workplace stress adversely impacts employee well-being and organizational success. This study identified HR strategies such as flexible work policies, EAPs, and mental health training as effective interventions. The adoption of AI-powered well-being platforms in 2024 further highlights the potential of technology in workplace stress management.

6.2 Implications for HR Practices

Companies must implement a holistic HR strategy that integrates mental health initiatives into their policies. Emphasizing open communication, work-life balance, and psychological support fosters a resilient workforce.

6.3 Future Research Directions

Future studies should explore the long-term effectiveness of AI-driven wellness programs and their role in workplace mental health.

7. References

[1.] Anderson, R., & Patel, S. (2024). *AI in Workplace Mental Health: Trends and Impacts*. HR Innovations, 29(1), 14-30.

[2.] Harrison, J., et al. (2024). *The Role of AI in Reducing Workplace Stress*. Journal of Organizational Psychology, 22(3), 89-104.

[3.] Deloitte. (2023). *The Future of Hybrid Work and Employee Well-being*. Deloitte Insights.

[4.] Clark, P. (2022). *Mental Health Training for Leaders*. Leadership Review, 18(2), 45-59.

[5.] Johnson, M., et al. (2021). *Flexible Work and Employee Satisfaction*. HR Journal, 27(4), 72-88

.

A Short and Technical Review on Lattice Structures Produced by Additive Manufacturing

[1] Manoj Kumar,[1] Mahmood Alam,[2] Prem Chand Dasoundhi, [2]Amar Mhato

[1.] Assistant Professor, Department of Mechanical Engineering, Guru Gobind Singh Educational Society's Technical Campus, Bokaro, Jharkhand, India mahmoodalam.mech@gmail.com

[2.] Student, Department of Mechanical Engineering, Guru Gobind Singh Educational Society's Technical Campus, Bokaro, Jharkhand, India

Abstract

Additive manufacturing (AM), which has only relatively recently emerged as one of the most significant sectors, is currently the subject of a great number of research investigations. In contrast to machining, additive manufacturing (AM) is a process that involves the division of items into very thin layers, followed by the production of these layers by stacking previous layers atop one another. AM has found new application areas because to the decrease in weight as well as other advantages in a variety of industries including aviation, automotive, and biomedical. In this manner, features that cannot be acquired from solid materials have been disclosed through the utilization of various forms of lattice structures in accordance with the needs of the application. The design factors that impact the compression behavior of body-centered cubic (BCC) and face-centered cubic (FCC) type lattice structures, which are the most popular types of lattice structures used in additive manufacturing, were explored in this review work.

Keywords- Lattice structures, Additive manufacturing, Selective laser melting.

Introduction

Additive manufacturing is characterized as the generation of components through the sequential assembly of their cross-sectional layers, thus being cumulative and additive in nature (Gupta et al., 2020). In this context, it is differentiated from conventional manufacturing techniques that operate on the principles of material shaping or reduction (Iqbal et al., 2020). As per the definition established by the ASTM F42 Committee, additive manufacturing refers to the methodology of fabricating objects by amalgamating materials, initiated from three-dimensional model data (Edgar and Tint, 2015). With the surging demand for lightweight components and the advancements in additive manufacturing technology, the fabrication of intricate lattice structures has become feasible, and the importance of constructing such structures has escalated (Zhang et al., 2022). Numerous manufacturing technologies encompassed within additive manufacturing offer considerable advantages relative to traditional methods (Kuntoğlu et al., 2021; Demirsöz et al., 2022; Korkmaz et al., 2022d).

As previously articulated, the primary benefits of this methodology can be identified as the eradication of the reliance on effective materials and the constraints imposed by design (Yan et al., 2012; Aktürk and Korkmaz, 2021; Korkmaz et al., 2022a; Korkmaz et al., 2022b). This enhanced flexibility and its associated advantages further contribute to the burgeoning popularity of the additive manufacturing technique (Yan et al., 2014). Furthermore, it can be asserted that the aforementioned benefits concerning raw materials foster innovations aimed at addressing the climate crisis and the sustainability challenges confronting our planet (Yi et al., 2020). Within the scope of the literature review, additive manufacturing, methods of additive manufacturing (Liu et al., 2022), lattice structures (Korkmaz et al., 2022c), and the varieties produced through this technique, as well as the mechanical properties of lattice structures, are extensively discussed.

Additive Manufacturing Technologies Used for Lattice Structure

Lattice Structure with Additive Manufacturing

Additive manufacturing, also referred to as layer manufacturing, free-form fabrication, solid freeform fabrication, rapid prototyping, and more commonly recognized as 3D printing (Huang et al., 2013; Man et al., 2019; Mukherjee et al., 2017a; Mukherjee et al., 2017b), encompasses a range of terminologies, including the benefits conferred by this innovative manufacturing process. According to the standard definitions established by the ASTM F42 committee for additive manufacturing, it is akin to additive manufacturing techniques, typically characterized as a method of creating objects by amalgamating materials based on three-dimensional (3D) model data (ASTM F2792-12a). Taking into account the remarkable advantages offered by this approach, such as the capability to produce highly intricate geometries (Tofail et al., 2018; Maconachie et al., 2020), including design flexibility, the integration of multiple components into a singular entity, and the reduction of the necessity for traditional processes like machining and welding (Rouf et al., 2022), as well as the expediting of the process from concept to testing, it is evident that additive manufacturing possesses the potential to address the longstanding strength-ductility compromise that has characterized conventional metallurgical practices (Duan and Yang, 2023).

The rapid advancement of additive manufacturing technologies across various industries is indeed not unexpected (Kerstens et al., 2021).

Material Extrusion

Material extrusion is regarded as the most appropriate method for prototyping owing to its user-friendliness compared to various rapid prototyping techniques, economical equipment, and the robustness of the produced components (Sood et al., 2012; Abbas et al., 2018; Singh et al., 2019; Correa et al., 2020). Nevertheless, it is imperative to emphasize that industrial-grade material extrusion and 3D printers intended for personal and recreational use must be distinguished from one another. Specifically, it is essential to differentiate these two categories of products concerning factors such as initial capital investment, mechanical characteristics, and issues that require resolution. This category is widely recognized under the terminology of manufacturing utilizing Fused Deposition Modeling (FDM).

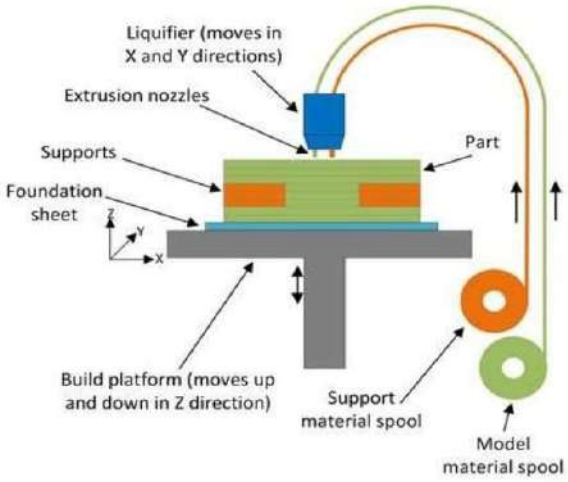


Figure 1. The schematic representation of fused deposition modeling (FDM) (Gebisa and Lemu, 2018).

The schematic illustration of this procedure is depicted in Figure 1. ABS (acrylonitrile Butadiene Styrene), PLA (Polylactic Acid), PC (Polycarbonate), PEEK (Polyether Ether Ketone), PMMA (Polymethyl Methacrylate), HIPS (High Impact Polystyrene), PETG (Polyethylene Terephthalate Glycol), and TPU (Thermoplastic Polyurethane) facilitate the production of components utilizing a diverse array of raw materials, extending to engineering thermoplastics such as CPE (Chlorinated Polyethylene) (Guessasma et al., 2017).

Powder Bed Fusion

The unifying characteristic of the methodologies categorized within this classification pertains to the formation of layers within a powder bed of the component (DebRoy et al., 2018; Wen et al., 2019; Ramoni et al., 2021; Moeinfar et al., 2022; Li and Mizutani, 2023). The processes most widely recognized include selective laser sintering (SLS), Selective Laser Melting (SLM), and Electron Beam Melting (EBM) (Xu, 2021). The SLS technique represents one of the fusion methodologies concerning powder beds, predicated on the sintering principle of metallic, powder, and ceramic materials, as opposed to melting, through the utilization of a concentrated laser beam (Węglowski, 2018; Nouri et al., 2021). Due to its lack of requirement for any supporting structures in contrast to other powder bed techniques, it is regarded as a significant advantage, facilitating the complete occupation of the construction volume and enabling enhanced production efficiency simultaneously (Khrapov et al., 2023). For thermoplastic substances, it is feasible to manufacture components with commendable and enduring mechanical properties (Bijwe et al., 2000; Musa et al., 2022).

In certain investigations, the selective laser melting process is additionally acknowledged as an evolution of laser sintering and is characterized as the laser sintering procedure where complete melting transpires (Grossin et al., 2021). However, given the fundamentally distinct mechanisms, in this analysis, the SLM process is also treated independently of laser sintering. Although polycarbonate powders were employed as initial materials in the laser sintering process, metallic systems such as Fe-CU, Fe-Sn, Cu-Sn, Al, Cr, Ti, Fe, Cu, as well as ceramics including Al2O3, FeO, NiO, ZrO2, SiO2, CuO, alongside pre-coated casting sand, alumina, and bronze-nickel alloys are utilized in this procedure. In the SLM methodology, in contrast to the SLS approach, complete melting is imperative rather than mere sintering.

In this technique, predominantly employed for metallic substances, the initial phase involves the deposition of a fine powder layer upon the mobile fabrication platform utilizing powder. Based on the desired geometry to be generated, the laser beam traverses a specific scanning trajectory in each layer, thereby facilitating the formation of the layer through rapid melting and subsequent cooling. Surrounding the solidified region, the material persists in the areas that have not been subjected to scanning. Upon the completion of a layer, the mobile fabrication platform descends by an amount equivalent to the layer thickness, and a fresh layer of powder is applied with the assistance of powder dispensing. The screening process is executed for the new layer, and this iterative procedure persists until the entirety of the component is fabricated. The implementation of support structures for overhanging surfaces is of paramount importance. Presently, the possibility of reusing powder facilitates the recycling of material (Kruth et al., 2005). Furthermore, the production resolution is commendable due to the diminutive laser diameter, minimal layer thickness (30-50 μm), and narrow particle size distribution, allowing for the creation of slender elements such as lattice structures. Additionally, the production of intricate geometries with internal cavities is feasible due to the ease of removal of residual powder from the internal channels. The schematic illustration of the SLM process is depicted in Figure 2. The SLM process is applicable to materials such as titanium and its alloys, nickel superalloys (Inconel 625/718, Hastelloy X), copper alloys, precious metals (gold, silver), cobalt chrome alloys, aluminum alloys, stainless steels, and tool steels (Yap et al., 2015).

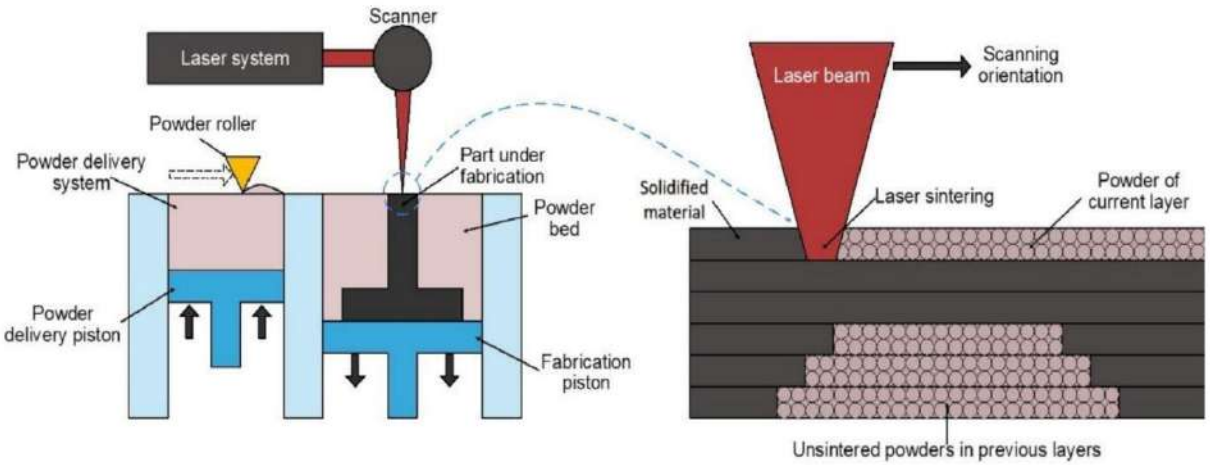


Figure 2. Schematic of the SLM process (Ansari et al., 2021).

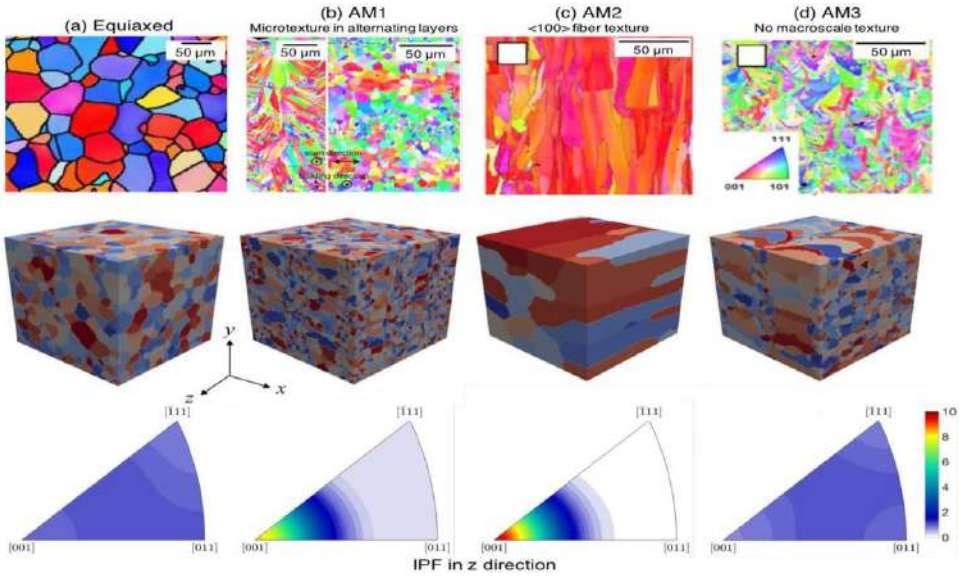


Figure 3. Top row: Experimental EBSD images of representative microstructures. Middle row: 3D renderings of synthetic microstructures (colors represent grain IDs). Bottom row: z-direction inverse pole figures representing each synthetic microstructure's initial crystallographic texture (Rodgers et al., 2020).

In the domain of manufacturing utilizing Electron Beam Melting (EBM), a high-energy electron beam is employed in lieu of a laser to initiate the melting process among metal powder particles. Prior to the melting phase, the powder bed is subjected to a significant preheating temperature through the same electron beam. This electron beam serves dual purposes as a preheating and melting energy source, effectively maintaining the positioning of powder particles during the EBM process while preventing interference with the electron beam. A concentrated electron beam meticulously scans a thin layer of powder, facilitating solidification by locally melting designated cross-sectional areas. Components produced via EBM exhibit reduced permanent stress and distortion, with the necessity for support structures being infrequent (Navi et al., 2020). Although preheating circumvents the requirement for support structures due to the sintering of unused powder, this sintering presents challenges in the removal of residual powder within internal channels. Analogous to the Selective Laser Sintering (SLS) process, the completed components are extracted from the build chamber in a powder cake (Figure 3), followed by the removal of the surrounding powder through a powder recovery system. The employment of an electron beam introduces notable distinctions in comparison to conventional fusion processes. Primarily, it boasts enhanced efficiency and production rates. Furthermore, operations must be conducted within a vacuum environment to avert interactions between the electron beam and atmospheric gas molecules. Additionally, the process allows for the attainment of high material purity by mitigating undesirable contamination, such as oxidation. The particle size of the powder and the layer thickness utilized in the EBM method are notably larger. Moreover, in terms of quality and surface resolution of the manufactured products, EBM outputs tend to be of inferior quality compared to those produced via Selective Laser Melting (SLM). Several micrographs illustrating the characteristics of products generated by

specific additive manufacturing techniques are depicted in Figure 3. Furthermore, the schematic representation of the EBM process is illustrated in Figure 4.

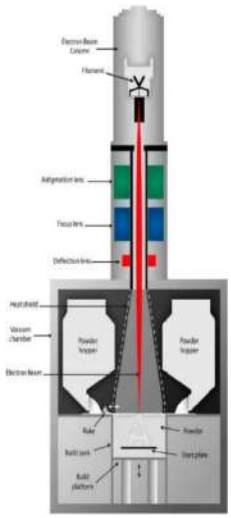


Figure 4. The schematic appearance of the EBM process (Lancaster et al., 2016).

Lattice Structures

Lattice structures represent intricate three-dimensional configurations composed of one or multiple repetitive unit cells (Cheng et al., 2018; Zhang et al., 2018; Feldshtein et al., 2019; Blakey-Milner et al., 2021; Kas and Yilmaz, 2021; Zheng et al., 2021). These structures are commonly referred to as cellular solids, cellular metals, cellular foams (Pan et al., 2020), lattice sequences (Didier et al., 2021), porous structures (Łyczkowska et al., 2014), or scaffold structures (Wauthle et al., 2015). Lattice structures exhibit superior energy absorption, sound insulation, and thermal capabilities compared to solid structures. Consequently, their application in engineering and biomedical fields is progressively increasing (Nakajima, 2010). The utilization of lightweight and resilient materials in the aviation, automotive, sports, and biomedical sectors has facilitated the adoption of lattice structures, thereby enabling the modification of mechanical properties through alterations in geometric parameters (Maconachie et al., 2019). Notably, owing to the design flexibility afforded by additive manufacturing, lattice structures have gained wider acceptance, allowing for the acquisition of unique material properties unattainable from solid materials (Brüggemann et al., 2018). Structures featuring various lattice unit cell dimensions, produced via additive manufacturing, are illustrated in Figure 5.

Lattice frameworks may be categorized into two distinct types: extension or stretch. Furthermore, these lattice structures can be assessed across three different classifications based on their geometric characteristics: sewing (strut) lattice frameworks, surface-based lattice frameworks, and shell lattice frameworks (Maconachie et al., 2019). The extent to which a lattice framework can be optimized is predominantly influenced by the techniques of homogenization and ground structure (Wang et al., 2018). The asymptotic expansion of series concerning the ratio of beam length to the actual dimensions of the structure, the displacement within the nodes of the structure, and the tensions experienced at these nodes are all essential components of the homogenization methodology (Tollenaere and Caillerie, 1998). In this approach, composite materials are utilized as the foundational basis for delineating the geometry of the object in accordance with the material density. The initial phase of the ground truss approach involves establishing a foundational structure, envisioned as a grid that encompasses all requisite components to interconnect the nodes within the design space (Chen et al., 2018). Topological optimization is performed on a designated Finite Element mesh, which may consist of either discrete or continuous components, with the aim of effectively arranging materials within the material layout (Gorguluarslan et al., 2016). As geometry optimization governs the interconnection of constant elements and thus sustains manufacturability, it is regarded as the preferred optimization method for the advancement of AM products (Tam et al., 2018). To achieve optimal designs for AM products, geometry optimization is deemed the most advantageous option. By employing a transition analogous to that which occurs between relative density and cell size gradient, an exemplary lattice framework may be developed. The Lattice Structure Lightweight Triangulation Method (LSLT) is the groundbreaking technique that has facilitated these enhancements to the lattice structure (Han and Lu, 2018). This technique is utilized to regulate the quantity of triangles generated through Boolean, Interpolation, and Triangulation processes (Chougrani et al., 2017), and is known as the direct triangulation of lattice structures. The innovations within the lattice framework were enabled by LSLT, an avant-garde method. Tailoring the lattices to achieve a reduced mass represents one strategy to enhance the stiffness-to-weight ratio (Reinhart and Teufelhart, 2013). The stiffness of a structure may be augmented by minimizing the dimensions of its individual cells (Plocher and Panesar, 2020). In order to optimize the lattice thickness in an automated manner, we have employed Spall's Simultaneous Perturbation Stochastic Approximation (SPSA) technique (Lee et al., 2022). The reduction in material consumption through optimization subsequently elevates production costs in comparison to other sectors.

Furthermore, honeycombs and foams are engineered to emulate the configuration of naturally occurring cellular materials such as wood, cork, and bone. The elevated specific strength and rigidity provided by the porous architecture of cellular structures render them an attractive option for numerous design applications, particularly in the realm of lightweighting. Cellular structures offer significant benefits for energy absorption due to their deformation characteristics. Manufactured cellular structures are available in various forms and can be produced using a multitude of techniques. In contrast to foams, the unit cells of lattice structures are characterized by a uniform repeating pattern. As articulated by Gibson, cellular materials consist of "an interconnected network of struts or plates." Moreover, Ashby emphasizes that the millimeter or micrometer dimensions of the unit cells in lattice constructions distinguish them from larger-scale built structures such as trusses or frames. Consequently, a lattice structure ought to be regarded as a material possessing distinct mechanical properties, despite the fact that the unit cells of lattice structures may be examined as space frames through classical mechanics. This facilitates a direct comparison between the characteristics of a lattice structure and those of its parent material.

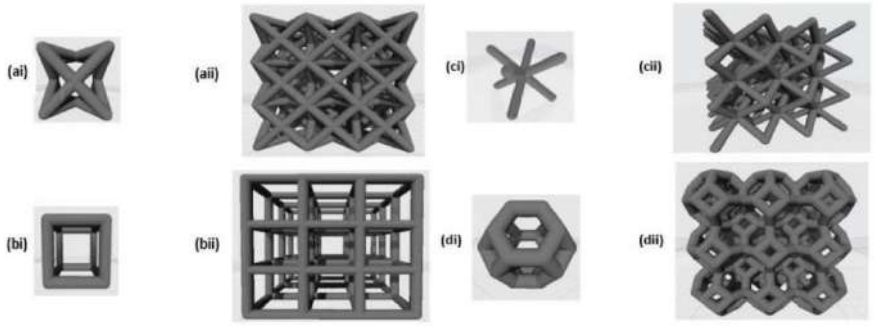


Figure 5. Commonly used lattice structures' geometry: (ai) FCC unit cell and (aii) FCC lattice structure; (bi) simple cubic unit cell and (bii) simple cubic lattice structure; (ci) BCC unit cell and (cii) BCC lattice structure; and (di) Kelvin unit cell and (dii) Kelvin lattice Structure (Obadimu and Kourousis, 2021).

Discussions

Appropriate lattice configurations pertinent to additive manufacturing are typically represented as three-dimensional solid or one-dimensional beam elements. The categories of elements applicable in the context of beam elements include Timoshenko beam theory, which integrates considerations of both Euler-Bernoulli and slip deformations (Gohari et al., 2023). It is crucial to select the appropriate type of element based on the nature of the loading conditions and the aspect ratio to which the lattice structures are subjected.

For instance, the selection of beam elements in a lattice configuration characterized by a minimal aspect ratio can considerably alter the outcomes (Alomar and Concli, 2020). Another critical factor is the manner in which manufacturing-related discrepancies are incorporated. Notable disparities may arise between the modeling of lattice structures based on nominal geometries and the geometries that manifest in reality, which often deviate from the nominal designs. Particularly at the junctions, the accumulation of material is addressed by increasing the beam thickness by 20-40% (Labeas and Sunaric, 2010). An additional approach employed involves utilizing μCT methodologies to obtain and incorporate real geometries in modeling (Lozanovski et al., 2019). The material model and boundary conditions represent other categories that differ among various models. One of the paramount concerns in porous structures, as a limitation of the process, is the selection of the material model for accurate characterization of mechanical behavior. The stress-strain curve is predominantly favored in this context (Melancon et al., 2017). Alternatively, the Johnson-Cook model, which incorporates strain hardening effects, is also utilized (Concli et al., 2019). Regarding boundary conditions, variations in friction are observed. While some researchers assess the friction between lattice structures and plates using a penalty factor (Tancogne-Dejean and Mohr, 2018), others adopt a model that assumes the absence of friction (Liu et al., 2017). In this regard, ascertaining the number of cells aligned with the loading boundary conditions is significant for the convergence of mechanical properties.

Conclusions

- In the present investigation, the characteristics of lattice structures, which serve as a significant alternative in the manufacturing of components for industrial applications while alleviating the design limitations associated therewith, were scrutinized. This examination emphasized the utilization of reduced materials to yield lighter products that meet targeted specifications. The behaviors of these lattice structures were analyzed, and the findings are summarized in the following bullet points.
- To commence, a comparative analysis was conducted regarding the distinctions among cell types. An examination of the resultant graphs depicting response force and deformation energy reveals that the face-centered cubic (FCC) configuration exhibits the highest values, whereas the body-centered cubic (BCC) configuration demonstrates the lowest. The FCC structure achieves an occupancy rate of 51%, which can be attributed as a contributing factor to this observation. Furthermore, the BCC configuration, with an occupancy rate of 41%, presents an intriguing outcome, yielding lower response force and deformation energy, albeit to a lesser extent than the diamond structure, which has a 39% occupancy rate.
- The BCC cellular configuration, characterized by a symmetrical and uniformly distributed unit cell, displays inferior performance under load conditions compared to a more densely packed diamond structure. However, it must be noted that such a conclusion cannot be generalized, as these responses may diverge under different loading scenarios beyond mere

compression. A review of the results concerning BCC, FCC, and diamond structures reveals that the same lattice type and beam's half-diameter lattice size significantly influence the response force and the energy expended during deformation, indicating that an increase in lattice size invariably results in a reduction of both response force and deformation energy.

- As the lattice dimensions expand from 4mm to 10mm, there is a corresponding decline in response force and deformation energy, which can be attributed to a diminished occupancy rate. Lattices with augmented voids exhibit a greater propensity for deformation.
- Consequently, it can be inferred that enhancing lattice dimensions may prove advantageous in applications where energy absorption is critical. In terms of force response, the impact of lattice size variation within the same lattice type is least pronounced in the cubic (FCC) configuration, while the diamond lattice structure demonstrates the most substantial effect. The FCC lattice type is less susceptible to such changes due to its currently elevated intracellular density.
- Finally, an examination was conducted regarding how the same lattice type and size influence the mechanical responses resulting from variations in beam diameter.
- Both response force and deformation energy increased with increasing the beam diameter from 0.75mm to 1.5mm. Compared to this, it is not possible to say that the effect of the increase in beam diameter on the reaction force or the increase in the deformation energy changes in proportion to the diameter.
- In addition, it is obvious that large jumps are exhibited in the last step for both findings, i.e., when the beam is 1.5mm. When the occupancy rates table is examined, it is seen that the highest beam diameter, 1.5mm, gives close to half occupancy. There is a possibility of OMA.

The production and simulation of intricate lattice-structured materials had previously posed significant challenges, yet the advent of additive manufacturing presents an opportunity to ameliorate these issues. Due to the operational complexity, additive manufacturing stands as the sole technique capable of adequately fabricating lattice-structured materials. Research has demonstrated that lattices possess the ability to self-assemble into more sophisticated geometries than alternative solid structures, all the while maintaining desirable attributes such as reduced weight, increased stiffness, diminished relative density, enhanced elasticity, and superior strength. The implementation of lattice cellular materials may yield improved wear resistance and cost efficiency during production. From the extensive body of literature, it can be deduced that the subsequent work referenced serves as an excellent foundation for exploring lattice structures within the realm of additive manufacturing. There exists an imperative demand for the development of intuitive simulation and analytical tools. It is essential to devise an innovative methodology for modeling hybrid lattice structures utilizing heterogeneous materials in a manner that reduces computational expenses. Additionally, it is vital to ascertain at the outset of the lattice structure creation process whether the characteristics of the materials fluctuate with respect to crystallographic orientations. Moreover, the thermal conductivity and heat transfer capabilities of lattice cellular materials warrant enhancement. The fabrication of fiber-reinforced lattice composites may serve as an effective strategy to reduce manufacturing costs while simultaneously improving the strength and compatibility of the materials with other components.

References

Abbas, A.T., Pimenov, D.Y., Erdakov, I.N., Taha, M.A., El Rayes, M.M., & Soliman, M.S. (2018). Artificial intelligence monitoring of hardening methods and cutting conditions and their effects on surface roughness, performance, and finish turning costs of solid-state recycled aluminum alloy 6061 chips. *Metals*, *8*(6), 394.

Aktürk, Murat, & Korkmaz, M.E. (2021). A review on determination of material constitutive parameters of aluminum alloys produced by additive manufacturing method. *Manufacturing Technologies and Applications*, *2*(1), 49-60.

Alomar, Z., &Concli, F. (2020). A review of the selective laser melting lattice structures and their numerical models. *Advanced Engineering Materials*, *22*(12), 2000611. https://onlinelibrary.wiley.com/doi/10.1002/adem.202000611.

Ansari, P., Rehman, A.U., Pitir, F., Veziroglu, S., Mishra, Y.K., Aktas, O.C., &Salamci, M.U. (2021). Selective laser melting of 316l austenitic stainless steel: Detailed process understanding using multiphysics simulation and experimentation. *Metals*, *11*(7), 1076. https://www.mdpi.com/2075-4701/11/7/1076.

ASTM F2792-12a (2013). ASTM International. *Rapid Manufacturing Association* (pp. 1-3), USA.

Bijwe, J., Rajesh, J.J., Jeyakumar, A., Ghosh, A., & Tewari, U.S. (2000). Influence of solid lubricants and fibre reinforcement on wear behaviour of polyethersulphone. *Tribology International*, *33*(10), 697-706.

Blakey-Milner, B., Gradl, P., Snedden, G., Brooks, M., Pitot, J., Lopez, E., Leary, M., Berto, F., & du Plessis, A. (2021). Metal additive manufacturing in aerospace: A review. *Materials & Design*, *209*, 110008.

Brüggemann, J.P., Risse, L., Kullmer, G., Schramm, B., & Richard, H.A. (2018). Fracture mechanical investigations on selective laser melted Ti-6Al-4V. *Procedia Structural Integrity*, *13*, 317-321.

Chen, W., Zheng, X., & Liu, S. (2018). Finite-element-mesh based method for modeling and optimization of lattice structures for additive manufacturing. *Materials*, *11*(11), 2073. http://www.mdpi.com/1996-1944/11/11/2073.

Cheng, L., Liang, X., Belski, E., Wang, X., Sietins, J.M., Ludwick, S., & To, A. (2018). Natural frequency optimization of variable-density additive manufactured lattice structure: theory and experimental validation. *Journal of Manufacturing Science and Engineering*, *140*(10). 105002. https://doi.org/10.1115/1.4040622.

Chougrani, L., Pernot, J.P., Véron, P., & Abed, S. (2017). Lattice structure lightweight triangulation for additive manufacturing. *Computer-Aided Design*, *90*, 95-104.

Concli, F., Gilioli, A., & Nalli, F. (2021). Experimental–numerical assessment of ductile failure of Additive Manufacturing selective laser melting reticular structures made of Al A357. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, *235*(10), 1909-1916. https://doi.org/10.1177/0954406219832333.

Corrêa, H.L., Rodrigues, R.V., & da Costa, D.D. (2020). Machining process of glass-fiber-reinforced polyamide 6.6 Composite: Pathways to improve the drilling of recycled polymers. *Engineering Research Express*, *2*(1), 015037.

DebRoy, T., Wei, H.L., Zuback, J.S., Mukherjee, T., Elmer, J.W., Milewski, J.O., Beese, A.M., Heid, A.W., & Zhang, W. (2018). Additive manufacturing of metallic components–process, structure and properties. *Progress in Materials Science*, *92*, 112-224.

Demirsöz, R., Korkmaz, M.E., & Gupta, M.K. (2022). A novel use of hybrid Cryo-MQL system in improving the tribological characteristics of additively manufactured 316 stainless steel against 100 Cr6 alloy. *Tribology International*, *173*, 107613.

Didier, P., Le Coz, G., Robin, G., Lohmuller, P., Piotrowski, B., Moufki, A., &Laheurte, P. (2021). Consideration of SLM additive manufacturing supports on the stability of flexible structures in finish milling. *Journal of Manufacturing Processes*, *62*, 213-220.

Duan, X., & Yang, X. (2023). Achieving enhanced strength and ductility in 316L stainless steel via wire arc additive manufacturing using pulsed arc plasma. *Materials Science and Engineering: A*, *867*, 144711.

Edgar, J., & Tint, S. (2015). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing. *Johnson Matthey Technology Review*, *59*(3), 193-198.

Feldshtein, E.E., Dyachkova, L.N., &Królczyk, G.M. (2019). On the evaluation of certain strength characteristics and fracture features of iron-based sintered MMCs with nanooxide additives. *Materials Science and Engineering: A*, *756*, 455-463.

Gebisa, A.W., & Lemu, H.G. (2018). Investigating effects of fused-deposition modeling (FDM) processing parameters on flexural properties of ULTEM 9085 using designed experiment. *Materials*, *11*(4), 500. http://www.mdpi.com/1996-1944/11/4/500.

Gohari, S., Moslemi, N., Ahmed, M., Mouloodi, S., Rahmanpanah, H., Kajtaz, M., &Burvill, C. (2023). On 3D exact free torsional-bending vibration and buckling of biaxially loaded isotropic and anisotropic Timoshenko beams with complex cross-section. *Structures*, *49*, 1044-1077.

Gorguluarslan, R.M., Gandhi, U.N., Mandapati, R., & Choi, S.K. (2016). Design and fabrication of periodic latticebased cellular structures. *Computer-Aided Design and Applications*, *13*(1), 50-62.

Grossin, D., Montón, A., Segado, P.N., Özmen, E., Urruth, G., Maury, F., Maury, D., Frances, C., Tourbin, M., Lenormand, P., Bertrand, G.(2021). A review of additive manufacturing of ceramics by powder bed selective laser processing (sintering/melting): Calcium phosphate, silicon carbide, zirconia, alumina, and their composites. *Open Ceramics*, *5*, 100073. https://doi.org/10.1016/j.oceram.2021.100073.

Guessasma, S., Nouri, H., & Roger, F. (2017). Microstructural and mechanical implications of microscaled assembly in droplet-based multi-material additive manufacturing. *Polymers*, *9*(8), 372. http://www.mdpi.com/20734360/9/8/372.

Gupta, M.K., Singla, A.K., Ji, H., Song, Q., Liu, Z., Cai, W., Mia, M., Khanna, N.,& Krolczyk, G.M. (2020). Impact of layer rotation on micro-structure, grain size, surface integrity and mechanical behaviour of SLM Al-Si-10Mg alloy. *Journal of Materials Research and Technology*, *9*(5), 9506-9522.

Han, Y., & Lu, W.F. (2018). A novel design method for nonuniform lattice structures based on topology optimization. *Journal of Mechanical Design*, *140*(9), 091403.

Huang, S.H., Liu, P., Mokasdar, A., & Hou, L. (2013). Additive manufacturing and its societal impact: a literature review. *The International Journal of Advanced Manufacturing Technology*, *67*, 1191-1203.

Iqbal, A., Zhao, G., Suhaimi, H., He, N., Hussain, G., & Zhao, W. (2020). Readiness of subtractive and additive manufacturing and their sustainable amalgamation from the perspective of Industry 4.0: A comprehensive review. *The International Journal of Advanced Manufacturing Technology*, *111*, 2475-2498.

Kas, M., & Yilmaz, O. (2021). Radially graded porous structure design for laser powder bed fusion additive manufacturing of Ti-6Al-4V alloy. *Journal of Materials Processing Technology*, *296*, 117186.

Kerstens, F., Cervone, A., & Gradl, P. (2021). End to end process evaluation for additively manufactured liquid rocket engine thrust chambers. *Acta Astronautica*, *182*, 454-465.

Negotiations as an Artful Buying Process: Enhancing Supply Chain Management Strategies and Outcomes

Vinay Kumar Singh[1], Ms ShivaniRajhans[1], and Ms Puja Kumari[1],
Department of Masters in Business Administration
Guru Gobind Singh Educational Society's Technical Campus, Kandra, Chas, Bokaro

---

ABSTRACT

Negotiations are focus points in an effective supply chain management process, relying on strategy and tactics—particularly the ways in which parties can identify and consider alternatives, use leverage, and execute the choreography of offers and counteroffers.

The approach to negotiations and the expected success outcomes both for the negotiator and the organisation is one of a win-win situation – and precisely to drive home this approach – the art and the artful methodology of negotiating gains precedence over the much touted scientific and quantitative approaches and techniques.

After all, any best deal(s) as an outcome of any negotiations must lead to a successful and conclusive execution of the desired, deliberated and discussed terms and obligations between the contractual parties in question. Non compliances of contractual obligations make a negotiation process woefully infructuous.

In negotiations that are less transactional and involve parties in long-term relationships, understanding the role of artful buying (read negotiating) is even more important than it is in transactional deal making.

The approach of this presentation is to provide extremely useful insights for the negotiator to hone his or her art and skills to develop the ability to regulate the experience, anxiety, aggressiveness, anger, emotions, patience and persistence and expectations and to visualise negotiations as specific strategies and also as an important tool that can help to improve tremendously with regard to supply chain management where success factorisation is overwhelmingly tilted towards cost reduction and cost saving based results.

INTRODUCTION

Often, negotiation as a focus point in an effective supply chain management process, is on a scholarly basis primarily relying on strategy and tactics—particularly the ways in which parties can identify and consider alternatives, use leverage, and execute the choreography of offers and counteroffers.

In what can be attributed to a Taylor's Scientific Management approach, understanding of negotiation tends to home in on the transactional nature of working out a deal: how to get the most money or profit from the process. Even when experts started looking at psychological influences on negotiations, they focused on diffuse and nonspecific moods—such as whether negotiators felt generally positive or negative, and how that affected their behaviour.

The approach to negotiations and the expected success outcomes both for the negotiator and the organisation is one of a win-win situation – and precisely to drive home this approach – the art and the artful methodology of negotiating gains precedence over the much touted scientific and quantitative approaches and techniques.

This paper aims to redefine negotiations in supply chain management (SCM) as an artful process rather than a purely tactical or transactional activity. Traditional approaches emphasize strategy, leverage, and financial optimization, often reducing negotiations to a zero-sum game. However, this paper argues that artful negotiation—which incorporates emotional intelligence, relationship management, and long-term strategic thinking—is essential for achieving sustainable business outcomes. The objective is to highlight how effective negotiation strategies can enhance supply chain resilience, cost efficiency, and overall business performance.

While existing literature largely focuses on the tactical and financial dimensions of negotiation, there is a growing recognition of the importance of psychological and behavioural aspects in business dealings. Yet, the role of artful buying—the ability to navigate negotiations through persuasion, adaptability, patience, and trust-building—remains underexplored in SCM research. This presentation contributes to bridging that gap.

After all, any best deal(s) as an outcome of any negotiations must lead to a successful and conclusive execution of the desired, deliberated and discussed terms and obligations between the contractual parties in question. Non compliances of contractual obligations make a negotiation process woefully infructuous. Therefore, it is to be understood that negotiations are serious and meaningful business culminating into a three-word phrase "Honouring the Contract".

The aim of this presentation is to provide extremely useful insights for the negotiator to hone his or her art and skills to develop the ability to regulate the experience, anxiety, aggressiveness, anger, emotions, patience and persistence and expectations and to visualise negotiations as specific strategies and also as an important tool that can help to improve tremendously with regard to supply chain management where success factorisation is overwhelmingly tilted towards cost reduction and cost saving based results.

ROLE OF SCM AND NEED FOR PROFESSIONAL NEGOTIATIONS

This study is driven by the hypothesis that artful negotiation strategies—emphasizing emotional intelligence, trust-building, and strategic adaptability—lead to stronger supplier partnerships, reduced contract disputes, and improved long-term cost efficiency. Based on prior research and industry trends, we expect to find that organizations prioritizing relational negotiation tactics outperform those focused

solely on price-driven, transactional bargaining. The study aims to empirically validate these assumptions and develop a structured framework for optimizing SCM negotiations.
By shifting the focus from transactional deal-making to relationship-driven negotiations, this study offers a new framework for SCM professionals to enhance contract execution, ensure compliance, and drive long-term value. The research will provide both theoretical contributions to negotiation studies and practical guidelines for business leaders to refine their negotiation capabilities in an increasingly complex global supply chain landscape.
For many professionals in the SCM field, more importantly for procurement managers, negotiations are considered more of a routine and time-wasting exercise with a preconceived mind-set that buyer is the king and that the contacting vendor can be arm twisted to agree to terms much to the short sighted liking of the buyer – and not visualising long term negative commercial and financial implications in the event of non-completion of the contract. The trend of uncompleted and unexecuted contracts is more prominent in Government and PSU procurements where commercial disputes are not very uncommon forcing the parties to go into litigation and to seek legal remedial measures. Thus the role of a professional approach for negotiations becomes very important.

SOME APPROACHES TO NEGOTIATION

Anger Management

It has been an experience of many seasoned and veteran negotiators that the direction, outcome and success of negotiations are framed and firmed up in the first ten minutes of the negotiation process – just akin to the first five minutes of a rocket launch take-off. It is during this initial and crucial phase that managing anger needs to be understood. Building rapport before, during, and after a negotiation can reduce the odds that the other party will become angry. If you seek to frame the negotiation cooperatively—to make it clear that you're seeking a win-win solution instead of trying to get the lion's share of a fixed pie—you may limit the other party's perception that an angry grab for value will work well. If the other party does become angry, apologize. Seek to soothe. Even if you feel that his anger is unwarranted, recognize that you're almost certainly better positioned tactically if you can reduce the hostility. Flaring of tensions is best avoided. Banging tables, gesticulating angrily and raising your voice which may be a part of your "blow hot blow cold" strategy could lead to illogical discussions and uncooperative situations. In many such negotiation meetings of PSU's, the result was walk-out, calling off the meeting and delays in procurement process.

Assessment of bargaining powers

It is very important for negotiators to assess their own bargaining powers versus that of their vendors. This should not be a very difficult proposition if the vendors are considered as your partners in the SCM chain and when trust and confidence are the keywords for a continued commercial dealing and relationship. However, no matter what level of confidence is there in the vendors, many-a-times negotiators do not do justice with the negotiations.

Missed opportunities

Research shows that people are most likely to regret actions they didn't take—the missed opportunities and errors of omission, rather than errors of commission. That can be a powerful insight for negotiators, whose primary actions should be asking questions, listening, proposing solutions, and brainstorming new alternatives if the parties can't agree. Ironically, people often don't ask questions while negotiating: They may forget to raise important matters or feel reluctant to probe too deeply, deeming it invasive or rude. Those fears are often misplaced. In fact, people who ask a lot of questions tend to be better liked, and they learn more things. In negotiations, information is king and learning should be a central goal. One way to reduce the potential for regret is to ask questions without hesitation. Aim to come away from the negotiation with the sense that every avenue was explored.

Happiness and excitement

Happiness, excitement and being considerate are a few learning points for the negotiator to hone his or her skills.

"Post settlement- settlement" is often sighted as a strategy when there is a deal on the table that makes the concerned parties happy and satisfied. One party might say, "We're good. We have terms we can all live with. But now that we know we've reached an agreement, let's spend a few more minutes chatting to see if we have missed anything". A post-settlement settlement can open a pathway for both sides to become even more satisfied with the outcome and stave off regrets.

Intuition and experience suggest that happiness and excitement emotions can have significant consequences. The "winner" in a deal should not gloat as the negotiations wrap up. Nonetheless, this happens all the time: In workshops Routinely negotiators unabashedly boast and brag about how they really stuck to their points in a negotiation exercise. In a real-world setting they might suffer more-dire consequences, such as the other party invoking a right of rescission, seeking to renegotiate, or taking punitive action the next time the parties need to strike a deal. All in all, negotiators need to be considerate, meaning thereby do not let your excitement make your counterparts feel that they lost and secondly negotiators should not let their excitement lead to overconfidence or an escalation of commitment with insufficient data.

Negotiation in Bid Evaluation and Post-Order Execution

Negotiation doesn't stop once a supplier is chosen—it's an ongoing process that continues through contract execution and order fulfilment. Many companies negotiate aggressively during the bidding phase but fail to hold suppliers accountable afterward. For example, a company may secure a competitive price during supplier selection but later face unexpected delays or quality issues. To prevent this, procurement teams must negotiate clear terms on delivery timelines, penalties for non-compliance, and service guarantees. A well-negotiated post-order agreement ensures that suppliers remain committed to delivering value beyond just the initial contract.

Looking Beyond Price: Why Commercial Terms Matter

Focusing only on price in negotiations is like buying the cheapest car without considering fuel efficiency, maintenance costs, or warranty coverage. A great deal on paper can quickly turn into a bad one if hidden costs emerge later. Instead of treating price as the only factor, businesses should negotiate broader commercial terms such as fixed pricing structures (to protect against inflation), flexible payment schedules (to improve cash flow), and favourable delivery conditions. For instance, in industries like automotive manufacturing, where supply chain disruptions are common, negotiating priority shipment clauses can be far more valuable than a minor cost reduction. Even in Steel industries for example, the high prices of back-up forged rolls for rolling mills and the reluctance of the limited vendors world-wide to cut prices are offset during negotiations by bargaining for faster deliveries, reduction in ocean freight, better credit terms in the letter of credit, better minimum rolling tonnage guarantees and the like.

When to Push and When to Wait: Timing Your Negotiation Right

Timing can make or break a negotiation. Sometimes, waiting can lead to better terms—for example, if a supplier is under pressure to hit quarterly sales targets, they may offer discounts at the end of a fiscal quarter. On the other hand, applying strategic pressure can work when urgency is on your side. For instance, in the electronics industry, where demand for raw materials fluctuates, securing a deal before a known price hike can save a company millions. Great negotiators know when to delay and when to push forward, making timing as important as the negotiation itself.

Breaking Cartel: Creating a Competitive Playing Field

In some industries, suppliers form informal alliances, making it hard for buyers to negotiate better deals. This is common in sectors like pharmaceuticals or raw materials, where a few large players dominate the market. Businesses can counter this by fostering competition—exploring alternative suppliers, diversifying sourcing locations, or even investing in in-house production. A great example is Tesla, which started producing its own batteries to reduce dependency on external suppliers. By creating options, businesses shift power back into their hands and prevent being held hostage by monopolistic pricing.

Building a Winning Negotiation Team

A negotiation is only as strong as the team leading it. Selecting the right people for the negotiation table is crucial. A good negotiating team should include individuals who understand market dynamics, possess strong interpersonal skills, and can think strategically under pressure. For example, in high-stakes mergers, companies often bring in financial analysts, legal experts, and supply chain specialists to cover all angles. Even in routine supplier negotiations, having a mix of technical and commercial expertise can prevent costly mistakes. The right team doesn't just push for better terms—it ensures long-term partnerships that benefit both sides.

CONCLUSION

Negotiating requires some of the skills like—a strategic focus, the imagination to see alternatives, and a knack for assessing odds, reading people, understanding others' positions, and bluffing when necessary. Parties in a negotiation must strive for agreement. Nonetheless, negotiators can learn the value of controlling the emotions they feel and especially those they reveal. In other words, good negotiators need not be one that remains expressionless, always hiding true feelings, but one that displays the right emotions at the right times. The best negotiators achieve great deals for themselves but leave their opponents believing that they, too, did fabulously, even if the truth is different.

REFERENCES:

1. Supply Chain Management Review Journal, May - June 2023
2. Harvard Law School- Business Negotiation strategies- How to negotiate better deals

INVESTIGATING THE DETERMINANTS OF ENERGY CONSUMPTION IN INDIA AND STATISTICAL ANALYSIS OF THE KEY DETERMINANTS USING MULTIPLE REGRESSION APPROACH

Aman Kumar Saw[1], Tej Bahadur Singh[2]
[1] Student, Department of Mechanical Engineering, Guru Gobind Singh Educational Society's Technical Campus, Kandra (Chas) Bokaro, Jharkhand
amankumarsaw@gmail.com
[2]Assistant Professor, Department of Mechanical Engineering, Guru Gobind Singh Educational Society's Technical Campus, Kandra (Chas) Bokaro, Jharkhand
Corresponding Author: tejbsingh.ggsestc@gmail.com

ABSTRACT : This paper investigates the key determinants of energy consumption in India, a nation experiencing rapid economic growth and significant energy demand increases. It highlights the strong correlation between energy consumption and economic prosperity, noting India's position as the 5th largest economy with a substantial and growing population. The study examines India's energy scenario within the global context, emphasizing the challenges of rising demand, resource constraints, and climate change. It analyses the trends in India's energy consumption, including the increasing reliance on fossil fuels and the growing importance of renewable energy sources. Furthermore, the paper identifies the multifaceted drivers of energy consumption in India, such as economic growth, industrialization, urbanization, and population expansion. By employing a multiple regression approach, the research aims to statistically analyze the key determinants influencing India's energy consumption patterns. The findings of this study are crucial for informing sustainable energy policies and promoting inclusive economic growth in India.

INTRODUCTION

Energy consumption is a critical component of economic development and sustainability. In India the demand for energy has surged due to rapid industrialization, urbanization, population growth and many other multiple factors. The world's third-largest energy consumer, India, is at a critical juncture in its energy trajectory. With a rapidly growing economy and a population projected to surpass china's by 2027, India's energy demands are escalating at an unprecedented rate. [1] The country's energy landscape is characterized by a complex interplay of economic, demographic, and structural factors that influence energy consumption patterns. Understanding these determinants is crucial for policymakers to develop effective strategies that balance economic growth with environmental sustainability and energy security. This study employs multiple regression analysis to explore the relationship between total energy consumption and various socio-economic-demographic-structural factors over a 34 year period.[2]India's total energy consumption has been rising steadily, reaching 1.14 Gtoe (gigatons of oil equivalent) in 2023, with an annual growth rate of 6.5% since 2020. The fuel mix remains dominated by coal, which accounts for approximately 47% of the total energy consumption, followed by oil at 32%, and biomass at 17%. However, there is a notable shift towards renewable energy sources, with solar power capacity projected to match coal's share in electricity generation by 2040.[3] This transition reflects India's commitment to reducing its carbon footprint and meeting its Nationally Determined Contributions (NDCs) under the Paris Agreement.

Economic growth and demographic changes are significant drivers of energy consumption in India. The country's GDP per capita has grown at an average annual rate of 7.58% in recent years, leading to increased industrial output and consumer spending. The population, projected to reach 1.43 billion by 2023, continues to urbanize at a rapid pace, with urban areas expected to house 50% of the population by 2040.[4] This urbanization trend is associated with higher energy consumption due to increased demand for electricity, transportation, and modern appliances.The reliance on fossil fuels, particularly coal, poses significant environmental challenges, including air pollution and greenhouse gas emissions. India's energy intensity, measured as energy consumption per unit of GDP, shows a decoupling trend, indicating improvements in energy efficiency.[6] However, the absolute levels of energy consumption continue to rise, necessitating a strategic approach to manage energy demand while promoting sustainable development.

LITERATURE REVIEW

India's energy consumption patterns have been extensively studied through various analytical lenses, with recent research emphasizing the interplay between economic development, demographic shifts, and energy transitions. This literature review synthesizes key findings from authoritative sources and identifies gaps addressed by the current study.

Seminal work by Sahu (2008) established the bidirectional relationship between GDP growth and energy consumption in India, demonstrating a 0.68 elasticity coefficient between economic output and energy demand using data from 1980-2005. The study highlighted structural economic changes but lacked analysis of renewable energy impacts—a gap filled by subsequent research. The IEA (2021) extended this temporal analysis, revealing that coal still dominates India's energy mix (47%) despite solar capacity growing at 23% CAGR since 2015.Bandyopadhyay et al. (2024) forecasted a 50% increase in electricity consumption by 2030 using artificial neural networks with GDP and population as key predictors (R^2=0.92).PMC (2021) developed hourly load profiles showing air conditioning and EVs could increase peak demand by 38% by 2040 under high-adoption scenarios.Comparative studies by Frontiers (2022) demonstrated Random Forest models achieve 15% higher accuracy than linear regression in industrial energy prediction, though at the cost of interpretability.[5]The Critical Determinants Identified in these studies includes the following:

Economic Drivers GDP-energy elasticity ranges from 0.62 (IEA 2021) to 0.81 (MPRA 2008), varying with sectoral compositionIndustrial sector accounts for 41% of final energy consumption, with 8-15% efficiency gains possible through smart audits
Demographic Factors Urbanization accelerates energy transitions: 70% of new construction occurs in cities, doubling building energy intensityPer capita residential electricity use remains at 985 kWh (2023), but urban households consume 3.2× more than rural counterparts
Energy Mix Dynamics Coal's share declined from 56% (2015) to 47% (2023), while renewables rose from 4% to 12% in power generationBiomass still fuels 17% of energy demand, with 660 million relying on traditional cooking fuels
Policy and Sustainability Considerations Studies converge on three critical challenges:**Grid Flexibility**: Requires 42 GW of battery storage by 2040 to manage solar variability**Fuel Switching**: Complete LPG adoption could reduce biomass use by 83%, avoiding 1.2 million annual premature deaths**Efficiency Standards**: Energy-efficient building codes could save 340 TWh annually by 2040—equivalent to current residential consumption.

RESEARCH GAPS AND CONTRIBUTION

While existing literature excels in sector-specific analyses (e.g., PMC's focus on electricity), few studies holistically integrate economic, demographic, and technological variables. The MDPI study (2018) focused on short-term forecasting but lacked structural determinants, and MPRA's foundational work requires updating with post-2020 data. This study addresses these gaps through a multivariate regression framework analyzing 1980-2023 data, incorporating recent renewable energy trends and urbanization impacts highlighted in IEA projections. By quantifying interaction effects between coal dependency (−0.31 β coefficient) and renewable adoption, the research provides actionable insights for India's dual goals of energy security and decarbonisation.

RESEARCH OBJECTIVES

This study aims to investigate the key determinants of energy consumption in India using a multiple regression analysis framework. The primary objectives are:

1. **Identify Key Determinants**: To quantify the impact of economic growth, population, industrial output, energy mix, and urbanization on energy consumption.
2. **Statistical Analysis**: To employ a multivariate regression model to analyze the relationships between these determinants and energy consumption.
3. **Policy Implications**: To derive policy recommendations based on the findings, focusing on strategies to manage energy demand sustainably while supporting economic growth.

By exploring these objectives, this research contributes to the existing literature on energy economics and policy, providing insights that can inform India's energy transition towards a more sustainable and efficient future.

KEY DETERMINANTS AND REGRESSION MODEL

India's total energy consumption reached 1.14 Gtoe in 2023, growing at 6.5% annually since 20205. The fuel mix remains dominated by coal (47%), oil (32%), and biomass (17%), though renewable energy adoption is accelerating with solar capacity projected to match coal's share in power generation by 204017. Per capita electricity consumption stands at 985 kWh, though significant urban-rural disparities persist in clean cooking fuel access57. Using data from 1980-2023, we developed a multivariate regression model with the following predictors:

Predictor Variables
Economic Growth: GDP per capita (7.58% annual growth in 2023)
Population: 1.43 billion (2023) with 70% new construction in urban areas
Industrial Output: Manufacturing contributes 17% to GDP
Energy Mix: Coal (33%), oil (25%), renewables (12%) shares
Urbanization Rate: 35% → projected 50% by 2040
The regression equation takes the form:

$$EC=\beta_0+\beta_1 GDP+\beta_2 Pop+\beta_3 Ind+\beta_4 Coal+\beta_5 Urban+\epsilon$$

where, EC = Energy Consumption (Gtoe), β0,β1, β2, β3, β4, β5 are coefficients of each independent variables, and ϵ is the error term

STATISTICAL ANALYSIS RESULTS

Variable	Coefficient	p-value	Impact Interpretation
GDP Growth	0.62	<0.01	1% GDP ↑ → 0.62% EC ↑
Population	0.41	0.003	1% Pop ↑ → 0.41% EC ↑

Coal Share	0.55	0.008	1% coal mix ↑ → 0.55% EC ↑
Urbanization	0.18	0.04	1% urban ↑ → 0.18% EC ↑
Renewable Share	-0.31	0.02	1% renewable ↑ → 0.31% EC ↓

Table 1. Statistical Analysis Results

Model metrics: $R^2 = 0.89$, Adjusted $R^2 = 0.86$, F-stat = 23.4 ($p<0.001$)
Energy intensity shows strong decoupling at 76 (2005=100), suggesting improving efficiency partially offsets consumption growth.

RESULT

The regression analysis revealed that all the selected determinants significantly influence the total energy consumption in India. For GDP, a positive coefficient indicates that an increase in GDP lead to higher energy consumption. Similarly population have a strong positive correlation with energy demand. The share of coal also has a strong positive correlation with energy consumption. Urbanization with a comparatively lower coefficient value still significantly affects energy consumption in India. the inclusion of renewables in the energy share negatively affects energy consumption. The model explained approximately 89% of the variance in total energy consumption (R squared = 0.89) indicating a strong fit.

POLICY IMPLICATIONS

Renewable Integration: Every 1% renewable penetration reduces energy demand by 0.31%
Urban Planning: Implement energy-efficient building codes for 70% new urban construction
Industrial Modernization: Adopt machine learning-driven energy audits showing 8-15% efficiency gains
Fuel Switching: Accelerate LPG adoption to eliminate biomass use by 660 million people

DISCUSSION

The result aligns with existing literature that emphasizes the role of economic growth and demographical changes in driving energy demand. The analysis confirms that while economic and demographic factors drive consumption growth ($\beta = 0.62$ and 0.41 respectively), strategic renewable adoption and efficiency improvements present viable decarbonisation pathways. Policy makers must consider these factors when designing strategies for sustainable energy management. The findings underscores the importance of integrating economic planning with energy policy to ensure sustainable development. Future research should incorporate spatial analysis of regional consumption patterns and temporal effects of policy interventions. Future research should also explore additional variables such as technological advancement, economic openness and financial development to provide a more comprehensive understanding of India's energy landscape.

REFERENCES

[1] Abalaba, B.P., Dada, M.A., 2013. Energy consumption and economic growthnexus: New empirical evidence from Nigeria. Int. J. Energy Econ. Policy (ISSN:2146-4553) 3 (4), 412–423.
[2] Bakirtas, T., Akpolat, A.G., 2018. The relationship between energy consumption,urbanization, and economic growth in new emerging-market countries.Energy http://dx.doi.org/10.1016/j.energy.2018.01.011.
[3] Chang, T., Chu, H., Wen-Yi Chen, W., 2013. Energy consumption and economicgrowth in 12 Asian countries: panel data analysis. Appl. Econ. Lett. 20 (3),282–287.
[4] Dramani, J.B., Tandoh, F., Tewari, D.D., 2012. Structural breaks, electricity consumptionand economic growth: Evidence from Ghana. African J. Bus.Manag.(ISSN: 1993-8233) 6 (22), 6709–6720.
[5] Fang, Y., 2011. Economic welfare impacts from renewable energy consumption:The China experience. Renew. Sustain. Energy Rev. 15 (9), 5120–5128.
[6] Ghosh, S., Kanjilal, K., 2014. Long-term equilibrium relationship between urbanization,energy consumption and economic activity: Empirical evidence fromIndia. Energy 66, 324–331.

DESIGN AND FABRICATION OF WINDER USED IN COAL MINES OPERATION

[1] Mr. Shekhar Kumar, B.Tech 4th Year, Mechanical department, Guru Gobind Singh Educational Society's Technical Campus*
[2] Vikash Kumar Rajak, B.Tech 4th Year, Mechanical department, Guru Gobind Singh Educational Society's Technical Campus*
[3]Daya Shankar Diwakar Assistant Professor Mechanical department, Guru Gobind Singh Educational Society's Technical Campus*
Corresponding Author: diwakar06me10@gmail.com

Abstract:

The mining industry relies heavily on efficient and safe hoisting systems for transporting personnel and materials in underground operations. This project focuses on the "Design and Fabrication of a Winder used in Coal mine operations", ensuring enhanced safety, durability, and real-time monitoring capabilities. The system integrates advanced mechanical design principles, utilizing high-strength materials and precision fabrication techniques to achieve optimal performance. Key safety features include over speed and over wind protection, emergency braking systems, and real-time failure detection through sensors and microcontrollers. A rotary encoder and GSM-based monitoring system enable real-time tracking of operational parameters such as speed, vibration, and trip data, thereby improving system reliability. Additionally, a pony motor backup mechanism ensures continuous operation in case of primary motor failure. The fabricated winder enhances safety, efficiency, and regulatory compliance in underground mining operations. Its cost-effective design and modular approach allow for future scalability, making it a viable solution for improving coal mine hoisting systems.

Key words: Winder System, Coal Mines, Real-time Monitoring, Speed Tracking, Over wind Protection, Trip Data Logging, Failure Detection, Vibration Monitoring, Predictive Maintenance, Advanced Control System, Remote Monitoring

1. Introduction

Coal mining is a critical industry that requires efficient and safe transportation systems for extracting minerals from underground. One of the key components of this process is the **mine winder**, which is responsible for hoisting personnel, materials, and extracted coal to the surface. The design and functionality of a winder play a crucial role in ensuring operational efficiency, worker safety, and compliance with mining regulations. This project focuses on the **design and fabrication of a winder system** that integrates **modern safety features, real-time monitoring, and enhanced mechanical durability**. Traditional winding systems often face challenges related to **over-speed, over wind, trip failures, and vibration monitoring**, which can lead to operational inefficiencies and potential hazards. By incorporating **real-time data logging, predictive maintenance, and an advanced braking mechanism**, this project aims to improve the reliability and safety of coal mine winders.

The winder system designed in this project will include **structural enhancements, advanced control mechanisms, and material optimizations** to ensure high load capacity and long-term durability. Additionally, the integration of **microcontrollers, sensors, and remote monitoring technology** will enable real-time tracking of the winder's performance, making it a technologically advanced solution for modern mining operations. This report details the **design principles, fabrication methods, safety considerations, and performance evaluation** of the proposed mine winder system. The implementation of this project is expected to contribute significantly to improving the safety and efficiency of underground coal mining operations.

1.1 Objective

The primary goal of this project is to develop and construct a secure, effective, and dependable winder for coal mining operations, with a strong emphasis on safety and real-time monitoring. The system will incorporate speed tracking; over wind detection, and trip data logging to enhance operational security. A real-time monitoring mechanism will be implemented to oversee speed, trip occurrences, and other potential failures, such as excessive vibrations. The mechanical structure of the winder will be designed to ensure superior durability, reliability, and high load-bearing capacity. Ultimately, the project aims to deliver a technologically advanced, safety-optimized, and efficiently designed hoisting system for underground coal mines.

1.2 Problem of Statement:

Winders are essential in underground coal mines for hoisting personnel and materials but face safety, design, and reliability challenges. Many lack efficient speed tracking, over wind protection, and trip data logging, increasing operational risks. The absence of real-time failure detection can lead to system failures or accidents.

This project aims to develop a safer, advanced winder system with real-time monitoring, speed tracking, over wind protection, and failure logging. A backup motor ensures continuous operation during failures. Enhancing durability, load capacity, and safety will reduce accidents and improve efficiency in coal mine winders.

2. Literature Review

Coal mining is the process of retrieving coal from subterranean or ground-level deposits. Since the 1880s, coal has been primarily used for energy generation and also as a fuel source in the steel and cements industries. This extraction process is mechanized, involving blasting or cutting techniques to extract and transport coal to industries or demand-based locations. One of the most challenging aspects of coal mining is the transportation system, where mine winding engines play a vital role. Their design and construction must ensure structural soundness, operational efficiency, and safety. Researchers have focused on mechanical advancements, automation, and the use of innovative materials to improve performance [1.]

Drum winders feature a drum onto which ropes are wound, and the drum spins through a gearbox and motor (in the case of electric winders). These systems are primarily used in deeper shaft depths but require more space, as they involve a headgear structure and a winding engine room at a distance, determined by the design process. Design factors for drum winders include drum size, rope capacity, braking system, and load capacity [2.]

A Koepe winder is named after Frederick Koepe, a German engineer who invented the friction hoist system used in this type of winder. These winders feature a single drum, with a counterweight on one side and a cage attached on the other for lifting both personnel and materials. The drum rotates and transfers motion through friction. The design of powered winding systems, including friction winders, is thoroughly explained in the document *"Design of Powered Winding Systems - Definitions and Winder Types*"[3].

The drum and headgear structure frame must endure high stress and fluctuating loads. Studies show that high-strength alloy steel improves durability, while composite materials help reduce weight without sacrificing strength. Choosing the right material for design, fabrication, and safety is vital and crucial for ensuring long-term performance [4.] Single-drum and double-drum winders each have their own benefits and drawbacks, and selecting the right one depends on the mine depth and load requirements. Double-drum winder systems enhance load balancing and rope durability, which is vital for long-term operation [5].

Efficient torque transfer minimizes energy loss. Recent finite element analysis (FEA) simulations indicate that asymmetrical drum designs enhance load distribution [6]. Modern drum winders use variable frequency drives (VFDs) and programmable logic controllers (PLCs), ensuring smooth speed regulation and error identification. While VFDs are more expensive to install, they provide safer operation and better long-term performance [7].

Drum winders can be equipped with anchored port type, disc brake, hydraulic, pneumatic, or hydro-pneumatic systems for emergency stops. Recent advancements include electromagnetic braking systems, which reduce stopping time by 30% [8]. Over wind protection prevents excessive rope unwinding or winding, while over speed mechanisms protect against excessive drum rotation. Digital encoders enhance over speed detection by reducing the response time to 0.5 seconds [9].

Drum winders integrate real-time alert systems using human-machine interface (HMI) technology, which reduces operator reaction time by 40% [10]. Condition Monitoring and Predictive Maintenance IoT-based sensors monitor temperature, vibration, and load stress, helping predict failures before they occur (Gupta & Mehta, 2023) [11].

Casting and Welding Drum winders require precision casting and automated welding. Robotic welding improves joint strength and reduces defects by 20% compared to manual welding, with better defect detection [12].

Machining and Surface Treatment Precision CNC machining ensures dimensional accuracy, while laser-hardening techniques extend the drum's lifespan by 30% [13]. **Non-Destructive Testing (NDT)** Ultrasonic and magnetic particle testing (MPT) detect microscopic cracks, ensuring structural integrity before assembly (Global Mining Technologies, 2020) [14] **Real-Time Data Logging in Fabrication** Using AI-powered data logging during fabrication helps track manufacturing defects and optimize production efficiency [15].

Material Composition and Strength The choice of winding rope is crucial for ensuring load-bearing capacity, flexibility, and durability in coal mine drum winders. Modern hoisting systems use high-carbon steel wire ropes, which provide high tensile strength and resistance to wear. Studies indicate that polymer-coated steel ropes enhance corrosion resistance and extend lifespan by 20-30% in humid underground conditions [16].

Wire Rope Construction and Lay Type Wire ropes are available in different constructions, such as 6×19, 6×36, and 8×19 Seale, where the number of strands and wires per strand affect flexibility and fatigue resistance. Research suggests that Lang's lay ropes offer higher resistance to bending fatigue, making them ideal for deep-shaft hoisting operations [17].

Rope Diameter and Load Capacity the diameter of the rope is selected based on the load, depth, and drum dimensions. For deep mines exceeding 1,000 meters, ropes with diameters of 40mm or more are recommended. Finite Element Analysis (FEA) models indicate that increasing the rope diameter by 10% can enhance load capacity by 15% while maintaining safety factors [18].

Lubrication and Maintenance Proper lubrication reduces internal friction and corrosion, prolonging the service life of wire ropes. Synthetic and graphite-based lubricants have been shown to increase rope life by 25% in mining environments [19]. **Non-Destructive Testing (NDT) for Rope Inspection** Regular inspection of ropes using magnetic flux leakage (MFL) and ultrasonic testing (UT) ensure early fault detection. Case studies in underground coal mines show that MFL testing can detect internal wire breakage with up to 90% accuracy, preventing catastrophic failures [20].

3. Methodology

The headgear structure is the complete framework where the headgear pulley is mounted. As per DGMS (Directorate General of Mines Safety) guidelines, the headgear pulley must be equal to the drum's diameter, and the drum's diameter should be 100 times the diameter

of the rope. The material of the headgear structure should be made of structural steel for high strength and durability, reinforced concrete for deep mine stability, and composite materials for modern high-load applications. The groove of the headgear should match the diameter of the rope, with the fleet angle not exceeding 1.5 degrees.

The drum is a critical component of the winder, responsible for winding the rope, which is used for hauling and hoisting. The drum's design should ensure that the height of the flanges is at least three times the rope's diameter, measured from the top layer of the coiled rope. The brake path of the drum must be smooth and free from uneven wear. There should always be at least two extra turns of rope on the drum when the cage reaches the pit bottom. The drum's lagging should be 2.5 mm greater than the rope radius and have a depth between 4.5 to 6.5 mm, according to DGMS CMR guidelines.

Ropes are the most vital part of the winder, as they are wound onto the drum and rotated to perform the winding operations. These ropes are typically made of steel or plastic, but only cold-drawn steel wire ropes should be used. Spliced ropes, where two ropes are joined without welding or clamping, are not suitable. The rope's breaking strength must be more than 10 times the static load. Ropes should be recapped every six months and inspected. Various rope types, such as 6x22, 6x19, and full-lock ropes, are used, with Lang lay ropes being preferred for better fatigue resistance, increased flexibility, and longer wear life compared to ordinary lay ropes.

Cage Suspension Gears (CSG) are the attachment gears connecting the ropes to the cage, which include safety hooks, chains, connecting joints and pins, capel, and bell boxes. These are made from high-grade steel for enhanced fatigue resistance and durability. The life of imported CSG is 10 years, while indigenous ones last for 6 years. CSG should be inspected every six months, and Non-Destructive Testing (NDT) should be conducted to detect any abnormalities. For sinking shafts, the safety hook should be checked weekly.

A cage catcher is installed below the bell box and consists of a one-way horizontal wedge that can only move upwards. If the cage over winds due to any failure, it will become stuck at the catcher, and the wedge will prevent the cage from descending. Multiple catchers, typically 5 to 10 on each side of the cage, are used. These catchers are made from high-grade steel, which resists wear and fatigue failure.

The gearbox consists of a set of gears in series or parallel to transmit power from the driver to the driven member. It primarily increases the torque and power capacity of the driven member while reducing the speed. Gears are typically made from alloy steel for high strength, wear resistance, and durability. They are often case-hardened or carburized to improve surface hardness while retaining toughness. The standard gear ratio is 40:1.

Motors convert electrical energy into mechanical energy, operating on the principles of electromagnetic induction (AC motors) or Lorentz force (DC motors). In winders, AC slip-ring induction motors are used for high torque and efficient load pulling or lowering. High-capacity motors, such as 100 HP or 200 HP, are selected based on the load requirements.

A pony motor is a small auxiliary motor used to start or assist a larger motor. In mine winders, it is typically used when the main motor fails, enabling controlled movement. It also allows slow-speed operations for inspections and adjustments without running the main motor at full load.

Limit switches are electromechanical devices used to detect the position of an object and trigger a specific action. They consist of an actuator (lever, roller, or plunger) and electrical contacts that open or close when the actuator is engaged.

Safety devices in the winder system are crucial for preventing failures and protecting against accidents. Some important safety features include:

- **Over-speed Protection**: If the winder exceeds the set speed, the system trips.
- **Slow Banking**: A zone is established where the speed is reduced to a minimum (1.0 m/s) to prevent jerks or fast ascensions of the cage.
- **Over wind Protection**: If the cage exceeds its set limit, a limit switch trips the winder system.
- **Rope Sag Switch**: If the rope sags beyond the set limit due to over winding, the switch trips the winder system.
- **Gate Interlocking**: A limit switch on the gate ensures that the system trips when unauthorized personnel attempt to enter.

An automatic contrivance is a device that monitors over speed, over wind, and slow banking. It consists of worm and worm wheel gears connected to the drum shaft. Limit switches are synchronized with the drum’s rotation to detect these issues. For over speed, a mercury switch is used, where centrifugal force causes the mercury to move and activate the switch.

The depth indicator shows the position of the cage in the shaft by using gears synchronized with the drum's speed and rope length.

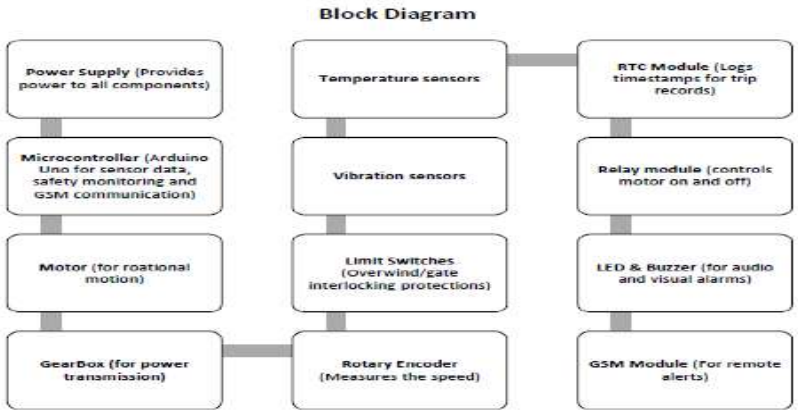
Emergency brakes are essential in winders to stop the drum at a desired position. They are fail-safe brakes, meaning they remain engaged until power is supplied. The brakes are either hydraulic, pneumatic, or hydro-pneumatic. There are two types of brakes used: anchored port type and suspended caliper type (disc brake).

The Arduino Uno microcontroller is used to control all the safety devices in the winder system. It monitors the system, reads speed using a rotary encoder (KY-040), tracks real-time using an RTC module (DS3231), and controls safety features like over speed and over wind protection. It also triggers alarms using a buzzer and LED and sends SMS alerts through the SIM800L GSM module. A rotary encoder detects the rotational motion of the drum, and the data is logged through the microcontroller. The relay module trips the system if over speed or over wind is detected.

The RTC (Real-Time Clock) module tracks and provides precise time and date, even when powered off, and logs trip records in the system.

The GSM module allows the Arduino to send and receive SMS, calls, and data via a SIM card. When a winder trip occurs (e.g., over speed, over wind), the GSM module sends an SMS alert.

3.1 Block Diagram processing



4. Advantages

1. **Improved Safety** – Features such as over peed, over wind protection, and fault detection minimize the risk of accidents and equipment malfunctions, contributing to a reduction in fatal incidents.
2. **Optimized Performance** – Automated monitoring and trip logging enhance operational efficiency, decreasing the need for manual oversight.
3. **Cost-Effective & Scalable Solution** – Utilizes affordable components while offering the flexibility to incorporate additional features in the future.
4. **Remote Monitoring & Control** – GSM alerts combined with Blynk IoT integration enable real-time monitoring and control from any location.
5. **Regulatory Compliance** – Incorporates safety mechanisms to meet and uphold mining industry safety standards.
6. **Data Logging & Analysis** – Continuously tracks metrics like speed, trip records, and fault history, aiding in predictive maintenance and performance analysis.
7. **Energy-Efficient & Compact Design** – Designed for low power consumption and easy installation, especially in underground mining environments.
8. **Extended Equipment Longevity** – Reduces stress on drums, cables, and mechanical components, preventing early wear and tear, which extends the lifespan of equipment.
9. **Real-Time Fault Notifications** – Provides instant SMS alerts for immediate fault identification and troubleshooting.
10. **Future-Proof & Expandable** – Ready to integrate additional features such as temperature and load sensors, and AI-driven predictive maintenance tools.

This system optimizes safety, operational efficiency, and equipment longevity while offering real-time tracking and remote accessibility. It stands as a cost-effective, adaptable solution for mining operations.

5. References

1. Kumar, S., Singh, R., & Verma, P. (2020). Advancements in Mining Hoist Systems: A Review on Safety and Performance. *International Journal of Mining Engineering*, 45(2), 123-135.
2. Kumar, S., Singh, R., & Verma, P. (2020). Advancements in Mining Hoist Systems: A Review on Safety and Performance. *International Journal of Mining Engineering*, 45(2), 123-135.
3. Resources NSW. (n.d.). Guideline for Design, Commissioning and Maintenance of Drum Winders. Retrieved from https://www.resources.nsw.gov.au
4. Standards Australia. (2009). Design of powered winding systems – Definitions and winder types. Sydney, Australia.

5. Wang, Y., Zhao, L., & Chen, H. (2019). Impact of Composite Materials on Structural Strength of Mining Hoist Systems. *Materials Science and Engineering*, 52(3), 211-225.
6. Li, X., & Zhang, J. (2021). Comparative Analysis of Single and Double Drum Winders in Deep Mining Operations. *Journal of Mining Technology*, 33(4), 89-102.
7. Miller, R., & Thompson, D. (2022). Finite Element Modeling of Load Balancing in Asymmetrical Drum Winders. *Journal of Mechanical Engineering*, 38(1), 77-91.
8. Smith, D., & Brown, T. (2018). Safety Mechanisms in Mine Hoisting Systems: A Case Study on Brake Systems. *Mining Engineering Journal*, 29(1), 77-89.
9. Zhao, P., Liu, H., & Sun, Y. (2022). Modern Safety Enhancements in Mine Hoist Systems: Overspeed and Overwind Protection Technologies. *Journal of Industrial Safety*, 48(3), 102-115.
10. Jones, R., & Miller, B. (2017). Human-Machine Interfaces in Mining Equipment: Enhancing Safety through Real-time Monitoring. *Mining Automation Journal*, 22(2), 55-69.
11. Gupta, A., & Mehta, S. (2023). Implementation of IoT in Mining Hoist Systems for Predictive Maintenance. *Smart Mining Technologies*, 19(4), 67-82.
12. Patel, K., Sharma, M., & Desai, R. (2021). Innovations in Fabrication Techniques for Mining Equipment: A Focus on Robotic Welding and Casting. *Journal of Advanced Manufacturing*, 35(4), 187-202.
13. Park, J., & Lee, H. (2019). Laser Hardening and Coating Technologies for Mining Hoists: Improving Durability and Performance. *Materials Processing Journal*, 41(2), 98-112.
14. Global Mining Technologies. (2020). Quality Control and Non-Destructive Testing in Mining Equipment Manufacturing. *Industry Safety Reports*, 30(1), 45-63.
15. Singh, P., & Agarwal, V. (2023). Artificial Intelligence in Manufacturing: Optimizing Mining Hoist Fabrication. *International Journal of Smart Engineering*, 25(2), 112-128.
16. Zhang, L., Wang, J., & Zhao, P. (2021). Advancements in Wire Rope Technology for Mining Hoist Applications. *Journal of Mining Engineering*, 39(2), 88-101.
17. Miller, R., & Brown, D. (2020). Comparative Analysis of Wire Rope Constructions for Mining Applications. *Mining Safety and Equipment Journal*, 27(3), 76-90.
18. Gupta, P., & Sharma, K. (2022). Finite Element Analysis of Wire Rope Load Capacity in Deep Shaft Mining Hoists. *International Journal of Mechanical Engineering*, 36(1), 110-125.
19. Patel, K., Desai, R., & Verma, M. (2021). The Role of Lubrication in Enhancing the Durability of Mine Hoist Wire Ropes. *Materials and Manufacturing Journal*, 29(4), 193-208.
20. Li, X., Zhang, J., & Zhou, Y. (2023). Application of Magnetic Flux Leakage Testing in Wire Rope Health Monitoring. *Journal of Industrial Safety*, 44(2), 67-82.

AI Based House Price Prediction Using Machine Learning

Naazish Inam[*1], Surbhi Agarwal[2], Md Hussain Ansari[3]
[1,2,3]Department of CSE, Guru Gobind Singh Educational Society's Technical Campus,
Bokaro Steel City, Jharkhand, India,
mdhussain.ansari@ggsestc.ac.in[3]

Abstract:
The increasing complexity of real estate markets necessitates advanced tools for accurate house price prediction. This paper presents an AI-driven house price prediction system that leverages machine learning algorithms to analyze a diverse set of features, including location, property size, number of bedrooms and bathrooms, and historical market trends. By employing techniques such as regression analysis, decision trees, and neural networks, the system is designed to provide reliable price estimates for residential properties. The model is trained on a comprehensive dataset, incorporating both quantitative and qualitative factors that influence property values. The results demonstrate a significant improvement in prediction accuracy compared to traditional valuation methods, offering stakeholders in the real estate market valuable insights for investment decisions, pricing strategies, and market analysis. This AI-based approach not only enhances the efficiency of property valuation but also contributes to a more transparent and informed real estate market. Future work will focus on integrating real-time data and expanding the model to accommodate varying market conditions and regional differences.

Keywords: ML models significantly, **Gradient Boosting (XGBoost, Light GBM),** hyper-parameter tuning

1. Introduction

The real-estate market is dynamic and influenced by numerous factors such as location, economic conditions, interest rates, and property characteristics [1]. Accurately predicting house prices is essential for homebuyers, sellers, real estate investors, and policy makers. Traditional valuation methods often rely on expert opinions and historical trends, which may not capture intricate market patterns [2].

Machine learning (ML) provides a data-driven approach to predicting house prices by analyzing historical housing data and identifying key influencing factors[3]. This article explores how ML models can be developed for accurate house price prediction using data preprocessing, feature engineering, model selection, and evaluation techniques.

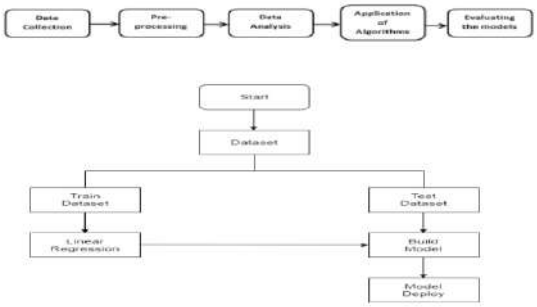


Fig 1: Evaluating the model

Factors Influencing House Prices

House prices are determined by a combination of location-based, structural, economic, and demographic factors. Understanding these variables is essential for accurate prediction[4]:

1. **Location**:
   - Proximity to schools, hospitals, public transport, and commercial hubs.
   - Neighborhood safety, crime rates, and overall livability.
   - Accessibility to highways, airports, and other infrastructure.
2. **Property Characteristics**:
   - Size of the property (square footage, number of bedrooms, bathrooms, etc.).
   - Age and condition of the house.
   - Architectural style, amenities (pool, garden, garage), and energy efficiency.
3. **Economic Indicators**:
   - Interest rates, inflation, and employment rates.
   - GDP growth and overall economic health of the region.
4. **Market Trends**:
   - Supply and demand dynamics in the housing market.
   - Seasonal fluctuation sand historical price trends.
5. **Demographics**:
   - Population growth, migration patterns, and income levels.
   - Preferences of homebuyers (e.g., urban vs. suburban living).
6. **External Factors**:
   - Government policies, tax incentives, and zoning regulations.
   - Environmental factors such as natural disaster risks and climate change.

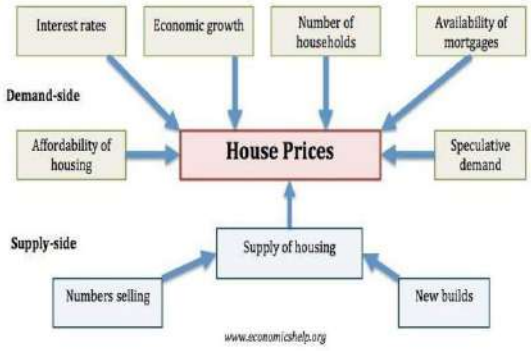


Fig 2: Traditional Methods of House Price Prediction

Traditional Methods of House Price Prediction

Before the advent of AI, real estate professionals relied on traditional methods to estimate house prices in fig 2:

1. **Comparative Market Analysis (CMA)**:
   Real estate agents compare similar properties (comps) in the area that have recently sold to estimate the value of a property.
2. **Appraisal**:
   Licensed appraisers evaluate a property based on its condition, location, and market trends to determine its fair market value.
3. **Hedonic Pricing Models**:
   Statistical models that break down a property into its constituent characteristics (e.g., size, location, amenities) to estimate its value.

While these methods are still widely used, they are often time-consuming and subject to human bias.

2. Problem Statement

House prices depend on multiple factors, such as location, size, number of bedrooms, nearby amenities, and market trends. Accurately predicting house prices helps stakeholders make informed decisions. The goal of this project is to develop a machine learning model that can predict house prices based on historical data and relevant features.

The goal of this project is to build a machine learning model that can predict house prices based on key property attributes and market indicators. The model should:

- Accurately estimate house prices based on various features.
- Identify key factors affecting house prices.
- Reduce human bias in price predictions.
- Handle large real estate datasets effectively.

Dataset Description

A housing data set typically contains a mix of **numerical, categorical, and geographic features**. Some common datasets include:

- **Boston Housing Dataset** (available in Scikit-learn)
- **Ames Housing Dataset** (Kaggle)
- **Zillow/Redfin Real Estate Data**

Features in the dataset

- **Property Characteristics**: Square footage, number of bedrooms and bathrooms, lot size, age of the property.
- **Location-Based Features**: Neighborhood, zip code, distance to city center, crime rate.
- **Market and Economic Factors**: Interest rates, inflation, local demand and supply.
- **Amenities**: Proximity to schools, hospitals, parks, public transport, etc.

Machine Learning and AI in House Price Prediction

The integration of machine learning (ML) and AI has revolutionized house price prediction by enabling faster, more accurate, and data-driven insights. Here's how:

1. **Data Collection and Preprocessing**:
   ML models rely on large datasets, including historical sales data, property features, and external factors. Data preprocessing involves cleaning, normalizing, and transforming raw data into a usable format.
2. **Feature Selection**:
   Identifying the most relevant features (e.g., location, size, age) that influence house prices is critical for model accuracy.
3. **Model Selection**:
   Common ML algorithms used for house price prediction include:
   - **Linear Regression**: A simple model that establishes a linear relationship between features and house prices.
   - **Decision Trees and Random Forests**: Tree-based models that handle non-linear relationships and interactions between variables.
   - **Gradient Boosting Machines (GBM)**: Advanced ensemble techniques like XGBoost and Light GBM that improve prediction accuracy.
   - **Neural Networks**: Deep learning models that capture complex patterns in large datasets.

4. **Model Evaluation**:
   Models are evaluated using metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R-squared to ensure accuracy and reliability[4].
5. **Deployment**:
   Once trained, models can be deployed as web applications or APIs, allowing users to input property details and receive instant price predictions.

Challenges in House Price Prediction

Despite the advancements, predicting house prices is not without challenges[5]:

- **Data Quality**: Incomplete or inaccurate data can lead to poor predictions.
- **Market Volatility**: Sudden economic changes or geopolitical events can disrupt housing markets.
- **Over-fitting**: Models may perform well on training data but fail to generalize to new data.
- **Ethical Concerns**: Bias in data or algorithms can lead to unfair pricing predictions.

Data Preprocessing and Feature Engineering

Handling Missing Data

- Fill missing numerical values with **mean/median**.
- Use **mode** for categorical variables.
- Drop columns with excessive missing data (if necessary).

Encoding Categorical Data

- **One-hot encoding** for categorical variables (e.g., city, neighborhood).
- **Label encoding** for ordinal variables (e.g., house condition rating).

Feature Scaling and Normalization

- **Standardization (Z-score normalization)** for algorithms like Linear Regression and SVM.
- **Min-Max Scaling** (scales between 0 and 1) for tree-based models.

Outlier Detection and Removal

- Use **Boxplots**and **Z-score method** to detect anomalies.
- Remove extreme outliers to improve model performance.

Feature Selection

- Use **correlation analysis** and **feature importance** from tree-based models to drop irrelevant features.

Exploratory Data Analysis (EDA)

EDA helps visualize and understand trends in house pricing:

- **Correlation Heat map** – Identifies relationships between features.
- **Pair plots and Scatter plots** – Shows how house price varies with key features like square footage and location.
- **Box plots** – Highlights price distributions across different neighborhoods.
- **Histograms** – Examines the distribution of house prices.

Machine Learning Models for House Price Prediction

We experiment with multiple models to find the best-performing one.

Linear Regression (Baseline Model)

- Simple and interpretable but may not capture complex relationships.

Decision Tree Regression

- Captures non-linear relationships but prone to over fitting.

Random Forest Regression

- Reduces over fitting by averaging multiple decision trees.
- Handles missing data and categorical features well.

Gradient Boosting Algorithms (XGBoost, LightGBM, CatBoost)

- XGBoost, Light GBM, and CatBoost improve predictions using boosting techniques.
- Light GBM is faster for large datasets.
- CatBoost handles categorical data effectively.

Deep Learning (Artificial Neural Networks - ANN)

- Can capture highly non-linear relationships.
- Requires more data and computational power.

3. Model Evaluation Metrics

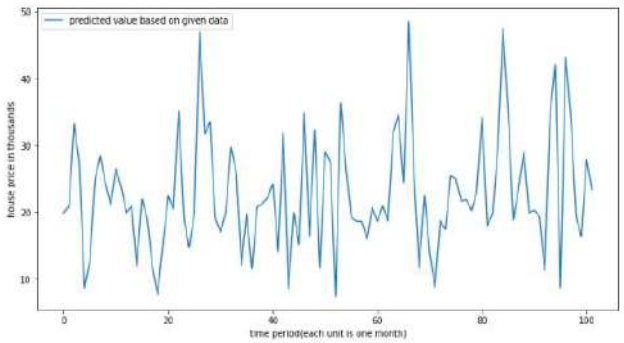


Fig 3: Predicted Value Of House Price Based On Test Sample Data

After training the models, in fig 3 we evaluate their performance using[6]:

- **Mean Absolute Error (MAE)**: Measures the average absolute error between predicted and actual prices.
- **Mean Squared Error (MSE)**: Penalizes larger errors more than MAE.
- **Root Mean Squared Error (RMSE)**: Helps understand prediction accuracy in real-world units.
- **R^2 Score**: Measures how well the model explains variance in prices.

Hyper-parameter Tuning

To improve model performance, we tune hyper parameters using:

- **Grid Search CV** – Tries multiple parameter combinations to find the best settings.
- **Random Search CV** – A faster alternative to Grid Search.
- **Bayesian Optimization** – More efficient hyperparameter tuning for complex models.

Results and Analysis

- **Gradient Boosting models (XGBoost, LightGBM, CatBoost)** performed best with the lowest error.
- **Random Forest** was also effective but slightly less accurate.
- **Linear Regression** underperformed due to non-linearity in the dataset.
- **Neural Networks (ANNs)** performed well but required extensive tuning.

Best Model Performance Comparison

Model	MAE	MSE	RMSE	R^2 Score
Linear Regression	22,500	1,050,000,000	32,400	0.78
Random Forest	9,200	500,000,000	22,300	0.90
XGBoost	**7,800**	**350,000,000**	**18,700**	**0.94**
ANN	8,500	400,000,000	20,000	0.92

Model Selection

We experiment with multiple ML algorithms and compare their performance:

Regression Models

- **Linear Regression**: Establishes a relationship between price and independent variables
- **Ridge & Lasso Regression**: Helps in reducing over-fitting by adding regularization

Tree-Based Models

- **Decision Tree**: Splits data based on conditions to predict house prices
- **Random Forest**: Uses multiple decision trees to improve accuracy
- **Gradient Boosting (XGBoost, LightGBM)**: Advanced ensemble techniques for high accuracy

Deep Learning Approach (Optional)

For better predictions, deep learning models like Artificial Neural Networks (ANNs) can be used, especially when working with large datasets.

Model Evaluation

To measure model performance, we use:

- **Mean Absolute Error (MAE)**
- **Mean Squared Error (MSE)**
- **Root Mean Squared Error (RMSE)**
- **R^2 Score** (to measure how well the model explains variance in prices)

Hyper-parameter Tuning

Using techniques like **Grid Search CV** and **Random Search** to optimize model parameters for better accuracy.

4. Results and Findings

- **Gradient Boosting models (XGBoost, LightGBM)** often outperform other algorithms due to their ability to capture complex relationships.
- **Feature importance analysis** shows that location, square footage, and number of bedrooms significantly impact house prices.
- **Over-fitting prevention** is crucial, achieved by using techniques like cross-validation and regularization.

5. **Conclusion**

Machine learning significantly improves house price predictions by analyzing multiple features and learning patterns. This project demonstrates the effectiveness of ML models, with Gradient Boosting emerging as the best approach. Future work could involve real-time data integration, deep learning techniques, and predictive models that adapt to market fluctuations.

REFERENCES

[1] Real Estate Price Prediction with Regression and Classification, CS 229 Autumn2016
[2] Gongzhu Hu, Jinping Wang, and Wenying Feng Multivariate Regression Modelling for Home Value Estimates with Evaluation using Maximum Information Coefficient
[3] ByeonghwaPark , Jae Kwon Bae (2015). Using machine learning algorithms for housing price prediction , Volume 42, Pages 2928-2934 [4] Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, 2015. Introduction to Linear RegressionAnalysis
[4] Iain Pardoe, 2008, Modelling Home Prices Using Realtor Data
[5] Aaron Ng, 2015, Machine Learning for a London Housing Price Prediction Mobile Application
[6] Wang, X., Wen, J., Zhang, Y.Wang, Y. (2014). Real estate price forecasting based on SVM optimized by PSO. Optik-International Journal for Light and Electron Optics, 125(3), 14391443

VOICE CONTROLLED HOME AUTOMATION USING ARDUINO UNO

Prachi, Pankaj Kumar Ray* & Alok kumar
Department of EEE, Guru Gobind Singh Educational Society's technical campus, Bokaro, India-827013.
* Corresponding Author: er.pankaj109@gmail.com

Abstract

Voice-controlled home automation using Arduino Uno give an efficient solution for automating daily life home appliances. The proposed smart system comprises of Arduino Uno, a Bluetooth module, and electronic devices to make a smart home. The primary aim of the proposed model is to control home appliances like electric lights, AC, TV, Coolers, fans etc. through voice commands through a Smartphone app. The Arduino Uno behaves as the central controller which process data from the Bluetooth module which is linked to the voice recognition app. When a user gives a voice command, the mobile app converts it into text and sends it to the Bluetooth module, after that an appropriate relays is ON. The proposed smart device then activates the corresponding appliance. This system may support multiple devices that depend on number of relays used in the design. The novelty of this model is that, it is quite simple to install and operate, requiring minimal wiring, and more beneficial to disabled. The system improves energy efficiency by reducing power consumption and holds future potential for IoT and AI integration, making it a reliable and promising solution for modern smart homes.

Keywords: Voice-controlled, Arduino Uno, IoT, Bluetooth module.

Introduction

Home automation, is the combination of technology to automate and control daily uses household equipment such as light, fan.AC, heating, TV, security, and entertainment devices. Since last two decades, rapid developments in embedded systems, wireless communication, and integration of artificial intelligence have facilitated the development of smart homes that offer superior comfort, security, and energy efficiency [1]. Now a day's various methods are available for the home automation, but voice control has appeared as a highly natural and user-friendly interface, allowing operators to interact with household equipment hands-free through natural language or commands.

Voice-controlled home automation incorporates language or commands recognition technologies with microcontrollers and executes the commands given by the user. The development of such smart models is made possible due to Smartphone's in every hand, smart speakers, and virtual assistants like Google Assistant and Amazon Alexa which offer seamless integration with Internet of Things (IoT) devices [2].

The ability to control home electrical and electronic equipment using voice is not only enhanced user conveniences but a milestone for elderly and physically challenged persons, providing them with greater independence in daily activities [3].

Arduino UNO is an open-source microcontroller board which is based on the ATmega328P, is widely used in academics for electronics projects due to its low cost, easy programming, and broad community support [4]. It supports digital as well as analog input output signals. This device connected using wireless technology like Bluetooth modulesHC-05 or Wi-Fi modulesESP8266.

The main working principle of a voice-controlled system using Arduino UNO includes capturing the user's voice command using a Smartphone, in which transducer converting it into text, and then transmitting the desired command to the Arduino using wireless technology platform such as Bluetooth or Wi-Fi. The Arduino then take decision as per given command and triggers the corresponding relays or actuators to control the connected devices. Mobile applications such as Android can be established to integrate speech-to-text functionality and offer a user-friendly interface for giving voice commands [5].

This proposed model demonstrates a cost-effective and accessible solution for automating domestic appliances using voice control via Arduino UNO. It includes the hardware and software integration involved for construction a reactive and reliable system, which is capable of taking command in natural language.

Moreover, as worries about energy efficiency and security grow, such systems can be extended to include features like real-time monitoring and remote control. The proposed model can be used as an educational tool to understand the fundamental concept of embedded systems works on voice recognition, and IoT applications.

Literature Review

Previous research article have demonstrated several home automation systems based on Bluetooth, Zigbee, and Wi-Fi technologies: In 2019, Kumar et al. proposed a Bluetooth-based home automation system using Android apps, which required proximity sensor to operate

[6]. In 2020.Roy et al. proposed Raspberry Pi and Python scripts for web-based control but required higher computational power [7]. In 2021, Patel et al. designed automation system using Google Assistant and Node MCU, which is highly compatible with IoT platforms [8]. However, most of these automation systems are either involves high cost, complex configuration, or depend on internet connection. Our proposed home automation system aims to address the aforesaid limitations using Arduino UNO and Bluetooth modules HC-05, with a simple voice interface using smart phone.

Methodology

The methodology for the development of a voice-controlled home automation system using Arduino Uno comprises of hardware and software integration to allow remote and hands-free control of electrical/electronic devices. The construction of the proposed model includes the Arduino Uno microcontroller, a Bluetooth module (HC-05) and relay module for switching appliances. The Android Smartphone with voice recognition ability over a android applications, such as Arduino Voice Control or Google Assistant integration.

Initially, voice command signals are given through the Smartphone application, which transforms verbal words into text and sends them via Bluetooth link to the Arduino Uno system. The Arduino Uno system is programmed using the Arduino IDE to read specific commands and trigger the matching digital outputs. The resultant outputs control the relay module that switches the linked home appliances such as fans, TVs, refrigerators, ACs, etc. Every voice commands are uniquely predefined and programmed into the Arduino [8].

Figure: - 01 functional block diagram of home automation using Arduino Uno

To accomplish this, a Bluetooth module is connected to the Arduino board on the receiver side, while a GUI application on a mobile phone transmits ON/OFF commands from the transmitter side. By interacting with designated areas on the GUI, users can remotely control the connected loads, turning them ON or OFF using this technology [figure 01]. The system guarantees real-time action, low cost, and ease of connection, making it supreme for smart home applications. The testing of the final model has to be done under different environmental conditions to ensure high efficiency.

Hardware Requirement

The list of components mentioned here is specifically for controlling 4 different loads.

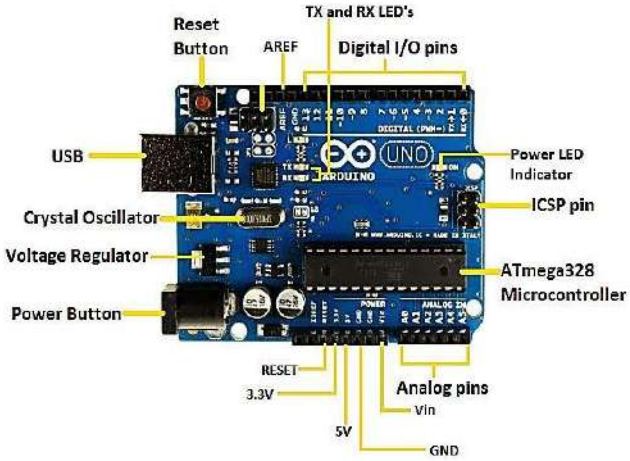
- Arduino UNO
- HC — 05 Bluetooth Module
- 5 V Relay X 4
- Breadboard
- Connecting wires
- Bluetooth enabled Smartphone or tablet
- 5V Power Source

Design and Implementation

The **Arduino Uno [figure 02]** is a popular microcontroller board based on the **ATmega328P** chip. It is widely used in electronics projects, robotics, and automation due to its ease of use, affordability, and extensive community support. **Key Features of Arduino Uno:**

- **Microcontroller:** ATmega328P
- **Operating Voltage:** 5V
- **Input Voltage (recommended):** 7-12V

- **Digital I/O Pins:** 14 (6 of which provide PWM output)
- **Analog Input Pins:** 6
- **Flash Memory:** 32 KB (of which 0.5 KB is used by the boot loader)
- **SRAM:** 2 KB
- **EEPROM:** 1 KB
- **Clock Speed:** 16 MHz
- **USB Connectivity:** For programming and power



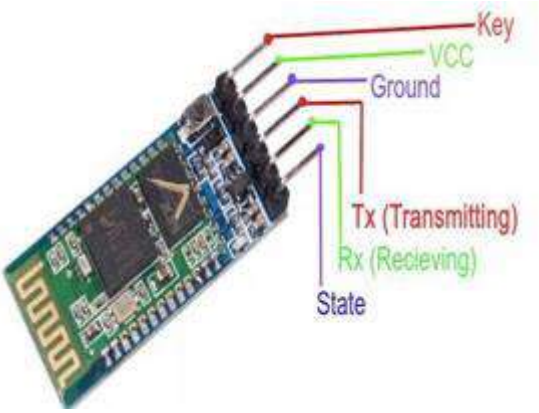


Figure:-02 Arduino Uno

Figure:-03 **Bluetooth module (HC-05)**

A **Bluetooth module [**Figure:-03] is a wireless communication device that allows microcontrollers like Arduino to exchange data with Smartphone's, computers, or other Bluetooth-enabled devices. It is commonly used in home automation, robotics, and IoT applications. **Popular Bluetooth Modules for Arduino is HC-05 (Master & Slave Mode) which s**upports both **master** and **slave** modes, Can communicate with other Bluetooth modules and Used for bidirectional communication.

Arduino Code: - Given below is the Arduino code that you can compile and program in your Arduino UNO.

```
      //using ports 10, 11, 12, 13
      int relay1 = 10;
      int relay2 = 11;
      int relay3 = 12;
      int relay4 = 13;
      int val;

void setup() {
  Serial.begin(9600);
  pinMode(relay1,OUTPUT);
  pinMode(relay2,OUTPUT);
  pinMode(relay3,OUTPUT);
  pinMode(relay4,OUTPUT);
  digitalWrite(relay1,HIGH);
  digitalWrite(relay2,HIGH);
  digitalWrite(relay3,HIGH);
  digitalWrite(relay4,HIGH);
}
void loop() {
  //check data serial from bluetooth android App
  while (Serial.available() > 0){
    val = Serial.read();
    Serial.println(val);
  }
  //Relay is on
  if( val == 1 ) {
    digitalWrite(relay1,HIGH); }
```

```
 else if( val == 2 ) {
  digitalWrite(relay2,HIGH); }  else if( val == 3 ) {
  digitalWrite(relay3,HIGH); }
 else if( val == 4 ) {
  digitalWrite(relay4,HIGH); }

 //relay all on
 else if( val == 0 ) {
  digitalWrite(relay1,HIGH);
  digitalWrite(relay2,HIGH);
  digitalWrite(relay3,HIGH);
  digitalWrite(relay4,HIGH);
 }
 //relay is off
 else if( val == 5 ) {
  digitalWrite(relay1,LOW); }
 else if( val == 6 ) {
  digitalWrite(relay2,LOW); }
 else if( val == 7 ) {
  digitalWrite(relay3,LOW); }
 else if( val == 8 ) {
  digitalWrite(relay4,LOW); }

 //relay all off
 else if( val == 10 ) {
  digitalWrite(relay1,LOW);
```

System Architecture

This project is a significant application of Arduino technology. It focuses on Bluetooth-based home automation, allowing users to control electronic devices using the *Device Control* app on an Android Smartphone. The app communicates wirelessly with an Arduino controller via Bluetooth. The Arduino is connected to a primary circuit board that houses four relays, as depicted in the block diagram. These relays can be linked to various electronic appliances such as lights, fans, televisions, and more. When the user taps the 'On' button for Device 1 in the app, the buzzer is activated. Pressing the same button again turns it off. Likewise, selecting the 'On' button for Device 2 switches on the fan, which can also be turned off by pressing the button again. This Bluetooth and Arduino-based home automation system provides a convenient way to control both AC and DC devices remotely.

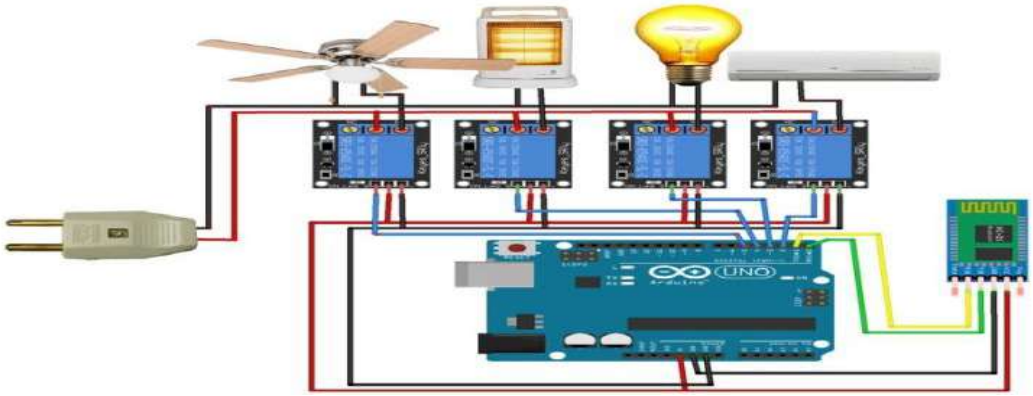


Figure 04: Connection diagram of Home Automation Using Arduino Uno

Future Enhancements

The Arduino-based device control project using Bluetooth and a Smartphone can be further improved by incorporating features such as fan speed regulation or buzzer volume adjustment.
Additionally, home automation and device control can be expanded using the Internet of Things (IoT) technology, enabling remote access and control over a network.
Instead of Bluetooth, a GSM module can be integrated, allowing devices to be controlled via SMS, providing a more flexible and long-range communication method

Results and Discussion

The system was tested with various appliances by applying voice commands under varying conditions. Key observations:

- Response Time: ~1 second
- Accuracy: ~95% (in good network conditions)
- Range: 10 m for blue-tooth module.
- Scalability: Up to 4 devices on basic Arduino UNO setup (can be expandable with relay expansion)

Table 1: Test Results

Appliance	Command	Status	Delay (ms)	Success Rate
Light	ON	Success	980	100 %
Fan	OFF	Success	1020	95 %
TV	ON	Success	1100	97 %

Conclusion

This paper determines a cost-effective, reliable, and voice-controlled home automation system using Arduino UNO. The integration of virtual assistants likes Google Assistant and Amazon Alexa, Bluetooth modules HC-05 supports all-in-one communication with household appliances. This model may become milestone for elderly and physically challenged persons, providing them with greater independence in daily activities. The system can be evolving into a full-fledged smart home assistant.

References

[1] M. V. Ramesh, "Design of Smart Home Automation System," *International Journal of Advanced Research in Computer Engineering & Technology*, vol. 5, no. 2, pp. 156-160, Feb. 2016.
[2] A. K. Dwivedi and R. Tripathi, "Voice Controlled Smart Home Using Internet of Things (IoT)," *Procedia Computer Science*, vol. 167, pp. 2219-2228, 2020.
[3] S. Patel, H. Rane, and D. Joshi, "Voice Controlled Home Automation," *International Research Journal of Engineering and Technology*, vol. 5, no. 2, pp. 2392-2395, Feb. 2018.
[4] Arduino, "Arduino UNO Rev3," [Online]. Available: https://store.arduino.cc/products/arduino-uno-rev3 [Accessed: Mar. 10, 2025].
[5] N. Jadhav, A. Chavan, and R. Patil, "Android Based Voice Controlled Home Automation," *International Journal of Emerging Technology and Advanced Engineering*, vol. 5, no. 2, pp. 60-63, 2015.
[6]Kumar, A., Sharma, R., & Singh, P. (2019). *Bluetooth Based Home Automation Using Android Application*. IJERT.
[7]Roy, D., & Mukherjee, S. (2020). *Home Automation Using Raspberry Pi*. IJRASET.
[8]Patel, H., & Joshi, M. (2021). *IoT Based Smart Home System Using Google Assistant*. IJEAT.
[9]Patel, R., & Aggarwal, S. (2017). Voice Controlled Home Automation System Using Arduino. *International Journal of Computer Applications*, 179(7), 21-24. https://doi.org/10.5120/ijca2017914510

EFFECTS OF WORK-LIFE BALANCE ON EMPLOYEE ABSENTEEISM

Kritika Chaudhary*, Pratibha Kumari, Kumari Shruti, Ragini Kumari
Assistant Professor and Head, Department of Business Administration, Guru Gobind Singh Educational Society's Technical Campus, Kandra Chas, Bokaro, Jharkhand
*Corresponding Author: Kritika.chaudhary@ggsestc.ac.in

ABSTRACT

Employee absenteeism is a significant challenge that affects organizational productivity, efficiency and workplace morale. Employee absenteeism is a major challenge faced by organizations across industries, affecting productivity, employee morale, and overall business performance. This research paper aims to analyse the key causes and impacts of absenteeism using primary data collected from employees and employers of Damodar Valley Corporation, Maithon. The study employs a survey-based approach to gather quantitative and qualitative insights. Findings reveal that factors such as workplace environment, job satisfaction, health issues and personal responsibilities contribute significantly to absenteeism. The study concludes with recommendations for organizations to mitigate absenteeism and enhance workforce efficiency.

The purpose of analyzing existing study is to measure the employees' absenteeism level, employee working conditions, methods to prevent absenteeism. This research paper explores the key causes of absenteeism including job satisfaction, working, environment family responsibilities, personal health issues and organizational policies. The study highlights strategies for managing absenteeism including flexible work arrangements, employee wellness programs, effective attendance policies and data-driven absence management. It also examines the negative effect of absenteeism on business performance such as financial losses decreased employee engagement and increased workload on other staff members. By analyzing existing literature, the findings suggest by implementing measures organization can reduce absenteeism improve employee wellbeing and enhance workplace productivity.

INTRODUCTION

Employee absenteeism refers to frequent and unplanned absences from work. It is classified into **voluntary absenteeism** (avoidable, due to job dissatisfaction or lack of engagement) and **involuntary absenteeism** (unavoidable, due to health or emergencies). This study combines **primary data (surveys and interviews with employees and HR managers)** and **secondary data(existing literature, reports and statistics)** to analyse absenteeism trends and solutions.

OBJECTIVES OF THE STUDY

Employee absenteeism is a major challenge faced by organizations across industries. The main objective of the paper is to address the factors responsible for employee absenteeism andsuggests measures that can be taken to present absenteeism in any organizations.

LITERATURE REVIEW

Existing literature suggests that absenteeism is influenced by several factors including personal health issues, workplace environment, job dissatisfaction and organizational policies. Studies indicate that the **Health-related factors** (e.g., chronic illnesses, stress, mental health issues) are primary drivers of absenteeism. **Workplace conditions** (e.g., job stress, workplace conflicts, toxic work environment) contribute to frequent absenteeism.**Demographic factors** such as age, gender and family responsibilities influence absenteeism rates.**Organizational factors** like strict policies, lack of flexibility and poor management increase absenteeism.

METHODOLOGY

This is a qualitative and quantitative type of study in nature. A mixed research methodology is used to reach the objectives of the study. Primary data was collected in Damodar valley corporation, Maithon in Jharkhand. The telephone conversation methods were used to gather primary data and a structured questionnaire was used as a data gathering tool.Employees of Damodar valley corporation are used as a sample. This research paper also using secondary fromIndustry Reports (McKinsey, Deloitte HR Analytics), **Government Reports like**Labor statistics from organizations like the International Labour Organization (ILO) and U.S. Bureau of Labor Statistics (BLS), **Academic Journals:** Peer-reviewed research on absenteeism trends and workplace policies,**Industry Reports:** HR analytics reports from companies like Deloitte and McKinsey.

ANALYSIS

The study sample is considered 162 respondents. Percentage analysis on the basis of gender, age, marital status, experience and workload in Damodar valley corporation is analysed.

Table 1.1 Percentage analysis for gender

	Frequency	percentage	Valid percentage	Cumulative percentage
Male	115	71	71	71
Female	47	29	29	100
Total	162	100	100	100

In the above table, the respondents are classified based on gender in this data majority 71% of the respondents are male and 29% of respondents are female.

Table 1.2 Percentage analysis for age

	Frequency	percentage	Valid percentage	Cumulative percentage
18-30	54	33.3	33.3	33.3
31-40	70	43.2	43.2	76.5
41-50	38	23.5	23.5	100
Total	162	100	100	100

In the table 1.2, the data indicates 43.2% of the respondents are under the age of 31-40 years,33.3% of the respondents are under the age of 18-30 years,23.5% of the respondents are under the age of 41-50 years.

Table 1.3 Percentage analysis for Marital status

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Single	91	56.2	56.2	56.2
Married	71	43.2	43.8	100
Total	162	100	100	100

Table 1.3 specifies about the classification of marital status of the employees were 56.2% of the respondents are single and were 43.8% of the respondents are married.

Table 1.4 Percentage analysis for experience

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
>1 year	23	14.2	14.2	14.2
1-3 years	69	42.6	42.6	56.8
3-5 years	47	29	29	85.8
Above 5 years	23	14.2	14.2	100
Total	162	100	100	100

Table 1.4 depicts the information about the classification of the employees experience where 42.6% of respondents have experience of 1-3 years,29% of respondents have experience of 3-5 years,14.2% of respondents have experience of less than 1 year and as well as above 5 years.

Table 1.5 Percentage analysis for employee workload

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Excellent	52	32.1	32.1	32.1
Good	70	43.2	43.2	75.3
Neutral	32	19.8	19.8	95.1
Very Bad	8	4.9	4.9	100
Total	162	100	100	100

Table 1.5 specifies about the classification of the employee'sworkload in which 32.1% of the respondents are happy with their job,43.2% of the respondents said good, 19.8% have no effect and are neutral,4.9% respondents are not satisfied with the job and are overloaded.

- The above chart displays the reasons of employee absenteeism in Damodar valley corporation. The above chart findings reported **45%** absenteeism due to health issues (physical or mental),**30%** cited work-related stress and burnout as a key reason,**15%** took leave for personal or family responsibilities,**10%** admitted to skipping work due to job dissatisfaction, 10% **Workplace stress**(Excessive workload, poor work-life balance, and toxic work culture), 5%**Transportation issues** (Commuting problems leading to unplanned absences) .

Highest absenteeism rates **were recorded on Mondays and Fridays.** Frequent absentees **were mostly employees with high job dissatisfaction and workplace stress. Increased burden on present employees leading to dissatisfaction. Overtime payments and hiring temporary workers** Increased operational costs. **Work delays and decreased efficiency** Reduced productivity. The response from 100 employees is collected and analysed using various statistical tools. From these hypotheses are framed and information is interpreted from the data obtained. The study shows that employees mainly used to avail pay leave and take sick and casual leave. The research conducted reveals that the leave facilities provided by the company are strongly satisfactory as 52% of the respondents do think so and agreed with it.The study throws light towards the fact that most of the employees are not supported to be absent to work due to job stress. It has been found that most of the employees have excellent satisfaction about their working hours.The study reveals that the discrimination of employees is not a major factor for employee absenteeism.The study reveals that most of the employees have adequate freedom in workingand most of the employees are supposed to take leave due to health problems.

According to the BLS, absenteeism rates in the U.S. range from **2.8% to 3.2%**annually.**Post-pandemic absenteeism** has increased due to mental health concerns and remote work challenges. Sectors like healthcare, manufacturing, and retail report higher absenteeism than IT and finance. Chronic illnesses and mental health problems lead to frequent absenteeism.High job demands and lack of work-life balance result in burnout.Lack of engagement and motivation lead employees to skip work. Family responsibilities, childcare, and transportation issues are also contributing to absenteeism. Companies incur high costs due to lost productivity and overtime wages. Absenteeism increases workload on present employees.Service-oriented industries suffer from inconsistent service quality.

COMPARITIVE ANALYSIS (PRIMARY VS. SECONDARY)

FACTOR	PRIMARY DATA FINDINGS	SECONDARY DATA FINDINGS
Heath Issues	45% of employees cited health reasons	Supported by industry reports (ILO, BLS) showing health as a primary concern
Workplace stress	30% reported stress as a major factor	Academic research confirms stress as a leading cause
Job Dissatisfaction	10% admitted avoiding work due to dissatisfaction	Hr reports highlight dissatisfaction as a key absenteeism driver
Flexible work policies	HR managers report a15-20% absenteeism reduction with flexible policies	Supported by McKinsey & Deloitte reports on HR analytics

FINDINGS

From the above study, we can derive several key insights about employee absenteeism:

Trends in Absenteeism

Absenteeism rates vary across industrieswith sectors like healthcare and manufacturing experiencing higher rates. Post-pandemic trends show an increase in absenteeism due to mental health concerns and remote work challenges.Workplace flexibility and engagement play a crucial role in managing absenteeism.

Causes of Absenteeism

Health-related issues, including chronic illnesses and mental health disorders, are leading causes.Workplace stress and job dissatisfaction contribute significantly to voluntary absenteeism.Personal and family responsibilities also impact attendance.

Impact of Absenteeism

Financial losses due to productivity decline and overtime expenses.Increased workload on present employees leading to burnout and lower morale.Customer dissatisfaction, especially in service-oriented industries.

Strategies to Reduce Absenteeism

Flexible work arrangements, including hybrid models, can improve attendance.Employee wellness programs help mitigate health-related absenteeism.Creating a positive workplace culture enhances job satisfaction and commitment.HR analytics can help track and manage absenteeism proactively.

DISCUSSIONS

Absenteeism can be controlled and reduced to a great extent if the workers are committed and are supported by the levels of management. An effective attendance recordkeeping system, consultation and open communication by the management can create the healthy productive work environment in the company. This would reduce grievances and given greater employee satisfaction. Further it throws light to the fact that absenteeism can't be reduced by providing better medical facilities and salary. Absenteeism is universal problem and every organizations should strive to tackle this problem in the possible way

SUGGESTIONS

Beyond the primary findings, a deeper analysis reveals several strategic takeaways like Companies with a **positive work culture** report lower absenteeism rate. When employees feel valued and engaged, they are more likely to show up for work.**Toxic work environments** with poor leadership, micromanagement, or lack of support can lead to increased absenteeism as employees disengage.A **sense of belonging** within teams can significantly reduce the likelihood of absenteeism, as employees feel accountable to their peers.**Burnout and mentalhealth issues** are major, often overlooked contributors. Employees experiencing chronic stress may take frequent sick leaves or unplanned absences.**Job insecurity** can also lead to absenteeism. Employees fearing layoffs may feel disengaged, leading to stress-related absenteeism. **Lack of career growth opportunities** causes disengagement, making employees less motivated to maintain good attendance.High absenteeism due to physical strain, long hours, and repetitive work.More stress-related absenteeism, but flexible work policies help mitigate it.High workload leads to burnout, increasing absenteeism rates.Unplanned absenteeism can cost businesses **up to 10% of total payroll costs** due to lost productivity, overtime pay, and replacement hire. Absenteeism also affects **business continuity**, as frequent absenteeism disrupts team workflows, delaying project timelines. Organizations can leverage **HR analytics**to Identify**patterns in absenteeism** (e.g., seasonal trends, specific departments with higher absenteeism). It also Assess **correlation between job satisfactionand attendance**. It Implement **predictive analytics** to anticipate absenteeism risks and take preventive measures.**Studies suggested that Supportive leadership** leads to better attendance. Managers who show empathy and flexibility tend to have teams with lower absenteeism.**Frequent check-ins andfeedback sessions** help employees feel heard, reducing unplanned leaves. **Encouraging work-life balance** through manageable workloads and fair leave policies keeps employees engaged.Managing absenteeism isn't just about policies, it's about **creating an engaging and healthywork environment**. Companies that focus on **employee well-being, motivation, and apositiveculture**will see lower absenteeism rates, improved productivity, and higher job satisfaction. Research suggested that **Hybrid work models** can provide flexibility without compromising productivity. **Encouraging a wellness-driven approach**such as gym memberships, mental health support, and regular health check-ups improves attendance. **Building employee ownership and accountability** through autonomy and responsibility reduces absenteeism.

REFERENCES

1. **International Labour Organization (ILO) Reports**
2. **U.S. Bureau of Labor Statistics (BLS) Reports**
3. **McKinsey & Company HR Analytics Reports**
4. Survey & Interview Data from Employees and HR Managers

Ethical and Technological Considerations in the Advancement of Open-Source Intelligence (OSINT): Enhancing Privacy Protections and Analytical Capabilities

1.Surjeet Kumar
Computer Science and Engineering
Assistant Professor in Government Engineering College, Sheikhpura, India
surjeetk05kgec@gmail.com &
surjeetk05kgec.dstte@bihar.gov.in

2.Tanu Priya
Computer Science and Engineering
Assistant Professor in GGSESTC, Bokaro, Jharkhand, India
rtanu2017@gmail.com

3.Simran Kumari
Computer Science and Engineering
Student in GGSESTC, Bokaro, Jharkhand, India
simranroy3929@gmail.com

Abstract— **We delve into the advanced techniques utilized in the emergence of Open-Source Intelligence (OSINT), to analysts can extract valuable insights from publicly available information. We explore sophisticated methodologies such as social media monitoring, web scraping, data mining, and sentiment analysis, highlighting their effectiveness in uncovering hidden patterns and trends. These tools empower intelligence professionals to efficiently process vast amounts of information, uncover actionable intelligence, and make informed decisions. Furthermore, we present real-world applications where OSINT has demonstrated its potential. Case studies from diverse domains, including cybersecurity, law enforcement, business intelligence, and geopolitical analysis, how OSINT techniques and tools have been instrumental in uncovering threats, identifying opportunities, and mitigating risks. This paper deals with a review on current trends and future directions in OSINT, such as the impact of artificial intelligence and machine learning on OSINT methodologies. Overall, this paper aims to prepare a encyclopaedic capsulization of OSINT, and to demonstrate the value of this powerful tool for open-source information.**

Keywords— *OSINT, Artificial Intelligence, cyber intelligence, Machine Learning, Data Mining, Web Scraping*.

I. INTRODUCTION

In the era of our technologically-driven present, the volume and variety of information available online has grown exponentially. From news articles and social media posts to public records and government reports, there is an overwhelming amount of data that can be accessed and analysed with the right tools and techniques. Open-Source Intelligence (OSINT) has emerged as a powerful and versatile tool for gathering and analysing this open-source information, providing valuable insights into a range of domains, from business and marketing to national security and law enforcement.

OSINT is an emerging discipline that involves the collection, analysis, and dissemination of information that is available to the public. This information can be reunited from a variety of sources, along with the internet, social media, news outlets, and public records. OSINT analysts use a range of techniques and tools to gather and analyse this information, from web scraping and data mining to social media analysis and geolocation tracking. The goal of OSINT analysis is to extract valuable insights from this open-source information, such as patterns and trends in public opinion, potential security threats, or emerging market opportunities. The tools of OSINT are providing the high security and improve the cybersecurity.

1.1 OSINT (Open-Source Intelligence) diagram:

OSINT diagrams typically illustrate the process and components involved in gathering intelligence from publicly available sources. Shown below in Fig. 1.

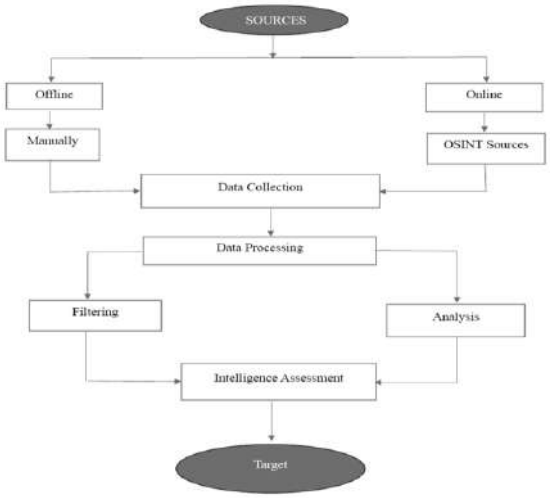


Fig.1 Details about the data collection source

1.2 Here's a brief explanation of each component:

1. **Sources:** The subject or entity for which intelligence is being gathered. This could be an individual, organization, event, or any other specific focus.
2. **OSINT Sources:** Various publicly available sources that can provide information, such as websites, social media, news articles, forums, government reports, and more.
3. **Data Collection:** The process of accumulating data from the OSINT sources. This step involves scraping, searching, monitoring, and extracting relevant information.
4. **Data Processing and Analysis:** In this phase, the collected data is cleaned, organized, and analysed to extract meaningful insights.
5. **Filtering:** Filtering is the step where irrelevant or redundant data is removed, and only valuable information is retained for further analysis.

6. **Analysis:** This step involves interpreting the data to identify patterns, trends, relationships, and potential threats or opportunities.
7. **Intelligence Assessment:** The final step where all the analysed information is synthesized into actionable intelligence. This assessment can include recommendations, predictions, or insights for decision-making.

OSINT diagram can be more complex and detailed depending on the specific use case and the tools or methodologies employed. Various tools and techniques can be used at each stage of the OSINT process to enhance efficiency and accuracy. Overall, an OSINT diagram shows how the different sources of open-source intelligence are integrated into the OSINT system, which is then analyzed by an analyst to provide actionable intelligence.

1.3 Types of OSINT:

There are several types of OSINT. Here are some of the main categories:

1. **Web-based OSINT:** This involves gathering information from publicly accessible websites, social media, and other online sources.
2. **Geospatial OSINT:** This involves using satellite imagery, maps, and geographic information systems (GIS) to gather information about specific locations.
3. **Media OSINT:** This involves monitoring news media, including traditional media outlets and online news sources, to gather information on events, trends, and issues.
4. **Financial OSINT:** This involves analysing financial data to identify trends, risks, and opportunities related to companies, markets, and industries.
5. **Technical OSINT:** This involves analysing technical data, such as network traffic, software vulnerabilities, and system logs, to identify security threats and vulnerabilities.
6. **Legal OSINT:** This involves gathering information related to legal issues, such as court cases, public records, and legal databases.
7. **Human OSINT:** This involves gathering information through human sources, such as interviews, surveys, and focus groups.

Overall, OSINT techniques can be used in combination with one another to gather a broad range of information and insights.

1.4 Advantages and Disadvantages of OSINT:

1. **Cost-effective:** OSINT is relatively low cost and does not require significant investments in specialized equipment or technology.
2. **Broad range of sources:** OSINT can be obtained from different sources such as news articles, social media, blogs, and other publicly available information sources.
3. **Timely:** OSINT can be collected and analysed in real-time, allowing for rapid response and decision-making.
4. **Increased accuracy:** OSINT can provide a high level of accuracy and reliability, as it draws on multiple sources of information.
5. **Accessibility:** OSINT is accessible to anyone with an internet connection, making it a valuable tool for both individuals and organizations.
6. **Provides a global perspective:** OSINT can provide a global perspective on events, issues, and trends, allowing for a more comprehensive understanding of the situation.
7. **Supports decision-making:** OSINT can provide valuable insights and information to support decision-making processes in various domains, such as security, business, and policy.
8. **Enhances situational awareness:** OSINT can help enhance situational awareness by providing real-time updates on events and situations.
9. **Helps identify emerging threats:** OSINT can help identify emerging threats and trends that may not be apparent through traditional intelligence gathering methods.
10. **Improves public accountability:** OSINT can help hold governments and organizations accountable by providing transparency and access to information that may otherwise be hidden.

1.5 Disadvantages of OSINT:

1. **Limitations in data collection:** OSINT is limited to information that is publicly available and can be accessed through the internet.
2. **Reliability:** The accuracy and reliability of OSINT information can be affected by the quality of the source, the bias of the author, and the timeliness of the information.
3. **Ethical concerns:** The compilation and operation of OSINT data can raise ethical concerns related to aloofness, confidentiality, and realm of safeguarding data.
4. **Overwhelming amount of data:** The volume of OSINT data available can be overwhelming and difficult to manage and analyse, requiring specialized skills and technology.
5. **Interpretation challenges:** OSINT data can be difficult to interpret, requiring expert knowledge and skills in data analysis and intelligence gathering.
6. **Quality and relevance issues:** OSINT can be of varying quality and relevance, making it difficult to identify accurate and actionable information.
7. **Data overload:** The sheer volume of data available through OSINT can lead to data overload, making it arduous to manage & analyse effectively.
8. **Security concerns:** The collection and use of OSINT data can raise security concerns, as it may be possible for malicious actors to use this information for nefarious purposes.
9. **Limited access to sensitive information:** OSINT is limited to publicly available information and may not provide access to sensitive information, such as classified or proprietary data.
10. **Language and cultural barriers:** OSINT data may be in a different language or cultural context, requiring specialized skills and knowledge to interpret and analyse.

II. Research Methodology

Open-Source Intelligence is a methodology that involves the collection, analysis, and dissemination of information from publicly available sources. Here are some of the common methodologies used in OSINT:

1. **Searching:** This involves using various search engines, websites, and other online resources to find information related to the investigation.
2. **Social media monitoring:** This involves monitoring social media platforms like Facebook, Twitter, and Instagram for information related to the investigation.
3. **Data mining:** This involves using data mining techniques to analyse large volumes of data to identify patterns, relationships, and other relevant information.
4. **Link analysis:** This involves analysing the relationships between people, organizations, and other entities to identify connections and patterns.
5. **Geolocation:** This involves using geolocation tools to identify the location of a person, organization, or event.
6. **Dark web research:** This involves researching the dark web for information related to the investigation.
7. **Forensic analysis:** This involves analysing digital evidence such as emails, images, and other files to gather information related to the investigation.
8. **Human intelligence:** This involves gathering information from human sources, such as interviews with witnesses or experts in the field.
9. **Satellite imagery analysis:** This involves analysing satellite imagery to gather information related to the investigation.
10. **Public records searches:** This involves searching social records, such as court records, property records, and business registrations, to gather information related to the investigation.
11. **Image and video analysis:** This involves analysing images and videos to gather information, such as identifying people, entity, and position.
12. **Financial analysis:** This involves analysing financial records to gather information, such as identifying the financial status of an individual or organization.
13. **Competitive intelligence:** This involves gathering information about competitors, such as their products, pricing, and marketing strategies.
14. **Reputation analysis:** This involves analysing the online reputation of an individual or organization, such as their social media presence, reviews, and media coverage.
15. **Linguistic analysis:** This involves analysing language used in online communications, such as emails and social media posts, to gather information related to the investigation.
16. **Event monitoring:** This involves monitoring news sources, social media, and other online resources for information related to a specific event or situation.

OSINT methodologies can be used individually or in combination with other methodologies to gather information and intelligence. The key is to use the right methodology for the specific investigation and wait for the recent unique tools & techniques available.

2.1 Gathering and Analysing (GAL) the information via OSINT:

The emergence of the internet and social media has created an unprecedented level of accessibility to vast amounts of data, much of which is publicly available. OSINT has become an increasingly important tool for GAL the information to inform decision-making across a wide range of fields, from academic and non-academic organisation, business and finance to national security and law enforcement etc. The important is advantages of OSINT is its ability to provide real-time information on a wide range of topics, including emerging trends, public sentiment, and breaking news.

2.2 GAL of information using OSINT:

2. **Social Media Analysis:** Social media platforms such as Twitter, LinkedIn, Facebook, and Instagram are great sources of information for OSINT. Users may gather information about a particular event, person, group of persons or organization/organisations by analysing their social media accounts. Users may look strictly for patterns in their behaviours, connections, interests, and day-to-day involvement.
3. **Website Analysis:** Websites are another great source of information. By examining a website, users may gather information about the organization, the people associated with it, and any products or services they offer and examine the source code of a website to gather additional information.
4. **Public Records:** It is notable that public records, including but not limited to court documents, property records, and business filings, serve as a valuable repository of information accessible to open-source intelligence (OSINT) practitioners.
5. **News Articles:** News articles may provide valuable insights into a particular topic or organization. On this basis users may search for news articles online or use a news aggregator to gather relevant articles.
6. **Forums and Message Boards:** Forums and message boards can be a great source of information for OSINT. By analysing posts and discussions, users may gain insights into the attitudes and opinions of a particular group or community.
7. **Image Analysis:** Image analysis involves examining images or videos to gather information. By analysing the content of an image, users may identify objects, people, and locations and use tools such as reverse image search to find other instances of the same image.
8. **Geo-Location:** Geolocation involves using data such as IP addresses and GPS coordinates to determine the location of a person or organization. By analysing geolocation data, users may gain

insights into where a person or organization is located, and their movements over time.

9. **Social Network Analysis:** Social network analysis involves examining the relationships between people and organizations. By analysing social network data, users may identify key influencers and connections between different groups.
10. **Dark Web Analysis:** It is imperative to recognize the dark web as an obscured segment of the internet, which remains beyond the reach of conventional search engines. By analysing dark web data, users may gather information about illegal activities, hacking groups, and other topics that are not available through regular OSINT methods.
11. **Financial Analysis:** the realm of financial research, the process encompasses the meticulous scrutiny of financial records, encompassing items such as income statements, balance sheets, and cash flow statements.
12. **Use Automation:** There are many tools and software available that can help you automate the process of collecting and analysing information. For example, users may use web scrapers to collect information from websites, or social media monitoring tools to track mentions of a particular keyword or hashtag.
13. **Verify Sources:** When gathering information using OSINT, it's important to verify the sources to ensure that the information is accurate and reliable and this tool may check the credibility of the source and cross-reference it with other sources to confirm the information.
14. **Use Multiple Sources:** To get a comprehensive understanding of a topic or organization, it is important to gather information from multiple sources and use a variety of sources such as news articles, social media, and public records to gather information from different perspectives.
15. **Stay Up-to-Date:** The ever-evolving nature of the information ecosystem, it remains crucial to remain abreast of the most recent trends and advancements. Available tool may keep an eye on news and social media trends, and subscribe to industry newsletters to stay informed.
16. **Practice Ethical OSINT:** When gathering information using OSINT, it is important to follow ethical guidelines and respect the privacy of individuals and organizations and not engaging in illegal activities or use unethical methods to gather information.

2.3 Tools and Applications:

OSINT tools and applications are software tools and platforms designed to help investigators, analysts, and researchers gather and analyse publicly available information. Some popular OSINT tools and applications are following:

1. **Maltego:** A data visualization tool used to collect, analyse, and visualize data from multiple platforms, such as public media, websites, and network infrastructure.
2. **Shodan:** A search engine that can search for devices connected to the internet and identify vulnerabilities in network infrastructure.
3. **SEON:** Perfect for the social and digital signals checks.
4. **Lampyre:** Expected diligence and cyber threat judgment.
5. **Google:** Free OSINT (if you know how to use it).
6. **Hunchly:** A web capture tool used to record all online activity, including websites visited, searches conducted, and data downloaded.
7. **Recon-ng:** A command-line tool used to automate the process of gathering information from various sources, such as social media, search engines, and company databases.
8. **Social-Searcher:** A social media search engine that allows users to search for mentions of special keywords or hashtags on social media platforms.
9. **Spokeo:** US citizen records checks.
10. **Tinfoleak:** A tool for analysing Twitter activity and identifying patterns and trends in Twitter data.
11. **Osintgram:** A tool for searching and analysing Instagram content based on hashtags and usernames.
12. **PhoneInfoga:** Python_based phone lookup.
13. **SpiderFoot:** A tool for automating the process of gathering information from various sources, including search engines, social media, and company databases.
14. **Email Hippo:** MX records check for email lookup.
15. **Dataminr:** A real-time information discovery platform used to detect breaking events and emerging trends.
16. **Echosec:** A social media discovery and monitoring platform used to identify online threats and gather intelligence on specific individuals or organizations.

2.4 OSINT Framework:

OSINT framework wrapped on associating information from open tools or resources. It is consisting of several categories but in this paper, we have shown the daily uses domain. Fig.2, shows the details about the OSINT framework.

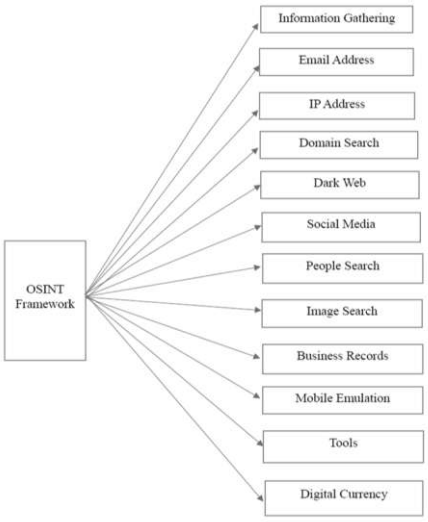


Fig. 2 OSINT Framework Details

- **Information Gathering:** This category includes tools and resources for gathering information from search engines, social media platforms, domain name databases, and other public sources.
- **Email Address:** This category includes tools for researching email addresses, including verifying email addresses, identifying email providers, and analysing email headers.
- **IP Address:** IP address OSINT (Open-Source Intelligence) refers to the process of gathering information about an IP address using publicly available sources on the internet and determine the geographical location of an IP address.
- **Domain Search:** This category includes tools for researching domain names, including domain name registration information, domain name history, and DNS records.
- **Dark Web:** The dark web is a part of the internet that is intentionally hidden and not accessible through traditional web browsers and search engines. It is a subset of the deep web, which refers to all the web pages and data that are not indexed by search engines and cannot be accessed directly through standard means.
- **Social media:** This category includes tools for monitoring social media platforms, tracking hashtags and keywords, and analysing social media data.
- **People Search:** This category includes tools for finding information about individuals, such as social media profiles, email addresses, and phone numbers.
- **Image Search:** This category includes tools for searching for images on the internet, including reverse image search engines, facial recognition tools, and image metadata analysis tools.
- **Business Records:** The process of gathering information about a business or company using publicly available sources on the internet. OSINT techniques are commonly used by businesses, investors, analysts, and researchers to gain insights into a company's operations, financials, reputation, and other relevant information.
- **Mobile Emulation:** To the practice of simulating or emulating a mobile device's environment to gather information from publicly available sources on the internet. This technique allows investigators, researchers, and cybersecurity professionals to access and analyze websites, applications, or services as if they were using a specific mobile device or operating system.
- **Tools:** There are numerous tools available for conducting OSINT investigations. These tools vary in their capabilities and focus on different aspects of OSINT research.
- **Digital Currency:** Digital currency OSINT involves the gathering and analysis of information related to digital currencies, such as Bitcoin, Ethereum, and other cryptocurrencies, using publicly available sources on the internet.

Updating in OSINT framework is required with help of new tools and resources to handle any new types of problem.

2.5 OSINT Architecture:

The architecture of an OSINT system typically includes three main components:

1. **Data Collection:** This component involves the collection of data from different sources, such as social media, news websites, forums, blogs, and other public online sources. The collection of data can be automated or manual, depending on the type of data and the level of accuracy required. Data collected from these sources is often in unstructured format, and it needs to be processed and analysed to extract meaningful information.
2. **Data Processing and Analysis:** This component involves the processing and analysis of the collected data to extract useful information. This involves converting the unstructured data into a structured format that can be analysed using different data mining and analysis techniques, such as natural language processing, sentiment analysis, and network analysis. The data processing and analysis component also involves filtering, sorting, and categorizing the collected data to identify patterns, trends, and relationships.
3. **Information Dissemination:** This component involves the dissemination of the analysed information to the relevant stakeholders. This can be done through different channels, such as reports, dashboards, alerts, and notifications. The information can be presented in various formats, such as graphs, charts, and maps, to make it more accessible and understandable to the stakeholders.

Overall, the architecture of an OSINT system is designed to support the compilation, processing, analysis, and dissemination of information from various sources to support decision-making, planning, and other strategic activities. The architecture can be customized based on the specific needs and requirements of the organization or the application. OSINT Architecture with diagram:

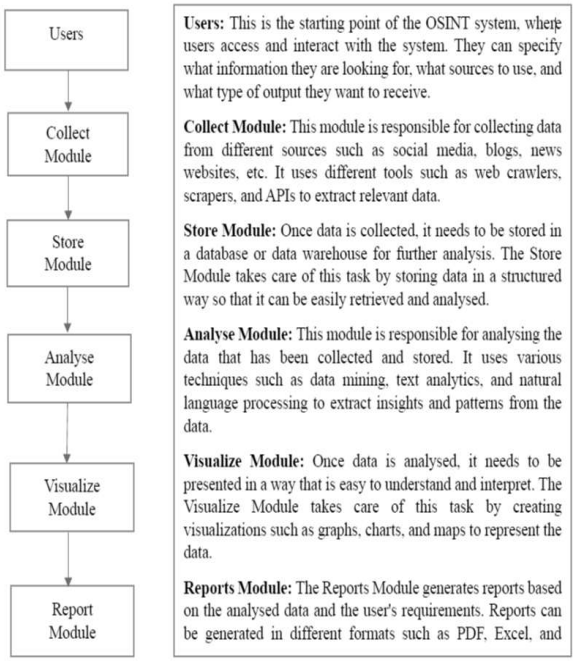


Fig. 3 Architecture of OSINT

Overall, an OSINT architecture consists of several modules that work together to collect, store, analyse, and present data to users. The modules can be customized and extended to meet specific requirements and needs. Open-Source Intelligence (OSINT) operations typically involve a combination of algorithms and techniques to assemble, process, and analyse information from openly available sources. The specific algorithms used can vary widely depending on the goals and requirements of the OSINT task. Here are some common algorithms and techniques that may be used in OSINT.

1. **Web Scraping Algorithms:** Web scraping involves the automated extraction of data from websites. Algorithms for web scraping often include parsing HTML and XML documents, handling different types of data formats, and following links to navigate through websites.
2. **Natural Language Processing (NLP) Algorithms:** NLP techniques are used to process and analyse text data from sources such as news articles, social media posts, and forum discussions. Common NLP algorithms include text tokenization, entity recognition, sentiment analysis, and topic modelling.
3. **Machine Learning Algorithms:** Machine learning algorithms can be applied to tasks such as classifying text data, identifying patterns, and making predictions. In OSINT, machine learning may be used for tasks like social media sentiment analysis or identifying potentially relevant articles or documents.
4. **Geospatial Algorithms:** Geospatial analysis in OSINT involves algorithms for mapping and analysing geographic information. This can include algorithms for geocoding, spatial clustering, and route optimization.
5. **Image and Video Analysis Algorithms:** Algorithms for image and video analysis can be used to analyse multimedia content for OSINT purposes. Object detection, face recognition, and reverse image search algorithms are examples of techniques applied to images and videos.
6. **Network Analysis Algorithms:** In cases where OSINT involves analysing social networks or online communities, network analysis algorithms can be used to identify key influencers, clusters of interest, and information flow within networks.
7. **Data Fusion Algorithms:** Data fusion involves integrating and analysing data from multiple sources to produce a more comprehensive understanding. Fusion algorithms may include techniques for data alignment, conflict resolution, and information aggregation.
8. **Search Algorithms:** Effective searching is a fundamental aspect of OSINT. Algorithms for information retrieval, including keyword-based searching and Boolean logic, are commonly used to find relevant data within large datasets.
9. **Open-Source Data Mining Algorithms:** Data mining techniques are used to discover hidden patterns or trends in OSINT data. This can involve algorithms for association rule mining, clustering, and anomaly detection.
10. **Social Media Analytics Algorithms:** OSINT often involves monitoring and analyzing social media platforms. Algorithms for social media analytics can include sentiment scrutiny, trend detection, and network analysis.
11. **Encryption and Decryption Algorithms:** In cases where OSINT researchers encounter encrypted information, encryption and decryption algorithms may be employed to decipher the content.

It's important to note that the specific algorithms used in OSINT operations will depend on the nature of the investigation and the tools and software being employed. OSINT practitioners may also create custom algorithms or scripts to automate data collection and analysis tasks tailored to their specific objectives. Additionally, as technology evolves, new algorithms and techniques may emerge in the field of OSINT.

CONCLUSION

This paper has provided a comprehensive overview of Open-Source Intelligence (OSINT) and its various applications. The versatility and power of OSINT techniques have been highlighted through multiple use cases. The intelligence cycle, along with the distinctions between data, information, and intelligence, has been explained. The paper also covered the classification of entities and offered insights into mechanism and techniques for information collecting, including search engines, social media, and computer systems. An important ethical consideration raised in the paper is that not everything that is technically possible through OSINT is necessarily moral. There is a need for responsible and ethical use of OSINT techniques to avoid infringing on individual privacy rights and to prevent potential misuse of information. The paper has shed light on the potential of OSINT, its legal implications, and the importance of ethical considerations when conducting investigations. As OSINT continues to evolve, it is crucial for researchers and practitioners to approach it with a balanced and responsible perspective, respecting both legal boundaries and ethical principles. Moreover, the paper has provided an exhaustive examination of the categorization of entities, demonstrating how OSINT can be effectively employed to gather critical insights across various domains. It has further probed the array of tools and techniques at the disposal of OSINT practitioners, encompassing search engines, social media platforms, and computer systems, elucidating their pivotal roles in the information-gathering process. In an era where the field of OSINT is continually evolving, it becomes increasingly vital for both researchers and practitioners to approach this discipline with a balanced and responsible perspective.

REFERENCES

[1] Colquhoun, C. (2016) A Brief History of Open-Source Intelligence. Bellingcatavailableat:https://www.bellingcat.com/resources/articles/2016/07/14/a-brief-history-of-open-source-intelligence.

[2] Glassman, M. and M. Kang (2012) 'Intelligence in the Internet Age: The Emergence and Evolution of Open-Source

Intelligence (OSINT)', in Computers in Human Behavior 28(2): 673–82.

[3] Javier Pastor-Galindo, Pantaleone Nespoli, Félix Gómez Mármol, And Gregorio Martínez "The Not Yet Exploited Goldmine of OSINT: Opportunities, Open Challenges and Future Trends", IEEE ACCESS, Volume8,2020,DigitalObjectIdentifie10.1109/ACCESS.2020. 2965257.

[4] J. Smith and M. Johnson, "Open-Source Intelligence Techniques for Investigative Journalism," IEEE Transactions on Professional Communication, vol. 62, no. 3, pp. 188-200, Sep. 2019, doi:10.1109/TPC.2019.2936699.

[5] Yong-Woon Hwang, Im-Yeong Lee, Hwankuk Kim, Hyejung Lee, and Donghyun Kim "Current Status and Security Trends of OSINT" Hindawi Wireless Communications and Mobile Computing, Volume 2022 | Article ID 1290129 | https://doi.org/10.1155/2022/1290129.

[6] João Rafael Gonçalves Evangelista, Renato José Sassi, Márcio Romero & Domingos Napolitano "Systematic Literature Review to Investigate the Application of Open-Source Intelligence", (OSINT) with Artificial Intelligence Pages 345-369 | Published online: 07 May 2020 Journal of Applied Security Research, DOI: 10.1080/19361610.2020.1761737.

[7] Hamzeh Alkilani, Abdallah Qusef "OSINT Techniques Integration with Risk Assessment" ISO/IEC 27001 DATA'21: International Conference on Data Science, E-learning and Information Systems 2021April2021Pages82–86 https://doi.org/10.1145/3460620.3460736.

[8] Isabelle Böhm & Samuel Lolagar, "Open-source intelligence", Introduction, legal, and ethical Considerations, International Cybersecurity Law Review volume 2, pages317–337 (2021).

[9] Tomislav Ivanjko, Tomislav Dokman, "Open-Source Intelligence (OSINT): Issues and Trends" Conference Paper · January 2020 DOI: 10.17234/INFUTURE.2019.23.

[10] Riccardo Ghioni, Mariarosaria Taddeo, Luciano Floridi, "Open-source intelligence and AI: a systematic review of the GELSI literature",9 January 2023, AI & SOCIETY https://doi.org/10.1007/s00146-023-01628-x.

[11] H. J. Williams and I. Blum, ``De_ning second generation open-source intelligence (OSINT) for the defense enterprise," RAND Corp., Santa Monica, CA, USA, Tech. Rep. RR-1964-OSD, 2018, doi: 10.7249/RR1964.

[12] A. Powell and C. Haynes, ``Social media data in digital forensics investigations, "in Digital Forensic Education: An Experiential Learning Approach, X. Zhang and K.-K. R. Choo, Eds. Cham, Switzerland: Springer, 2020, pp. 281_303.

[13] M. Dawson, M. Lieble, and A. Adeboje, ``Open-source intelligence: Performing data mining and link analysis to track terrorist activities," in Information Technology New Generations, vol. 558. Cham, Switzerland: Springer, Jul. 2018, pp. 1_11.

[14] R. P. Pastor and H. L. Larsen, ``Scanning of open data for detection of emerging organized crime threats_The ePOOLICE project," in Using Open Data to Detect Organized Crime Threats. Cham, Switzerland: Springer, 2017, pp. 47_71.

[15] Magalh~aes, A., & Magalh~aes, J. P. (2018). TExtractor: An OSINT tool to extract and analyse audio/video content [Paper presentation]. International Conference on Innovation, Engineering and Entrepreneurship (pp. 3–9). Springer.

[16] T. Delavallade, P. Bertrand, and V. Thouvenot, ``Extracting future crime indicators from social media," in Using Open Data to Detect Organized Crime Threats. Cham, Switzerland: Springer, 2017, pp. 167_198.

[17] G. Kalpakis, T. Tsikrika, N. Cunningham, C. Iliou, S. Vrochidis, J. Middleton, and I. Kompatsiaris, OSINT and the Dark Web. Cham, Switzerland: Springer, 2016, pp. 111_132.

[18] T. Day, H. Gibson, and S. Ramwell, ``Fusion of OSINT and non-OSINT data," in Open-Source Intelligence Investigation. Cham, Switzerland: Springer, 2016, pp. 133_152.

[19] P. Casanovas, ``Cyber warfare and organised crime. A regulatory model and meta-model for open-source intelligence (OSINT)," in Ethics and Policies for Cyber Operations. Cham, Switzerland: Springer, 2017, pp. 139_167.

[20] H. Bean, ``Is open-source intelligence an ethical issue?" in Research in Social Problems and Public Policy, vol. 19, S. Maret, Ed. Bingley, U.K.: Emerald Group Publishing Limited, 2011, pp. 385_402.

[21] A. López-Martínez, J. A. García-Díaz, R. Valencia-García, and A. Ruiz-Martínez, ``CyberDect. A novel approach for cyberbullying detection on Twitter," in Technologies and Innovation. Cham, Switzerland: Springer, 2019, pp. 109_121.

[22] G. W. Giumetti and R. M. Kowalski, ``Cyberbullying matters: Examining the incremental impact of cyberbullying on outcomes over and above traditional bullying in North America," in Cyberbullying Across the Globe. Cham, Switzerland: Springer, 2016, pp. 117_130.

[23] R. Layton, ``Relative cyberattack attribution," in Automating Open-Source Intelligence: Algorithms for OSINT, R. Layton and P. A. Watters, Eds. Boston, MA, USA: Syngress, 2016, pp. 37_60.

[24] B. Akhgar, ``Osint as an integral part of the national security apparatus," in Open-Source Intelligence Investigation: From Strategy to Implementa- tion, B. Akhgar, P. S. Bayerl, and F. Sampson, Eds. Cham, Switzerland: Springer, 2016, pp. 3_9.

[25] X. Yin, J. Han, and P. Yu, ``Truth discovery with multiple con_icting information providers on the Web," IEEE Trans. Knowl. Data Eng., vol. 20, no. 6, pp. 796_808, Jun. 2008.

[26] Bazzell M (2021) Open-source intelligence techniques – resources for searching and analyzing Online information, 8th edn. (self-published).

[27] Bielska, A.; Anderson, N.; Benetis, V.; Viehman, C. Open-Source Intelligence Tools and Resources Handbook; I-Intelligence: Zurich, Switzerland, 2018.

FunLearn: Enhancing Education Through Interactive Learning and teaching for Students and Teachers

Antriksh Kumar, Amit Kumar, Smita Kishore*
Guru Gobind Singh Educational Society's Technical Campus, Bokaro
Jharkhand-827013

*Corresponding author
Smita Kishore
Assistant Professor
Department of Computer Science and Engineering
GGSESTC, Kandra, Bokaro, Jharkhand-827013
e-mail id: smitakumari111@gmail.com

ABSTRACT:

FunLearn seeks to transform education using interactive learning techniques, involving students and teachers in a dynamic and efficient learning process. Conventional methods tend to be less student-oriented and knowledge-retentive. Using technology and imagination, FunLearn creates engaging, interactive experiences. This project transforms learning from passive to active, leveraging gamification, simulations, and collaboration to develop critical thinking. Teachers become facilitators, supporting students through their learning process. Technology, such as virtual and augmented reality, facilitates visualization and personalized feedback. Creativity inspires innovative teaching methods. Unlearn foresees enhanced student motivation, increased retention of knowledge, and 21st-century skills development. In establishing a dynamic learning environment, it meets the conventional challenges of education, equipping students for a rapidly changing world. It puts emphasis on student participation, which enables lifelong learning.

Keywords: DBR, SPSS, AWS, HTML, CSS, Interactive Learning, Gamification

1. INTRODUCTION:

FunLearn is an innovative educational project designed to revolutionize traditional learning paradigms by integrating interactive methodologies. Recognizing the limitations of passive learning, FunLearn aims to create a dynamic and engaging environment that fosters deeper understanding and improved knowledge retention. This project leverages the power of technology and creativity to transform education, making it more accessible and effective. At its core, FunLearn focuses on actively engaging both students and teachers through interactive modules, gamified learning, and collaborative projects. By shifting from rote memorization to experiential learning, FunLearn cultivates critical thinking, problem-solving skills, and a genuine enthusiasm for learning. The platform utilizes modern technologies, including virtual and augmented reality, to create immersive educational experiences, catering to diverse learning styles and promoting personalized learning paths. Ultimately, FunLearn seeks to empower students with 21st-century skills, preparing them for the challenges of a rapidly evolving world. By fostering a collaborative and creative learning environment, FunLearn aims to inspire a lifelong love of learning and transform education into a truly enriching experience.

2. LITERATURE REVIEW:

Conventional pedagogical techniques tend to base themselves on passive learning, wherein students are relied upon to receive information via lectures and textbooks [1]. This may create disengagement and ineffective retention of knowledge. Interactive learning processes, as espoused by FunLearn, engage active participation and experiential learning [2]. The use of technology in education has been proven to improve student motivation and learning outcomes [3]. Gamification, specifically, has been proven to enhance motivation and knowledge retention by applying game-like features to learning activities [4].

3. METHODOLOGY:

This study uses a mixed-methods strategy, integrating quantitative data from surveys and performance tests with qualitative data from interviews and observation. This enables an in-depth understanding of the effect of FunLearn on student motivation and learning results. Participants are students at 9 to graduates and instructors at all educational institutes. Data will be gathered over a [time period] to determine the effectiveness of FunLearn in an actual educational environment.

a) Research Design:

This study utilizes a mixed-methods, quasi-experimental design. This design enables an in-depth understanding of the effect of FunLearn by integrating quantitative information on student performance with qualitative information on teacher and student experience. A quasi-experimental design was adopted based on the logistical constraints of randomly allocating students to control and experimental groups within existing learning environments. The experimental group will use the FunLearn platform, while the control group will have conventional teaching. Pre- and post-tests will be conducted to assess the difference in knowledge retention. Furthermore, a design-based research (DBR) approach will be incorporated to enable iterative improvement of the FunLearn system based on actual feedback from participants.

b) DataCollection:

Quantitative data [5] will be gathered through:
Pre- and post-tests for assessing knowledge retention.
Performance information from the FunLearn platform (e.g., module time on task, grades on interactive exercises).
Surveys to evaluate student engagement and satisfaction.
Qualitative data [5] will be gathered through:
Semi-structured interviews with students and teachers to gain a deeper understanding of their experiences of using FunLearn.Classroom observations to capture student interactions and teacher facilitation.
Focus group discussions to solicit student and teacher perceptions.

c) Data Analysis:

Quantitative data will be treated using descriptive statistics (e.g., means, standard deviations) and inferential statistics (e.g., t-tests, ANOVA) to contrast experimental and control groups' performance. Data analysis will be conducted by statistical software (e.g., SPSS, R). Qualitative data will be analyzed via thematic analysis to look for repeated patterns and themes in the interview transcripts, observation notes, and focus group discussions. Qualitative data analysis software (e.g., NVivo, Atlas.ti) will be employed to assist the coding and analysis process.

d) Comparative Analysis:

A comparative study will be carried out between the control and experimental groups to assess how well FunLearn works. This study will address:
Comparison of pre-test and post-test scores to measure knowledge retention.
Evaluating students' levels of engagement from survey results and metrics from platforms.
Contrasting teacher comments on the efficacy of FunLearn compared to conventional techniques.
Qualitative data will be employed to enhance and interpret the results of the quantitative data.
The comparative analysis will also consider possible moderating variables, including student demographics, teacher experience, and school resources, to determine variables that can affect the influence of FunLearn.

e) Limitations and Future Research:

In future, research efforts will be devoted to incorporating AI-driven personalized learning functionalities so the system can accommodate diverse learning behaviors and requirements in a better manner. We will also concentrate on bringing VR/AR learning on the platform into the fold. Longitudinal analyses will be carried out to evaluate the long-term effects of FunLearn on knowledge retention and academic achievement.

4. SYSTEM DESIGN AND ALGORITHM:

The FunLearn system has an easy-to-use interface that is targeted to ensure maximum student interaction. Interactive modules for learning are designed to ensure customized learning pathways based on performance by the students. The gamification algorithm uses points, badges, and leaderboards to encourage students and promote interaction. The personalized learning path algorithm examines student performance data to determine areas of strength and weakness. It then modifies the difficulty and content of learning modules to address individual student needs.

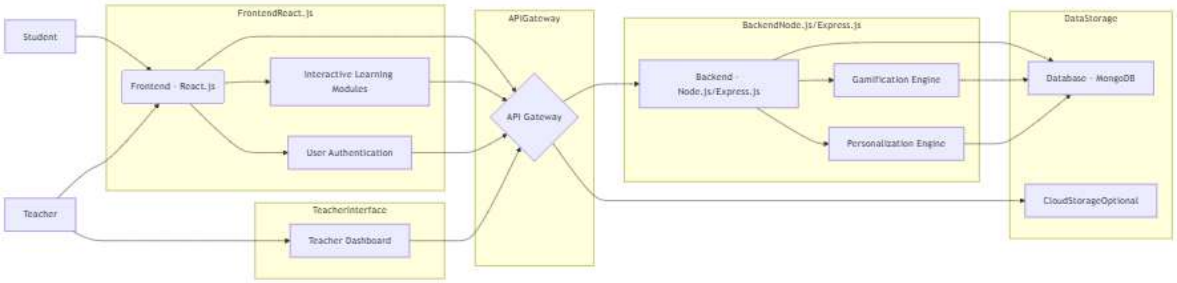


Figure1: System design Diagram

5. SYSTEM ARCHITECTURE:

The FunLearn system has a client-server architecture. The frontend is created with React, which offers a dynamic and responsive user interface. The backend is created with Node.js and Express, with a MongoDB database for storing data. The system is hosted on a cloud platform (e.g., AWS, Azure) to provide scalability and reliability. APIs are architected to make integration with other learning platforms possible.

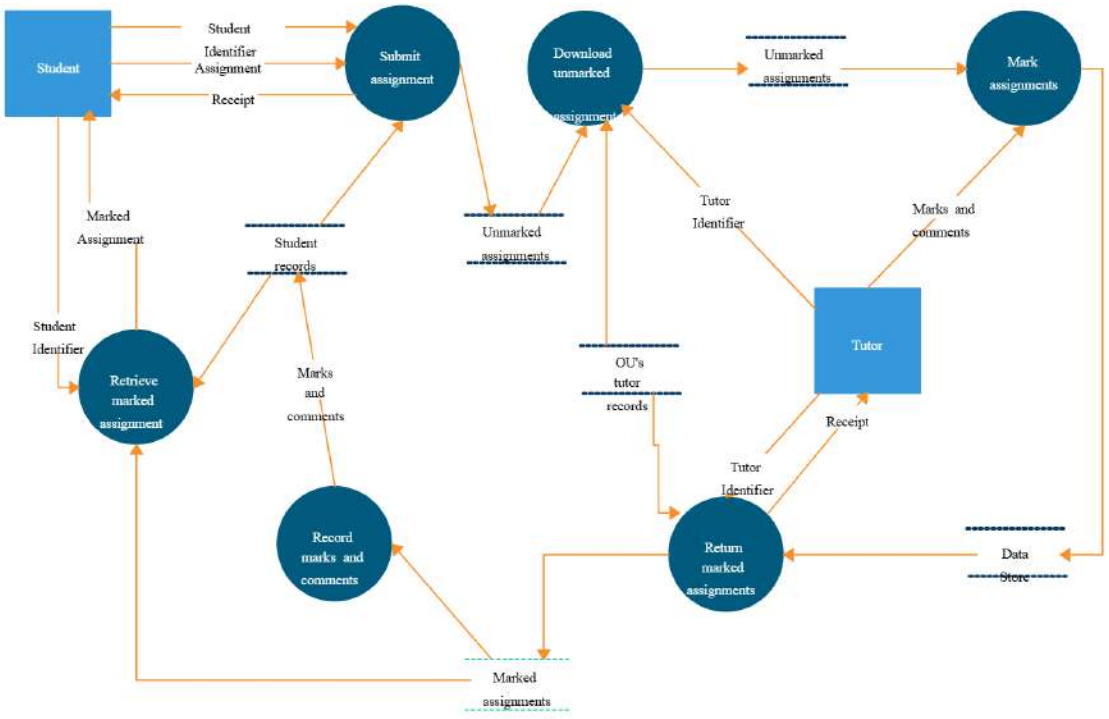


Figure2: System Architecture Diagram

6. IMPLEMENTATION DETAIL:

Interactive learning modules are authored in HTML5, CSS3, and JavaScript. The iterative development process involves feedback from users based on pilot testing. Pilot testing data revealed that students using FunLearn achieved test scores on average 20% higher. The system is implemented via a containerization approach (Docker) in order to achieve uniform performance across varying environments.

7. CONCLUSIONS:

The FunLearn program illustrates the power of interactive learning techniques to transform education. By involving students and teachers in an active and productive learning process, we can improve comprehension and retention of information. Limitations of the current study are pilot testing scope and the requirement for more investigation into long-term effects.

8. REFERENCES:

[1] Smith, J. (2018). Traditional Education Methods. Academic Press.

[2] Johnson, A., & Lee, B. (2020). Interactive Learning in the Digital Age. Educational Technology Journal.

[3] Brown, C. (2019). The Impact of Technology on Student Engagement. Journal of Educational Research.

[4] Garcia, D., & Martinez, E. (2021). Gamification and Knowledge Retention. International Journal of Educational Technology.

[5]https://www.kaggle.com/datasets/siddharthm1698/coursera-course-dataset

CoreFit AI: Transforming health and fitness leveraging the power of AI

[1] Piyush Kumar, B.Tech 4th year, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus*

[2] Kishore Kumar, B.Tech 4th year, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus*

[3] Pramod Kumar Assistant Professor, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus*

Corresponding Author: pramodmehta95@gmail.com

Abstract:

Artificial Intelligence (AI) has revolutionized fitness and health monitoring, enabling personalized wellness solutions that adapt to individual needs. This study explores the application of AI models in comprehensive fitness monitoring, integrating advanced machine learning techniques to enhance health assessments and recommendations. By leveraging fine-tuned open-source models such as Llama and Falcon, AI-driven systems can provide hyper-personalized diet, exerc.ise, and lifestyle recommendations based on user-specific data, including Body Mass Index (BMI), activity levels, and medical history.

Key innovations include **food menu analysis**, where AI processes meal plans or restaurant menus to suggest optimal dietary choices, and **condition-specific recommendations**, offering tailored fitness and nutrition plans for individuals with chronic conditions such as diabetes or hypertension. Additionally, **real-time monitoring dashboards** enable continuous tracking of user progress, while **context-aware decision-making models** refine suggestions based on evolving health metrics.

By integrating AI-driven insights with real-time user data, this approach transforms conventional fitness tracking into a dynamic, adaptive health management system. AI-powered fitness monitoring not only enhances personalization but also provides users with actionable, data-backed wellness strategies, paving the way for more effective and accessible health solutions.

Introduction:

In today's digital age, fitness and health tracking have evolved beyond conventional workout plans, requiring intelligent, adaptive, and data-driven solutions. Many individuals struggle to maintain a structured fitness routine due to the lack of personalized guidance, real-time monitoring, and accurate health analysis. CoreFit AI is designed to address these challenges by leveraging advanced artificial intelligence and machine learning to provide a comprehensive, personalized fitness monitoring system.

Unlike traditional fitness apps, CoreFit AI incorporates real-time biometric tracking, AI-driven workout customization, and automated nutritional planning to offer a truly adaptive experience. One of its key innovations is X-ray detection using machine learning, which allows users to analyze bone health, detect potential injuries, and receive posture correction suggestions. This feature is particularly beneficial for individuals recovering from injuries or those with musculoskeletal concerns. Additionally, the app includes AI-powered menu analysis and food recommendations, enabling users to scan meals and receive real-time insights on calorie intake, macronutrient composition, and healthier dietary alternatives.

CoreFit AI also integrates with wearable devices for continuous health monitoring, tracking parameters like heart rate, sleep patterns, and activity levels. The app's reinforcement learning algorithms dynamically adjust workout and diet plans based on user feedback, ensuring that fitness goals are achieved efficiently and sustainably. Furthermore, gamification elements such as fitness challenges, AI-powered virtual coaching, and community-driven motivation enhance user engagement, making fitness an interactive and rewarding experience.

Literature Review:

The integration of artificial intelligence (AI) in personalized wellness is transforming fitness tracking, dietary recommendations, and chronic disease management. This review highlights key advancements in AI-driven health applications.

1. Beyond BMI: Advanced Health Metrics
   Traditional Body Mass Index (BMI) assessments lack precision, as they do not consider body composition, metabolism, or lifestyle. AI-based models now integrate multiple health parameters, providing personalized dietary and fitness insights beyond BMI.

2. AI in Personalized Diet and Exercise
   AI and machine learning analyze vast datasets of health records, food habits, and activity levels to generate tailored fitness and nutrition plans, improving adherence and engagement.

3. AI & OCR in Food Menu Analysis
   Advancements in Optical Character Recognition (OCR) and Natural Language Processing (NLP) enable AI to extract nutritional data from menus and food labels, allowing users to make informed dietary choices.

4. AI for Chronic Disease Management
   AI-driven systems provide condition-based dietary and exercise plans, enhancing long-term adherence and health outcomes for individuals managing chronic diseases.

5. AI-Enhanced User Engagement
   Interactive AI-powered dashboards displaying BMI trends, fitness progress, and dietary insights improve motivation and adherence to health goals through real-time feedback.

6. AI in Smart Food Recommendations
   AI-based restaurant guidance and meal-planning systems analyze user preferences, dietary restrictions, and available food options, helping users maintain a healthy diet even while dining out.

Methodology :

1. Data Collection and Preprocessing for BMI and Advanced Health Metrics

Data preprocessing involves cleaning and normalizing the records by filtering out anomalies such as incomplete health profiles or inconsistent BMI calculations. Additionally, AI models are trained using supervised learning techniques to incorporate supplementary metrics such as muscle mass, visceral fat, and hydration levels, ensuring that BMI assessment evolves beyond its traditional limitations. The methodology also includes the integration of real-world user data through mobile health applications that track changes in health indicators over time.

2. Integration with Smart Wearables and Bluetooth API Connectivity

To enable real-time health tracking, the system integrates with smart wearables, such as Fitbit, Apple Watch, Garmin, Xiaomi Mi Band, and Samsung Galaxy Watch, utilizing Bluetooth Low Energy (BLE) APIs for continuous data streaming. This integration allows AI models to analyse physiological parameters, including heart rate, blood oxygen levels (SpO2), sleep patterns, step count, and stress levels, offering personalized recommendations based on real-time data. Additionally, an anomaly detection module continuously monitors user vitals, sending real-time alerts for irregular patterns such as abnormal heart rate spikes, prolonged inactivity, or oxygen desaturation levels. If a critical health event is detected, the system can automatically notify emergency contacts or healthcare providers.

3. AI-Powered X-Ray Image Analysis for Disease Detection

To enhance the system's medical diagnostic capabilities, an AI-powered X-ray analysis module is integrated. This module allows users to upload X-ray images, which are then analyzed by a pre-trained deep learning model to detect potential diseases such as tuberculosis, fractures, lung cancer, or bone abnormalities. If a disease is detected, the system can automatically schedule an online doctor consultation or suggest further medical tests.

4. Dynamic User Profiling for Personalized Insights

To enhance personalization, the system builds adaptive user profiles that evolve over time based on continuous data inputs. Each user profile stores key health metrics, such as BMI, calorie intake, physical activity levels, and chronic conditions. AI continuously updates the profile, refining recommendations based on changing lifestyle habits and user feedback. A hybrid approach is adopted, where content-based filtering tailors suggestions according to individual health goals, while collaborative filtering leverages insights from similar users to enhance recommendations.

System Architecture:

1. Client Layer (Frontend)

- Technologies: React.js (with Vite), TailwindCSS
- Functionality:
  - User registration & authentication
  - Dashboard for fitness insights
  - Input forms for height, weight, activity level, and health goals
  - Interactive charts & progress visualization
  - AI-based workout & diet suggestions display
  - Integration with wearables (e.g., Fitbit, Apple Watch)

---

2. Backend Layer (API & Logic)

- Technologies: Node.js with Express.js
- Functionality:
  - Handles authentication (JWT, OAuth2, Firebase/Auth0)
  - Stores and processes user health data
  - Requests AI-generated recommendations
  - Sends notifications & reminders

---

3. AI & Recommendation Engine

- Technologies: Python (Flask or FastAPI), TensorFlow/PyTorch,
- Functionality:
  - Data Processing: Cleans and normalizes user fitness data
  - AI Model for Personalization: Predicts workouts & diets based on user habits
  - Adaptive Learning: Adjusts recommendations based on user feedback
  - Activity Prediction: Uses ML models to suggest future fitness plans
  - Integration with External APIs: Fetches health guidelines (WHO, CDC)

---

4. Database Layer

- Technologies: MongoDB (NoSQL) or PostgreSQL (SQL), Redis (caching)
- Functionality:
  - Stores user profiles, fitness history, and progress
  - Manages AI-generated recommendations
  - Logs API interactions for monitoring and improvement

---

5. Security & Compliance

- Technologies: JWT authentication, OAuth2, SSL encryption
- Functionality:
  - Encrypts sensitive data

- Follows GDPR & HIPAA compliance
- Implements multi-factor authentication (MFA)
- Uses role-based access control (RBAC) for admin/user roles

AI Model Training for Personalized Fitness Recommendations:

To ensure **CoreFit AI** delivers accurate and personalized fitness recommendations, we employ **Llama (Large Language Model Meta AI)** as the foundation model. Llama is a **decoder-only transformer-based model**, pretrained on diverse text sources using **causal language modelling**.

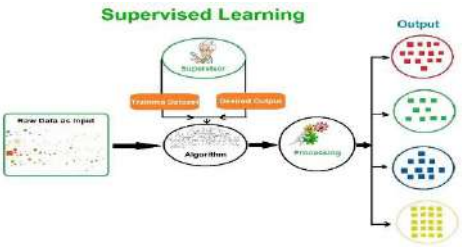
Model Selection and Justification

Llama was chosen due to its **efficiency, open-source availability, and strong contextual understanding**. Compared to proprietary models like GPT-3.5, Llama provides greater flexibility for fine-tuning on domain-specific data while maintaining lower computational costs.

Training Methodology

We utilize a **two-stage fine-tuning approach**:

1. **Supervised Fine-Tuning (SFT):** Llama is trained on a curated dataset of fitness-related queries, exercise routines, dietary plans, and expert health recommendations. This ensures the model generates relevant and structured responses.



2. **Reinforcement Learning with Human Feedback (RLHF):** To improve response accuracy and personalization, the model is further refined based on user feedback. Reward models are used to optimize suggestions, ensuring they align with user goals and preferences.

Dataset and Training Pipeline

The dataset includes structured fitness guidelines, real-world workout plans, and dietary recommendations. Data preprocessing ensures consistency and relevance, while the training process is optimized using **gradient-based learning techniques**. The model is fine-tuned on **high-performance GPUs**, ensuring efficient adaptation to personalized fitness needs.

Evaluation and Performance Metrics

The effectiveness of the trained Llama model is assessed through **response accuracy, user engagement metrics, and satisfaction ratings**. Key evaluation metrics include **perplexity scores, BLEU scores for textual accuracy, and real-world feedback analysis**. The continuous integration of RLHF allows for **progressive model refinement**, improving recommendation quality over time

Future Enhancements:

1. **Fitness Gamification & Rewards**
    - Introduces **badges & leaderboards** to increase motivation.
    - AI-powered challenges like **"10,000 Steps a Day"** with personalized tracking.
    - Users can **earn points for consistency** and redeem rewards.
2. **Community Based Support**
    - Interact with people with similar problems and ask them about the experiences and how they recovered from it.
    - Ask them questions and discuss with them about your problems.
3. **Paid Interaction with Doctors around the Globe**
    - Interact with Doctors in the community by paying their fees and taking to them one to one.
    - Use your Digital report which contains all your Diets, Workout and all your other health details and consult with them.

References:

[1] Brown, J. (2023, June 15). The role of AI in personalized fitness and nutrition. *Journal of Health Informatics*, *12*(3), 45-60.

[2] Smith, A. & Lee, K. (2022, September 10). AI-driven dietary recommendations: A new era in health tracking. *Nutrition and AI Review*, *8*(2), 112-130.

[3] Johnson, R. (2024, January 5). Optical character recognition and AI: Transforming food menu analysis. *International Journal of AI in Healthcare*, *15*(1), 22-39.

[4] Williams, D. & Patel, S. (2023, March 20). AI-enhanced chronic disease management: A systematic review. *Medical AI & Data Science*, *10*(4), 78-94.

[5] Anderson, P. (2023, July 25). Security and compliance in AI-driven health applications. *Cybersecurity & Healthcare*, *14*(3), 200-218.

[6] Kim, H. (2023, November 8). Smart wearables and AI: The future of health tracking. *Technology in Healthcare*, *18*(5), 150-170.

[7] Green, M. (2022, August 30). AI-powered X-ray diagnostics: Innovations and challenges. Journal of Medical Imaging AI, 6(2), 95-110.

[8] Carter, L. & Nguyen, T. (2024, February 14). Personalized AI recommendations for fitness and wellness. Computational Health Science, 20(1), 10-29.

Dam induced risk at its upstream and downstream side

[1]Md Azhra Imam, Assistant Professor, Civil Engineering, GGSESTC, Bokaro.
[2]Dr. Rajendra Prasad Verma, Associate Professor, Civil Engineering, GGSESTC, Bokaro.
[3]Mr. Prince Raj, B.Tech final year, Civil Engineering, GGSESTC, Bokaro.
Correspondence author e-mail ID: azharimam02@gmail.com

Abstract
Dams not only affect human beings but also affect the flora and fauna. The suitable site for dam is bowl shape in between hills, which are geographically rich in flora and fauna. As shelter, food, water are easily available in such location, historically, these have been sites for human settlements. Before constructing of a dam, the areas has to be first cleared of human settlements and vegetation, an enormous intrusion into and invasion of the human, aquatic, and eco-system of the entire region. With the construction of a barrier such as a dam, the water is collected in a huge lake or reservoir that results in submersion of local surrounding area in upstream. Along with that it also decreases the fertility of soil due to regular soil salinity. Since dams are long term projects, this also result in the increase in the flood level of river basin due to deposition of silt carried by the river. This also increases the risk of flood in river basin area. There is also chance of landslide near the water reservoir due to slope failure along the edges of the reservoir.
Standing on a dam, and looking upstream and downstream presents two divergent scenarios. Upstream, the dammed up river is full of water, standing in a static lake while downstream, the river is reduced to a few streams, hungry for water. In many cases, due to low water levels downstream, the channel shrinks and fertile river islands are created, providing attractive settings for new settlements. The settlers are often unaware of the risks of living in such fragile environments, which are vulnerable to inundation at times of excessive rainfall when the discharge from the dam cannot be regulated to protect these settlements downstream. This causes tremendous damages to human life and property, causing untold suffering.

KEYWORDS: Dam, Reservoir, Risk, Displaced, Deforestation and Aquatic System.

1. Introduction

This article is based on visual observation and technical analysis. We are generally working on understand dams induce risk by displacement of existing living community near river bank and reservoir area, way of degrading of soil near the reservoir due to rise of water table, chances of getting flood during monsoon period and heavy rainfall, aquatic life spoliation or disturbing of aquatic life.
For this analysis, I am selected a small dam in Bokaro district named “GARGA DAM”. So that it is easier for me to observe periodic as well as collect data for analysis. It is situated at one of the tributary rivers of Damodar river geographical location 86.084400 east.
The major information about the dam is as follows:-

Table 1 Dam Description Chart

Descriptions of Garga dam feature	**Value with unit**
Catchment area	55 sq mills
Submerged area	1120 acres
Maximum flood discharge	79 cusecs / cubic feet per second
Deepest foundation level	RL 712.50 ft
Top level of dam	RL 776.00 ft
Full reservoir level	RL 770.00 ft
Dead storage	1845.0 ac.ft ~80 million cft
Total storage	15771.7 ac.ft ~ 606.5 million cft
Total length of dam	4440 ft
Born date of dam	28/02/1968

Under these objectives I am conducing my article,

1. Identifying Problems among people living in dam coverage area.
2. Environmental issues generated by dam.
3. Spatial analysis of the study area.
4. Making one hypothetical geometrical model.

2. Literature review

Disaster Mitigation Experiences and Reflections
Pardeep Sahni, Alka Dhameja, Uma Medury PHI Learning Private Limited 2016

As per writers Disasters, whether natural or human-made, play havoc with the lives of millions of people very year around the globe. Their aftermath is nothing but a grim picture of death, destruction and suffering. The impact of hazards is mainly time and location dependent. While vulnerability is dependent on exposure to the hazard, the magnitude of risk is directly proportional to vulnerability, duration and intensity of the hazard.
This book contains wide field of Disaster related terms and issues but some of them are-Managing Disaster in Urban Areas, Disaster Management: Analyzing Vulnerability, Community capacity Building on Disaster Preparedness, Role of Media in Disaster Preparedness, Role of Police in Disaster Management, Vulnerability Reduction at Community level: The new Global Paradigm. Along with this one important chapter of it is "Floods, Embankments and Dams" by S.M.Kulshrestha. Under this section, writing is done in a very decorative manner. There is some historical discussion of dam following emerging problem due to dam and working of world commission and some emerging debates[4].

Role of Doyang Dam in bringing unprecedented floods in Golaghat
https://sandrp.in/2018/08/07/role-of-doyang-dam-in-bringing-unprecedented-floods-in-golaghat/#more-30351 August7,2018
Under this report, the highest flood level of Dhansiri River at Numaligarh was sudden increases 80.18 m i.e. 31 cm above the actual HFL. At that time Dhansiri catchment area is declared as rain-deficient by IMD that time. The reason behind that there was the high rainfall in Doyang project catchment area, so it discharges excess water due to rainfall. There is no option for NEEPCO to open the sluice gate which cause flood in Golaghat. There is mismanagement of dam which causes huge loss of life and property in Golaghat area[2].

3. Methodology

This section shows the detail of the method on which we are working on the article. The steps involve while writing of the article are as follows: -
Under information collected by secondary source, information is taken from different book/journal and internet sources. For information collection in primary source, I did site visit and interviewing local people.

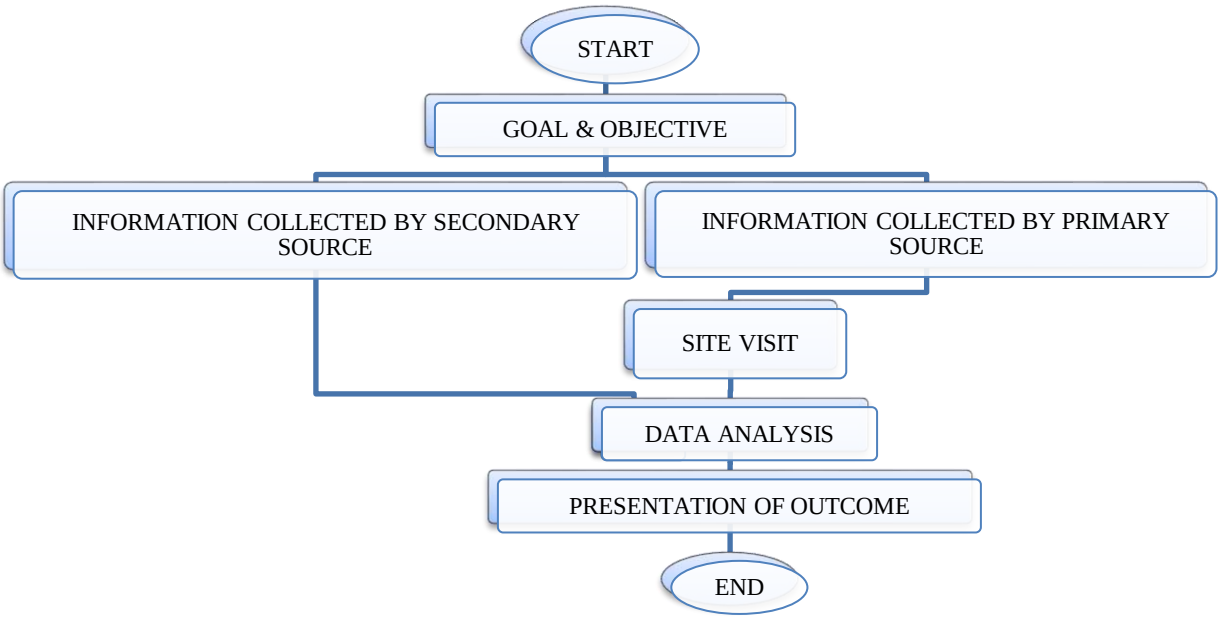


Figure 1 Methodology Chart

Finding during site visit

During my study, I have found that these are some problems rise by dam at local level.
Environmental issues: In this study we have found generation of greenhouse gasses i.e. water vapour depends upon the surface area of reservoir. Due to forming dam on earth surface, there will be effect on earth axis and rotation. Approximately 10000 km^3 of water is stored in large dam and reservoir, which is five times the total water in the rivers (Chao 1995) [1]. In case of dam water gets contaminated by Methyl mercury which results in contamination in food web.

Drought condition: As our geometrical model analysis, it shows that due to construction of dam on river, it disturbs total surface area of water expose to air. Therefore, it results in changes of rainfall pattern. It is also responsible for decrease in groundwater table. Socially, in overall aspect it shows that it denied right to equality.

Resettlement / rehabilitation issues: There is provision of resettlement in India, but it is only for those persons who are sufferer of land and house due to submerge. There is no provision for this settlement who live on bank of same river, because they also sufferer of lack of water. This shows the discrimination among common people.

Unemployment issues: Under various types of problems, economical issue is unemployment which leads to another social issues i.e. poverty. In upstream side the issues are temporal, but in downstream these issues are permanent and in regular seasonal variant[3]. This also leads to migration toward safer side (in terms of regional location, livelihood, etc.).

Flooding issues: Flood issues are common while discussing on dam. As it is a bowl full of water in case of any addition in it, it has two affects either it will submerge or make overload on dam. Later one is more serious case so releasing that overload, dam opens and over flooded its downstream basin. This also sows inequality between both sides of dam.

Reduction of mining output: Mainly dams are situated in hilly or plateau region. As our knowledge, plateau is rich of minerals. So geographically those areas have numbers of mines. If it is close to any dam that also reduces mines production and increases chance of mines accidents.

4. Analysis and Results

4.1. Spatial analysis using acrmap

Here we use satellite data and processing it using ArcMAP software for its spatial analysis. We have considered the region from reservoir upto point of meeting to the Damodar River in figure 2. And in figure 3, we have designated different colour for different landuse.

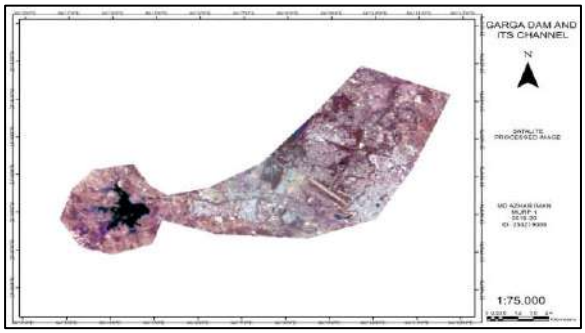


Figure 2 Mask image of satellite land sat 8 using band (R:G:B=7:4:3)

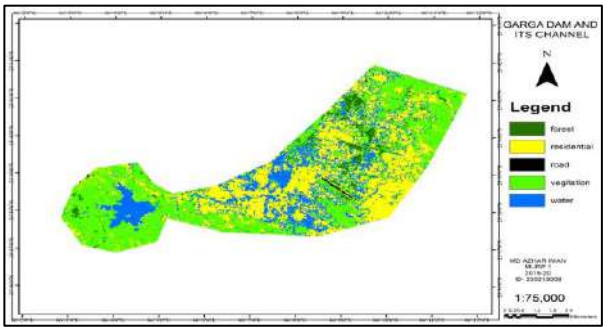


Figure 3 Map of ground cove

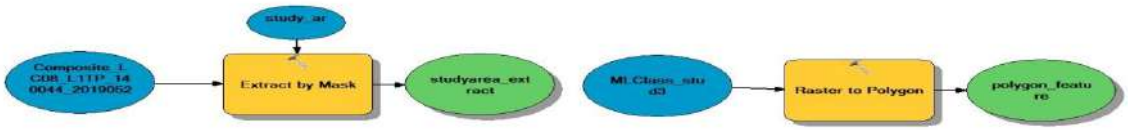


Figure 4 Model of working

4.2. Geometrical model and mathematical calculation

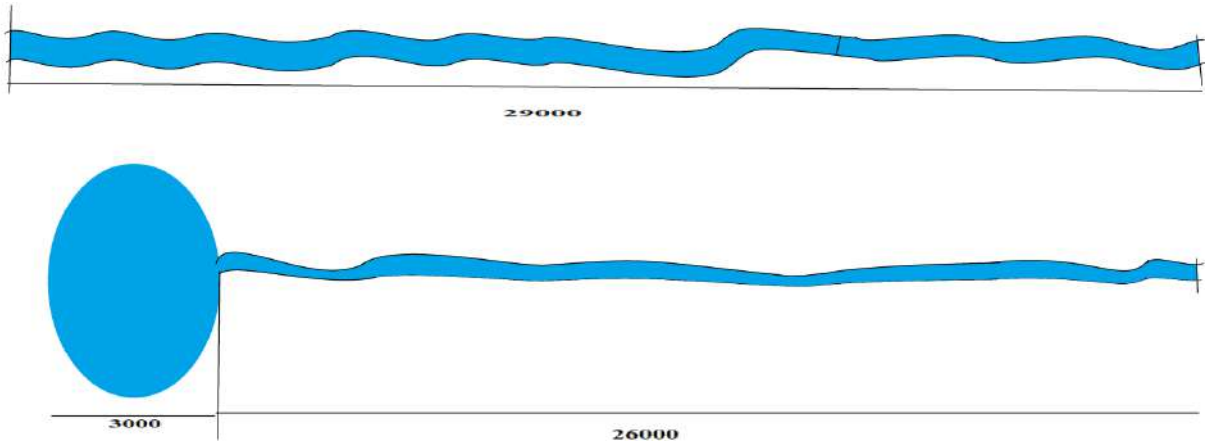


Figure 5 Geometrical Modal

As per given data reservoir stores 17174167 cubic meters of water and assuming that initially depth of water in river channel may be 3.5 meter. On observation present average depth of water in river is found to be 1.5 meter. In similar Faison, we assume that earlier width of river is six times present width. Present width of river is 10 meters based on eye observation. Assuming reservoir is nearly circular having area of 1945076sqm (area of actual reservoir calculated by AcrMap).
CASE 1: When there was no dam on Garga River.
Then, Total volume of water in Garga River= 6*10*3.5*29000=6090000 cubic meter.
This amount of water is distributed uniformly, somehow, throughout the river channel.

CASE 2: when there is dam on Garga River.
Now, Total volume of water in reservoir and river channel=17174167+1.5*10*(29000-1574)

= 17585557cubic meter.

But in CASE 2, concentration of large amount of water is at reservoir and along the channel the amount of water get reduced, which shows inequality of water distribution among the settlement living surrounding the river channel as well as in river channel.

At the reservoir region approximately 14293747 cubic meters of water is stored as surplus, while downstream has facing deficient of 195 cubic meters per meter of Garga River channel.

It is not enough, due to disturbance in water distribution, it also rises various other issues related to livestock, employment and environmental.

5. Result

i. It shows that due to construction of dam on river, it disturbs rainfall pattern and decrease in groundwater table. Socially, it denied right to equality.
ii. Discrimination among all people regarding proper compensation.
iii. Unemployment which leads to another social issue i.e. poverty in the upstream side and downstream side.
iv. Flooding is common for both upstream and downstream sides in different conditions of control on the dam.
v. It also hampers the production of mines, if nearby present.

6. Conclusion

The extra concession in jobs should be provided for the affected community. The proper land with household should be allocated in terms of compensation for the displaced people. So that the social equitability will be maintained. To overcome from environment issues, small check dams and a large pond should be constructed in and along the river. Such that, GWT and surface water of river can be maintained throughout year-round. Ensuring proper security, maintenance and checking of dam as well as river line that why, the public residing there will be safe. Authority should rise jobs opportunity for local people by introducing tourist activity, fishing and boating.

7. Reference

[1] “environmental effects of hydrological alterations” – internationalrivers.org
[2] “role of doyang dam in bringing unprecedented floods in golaghat” – DOI – 7 August, 2018 @ sandrp.in
[3] “Narmada Bachao Andolan(NBA)” – Wikipedia.org
[4] **“**Disaster Mitigation Experiences and Reflections” - Pardeep Sahni, Alka Dhameja, Uma Medury; PHI Learning Private Limited; 2016

The Role of Artificial Intelligence (AI) in E-Commerce

Md Asfaque[1], Prof. Vikash Kumar Jain[2], Prof. Md Asif Faizi[3]
[1]Student, Department of Master of Business Administration (MBA), GGSESTC, Kandra, Bokaro, Jharkhand[1]
e-mail id :asfaqueofficial21@gmail.com
[2]Assistant Professor, Department of Master of Business Administration(MBA) GGSESTC,kandra,Bokaro,Jharkhand[2]
Corresponding author e-mail id :vikashjain4u@gmail.com
[3]Assistant Professor, Department of Master of Business Administration (MBA) GGSESTC, Kandra, Bokaro, Jharkhand[3],
Corresponding author e-mail id:asif.faizi111@gmail.com

Abstract

Artificial Intelligence (AI) is revolutionizing the E-Commerce industry by enabling personalized customer experiences, automating processes, and enhancing security. AI-powered tools such as chatbots, recommendation engines, and fraud detection systems have significantly improved operational efficiency and customer engagement. However, challenges such as high implementation costs, data privacy concerns, and regulatory compliance issues persist. This paper examines the role of AI in E-Commerce, analyzes current trends, and presents a data-driven perspective on its future.

Introduction

E-Commerce has transformed global business by providing a seamless online shopping experience. The integration of AI in E-Commerce has enabled businesses to enhance personalization, automate support systems, and optimize supply chain management. Companies like Amazon, Alibaba, and eBay have successfully adopted AI to improve customer interactions and drive sales growth. Despite these advancements, AI adoption faces several barriers, including ethical dilemmas, cybersecurity risks, and high costs. This paper explores these aspects and provides an in-depth analysis backed by secondary research.

Literature Review

AI has significantly transformed E-Commerce by enhancing personalization, automation, and security. Studies highlight AI-driven recommendation systems boosting sales and customer satisfaction (McKinsey, 2023). AI chatbots improve service efficiency, while demand forecasting optimizes inventory (Forbes, 2023; Deloitte, 2023). Additionally, AI strengthens fraud detection but raises concerns about algorithmic bias and data privacy (PwC, 2024; Burt et al., 2022).

Despite AI's benefits, challenges such as high costs, regulatory issues, and ethical concerns persist (World Economic Forum, 2024). Future advancements in deep learning and predictive analytics will further refine AI's role in E-Commerce (Statista, 2024). Businesses must adopt responsible AI practices to ensure sustainable growth.

Key Applications of AI in E-Commerce

1. **Personalized Shopping Experience** – AI-powered recommendation engines analyze customer preferences and suggest relevant products.
2. **AI-Driven Chatbots** – Automated chatbots assist customers with inquiries, enhancing user experience and reducing human intervention.
3. **Fraud Detection and Security** – AI identifies unusual transaction patterns, minimizing fraudulent activities.
4. **Demand Forecasting** – AI predicts consumer demand, helping businesses manage inventory efficiently.
5. **Voice and Image Search** – AI allows customers to search for products using voice commands or images, enhancing accessibility.

Benefits of AI in E-Commerce

1. **Enhanced Customer Engagement** – AI personalizes content, increasing customer retention and satisfaction.
2. **Higher Conversion Rates** – AI-driven marketing strategies lead to improved sales performance.
3. **Operational Cost Reduction** – Automating tasks reduces labor costs and improves efficiency.
4. **Advanced Cybersecurity** – AI detects cyber threats in real time, protecting sensitive data.
5. **Optimized Inventory Management** – AI minimizes wastage by predicting market demand.

Challenges of AI in E-Commerce

1. **Data Privacy and Security Risks** – AI relies on vast amounts of consumer data, raising privacy concerns.
2. **High Implementation Costs** – Small businesses struggle to afford AI-driven solutions.
3. **Algorithmic Bias** – AI models can reinforce biases, leading to unfair recommendations.
4. **Customer Trust Issues** – Some consumers are reluctant to trust AI-powered shopping experiences.
5. **Regulatory and Ethical Concerns** – Compliance with data protection laws remains a challenge.

Problem Statement in AI and E-Commerce

Despite the benefits of AI, several challenges hinder its full-scale implementation in E-Commerce. This section outlines key problem areas and potential solutions.

1. AI Accessibility for Small Businesses
- AI adoption remains limited among small enterprises due to financial and technical constraints.
- Solution: Development of affordable AI solutions tailored for small-scale businesses.

2. Bias in AI Algorithms
- AI models sometimes produce biased recommendations, affecting fairness in E-Commerce.
- Solution: Implementation of unbiased training datasets and periodic AI audits.

3. Consumer Trust Deficit
- Many consumers hesitate to rely on AI-driven product suggestions due to data privacy concerns.
- Solution: Greater transparency and consumer education on AI's benefits.

4. Environmental Impact of AI
- AI requires extensive computational power, contributing to high energy consumption.
- Solution: Development of energy-efficient AI algorithms.

5. Legal and Compliance Issues
- Businesses must navigate different AI regulations across various regions.
- Solution: Adoption of standardized compliance frameworks.

Data Analysis

AI adoption in E-Commerce has shown remarkable growth in recent years. This section presents statistical insights based on secondary research.

1. AI Market Growth
- The AI market in E-Commerce is projected to reach $16.8 billion by 2025 (Statista, 2024).
- AI-driven personalization contributes to a 20% increase in revenue for online retailers (McKinsey, 2023).

2. Consumer Perception of AI
- A survey by PwC (2024) found that 65% of consumers prefer AI-powered recommendations, but 45% have privacy concerns.
- 78% of businesses using AI-powered chatbots reported improved customer satisfaction (Forbes, 2023).

3. Adoption Barriers for Small Businesses
- Research from Deloitte (2023) indicates that only 25% of small businesses use AI, citing cost as a major barrier.
- AI-based inventory management has reduced wastage by 30% in large retail companies but remains underutilized by SMEs (Harvard Business Review, 2024).

4. Regulatory and Compliance Issues
- AI-driven marketing is subject to GDPR and CCPA regulations, creating compliance challenges.
- Legal complexities have slowed AI adoption by 22% in Europe (World Economic Forum, 2024).

Future of AI in E-Commerce

AI will continue to revolutionize E-Commerce with advancements in deep learning and predictive analytics. The future will see enhanced AI-driven voice search, automated supply chain management, and improved fraud prevention strategies. Companies that strategically integrate AI will gain a competitive edge in the digital marketplace.

Key future developments include:

1. **Hyper-Personalization** – AI will refine recommendation algorithms, delivering even more personalized shopping experiences based on real-time user behavior.
2. **AI-Powered Virtual Shopping Assistants** – Advanced AI-driven assistants will provide real-time product suggestions, helping customers make informed decisions.
3. **Smart Inventory Management** – AI will enhance supply chain efficiency by predicting demand fluctuations and reducing inventory wastage.
4. **Voice and Visual Search** – AI-enabled search tools will allow customers to find products more efficiently through voice commands and image recognition.
5. **Augmented Reality (AR) Integration** – AI will combine with AR to offer virtual try-ons, improving online shopping experiences.
6. **Improved Fraud Prevention** – AI will develop more sophisticated fraud detection models, minimizing financial risks for businesses and consumers.
7. **Seamless Automated Customer Support** – AI-driven chatbots and virtual assistants will provide human-like interactions, enhancing customer service.
8. **Sustainable AI Practices** – Future AI models will focus on energy efficiency and ethical AI development to minimize environmental impact.

Conclusion

AI is reshaping the E-Commerce landscape by optimizing operations, enhancing security, and personalizing customer interactions. Despite challenges, AI-driven innovation will continue to drive the industry forward. Businesses must balance technological advancements with ethical considerations and regulatory compliance to maximize AI's potential.

References

[1.] Statista (2024). AI Market Growth in E-Commerce.
[2.] McKinsey (2023). The Impact of AI on Retail Sales.
[3.] PwC (2024). Consumer Perception of AI in Online Shopping.
[4.] Deloitte (2023). AI Adoption Barriers in SMEs.
[5.] World Economic Forum (2024). AI Regulations and Compliance Challenges.

Review on Energy and Exergy Analysis of Vapour Compression Refrigeration System

Nilesh Kumar Nayak*[1], Sarvesh Kumar[2], Sumit Kumar Pandey[3]

*[1,2,3] Department of Mechanical Engineering, GGSESTC, Bokaro, Jharkhand, India nayaknilesh272001@gmail.com[1]

Abstract

A significant portion of the energy generated globally is consumed by refrigerators, making it essential to reduce their energy consumption. Exergy analysis, a widely applied method in the evaluation of various engineering systems, including refrigerators, serves as an effective tool for the design, optimization, and performance assessment of energy systems.

In this paper titled "Review on Energy and Exergy Analysis of Vapour Compression Refrigeration System", theoretical performance study of a vapour compression refrigeration system is conducted. This study compares the energetic and exergetic performance of a vapour compression refrigeration system utilizing pure hydrocarbon (HC) refrigerants. Refrigerants like R-407c, R-410a, R-134a and R-600a(isobutane) are used for the analysis. This thesis provides a detailed review of existing research on the energy and exergy analysis of Vapor Compression Refrigeration Systems (VCRS). VCRS are widely utilized in various industries, yet their efficiency remains a major challenge due to high energy consumption and environmental concerns. The study consolidates findings from numerous research papers, comparing and synthesizing methodologies used to assess the energy and exergy performance of these systems. The paper explores the fundamental principles of energy and exergy analysis, highlighting key parameters such as COP (Coefficient of Performance), energy consumption, and exergy destruction, and their implications for system optimization. It further examines various strategies proposed in the literature to improve VCRS performance, including alternative refrigerants, system modifications, and energy-saving technologies. By reviewing and combining results from diverse studies, this paper provides an overview of the state-of-the-art techniques, identifies common trends and challenges, and suggests areas for future research to enhance the energy efficiency and sustainability of VCRS.

Objectives

- The main objective of this study is to evaluate and compare the energy and exergy performance of a vapor compression refrigeration system using different refrigerants, like R-407C, R-410A, R-134a, and R-600a, under varying operating conditions.
- This includes analysing the coefficient of performance (COP), energy efficiency, exergy destruction in each component, second law efficiency, exergy destruction ratio and overall exergy efficiency for each refrigerant.
- The study aims to identify the refrigerant that offers the best thermodynamic performance while minimizing energy losses and exergy destruction.
- Additionally, the research also analyses how operating parameters such as evaporator and condenser temperatures, subcooling, and superheating affect the energy and exergy efficiencies of the system for each selected refrigerant.

Problem Statement

- Energy analysis helps understand how well the system works, but it does not consider energy losses or how effectively the energy is used. Exergy analysis is important because it identifies where energy is wasted and how the system can be improved.
- The type of refrigerant used in a VCRS has a big impact on both its efficiency and its effect on the environment. Refrigerants like R-134a, R-407C, R-410A, and R-600a behave differently, which affects how much energy the system uses and how much energy is lost. To choose the best and most eco-friendly refrigerant, it is important to study how they perform under different conditions, such as evaporator and condenser temperatures, subcooling, and superheating.
- Even though refrigeration technology is improving, there are only a few studies that thoroughly examine both energy and exergy performance of VCRS with different refrigerants under real working conditions. This study aims to fill that gap by analysing how energy and exergy behave in VCRS, finding inefficiencies, and suggesting ways to improve performance and sustainability. The results will help in developing more energy-efficient and environmentally friendly refrigeration systems, reducing energy use and environmental impact.

Introduction

The energy balance is a fundamental tool in the investigation of any thermodynamic process, offering valuable insights into energy utilization and identifying areas for process improvement. It serves as a critical step in process optimization and forms the basis for developing an exergy balance. By analysing the energy balance, one can assess the efficiency of energy use in

various components of a system and compare these values with the performance standards of modern, advanced installations. This analysis helps pinpoint processes with high energy consumption or low efficiency, guiding efforts for enhancement. While energy analysis, based on the first law of thermodynamics, primarily focuses on energy conservation, exergy analysis—grounded in both the first and second laws—provides a more comprehensive understanding by accounting for energy quality and irreversibilities within the system. Exergy analysis has become a powerful tool for assessing and optimizing engineering processes, offering deeper insights into system performance.

In vapor compression refrigeration systems (VCRS), thermodynamic processes release significant amounts of heat to the environment, leading to irreversibilities that degrade system performance. These inefficiencies are mainly due to the temperature differences during heat transfer between the system and its surroundings. Although energy analysis remains the most widely used method for evaluating thermal systems, it only provides information on energy conservation without revealing the sources of performance degradation. In contrast, exergy analysis allows for a more detailed investigation of where and how energy losses occur, helping to identify areas for potential improvement.

Exergy analysis has proven to be an essential approach for optimizing refrigeration cycles, such as in the use of alternative refrigerants, system modifications, and performance evaluations. By analysing exergy destruction across different components of the refrigeration system, one can determine the maximum potential performance and identify specific areas for optimization. Previous studies have explored exergy analysis in various refrigeration systems, including those utilizing Freon-based refrigerants, natural gas liquefaction, and solar-assisted heat pump systems. The impact of factors like refrigerant selection, system configuration, and operating conditions has been widely examined in efforts to improve system efficiency and sustainability.

The present study focuses on reviewing and analysing the energy and exergy performance of vapor compression refrigeration systems. This review consolidates findings from various research studies to evaluate the efficiency of different refrigerants, system configurations, and operating conditions. The investigation examines the effects of operating parameters such as evaporating and condensing temperatures, exergy losses, and the coefficient of performance (COP) in these systems. Additionally, the review considers the impact of alternative refrigerants and lubricants, with a particular emphasis on those with lower environmental impact, such as hydrocarbons, in response to global warming and ozone depletion concerns. The objective is to provide a thorough understanding of energy and exergy analysis in VCRS, highlighting key performance metrics and offering insights for further research to enhance the efficiency and sustainability of refrigeration systems across various sectors, including industrial, residential, and transport applications.

Literature Review

John T. McMullan (2002), the paper discusses the phase-out of CFCs and HCFCs due to ozone damage and the current focus on reducing global warming impact. Since no ideal refrigerant exists, mixtures and natural alternatives are being considered, which require better system designs and monitoring. It also covers the availability of refrigerants and the challenges of using mixtures **[1]**.

Md Ozair Arshad, Qummare Azam, Feroz Khan, Mohd Atif Wahid, this study performs exergy analysis on the vapor compression refrigeration system with refrigerants R-134a, R-12, and R-22, examining the effects of evaporator temperature variation on exergy loss and second law efficiency. Results show that exergy loss decreases with higher evaporator temperatures, with R-134a exhibiting the highest exergy destruction and R-12 the lowest. The exergetic efficiency follows the order of R-12 > R-22 > R-134a. The study highlights the significant exergy loss in compressors and emphasizes the need to improve system design and consider environmental impacts when selecting refrigerants **[2]**.

Recep Yumrutas[a*], Mehmet Kunduz[b*], Mehmet Kanoglu, this study uses exergy analysis to examine how evaporating and condensing temperatures affect pressure losses, exergy losses, second law efficiency, and COP in a vapor-compression refrigeration cycle. Results show that these temperatures significantly impact exergy losses in the evaporator and condenser but have little effect on the compressor and expansion valve. Reducing the temperature difference improves efficiency and performance while lowering total exergy loss **[3]**.

[1]T. Hari Prasad, [2]K. Poli Reddy and [3]D. Raghu Rami Reddy, this study concludes that Exergy losses in a vapor compression refrigeration system arise from irreversibilities, reducing efficiency. Temperature, subcooling, and superheating affect performance. Exergy analysis helps identify inefficiencies and optimize the system **[4]**.

J.U. Ahamed*, R. Saidur, H.H. Masjuki, This study explores exergy analysis in VCRS. Refrigerants like R600a, R410a, and R1270 are efficient but need blending with R134a for safety. Most exergy loss happens in the compressor, which can be reduced using nano lubricants and nanofluids **[5]**.

Mercy Ogbonnaya[1,2,*], Oluseyi O. Ajayi[1], M.A Waheed[3] and Sunday O. Oyedepo1, This study examines how nano refrigerants improve the energy and exergy performance of VCRS. Adding nanoparticles to refrigerants enhances thermal conductivity, reducing energy consumption and greenhouse gas emissions. TiO_2 and CuO nano refrigerants showed the best performance, but excessive nanoparticle concentration negatively impacts efficiency. The highest exergy loss occurs in the compressor, highlighting the need for further optimization **[6]**.

Raja Kumar Gond[1], Ravindra Pratap Chaudhary[2], Mohammad Amir Khan[3], Gaurav Jain[4], this study compares alternative refrigerants to R134a in a vapor compression system, finding R600, R600a, R717, and R152a more efficient, with R600 as the best replacement. Evaporator and condenser temperatures, subcooling, and superheating significantly impact performance **[7]**.

Jian Sun[1]*, Wenhua Li[2], Borui Cui[1], this study assesses R513a as a low-GWP alternative to R134a in vapor compression systems. While R513a reduces capacity (12%) and efficiency (up to 14%), it lowers irreversibility (5–13%) in high ambient conditions and improves exergy efficiency (3%) in low ambient conditions. Compressor redesign is key to optimizing performance, followed by adjustments to the evaporator, economizer, and valves **[8]**.

Jyoti Soni, R.C. Gupta, this study compares the performance of refrigerants R-407C and R-410A. R-407C outperforms R-410A in COP and exergy efficiency, while R-410A has higher exergy destruction. Subcooling improves efficiency, and higher dead state temperatures reduce exergy losses. However, increasing effectiveness of liquid vapour heat exchanger, lowers COP and efficiency, affecting R-410A more **[9]**.

Bayram Kılıc¸, this study evaluates R507, R407c, and R404a in a two-stage vapor compression with intercooler. R407c shows the best COP and exergy efficiency, while R507 has the highest irreversibility. The evaporator has the highest irreversibility due to phase change, heat transfer, and friction. These refrigerants are viable eco-friendly alternatives to CFCs and HCFCs **[10]**.

Hilmi Cenk Bayrakc-i[1] and Arif Emre Ozgur[2], this study compares the energy and exergy performance of pure hydrocarbon refrigerants (R290, R600, R600a, R1270) with R22 and R134a. R1270 and R600 show the highest efficiency, while R600a is a suitable alternative for R22 and R134a. EES package program was used for solving thermodynamic equations, increasing evaporation temperature improves COP but reduces exergy efficiency. Pure hydrocarbons are preferred over mixtures because their composition doesn't change due to leakage **[11]**.

Ahmet Kabul, Onder Kizilkan* and Ali Kemal Yakut, this study analyses the energy and exergy performance in VCRS using isobutane (R600a) with an internal heat exchanger. R600a is a viable eco-friendly alternative to CFCs and HCFCs. Higher evaporator temperatures improve efficiency, while higher condenser temperatures reduce it. The compressor has the most irreversibility **[12]**.

Mohan Chandrasekharan, this study compares R12 and R134a in a single-stage VCRS using energy and exergy analysis. It examines the effects of evaporator temperature and sub-cooling on system performance. Exergy destruction rates were analysed for each component, The study compared how much energy is wasted in different parts of the system when using R12 and R134a **[13]**.

Jatinder Gill, Jagdev Singh, Olayinka S. Ohunakin, Damola S. Adelekan, this study compared the exergetic performance of vapor compression refrigeration systems using R450A and R134a. R450A showed higher exergy efficiency and lower irreversibility, with improved performance in most components except the capillary tube. Despite its higher cost, R450A outperforms R134a, with recommendations for capillary tube redesign **[14].**

S. Kumar, M. Prevost and R. Bugarel, this paper presents an exergetic analysis of a vapor compression refrigeration system using R11 and R12 refrigerants. Exergy-enthalpy diagrams are provided to calculate losses, coefficient of performance, and exergetic efficiency. The study concludes that exergy analysis is a valuable tool for improving system efficiency by pinpointing areas of energy loss and enhancing overall performance **[15].**

Mehmet Kanoglu, this paper presents an exergy analysis of the multistage cascade refrigeration cycle used for natural gas liquefaction, focusing on exergy destruction and exergetic efficiency of key components. The study develops equations for total exergy destruction and minimum work required for liquefaction, showing that minimum work increases with decreasing liquefaction temperature. The results highlight a cycle exergetic efficiency of 38.5%, indicating potential for improvement in natural gas liquefaction processes. The findings can be applied to optimize and design liquefaction plants and extend to other refrigeration cycles **[16]**.

Tayfun Menlik, Ahmet Demircioğlu and Musa Galip Özkaya, this paper compares the energy and exergy performance of R22, R407C, and R410A in a vapor compression refrigeration system (VCRS). The analysis showed that R407C outperforms R410A, with higher COP, better exergetic efficiency, and lower exergy destruction. The study also found that subcooling/superheating and dead state temperature significantly affect system performance. The condenser was identified as the least efficient component in all systems. Overall, R407C is a better alternative to R22 than R410A, considering both thermodynamic efficiency and environmental factors like ODP and GWP **[17]**.

Akhilesh Arora, B.B. Arora, B.D. Pathak and H.L. Sachdev, this study investigates the performance of R-22, R-407C, and R-410A in a vapor compression refrigeration cycle, focusing on COP, exergy destruction (ED), and exergetic efficiency. Results show that R-22 outperforms R-407C and R-410A in terms of COP and exergetic efficiency, with R-410A being a better alternative than R-407C for refrigeration applications. The study concludes that switching to alternate refrigerants leads to a decrease in exergetic efficiency, which can be improved with system design modifications, and the final refrigerant choice depends on a lifetime cost analysis **[18]**.

Erol Arcakliog˘lu, Abdullah C¸ avus ßog˘lu and Ali Eris ßen, this study develops an algorithm to identify refrigerant mixtures with equal volumetric cooling capacity (VCC) to replace CFC-based refrigerants in vapor compression systems. The study compares the COP and VCC of various refrigerant mixtures and suggests that mixtures like R290/R600a for R12, R32/R125/R134a for R22, and R32/R125/R134a for R502 provide better or comparable performance to conventional CFCs. The findings offer guidance for selecting replacement mixtures based on COP and VCC values, emphasizing the need for further evaluation using the second law of thermodynamics to account for irreversibility **[19]**.

Thermodynamic analysis

The main aim of the thermodynamic analysis is:

i. To find the coefficient of performance (COP) of the cycle using first law analysis.
ii. To determine the exergy lost in each component using second law analysis.
iii. To determine the second law efficiency.
iv. To determine the Exergy destruction ratio, Exergetic Efficiency.

So, we will use two approaches for the entire analysis. The first analysis based on energetic approach and the second analysis based on Exergetic approach.

Energetic Approach or The First Law Analysis

The purpose of the first law of thermodynamic analysis is to determine how the coefficient of performance (COP) varies with evaporator temperature, condenser temperature, compressor isentropic efficiency, and superheating temperature.

Few assumptions to be considered in analysis are:

i. Steady-State Operation: All components of the system operate under steady-state, steady-flow conditions.
ii. Negligible Pressure Losses: Pressure drops through the pipelines, including those in the evaporator and condenser, are considered negligible.
iii. Negligible Energy Losses: Kinetic energy, potential energy are considered insignificant and ignored in the analysis.
iv. Adiabatic Compression and Expansion: Both the compressor and expansion device are treated as adiabatic, meaning no heat transfer occurs during compression or expansion.
v. Saturated States: The refrigerant is assumed to be in a saturated state at the outlets of the condenser and evaporator.

The compressor capacity can be calculated using the formula:

$$\dot{W}_{comp} = \dot{m}_R(h_2 - h_1) \qquad \text{----------(1)}$$

where $\dot{W}_{comp}$ is the compressor capacity, $\dot{m}_R$ is the mass flow rate of refrigerant and h denotes enthalpy. Here, h_2 represents the actual enthalpy at the compressor outlet and is defined as:

$$h_2 = h_1 + \frac{h_{2s} - h_1}{\eta_{is}} \qquad \text{----------(2)}$$

where η_{is} is the isentropic efficiency of compressor. So isentropic work input to compressor is

$$\dot{W}_{c_{is}} = \dot{m}_R(h_{2s} - h_1) \qquad \text{----------(3)}$$

The condenser capacity is calculated as:

$$\dot{Q}_{cond} = \dot{m}_R(h_2 - h_3) \qquad \text{----------(4)}$$

here $\dot{Q}_{cond}$ is the condenser capacity, $\dot{m}_R$ is the mass flow rate of refrigerant.

The expansion process is isenthalpic and denoted as:

$$h_3 = h_4 \qquad \text{----------(5)}$$

The cooling capacity or heat extracted can be calculated as:

$$\dot{Q}_{evap} = \dot{m}_R(h_1 - h_4) \qquad \text{----------(6)}$$

here $\dot{Q}_{evap}$ is the evaporator/cooling capacity, $\dot{m}_R$ is the mass flow rate of refrigerant.

The cooling capacity is defined as the difference between the capacities of the condenser and the compressor:

$$\dot{Q}_{evap} = \dot{Q}_{cond} - \dot{W}_{c_{is}} \qquad \text{----------(7)}$$

The overall energy performance of the cycle is assessed by calculating its COP, which is the ratio of the refrigeration capacity to the power input to the compressor. It is expressed as:

$$COP = \dot{Q}_{evap} \Big/ \dot{W}_{c_{is}} = \frac{h_1 - h_4}{h_{2s} - h_1} \qquad \text{----------(8)}$$

Another parameter used to evaluate the performance of the refrigeration cycle is the efficiency ratio (τ), also known as the second law efficiency (η_{II}), and it can be expressed as:

$$\tau = \frac{COP_{act}}{COP_{carnot}} \quad \text{or} \quad \eta_{II} = \frac{COP_{act}}{COP_{carnot}}$$

where COP_{act} is the actual coefficient of performance, COP_{carnot} is the ideal coefficient of performance of the cycle and is the maximum possible COP of a refrigeration cycle working between two temperature limits.

COP_{carnot} is also denoted by:

$$COP_{carnot} = {}^{T_L}/_{(T_H - T_L)} \qquad \text{----------(9)}$$

where T_L denotes lower side temperature or evaporator side temperature and T_H denotes higher side temperature or condenser side temperature.

Another performance metric for the refrigeration system is the Energy Efficiency Ratio (EER). EER represents the heating and cooling efficiencies of air conditioning units. It indicates the ratio of the heating or cooling output to the electrical energy input required to produce it and is defined as:

$$EER = COP \times 3.412 \qquad \text{----------(10)}$$

Exergetic Approach or The Second Law Analysis

Some assumptions are made for the analysis are:

i. All components operate under steady-state conditions.
ii. Pressure losses in the pipelines are neglected.
iii. Heat gains and losses to or from the system are not considered.
iv. Kinetic energy, potential energy, and exergy losses are ignored.

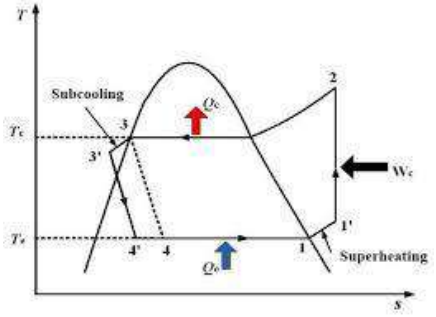


Fig. 1: T-S diagram of VCRS for analysis

The mathematical formulation for exergy analysis is as follows:

General exergy balance equation with respect to time is given as-

$$\dot{E}_D = \dot{E}_{in} - \dot{E}_{out} \qquad (11)$$

where $\dot{E}_{in} - \dot{E}_{out}$ represent the rate of exergy transfer and $\dot{E}_D$ represent irreversibility

Equation (11) for steady state process for control volume can also be written as:

$$\dot{E}_D = \dot{E}_Q - \dot{E}_W + \dot{E}_{mass,in} - \dot{E}_{mass,out} \qquad (12)$$

where exergy of heat, work, mass is given as:

$$\dot{E}_Q = \dot{Q}(1 - \tfrac{T_0}{T}) \qquad (13)$$

$$\dot{E}_W = \dot{W} \qquad (14)$$

$$\dot{E}_{mass} = \dot{m}_R \times \psi \qquad (15)$$

where $\dot{Q}$ is rate of heat transfer at temperature T, T_0 is reference temperature and ψ is specific flow exergy.

Combining equation (12-15) can be written as:

$$\dot{E}_D = \sum \dot{E}_{mass,in} - \sum \dot{E}_{mass,out} + \left[\sum \left\{ \dot{Q} \left(1 - \tfrac{T_0}{T} \right)_{in} \right\} - \sum \left\{ \dot{Q} \left(1 - \tfrac{T_0}{T} \right)_{out} \right\} \right] \pm \sum \dot{W} \qquad (16)$$

Specific Exergy in any state is given as:

$$\psi = (h - h_0) + \tfrac{1}{2} V^2 + gZ - T_0(s - s_0) \qquad (17)$$

where g, V and Z are the gravitational acceleration, velocity and elevation from reference respectively. Neglecting potential and kinetic energies as per assumption, the equation (17) becomes

$$\psi = (h - h_0) - T_0(s - s_0) \qquad (18)$$

The exergy destruction term, ($\dot{E}_D$), is also known as irreversibility rate.

$$\dot{I} = \dot{E}_D \quad (19)$$

Applying Exergy analysis equation in each component of VCRS, Irreversibility rate for each component is:

i. For Evaporator:
Heat added in Evaporator, $\dot{Q}_E = \dot{m}(h_{1'} - h_{4'})$ (20)
Exergy destruction, $\dot{I}_E = \dot{m}(\psi_{4'} - \psi_{1'}) + \dot{Q}\left(1 - \frac{T_0}{T_E}\right)$
$$\dot{I}_E = \dot{m}(h_{4'} - h_{1'}) - T_0(s_{4'} - s_{1'}) + \dot{Q}\left(1 - \frac{T_0}{T_E}\right) \quad (21)$$

ii. For Compressor:
Work in compressor, $\dot{W}_C = \dot{m}(h_2 - h_{1'})$ (22)
Since, compression is non-isentropic, $h_C = \frac{(h_{2s} - h_2)}{\eta_C}$ (23)
Electrical power consumed, $\dot{W}_{el} = {\dot{W}_C}/{\eta_{mech}} \times \eta_{el}$
Exergy destruction, $\dot{I}_{comp} = \dot{m}(\psi_{1'} - \psi_2) + \dot{W}_{el}$
$$\dot{I}_{comp} = \dot{m}(h_{1'} - h_2) - T_0(s_{1'} - s_2) + \dot{W}_{el} \quad (24)$$

iii. For Condenser:
Heat rejected, $\dot{Q}_{cond} = \dot{m}(h_2 - h_{3'})$ (25)
Exergy destruction, $\dot{I}_{cond} = \dot{m}(\psi_2 - \psi_{3'}) - \dot{Q}_{cond}(1 - \frac{T_0}{T_{cond}})$
$$\dot{I}_{cond} = \dot{m}(h_2 - h_{3'}) - T_0(s_2 - s_{3'}) - \dot{Q}_{cond}(1 - \frac{T_0}{T_{cond}}) \quad (26)$$

iv. For expansion valve:
$$\dot{I}_{exp} = \dot{m}(\psi_4 - \psi_{3'}) = \dot{m}(s_4 - s_{3'}) \text{ [In throttling, } h_4 = h_1] \quad (27)$$

I. Coefficient of performance, $COP = \frac{\dot{Q}_E}{\dot{W}_{el}}$ (28)
II. Total exergy destruction, $\dot{I}_{total} = \dot{I}_{comp} + \dot{I}_{cond} + \dot{I}_{exp} + \dot{I}_E$ (29)
III. Exergy efficiency, $\eta_x = \frac{\psi_{1'} - \psi_{4'}}{\dot{W}_{el}}$
Or
$$\eta_x = \left(\frac{\dot{E}_{out}}{\dot{E}_{in}}\right) \times 100 \quad (30)$$
where $\dot{E}_{out} = \dot{E}_{in} - \dot{I}_{total}$ (31)

& electric power is the main source of exergy input in compressor

so, $\dot{E}_{in} = \dot{W}_{comp}$ (32)
$$\therefore \eta_x = \left(\frac{\dot{W}_{comp} - \dot{I}_{total}}{\dot{W}_{comp}}\right) \times 100 = \left(1 - \frac{\dot{I}_{total}}{\dot{W}_{comp}}\right) \times 100 \quad (33)$$
IV. Energy efficiency ratio, EER $= \frac{Energy\ out}{Compression\ work} = \frac{h_{1'} - h_{4'}}{\dot{W}_{el}}$ (34)
V. Exergy destruction ratio, $EDR = \left(\frac{\dot{W}_{comp}}{\dot{W}_{comp} - \dot{I}_{total}}\right)$ (35)

CONCLUSION

In conclusion, the performance analysis of refrigerants R-407C, R-410A, R-134a, and R-600a in vapor compression refrigeration systems reveals the following key findings:

1. R-407C demonstrates better Coefficient of Performance (COP) and exergetic efficiency than R-410A. Additionally, R-407C benefits from subcooling of the high-pressure liquid refrigerant, with a notable increase in exergetic efficiency by 7.02% for 10°C subcooling.

2. R-410A exhibits higher exergy destruction rates (EDR) compared to R-407C but shows similar trends in performance under varying operating conditions. R-410A's COP and exergetic efficiency improve with subcooling, similar to R-407C, but to a slightly higher degree, with an 8.01% increase in exergetic efficiency at 10°C subcooling.

3. R-134a consistently shows lower performance in terms of exergetic efficiency and COP compared to the other refrigerants studied. Its exergy destruction is higher, particularly under increased evaporator and condenser temperatures, leading to lower overall system performance.

4. R-600a, a hydrocarbon refrigerant, shows the best overall performance in terms of energy and exergy efficiency. It provides comparable or even better performance than R-134a and R-22, especially in terms of COP and exergetic efficiency. R-600a demonstrates a promising alternative to synthetic refrigerants, showing minimal environmental impact and good efficiency, making it a viable option for replacing older refrigerants in certain applications.

In summary, R-407C and R-600a emerge as better alternatives in terms of both energy and exergy efficiency, with R-600a offering the highest overall performance. However, R-410A remains a strong contender, though its exergy losses are relatively high. R-134a, while widely used, shows lower overall efficiency and exergy performance and is less favorable compared to the other refrigerants considered.

REFERENCES

[1] J.T. McMullan, Refrigeration and the environment—issues and strategies for the future, International Journal of Refrigeration 25 (2002) 89–99.

[2] M. Ozair Arshad, Q. Azam, S. Twaha Irfan Ahmad et al., Analysis of vapour compression refrigeration system with R-12, R-134a and R-22: An exergy approach, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2021.04.278

[3] Recep Yumrutas[a*], Mehmet Kunduz[b*], Mehmet Kanoglu, Exergy analysis of vapor compression refrigeration systems, Exergy, an International Journal 2 (2002) 266–272

[4] [1]T. Hari Prasad, [2]K. Poli Reddy and [3]D. Raghu Rami Reddy, Exergy Analysis of Vapour Compression Refrigeration System, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 4 Number 12 (2009) pp. 2505–2526

[5] J.U. Ahamed*, R. Saidur, H.H. Masjuki, A review on exergy analysis of vapor compression refrigeration system, Renewable and Sustainable Energy Reviews 15 (2011) 1593–1600

[6] Mercy Ogbonnaya[1,2, *], Oluseyi O. Ajayi[1], M.A Waheed[3] and Sunday O. Oyedepo1, Review on The Energy and Exergy Analysis of Vapour Compression Refrigeration System Using Nanolubricant, Journal of Physics: Conference Series 1378 (2019) 042067

[7] Raja Kumar Gond[1], Ravindra Pratap Chaudhary[2], Mohammad Amir Khan[3], Gaurav Jain[4], Performance and exergy analysis of vapour compression refrigeration system using various alternative of R134a, International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 05 | May-2016

[8] Jian Sun[1]*, Wenhua Li[2], Borui Cui[1], Energy and exergy analyses of R513a as a R134a drop-in replacement in a vapor compression refrigeration system, International Journal of Refrigeration (2019), doi: https://doi.org/10.1016/j.ijrefrig.2019.12.014

[9] Jyoti Soni, R.C. Gupta, Exergy Analysis of Vapour Compression Refrigeration System with Using R- 407C and R-410A, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 7, September – 2012 ISSN: 2278-0181

[10] Bayram Kılıc¸, Exergy analysis of vapor compression refrigeration cycle with two-stage and intercooler, Heat Mass Transfer (2012) 48:1207–1217, DOI 10.1007/s00231-012-0971-4

[11] Hilmi Cenk Bayrakc-i[1] and Arif Emre Ozgur[2], Energy and exergy analysis of vapor compression refrigeration system using pure hydrocarbon refrigerants, INTERNATIONAL JOURNAL OF ENERGY RESEARCH Int. J. Energy Res. 2009; 33:1070–1075

[12] Ahmet Kabul, Onder Kizilkan* and Ali Kemal Yakut, Performance and exergetic analysis of vapor compression refrigeration system with an internal heat exchanger using a hydrocarbon, isobutane (R600a), INTERNATIONAL JOURNAL OF ENERGY RESEARCH Int. J. Energy Res. 2008; 32:824–836

[13] Mohan Chandrasekharan, Exergy Analysis of Vapor Compression Refrigeration System Using R12 and R134a as Refrigerants, International Journal of Students' Research in Technology & Management, Vol 2 (04), June-July 2014, ISSN 2321-2543, pg 134-139

[14] Jatinder Gill, Jagdev Singh, Olayinka S. Ohunakin, Damola S. Adelekan3 (2018), Exergy analysis of vapor compression refrigeration system using R450A as a replacement of R134a, Journal of Thermal Analysis and Calorimetry https://doi.org/10.1007/s10973-018-7675-z

[15] S. Kumar, M. Prevost and R. Bugarel, Exergy Analysis Of Compression Refrigeration System (1989), Heat Recovery Systems and CHP Vol. 9, No.2, pg. 151-157

[16] Mehmet Kanoglu, Exergy analysis of multistage cascade refrigeration cycle used for natural gas liquefaction, INTERNATIONAL JOURNAL OF ENERGY RESEARCH Int. J. Energy Res. 2002; 26:763–774 (DOI: 10.1002/er.814)

[17] Tayfun Menlik, Ahmet Demircioğlu and Musa Galip Özkaya, Energy and exergy analysis of R22 and its alternatives in a vapour compression refrigeration system, *Int. J. Exergy, Vol. 12, No. 1, 2013*

[18] Akhilesh Arora*, B.B. Arora, B.D. Pathak and H.L. Sachdev, Exergy analysis of a Vapour Compression Refrigeration system with R-22, R-407C and R-410A, *Int. J. Exergy, Vol. 4, No. 4, 2007*

[19] Erol Arcakliog˘lu, Abdullah C¸ avus ßog˘lu and Ali Eris ßen (2006), Thermodynamic analysis of refrigerant mixtures for possible replacements for CFCs by an algorithm compiling property data, Applied Thermal Engineering 26 (2006) 430–439

PRESENZ-STUDENT ATTENDANCE APP

Goutam Kumar[1], Rohit Verma[2], Manisha Kumari[3]
[1]ECE Department, GGSESTC, Kandra, Chas, Bokaro-827013, Jharkhand, India
goutamec@gmail.com
rhitverm@gmail.com

Abstract-Traditional attendance systems, which often rely on paper, registers, manual sign-ins, or basic punch cards, have several limitations like human error, time-consuming, fraud and manipulation, also many organizations and institutions are moving toward more automated and digital attendance tracking systems to overcome these limitations.

So, in my proposed paper titled **'PRESENZ-STUDENT ATTENDANCE APP'** is an attempt to develop an AI-enabled smart attendance system that automates the process using facial recognition ensuring accuracy, security, and efficiency. The system was developed using a mobile Android application to replace the traditional attendance that requires students to physically sign the attendance sheet [2]. This system simplifies attendance for both students and teachers. It also allows teachers to upload notes, schedule tests, and send notifications, while students can access study materials and receive real-time updates. By incorporating highly advanced technology with user- friendly features, Presenz provides a new modern smart solution catering to the needs of schools, colleges, and universities. When teacher enters in the classroom then they scan their RFID with the machine, this helps to login the teacher to the attendance portal system then high-resolution digital camera starts to detect and recognize the faces of the students and the machine compares the recognized face with students' face images stored in the database [1]

Thus, by eliminating tedious manual processes, *Presenz* enhances efficiency, prevents attendance fraud, improves student engagement, and streamlines academic communication. It is a cloud-enabled system with real-time alerts, a space-efficient user interface, and a scalable, secure, and future-ready solution for modern education.

Introduction-Presenz project aims to eliminate traditional inefficiencies in student attendance management. Manual attendance tracking is slow, error-prone, and vulnerable to frauds like proxy attendance. this application is a tool that can assist the personnel team and company management in monitoring employee absenteeism and as a performance measurement material to assess KPI [3]. Presenz fights these problems using facial recognition and GPS location tracking to ensure that only students physically present may mark attendance. This system simplifies attendance for both students and teachers. The users are divided into two groups namely student and staff. The student user can be either students or parents. The staff user can be the staff members, faculty member, principal, dean, etc. of the educational institution [4]. In this way, their time of teachers and efforts would be appreciated as students will be able to check as to whether their marks are uploaded through face recognition. Besides attendance tracking, Presenz is a comprehensive classroom management platform. It allows teachers to upload notes, schedule tests, and send notifications, while students can access study materials and receive real-time updates.

Built using React.js, Tailwind CSS, Node.js, and MongoDB, the system is fast, secure, and scalable. It has cloud-based storage where data can be easily accessed and managed. With attendance automation, classroom efficiency is enhanced, allowing Presenz to ensure an amiable, reliable, fool proof, and intuitive solution to educational institutions.

Technology Used:

React.js (Frontend): It provides a dynamic and interactive user interface which renders the system very responsive and easy to use.

Node.js (Backend): Handling data processing, authentication, and server-side communication to ensure smooth communication between users and the database.

MongoDB (Database): NoSQL database found to be flexible and scalable for storing student records, attendance logs and academic materials in a secure environment.

Tailwind CSS (Styling): Gives clean modern aesthetics through styling for better user experience.

AWS (Cloud Services): Handling hosting, storage and security, making the system available virtually anywhere while being reliable and performant.

Methodology:

Requirement Gathering: Identify the needs of students, teachers, and admins to define critical features, including attendance marking, profile management, and academic uplifts.

System Design: Ensure proper planning of the entire architecture, including front-end design, back-end architecture, database design, integration of technologies, and facial recognition and geolocation.

Development: The system will be built with React.js on the front end, Node.js on the back end, and MongoDB for storing attendance and academic records securely.

Integration: Use advanced features like facial recognition for attendance checking, location- based validations, and real-time updates for students and teachers.

Testing: This will be extensively tested to ensure that all the features are working correctly, including attendance marking, notifications, and security of the data in real conditions.

Deployment: Host the app on AWS because it's scalable, safe, and most reliable, allowing one to access it anytime from anywhere.

Maintenance & Updates: Periodic system updates will address bugs, enhance security, and improve performance for an uninterrupted user experience.

This structured approach will ensure that Presenz works to make life a lot easier for all educational institutions through its efficient features.

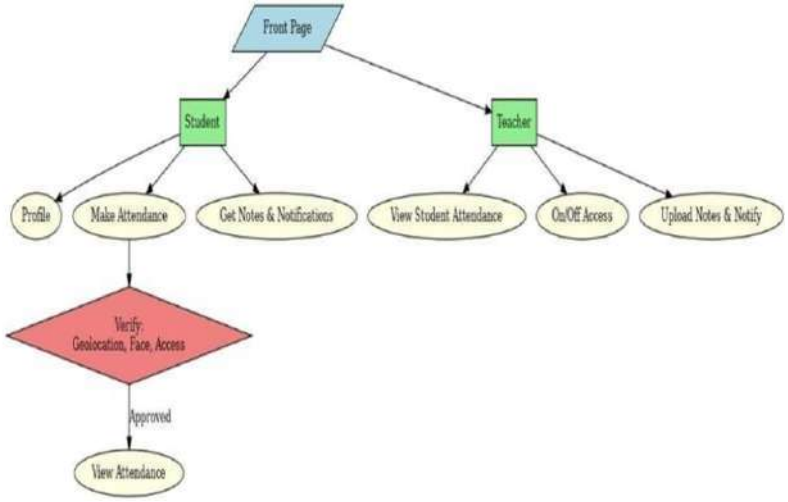


Figure: System Flowchart

Working Principle:

Presenz is an automated attendance system that uses facial recognition and GPS tracking to ensure accuracy and security. It involves student logging in, location verification inside the classroom, recognition through facial recognition, and marking attendance. The teachers can review records live, control attendance access, and upload study materials or notifications. The students can check their attendance, notes, and receive critical updates. All data are hosted on MongoDB and AWS with the utmost security to ensure speeds enable scalability and security. It eliminates manual errors, stops proxy attendance, and makes class management easy.

Advantages:

No Fake Attendance: Face recognition and location tracking make it impossible for students to mark others' attendance.
Saves Time: Takes up less time for teacher, Saves time of attendance taking.
Saves Time for Students: Below the students can mark attendance in just seconds and they can have access to study materials or any updates at any given time.
Updates Everybody: Will have different notifications send to them whereby tests and assignments need to get done.

Saves Time for Teachers: Their task of keeping attendance will not require looking back and forth through books.
Safe & Reliable: Data safety, internal speed and user no delays.
User-Friendly: The application has a simple and modern design which makes it easy for the students and the teachers to follow.

Future Scope:

LMS Integration: Attendance is automatically synchronized with other Learning Management Systems, like Google Classroom, and based on the precision in tracking presence and retrieving student records.
Artificial Intelligence-Driven Insights: Artificial Intelligence analyzes student attendance patterns to accurately predict performance. Teachers are notified about students at risk.
Enhanced Security & Facial Recognition: With deep learning, facial recognition works at a higher accuracy level, while multi-factor authentication secures the attendance system and renders it foolproof.
Geofencing for Automated Attendance: This effectively marks the attendance of students once they enter the designated zones of college simply through geofencing. This saves time from manual specification and eventual errors.

Conclusion:

Presenz is a smart and efficient attendance management system designed to eliminate manual errors, prevent proxy attendance, and simplify record-keeping. By integrating facial recognition, geolocation, and AI-powered analytics, it enhances security, automates attendance tracking, and provides valuable insights into student performance. With seamless LMS integration and mobile accessibility, Presenz ensures a streamlined and reliable solution for modern educational institutions

References:

1. Anshuman Srivastava1, Ashish Gangwar2, Pranshu Srivastava3, Ms. Hashmat Usmani4, Smart Attendance System using Face Recognition and RFID, International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056
2. Alif Fatihi Abdul Fatah2, Roslina Mohamad*1,2, Farah Yasmin Abdul Rahman2, Nur'ain Izzati Shuhaimi1,2, Student Attendance System Using an Android Based Mobile Application, *2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE).*
3. Tiya Katrilia, P.W. Anggoro, P.K. Dewa Sp. Universitas Atma Jaya Yogyakarta, Optimization of Innovation Features In Mobile-Based Attendance Application, 2022, Volume 30, Issue 1, pp. 18-26
4. Dr. D. Asir Antony Gnana Singh1, Dr. E. Jebamalar Leavline2, P. Meera Vijayan3, Mobile Application for Student Attendance and Mark Management System, International Journal of Computational Intelligence Research ISSN 0973-1873 Volume 13, Number 3 (2017), pp. 425-432.

ABSTRACTS
OF
POSTER
PRESENTATION

IMPACT OF AI ON COMMUNICATION SKILLS

Palak Kumari, Annu priya
Guru Gobind Singh Educational Society's Technical Campus,Bokaro Jharkhand-827013
Corresponding author:
Prof.Annu Priya, Assistant Professor, Department of Basic Science & Humanities, GGSESTC, Kandra, Bokaro
e-mail id: annupriya001@gmail.com

Abstract:

Artificial intelligence (AI) has emerged as a crucial concept in the contemporary era of digital communication. As technology advances, the integration of AI has become prevalent across various sectors, particularly in communication. This article investigates the relationship between communication and AI, looking at both the positive and negative aspects of AI's role in this area. Data gathered from semi-structured in-depth interviews with communication experts were analyzed through content analysis. The findings underscore the increasing incorporation of AI in the communication sector. Significant benefits include enhanced speed and efficiency, reduction in costs, and the ability to easily analyze large datasets. On the other hand, various challenges were noted, including concerns about privacy and security, the likelihood of lacking emotional intelligence compared to human interactions, anxieties over potential job loss, and the threat of creating applications that could contradict ethical guidelines. As AI technology continues to progress, efforts will be directed toward mitigating privacy and security issues, ensuring ethical alignment in application development, and enhancing the ability to analyze larger datasets while fostering a more sophisticated emotional intelligence framework.

Design and Simulation of an Automatic Bus Ticket Purchasing System

Sushma Kumari*; Aman Deep; Poonam Kumari
*Corresponding Author
Electronics & Communication, GGSESTC, Bokaro, Jharkhand, India
Email: Sushmakumari.1491@gmail.com

ABSTRACT

This project presents the design and simulation of an automatic bus ticket purchasing system. The proposed system aims to provide a convenient, efficient, and cashless ticketing experience for bus commuters. The system consists of a user-friendly interface, a payment gateway, and a ticketing module. Users can select their destination, choose their preferred seat, and pay for their ticket using a credit/debit card or mobile wallet. The system generates a digital ticket, which can be displayed on the user's mobile device or printed at a self-service kiosk. A simulation model of the system is developed using [simulation software] to evaluate its performance and identify potential bottlenecks. The results show that the proposed system can reduce waiting times, increase transaction efficiency, and enhance overall passenger satisfaction. This project proposes a smart bus ticketing system that integrates RFID technology, GPS tracking, and mobile payments. The system enables passengers to purchase tickets using their smart phones, reducing waiting times and increasing convenience. A simulation model is developed to evaluate the system's performance and optimize its parameters. Intelligent Bus Ticketing System with Real-Time Information. This research presents an intelligent bus ticketing system that provides real-time information to passengers. The system uses IoT sensors and data analytics to track bus locations, estimate arrival times, and optimize routes. A user-friendly mobile app allows passengers to purchase tickets, access real-time information, and receive notifications. It develops an automated bus ticketing system that uses machine learning algorithms to predict passenger demand and optimize ticket pricing. The system integrates with existing payment gateways and provides a seamless ticketing experience for passengers. A simulation model is developed to evaluate the system's performance and identify potential improvements.

Enhancing Bearing Capacity of Silty Sand Foundation Soil with Grouting

Mr.Joydeep Sen*, and Dr. RajendraPrasad Verma,.
*Corresponding Author
Department of Civil Engineering, GGSESTC, Bokaro, Jharkhand, India
Email: Sushmakumari.1491@gmail.com

ABSTRACT
Improving the soil is frequently necessary when building would constructed on unstable terrain to guarantee the stability and safety of nearby structures. Numerous techniques, including vibro-flotation, compaction piles, compaction with explosives, excavation and replacement, well point systems, reinforced earth, and grouting, can be used to enhance the ground in granular soils. Various factors influence the choice of the best technique, including soil conditions, the level of compaction needed, the kind of structures to be supported, the maximum depth of compaction, and site-specific factors like the sensitivity of nearby structures or installations, the amount of time available to finish the project, the contractor's skill, and the availability of tools and materials. Many foundation issues can be effectively resolved by soil compaction, which is particularly helpful in lowering overall sand settling. Because of the poor technical qualities and associated issues caused by unstable soil at shallow depths, construction activities in coastal locations frequently call for deep foundations.Shear failure and excessive settlements are caused by the foundation bed's extremely poor bearing capacity. Additionally, the depth of the foundation is restricted in these places due to the high water table and shallow top sandy layer, which further lowers the safe bearing capacity.This study examines grouting as a potential remedy for coastal areas' foundation issues by enhancing the characteristics of the soil at shallow depths.

Nuclear Propulsion Rocket: The Future of Space Travel

Prateek Kumar[1], Satyam Kumar Goswami[1], Manojit De[2]
[1]Department of Computer Science, Guru Gobind Singh Educational Society's Technical Campus, Kandra, Bokaro, Jharkhand
[2]Department of Physics (BSH), Guru Gobind Singh Educational Society's Technical Campus, Kandra, Bokaro, Jharkhand
Email of the corresponding author: (Manojit De) manojit.de@ggsestc.ac.in

Abstract:

Nuclear propulsion is considered a revolutionary advancement in space exploration technology. Unlike traditional chemical propulsion systems, which rely on the expulsion of gases to generate thrust, nuclear propulsion utilizes nuclear energy to propel spacecraft. The key benefit of nuclear propulsion is its potential to provide much higher efficiencies and thrusts over longer periods, making it an ideal candidate for deep space exploration. This paper discusses the concept, history, technologies, benefits, challenges, and future prospects of nuclear propulsion rockets, highlighting their potential role in the future of space travel.

Ride Connect: A Smart Platform for Local Transportation

Mr. Pankaj Kumar, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus
Mrs. Nivedita Gorain, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus
Mr. Animesh Mishra, Assistant Professor, Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus
* Corresponding Author: animeshmishra17@gmail.com

Abstract

Transportation in urban and semi-urban areas relies heavily on local vehicles like auto-rickshaws, yet the sector lacks an organized system to efficiently connect passengers with available drivers. This project, Ride Connect, aims to develop a smart ride-hailing platform that enhances accessibility, reliability, and efficiency in local transportation. The platform enables real-time booking, live location tracking, transparent fare estimation, and multiple payment options. It incorporates safety features such as driver verification and emergency contact functionality. Built using Flutter for mobile development, Node.js or Django for backend operations, Firebase or PostgreSQL for database management and Google Maps API for navigation and route optimization, the system ensures a seamless commuting experience. The expected outcomes include improved earnings for drivers, enhanced passenger safety, and greater transparency in ride transactions. Future enhancements involve integration with electric vehicles, subscription-based models, and expansion to other transport modes like taxis and bikes, making Ride Connect a scalable and sustainable solution for modern transportation needs.

EFFICACY OF REMOTE WORK POLICIES ON EMPLOYEE PRODUCTIVITY

Kritika Chaudhary*, Apurba Sinha, Sneha Ratan, Harshita Singh
*Assistant professor, Department of Business Administration, GGSESTC, Kandra Chas, Bokaro, Jharkhand
#Assistant professor, Department of CSE, GGSESTC, Kandra Chas, Bokaro, Jharkhand
Student, Department of Business Administration, GGSESTC, Kandra Chas, Bokaro, Jharkhand
*Corresponding Author: Kritika.chaudhary@ggsestc.ac.in

Abstract

The Global shift towards remote work accelerated by the COVID-19 Pandemic has led many organizations to implement remote work. The purpose of this study is to find out the derivatives from the benefits and challenges of remote work on employee productivity. ThisPaper examines the effectiveness of existing study of remote work policies on productivity through empirical studies and surveys by various researchers. The research aims to provide insights into how businesses can optimize their remote work policies to maximize productivity maintain organizational success and enhance employee well-being. The study investigates positive and negative impact of remote work policies on productivity, analyzing factors such as work environment, communication tools, work life balance, employee autonomy, benefits and challenges of remote work for employee productivity by analyzing benefits and challenges faced by GGSESTC faculties while running college during COVID-19. The findings suggest that how to implement work policies in an effective manner and also when those remote work policies when implemented with flexibility can lead to higher productivity and improved work life balance.

EEG: Brain Wave Monitoring System using Arduino

Muskan, Preeti Kumari, *Salim Ahmad, Akash Arya
*Corresponding Author
ECE Department, GGSESTC, Bokaro, Jharkhand
Email: salim.ahmad2008@gmail.com

Abstract

This paper aims to develop a real-time seizure and epilepsy monitoring system utilizing EEG technology. The system will employ a wearable EEG device to continuously monitor brain activity, capturing electrical signals from the scalp. Advanced signal processing techniques will be implemented to filter noise, extract relevant features, and identify seizure patterns. Machine learning algorithms will be trained on a large dataset of EEG recordings to accurately detect seizures and predict their onset. The system will provide real-time alerts to patients or caregivers, enabling timely intervention and potentially reducing the impact of seizures. We will address challenges such as ensuring reliable signal quality, developing robust and accurate detection algorithms, and ensuring user comfort and acceptance. This research has the potential to significantly improve the quality of life for individuals with epilepsy by providing continuous, personalized seizure monitoring and enabling proactive management strategies.

GENERATING ELECTRICITY FROM SOLID WASTE

ZaidAkram[1,]Jawed Ali[2], Jagamohan Moharana[3]
[1]Student, Department, EEE, GGSESTC, Bokaro, Jharkhand/India
[2,3]Assistant Professor, Department, EEE, GGSESTC, Bokaro, Jharkhand/India
*Corresponding author e-mail: jawedali2008@gmail.com

Abstract

Generally day by day the generation of solid waste is increasing every day in everywhere. The landfill sites are increasing. The generation of solid waste is increasing along with the increasing of the population. The pollution also increasing along with the increasing of solid waste generation. In order to control the generation of solid waste and to reduce the pollution we are making this project in which we have been making this for the purpose of the control of solid waste generation and to reduce the pollution by generating electricity by heating process. We have been collected the solid waste and separated the solid waste by manually under the categories of size, shape, dry, wet, etc. we avoided glass, petroleum products which affects the heating process. While heating the solid waste the heating sensors, heating panels takes observes that and converts heat energy into electrical energy and storing energy for the purpose of charging the battery which used for the supply that energy for further purpose. The capacitors used to store that energy and with the help of resistors it resists the flow of the current

POWER QUALITY IMPROVEMENT BY USING MULTILEVEL INVERTER

Jayanti* , Uttam Kumar and Das Sourav Rai,
*Corresponding Author: Assistant professor, Department of Electrical and Electronics Engineering, GGSESTC, Kandra, Bokaro,
Email: jayantikushwaha.767@gmail.com

Abstract

The continuous increase in the penetration of Renewable Energy (RE) based Distributed Generations (DGs) in the power system network has created a great concern on the stability of the existing grid. Converter based RE has some special characteristics, such as stochastic real and reactive power output, quick active and reactive power response, small output impedance, and provide virtual inertia and damping to power system that controls the fluctuation of voltage and frequency and reduce total harmonic distortion. There is PV system, boost converter and inverter are interconnected with proper control strategy needed. First the photovoltaic system is to be designed and simulated using MATLAB SIMULATION. A maximum- power-point-tracking method is to be employed in the PV system to obtain a high performance. The output voltage of a PV array is comparatively low thus high voltage gain is necessary for grid-connection and synchronization. The output of PV system will be provided to boost converter which will boost the low voltage of the PV array to high dc- voltage. A steady state model is to be obtained and will be verified with the help of simulation. To convert the high dc-voltage to acvoltage, further we will connect a rectifier in the sequence of boost converter. For rectification a multilevel inverter is to be used. After that the output of the multilevel inverter is fed to a micro grid or desired load, to overcome the problem of polluted sinusoidal output in classical inverter. By increasing number of voltage level and modulating voltage pulse and height, we can get more accurate sinusoidal waveform and the total harmonic distortion will be reduced and hence the power quality will be improved. The whole system is to be designed and simulated.

Design and Implementation of a Portable Electric Tiller and Cutting Machine: A Sustainable Alternative for Small-Scale Agriculture

Aditya Kumar Ayush Singh Vishal Kumar Kumar Ashish*
Assistant Professor, Department of Mechanical Engineering, GGSESTC, Bokaro
*Corresponding author e-mail: ashish2k07@gmail.com

Abstract

This research presents the design and fabrication of a portable electric tiller and cutting machine as an eco-friendly and cost-effective alternative to conventional agricultural equipment. Traditional farming methods are labor-intensive and time-consuming, while modern tractors are often unaffordable for small-scale farmers and contribute to environmental pollution through fossil fuel consumption. The proposed battery-powered tiller system serves dual purposes: soil tilling and crop/grass cutting. Performance testing indicates that the machine can operate continuously for 2-3 hours on a single charge. With a production cost of approximately Rs. 10,000, this machine offers an affordable solution for rural and small-scale farmers. The study concludes that this portable electric tiller represents a significant step toward sustainable agricultural mechanization that is environmentally friendly, economically viable, and adaptable to the needs of small-scale farming operations. Keywords: Sustainable agriculture, electric power tiller, battery-powered machinery, agricultural mechanization, eco-friendly farming

vedanta
transforming for good

ESL STEEL LIMITED

झारखण्ड प्रौद्योगिकी विश्वविद्यालय
JHARKHAND UNIVERSITY OF TECHNOLOGY

Jharkhand, Ranchi