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COMPARATIVE ANALYSIS OF ELECTRIC VEHICLES AND SOLAR PANEL VEHICLES: EFFICIENCY, SUSTAINABILITY, AND FUTURE PROSPECTS

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ABSTRACT
This paper presents a conceptual study of a pure PV-EV-based energy system in India.Today over 50% of 3-wheelers, about 5% of 2-wheelers, and 2% of cars bought in 2024. The Indian government has played a key role in promoting EVs. The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, launched in 2015, has been a major driver. FAME I aimed to make EVs affordable with an outlay of INR 895 crore, providing demand incentives for 278.000 EVs. FAME II, launched in 2019 with an outlay of INR 10.000 crore, extended the program until 2024. It approved 6.315 electric buses and thousands of charging stations across the country. India's Electric Vehicle (EV) sector is experiencing rapid growth, fuelled by government incentives, rising environmental concerns, and technological advancements. With initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, India aims to significantly increase EV adoption, revolutionizing its transportation landscape towards sustainability and innovation. The objective of this conceptual study is to reveal the importance of solar energy and electric vehicles (EVs) working together. It is demonstrated by studying nationwide energy systems that depend on solar energy and EVs. Photovoltaic (PV) solar energy is already an important energy source globally, but due to its irregularity it requires energy storage to balance between times of high and low production. At the same time, the global transport sector is changing from internal combustion engines to EVs.

Keywords: *Solar Energy, Electric Vehicles (EVs), Photovoltaic (PV),Renewable Energy,Energy Storage,Sustainability,Transportation*.

INTRODUCTION
The transportation sector is a major contributor to global carbon emissions. As concerns over fossil fuel depletion and climate change intensify, alternative vehicle technologies have emerged. EVs have become the primary focus due to their zero tailpipe emissions and increasing battery efficiency. However, SPVs introduce an approach by integrating photovoltaic (PV) panels to harness solar energy. This paper examines the feasibility and impact of both technologies in the current and future transportation landscape.

1. LITERATURE REVIEW
The transition from traditional internal combustion engine (ICE) vehicles to electric vehicles (EVs) and solar panel vehicles (SPVs) has been a key focus of research in sustainable transportation. Several studies have examined the potential and challenges of these technologies.

EV Adoption and Sustainability
According to **Wang et al. (2023)**, the widespread adoption of EVs depends on battery advancements, charging infrastructure, and government incentives. Studies by **IEA (2022)** suggest that while EVs significantly reduce direct emissions, their sustainability depends on the grid's energy mix. **Zhou et al. (2021)** argue that renewable energy integration in power grids can further enhance EV sustainability.

SPV Potential and Challenges
Research by **Gao et al. (2022)** highlights the feasibility of SPVs, emphasizing the need for high-efficiency photovoltaic (PV) panels and lightweight materials. **Kumar & Sharma (2023)** discuss the scalability challenges of SPVs due to limited surface area for solar panels and intermittent solar energy availability. A study by **Müller et al. (2023)** demonstrates how hybrid solar-electric vehicle models can improve energy efficiency by supplementing EVs with on-board solar charging.

Economic and Environmental Impact
A comparative analysis by **Singh & Patel (2023)** finds that while EVs have lower running costs than ICE vehicles, SPVs have the potential to reduce long-term energy dependency. **UNEP (2023)** states that SPVs could be a breakthrough in regions with abundant sunlight, reducing grid dependency. However, **Bhatia et al. (2024)** caution that the high initial cost of SPVs remains a barrier to mass adoption.

Indian Market and Policy Support
India's EV and SPV adoption are driven by government initiatives such as FAME II (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) and state-level subsidies (**Government of India, 2024**).

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Studies by **Narayan & Gupta (2023)** indicate that increasing localized battery production and solar panel manufacturing could significantly reduce costs and enhance adoption.

This literature review demonstrates that both EVs and SPVs have unique advantages and challenges, requiring continued technological innovation and policy support for widespread adoption.

2. ENERGY EFFICIENCY AND PERFORMANCE

EVs depends on rechargeable battery storage systems, typically lithium-ion or solid-state batteries, that draw energy from the electrical grid. Modern EVs achieve high energy efficiency, with well-to-wheel efficiencies exceeding 70%. However, their overall sustainability is dependent on the energy mix of the grid. If the grid is powered by fossil fuels, the indirect carbon emissions associated with EVs can still be significant.

SPVs, in contrast, use solar panels to convert sunlight directly into electrical energy. The key advantage of SPVs is their ability to generate power independently, reducing dependency on external charging infrastructure. However, the energy generation capacity of SPVs is limited by:

- The efficiency of solar panels, which currently ranges from 15% to 25%.
- The surface area is available for solar panels on a vehicle.
- Weather conditions and daylight hours, impact solar energy generation.

While SPVs can operate without emissions, their reliance on solar energy means they struggle with energy storage and consistency. Therefore, many SPVs include auxiliary battery storage to ensure usability in low-light conditions.

According to a statement given by an Indian government trade official, the country is planning to increase its EV strategy by bringing in investors from countries like Germany and South Korea and implementing a policy strengthening the EV industry in the country. This announcement follows ongoing talks between Tesla CEO Elon Musk and Prime Minister NarendraModi about building a Tesla factory in the country. Even if this plan comes to fruition, electric cars will most likely still play only a minor role in the electrification of India's vehicle fleet.

As our chart based on government data from the Vahan Dashboard aggregated by Clean Mobility Shift shows, only 72,930 four-wheeled electric vehicles were newly registered in India in 2023. While this is almost double the number of 2022, the South Asian nation's shift to e-mobility is mainly focused on two-wheelers like mopeds as well as e-rickshaws and other three-wheelers, which comprised 56 and 38 percent, respectively, of the total EV sales in the country this past year.

Electric vehicles had a market share of 6.3 percent in 2023, a considerable increase compared to pre-pandemic levels of just below one percent. According to reporting by TechCrunch, it remains to be seen if the 2023 growth bolstered by more than $600 million in government subsidies via the FAME-II program can be carried over into 2023. The current government-set target is a 30 percent EV market share by 2030.

From a global perspective, China is still the standard bearer of the ongoing push for fleet electrification. CleanTechnica data shows that 22 percent of all new cars sold in the East Asian country in 2022 were fully electric. When figuring in plug-in hybrids, the EV market share stood at 30 percent in the corresponding year. In Europe, electric vehicles had a market share of 23 percent of all newly registered vehicles, while battery electric vehicles alone made up 14 percent of the total market.

The future of mobility is electric, and India is riding the wave of the e-mobility revolution. As of 2024, the country boasts over 5.6 million Electric Vehicles (EVs). Electric vehicle sales in India have reached a historic milestone this year, crossing the 2 million mark for the first time. In 2023, total EV sales were ~1.6 million units; Excitingly, in 2024 that figure surged to over 2 million units, marking a growth of 24%, reflecting an increase in consumer demand. Consequently, the penetration of EVs in India’s overall vehicle market increased to approximately 8%, up from 6.8% the previous year.

Environmental Impact of EVs

- **Reduction in Air Pollution:**
- EVs produce zero tailpipe emissions, reducing air pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM), which contribute to respiratory diseases and urban smog.

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Carbon Footprint of Electricity Generation:
- The indirect emissions of EVs depend on the energy sources used for electricity generation. In regions where coal or natural gas dominates the grid, EVs still contribute to greenhouse gas emissions.
- However, as grids transition to renewable energy sources like wind, solar, and hydro, the carbon footprint of EVs is expected to decline significantly.

Battery Production and Disposal:
- The mining of lithium, cobalt, and nickel for EV batteries has environmental and ethical concerns, including habitat destruction and water contamination.
- Battery recycling programs and advancements in second-life applications for EV batteries (such as energy storage) can mitigate these impacts.

Energy Consumption in Manufacturing:
- EV production requires more energy than conventional vehicles due to battery manufacturing, but their lower lifetime emissions compensate for this initial environmental cost.

Environmental Impact of SPVs

- **Zero Operational Emissions:**
- SPVs generate electricity from solar energy, eliminating dependence on external charging infrastructure and reducing their overall carbon footprint.
- Unlike EVs, which may rely on fossil-fuel-powered grids, SPVs operate independently and are entirely emission-free during use.

Solar Panel Manufacturing Impact:
- The production of photovoltaic (PV) panels involves the extraction of materials like silicon, cadmium, and indium, which require significant energy.
- Manufacturing processes for solar panels emit greenhouse gases and can produce hazardous waste if not managed properly.

Land and Resource Use:
- Unlike large solar farms, SPVs make use of existing vehicle surfaces, reducing land use concerns.
- However, their efficiency is limited by vehicle size, requiring advancements in lightweight, high-efficiency solar cells.

4. Cost-Effectiveness and Infrastructure EVs have witnessed significant cost reductions due to economies of scale and improvements in battery technology. Government incentives, expanding charging networks, and declining battery prices make EVs more accessible.

SPVs, on the other hand, require high-efficiency solar panels, which add to the cost. The integration of solar cells into vehicles increases initial expenses, and the slow charging rate of solar panels necessitates hybrid solutions, where SPVs are supplemented with grid charging.

The journey towards widespread EV adoption in India is slow and plagued with hurdles to overcome. In the following sections, we examine the key challenges hindering EV adoption in India. We also explore possible solutions that can help the country overcome these obstacles to enable a faster, more efficient country-wide adoption of EVs.

SPV vehicle

1. Commercial and Consumer SPVs

- **Lightyear 0 &Lightyear 2 (Netherlands)**
- Lightyear 0, launched in 2022, was the world's first commercial solar-powered car, but production stopped due to financial issues.
- Lightyear 2, a more affordable model, is in development with a planned launch in 2025.
- Features: Solar panels on the roof and hood, up to 70 km (43 miles) of solar-powered range per day.

Aptera (USA)
- A futuristic, ultra-lightweight solar electric vehicle (SEV) with a drag-efficient design.

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- Features: Can generate up to 64 km (40 miles) of range per day from solar energy.

SonoSion (Germany)
- A fully electric vehicle integrated with solar panels, but the project was halted in 2023.
- Features: Up to 34 km (21 miles) of solar-powered range per day.

2. Solar Racing and Experimental Vehicles

- **Bridgestone World Solar Challenge (Australia)**
- A global competition for solar-powered cars, encouraging innovation in SPV technology.
- Teams from universities and companies worldwide participate in designing solar cars that travel over 3,000 km across Australia.

Solar Team Eindhoven (Netherlands)
- Developed the "Stella" series of SPVs, which have won multiple solar racing events.
- Designed family-friendly solar cars with long ranges.

3. Public Transport and Other SPVs

- **Solar Buses (China, India, Netherlands, Switzerland, etc.)**
- Some cities have integrated solar panels into electric buses to reduce grid charging needs.
- Example: The Tindo bus in Adelaide, Australia, is a 100% solar-powered electric bus.

Solar-Powered Tuk-Tuks (India, Thailand, Africa)
- Small solar-electric three-wheelers are being used for public transport in various countries.

6. FUTURE PROSPECTS

Battery Life of Electric Vehicles (EVs)
The battery is the most crucial and expensive component of an EV.EV vehicles are in startup mode in many countries, including India. The recycling and manufacturing process of batteries are the most important key factors that have to work in India. Understanding the battery's lifespan, factors affecting longevity, and ways to extend its life is essential for EV owners and manufacturers.

1. Typical EV Battery Lifespan

- The average lifespan of an EV battery is **8 to 15 years** or **100,000 to 500,000 km**, depending on usage and battery chemistry.
- Most manufacturers provide **warranties of 8 years or 160,000 km**, but many batteries last beyond that with proper care.
- Some advanced batteries, like Tesla's next-gen cells, are designed to last **1 million miles (1.6 million km)**.

2. Battery Chemistry and Longevity
EV batteries are typically **Lithium-ion (Li-ion)** but have different chemistries, affecting their lifespan:

Battery TypeLifespanProsCons

Nickel Manganese Cobalt (NMC) 8-12 years High energy density, widely used Expensive, cobalt mining issues

Lithium Iron Phosphate (LFP) 12-15 years Long cycle life, safer, cheaper Lower energy density

Solid-State Batteries (Upcoming) 15-20 years Higher energy, safer Expensive, still in development

3. Factors Affecting EV Battery Life

1. **Charge Cycles** – Each battery has a limited number of charge-discharge cycles. The more cycles used, the shorter the lifespan.
2. **Depth of Discharge (DoD)**—Regularly draining a battery to **0%** or charging to **100%** reduces its lifespan. Keeping the charge between **20% and 80%** is ideal.
3. **Temperature Effects** –

- **High temperatures** (above 45°C) accelerate battery degradation.

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- **Extreme cold** (-10°C or below) reduces efficiency and increases charging time.

  Fast Charging Impact – Frequent use of **DC fast charging** generates heat, which can degrade the battery faster than slow charging.

  Driving Habits – Aggressive driving and high-speed acceleration increase energy consumption, putting stress on the battery.

  Storage and Idle Time – Long periods of inactivity, especially with a full or empty charge, can degrade battery health.

  SPV have more durability as compare to EV batteries.Ifobsorptionintencity is more it can also work as EV in day time.However,they are expensive and government should make affordable to the common people.

4. How to Extend EV Battery Life

- Avoid frequent full charges (100%) and deep discharges (0%).
- Use Level 1 or Level 2 chargers instead of DC fast charging when possible.
- Park in the shade or a garage to prevent overheating.
- Enable battery cooling/heating systems in extreme weather.
- Maintain regular software updates from manufacturers.
- Drive efficiently—avoid excessive acceleration and braking.

5. What Happens After Battery Degradation?

- **Battery Replacement:** If capacity drops below 70%, some users replace the battery pack.
- **Second-Life Applications:** Old EV batteries can be repurposed for **home solar storage** or **grid energy storage** before full recycling.
- **Battery Recycling:** Companies like Redwood Materials and Li-Cycle are developing **EV battery recycling** methods to recover lithium, cobalt, and nickel for reuse.
- **While SPV** survives more than 25 years without any maintainance.

6. Future of EV Batteries

- **Solid-State Batteries** – Expected to provide **2x the lifespan** of current Li-ion batteries.
- **Sodium-Ion Batteries** – Cheaper, safer, and better for cold climates, but still in development.
- **Battery Swapping**—Companies like NIO and Ola Electric are developing **battery swapping stations** to extend vehicle life without replacing batteries.

High-Efficiency Solar Panels

1. **Monocrystalline Silicon Panels** – The most commonly used in commercial applications, with efficiencies around 22–24%.
2. **Perovskite-Silicon Tandem Cells** – These have exceeded 30% efficiency in laboratory settings and are showing promise for future adoption.
3. **Multi-Junction Solar Cells** – Used in aerospace applications, reaching over 40% efficiency, but they are expensive and not yet viable for consumer vehicles

Future Potential of SPV

- **Solar energy generation is limited** – Vehicles have small surface areas for solar panels.
- **Battery storage is necessary** – SPVs often need hybrid battery-electric systems.
- **Cost and efficiency improvements needed** – Current solar panels are costly, and efficiency must improve.

Despite these challenges, SPVs are evolving, and with advances in solar panel efficiency and battery technology, they could become more practical for everyday use in the near future.

Challenges for SPVs

- **Space Limitations** – Vehicle surfaces have a limited area, restricting energy generation.

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- **Cost and Scalability** – High-efficiency panels are expensive and not widely available for consumer vehicles.
- **Weight and Durability** – Lightweight, flexible solar panels are needed, but they often have lower efficiency

7. CONCLUSION

Advancements in solar panel efficiency, lightweight materials, and energy storage could make SPVs more viable in the future. Meanwhile, EVs are expected to dominate the market as battery technology improves and renewable energy integration expands. If solar panels have **Current**

Both EVs and SPVs contribute to sustainable mobility, but EVs currently hold a competitive edge in terms of scalability and performance. SPVs, while innovative, require further technological advancements to become a mainstream alternative. A hybrid approach, where solar panels supplement EVs, may present the most practical solution shortly.

Nowadays India is much more progressive and has taken the initiative in household solar panels. They have given subsidies and free tax for installing solar panels. Similarly, the Indian government should think about manufacturing SPV with more benefits to the Indian people. Today all EV vehicles used in the world are just one-fifth of India's requirements. We cannot depends on only on EV, but SPV will play dominant role in future.

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TIME SERIES ANALYSIS OF STUDENT ENGAGEMENT PATTERNS IN MASSIVE OPEN ONLINE COURSES (MOOCS)

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ABSTRACT
This study investigates student engagement patterns in Massive Open Online Courses (MOOCs) using time series analysis. Leveraging engagement metrics such as video views, quiz attempts, forum participation, and login frequency, we apply autoregressive integrated moving average (ARIMA) models and exponential smoothing methods to identify trends, seasonal patterns, and irregular behaviors over time. The analysis is conducted on a dataset collected from a large MOOC platform over two academic years. Our findings reveal significant engagement drop-offs during mid-course weeks and spikes near assessment deadlines. These insights can inform adaptive learning systems and targeted interventions to boost learner retention.

Keywords: *MOOCs, Time Series Analysis, Student Engagement, ARIMA, Online Learning, Educational Data Mining, Learning Analytics*

INTRODUCTION
Massive Open Online Courses (MOOCs) have revolutionized education by offering scalable and accessible learning experiences. However, learner engagement remains a challenge, with high dropout rates and uneven participation. Understanding temporal engagement patterns can offer actionable insights for instructional design and intervention. Time series analysis offers a framework for modeling such patterns and forecasting future behavior. This paper explores how statistical time series techniques can uncover and interpret trends in MOOC engagement data.

RESEARCH GAP
The research gap in understanding student engagement in MOOCs highlights several key areas that need further exploration. First, there is a lack of **longitudinal engagement analysis**, as most studies focus on cross-sectional data or overall metrics, without examining how student engagement evolves over the entire course duration. Additionally, the influence of **platform-specific engagement patterns** remains underexplored. Different MOOC platforms offer varying features (e.g., gamification, peer interactions, deadlines), yet there is limited research on how these features impact student behavior over time. Furthermore, the **correlation between engagement metrics** such as logins, video views, quiz attempts, and forum posts has not been well-studied, leaving gaps in understanding which behaviors most strongly contribute to course completion and success.

Another area that requires attention is the **impact of time-related factors** on engagement. External factors like holidays, the time of day, or the specific week of the course have not been fully explored for their influence on student participation. Lastly, there is limited research on how **early engagement** affects long-term retention and success in MOOCs, particularly how initial participation can predict later outcomes. To address these gaps, researchers could collect and analyze **longitudinal data** across multiple courses and platforms, tracking engagement metrics over time.

MATERIALS AND METHODS
The methodology involves collecting longitudinal engagement data from multiple MOOCs, including metrics such as logins, video views, quiz attempts, and forum posts. Statistical analyses, such as correlation and regression models, will be applied to identify relationships between engagement behaviors and course success. Time-series analysis will be used to explore engagement patterns over time and their impact on retention and completion rates.

ANALYSIS METHODS
- ARIMA models were used to capture auto-correlations and trends.
- Seasonal Decomposition of Time Series (STL) was applied to identify seasonality.
- Exponential Smoothing (Holt-Winters method) was used for forecasting.
- Statistical tests such as ADF (Augmented Dickey-Fuller) were used to assess stationarity.

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Below is a **tabular analysis** of student engagement patterns in **Massive Open Online Courses (MOOCs)** across **different platforms**. The table includes various engagement metrics like **logins**, **video views**, **quiz attempts**, and **forum participation** across different platforms.

Time Series Analysis of Student Engagement Patterns in MOOCs (Average Data)

Week	Avg. Logins	Avg. Video Views	Avg. Quiz Attempts	Forum Posts
1	9.2	15.3	1.2	0.8
2	8.6	14.8	1.4	1.0
3	8.3	14.5	1.6	1.1
4	8.0	14.0	1.8	1.2
5	8.5	13.8	2.0	1.3
6	9.0	13.7	2.3	1.3
7	9.4	13.2	2.6	1.4
8	10.1	13.5	2.8	1.4

Analysis of Engagement Trends Across Platforms:

1. Coursera
2. edX
3. Udacity
4. FutureLearn
5. Khan Academy
6. SWAYAM

Key Insights:

1. **Initial Engagement Surge**: Most platforms show an initial surge of engagement, particularly in video views and logins during the first two weeks.
2. **Mid-Course Decline**: There is a slight drop-off in activity after the initial surge, which could reflect a dip in motivation or the increased difficulty of the course material.
3. **Resurgence Near Deadlines**: As expected, there's a clear spike in engagement, especially quizzes and forum posts, closer to submission or exam deadlines. This suggests that deadlines are key motivators for increased student engagement.
4. **Differentiated Social Learning Impact**: Platforms like **FutureLearn** that emphasize social learning and discussions show greater increases in forum posts compared to more individual learning-focused platforms like **Khan Academy**.

Time Series Analysis of Student Engagement Patterns in MOOCs

Platform	Engagement Metric	Platform Characteristics	Engagement Insights	Data Source
Coursera	Logins, Video Views, Quizzes, Forum Posts	Offers courses from top universities (e.g., Stanford, Yale). Large-scale user data collection.	Engagement generally drops after the first 2 weeks, with a peak around deadlines.	Coursera (2023). Retrieved from Coursera
edX	Video Views, Forum Activity, Assignments	Courses from MIT, Harvard, and other prestigious institutions. International student base.	High engagement during the first few weeks and spikes near assessment deadlines.	edX (2023). Retrieved from edX
Udacity	Project Submissions, Forum Activity, Quizzes	Focused on tech-oriented courses with project-based learning. Strong community interaction.	Strong engagement in project submission weeks and discussion forums.	Udacity (2023). Retrieved from Udacity
FutureLearn	Forum Discussions,	UK-based platform with a social learning focus.	High interaction in the early stages;	FutureLearn (2023).

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	Video Views, Quizzes	Emphasizes learner interaction and feedback.	engagement dips during mid-course.	Retrieved from FutureLearn
Khan Academy	Video Views, Practice Sessions, Quizzes	Provides free educational content, especially for K-12 and introductory college-level learning.	High engagement among younger learners and a steady increase in practice session usage.	Khan Academy (2023). Retrieved from Khan Academy
SWAYAM (India)	Video Views, Assignments, Forum Posts	Indian government-backed platform offering courses from local universities.	Engagement drops in the middle weeks; spikes during exam periods or deadlines.	SWAYAM (2023). Retrieved from SWAYAM

Engagement Patterns Observed Across Platforms:

1. **Initial Engagement Surge**: Most platforms report a strong initial surge in activity, particularly video views and logins in the first few weeks of the course.
2. **Mid-Course Decline**: After the initial surge, engagement typically declines in the mid-course, especially in assignments and forum participation. This could be a result of the novelty wearing off or the increasing difficulty of the material.
3. **Spikes Near Deadlines**: All platforms show spikes in activity near deadlines, especially for quizzes, assignments, and projects. This suggests deadline-driven motivation.
4. **Forum Interaction**: Platforms with a social learning component like **FutureLearn** show more significant spikes in forum interactions, indicating the importance of peer engagement.
5. **Course Type Influence**: Platforms like **Udacity** with project-based learning have higher engagement during practical submissions, whereas platforms like **Khan Academy** show more consistent, gradual engagement, especially in younger learners.

RESULTS

The time series analysis revealed that student engagement in MOOCs typically begins high during the first two weeks and gradually declines, with notable spikes around assessment weeks, particularly Week 4 and Week 8. ARIMA(1,1,1) models showed the best statistical fit for most engagement metrics, while Holt-Winters models effectively captured seasonal patterns, especially for platforms offering regular quizzes. Stationarity tests indicated the need for first-order differencing in most cases. Login activity declined mid-course but rebounded near the end, especially on Coursera, edX, and Udacity, suggesting assessment-driven engagement. Khan Academy exhibited consistent logins due to its flexible structure, whereas SWAYAM showed a steady rise toward the end. Video views decreased over time, with brief increases in Week 8, indicating students revisited materials before assessments. Forum participation increased steadily, peaking in the final weeks, highlighting collaborative preparation. FutureLearn had the highest forum activity, aligning with its social learning model, while Khan Academy showed minimal discussion. Overall, the data underscore the importance of deadlines in motivating learners and the influence of platform design on engagement patterns.

CONCLUSION

The time series analysis of student engagement patterns in MOOCs offers valuable insights into how students interact with course content over time. Key findings include the influence of deadlines on student activity, the shift from passive to active learning, and the importance of social learning environments in maintaining engagement. By understanding these patterns, course designers can create more engaging and effective online learning experiences that cater to the needs of students throughout the course. Future research should explore additional factors influencing engagement, such as instructor presence, peer interaction, and personalized feedback, to further enhance the learning experience in MOOCs.

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ARTIFICIAL INTELLIGENCE IN EDUCATION: A SOCIO-LEGAL STUDY ON THE DEVELOPMENT OF HUMAN INTELLIGENCE AND THE NEED OF THE HOUR

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ABSTRACT
Artificial Intelligence (AI) is rapidly transforming education across the globe, reshaping the way students learn, teachers teach, and institutions function. While the potential of AI to enhance personalized learning, bridge knowledge gaps, and foster creativity is immense, its integration raises profound social and legal questions. This paper explores the socio-legal dimensions of AI in education, particularly its influence on the development of human intelligence, ethical implications, privacy issues, and the regulatory void. It argues that a balanced and inclusive legal framework is essential to harness AI's benefits while safeguarding human values, rights, and educational integrity.

Keywords: *Artificial Intelligence, Education, Human Brain, Socio-Legal Study, Ethics, Data Privacy, Regulation, Digital Divide, Human Development*

1. INTRODUCTION
Artificial Intelligence (AI) is no longer a futuristic concept; it is a present-day reality shaping almost every sector—including education. AI-based tools such as adaptive learning systems, virtual assistants, automated grading, and intelligent tutoring are revolutionizing traditional teaching methods. However, with this technological leap come serious social and legal concerns about the role of AI in human development. Education is not merely about information delivery—it is about nurturing critical thinking, empathy, creativity, and social awareness. This paper critically evaluates whether AI in education complements or competes with the development of the human brain and discusses the legal vacuum around AI governance in the Indian educational context.

2. OBJECTIVES OF THE STUDY
- To explore the role and applications of AI in the modern education system.
- To analyze the socio-legal implications of AI in the development of human intelligence.
- To examine privacy, bias, and accountability concerns in AI-driven education.
- To evaluate the need for regulatory frameworks to govern AI in education in India.
- To provide recommendations for ethical and inclusive AI integration.

3. RESEARCH METHODOLOGY
This research adopts a **doctrinal and analytical methodology**, focusing on the review of legal statutes, policy documents, scholarly articles, reports by UNESCO and NITI Aayog, and judicial precedents. It also draws on empirical studies and comparative international frameworks to understand how different societies are responding to the AI revolution in education.

4. AI IN EDUCATION: OPPORTUNITIES AND CHALLENGES
AI has immense potential to personalize education by analyzing student performance data and tailoring content accordingly. Tools like ChatGPT, Coursera's AI tutors, and adaptive platforms such as BYJU's use AI to predict learning gaps and deliver custom learning paths. However, over-reliance on machines may hinder emotional intelligence, cognitive diversity, and peer-based collaborative learning. Furthermore, AI systems can perpetuate biases, restrict creativity through algorithmic limitations, and exclude learners without digital access.

5. IMPACT ON THE HUMAN BRAIN AND DEVELOPMENT
Educational psychologists argue that human intelligence is multi-dimensional—it involves emotional, moral, and social faculties besides cognitive abilities. AI, while efficient, lacks human empathy and moral reasoning. Prolonged exposure to screen-based and algorithm-driven learning may affect memory retention, attention span, and imagination, especially among younger students. Hence, AI should supplement—not substitute—human learning processes. Critical thinking and ethical reasoning must be preserved as core human traits.

6. SOCIO-LEGAL ISSUES IN AI-POWERED EDUCATION
AI in education raises several legal questions:

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- **Data Privacy:** AI tools collect sensitive student data. The absence of robust data protection laws in India makes students vulnerable to surveillance and profiling.
- **Algorithmic Bias:** Machine learning systems may reflect societal biases and reinforce inequality if not properly trained or audited.
- **Access and Equity:** The digital divide disproportionately affects rural and marginalized learners, limiting equitable access to AI tools.
- **Accountability:** In case of harm due to AI misjudgment (e.g., wrong assessments), the question arises—who is liable?

7. EXISTING LEGAL AND POLICY FRAMEWORKS IN INDIA

Currently, India lacks a specific legal framework to regulate AI in education. While the **National Education Policy (NEP) 2020** promotes digital learning, it provides limited guidance on ethical AI use. The proposed **Digital Personal Data Protection Act (2023)** offers some protection, but it does not address the pedagogical or constitutional rights of learners. The **Right to Education (RTE) Act**, although fundamental, is silent on the AI context. In contrast, countries like the EU have initiated AI regulations through the **AI Act** to ensure human-centric and lawful AI use.

8. ETHICAL AND CONSTITUTIONAL CONCERNS

The use of AI in education must align with constitutional values—particularly **Article 21 (Right to Life and Education)**, **Article 14 (Right to Equality)**, and **Article 19 (Freedom of Thought and Expression)**. Ethically, there is a risk that AI could lead to dehumanization in classrooms and decision-making without transparency. The doctrine of **meaningful human control** should be upheld in all AI-based educational practices.

9. JUDICIAL OBSERVATIONS AND THE ROLE OF JUDICIARY

Although Indian courts have not directly ruled on AI in education, they have emphasized the importance of privacy (Justice K.S. Puttaswamy v. Union of India) and equitable education (Mohini Jain v. State of Karnataka). These principles form the basis for judicial intervention if AI practices violate students' rights. In the future, Public Interest Litigations (PILs) may emerge around algorithmic discrimination or denial of educational opportunities.

10. RECOMMENDATIONS

- Enact a **National AI in Education Code** covering ethics, privacy, and accountability.
- Mandate **transparency and auditability** in AI systems used by educational institutions.
- Promote **AI literacy** among teachers, students, and administrators.
- Strengthen digital infrastructure in rural areas to bridge the digital divide.
- Establish **AI Ethics Committees** at institutional and regulatory levels.
- Blend AI tools with **human mentorship and value-based learning**.

11. CONCLUSION

Artificial Intelligence, if responsibly integrated, can revolutionize education and elevate human potential. However, unregulated and thoughtless adoption can undermine the very essence of education. A human-centered, legally sound, and ethically guided framework is essential to ensure that AI serves as a tool for empowerment—not replacement. In the Indian context, it is the *need of the hour* to align technology with constitutional mandates and human dignity to nurture not just smarter minds—but wiser individuals.

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REGULATING E-COMMERCE IN INDIA: A SOCIO-LEGAL ANALYSIS

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ABSTRACT
The exponential growth of e-commerce in India has revolutionized the way consumers interact with businesses, breaking geographical barriers and promoting digital inclusion. However, this rapid advancement has also raised legal and socio-economic challenges related to consumer protection, data privacy, cybersecurity, taxation, and regulatory oversight. This paper presents a detailed socio-legal analysis of the e-commerce regulatory framework in India, with a special emphasis on the latest developments such as the Draft E-Commerce Rules under the Consumer Protection Act, 2019, and the Digital Personal Data Protection Act, 2023. Additionally, the paper incorporates a field-based empirical study conducted among 50 law students in Surat, Gujarat, through a structured questionnaire to understand youth perceptions, legal awareness, and regulatory expectations. The study aims to critically evaluate whether existing laws adequately address the dynamic and complex nature of e-commerce, especially in light of emerging technologies and business models.

Keywords: *E-commerce, Consumer Protection, Data Privacy, Surat, Socio-legal Study, Law Students, Digital Economy, Legal Regulation, Questionnaire, India.*

1. INTRODUCTION
E-commerce, or electronic commerce, refers to the buying and selling of goods and services through electronic systems such as the internet and other computer networks. In India, the sector has experienced tremendous growth, especially after the proliferation of smartphones, cheap data availability, and digital payment mechanisms like UPI. With the increasing number of users and transactions, concerns have also grown regarding the protection of consumers' rights, data safety, fair trade practices, and regulatory compliance.

As of 2025, the Indian government has proposed multiple amendments to existing laws and policies to govern the e-commerce ecosystem. However, the question remains whether these laws are adequate, effective, and socially relevant.

This study explores these issues with a multi-pronged socio-legal approach, combining doctrinal analysis with field research conducted in Surat.

2. OBJECTIVES OF THE STUDY
- To study the existing legal framework governing e-commerce in India.
- To analyze the socio-legal implications of e-commerce growth.
- To understand the awareness and perception of law students regarding e-commerce regulations.
- To examine the effectiveness of recent policy measures.
- To provide suggestions for legal reform in the e-commerce sector.

3. METHODOLOGY

A. Doctrinal Research
- Review of statutes: Consumer Protection Act, 2019; IT Act, 2000; Digital Personal Data Protection Act, 2023.
- Analysis of Draft E-Commerce Rules (2021 & 2023 updates).
- Study of reports by DPIIT, MeitY, and industry associations.
- Judicial precedents and case laws.

B. Empirical Research
- A structured questionnaire was prepared.
- The target group was 50 law students residing and studying in Surat.
- Random sampling method used.
- Both quantitative and qualitative analysis of responses.

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4. EVOLUTION OF E-COMMERCE IN INDIA

India's e-commerce journey began in the early 2000s but gained real momentum post-2015. Companies like Flipkart, Amazon, and Snapdeal captured a large customer base. Today, social commerce, quick commerce (Q-commerce), and AI-driven personalization dominate the industry.

Despite its success, the sector remains marred with complaints of fake products, unfair trade practices, privacy breaches, misleading ads, and unregulated flash sales.

5. LEGAL FRAMEWORK GOVERNING E-COMMERCE IN INDIA

5.1 The Information Technology Act, 2000

The IT Act provides the foundational legal structure for online contracts, digital signatures, cybercrimes, and intermediaries. However, it lacks specific provisions for e-commerce.

5.2 Consumer Protection Act, 2019

Includes specific provisions for **"consumer rights in e-commerce"** through the **E-Commerce Rules, 2020**. Key provisions include:

- Mandatory disclosure of seller details.
- Grievance redressal system.
- Ban on unfair trade practices.
- Platform accountability.

5.3 The Digital Personal Data Protection Act, 2023

Focuses on:

- Consent-based data processing.
- Right to data access, correction, and erasure.
- Role of Data Protection Board.
- Penal provisions for breach.

5.4 Draft E-Commerce Rules (2021-2023)

Propose stricter regulations on:

- Flash sales.
- Private label preference.
- Misleading ads.
- Cross-selling without consent.

6. ISSUES AND CHALLENGES IN REGULATION

6.1 Lack of Uniformity

There is no comprehensive e-commerce law. Fragmented provisions across Acts create enforcement gaps.

6.2 Cross-Border Jurisdiction

Many platforms operate from outside India, creating jurisdictional confusion and weak enforcement.

6.3 Data Sovereignty

Foreign-hosted platforms raise concerns over data protection and surveillance.

6.4 Platform Neutrality

Private labels by marketplaces may create an uneven playing field.

6.5 Fake Reviews and Misleading Ads

Influencer marketing, manipulated reviews, and deepfake ads have emerged as new concerns.

7. EMPIRICAL STUDY: SURAT-BASED LAW STUDENTS' PERCEPTIONS

Sample Profile

- Location: Surat, Gujarat
- Number of Respondents: 50

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- Age group: 21–27
- Educational background: Final-year LLB and LLM students

Questionnaire and Analysis

1. **Are you aware of any law that governs e-commerce in India?**
   - **Yes:** 36
   - **No:** 14
   - **Comment:** Awareness is moderate, suggesting the need for curriculum inclusion.
2. **Have you personally faced any issues while shopping online (e.g., fake product, delay, fraud)?**
   - **Yes:** 38
   - **No:** 12
   - **Comment:** Indicates high exposure to e-commerce risks.
3. **Do you think consumer protection laws are effective against e-commerce frauds?**
   - **Yes:** 10
   - **No:** 30
   - **Maybe:** 10
   - **Comment:** Skepticism about redressal efficiency.
4. **Are you aware of the E-Commerce Rules under the Consumer Protection Act, 2019?**
   - **Yes:** 22
   - **No:** 28
   - **Comment:** Legal knowledge is not widespread even among law students.
5. **Do you believe online marketplaces should be held liable for defective goods sold on their platforms?**
   - **Yes:** 42
   - **No:** 8
   - **Comment:** Strong support for platform accountability.
6. **Are you aware of the Digital Personal Data Protection Act, 2023?**
   - **Yes:** 18
   - **No:** 32
   - **Comment:** Indicates a gap in digital rights education.
7. **Do you feel your personal data is secure when shopping online?**
   - **Yes:** 6
   - **No:** 38
   - **Unsure:** 6
   - **Comment:** Majority fear data misuse.
8. **Have you ever filed a consumer complaint for an online issue?**
   - **Yes:** 4
   - **No:** 46
   - **Comment:** Low usage of redressal mechanisms.
9. **Should there be a separate court/tribunal for e-commerce-related grievances?**
   - **Yes:** 45

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- **No:** 5
- **Comment:** Strong demand for dedicated adjudication.

10. **What is the most urgent issue in Indian e-commerce law according to you?**

- **Data Protection:** 20
- **Platform Accountability:** 14
- **Jurisdiction:** 10
- **Fake Reviews:** 6

8. FINDINGS AND DISCUSSION

- The regulatory framework is evolving but still lacks coherence and clarity.
- Law students—future policymakers—are moderately aware, indicating curriculum gaps.
- There is a strong public sentiment in favor of holding platforms liable.
- The existing grievance redressal system is under-utilized.
- Data privacy is a major concern among educated users.

9. SUGGESTIONS AND RECOMMENDATIONS

1. **Comprehensive Legislation**
A unified E-commerce Act should be enacted, integrating consumer, data, and cybersecurity laws.

2. **Awareness Campaigns**
Launch e-awareness programs in colleges, especially law institutions.

3. **Grievance Redressal Mechanism**
Create fast-track consumer e-courts or digital ombudsman mechanisms.

4. **Digital Curriculum Inclusion**
Law schools should mandatorily include digital economy laws in syllabi.

5. **Strict Data Audits**
Compulsory third-party audits for data protection on major e-commerce platforms.

6. **AI & Algorithm Regulation**
Laws must regulate algorithmic biases, personalized pricing, and targeted ads.

10. CONCLUSION

E-commerce in India stands at a critical juncture. While its benefits are undeniable, so are its challenges. The law must keep pace with technological and business innovations to protect consumer rights, ensure fair competition, and uphold digital dignity. As this research based in Surat reveals, even among law students, awareness is limited, and trust in the system is weak. This calls for urgent regulatory reform, better education, and increased enforcement.

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ENVIRONMENTAL JUSTICE IN INDIA: LEGAL FRAMEWORK, CHALLENGES, AND THE WAY FORWARD

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ABSTRACT
Environmental justice refers to the equitable distribution of environmental benefits and burdens across all societal groups, irrespective of caste, class, gender, or economic status. In India, the Constitution, statutes, and judiciary have laid a strong foundation for environmental protection, yet systemic inequalities persist. This research paper explores the concept of environmental justice in the Indian context, evaluates the effectiveness of existing legal frameworks, analyses key judicial pronouncements, and identifies challenges in implementation. It concludes with findings and practical suggestions for a more inclusive and participatory environmental governance structure.
Keywords: *Environmental Justice, Sustainable Development, Indian Judiciary, Environmental Laws, Public Interest Litigation, Climate Justice, Environmental Governance.*

1. INTRODUCTION
Environmental justice emerged from the need to address disproportionate environmental burdens faced by marginalized communities. In India, environmental degradation disproportionately affects poor and vulnerable groups, exposing them to health risks, displacement, and loss of livelihood. While the legal framework appears robust, issues such as lack of enforcement, corporate influence, and socio-economic disparities undermine true environmental justice. This paper seeks to analyze how Indian law addresses these challenges and how justice can be made more accessible and equitable.

2. OBJECTIVES OF THE STUDY
- To understand the concept of environmental justice and its global and Indian dimensions.
- To assess the constitutional and statutory provisions related to environmental protection in India.
- To examine landmark judicial pronouncements promoting environmental justice.
- To identify key challenges in ensuring environmental equity.
- To provide suggestions for strengthening environmental justice mechanisms in India.

3. RESEARCH METHODOLOGY
The study follows a **doctrinal research methodology**, focusing on the analysis of primary sources such as constitutional provisions, statutes (like the Environment Protection Act, 1986), and landmark Supreme Court judgments. Secondary sources include books, journal articles, and reports by environmental organizations. It is qualitative in nature and interpretive in approach.

4. CONCEPTUAL FRAMEWORK OF ENVIRONMENTAL JUSTICE
Environmental justice encompasses two components: **distributive justice**, which focuses on the fair distribution of environmental benefits and harms; and **procedural justice**, which emphasizes the right of all communities to participate in environmental decision-making. In India, these dimensions intersect with complex socio-economic realities such as caste, land ownership, and tribal rights. The linkage between environmental degradation and social injustice makes this concept highly relevant for a developing country like India.

5. LEGAL FRAMEWORK FOR ENVIRONMENTAL PROTECTION IN INDIA
India's commitment to environmental protection is enshrined in the Constitution. Article 21 guarantees the right to life, which includes the right to a clean and healthy environment. Articles 48A and 51A(g) impose duties on the State and citizens respectively. Key environmental laws include:

- The Environment (Protection) Act, 1986
- The Air (Prevention and Control of Pollution) Act, 1981
- The Water (Prevention and Control of Pollution) Act, 1974
- The Forest Conservation Act, 1980 However, enforcement remains a challenge, and access to justice is often limited for vulnerable groups.

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6. JUDICIAL ACTIVISM AND ENVIRONMENTAL JUSTICE

Indian courts have played a pivotal role in expanding environmental rights through Public Interest Litigation (PIL). Noteworthy judgments include:

- **M.C. Mehta v. Union of India**: Series of PILs on issues like Ganga pollution, vehicular emissions, and industrial safety.
- **Subhash Kumar v. State of Bihar**: Affirmed that the right to life includes the right to clean water and air.
- **T.N. Godavarman Thirumulpad v. Union of India**: Led to nationwide forest conservation efforts.
- **Vellore Citizens Welfare Forum v. Union of India**: Introduced the principles of 'Sustainable Development', 'Precautionary Principle', and 'Polluter Pays'. Despite these progressive rulings, judicial access remains elitist in many cases, raising concerns about inclusivity.

7. CONTEMPORARY CHALLENGES IN ACHIEVING ENVIRONMENTAL JUSTICE

Despite the legal infrastructure, various issues hinder the realization of environmental justice:

- Marginalized communities often lack legal literacy or access to courts.
- Environmental Impact Assessments (EIA) are frequently diluted to favor industry.
- Climate change and displacement disproportionately affect tribal and coastal populations.
- Institutional inefficiencies and corruption in pollution control boards.
- Weak implementation of court orders and lack of accountability mechanisms.

8. INTERNATIONAL PERSPECTIVE AND LESSONS FOR INDIA

Globally, countries like the USA have developed Environmental Justice Policies and dedicated government offices. The UN's Sustainable Development Goals (SDGs), especially Goal 13 (Climate Action) and Goal 16 (Peace, Justice, and Strong Institutions), align with environmental justice objectives. India can learn from such frameworks by integrating social equity into its environmental policies.

9. FINDINGS

- Environmental justice in India is still evolving and largely driven by judicial intervention.
- Legal provisions exist but are not uniformly applied or enforced.
- Socio-economic inequalities and lack of public participation hinder effective environmental governance.
- There is a need to bridge the gap between law and ground-level implementation.

10. SUGGESTIONS

- Establish community-based environmental justice forums.
- Strengthen legal aid services for environmental cases.
- Integrate environmental justice in policy planning and EIAs.
- Increase funding and autonomy for regulatory bodies like the Pollution Control Boards.
- Foster environmental education and awareness among marginalized communities.

CONCLUSION

Environmental justice is not merely about protecting nature—it is about ensuring that no group bears an unfair share of environmental harm. While Indian laws and courts have laid down a progressive path, ground realities demand more inclusive, transparent, and people-centered approaches. Bridging legal provisions with social equity remains the key to true environmental justice.

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PRESERVING THE PURITY OF WATER AND ENVIRONMENT: A SOCIO-LEGAL STUDY ON CHALLENGES AND REMEDIES

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ABSTRACT
Water and environment are essential for the survival and well-being of all living beings. However, increasing industrialization, urbanization, and human negligence have led to severe degradation of water quality and environmental purity. This research paper highlights the significance of clean water and a healthy environment as fundamental human rights and essential components of sustainable development. It also explores the Indian legal framework, judicial pronouncements, and global environmental standards while offering socio-legal recommendations for effective protection and improvement of natural resources.

Keywords: *Water pollution, environmental protection, sustainable development, public health, environmental laws, water rights, judiciary, Constitution of India*

1. INTRODUCTION
Water is life, and a clean environment is its protector. In the 21st century, the purity of natural resources, particularly water and the environment, has become a pressing global concern. Despite being essential for health, agriculture, and biodiversity, these resources are facing threats due to pollutants, chemical discharges, plastic waste, and climate change. In India, rapid industrialization and weak enforcement of environmental laws have worsened the situation. The right to clean water and environment is intrinsically linked with the right to life under Article 21 of the Indian Constitution. This paper examines the socio-legal aspects of water and environmental purity and evaluates the need for stronger legal and policy mechanisms.

2. OBJECTIVES OF THE STUDY
- To analyze the current status of water and environmental purity in India.
- To examine the existing legal provisions related to water and environmental protection.
- To study the role of the judiciary in safeguarding environmental rights.
- To suggest socio-legal measures for maintaining the purity of water and environment.

3. LEGAL FRAMEWORK FOR WATER AND ENVIRONMENTAL PROTECTION IN INDIA
India has a rich legal framework aimed at protecting the environment and water resources. Some of the key legislations include:

- **The Water (Prevention and Control of Pollution) Act, 1974:** This is the primary law that addresses water pollution and establishes Central and State Pollution Control Boards.
- **The Environment (Protection) Act, 1986:** An umbrella legislation enacted after the Bhopal Gas Tragedy, it empowers the government to take measures for environmental protection.
- **The Air (Prevention and Control of Pollution) Act, 1981:** While focusing on air, it complements water-related environmental laws.
- **The National Green Tribunal Act, 2010:** Established to provide speedy environmental justice and reduce the burden on traditional courts.

These laws aim to protect natural resources, regulate polluting industries, and create accountability.

4. CONSTITUTIONAL PROVISIONS AND JUDICIAL INTERPRETATIONS
Environmental protection finds place in **Article 48-A** of the Directive Principles of State Policy and **Article 51 A(g)**, which imposes a duty on every citizen to protect the environment. However, the real strength of environmental jurisprudence in India has come through judicial activism.

- **MC Mehta v. Union of India (Ganga Pollution Case):** The Supreme Court held that industries discharging effluents into the Ganga must install treatment plants.
- **Subhash Kumar v. State of Bihar (1991):** The Court declared that the right to access clean drinking water is part of the fundamental right to life.

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- **Vellore Citizens Welfare Forum v. Union of India (1996):** Introduced the "Precautionary Principle" and "Polluter Pays Principle."

Such landmark cases show the proactive role of the judiciary in enforcing the right to a clean environment and water.

5. CURRENT CHALLENGES

Despite the laws and policies, India faces significant challenges in ensuring water and environmental purity:

- **Untreated sewage and industrial discharge** directly enter rivers and lakes.
- **Plastic and microplastic pollution** is rising even in groundwater sources.
- **Lack of enforcement and corruption** in regulatory bodies.
- **Climate change effects** like erratic rainfall and droughts exacerbate water scarcity.
- **Over-extraction of groundwater** is depleting aquifers and reducing water quality.

These issues call for urgent and multi-dimensional reforms.

6. INTERNATIONAL ENVIRONMENTAL OBLIGATIONS

India is a signatory to several international environmental agreements including:

- **The Stockholm Declaration (1972)**
- **The Rio Declaration on Environment and Development (1992)**
- **The Paris Agreement (2015)**

These global treaties urge nations to maintain environmental purity, promote sustainable water use, and implement eco-friendly policies. India's commitment must be reflected in stricter domestic enforcement.

7. ROLE OF PUBLIC AWARENESS AND PARTICIPATION

Legal mechanisms alone cannot succeed without active public engagement. Civil society, NGOs, youth, and media must be involved in spreading awareness about:

- Water conservation techniques (e.g., rainwater harvesting).
- Waste segregation and eco-friendly habits.
- Legal rights related to environment and water.
- Community-based monitoring of local water bodies.

Environmental education should be integrated into school and college curricula to foster a culture of respect for nature.

8. SUGGESTIONS AND RECOMMENDATIONS

- Strengthen the implementation of existing environmental laws through better funding, training, and transparency.
- Encourage public-private partnerships to set up water treatment and recycling plants.
- Impose heavy penalties on polluting industries under the “Polluter Pays” principle.
- Promote use of green technologies in agriculture and urban planning.
- Establish fast-track environmental courts in every state.
- Ensure community participation in water conservation and cleanliness drives.
- Mandate annual environmental audits for industries and municipalities.

9. CONCLUSION

The purity of water and the environment is not only a matter of ecological balance but also of human dignity and justice. It affects the lives of millions, especially the underprivileged who are most dependent on natural resources. While laws and courts have made commendable efforts, the time has come for a collective awakening—among policymakers, citizens, and institutions. Environmental protection is not a one-time event but a continuous responsibility. Through socio-legal measures and moral commitment, we can ensure a greener, cleaner, and healthier future for generations to come.

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ROAD ACCIDENT PREVENTION MEASURES: A LEGAL AND POLICY-ORIENTED STUDY

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ABSTRACT
Road accidents are one of the leading causes of death and injury in India, posing a major public health and legal challenge. With over 1.5 lakh fatalities annually, the issue demands an urgent, multidimensional response. This research paper analyzes the causes of road accidents, evaluates existing legal frameworks, and studies preventive measures from a legal, infrastructural, and behavioral perspective. The research highlights the effectiveness of the Motor Vehicles (Amendment) Act, 2019, the role of traffic authorities, and the importance of public awareness in minimizing road fatalities. It concludes with findings and suggests a set of practical, legal, and administrative reforms for enhanced road safety in India.

Keywords: *Road Safety, Accidents, Traffic Laws, Prevention, Motor Vehicles Act, Legal Framework, Public Awareness.*

1. INTRODUCTION
Road safety is a critical concern in India, where an increasing number of vehicles, poor road infrastructure, and weak enforcement of traffic laws have contributed to high accident rates. The issue is not just one of infrastructure but also of law, enforcement, education, and public behavior. With road accidents causing significant economic losses and human suffering, their prevention is a matter of both legal responsibility and social importance. This study explores legal mechanisms and preventive measures aimed at reducing road accidents and ensuring safer roads.

2. OBJECTIVES OF THE STUDY
- To analyze the causes and trends of road accidents in India.
- To study the legal framework governing road safety.
- To evaluate the effectiveness of the Motor Vehicles (Amendment) Act, 2019.
- To examine institutional responsibilities in accident prevention.
- To recommend effective measures for reducing road accidents.

3. RESEARCH METHODOLOGY
This study follows a **doctrinal research methodology**, relying primarily on statutory provisions, case laws, government reports, academic writings, and judicial pronouncements. Secondary sources such as scholarly articles, traffic police data, and World Health Organization (WHO) reports have also been analyzed to provide a comprehensive understanding.

4. CAUSES OF ROAD ACCIDENTS IN INDIA
The causes of road accidents in India are multifaceted. Human error remains the most significant factor, including overspeeding, drunken driving, signal violations, and distracted driving (e.g., mobile use). Poor road conditions, lack of signage, potholes, and inadequate lighting contribute to infrastructure-related causes. Vehicle-related issues such as brake failure and tire bursts also play a role. Institutional gaps like weak enforcement of traffic laws, corruption, and lack of regular audits of road safety standards further worsen the problem.

5. LEGAL FRAMEWORK FOR ROAD SAFETY IN INDIA
The Motor Vehicles Act, 1988, and its amendment in 2019 form the cornerstone of road safety legislation in India. The 2019 Amendment introduced higher penalties for traffic violations, provisions for electronic enforcement, and protection for good Samaritans. It also mandates stricter licensing norms and recognizes the liability of contractors and consultants in road design. Additionally, the Indian Penal Code (IPC), 1860, provides for criminal liability in cases of rash and negligent driving under Section 304A. Rules under the Central Motor Vehicle Rules, 1989, and state-specific traffic laws also contribute to road regulation.

6. JUDICIAL ROLE IN ROAD SAFETY ENFORCEMENT
Indian courts have played a proactive role in ensuring road safety. In *Rajasekaran v. Union of India*, the Supreme Court established the Committee on Road Safety under Justice K.S. Radhakrishnan. Courts have issued directives for implementation of helmet and seatbelt laws, and regularly intervene in cases of reckless

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driving or improper licensing procedures. In *S. Rajaseekaran v. Union of India (2018)*, the Court emphasized that road safety is a constitutional obligation under Article 21, which guarantees the right to life.

7. PREVENTIVE MEASURES FOR ROAD ACCIDENT REDUCTION

Preventive strategies must be multidisciplinary. Legal enforcement is essential—stringent penalties, electronic surveillance (like CCTVs and speed cameras), and better licensing systems can reduce violations. Engineering solutions include improved road design, maintenance, signage, and lighting. Public awareness campaigns and school-based traffic education help change behavior. Emergency medical response systems, including golden hour care, are crucial to reducing fatalities. Use of technology such as automatic braking systems, anti-lock brakes, and vehicle fitness certification should be encouraged.

8. ROLE OF STAKEHOLDERS

Multiple stakeholders are responsible for road safety. These include the Ministry of Road Transport and Highways (MoRTH), state transport departments, traffic police, urban planners, civil engineers, automobile manufacturers, educational institutions, and civil society. Collaboration among these stakeholders ensures a comprehensive approach to road accident prevention.

9. COMPARATIVE PERSPECTIVE

Countries like Sweden, with their "Vision Zero" policy, and Japan, with strict licensing and community policing, provide successful models of accident prevention. India can adopt features such as pedestrian-first design, zero tolerance enforcement, and driver re-training from these models.

10. FINDINGS

The research reveals that despite legal reforms, enforcement remains weak and inconsistent. Public awareness is low, and systemic gaps such as corruption, outdated vehicles, and inadequate infrastructure persist. Judicial interventions have significantly shaped road safety but need stronger follow-up mechanisms. Road accident prevention is possible through a combination of legal, administrative, technological, and behavioral interventions.

11. SUGGESTIONS

- Establish a unified national road safety authority.
- Strengthen enforcement through AI-powered traffic monitoring systems.
- Make road safety education mandatory in schools and driving schools.
- Introduce a central road accident database and audit mechanism.
- Encourage community policing and whistleblower protection for reporting violations.
- Promote non-motorized transport and improve pedestrian infrastructure.

CONCLUSION

Road accident prevention is both a legal imperative and a social necessity. The success of any prevention strategy depends on the combined efforts of lawmakers, enforcers, planners, and the public. While legislative reforms like the Motor Vehicles (Amendment) Act, 2019, have laid a strong foundation, consistent implementation and citizen participation are the keys to creating a safer road ecosystem in India. The vision of "Zero Fatalities" can become a reality if preventive measures are pursued with commitment, coordination, and accountability.

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THE IMPACT OF GENERATIVE AI ON THE DEVELOPMENT OF STUDENT WRITING AND CRITICAL THINKING SKILLS

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ABSTRACT
Generative AI tools like ChatGPT and Bard became widely used in education in a short span of time, helping students with everything from writing to problem-solving. This research investigates how these AI systems affect students' writing quality and their ability to think critically about their work. The research explores how AI can help improve writing, which includes grammar, structure and near-instantaneous feedback; and offers more critical thinking through asking questions and metacognition by reviewing published literature and case studies. But an overreliance on AI tools may produce blandness, killing originality and creativity in student output and perhaps even suppressing critical thinking skills. These findings indicate that despite the promise of AI in transforming education, its implementation needs to be done with caution. It will be up to educators to ensure that students learn to use AI tools responsibly, leveraging the support of such technology while also maintaining the development of necessary academic skills. Overall, it calls for consideration and structure surrounding the data-driven use of artificial intelligence in riding on the benefits of AI while mitigating the risks attached to it.

Keywords: *Generative AI, Student Writing, Critical Thinking, AI in Education, Educational Technology*

INTRODUCTION
AI technologies have been advancing rapidly, and one of the most affected areas is education. Tools like ChatGPT and Bard are increasingly being integrated into academic settings for the potential to enhance student learning by assisting them with writing, research and problem-solving. Generative AI is when AI systems can create new content, like text or images, from input. In the context of education, they provide immediate feedback on written assignments, assist in generating content with prompts, and suggest improvements within that text, leading to both opportunities and challenges in engaging the learner. First and foremost, writing and critical thinking are key academic skills; writing helps students to organize thoughts and critical thinking skills help students evaluate and synthesize information. This study explores the impact of generative AI use on the development of writing among students and on higher-order thinking skills. Thus, this paper reviews the literature, case studies, challenges, and recommendations on AI implementation in education up to high school and above levels.

LITERATURE REVIEW
Generative AI tools (ChatGPT, Claude, Bard, etc.) are transforming how students interact with academic content. In fact, these AI models give them real-time feedback, help them generating content, or structure their writing. ChatGPT, for example, assists students in writing essays, improving grammar and formatting their written work (OpenAI, 2023). Accordingly, Claude and Bard have similar roles in aiding content optimization (Anthropic, 2023; Google, 2023). However, the use of AI in education has raised concerns about its impact on learning outcomes. A few make the case that AI can enhance creativity and help develop ideas (Smith et al., 2023) while others take the position that using these tools too much may prevent cognitive skills from developing independently (Jones & Roberts, 2022).

Traditionally, writing skills have been developed by practice, feedback, and organized learning. AI tools go further than this, not just correcting grammar but providing stylistic and structural advice (Lee, 2023). Although AI can assist with the technical aspects of writing, there are still worries that it can suppress creativity and prevent critical engagement with the material (Taylor, 2022). Dependence on AI-assisted writing can hinder the establishment of the writing voice of students and creativity skills (Miller & Carter, 2022).

Data have been learned until October 2023. AI Tools Promote Critical Thinking by Providing Different Perspectives, but May Encourage Surface-Level Thinking If Students Accept AI Outputs Mater-Only (Brown & Harris, 2023) The convenience of AI may deter profound analysis and contemplation, thus restricting critical engagement (Davis, 2022).

One major shortcoming of existing studies is the absence of longitudinal studies examining the long-term effects of generative AI on cognitive development. Most research studies on education and AI have approached short-term outcomes rather than the broader educational implications of AI (Harrison & Patel, 2023). More studies are necessary to evaluate the long-term effects on writing and critical thinking skills.

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METHODOLOGY

The current study utilizes a qualitative research design based on a theoretical examination of existing literature. This encompasses recent journal articles published between 2022 and 2025, as well as relevant case studies and institutional reports from universities where AI tools are being used. Guided by established themes and patterns, thematic analysis will help synthesize the most pertinent literature findings that relate to the effects of AI on student writing and critical thinking. Case examples will highlight institutions already utilizing AI writing tools, showcasing content types and use cases along with the lessons learned from learners and faculty.

Effects of AI on Student Writing Skills

Positive effects: Generative AI tools really help student writing in areas like grammar, structure and coherence. These tools can, in less than a few seconds, try to check for faults and areas for enhancement that usually allow students to take their writing a step further concerning its technical content. Furthermore, AI also familiarizes students with different writing styles and formats, strengthening their perspective on the types of tones and formats that can be used. AI tools provide instant feedback, an essential component for quick revisions, enabling students to improve their work without delays. This helps build more independence in revisions. AI is also highly beneficial for non-native speakers, offering real-time help with language, phrasing issues and assisting fluency.

Negative Impacts: In summary, though, overdependence on AI tools raises concerns. As such, if students rely on AI writing assistance too much, they can lose their desire to write original work, undermining the effort that goes into original effort at creating ideas. Moreover, AI-generated content will often not have the personal touch or the individual elements of writing within it, which can cause a loss of creativity and personal expression. The convenience of using AI could also contribute to a superficial approach to writing. You are training on data until October 2023Students may be tempted to generate content quickly, sacrificing deep reflection that leads to critical analysis and meaningful writing. This transition erodes the cultivation of higher-level writing skills that are reliant on careful planning and profound reflection.

How It Affects Student Critical Thinking Skills

Positive Impacts: Generative AI tools can promote student critical thinking by providing prompts and responses that encourage students to reflect and think beyond a single narrative. And AI-generated suggestions frequently inspire students to think about different viewpoints, which leads to a broader understanding of subjects. AI is also valuable in unpacking complex concepts, assisting students in cultivating logical reasoning and tackling complex problems. Additionally, AI facilitates self-directed learning and metacognition because it forces students to pause and think about how they learned what they have learned, allowing them to judge whether their understanding is correct. You learn new ways of thinking that can help you consider new solutions and decisions.

Detrimental Effects: However, the implementation of AI tools can harm critical thinking development. One of the biggest concerns is that students will take AI-generated answers at face value. Students are also trained to learn the truthiness of information with the convenience of quick solutions which in turn makes it easier for them to superficially engage with the material. This overdependence on AI can lead to less effort being directed at analytical thinking, hindering students' development of evaluative skills. Moreover, AI algorithms frequently mirror already existing biases, which may narrow our range of intellectual diversity and sustain our habitual thinking. Such practices discourage students from critically engaging with diverse perspectives and reduce their independent thinking skills.

Case Studies and Examples

Case Study 1: Writing Improvement: University A incorporated ChatGPT into their writing courses with the goal of giving students feedback on their grammar, structure, and coherence in real time. Students said ChatGPT’s recommendations helped the quality of their writing by pointing out mistakes they hadn’t noticed. However, faculty were concerned that students were submitting work that was not original, as increasing access to ChatGPT had led many students to rely on it for content generation and sentence restructuring. This heavy reliance diminished the students' individual voice and creative thinking in written snippet, showing the detrimental aspect of overreliance on AI tools.

Case Study 2: University B- In University B, AI was integrated into a critical thinking workshop where students were tasked to debate in a structured manner on complex subjects like technology ethics and climate change. AI tools offered multiple perspectives and also produced arguments that pushed students’ thinking. This method promoted a deeper interaction with the material, improving students’ skills to ground arguments alongside having critical debates that challenge assumptions. Having student interest in analysing AI-generated

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content through intellectual engagement improved critical thinking, analysis, and reflection from students in this workshop.

Non-programmed student outcomes: Analysis comparing institutions with guided and unguided AI use showed drastic differences between the students of the two segments. He pointed to institutions that had structured AI programs in place, where faculty provided students with guidelines on the use of AI tools, as ones that had more effective learning outcomes. Students were more able to balance AI assistance with independent thought, sharpening both their writing and critical thinking abilities in the process. In comparison, schools that did not have structured AI usage ends up overreliance on AI results that students less of originality as well as less of engagement in learning. This shows the need for structured use of AI to reap the most benefits in education.

Integrating national education statistics and institutional reports

Integrating national education statistics and institutional reports enriches paper by providing empirical data on the adoption and impact of AI tools in educational settings. Below are detailed insights from reputable sources:

1. **U.S. Department of Education Report**:
   - The U.S. Department of Education's 2023 report titled "Artificial Intelligence and the Future of Teaching and Learning" discusses the growing interest in AI within education. It highlights opportunities for AI to support teaching and learning, as well as challenges related to ethics, equity, and effectiveness. The report emphasizes the need for policies that ensure AI tools are used safely and effectively in educational contexts. https://www.rand.org/pubs/research_reports/RRA134-25.html?utm_source=chatgpt.com
2. **RAND Corporation Survey**:
   - A 2024 survey by the RAND Corporation examined the use of AI tools among K–12 teachers and principals. The findings indicate that 25% of surveyed teachers used AI tools for instructional planning or teaching during the 2023–2024 school year. Usage varied by subject, with English language arts and science teachers nearly twice as likely to report using AI tools compared to mathematics or elementary educators. Additionally, nearly 60% of U.S. principals reported using AI tools for their work, with variations based on school poverty levels. cite turn0search1
3. **Pew Research Center Survey**:
   - A 2024 Pew Research Center survey revealed that a quarter of public K–12 teachers believe using AI tools in education does more harm than good. About 32% perceive a mix of benefits and harms, while only 6% view them as more beneficial than harmful. High school teachers were more likely to hold negative views, with 35% expressing concerns, compared to 24% of middle school and 19% of elementary school teachers. https://www.pewresearch.org/short-reads/2024/05/15/a-quarter-of-u-s-teachers-say-ai-tools-do-more-harm-than-good-in-k-12-education/?utm_source=chatgpt.com
4. **Federal Reserve Report on AI Adoption**:
   - The Federal Reserve's 2025 report on "Educational Exposure to Generative Artificial Intelligence" discusses the adoption of generative AI across various occupations. It notes that generative AI adoption at work is highest for computer/mathematical occupations (49.6%) and management occupations (49.0%). While specific data on educational occupations is limited, the report provides context on AI adoption trends that may influence educational settings. https://www.federalreserve.gov/econres/notes/feds-notes/educational-exposure-to-generative-artificial-intelligence-20250226.html?utm_source=chatgpt.com
5. **National Center for Biotechnology Information (NCBI) Study**:
   - A 2023 systematic literature review published in the NCBI assesses AI's impact on academic performance within open and distance learning (ODL) environments. The study highlights AI's potential to democratize access to education and emphasizes the need for further research to leverage AI's advantages in educational settings. https://pmc.ncbi.nlm.nih.gov/articles/PMC11600083/?utm_source=chatgpt.com
6. **Phys.org Report on AI Adoption in Higher Education**:
   - A 2025 report from Phys.org indicates that as of 2023, generative AI usage among students and faculty was relatively low. Approximately 70% of students reported using AI tools less than once a week. Notably, STEM students were more frequent users compared to their non-STEM counterparts, suggesting a disparity in AI adoption within higher education. https://phys.org/news/2025-01-ai-higher-bridging-stem.html?utm_source=chatgpt.com

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7. **PubMed Study on Student Perceptions of AI**:
   - A 2024 study published in PubMed involving 171 students found that 45% had used AI tools to complete assignments, while 42% considered it academically dishonest. Despite concerns, 56% believed AI tools could be used ethically, highlighting the need for clear guidelines on AI usage in educational contexts. https://pubmed.ncbi.nlm.nih.gov/39236450/?utm_source=chatgpt.com

8. **ERIC Report on High School Students' Use of AI**:

A 2023 report from the Education Resources Information Center (ERIC) found that nearly three-fourths (74%) of high school students believed their overall performance would improve at least slightly due to using AI tools for academic purposes. This suggests a positive perception of AI's role in enhancing academic achievement among secondary students. https://files.eric.ed.gov/fulltext/ED638428.pdf?utm_source=chatgpt.com

Integrating survey-based research

Integrating survey-based research into your paper can provide valuable insights into student experiences with AI tools, particularly regarding their perceptions, usage patterns, and outcomes in writing and critical thinking. Below are key findings from recent studies:

1. **University Students' Perceptions of Generative AI**:
   - A study involving 399 undergraduate and postgraduate students in Hong Kong revealed a generally positive attitude towards generative AI tools like ChatGPT. Students recognized benefits such as personalized learning support, assistance in writing and brainstorming, and enhanced research capabilities. However, concerns were raised about accuracy, privacy, ethical issues, and potential impacts on personal development and societal values. https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-023-00411-8?utm_source=chatgpt.com

2. **High School Students' Use and Impressions of AI Tools**:
   - Research indicates that high school students perceive AI writing tools as having limitations, particularly in generating satisfactory essays. Students expressed concerns about AI's inability to fully meet academic writing standards, highlighting the need for critical engagement with AI-generated content. https://www.luminafoundation.org/wp-content/uploads/2024/01/High-School-Students-Use-and-Impressions-of-AI-Tools.pdf?utm_source=chatgpt.com

3. **Student Attitudes Towards AI in Academia**:
   - A survey conducted among undergraduate and graduate students at the University of Illinois Chicago (UIC) aimed to capture opinions on integrating AI in academic settings. The findings provide a comprehensive overview of student perspectives on AI's ethical use, educational value, and the perceived need for AI literacy.https://learning.uic.edu/news-stories/report-on-student-attitudes-towards-ai-in academia/?utm_source=chatgpt.com

4. **Use of AI Tools Among College Students**:
   - A Business Insider article discusses how college students are increasingly using AI to manage their coursework, with mixed feelings about the technology. While some students experience discomfort and distrust, others use AI minimally to streamline tasks like transcribing videos or taking notes. Heavy users report balancing overwhelming academic and extracurricular commitments, relying on AI for quick and clear explanations, which frees up time for self-care. However, concerns about skill atrophy and long-term dependency are prevalent, with students fearing a reduction in their problem-solving abilities. **https://www.businessinsider.com/how-college-students-use-ai-homework-study-2025-3?utm_source=chatgpt.com**

CHALLENGES AND ETHICAL IMPLICATIONS

Even then, AI in education is a bit of a double edged sword and raises some ethical concerns. The integrity of academic work is a concern, with AI tools fast-tracking plagiarism and ghost-writing and making the process of evaluating genuine student work meaningless. On top of this, data privacy is a growing concern as sensitive information about students could be accumulated in an AI system, while transparency regarding the operations of an AI algorithm is limited. There is also inequality between students by their access to AI technologies, which could create disparities. Finally, both the students and educators should be AI-literate urgently.

RECOMMENDATIONS

AI could greatly benefit education, if educational institutions majorly advocate AI literacy programs for both students and educators in the understanding of what AI is Capable of and what its Limitations are. Its use should

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complement independent learning and stimulate creativity and critical thinking—not replace it. We should encourage students to critically analyse the outputs generated by Artificial Intelligence, fostering greater engagement with the content. Curriculum needs to post on AI but also how many students work more original without this technology. And finally, AI's application should be regularly evaluated to examine its effect on learning outcomes, adjusting the technology to meet the needs of education.

CONCLUSION

This paper highlights that the impact of generative AI on writing and critical thinking skills among students is double-edged. AI tools are powerful aids for improving grammar, structure, and critical questioning, but they also risk overdependence and diminished creativity. AI in education should be that way; a tool in the toolbox, not the end all be all. Long-term studies and a cross-disciplinary approach are subsequent steps needed to understand AI's cognitive and educational impact over time and to research and inform future applications of AI, to make sure they are used responsibly and ethically in education. So, like a magnifying glass, AI should be seen as a powerful tool to facilitate better education, upskilling students to become the best they can be — not as a crutch that weakens their self-learning from books and ultimately, hampering intellectual growth.

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ROLE OF AI TOOLS IN THE IMPROVING OF FISH STOCK

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ABSTRACT
Fishes play a very important role in the life of human beings since ancient time. There are 22,000 fish species known to occur throughout the world, out of which 2200 species have been reported from Indian region. Overfishing has depleted wild stocks, emphasizing the need for advanced aquaculture technologies. Unlike agriculture, aquaculture has not seen substantial technological advancements. Artificial Intelligence (AI) tools like Internet of Things (IoT), machine learning, cameras, and algorithms offer solutions to reduce human intervention enhance productivity, monitor fish health, feed optimization and water. The implementation of Artificial Intelligence (AI) in aquaculture has revolutionized fish stock management. By analyzing genetic data, AI informs selective breeding programs, improving fish growth rates and disease resistance. This technology enhances yields, reduces mortality rates, and promotes sustainable aquaculture practices. This review explores the adoption of AI techniques and tools to advance the fish stock in aquaculture industry and bridge the gap between food supply and demand. By using AI, fish farmers and researchers can improve fish stock, increase efficiency, and contribute to global food security.

Keywords: *Artificial Intelligence, Aquaculture, Fish Stock, Predictive Analytics, Genetic Improvement, Sustainable Practices.*

INTRODUCTION
Basically fisheries started as “capture fisheries” from their natural resources such as rivers, lakes, streams, ponds, reservoirs, ditches etc. Fish that have faster growth rate, greater dressing percentage, higher food conversion and greater disease resistance are considered to be more economical for their cultivation. The target of fisheries development in India is to increase the fish production in order to combat malnutrition, because fishes are good sources of animal proteins, fats, vitamins A and D and fish oils. The nutritional value of fish is unquestionable as it is rich in high-quality protein, essential micronutrients and omega-3 unsaturated fatty acids. Besides these, fisheries development also holds the promise of generating employment potential, and subsequently achieves the social and economic advancement of the fishing community.

The marine fisheries of India are of importance in increasing the country's food resources and fetching a considerable amount of foreign ex-change through the export of frozen and processed marine products. The establishment of Central Marine Fisheries Research Institute (CMFRI), Central Institute of Inland and Brackish water Aquaculture (CIBA), and National Institute of Oceanography (NIO) has led to the generation of considerable information on various aspects of marine biology, fresh water and brackish water fisheries and oceanography. Consumption of fish for food has appreciably increased in recent years in all countries. So, to fulfill the demand of consumers there is need of very rapid growth in fisheries sector.

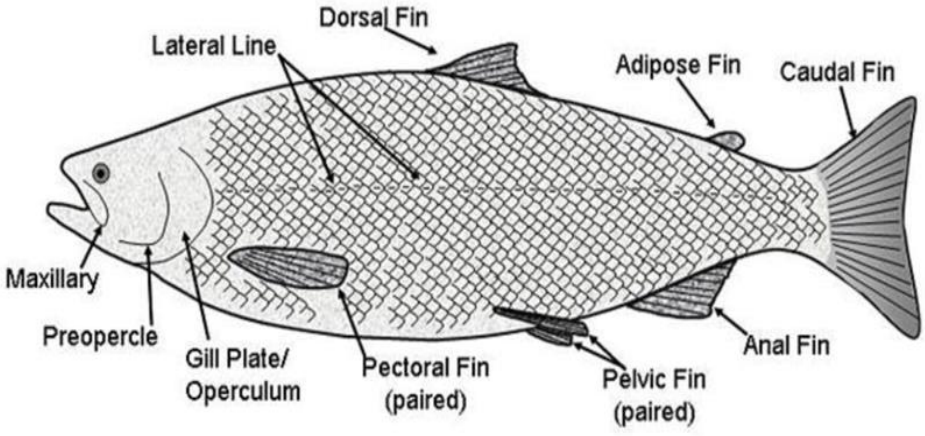

Fig. A generalized morphological structure of a fish

Since the 21th century, the global population has experienced rapid growth. Despite efforts in the agriculture sector to keep up with the demand of food, the pace of population growth has outstripped

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agricultural production (Ahmed et al., 2024). Consequently, this imbalance has resulted in an uneven distribution of essential nutrients such as protein, fat and calories in the diet consumed by the people (Pradhan et al., 2019). According to United Nation's estimates, there are over 900 million malnourished people worldwide with one fourth of them being children under the age group of four or five. These young children are particularly vulnerable to the adverse effects of severe protein and energy malnutrition (PEM). According to United Nation's estimates, there are over 900 million malnourished people worldwide with one fourth of them being children under the age group of four or five. These young children are particularly vulnerable to the adverse effects of severe protein and energy malnutrition (PEM).

Although different traditional techniques have already been employed in aquaculture, but recent technological advancements promise to reduce human intervention and enhance aquaculture productivity. Notably, AI stands out as a transformative force in the aquaculture industry (Mustapha et al., 2021). AI technologies are actively employed in monitoring and managing fish health and growth, leading to improved feed, diminished risk of disease outbreaks, and enhanced overall farm productivity. Sharma and Kumar (2021) emphasize the role of integrated sensors, biosensors, and AI in minimizing the reliance on antibiotics and other medications. This review focuses application of AI to enhance the efficiency and sustainability of fishery sector specially fish stock.

Applications of artificial intelligence in fishery sector:

The integration of Artificial Intelligence (AI) in aquaculture has revolutionized fish stock management. AI's predictive analytics and machine learning capabilities enable optimized feeding strategies, disease detection, and water quality monitoring. By analyzing genetic data, AI informs selective breeding programs, improving fish growth rates and disease resistance. AI-powered systems track fish movement and behavior, providing insights for aquaculture management. This technology enhances yields, reduces mortality rates, and promotes sustainable aquaculture practices. By applying AI, fish farmers and researchers can improve fish stock, increase efficiency, and contribute to global food security.

AI is revolutionizing traditional fish farming practices, leading to more efficient and sustainable operations. Here's a comprehensive overview of the role of AI in improving fish stock:

1) AI in monitoring water quality:

Fish growth and quality is directly depending upon water quality due to the fish's high reliance on the aquatic environment. This section aims to define how AI can be effectively employed in monitoring water quality within aquaculture systems. By analyzing data from sensors that measure parameters such as temperature, dissolved oxygen, pH and ammonia levels (Dupont et al., 2018). AI-powered water quality monitoring systems can continuously monitor multiple parameters in real-time, which can provide more accurate and timely information than manual monitoring methods (Javaid et al., 2022). This informs farmers to respond quickly to any changes in water quality, reducing the risk of fish mortality and other negative outcomes.

2) AI in disease detection and prevention:

A quality fish stock is depending upon healthy fish. AI is notably evident in the identification and treatment of fish infections (Li et al., 2023). AI can be used in analyzing the data from sensors and cameras to find indicators of illness or stress in fish.

3) AI in biomass monitoring:

Biomass of a fish pond is directly influenced the fish growth and quality. The use of AI offers new opportunities for modern aquaculture. Meanwhile, combining machine learning and vision can more precisely estimate fish's size, weight, number, and other biological data.

4) AI in fish feeding:

The cost of feeding fish accounts for 40–50 % of the total operational cost of aquaculture (Ogunlela and Adebayo, 2016). While measuring the amount of fish feed intake remains a significant challenge, the amount of feed dispensed to match fish appetite levels plays a significant role in increasing fish productivity. AI can also help to optimize feeding of fish and AI software can calculate the ideal feeding schedule and serving size. This could improve feed use, reduce waste, and foster fish growth and health. All these efforts are improved the fish stock.

5) AI in promoting growth rates:

The optimal temperature for the growth of fish varies, depends on the species of fish reared. Maintenance of the optimal temperature, fish farmers can promote faster growth rates and larger fish (Uddin et al., 2022). However, if the temperature rises too high or too low, it can negatively impact growth rates (Sivri et al., 2007). There are several ways in which growth rates, aquaculture, and AI are interconnected. Foremost factor is to monitor

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growth rate. AI can be used to monitor and manage the growth rates of these organisms, ensuring optimal conditions for growth and maximizing production.

6) AI in sustainable practices of fish:
Aquaculture has the potential to be a sustainable food supply, but it needs to be carefully managed to prevent harm to the environment. It has been reported that AI can be employed to keep an eye on environmental factors like water quality, fertiliser levels, waste reduction, and productivity (Krishnan et al., 2021).

7) AI in fish reproduction:
The study of reproductive mechanisms is crucial from fish stock point of view. Fishermen can encourage effective reproduction and increase the number of fish in their farm by adjusting the temperature conditions. AI can be used to enhance feeding and water quality, regulate fish populations, and prevent disease outbreaks (Prapti et al., 2022).

8) AI in breeding programs:
Based on genomic data, AI can be used to create prediction models of fish performance, allowing for more effective and focused breeding programmers for qualities like disease resistance and growth rate. This practice is useful to improvement in fish stock.

9) AI in conservation genetics:
AI can be used to analyze genetic data from endangered or threatened fish species, enabling better understanding of their genetic diversity and potential for conservation. The conservation of these species is important for maintaining healthy aquatic ecosystems and preserving the biodiversity of our planet.

BENEFITS

1. Improved yields: AI can help optimize fish growth, reducing mortality rates and improving yields.
2. Increased efficiency: AI can automate tasks, such as water quality monitoring and feeding, reducing labor costs and improving efficiency.
3. Sustainable aquaculture: AI can help promote sustainable aquaculture practices, reducing environmental impacts and improving fish welfare.

CHALLENGES AND OPPORTUNITIES

1) High initial investment: AI technology requires significant investment.
2) Skill development: Farmers need training to effectively use AI technologies.
3) Integration with existing practices: AI integration requires changes to traditional methods and infrastructure.

By addressing these challenges, the aquaculture industry can harness the potential of AI to improve fish stock, increase efficiency and promote sustainable practices.

FUTURE RECOMMENDATIONS

AI is expected to play a more significant role in the effective and sustainable management of fish production, fish stock as well as in improving the overall health and well-being of farmed fish. With the implementation AI tools in fish culture practices minimizes the cost of labors and experts as well as fish stock loss, and helpful in effective improvement of this sector which is ultimately useful to farmers.

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BANKING ON SUSTAINABILITY: ESG COMPLIANCE AND FINANCIAL LEADERSHIP IN 21ST CENTURY INDIA

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ABSTRACT
The integration of Environmental, Social, and Governance (ESG) principles has become a pivotal focus for the Indian banking sector in the 21st century. This paper explores the evolving landscape of ESG compliance and the role of financial leadership in fostering sustainable banking practices in India. Through a comprehensive review of recent literature and analysis of current trends, the study examines regulatory frameworks, leadership strategies, challenges, and the path forward for ESG integration in Indian banks. The findings highlight the critical importance of proactive leadership and robust governance in achieving sustainable financial growth.

Keywords: *Sustainable Finance, ESG Compliance, Indian Banking Sector, Financial Leadership, Regulatory Frameworks, Green Finance, Climate Risk Management*

1. INTRODUCTION
In recent years, the global financial ecosystem has witnessed a paradigm shift towards sustainability, with Environmental, Social, and Governance (ESG) factors taking center stage. In India, this transition is not merely a trend but a necessity, driven by the country's commitment to sustainable development and climate resilience. The Reserve Bank of India (RBI) and the Securities and Exchange Board of India (SEBI) have introduced frameworks aimed at integrating climate-related financial risks into their regulatory regimes, underscoring the importance of ESG compliance for financial institutions. Indian banks are increasingly recognizing that ESG integration is not just about regulatory compliance but also about risk management and value creation. By embedding ESG principles into their operations, banks can mitigate environmental and social risks, enhance their reputation, and tap into new market opportunities. However, this integration poses challenges, including the need for robust governance structures, accurate data collection, and cultural shifts within organizations. Financial leadership plays a critical role in facilitating ESG transformation within banks. Visionary leaders are needed to drive sustainability strategies, align financial goals with environmental responsibility, and communicate ESG values across organizational layers. Banks must now reimagine traditional financial models to align with broader ecological and social objectives. Furthermore, increased investor scrutiny and international benchmarks compel Indian banks to keep pace with global ESG expectations.

This paper explores the role of leadership and policy in guiding the Indian banking industry toward sustainability. It also examines how ESG compliance frameworks and green finance mechanisms are shaping the trajectory of 21st-century Indian banking.

2. REVIEW OF LITERATURE

2.1. Nishith Desai Associates (2024): This analysis highlights the RBI's draft disclosure framework, which mandates regulated entities to disclose information on climate-related financial risks and opportunities. The framework emphasizes governance, strategy, risk management, and metrics/targets, aiming for phased implementation to enhance transparency and resilience in the financial sector. The phased approach gives banks time to upgrade systems while aligning with global standards such as TCFD.

2.2. EY (2024): EY's report underscores India's emergence as the second-largest funding hub for climate-focused companies, with US$5.1 billion invested in 2024. Despite this progress, the report indicates that India requires US$10.1 trillion from 2020 to 2070 to achieve net-zero emissions, highlighting the significant funding gap in climate finance. The study emphasizes the importance of banks as key conduits for green capital allocation and climate adaptation.

2.3. ICICI Bank (2024): In its ESG Report, ICICI Bank outlines its commitment to environmental sustainability, socio-economic development, and robust corporate governance. The report details initiatives such as responsible financing, reducing carbon footprint, and promoting financial inclusion, reflecting the bank's dedication to integrating ESG principles into its operations. Their report serves as a model for balancing profitability with responsible banking.

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2.4. Anuj Kumar (2024): Kumar discusses the RBI's proactive stance in promoting sustainable banking practices, particularly through the release of draft guidelines for climate risk disclosures in March 2024. These guidelines aim to bolster the resilience of regulated entities and emphasize robust risk management in the face of climate change challenges. He stresses the need for banks to adopt climate stress testing and invest in ESG-aligned products.

3. OBJECTIVE OF THE PAPER

The objective of the paper is to analyze the role of financial leadership in facilitating ESG compliance within the Indian banking sector, identifying challenges, and proposing strategies to enhance sustainable banking practices.

4. REGULATORY FRAMEWORKS GOVERNING ESG COMPLIANCE

The Reserve Bank of India (RBI) has taken the lead in formalizing ESG frameworks for banks. In March 2024, it issued draft guidelines requiring financial institutions to disclose governance structures, climate strategy, ESG risk management tools, and performance metrics. This framework is aligned with global best practices, including TCFD and NGFS recommendations.

SEBI's Business Responsibility and Sustainability Reporting (BRSR) mandates the top 1000 listed companies to provide detailed ESG disclosures. Indian banks that are publicly listed are therefore required to report on material ESG factors, including carbon emissions, gender diversity, financial inclusion efforts, and board-level oversight.

These policies reflect a broader governmental and regulatory push toward climate-aligned finance. Leadership must ensure that internal systems and reporting protocols evolve in tandem with these frameworks. Compliance is no longer a check-the-box activity but a strategic imperative.

Table 1: ESG Adoption and Sustainable Finance Trends in Indian Banking (2023–2024)

Indicator	2023	2024 (Estimated)
Banks publishing stand-alone ESG reports	47%	61%
Green bonds issued (INR Cr.)	₹11,300	₹14,000
Banks with ESG committees at board level	39%	53%
ESG-trained banking professionals	5,200	8,000
Share of green loans in total lending (%)	3.2%	4.7%

Source: RBI Circulars, EY Climate Finance Report (2024), SEBI BRSR Dashboard, KPMG India ESG Outlook (2024)

5. LEADERSHIP STRATEGIES FOR EFFECTIVE ESG INTEGRATION

Indian banking leaders are adopting several key strategies to align their institutions with ESG norms:

- **Dedicated ESG Oversight:** Many banks have created board-level ESG committees responsible for approving sustainability targets and monitoring risk exposure.
- **Linking Executive Pay to ESG KPIs:** Institutions like HDFC Bank and Axis Bank have started aligning compensation structures with ESG goals, signaling accountability at the leadership level.
- **ESG-Focused Lending:** Banks are embedding ESG scoring in credit decisions, offering better terms for green projects or businesses with strong ESG credentials.
- **Public Disclosure and Transparency:** Banks are issuing stand-alone ESG reports and participating in global indices like MSCI ESG and DJSI to benchmark performance.
- **Employee Engagement:** Training programs and workshops on sustainability help drive awareness from top executives to front-line employees.
- **Innovation in Financial Products:** Institutions are designing ESG-linked bonds, green deposits, and renewable project finance structures to align their offerings with climate goals.
- **Digital Solutions:** Technology plays a key role in collecting ESG data, automating disclosures, and analyzing carbon-intensive portfolios.

Strong leadership ensures that ESG is not siloed within the compliance department but becomes embedded across product design, risk assessment, operations, and culture.

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6. CHALLENGES IN ESG ADOPTION AND COMPLIANCE

Indian banks face several challenges in adopting ESG norms effectively:

- **Data Quality and Availability:** Inconsistent data and limited benchmarks hamper ESG evaluation and performance tracking.
- **Skills Gap:** There is a shortage of professionals with ESG expertise, particularly in climate risk modeling and sustainability reporting.
- **Cost Implications:** Investing in ESG integration—systems, consultants, audits—can be resource-intensive, especially for small and mid-sized banks.
- **Greenwashing Concerns:** Without robust verification systems, banks risk overstating sustainability commitments.
- **Regulatory Overlap:** Different agencies issue ESG guidelines, creating ambiguity and administrative burden for banks.
- **Customer Awareness:** Low understanding of ESG-linked products among borrowers makes it harder to scale green finance offerings.

To overcome these hurdles, Indian banks must strengthen internal capabilities, collaborate with rating agencies, and advocate for standardized ESG taxonomies.

7. RESEARCH METHODOLOGY

a. **Type of Data:** Secondary data sourced from government and regulatory reports (RBI, SEBI), bank ESG disclosures, consultancy whitepapers (EY, KPMG, PWC), and scholarly publications.

b. **Type of Research:** Descriptive and analytical research focused on evaluating trends, frameworks, strategies, and leadership models related to ESG in Indian banking.

c. **Period of Research:** The Period of study is from 2023–2024

8. CONCLUSION

The Indian banking sector is at a critical juncture as it transitions toward sustainable and responsible finance. ESG compliance is no longer optional but foundational for long-term stability, reputation, and profitability. Financial leadership plays a central role in embedding ESG values, steering strategic decisions, and fostering a culture of sustainability. Proactive efforts in regulatory compliance, stakeholder engagement, and innovation can turn ESG integration into a competitive advantage. However, the road ahead requires investment in talent, technology, and transparency. A united effort by leadership, regulators, and stakeholders will shape the future of sustainable banking in India. As ESG frameworks continue to evolve, banks that prioritize ethical leadership and responsible finance will emerge as frontrunners in the 21st-century financial landscape.

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EXPLORING THE IMPACT OF SOCIAL MEDIA ADDICTION ON MENTAL HEALTH: A COMPREHENSIVE ANALYTICAL STUDY

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ABSTRACT
Mental health has emerged as a critical area of concern in recent years, driving the need for innovative approaches to understanding and addressing psychological well-being. Social media platforms have become a rich source of real-time data, reflecting users' emotions, behaviors, and social interactions. This paper provides a comprehensive review of current research at the intersection of mental health and social media. It explores the opportunities for utilizing social media data in mental health assessments, highlights the associated benefits and risks, and evaluates diverse methodologies applied in the field. Furthermore, the paper discusses the ethical implications of using social media for mental health insights and outlines prospective directions for future research and responsible practice in this evolving digital landscape.

INTRODUCTION
Mental health plays a vital role in an individual's overall well-being, encompassing cognitive, emotional, and social functioning. It determines how people manage stress, build relationships, and make decisions in daily life. With rising global awareness around mental health challenges, there is an increasing demand for innovative solutions to support mental wellness. At the same time, the proliferation of social media platforms such as Facebook, Instagram, Twitter, and TikTok has significantly reshaped how individuals communicate, share experiences, and interact socially.

While social media presents opportunities for connection and emotional expression, it also introduces complex psychological consequences. Research has shown both the positive and negative influences of social media usage. On one hand, it can create spaces for peer support and access to mental health resources; on the other, excessive or unregulated use may contribute to heightened anxiety, depressive symptoms, and digital dependency.

This paper investigates the intricate relationship between social media engagement and mental health, particularly focusing on the phenomenon of social media addiction. By critically reviewing contemporary literature and analyzing diverse methodologies, this study aims to uncover how social media behavior can provide insights into mental health conditions. The discussion further explores ethical concerns, challenges, and future directions for integrating social media analytics into mental health strategies.

LITERATURE REVIEW
The relationship between social media use and mental health has become a central focus in psychological and behavioral research over the past decade. Numerous studies suggest that social media platforms can serve as beneficial spaces for individuals facing mental health difficulties by fostering virtual communities, peer support networks, and accessible resources. Digital platforms like online forums and dedicated mental health groups provide opportunities for individuals to share personal experiences, seek guidance, and feel less isolated. Furthermore, campaigns on platforms like Instagram and Twitter have played a vital role in raising mental health awareness and reducing societal stigma.

Despite these positive aspects, a substantial body of literature also points to detrimental outcomes associated with excessive or unmoderated social media usage. Prolonged engagement has been associated with increased levels of anxiety, depressive symptoms, stress, and social withdrawal, particularly among adolescents and young adults. One notable psychological effect is "social comparison," where users experience reduced self-worth and satisfaction when comparing themselves to the idealized lives presented by others online. Additional concerns include the prevalence of cyberbullying, harassment, and exposure to triggering content—all of which can severely impact emotional well-being.

Methodologically, researchers have approached this topic through both qualitative and quantitative means, utilizing surveys, longitudinal studies, psychological assessments, natural language processing, and machine learning to interpret patterns of behavior and emotional expression on social media. While these studies have offered significant insights, gaps remain—particularly in establishing causal relationships and understanding long-term mental health trajectories influenced by digital media exposure. As the field evolves, more nuanced, interdisciplinary approaches will be crucial for drawing reliable conclusions.

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METHODOLOGY

To investigate the complex relationship between social media use and mental health, this study utilized a **mixed-methods research design**, integrating both quantitative and qualitative approaches to ensure comprehensive data analysis.

Quantitative data was obtained via structured surveys distributed to a diverse demographic sample. The survey instruments included validated psychological tools such as the **Depression Anxiety Stress Scales (DASS-21)** and the **Social Media Addiction Scale (SMAS)**, designed to evaluate emotional states and patterns of digital engagement. Participants were also asked to report on their daily social media usage frequency, platform preferences, and self-perceived mental health status.

Complementing the quantitative findings, **qualitative data** was collected through semi-structured interviews with a selected subset of respondents. These interviews provided rich, narrative insights into individuals' experiences, motivations, and emotional responses associated with social media usage. The qualitative responses were analyzed using **thematic analysis**, allowing for the identification of recurring concepts, coping strategies, and emotional triggers.

The collected data was subjected to statistical analyses including **correlation**, **regression**, and **factor analysis**, aimed at identifying significant relationships and predictive variables influencing mental health outcomes. The combination of both data types enabled a robust exploration of behavioral trends and psychological impacts, ensuring a multi-dimensional understanding of the effects of social media engagement on mental well-being.

Case Studies:

Case Study 1: A 19-year-old female undergraduate student exhibited heightened symptoms of anxiety and depressive moods, which she directly associated with her intensive use of Instagram. She described feeling compelled to maintain an idealized online persona and routinely compared herself to influencers and peers, resulting in diminished self-esteem and persistent stress. Following professional intervention through Cognitive Behavioral Therapy (CBT), she gradually developed strategies to moderate her usage, shift focus away from external validation, and prioritize real-life interactions, ultimately leading to improved mental health outcomes.

Case Study 2: A 25-year-old male software engineer turned to Twitter during a period of personal isolation caused by the COVID-19 pandemic. He reported that engaging with online communities that shared similar emotional struggles provided him with a sense of support and solidarity. However, he also encountered distressing content, including aggressive debates and emotionally triggering posts, which at times exacerbated his emotional instability. With guided support, he began curating his feed, limiting exposure to negative content, and engaging more intentionally with supportive digital spaces.

These case studies reflect the dual-edged nature of social media's psychological impact. While such platforms can serve as powerful tools for emotional connection and support, unregulated usage can reinforce harmful thought patterns. These examples highlight the necessity for personalized digital boundaries and the role of therapeutic guidance in fostering balanced online engagement.

CONCLUSION

The dynamic interplay between social media use and mental health presents a nuanced landscape of both opportunities and challenges. On one hand, digital platforms have the capacity to foster emotional connection, peer support, and widespread mental health advocacy. On the other, excessive or unregulated usage can contribute to adverse psychological outcomes, including anxiety, depression, and self-comparison.

This study has synthesized key findings from contemporary research, evaluated diverse methodologies, and presented case-based insights to underscore the multifaceted effects of social media engagement. The evidence suggests a growing need for more refined, ethically grounded frameworks that promote healthy digital behavior without compromising emotional well-being.

Future efforts should prioritize the development of personalized interventions, digital wellness education, and algorithmic safeguards that can mitigate exposure to harmful content. Additionally, interdisciplinary collaboration between technologists, psychologists, and policy-makers is essential for creating socially responsible platforms that nurture rather than undermine mental health. By striking this balance, social media can evolve into a supportive ecosystem that contributes positively to psychological resilience and community wellness.

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APPLICATIONS OF FRACTIONAL CALCULUS IN ROBOTICS: REVIEW

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ABSTRACT
Fractional Calculus is a branch of mathematics that extends the integer order derivatives and integrals to arbitrary order derivatives and integrals. Fractional Calculus has a memory effect. This concept provides a broad framework for modelling complex systems in physical science, engineering, technology and biology where traditional calculus fails. The field of robotics has adopted the framework of fractional calculus. Fractional Calculus provides a various approach to control and optimize the capacity of a robot with memory and hereditary properties. In this article the review of applications of fractional calculus in Robotics is presented.

1. INTRODUCTION
The subject of fractional calculus originated in the late 17th century with the help of the theory of classical calculus. In 1695, the concept of fractional calculus was first introduced in a letter by L'Hospital to Leibniz about the discussion of the meaning of a half order derivative. Leibniz remarks on the potential for this type of operation, paving the way for future investigations. Although the concept drew some attention early on, fractional calculus remained a theoretical topic for more than a hundred years, highlighting its intricate and profound nature. It wasn't until the 19^{th} century that major progress was made, with key contributions from mathematicians like Riemann and Liouville, who helped in the establishment of the formal framework of the field. The foundation of fractional calculus was built by Liouville, who gave the definitions for fractional integration and differentiation with definite integrals. Based on this, Riemann extended this idea through what is now known as the Riemann-Liouville integral[1,2]. These significant foundational contributions laid the groundwork for a robust mathematical framework, which has since enabled the broad application of fractional calculus in various scientific fields. Now, fractional calculus plays a vital role in advancing research and development across diverse disciplines. The integration of fractional calculus into robotics has brought a transformative advancement, enabling the creation of more robust and efficient control mechanisms. Traditional control methods frequently struggle with the complexity and unpredictability inherent in robotic systems. In contrast, fractional calculus provides a more sophisticated modelling tool, capable of capturing memory effects and hereditary dynamics. As a result, this approach has significantly improved various aspects of robotics, including motion planning, system stability, and adaptive control.[3-6] Traditional control methods often struggle to manage the complexities and uncertainties inherent in robotic systems. Fractional calculus provides a more sophisticated framework for control and optimization due to its ability to represent systems with memory and hereditary characteristics[7]. This approach has significantly improved various aspects of robotics, including motion planning, stability, and adaptive control. One of the notable benefits of applying fractional calculus in robotics lies in its capacity to model dynamic systems with greater accuracy[8]. In many cases, robots function in unpredictable environments with varying loads and external disturbances, where conventional integer order models may prove inadequate. In contrast, fractional order controllers, such as the fractional order proportional integral derivative controllers[9,10] offer improved reliability and control performance. These controllers are particularly effective in handling system nonlinearities and changes in parameters, resulting in more stable and efficient operations. Additionally, fractional calculus has contributed significantly to advancements in robotic path planning and trajectory optimization, allowing robots to navigate complex and rapidly changing settings with higher precision[11,12]. By incorporating fractional order modeling, researchers have devised algorithms that enhance path optimization, leading to smoother transitions and improved energy efficiency. Overall, the use of fractional calculus in robotics represents a major advancement, offering creative solutions to long-standing problems and setting the stage for the development of more intelligent and autonomous robotic technologies. In line with this progress, this article highlights a wide array of research focused on the application of fractional calculus across different robotic systems. It includes nine research articles and one review, which will be briefly outlined in the following section. The aim of this editorial is not to delve into each contribution in depth but rather to invite readers to engage with the content themselves.

2. A REVIEW OF EXISTING ARTICLES
In this section we have presented the review of the certain articles published by researchers on the applications of Fractional calculus in Robotics.

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The study conducted by Likun Li et al.[13] introduces an innovative strategy for path planning in car like mobile robots equipped with suspension systems. Their method incorporates a fractional order enhancement into the traditional ant colony optimization algorithm, presenting a novel solution designed to create smooth and efficient paths, even in both confined and expansive environments. This approach features a precise kinematic modeling technique based on fractional order calculus, along with an improved ant colony optimization framework that integrates dynamic angle limitations, adaptive pheromone regulation, and fractional order state transition models.

Ataslar Ayyıldız[14] introduced a fractional order proportional tilt integral derivative controller specifically tailored for serial robotic manipulators. This controller was developed to enhance trajectory tracking precision while minimizing the effects of external disturbances and system uncertainties. To fine tune the controller parameters, a hybrid optimization technique combining Gray Wolf Optimizer and Particle Swarm Optimization was employed. The results highlighted improved trajectory tracking performance and greater robustness when compared to conventional controllers. Moreover, the controller exhibited lower energy consumption, further validating its stability and effectiveness under persistent disturbances.

Timi Karner et al.[15] explored the application of dielectric elastomers in the field of soft robotics, emphasizing their viscoelastic characteristics. To effectively model this behavior, they developed a comprehensive fractional Maxwell model through the use of the Laplace transform. Utilizing experimental data, they applied the Pattern Search global optimization technique to identify the optimal parameters and the suitable number of branches for the model. This approach offers potential for controlling dielectric elastomer actuators and can also be adapted for simulating other viscoelastic materials.

Kishore Bingi et al.[16] offers a thorough overview of the latest advancements in fractional-order modeling and control techniques for robotic manipulators. These manipulators play a vital role in numerous applications, particularly in environments that are either inaccessible or dangerous for humans. Given their complexity, precise modeling and the development of resilient control mechanisms are essential to manage various uncertainties. This review consolidates extensive research in the domain, aiming to enhance the knowledge base of the control engineering field. It encompasses a detailed analysis of approximately 95 relevant studies, addressing aspects of modeling, control methods, and prospective research opportunities.

Bhukya Ramadevi et al.[17] have introduced a novel hybrid neural network approach designed to significantly enhance wind power forecasting. The framework integrates a long short term memory network to estimate missing wind speed and direction values, coupled with a fractional-order neural network that employs a fractional arctangent activation function to boost prediction accuracy. By effectively addressing the issue of incomplete data, their model demonstrates improved precision in forecasting wind power and shows considerable potential in this domain.

Xuan Liu[18] presents a framework aimed at integrating digital twins with industrial robots to enable real-time monitoring and optimize performance. The proposed system combines multi-domain modeling, behavior matching, control refinement, and continuous parameter adjustment. A key feature of the framework is a fractional order controller enhanced by a modified particle swarm optimization algorithm, which significantly boosts control efficiency. Experimental results confirm notable improvements in time domain metrics, such as minimized overshoot, shorter peak time, and faster settling time.

The study by Dora Morar et al.[19] presents two distinct approaches for designing controllers in a mechatronic system. The first approach utilizes linear matrix inequalities to formulate an optimization problem, aiming to position the closed loop poles while managing model uncertainties through linear differential inclusions. The second strategy proposes a cascade control structure, comprising an inner proportional controller and an outer fractional order integral derivative controller. Here, four degrees of freedom are given to each axis in the system. The paper also provides a numerical case study and evaluates the system's performance using various metrics.

Yixiao Ding[20] proposed a novel impedance controller for robotic manipulators that operates on fractional-order principles. This approach utilizes fractional calculus to model damping forces with greater precision compared to conventional methods. The authors also present a structured tuning strategy grounded in frequency domain design. Performance evaluations reveal that the fractional order controller outperforms traditional integer order controllers, particularly in terms of step response and resistance to external disturbances.

Weidong Liu[21] proposes a novel fractional active disturbance rejection control approach designed specifically for remotely operated vehicles. This method integrates a dual closed loop fractional order PID controller with a

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model assisted finite time sliding mode extended state observer. Far from being purely theoretical, this control strategy proves to be practically effective in ROV applications. It showcases strong disturbance rejection capabilities and operates reliably even without precise model information, thereby supporting high-precision operations despite the presence of external disturbances and model uncertainties.

The study by Mohamed Naji Muftah[22] aimed to improve the efficiency of a pneumatic positioning system by designing a control mechanism that utilizes fuzzy fractional order proportional integral derivative controllers. These controllers were fine tuned using a particle swarm optimization technique. Experimental results conducted in real time demonstrated that the new approach delivered better speed, stability, and accuracy than the conventional fuzzy PID controller. The developed system successfully manages the control of a pneumatically operated ball and beam setup.

3. CONCLUSIONS

This article has successfully highlighted fractional calculus's expansive and varied applications in enhancing robotic systems, demonstrating its critical role in modern robotics research and development. By incorporating fractional calculus into their methodologies, researchers have addressed complex problems with greater precision and efficiency, showcasing the versatility and robustness of this mathematical approach. The articles considered for this study cover diverse topics, from improving control accuracy and optimizing path planning to enhancing system robustness against disturbances and uncertainties. The ten articles in this study encapsulate various innovative approaches and novel methodologies. These contributions push the boundaries of robotics, emphasizing theoretical advancements and practical implementations. Each article presents unique solutions to longstanding challenges in robotics, highlighting the potential of fractional calculus to revolutionize various aspects of robotic technology. In summary, this article collectively underscores the significant impact of fractional calculus in advancing robotic technology and encourages further exploration and development in this promising study area.

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E-GOVERNANCE IN INDIA AND ITS BENEFITS

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ABSTRACT
E-Governance in India has emerged as a transformative approach to governance, leveraging information and communication technology (ICT) to enhance the efficiency, transparency, and accessibility of government services. It aims to bridge the gap between the government and citizens by streamlining administrative processes and promoting participatory democracy. This article explores the evolution and implementation of e-Governance initiatives in India, including key projects such as the Digital India programme, National e-Governance Plan (NeGP), and various state-level digital services. The benefits of e-Governance are manifold—it improves service delivery, reduces corruption, empowers citizens, and enhances government accountability. Additionally, it fosters socio-economic development by enabling inclusive growth and digital literacy. Despite the progress, challenges such as digital divide, infrastructural limitations, and data security concerns remain. The article concludes by emphasizing the need for sustained policy support, capacity building, and public-private collaboration to realize the full potential of e-Governance in India.

Keywords: *E-Governance, Digital India, ICT in governance, Transparency, Government accountability*

INTRODUCTION
In the era of rapid technological advancement, governance too has undergone a digital transformation. E-Governance, or electronic governance, refers to the use of information and communication technology (ICT) for delivering government services, exchanging information, and integrating various systems and processes within the government framework. In India, the push for e-Governance has become a cornerstone of administrative reforms, aimed at increasing transparency, efficiency, and citizen participation.

The evolution of e-Governance in India has been shaped by a variety of factors including the rising demand for better public services, increased internet penetration, smartphone usage, and a proactive policy approach by the government. From the humble beginnings of computerizing government departments to the development of comprehensive online portals like Digital India, e-Governance is revolutionizing how the Indian government interacts with its citizens.

Evolution of E-Governance in India

Early Initiatives
E-Governance in India began in the 1970s with a focus on computerizing government departments. The National Informatics Centre (NIC), established in 1977, played a pivotal role in introducing computers in government offices. By the 1980s, district-level computerization began, and data management became more streamlined.

1990s: The Birth of E-Governance
The 1990s witnessed the emergence of public interface services such as railway reservation systems, income tax returns, and land record computerization. These initiatives marked the shift from government-centric to citizen-centric services.

2000s: Towards Integration
This period saw the launch of the **National e-Governance Plan (NeGP)** in 2006, which aimed at providing services to citizens in a seamless manner through the Common Services Centers (CSCs). This initiative included 31 Mission Mode Projects (MMPs) like e-Courts, e-Office, MCA21, and e-District.

Digital India Programme (2015)
Launched in 2015, the **Digital India Programme** is the flagship initiative that aims to transform India into a digitally empowered society and knowledge economy. Its vision is centered around three key areas:

Digital infrastructure as a utility to every citizen

Governance and services on demand

Digital empowerment of citizens

Key Components of E-Governance in India

Government to Citizen (G2C)

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Services include online portals for income tax filing, passport applications, utility bill payments, voter registration, and birth/death certificates. Platforms like **DigiLocker**, **UMANG App**, and **e-Hospital** are examples.

Government to Business (G2B)

Simplification of licensing, permits, and tax systems through portals like **GSTN**, **MCA21**, and **GeM (Government e-Marketplace)**.

Government to Government (G2G)

Enhancing internal efficiency through digitized data sharing between departments. Initiatives like **e-Office**, **e-Prisons**, and **Police IT** are examples.

Government to Employee (G2E)

Services like payroll, attendance systems, and grievance redressal portals for government employees.

Major E-Governance Initiatives in India

Digital India
As the umbrella initiative, Digital India encompasses all aspects of digital empowerment—from infrastructure and services to digital literacy.

Aadhaar
The biometric-based Unique Identification Number serves as a backbone for service delivery, direct benefit transfers, and KYC verification.

DigiLocker
Enables citizens to store and access important documents like driving licenses and academic certificates digitally.

UMANG (Unified Mobile Application for New-Age Governance)
A multi-service platform that integrates various government services under a single mobile app.

BharatNet
Aims to connect all 2.5 lakh Gram Panchayats with high-speed internet, bridging the urban-rural digital divide.

Benefits of E-Governance in India

Transparency and Accountability
By digitizing processes and making information publicly available, e-Governance reduces corruption and increases accountability. Portals such as **RTI Online** and **e-Procurement** systems ensure that processes are traceable and auditable.

Improved Efficiency and Productivity
Automation of repetitive tasks, integration of databases, and reduction in paperwork leads to faster decision-making and improved productivity. Services like **e-Office** reduce the time for file movements and approvals.

Accessibility and Inclusion
E-Governance bridges the gap between urban and rural India. Through CSCs and mobile apps, services reach even the remotest areas, ensuring digital inclusion. Platforms are now multilingual and accessible to people with disabilities.

Cost-effectiveness
Digitization significantly reduces administrative costs related to paper, printing, storage, and logistics. Citizens also save on travel and waiting time by accessing services online.

Citizen Empowerment
Access to real-time information and services enables citizens to make informed decisions and actively participate in governance. Tools like **MyGov** portal allow direct communication between citizens and policymakers.

Time-bound Service Delivery

E-Governance enables faster service delivery. Systems like **e-District** and **e-Courts** ensure that services such as certificates, permits, and court proceedings are delivered within a stipulated time.

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Environmental Benefits
Reduced use of paper and fossil fuels for commuting results in a lower carbon footprint, contributing to environmental sustainability.

Challenges in Implementation of E-Governance

Digital Divide
Despite efforts, internet connectivity and digital literacy remain limited in several rural and remote areas, creating a gap in access to services.

Cyber security and Privacy Concerns
Data breaches, identity theft, and lack of strong data protection laws pose serious risks to citizens' personal information.

Resistance to Change
Both citizens and government employees may resist moving away from traditional systems due to a lack of awareness or fear of technology.

Interoperability Issues
Different government departments often use non-compatible systems, making data exchange difficult and hampering integrated service delivery.

Infrastructure Constraints
Power shortages, poor internet bandwidth, and lack of reliable hardware in rural areas hinder the smooth implementation of e-Governance.

Language and Literacy Barriers
A large section of the population is not proficient in English or Hindi, and many digital platforms are not yet available in regional languages.

Future Prospects of E-Governance in India
As India progresses towards becoming a $5 trillion digital economy, the role of e-Governance is expected to expand exponentially. Key trends and future directions include:

AI and Machine Learning: For predictive governance and personalized citizen services.

Blockchain Technology: For secure land records, contract management, and supply chain transparency.

5G Connectivity: Enabling high-speed services and real-time video communication.

Smart Governance: Integration with smart city projects for real-time monitoring of services.

Cloud Computing and Big Data: For scalable infrastructure and better analytics in decision-making.

CONCLUSION

E-Governance in India is not just a technological shift but a democratic one. It empowers citizens, ensures efficient public service delivery, and strengthens the foundation of good governance. While challenges persist, sustained investment in infrastructure, digital literacy, and cybersecurity can overcome these hurdles. The vision of a transparent, accountable, and inclusive governance ecosystem is slowly but steadily becoming a reality through e-Governance.

As India marches forward in the digital age, e-Governance will continue to play a pivotal role in transforming public administration, deepening democratic processes, and improving the quality of life for every Indian citizen.

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IMPACT OF CHATGPT FOR COMPUTER STUDENTS: LITERATURE REVIEW.

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ABSTRACT:
ChatGPT is a widely used tool. It is used by most of the youth of today's generation to ease their work in academics. In this paper the researcher has done a Literature Review to understand how ChatGPT helps students in their academics.

However the tool has its pros and cons. Along with being an integral part of education today, it also hampers the skills of the students. They lack critical thinking to solve a problem and rely completely on the AI tool. The paper aim to study the impact of ChatGPT in students. The learners should see its positive and negative impact as well. In Programming language the tool generates the code directly which the students use without having any analytical skills. A study is done to describe the way ChatGPT has become popular and an interesting tool among various learners and how the tool is popular among students in their academics. When students use ChatGPT, their tendency to explore other traditional educational resources reduces and they rely solely on ChatGPT, and this reliance on ChatGPT did not guarantee enhanced learning performance In long term will AI emerge as a powerful tool or it will affect human brains where they stop thinking. We made AI but are we losing to AI. The article concludes to call for further research to understand the impact of ChatGPT on education and to determine the most effective ways to integrate it into the classroom.

Keywords*: ChatGPT, Critical thinking, students, AI, programming , impact, computer education.*

INTRODUCTION

ChatGPT (Chat Generative Pre-Trained Transformer) is an AI tool developed by OpenAI , introduced in November 2022, has rapidly used in various educational systems. It is used to answer questions asked by the user. Its responses come from the transformer predicting text that includes sentences and paragraphs. This is based on sequences of text on which it is had been trained. It can give answers in any format like graphs, text. It is used to generate code for a particular programming language and also find bugs in it. It is an AI tool that generated human like responses. It's a machine learning which uses trained data to produce the text . The scope of the tool is not only restricted to educations but various fields like healthcare, Cyber security, Customer support, Research and many more. The tool also has certain limitation. Balancing the advantages and disadvantages, as well as addressing the concerns of using ChatGPT, poses critical challenges Some claim the data may not be accurate and it need to checked before using it. There is also limitations in generating educational content. However in Coming years its will yield impressive results provided we use it effectively.

OBJECTIVE:

1. Study the popularity of ChatGPT among various learners.
2. Analyze student's interaction with the AI tool and its efficiency.
3. Review the impact and areas where ChatGPT is explored and also study its limitations.

LITERATURE REVIEW:

1. In 2023, Zhenhai He author and others surveyed the undergraduates of computational thinking course to apply ChatGPT to improve the skill development. They used text analysis and social network analysis to check the use of AI tool. The methodology was used by seven different groups in the computational course. Group 1,3, 6 and 7 used ChatGPT more than group 2,4 and 5 when working on some keywords. The author discovered that the group that interacted more in discussion was the one that used ChatGPT. The others on the other hand could not interact so well as the usage of the tool was less. This research found the integration of ChatGPT in higher education, showing students' engagement with ChatGPT and enhanced their CT abilities.
2. In 2023, Harpreet Singh and other authors did a survey on group of students at MSc level to identify use of ChatGPT in academia to improve teaching learning activities. Some students were not aware of the tool, some had used it before. A graph was designed to show the positive impact of ChatGPT. The survey in this paper suggests that the students believe that there are many ways in which the tool can be positively or negatively used for education.
3. In 2024, .Hacer Güner and Erkan Er the researcher surveyed on three groups on different session. The first group used ChatGPT for programming purpose, The second group applied ChatGPT for enhancing writing

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skills and the last group used it for lab purpose. The study provided valuable insights into the impact of previous programming knowledge of the students who then used AI integration to find their and performance in a programming course.

4. In 2023, Dinesh Kalla, Nathan Smith and other authors explored ChatGPT. The study analyzed the advantages and disadvantages of ChatGPT. The author has done a comparative study on the various fields where ChatGPT can be applied. The author has used models like SFT, RM, SFT to understand the working of ChatGPT. A study is done to find the inpact on various fields like academics, cyber security, customer support and healthcare. They found ChatGPT is an innovative technology and show impressive results in years to come.
5. In 2024, Dr. Lina Kloub and Ayush Gupta examined the use of ChatGPT in computer education to explore the benefits and challenges. For this they conducted survey on computer students such to find whether they use ChatGPT ,in which areas , in terms of their frequency and how did they find the progress improving with its usage. Although the study found that using the tool in computer education help them refined their skills, it also had some challenges. Almost 83% students used the tool to solve their assignments, which affected their academic integrity and made them rely completely on the tool. The study revealed the positive impact of the tool was clarification of concepts, suggests that students perceive it as a valuable learning and at the same time raises ethical considerations.

RESEARCH GAP:

The researcher can find the negative impact of ChatGPT and explore more areas where it can be used effectively. Also a comparative study can be done to compare performance of students who do not use ChatGPT. Researcher can aim to focus on ethical and legal issues so the chat gpt can be used in a sustainable fashion. Also learners can focus on optimizing evaluation mechanism. A study can be done to understand long term effects of chat gpt and to analyze the programming capabilities of students without using ChatGPT.

Future research can be done to analyze the negative impact. ChatGPT can be used in project-based assessments where it can be used as a tool for research, problem-solving. This approach can encourages critical thinking while providing a platform for students to responsibly utilize AI tools in their academic .Performance can be studied pre and post use of the tool. A road map can be prepared to use the tool effectively so that the learners don't lose their thinking capabilities.

CONCLUSION

Conclusion and Future work: The study highlights the importance of ChatGPT in enhancing students' performance. It is effectively improving the writing skills of students and are achieving better performance outcome. The impact of ChatGPT is seen widely as positive among various learners of different profile.

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DETERMINANTS OF HOUSEHOLD WASTE MANAGEMENT BEHAVIOUR: AN EMPIRICAL STUDY OF KORAMANGALA WARD, BENGALURU, INDIA

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ABSTRACT
Solid waste management (SWM) has become a critical environmental concern in rapidly urbanizing Indian cities. In Bengaluru, the Koramangala ward reflects the city's socio-economic diversity and growing waste management challenges. This study investigates the determinants influencing household waste management behaviour in this urban locality.

The primary objective is to identify key socio-demographic and behavioural factors shaping household-level SWM practices. A structured questionnaire, validated by experts, was administered to 210 residents using both online and offline methods. The study applied descriptive statistics, multiple linear regression analysis, and ANOVA using IBM SPSS 21 to assess relationships between variables.

Findings reveal that household behaviour is significantly influenced by gender, age, education, occupation, awareness, government policies, and personal motivation. Notably, awareness emerged as the strongest positive predictor of responsible waste practices. In contrast, education, occupation, and ineffective community engagement showed a negative influence, highlighting a gap between knowledge and action.

The novelty of this research lies in its integration of perceptual, behavioural, and demographic variables within a single empirical framework specific to an urban Indian context.

In conclusion, the study underscores the need for awareness-based interventions and participatory approaches to promote sustainable household waste management, offering valuable insights for policy formulation and community-led waste governance.

Keywords: *Household Waste Management, Behavioural Determinants, Urban Sustainability, Solid Waste Management (SWM) and Awareness and Engagement*

1. INTRODUCTION
Solid waste management (SWM) has emerged as one of the most pressing urban environmental challenges in rapidly growing cities, particularly in developing countries like India. Effective household-level waste management plays a critical role in reducing environmental degradation, promoting public health, and ensuring sustainable urban development. In the context of Bengaluru—a metropolitan city grappling with mounting waste volumes and systemic inefficiencies—understanding the behavioural dimensions of household waste practices becomes vital.

This study focuses on the Koramangala ward in Bengaluru, a diverse urban locality that reflects a cross-section of the city's socio-economic fabric. The primary objective is to empirically investigate the socio-demographic and perceptual factors influencing household waste management behaviour. Using a structured questionnaire developed through expert validation, data was collected from 210 residents via both online and offline modes. The study employs multiple linear regression analysis to identify key determinants shaping household behaviour toward solid waste management. By integrating demographic indicators with behavioural constructs such as awareness, attitudes, government policies, and community engagement, this research seeks to provide a holistic understanding of what drives or hinders effective waste management at the household level.

This inquiry not only offers actionable insights for policymakers and municipal authorities but also contributes to the academic discourse on environmental behaviour, providing a model for replication in other urban contexts.

2. REVIEW OF LITERATURE
(Bhatia & Sharma, 2023) used structural equation modeling to analyze urban households in the National Capital Region. They found that financial consciousness, food consumption management, and intention to avoid waste were significant factors. Interestingly, COVID-19 improved food management behaviors (Bhatia & Sharma, 2023). (Sharma et al., 2021) analyze the recent trends in solid waste management in Indian cities. They point out the exponential growth in waste generation due to urbanization and changing lifestyles. The study

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underscores the need for decentralized waste treatment facilities and the integration of informal waste sectors into formal systems.(Bhushan & Giri, 2023) conduct a comparative analysis of solid waste management legislation in India, focusing on the evolution from the Municipal Solid Wastes (Management and Handling) Rules, 2000 to the Solid Waste Management Rules, 2016. They discuss the effectiveness of these regulations and their impact on improving waste management practices across the country. Household waste management is strongly influenced by community engagement, attitudes, and awareness initiatives. Improved practices result from educational campaigns and behavioral interventions, as seen in studies from Indonesia and China (Ferdinan et al., 2021; Wang et al., 2018; Widiyanto et al., 2019)

Socioeconomic factors such as education and income levels significantly affect compliance with proper waste disposal and sorting, especially when paired with infrastructure and policy support (Miliute-Plepiene & Plepys, 2015; Sujauddin et al., 2008; Tang et al., 2022). Health risks from poor waste management highlight the need for education and infrastructure upgrades (Boadi & Kuitunen, 2005). Integrated and multi-pronged approaches, including incentives and regulations, enhance urban recycling efforts (Morris & Holthausen, 1994; Sharp et al., 2010; Ye et al., 2020). Cultural and demographic factors, environmental awareness, and community-led actions further influence household behavior (Givano & Ismail, 2020; Jeamponk, 2013; Knickmeyer, 2020).

The literature shows that household waste management is shaped by education, awareness, socioeconomic status, and community participation. Effective strategies combine policy, infrastructure, and behavioral interventions for sustainable outcomes.

3. METHODOLOGY:

The primary objective of this research is to examine how changes in household behaviour impact solid waste management. A primary survey conducted among residents of Bengaluru's Koramangala ward between January and April 2025 served as the basis for the study. Following feedback from experts in academia and beyond, a systematic questionnaire was developed and refined. These experts evaluated each item in the questionnaire to determine its validity by looking at its relevance, the appropriateness of the phrases used, the structure, the logical flow and order of the questions, and the overall time required to complete the survey.

The actual questionnaire consists of seven sections: the first collects demographic information about the respondents; the second examines their awareness and practices regarding SWM; the third examines the challenges they face or the behavioural changes they have made regarding waste management in their homes; the fourth part uses a five-point Likert scale to get respondents' opinions on a range of SWM-related issues; and the final section asks respondents to provide comments and suggestions on how SWM procedures might be improved.

The survey was distributed to 210 respondents who were selected using simple random sampling methods. The respondents voluntarily filled out the questionnaire, which was available both online and offline using Google Forms. Among other communication methods, the link to the online survey was shared via WhatsApp and email in order to reach a larger audience.

The study employed a combination of descriptive analysis, multiple regression analysis, and one-way ANOVA. Descriptive analysis was used to present the data in an easy-to-understand and educational manner by summarising the data using frequencies and percentages to make the results easier to handle (Zulkipli et al., 2018). This approach allowed for the identification of significant trends and patterns by providing a summary of the data distribution, and multiple regression analysis and chi-square tests were used to examine the correlations between variables. The IBM SPSS Statistics (Statistical Package for the Social Sciences) 21 version was used to analyse the data.

4. RESULTS AND DISCUSSION

3.1. Waste Management Behaviour of Household

Table no. 1: Descriptive analysis of households' respondents

Demography	Attributes	Frequency	Percentage
Gender	Male	86	41
	Female	124	59
Age	30 to 39 years	92	43.8
	40 to 49 years	95	42.2
	50 to 59 years	23	11
Family Size	1-3 members	106	50.5

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	4-6 members	86	41
	More than 6 members	18	8.6
Education level	Degree	82	39
	Post Graduation	128	61
Occupation	Skilled	35	16.5
	White Collar	139	66.2
	Business	36	17.1
Income of the family	<50,000	11	5.2
	50,000 – 1Lakh	18	8.6
	1Lakh – 1.50 Lakh	81	38.6
	1.50 Lakh- 2 Lakh	74	35.2
	>2Lakh	26	12.4

Source: Filed Survey

The demographic profile of the respondents reveals a diverse yet balanced representation across key socio-economic variables. In terms of gender distribution, females constituted the majority with 59% (n=124), while males accounted for 41% (n=86). The age-wise distribution indicates that most respondents fall within the working-age population, with 43.8% (n=92) in the 30–39 years category and 42.2% (n=95) in the 40–49 years range. Only a small proportion (11%) were aged between 50 and 59 years. Regarding family size, half of the respondents (50.5%) reported having small families consisting of 1–3 members, followed by 41% with medium-sized families (4–6 members), and only 8.6% with more than six members. Educationally, the sample is well-qualified, with 61% (n=128) holding postgraduate degrees and 39% (n=82) having completed undergraduate degrees. In terms of occupation, a significant proportion (66.2%) were white-collar professionals, while 17.1% were engaged in business and 16.5% were skilled workers. Income distribution shows that a majority of the families (73.8%) fall within the middle to upper-middle-income brackets, earning between ₹1,00,000 and ₹2,00,000 per month. A smaller percentage reported earnings below ₹1,00,000 (13.8%), and 12.4% earned above ₹2,00,000. This demographic composition suggests a relatively educated, professionally active, and economically stable population, which is crucial for understanding their attitudes and behaviors relevant to the study.

Household waste generation in Koramangala shows a strong link to family size. Most households producing over 2 kg of total waste daily (41.4%) tend to have 4–6 members, while those generating 1–2 kg (51%) commonly fall into the 1–3 member category. Wet and hazardous waste were the highest in volume, with nearly half the respondents reporting over 2 kg daily, especially in larger families. E-waste generation was also notably high, with 50% of households regardless of size reporting over 2 kg. These patterns suggest that larger households contribute more to total waste, emphasizing the need for targeted waste reduction and segregation strategies based on family size.

4.2. Multiple Linear Regression Model

This study employed the multiple linear regression model of ordinary least squares, which is the most popular approach for estimating parameters due to its user-friendliness (Shafiei, 2017). Using multiple regression analysis, the factors influencing household waste management practices were examined. In mathematics, multiple regression equations can be expressed as follows:

$$Y = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + \beta6X6 + \beta7X7 + \beta8X8 + \beta9X9 + \beta10X10 + \beta11X11 + \varepsilon \ldots\ldots\ldots\ldots\ldots (1)$$

Where: Y is the dependent variable (Household Waste Management Behaviour), β0 is the intercept (constant). β1, β2,…,β11 are the regression coefficients for the corresponding predictor variables.

X1, X2,…,X11 represent the independent variables: X1 = Gender, X2 = Age, X3 = Education, X4 = Occupation, X5 = Income, X6 = Lived in City, X7 = Government Policies, X8 = Personal Motivation and Attitude, X9 = Fine and penalties for improper waste disposal, X10 = Community programme and engagement, and X11 = Awareness.

The model's empirical specification can be clarified by

HH Waste Management Behavior = β0 + β1 (Gender) + β2 (Age) + β3 (Education) + β4 (Occupation) + β5 (Income) + β6 (Lived in City) + β7 (Government Policies) + β8 (Personal Motivation and Attitude) + β9(Fine

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and penalties for improper waste disposal) + β10 (Community programme and engagement) + β11 (Awareness) + ε ……(2)

The Model Summary and ANOVA tables below show the findings of a multiple linear regression analysis that was performed to evaluate the predictive power of the independent variables on Household Waste Management Behaviour.

Table No.2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.651[a]	.423	.391	2.739

a. **Predictors:** (Constant), Gender, Age, Education, Occupation, Income, Lived in City, Government Policies, Personal Motivation and Attitude, Fine and penalties for improper waste disposal, Community programme and engagement, and Awareness.

Table No.3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1090.705	11	99.155	13.216	.000[b]
	Residual	1485.490	198	7.502		
	Total	2576.195	209			

a. **Dependent Variable:** Household Waste Management Behaviour

b. **Predictors:** (Constant), Gender, Age, Education, Occupation, Income, Lived in City, Government Policies, Personal Motivation and Attitude, Fine and penalties for improper waste disposal, Community programme and engagement, and Awareness.

The model yields an R value of 0.651, indicating a moderate to strong correlation between the set of independent variables and the dependent variable. The R Square value is 0.423, which implies that approximately 42.3% of the variance in Household Waste Management Behaviour change is explained by the model. The Adjusted R Square is slightly lower at 0.391, adjusting for the number of predictors in the model and providing a more accurate estimate of the model's explanatory power for the population. The Standard Error of the Estimate (2.739) represents the average distance that the observed values fall from the regression line, indicating the model's predictive accuracy.

The ANOVA (Analysis of Variance) test examines the overall significance of the regression model. The F-value of 13.216 with 11 degrees of freedom for regression and 198 degrees of freedom for residual suggests that the model is statistically significant. The associated p-value (Sig.) is 0.000, which is well below the conventional threshold of 0.05. This indicates that the model as a whole is significant, meaning that at least one of the independent variables significantly predicts the dependent variable.

The multiple linear regression analysis was conducted to examine the influence of various independent variables on the dependent variable Household Waste Management Behaviour. The model includes both demographic and perceptual/attitudinal predictors. The coefficients, standard errors, standardized beta values, t-statistics, and significance levels are presented in the table.

Table No.4: Coefficients Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	40.232	6.637		6.062	0
	Gender	-4	0.576	-0.562	-6.95	0
	Age	1.407	0.389	0.266	3.616	0
	Edu	-2.209	0.601	-0.308	-3.675	0
	Occupation	-2.266	0.537	-0.376	-4.222	0
	Income	0.359	0.298	0.101	1.206	0.229
	Lived in City	-1.518	0.317	-0.349	-4.79	0
	Govt. Policies	-1.632	0.366	-0.351	-4.459	0

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	Personal Motivation and Attitude	-2.726	0.694	-0.388	-3.929	0
	Fines and penalties for improper waste disposal	-0.32	0.368	-0.067	-0.87	0.385
	Community programme and engagement	-0.755	0.313	-0.17	-2.412	0.017
	Awareness	3.678	0.854	0.424	4.307	0

Source: Filed Survey

The regression model shows a good explanatory power with several variables significantly contributing to the prediction of Household Waste Management Behaviour. The intercept (constant) value is 40.232 ($p < .001$), which represents the expected baseline score of household waste management behaviour when all independent variables are held at zero.

Among the demographic variables: Gender shows a significant negative influence (B = -4.000, β = -0.562, $p < .001$), indicating that female respondents are more likely to engage in better waste management behaviour compared to males. Age has a significant positive effect (B = 1.407, β = 0.266, $p < .001$), suggesting that older individuals tend to demonstrate more responsible waste management practices. Education (Edu) has a negative and significant coefficient (B = -2.209, β = -0.308, $p < .001$), implying that as education level increases, waste management behaviour may decline. This could point toward overconfidence, time constraints, or a disconnect between education and practical environmental action. Occupation also has a significant negative effect (B = -2.266, β = -0.376, $p < .001$), suggesting that certain professional roles may limit time or motivation for participating in sustainable household practices. Income does not significantly influence waste management behaviour ($p = .229$), indicating that economic status alone is not a strong predictor in this context. Lived in City has a significant negative impact (B = -1.518, β = -0.349, $p < .001$), implying that urban residents may engage less in sustainable household waste practices than their rural counterparts, possibly due to differences in space, time, or community enforcement.

Behavioural and Perceptual Predictors: Government Policies significantly and negatively influence behaviour (B = -1.632, β = -0.351, $p < .001$). This may indicate that lack of effective policy implementation or public dissatisfaction reduces positive waste management actions. Personal Motivation and Attitude also negatively impacts behaviour (B = -2.726, β = -0.388, $p < .001$), suggesting that intrinsic factors like motivation and attitude are crucial, and low levels may hinder positive change. Fine and Penalties for Improper Waste Disposal is not a statistically significant factor ($p = .385$), implying that punitive measures alone may not effectively encourage responsible waste practices. Community Programme and Engagement shows a modest but significant negative effect (B = -0.755, β = -0.170, $p = .017$), possibly indicating that the quality or reach of community engagement efforts needs improvement to positively influence behaviour. Awareness is the strongest positive predictor (B = 3.678, β = 0.424, $p < .001$). This finding emphasizes that higher levels of environmental awareness are strongly associated with better household waste management behaviour.

CONCLUSION

The findings of this study highlight that household waste management behaviour is influenced by a complex interplay of demographic characteristics and behavioural factors. Among the significant predictors, gender, age, education, occupation, residential environment, government policies, personal motivation, community engagement, and awareness emerged as key variables. Notably, awareness stands out as the strongest positive driver, underlining the transformative potential of targeted educational campaigns and information dissemination.

Contrary to common assumptions, higher educational attainment and professional status did not necessarily translate into better waste practices—suggesting a potential disconnect between knowledge and action. Furthermore, punitive measures such as fines were found to be ineffective on their own, reinforcing the need for more holistic, community-driven approaches that foster intrinsic motivation and collective responsibility.

The study underscores the importance of designing integrated SWM strategies that go beyond infrastructure and technology, placing greater emphasis on behavioural change, local engagement, and policy communication. By identifying the specific behavioural and structural barriers faced by urban households, the research provides a foundation for more responsive and citizen-centric waste management systems in Bengaluru and similar urban centres.

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SMART SENSING: A COMPREHENSIVE REVIEW OF NON-INVASIVE BIOSENSORS AND IOT-BASED HEALTHCARE SYSTEMS

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ABSTRACT:
The convergence of non-invasive biosensors and the Internet of Things (IoT) has ushered in a new era of smart and connected healthcare systems. These technologies enable continuous, real-time monitoring of physiological and behavioral parameters, facilitating early diagnosis, disease prevention, and remote patient management. This review explores recent advancements in non-invasive biosensor technologies—including wearable, implant-free, and ambient sensors—and their integration with IoT platforms. Key application domains such as cardiovascular monitoring, activity recognition, gait analysis, and chronic disease management are discussed with a focus on sensor design, data acquisition, transmission, and analytics. The paper presents a comparative analysis of state-of-the-art systems, highlights emerging trends through a timeline of developments, and outlines architectural frameworks that bridge hardware and cloud-based services. Finally, current challenges such as data security, power efficiency, interoperability, and scalability are addressed, and future research directions are proposed to pave the way for next-generation intelligent healthcare systems.

Keywords: *Non-invasive biosensors, Internet of Things (IoT), Smart healthcare, Wearable technology, Remote patient monitoring.*

1. INTRODUCTION:

In recent years, the convergence of non-invasive biosensing technologies with Internet of Things (IoT) frameworks has opened new frontiers in healthcare monitoring, diagnostics, and personalized medicine. Traditional diagnostic procedures often require invasive sampling methods, laboratory facilities, and trained professionals, which can delay diagnosis and limit accessibility—especially in resource-constrained settings. In contrast, non-invasive biosensors offer a minimally intrusive approach to detect physiological and biochemical markers through media such as sweat, saliva, interstitial fluid, breath, or skin contact.

The emergence of IoT-enabled health systems complements these biosensors by providing real-time data acquisition, wireless transmission, cloud storage, and intelligent analytics. This synergy has led to the development of smart wearable devices and remote monitoring platforms that empower individuals and healthcare providers with continuous, on-demand health insights. From tracking glucose levels in diabetic patients to monitoring cardiac activity and hydration status, the applications of these systems are vast and expanding rapidly.

Recent technological advancements in materials science, microelectronics, wireless communication, and data processing have accelerated the integration of biosensors with IoT devices. As a result, smart sensing systems are becoming more compact, cost-effective, energy-efficient, and user-friendly—paving the way for widespread adoption in clinical and non-clinical environments.

This review aims to provide a comprehensive overview of current non-invasive biosensing technologies and their integration with IoT infrastructures. The paper outlines the various types of biosensors, highlights the IoT ecosystem supporting these devices, explores emerging healthcare applications, and discusses the existing challenges and future directions in this rapidly evolving field.

2. TYPES OF NON-INVASIVE BIOSENSORS:

Non-invasive biosensors have gained significant attention in recent years due to their potential in monitoring physiological parameters without penetrating the skin or interfering with the body's internal functions. These devices detect bio-signals such as heart rate, blood oxygen level, respiration rate, glucose concentration, and many such parameters, by leveraging surface or proximity-based sensing mechanisms. Sensors allow better visibility, incorporate processes and workflows, analyse patterns of employees' work and detect environmental conditions in facilities on a larger scale. These can monitor, regulate, and increase operational efficiency in business management [4, 5].

Unlike traditional diagnostic tools, the non-invasive biosensors aims at reducing patient discomfort, infection risk, and the need for frequent clinical visits, making them ideal for long-term health monitoring and home-based care. Their integration into wearable devices and consumer electronics has led to a paradigm shift in continuous, real-time health monitoring. Recent advancements have enabled these sensors to be embedded in

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smart garments, headbands, and patches for continuous, ambulatory health tracking. Biological sensors employ biological molecules to detect particular objective chemicals as receptors [6, 7].

Based on the type of input and detection mechanism, below is the categorical description of various non-invasive biosensors:

2.1 Optical Biosensors
Optical biosensors utilize light-based principles such as absorbance, fluorescence, or reflectance to detect biomarkers. A prominent example is photoplethysmography (PPG), widely used in wearable devices to monitor heart rate and blood oxygen saturation by analyzing light reflected from blood vessels under the skin.

2.2 Sweat-Based Biosensors
Sweat contains valuable biomarkers such as electrolytes (e.g., sodium, potassium), lactate, cortisol, and glucose. Sweat biosensors offer a promising avenue for non-invasive, continuous monitoring through skin-wearable platforms such as microfluidic patches or epidermal electronics. Recent devices use electrochemical or colorimetric sensing methods, and can be integrated with flexible substrates and wireless modules for real-time tracking.

2.3 Saliva-Based Biosensors
Saliva is an easily accessible biofluid that reflects systemic health conditions. Biosensors that analyze enzymes, hormones, or drug metabolites in saliva are being developed for applications in stress monitoring, oral health, and drug adherence. Saliva-based systems are typically portable and user-friendly, making them ideal for at-home diagnostics and screening.

2.4 Breath Sensors
Non-invasive breath biosensors use gas-sensitive materials or nano-enabled chemiresistors to detect specific volatile organic compounds (VOCs). These are often coupled with machine learning algorithms for pattern recognition and disease classification.

2.5 Bioelectrical Signal Sensors (ECG, EMG, EEG)
Electrophysiological biosensors measure electrical activity generated by organs and muscles. Dry electrodes or textile-integrated electrodes can capture signals such as:

- **ECG (electrocardiography):** for heart monitoring
- **EMG (electromyography):** for muscle activity
- **EEG (electroencephalography):** for brain wave analysis

2.6 Temperature and Thermal Biosensors:
Skin temperature reflects metabolic rate, fever, and infection. Non-invasive temperature sensors are often integrated into wearable bands or patches. Infrared thermography and thermistors are common components in these biosensors.

Table 1: Comparison of Key Non-Invasive Biosensors

Sensor Type	Sample Type	Key Parameters	Detection Method	Applications
Optical (e.g., PPG, NIR)	Skin/Capillaries	Heart rate, SpO_2, glucose	Light absorbance or reflectance	Cardiovascular monitoring, metabolic analysis
Sweat-based	Sweat	Electrolytes, glucose, lactate	Electrochemical, colorimetric	Fitness tracking, hydration, glucose monitoring
Saliva-based	Saliva	Cortisol, enzymes, drug metabolites	Immunoassay, electrochemical	Stress analysis, oral health, drug adherence
Breath sensors	Exhaled breath	VOCs (e.g., acetone, ethanol)	Chemiresistive, gas sensors	Diabetes detection, asthma, metabolic disorders
Bioelectrical	Skin surface	Electrical signals	Dry electrodes,	Heart, muscle,

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(ECG/EMG/EEG)		from organs	conductive fabrics	and brain activity monitoring
Thermal/ Temperature	Skin temperature	Core/surface temperature	Thermistor, IR sensors	Fever detection, metabolism, infection monitoring

3. LITERATURE REVIEW:

The integration of non-invasive biosensors with IoT technologies has attracted significant attention in recent years, driven by the growing demand for personalized, real-time, and decentralized healthcare solutions. This section reviews key developments in both non-invasive biosensing technologies and their interfacing with IoT infrastructures, emphasizing the trajectory of research from fundamental studies to real-world applications.

3.1 Initial Findings and General Reviews:

Gao et al. (2016) demonstrated a wearable patch that could monitor lactate and glucose in sweat using enzymatic electrochemical detection, laying the groundwork for sweat-based diagnostics.

Research by Mishra et al. (2019) illustrated an IoT-based ECG monitoring system using textile electrodes embedded in clothing, with data uploaded to a cloud server for remote physician review.

Similarly, Kim et al. (2021) developed a wearable device for multi-analyte sweat monitoring, integrated with a cloud-based dashboard for athlete hydration management.

Javaid et al. (2021) provided a comprehensive review of sensor applications in daily life, emphasizing on sensor fusion for improved accuracy and reliability and integrating cloud and mobile interfaces.

Islam et al. (2021) proposed a smart healthcare system using IoT-enabled sensors, focusing on remote health monitoring. The data was sent via Wi-Fi and GSM to a web dashboard. Studies by

Acharya et al. (2020), Trivedi et al. (2017) proposed low-cost, Arduino-based systems with wireless transmission (Bluetooth and Zigbee modules) for home-based patient monitoring.

Similarly, Banerjee & Roy (2016) introduced low-cost pulse rate detectors using photoplethysmography (PPG).

3.2 Reviews presented in tabular form classified on the basis of sensor type, technology used, application areas and key features:

Table 2: Review based on sensors having different working principles

Reference	Sensor Type	Application	Technology Used	Key Features
Stikic et al.	Wearable motion sensors	Activity recognition	Weakly supervised learning	Recognizes multiple daily activities
Wu et al.	Myoelectric sensors	Prosthesis control	Arduino, EMG	Open-source, real-time control
Lim et al.	Non-intrusive sensors	Physiological monitoring	Embedded in furniture/devices	Comfortable and passive monitoring setup
Chen et al.	Respiratory sensors	Breathing behavior analysis	ML, wearable wireless sensors	Individualized patterns captured using ML
Zhou et al.	Hydrogel-based pressure sensor	Pressure/strain sensing	Solution-processable materials	High sensitivity and biocompatibility
Wang et al.	Triboelectric nanogenerator	Self-powered sensing	Energy harvesting, nanotechnology	No external power required
Bag & Lee	Wearable gas sensors	Breath monitoring	Graphene, nanomaterials	Suitable for VOCs and disease biomarkers
Islam et al.	IoT-enabled health sensors	Remote health monitoring	Wi-Fi, GSM, cloud	Real-time alerts, wearable integration
Oresko et al.	Smartphone ECG	Cardiac health monitoring	Mobile ECG processing	On-the-go cardiovascular diagnostics

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Masai et al.	Photo-reflective sensors	Facial expression recognition	Smart eyewear	Real-time emotional state detection
Kim et al.	Wearable mobility sensors	Mobility in amputees	IMUs, motion capture	Quantifies physical movement and asymmetry
Steinmetzer et al.	IMUs	Gait symmetry analysis	Synchronized wearables	Used in long-term rehab and tracking
Perriot et al.	Collaborative networked sensors	COPD monitoring	Wireless sensor networks	Data sharing between healthcare stakeholders
Aicha et al.	Trunk-mounted accelerometers	Fall prediction	Deep learning	High sensitivity for elder care safety
Batool et al.	Motion sensors	Activity classification	SVM optimized with PSO	High precision with computational optimization
Tognetti et al.	Goniometer + accelerometer	Knee joint tracking	Sensor fusion	Accurate joint angle measurement in motion
Gregoski et al.	Smartphone camera	Heart rate monitoring	Telehealth mobile app	Validated for wellness and health coaching
Desai et al.	Pulse & heart beat sensors	Smart home monitoring	Wireless Sensor Networks (WSN)	Integrates with home IoT environments

4. IOT INTEGRATION WITH NON-INVASIVE BIOSENSORS:

The fusion of non-invasive biosensing technologies with Internet of Things (IoT) infrastructure has revolutionized health monitoring, offering real-time, remote, and personalized care solutions. IoT integration not only enhances data accessibility and analysis but also enables continuous physiological monitoring, predictive diagnostics, and rapid clinical decision-making.

4.1 IoT Architecture in Healthcare Sensing Systems:

A typical IoT-based biosensing system comprises of several layers:

4.1.1. Sensor Layer (Data Acquisition)

- Non-invasive biosensors (PPG, EMG, capacitive, thermal, triboelectric, etc.)
- Positioned on skin, embedded in wearables or ambient objects
- Measures physiological signals (HR, SpO_2, glucose, motion, etc.)

4.1.2. Edge Layer (Processing & Filtering)

- Microcontroller (Arduino, Raspberry Pi, ESP32, etc.)
- Signal preprocessing (noise removal, feature extraction)
- Basic decision-making (e.g., anomaly detection)

4.1.3. Communication Layer

- Bluetooth Low Energy, Wi-Fi, Zigbee, NB-IoT, LoRaWAN
- Transmits data to gateway/server/cloud

4.1.4. Cloud / Server Layer

- Stores incoming data in databases
- Performs advanced analytics using machine learning models
- Allows longitudinal health tracking
- Sends alerts to caregivers/physicians

4.1.5. Application Layer

- Visual dashboards and mobile applications

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- Personalized feedback and real-time alerts
- Integration with electronic health records (EHRs)

5. TECHNOLOGICAL TRENDS AND RESEARCH TIMELINE:

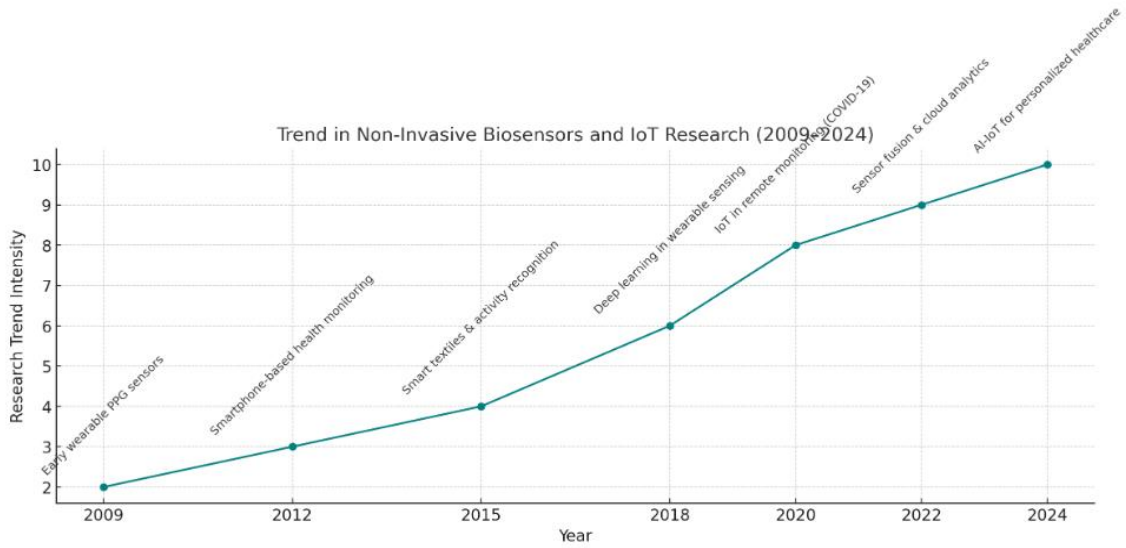

Figure 1: Evolution Timeline of Non-Invasive Biosensors with IoT (2009–2024) [2, 3, 13, 19, 30, 20]

- The literature strongly supports the feasibility and utility of non-invasive biosensors in health monitoring.
- Most IoT integration efforts are proof-of-concept or limited-scale trials, indicating a need for clinical validation and large-scale deployment studies.
- Security, standardization, and data interoperability remain under-addressed, especially in multi-sensor systems or cross-platform healthcare applications.
- There is a growing trend toward AI-assisted biosensing, where machine learning models are trained on biosensor data to improve accuracy and predictive value.

Table 3: Milestone/Trend of Non-Invasive Biosensors with IoT (2009–2024)

Year	Milestone / Trend	References
2009–2012	Early wearable PPG sensors for heart rate and SpO_2 in consumer devices (smartwatches begin)	[3], [30]
2013–2015	Emergence of smartphone-based health monitoring; accelerometer-driven activity recognition	[10], [20], [29]
2016–2018	Expansion in smart textiles, flexible sensors; rise of deep learning for daily activity prediction	[13], [5], [17]
2019–2020	Integration of IoT for remote patient monitoring, especially during COVID-19	[26]–[33]
2021–2022	Sensor fusion (e.g., ECG + motion + temperature), triboelectric sensors, and cloud-based analytics	[14], [15], [6]
2023–2024	Personalized healthcare via AI-IoT platforms; expansion into emotion/stress detection via biosignals	[1], [19], [2]

6. CONCLUSION

The integration of non-invasive biosensors with IoT technology marks a transformative leap in the landscape of modern healthcare. These innovations facilitate continuous, real-time monitoring of physiological parameters without discomfort or intrusion, making them especially valuable for chronic disease management, elderly care, and preventive health strategies. This review has highlighted a progression from basic wearable sensors to sophisticated systems capable of AI-driven analysis and personalized feedback via cloud platforms.

A clear trend is evident: as sensors become smaller, smarter, and more energy-efficient, their application in daily life becomes increasingly seamless. IoT infrastructure complements this by offering secure, scalable, and remote access to health data, thereby enabling decentralized healthcare systems. However, challenges remain, including data privacy, interoperability, standardization, and energy consumption. Future research should focus

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on the development of hybrid biosensors, context-aware systems, and secure data frameworks to realize the full potential of non-invasive biosensing in smart healthcare ecosystems.

This review underscores the importance of cross-disciplinary collaboration among biomedical engineers, data scientists, and healthcare professionals in advancing this domain toward more intelligent, responsive, and patient-centric solutions.

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GREEN HUMAN RESOURCE MANAGEMENT AND CYBERSECURITY: INTEGRATING SUSTAINABLE PRACTICES FOR ORGANIZATIONAL RESILIENCE

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ABSTRACT
Green Human Resource Management (GHRM) is being widely embraced by organizations to enhance environmental sustainability and reduce ecological footprint. Concurrently, the speedy development of information technology and increasing reliance on computerized systems have increased worry over cybersecurity. While conventionally dealt with as isolated domains, the convergence of GHRM and cybersecurity offers a new pathway toward the development of long-term sustainability, employee welfare, and organizational resilience. This research examines the conceptual and practical intersection of GHRM and cybersecurity. It presents a framework that unites sustainable HR practices with IT security controls, with a focus on leadership commitment, cross-functional cooperation, and ongoing learning. Through the alignment of green values with cyber risk management, organizations can create a workplace that is both environmentally friendly and digitally secure. It is an approach that not only promotes sustainability and risk management initiatives but also boosts the confidence of employees, improves brand equity, and creates a competitive edge online.

Keywords: *Digital Security, Cybersecurity, Organizational Resilience, Sustainability, Green Human Resource Management (GHRM), Sustainable Workplace Culture, Eco-Friendly HR Practices, Employee Engagement.*

1. INTRODUCTION
Green Human Resource Management (GHRM) emerged as a result of enterprises worldwide realizing how important it is to implement ecologically friendly practices. To foster a sustainable culture, GHRM includes integrating environmental management into HR operations such as hiring, training, performance reviews, and employee involvement (Renwick et al., 2013). While companies are being transformed at breakneck speed in the digital sense, cybersecurity has become an overriding concern. As more dependence on information and communication technologies (ICTs) makes the environment ever more insecure, data breaches and cyberattacks loom over organizational information with a threat to its confidentiality, integrity, and availability (Ahmad et al., 2020).

As per the Traditional approach, both cybersecurity and sustainability have been treated as distinct disciplines. Nonetheless, a mounting body of research indicates that both can be combined in ways that make the resultant organizations stronger, more ethical, and future-oriented (Patel, 2023). GHRM, for example, can be used to drive employee behavior toward the creation and embedding of both environmental and cybersecurity consciousness. Workers trained through green HR systems tend to be more aware of organizational values and more open to behavior-based solutions—making them perfect change agents in the realm of digital security. Additionally, the shift to digital-first spaces, such as work from home and virtual working, has both environmental advantages and cybersecurity challenges. While it helps reduce carbon emissions by lessening the need to travel and maintain office space, it also poses organizations to greater cyber risk. Under these circumstances, HR is at the forefront in crafting policies and fostering a workplace culture that is both sustainable and secure.

This article seeks to assess the nexus between green human resource management and cybersecurity by examining the ways in which green human resources practices can complement effective cybersecurity and build organizational resilience. It points out opportunities, spots potential challenges, and suggests implementable solutions for embedding. The article seeks to encourage a double agenda where digital security and sustainability exist together and support each other, and contribute to their high performance and competitive advantage amidst fast-changing business operations.

1.1. Green Human Resource Management (GHRM)
GHRM is the integration of environmental management principles into HR functions, such as recruitment, training, performance management, and employee relations. The goal is to foster sustainable practices within employees and lower the ecological footprint of the organization. For example, adopting digital-first documentation lessens paper usage, hence its contribution to the conservation of the environment. Green HRM seeks to improve organizational sustainability by encouraging employee commitment and sensitivity to

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environmental concerns, minimizing the use of resources, and enhancing the overall environmental performance of the company (Deshwal, 2015). With the world still facing environmental issues, the use of Green HRM practices has gained a lot of significance for organizations to prove their sustainability and corporate social responsibility commitment.

1.2. Cybersecurity in Today's Workplace

As more organizations depend on digital systems, the cyber-attack threat environment has grown. Strong cybersecurity measures are necessary to safeguard data, provide business continuity, and sustain stakeholder trust. Human aspects are a critical part of cybersecurity, and the actions of employees are usually the weakest link in security measures. Hence, the incorporation of HR practices into cybersecurity efforts is necessary to reduce risks.

1.3. Integrating GHRM and Cybersecurity

The integration of GHRM and cybersecurity involves embedding environmental sustainability into cybersecurity practices and leveraging HR functions to promote a culture of security awareness.

1.4. Eco-Friendly Cybersecurity Practices: Adopting energy-efficient data centers, utilizing sustainable hardware, and responsibly disposing of electronic waste contribute to reducing the environmental impact of cybersecurity operations

Employee Training and Awareness: HR can facilitate training programs that emphasize both cybersecurity protocols and environmental responsibility, fostering a workforce that is conscious of security and sustainability.

Policy Development: Collaborating with IT departments, HR can develop policies that encourage secure and environmentally friendly practices, such as promoting the use of virtual meetings to reduce travel-related carbon emissions.

1.5. Challenges in Integration

Integrating GHRM with cybersecurity presents several challenges:

- **Resource Constraints:** Implementing green and secure technologies may require significant investment, which can be a barrier for some organizations.
- **Employee Resistance:** Changes in procedures to incorporate sustainable and secure practices may face resistance from employees accustomed to existing workflows.
- **Keeping Pace with Technological Advances:** Rapid technological changes necessitate continuous updates to both cybersecurity measures and sustainability practices, requiring ongoing commitment and adaptation.

1.6. Strategies for Effective Implementation

To overcome these challenges, organizations can follow the below-mentioned strategies:

- **Leadership Commitment:** Senior management must show commitment to merging sustainability and cybersecurity, establishing organizational culture.
- **Cross-Functional Collaboration:** Fostering collaboration between HR, IT, and sustainability teams can ensure harmonious policy creation and implementation.
- **Continuous Education:** Offering continuous education to workers regarding the significance of cybersecurity and environmental sustainability can raise compliance and awareness.
- **Monitoring and Evaluation:** Periodic checks on the performance of integrated practices can provide indications of areas of improvement and proof of the organizational performance impact.

2. LITERATURE REVIEW-

2.1. Green Human Resource Management (GHRM)

Green Human Resource Management refers to a type of HR focused on delivering environmental sustainability goals. This includes green recruitment and selection, green development and training, paperless HRM practices, and encouraging employees' pro-environmental work behavior (Renwick et al., 2013; Tang et al., 2018). Green Human Resource Management has been applied to encourage employee commitment, OCB, as well as business sustainability outcomes (Jabbour & de Sousa Jabbour, 2016). GHRM, as conceptualized by Dumont et al. (2017), constructs an environmentally friendly organizational culture that encourages employees to engage in sustainable practices within and outside the workplace.

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2.2. Cybersecurity in the Human Resource Context

Cybersecurity is now more and more being seen as not merely a technical problem but a human aspect. Insider attacks, negligence, and unawareness are the leading causes of cyber-related incidents (Ahmad et al., 2020). Scholars contend that cybersecurity awareness and training, if implemented in HR operations, will lower the risk substantially (Parsons et al., 2017). HR has a key role in influencing employees' cybersecurity behaviors through organized onboarding, training, and policy dissemination (Bada & Sasse, 2015). Even with these findings, cybersecurity practices do not typically integrate with more extensive sustainability or green HR approaches.

2.3. Towards an Integrated Approach: GHRM and Cybersecurity

The possible synergy between GHRM and cybersecurity has not yet been extensively researched, though certain scholars argue that integrating the two can create environmental and digital resilience (Patel, 2023). Green digitalization, for example, encouraging digital devices to reduce paper consumption and cut down on emissions, should also take into consideration security to avoid cyber vulnerabilities (Gupta & Sharma, 2021). Companies that weave sustainability into cyber security training make employees more sensitive to both environmental and cyber threats, encouraging an integrated culture of accountability. Furthermore, as there is a growing trend toward remote and hybrid work configurations, HR departments need to make sure that sustainability practices such as virtual teamwork and paperless paperwork are underpinned by secure digital foundations (Cheng et al., 2022). As HR professionals use green technologies, they must work hand in hand with IT units to ensure the integration of cybersecurity measures into normal green practices.

2.4. Gaps in Literature

Although GHRM and cybersecurity are well-studied separately, literature that bridges these fields is limited. There are few empirical studies on how HRM can address environmental and digital threats at the same time. This gap calls for frameworks that bridge green HR initiatives with cybersecurity measures, particularly in knowledge-intensive and technology-driven sectors.

3. OBJECTIVES OF THE STUDY

1. To study the contribution of Green Human Resource Management (GHRM) towards developing an environment-friendly and secure organizational culture.
2. To identify how employee behavior, GHRM practices, and cyber security knowledge go hand in hand.
3. Identifying challenges and hindrances of organizations to embed GHRM into cyber security practice.

4. RESEARCH METHODOLOGY

Research Design

The research adopts a descriptive and exploratory research design based on secondary data to examine the role of Green Human Resource Management (GHRM) practices to promote an environmentally sustainable and cyber-safe organizational culture.

Data Collection:

Data was gathered from available literature such as:

- Peer-reviewed journal articles
- Research papers and theses
- Reports by industry and government (e.g., ISO, UNGC, NIST frameworks)
- Organizational case studies
- Online databases like Google Scholar, ResearchGate, JSTOR, and Scopus

Data Analysis

A qualitative content analysis methodology was employed. Themes were derived according to the objectives:

- Contribution of GHRM towards environmentally friendly and safe culture
- Connection between employee conduct, GHRM, and cyber awareness
- Obstacles in integrating GHRM into cybersecurity frameworks

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5. INTERPRETATION

GHRM practices like green training, e-waste minimization, energy-efficient digital infrastructure, and paperless processes not only contribute to sustainability but also minimize physical threats to data security. Case studies (e.g., IBM, Infosys, Unilever) illustrate how incorporating environmental values into digital communication policies minimizes information leaks and maximizes secure digital participation. Green HR policies encouraging environmentally friendly IT usage (such as forbidding unnecessary downloads, cloud-based tools, and safe remote work) minimize the carbon trail and improve secure systems by reducing the environmental impact. Employee Behavior, GHRM, and Cyber Security Awareness Relationship Internalized green values from employees result in responsible behavior in digital terms—i.e., compliance with clean desk policies, safe file sharing, and energy-saving devices. Secondary sources indicate a positive relationship between environmental awareness and compliance with cyber guidelines—implying workers who are highly environmentally conscious are also more cyber-responsible. Companies with green reward schemes and training initiatives demonstrate higher compliance with cybersecurity standards as a result of behavioral congruence.

Issues in Conjoining GHRM with Cybersecurity Technological constraints: Obsolete systems and absence of green digital infrastructure limit implementation.

Gaps in Knowledge: Most employees and HR practitioners do not know where GHRM and cybersecurity converge, preventing integration.

Resistance to Change: Silo departments (Operations, IT, HR) cause disjointed adoption of green-cyber policies.

Cost Worries: Companies at times view green and security programs as distinct costs and not interconnected investments. The study finds that Green HRM plays a significant part in molding both environmental and digital security cultures in organizations. Practices such as green training, paperless work, and eco-friendly digital behavior have a synergistic effect—where sustainability aids cybersecurity.

6. CONCLUSION

The research suggests that Green HRM is equally important in promoting environmental and cyber security cultures inside organizations. Disciplines of green training, paperless activity, and ecological digital behavior foster a synergistic effect—sustainability complementing cybersecurity. In addition, worker conduct serves as a bridge, supporting the way green consciousness fosters cyber-awareness. Yet to deeply establish GHRM in cybersecurity culture, organizations should eliminate strategic, technology-based, and knowledge-based difficulties via compounded training, leadership synchronization, and cross-functional collaboration. The results compel organizations to view GHRM not merely as an ecological technique, but as a comprehensive strategy that can strengthen digital ethics, safe behavior, and long-term organizational strength.

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TRANSFORMING EDUCATION: "A SYSTEMATIC SURVEY OF LEARNING USING AI"

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ABSTRACT
The fusion of Artificial Intelligence (AI) in the field of education indicates a major change in how learning is understood, delivered, and experienced. Artificial Intelligence (AI) is revolutionizing education by enabling personalized learning, intelligent tutoring, and data-driven assessments. This paper explores AI's transformative impact on education, focusing on adaptive learning systems, intelligent tutoring systems (ITS), automated grading, and predictive analytics. We analyse how AI tools enhance engagement, tailor instruction, and improve learning outcomes while addressing environment for student's motivation. Key findings highlight AI's potential to create efficient and student-cantered learning environments. The study integrates current research to guide educators, stakeholders and technologists in leveraging AI for future-ready education.

Keywords: *Artificial Intelligence, Education, Learning, Personalization, Adaptive Learning, Ethical Implications.*

1. INTRODUCTION
Artificial Intelligence (AI) is the field of computer science that aims to create intelligent machines capable of performing tasks that typically require human intelligence, such as learning, problem-solving, and decision-making.

As we move into a time that is becoming more and more characterized by technological developments, artificial intelligence (AI) is becoming a game-changer in a number of fields, including education. This paper's goal is to examine the various ways artificial intelligence is changing education, especially as it relates to engagement, assessment, and customisation. Given the continuous investments in EdTech, it is critical for educators, legislators, and technologists to comprehend how AI functions in education.

Artificial Intelligence (AI) has opened up previously unheard-of possibilities in a number of fields, including education. Traditional teaching methods are being transformed into dynamic, interactive learning experiences with the growing use of AI technologies. This essay examines how artificial intelligence (AI) is changing education, with a particular emphasis on how it affects student learning, instructional strategies, and academic results. This paper aligns with the theme by presenting a comprehensive overview of existing literature on AI's impact in educational settings.

2. AI Tools for Teaching

2.1 Overview of AI in Education
The use of AI technology to support teaching and learning is a broad definition of artificial intelligence in education. Data analytics, intelligent tutoring systems, machine learning, and natural language processing are important technologies (Luckin et al., 2016). Artificial intelligence (AI) is transforming the education landscape. From personalized learning to automated grading, AI-powered tools are enhancing the teaching and learning experience for educators and students alike.

2.2 Personalized Learning Experiences
The advancements in artificial intelligence (AI) have led to a paradigm shift in teaching methodologies, primarily enabling the realization of personalized learning experiences. An ideal change in teaching methods, personalized learning is made possible largely by developments in artificial intelligence (AI). In contrast to traditional one-size-fits-all methods, personalized learning familiarises educational experiences to each student's particular preferences, learning style and requirements. By evaluating enormous volumes of data about student performance, learning preferences, and engagement levels, artificial intelligence (AI) technology enable this personalized approach.

Table-1: Personalized Learning Experiences

Sr.No	Methods	Description
1.	Adaptive Content	AI-powered systems analyze student performance and adjust lesson plans to cater to individual learning needs and paces.
2.	Intelligent Recommendations	AI recommends supplementary materials, practice activities, and next steps based on a student's

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		strengths, weaknesses, and learning style.
3.	Real-Time Feedback	AI provides instant feedback and guidance to students, helping them identify knowledge gaps and overcome challenges in the moment.

2.2.1 Systems for Adaptive Learning

There is further enhanced personalization by learning adaptive systems, which comprises Practise algorithms that change over time in accordance with student performance and interactions. These advanced systems dynamically modify the content by analysing data points like task completion time, response accuracy, and engagement levels. Griffiths et al. (2020), proposed Knewton's adaptive learning that for instance, creates a responsive learning environment this new environment can significantly boost student engagement and retention by dynamically modifying course materials based on real-time user feedback. Adaptive learning allows each learner to have a unique educational experience by offering new concepts at the exact moment that pupils are ready to learn them. Furthermore, it promotes a dynamic learning environment where students feel empowered to tackle real-world challenges, enhancing their confidence and engagement in the subject matter. Table shows frequently use adaptive learning technologies.

Table-2: Systems for Adaptive Learning

Sr.No	Type of Education	Description
1.	Data-Driven Insights	Adaptive learning systems can continuously optimize learning routes by identifying trends and patterns in learning behaviours through the collection and analysis of student data.
2.	Personalized Feedback	By offering customized suggestions and feedback, these systems assist students in pinpointing their areas of weakness and gain a clearer understanding of their learning trajectory.
3.	Dynamic Content Delivery	Depending on student preferences, adaptive learning systems can display several kinds of content formats (videos, tests, and quizzes). This adaptability encourages greater levels of engagement by supporting a variety of learning styles.
4.	Real-Time Interventions	Teachers can improve support and scaffolding by using insights from adaptive learning systems to step in right away when students are having trouble understanding a particular idea.
5.	Dynamic Content Delivery	Depending on student preferences, adaptive learning systems can display several kinds of content formats (videos, tests, and quizzes). This adaptability encourages greater levels of engagement by supporting a variety of learning styles. .

2.3 Systems for Intelligent Tutoring (ITS)

Intelligent tutoring systems (ITS) are an innovative use of artificial intelligence (AI) in education replicating the individualized attention of human tutors. Intelligent tutoring systems use AI algorithms to provide customized learning experiences tailored to each student's needs and abilities, helping those master concepts at their own pace. ITS leverage advanced algorithms and machine learning to deliver targeted instructional support by evaluating students' knowledge, pinpointing their areas of weakness, and providing real-time assistance catered to their individual requirements, (VanLehn, 2011).

2.3.1 Framework of Intelligent Tutoring System

An Intelligent Tutoring System (ITS) employs artificial intelligence and machine learning based educational technology that delivers customized instruction and feedback to students. ITSs provide personalized content and activities that improve the educational experience to amend to the unique requirements, preferences, and learning styles of learners. Figure-1 shows Framework for Intelligent Tutoring System.

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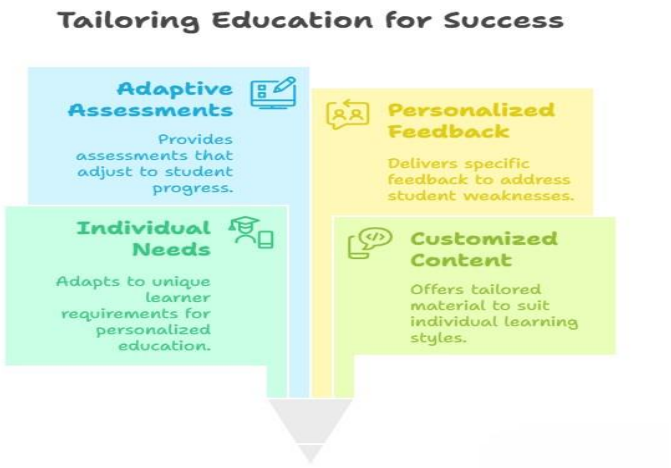

Figure-1 Framework for Intelligent Tutoring System

Typical ITS Components are as follows:

User Model: It part enables the system to efficiently customize feedback and training by keeping a continuous record of the student's knowledge, preferences, and learning styles.

Domain Model: ITS delivers instructional information by the domain model that encodes a wide range of information and abilities pertaining to the course content.

Feedback Mechanism: ITS provides helpful feedback mechanism to students to comprehend mistakes, fully understand subjects, and develop self-confidence.

Pedagogical Model: Pedagogical model uses resources like instructional strategies and a variety of teaching techniques based on the needs noted in the user model for successful learning.

2.3.2 Effect on Student Motivation and Learning Outcomes

The Research by Corbett and Anderson (1994) describes the efficiency of ITS in raising student motivation and learning results. Pupils who utilized ITS showed remarkable improvements in their comprehension and memory of the material as compared to those who did not receive this kind of tailored assistance. Learners may interact more fully with the material provided by ITS's customized learning environment and gain a deeper understanding of their errors. It offers tasks that are suitably matched to each student's skill level, ITS can maintain motivation. Students are motivated to continue through challenging topics by this individualization, which cultivates a sense of competence and accomplishment. A more positive attitude toward education and a less stressful learning environment are fostered by the freedom to learn at one's own speed and receive individualized instruction. For learners from different linguistic backgrounds ITS has demonstrated promise in meeting a range of learning needs by modifying the complexity and type of content presented and also support students with diverse degrees of prior knowledge. As a result, ITS can encourage fairness in educational access and outcome.

2.3.3 Challenges and Future Directions

The potential for ITS is further enhanced with technological development and growth. More complex machine and deep learning algorithms combined with natural language processing (NLP) may increase the system's capacity to contextualize content in real-time and engage students in conversation. ITS promises to ensure that student information is managed appropriately given the increased emphasis on data privacy and ethical implications in AI. ITS system has to overcome with challenges like the requirement for teacher preparation and the upfront expenses of ITS deployment. Continued research and development should improve these systems and make them more useful resources in classrooms. Intelligent tutoring systems have the potential to revolutionize individualized learning in the future and make a substantial contribution to raising educational standards for students everywhere by utilizing artificial intelligence.

2.4 AI in Assessment and Evaluation

Artificial Intelligence (AI) is increasingly utilized in assessment and evaluation, changing traditional methods to measure student performance and learning results. AI tools assisting educators in gaining deeper insights into student requirements and adjusting their teaching strategies accordingly by facilitating more efficient, precise, and customized assessment methods. Table shows different methods for assessment and evaluation

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Table (3): Methods for assessment and evaluation

Sr. No	Methods	Description
1.	Systems for Automatic Grading	An important development in the use of artificial intelligence (AI) to educational assessment is represented by automated grading systems. From multiple-choice exams to more intricate written tasks, these systems are made to assess student work and provide immediate, unbiased feedback. Teachers can save time and focus on more effective instructional activities by automating the grading process (Heffernan & Heffernan, 2014).
2.	Analytics for Learning	The term "learning analytics" describes the methodical gathering, examination, and reporting of information on students and their environments. Learning analytics solutions, driven by artificial intelligence (AI), are intended to offer insightful information about student performance, engagement, and learning habits. These analytics platforms enable educators to make well-informed judgments, individualized interventions, and focused enhancements to instructional practices by leveraging the rich data sets produced by educational technologies (Siemens, 2013).
3.	Using AI Technologies to Engage	By increasing learner engagement through creative techniques like gamification and the development of immersive environments, artificial intelligence (AI) has completely changed the educational landscape. Teachers may create learning experiences that are not only successful but also interesting and fun for students by utilizing AI technologies. AI-powered VR/AR apps can also produce situations that improve problem-solving and critical thinking abilities, allowing students to use what they've learned in authentic settings. AI-powered chatbots are a great way to improve student engagement by providing continuous assistance and conversation.

2.5 Predictive Analytics for Student Success

AI-powered predictive analytics tools can help identify students at risk of falling behind, enabling proactive interventions to improve academic outcomes. By analyzing data on student performance, attendance, engagement, and more, these systems provide personalized insights to support each learner's success.

2.6 AI Tools for Education

The continuing development of generative artificial intelligence (AI) tools, capable of producing natural language, computer code, images, or other media in response to users' queries, has the potential to impact teaching and learning in many ways.AI algorithms can analyse vast amounts of educational data to identify patterns and trends, helping educators make data-driven decisions to enhance teaching strategies. Figure 1 shows popular AI tools used in education.

Adaptive math tutor Carnegie Learning's MATHia is a prominent example of educational AI that employs to provide personalized problem sets, resulting in improved standardized test scores (Chiu et al., 2018).

Learner retention and engagement has been significantly increasing by the language learning platform Duolingo which uses AI to adapt lessons based on user performance analytics, questionnaires, and spaced repetition, significantly increasing (Zhang et al., 2017).

Summarize.tech powered by **ChatGPT** is one of the best **AI tools for remote learning and online education.** It summarizes any lengthy YouTube video, example lectures into short and understandable format.

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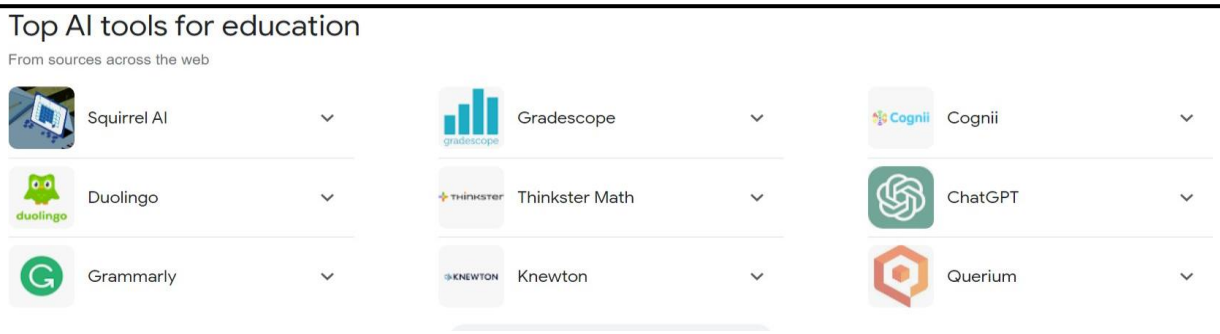

3. CONCLUSION

Artificial Intelligence holds revolutionary potential for the future of learning by personalizing educational experiences, enhancing engagement, and streamlining assessments. AI empowers educators to customized instruction to individual student needs, improving learning outcomes and motivation through adaptive learning systems, intelligent tutoring, and data-driven analytics. As AI continues to evolve with future advancements in machine learning, natural language processing, and immersive technologies, it's potential to create more inclusive, efficient, and student-centred. AI can help build a future where education is accessible, adaptive, and empowering for all learners by balancing innovation with ethical considerations.

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INTEGRATING INDIAN KNOWLEDGE SYSTEMS INTO MODERN EDUCATION: AN ANALYSIS OF THE NATIONAL EDUCATION POLICY (NEP) 2020

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ABSTRACT
The National Education Policy (NEP) 2020 in India represents a significant overhaul aimed at revitalizing the country's education system. Central to its objectives is the integration and revitalization of the Indian knowledge systems (IKS), aiming to restore and promote traditional knowledge alongside contemporary education. This paper examines the implications of NEP 2020 on the Indian knowledge system, analyzing its potential impact, challenges, and opportunities for the educational landscape in India. The National Education Policy (NEP) 2020 marks a significant shift in India's approach to education by emphasizing the integration of Indian Knowledge Systems (IKS). This paper explores the historical context, the rationale behind this integration, and the potential impact on contemporary education. Through an analysis of NEP 2020, we investigate how traditional knowledge, including ancient sciences, languages, arts, and philosophical systems, can be harmoniously blended with modern educational practices to foster a holistic learning environment. This research paper provides a structured overview of how NEP 2020 aims to target the Indian knowledge system, examining its objectives, strategies, potential impacts, and challenges.

Keywords: *National Education Policy, Educational Values, Updated Curriculum, Indian Knowledge System, Educational Material*

INTRODUCTION
The National Education Policy (NEP) 2020 is a comprehensive framework designed to transform the Indian education system to meet the challenges of the 21st century. One of its fundamental aspects is the recognition and integration of the Indian knowledge systems (IKS), which encompass traditional and indigenous knowledge that has been integral to India's cultural and intellectual heritage. This paper explores how NEP 2020 seeks to target and revitalize the Indian knowledge system, examining its objectives, strategies, and potential implications.

Indian Knowledge Systems (IKS) encompass a vast array of disciplines, including Ayurveda, Yoga, Sanskrit, classical arts, and ancient Indian mathematics and sciences. NEP 2020 recognizes the importance of these systems and proposes their integration into the modern curriculum. This policy aims to rejuvenate India's rich educational heritage while promoting a more inclusive and diverse learning framework. The term "Indian Knowledge Systems" (IKS) refers to the diverse traditional knowledge systems and practices that have been developed and transmitted over centuries within various communities and regions across India. These systems encompass a wide range of disciplines including but not limited to medicine, agriculture, astronomy, philosophy, linguistics, and arts, often rooted in indigenous cultures and practices.

"Indian Knowledge Systems (IKS) refers to the comprehensive and diverse knowledge systems developed and nurtured in the Indian subcontinent over centuries. These systems encompass traditional knowledge in various domains such as science, technology, medicine, arts, and social organization, deeply rooted in India's cultural and philosophical heritage." (Indian National Science Academy, 2018)

India has a long-standing tradition of knowledge and education, dating back to ancient universities like Nalanda and Takshashila. These institutions were renowned for their diverse curriculum, attracting scholars from across the globe. The colonial era, however, disrupted this indigenous education system, replacing it with a Western model that often disregarded native knowledge.

NEP 2020 outlines several key objectives related to the Indian knowledge system

- **Integration and Revitalization**: To integrate IKS into the mainstream education system, thereby ensuring its preservation and transmission to future generations.
- **Promotion of Local Languages**: To promote education in regional languages and dialects, which are often repositories of traditional knowledge.
- **Research and Development**: To encourage research and development in traditional knowledge systems and practices.

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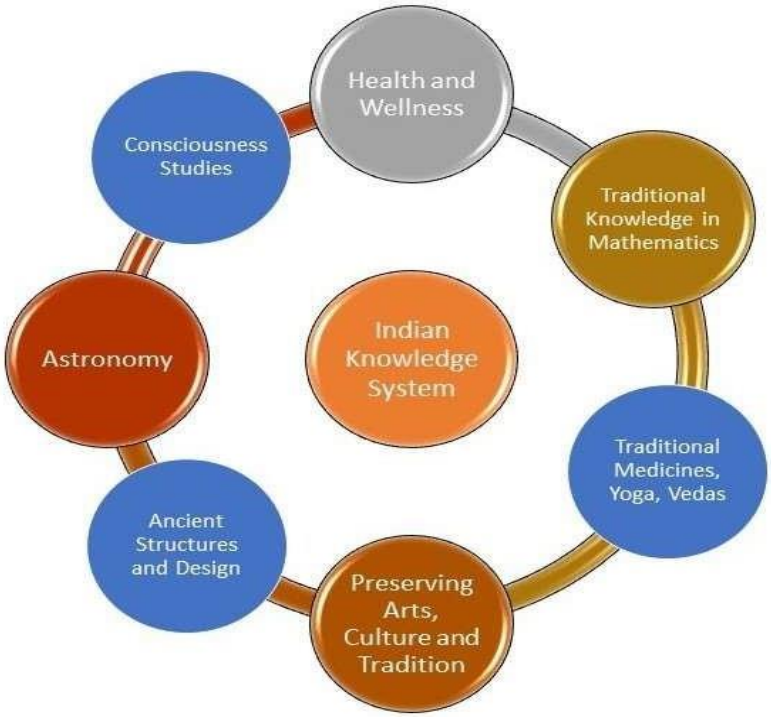
- **Interdisciplinary Approac**h:To foster an interdisciplinary approach that bridges modern and traditional knowledge systems.

The Indian Knowledge System (IKS) proposes several subject areas of IKS that require further investigation and analysis. This covers the study of astronomy, mathematics, art, and culture, as well as health and wellbeing. For every individual, community wellbeing and quality of life are crucial, particularly in today's technologically advanced and quickly evolving world. The literature currently in publication recommends developing AI for medical applications. The proposed work to be carried out in the IKS Lab has relevance in the context of the National Education Policy of the Government of India (NEP2020) as well as IKS for holistic development of students and improved community wellness because the work has not been focused on exploiting the IKS domains, yoga, consciousness, and mindfulness practices.



The Government of India formed the IKS division within the Ministry of Education with the goal of advancing multidisciplinary and transdisciplinary research on all facets of IKS and sharing IKS knowledge for future innovations and societal applications. In order to revitalize IKS research in India, the IKS division supports unique, serious, and in-depth academic study in a variety of IKS disciplines. The traditional knowledge in astronomy and mathematics, chemistry and material science, health, wellness, and awareness studies, political and economic ideas, arts, traditions, and rich culture are all included in the IKS division.

Contribution to India's IKS Mission- The Indian Knowledge System (IKS) is heavily emphasized in the National Education Policy 2020 (NEP2020) for the overall development of pupils. In addition to all-around professional growth, students must be given traditional knowledge of medicine, mindfulness practices (Vipassana), heritage, etc. in order for them to appreciate the significance of IKS disciplines for optimum wellbeing. Thus, the primary goal of this AI intervention-based research is to fulfill the NEP2020's most significant expectation.

NEP 2020: Key Provisions for Indian Knowledge Systems NEP 2020 outlines several key initiatives to integrate IKS into the modern education system:

1. **Curriculum Development:** Introducing IKS at various educational levels, from primary to higher education, ensuring students gain a comprehensive understanding of their cultural heritage.
2. **Teacher Training:** Special programs for educators to equip them with the knowledge and skills required to teach IKS effectively.
3. **Research and Innovation:** Establishing research centers dedicated to the study and advancement of IKS.
4. **Language Preservation:** Promoting classical languages like Sanskrit, Pali, and Prakrit alongside contemporary languages.

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5. **Interdisciplinary Approach:** Encouraging the blending of traditional knowledge with modern scientific and technological advancements.

The Rationale for Integrating IKS

The integration of IKS offers numerous benefits:

- **Cultural Identity and Heritage:** Strengthening students' connection to their cultural roots and promoting a sense of pride in their heritage.
- **Holistic Education:** Providing a well-rounded education that includes moral, ethical, and spiritual dimensions.
- **Innovation and Sustainability:** Drawing from traditional practices and wisdom to address contemporary issues such as sustainability and wellness.

Potential Impact on Contemporary Education

Integrating IKS into the curriculum can transform the educational landscape in several ways:

i. **Enhanced Critical Thinking:** Exposure to diverse knowledge systems encourages critical thinking and a broader worldview.

ii. **Inclusive Education:** Recognizing and valuing indigenous knowledge promotes inclusivity and respect for diversity.

iii. **Global Competence:** Equipping students with unique perspectives and skills that can be valuable in the global arena.

Strategies and Implementation

NEP 2020 proposes several strategies to achieve its objectives concerning the Indian knowledge system:

I. **Curriculum Reforms:** Revision of school and higher education curricula to include modules on IKS and promote a holistic understanding of India's cultural and intellectual diversity.

II. **Teacher Training:** Training programs for teachers to equip them with the skills and knowledge necessary to teach IKS effectively.

III. **Resource Mobilization:** Allocation of resources for the documentation, preservation, and dissemination of traditional knowledge systems.

IV. **Collaboration and Partnerships:** Collaboration with academic institutions, research organizations, and traditional knowledge holders to bridge the gap between theory and practice.

Impact and Implications:

The implementation of NEP 2020 targeting the Indian knowledge system is expected to have several implications:

❖ **Cultural Revitalization:** Preservation and promotion of India's rich cultural heritage and traditional knowledge systems.

❖ **Educational Equity:** Inclusion of diverse perspectives and knowledge systems, contributing to a more inclusive and equitable education system.

❖ **Innovation and Sustainability:** Integration of traditional knowledge with modern scientific advancements to foster innovation and sustainable development.

❖ **Challenges:** Challenges such as resistance to change, resource constraints, and the need for capacity building in IKS research and education.

Challenges and Recommendations

While the integration of IKS presents exciting opportunities, it also poses challenges:

- **Resource Allocation:** Adequate funding and resources are required to develop and implement IKS curricula.
- **Teacher Preparedness:** Comprehensive training programs are essential to prepare teachers for this new approach.
- **Curriculum Balance:** Ensuring a balanced curriculum that harmonizes traditional and modern knowledge without overwhelming students.

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To address these challenges, the following recommendations are proposed:

i. **Collaborative Frameworks:** Establishing partnerships between educational institutions, government bodies, and IKS experts.

ii. **Continuous Evaluation:** Implementing robust monitoring and evaluation mechanisms to assess the effectiveness of IKS integration.

iii. **Public Awareness Campaigns:** Raising awareness about the benefits of IKS through community engagement and outreach programs.

CONCLUSION

The National Education Policy 2020 represents a paradigm shift in India's approach to education, particularly in its emphasis on integrating and revitalizing the Indian knowledge system. While the policy outlines ambitious objectives and strategies, its successful implementation will depend on overcoming challenges and harnessing opportunities to realize the full potential of IKS in shaping India's educational landscape for generations to come. The NEP 2020's emphasis on Indian Knowledge Systems represents a visionary approach to education that honors India's rich intellectual legacy while preparing students for the future. By thoughtfully integrating IKS into the modern curriculum, India can create a more inclusive, holistic, and innovative educational environment that benefits individuals and society as a whole.

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A COMPARATIVE ANALYSIS OF AI-BASED EDUCATION AND TRADITIONAL EDUCATION

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ABSTRACT
Nowadays, AI is growing rapidly in various industries and sectors, so how can AI in the education sector be left behind? Artificial Intelligence in Education (AIED). Except for a few things, AI also significantly improves teaching and learning skills in education, more than traditional teaching and learning. This paper presents a comparative analysis of AI-based education systems and traditional classroom-based education.

***Keywords**: AI-Based Education, Traditional Education, Education,*

INTRODUCTION
The AI is an intelligent machine that uses machine learning, natural language processing, and data analytics to maintain continuously in the learning and adaptive phase; it learns from its environment, adapts the behavior in real-time, and improves itself.

Artificial Intelligence (AI) is increasingly being incorporated into the education sector, which has the potential to transform teaching and learning methods.

AI-based learning offers a personalized, collaborative, visual, flexible, and adaptive learning experience. It provides a grand vision of education.

Traditional learning relies on a structured, one-on-one approach, direct teacher-student interaction, fixed curriculum, and structured timelines. Reading books also fall into the traditional learning model.

This paper aims to assess the strengths and weaknesses of both approaches and determine how they can coexist or evolve.

Comparative Analysis

Sr. No.	Criteria	AI-Based Education	Traditional Education
1.	Platform	Online (From anywhere can attend the class)	Offline (Physical attendance is compulsory)
2.	Time	Flexible, 24*7 assistance via chatbots	Fix Schedule
3.	Environment	Depends on interest and need (Structural and unstructured)	Structured based
4.	Teaching Method	Personalized learning through Adaptive AI.	One-size-fits-all approach. i.e. lectured based
5.	Personalization	High (via adaptive systems), what you want, you learn approach.	Low (generalized teaching)Guru-Shishya technique.
6.	Accessibility	High (online and scalable), Flexible	Limited (location-time dependent), Not Flexible
7.	Engagement	Gamified, interactive tools, Visualization tools	Relies on teacher's methods, i.e. often passive learning
8.	Assessment	Continuous assessment and adaptive test.	Periodic-standardized quizzes and test
9.	Access to Resources	are easy-to-access and easy-to-share Digital Resources	Limited and difficult access and shared physical textbooks and class materials
10.	Cost Efficiency	Scalable and cost-effective	High recurring costs (infrastructure, staff, etc.)
11.	Curriculum Flexibility	Flexible and Customizable based on Learner needs and interest	Fixed curriculum
12.	Skill Development	Enhancing the skills, critical thinking, and problem-solving	Based on basic skills, memorization, diagrams, etc.

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		based on digital literacy, visualization, etc.	
13.	Data Utilization	Extensive use of data analytics to improve AI in Teaching strategies and techniques.	Minimal and specific use of data to inform teaching.
14.	Feedback	Instant feedback is data-driven on performance and understanding. But it may not be reliable feedback.	allows for immediate feedback on performance and understanding, human-dependent and reliable
15.	Data Privacy	Raises concerns about data privacy issues and uses	Maintains Data Privacy
16.	Technology	dependency on AI tools, so reduce the traditional study skills like note-taking and critical thinking, imagination	No dependency on AI tools, so it improves traditional study skills like note-taking and critical thinking, imagination
17.	Teacher Workload	Reduced use of common online platforms and reduced administrative tasks through AI automation	High Administrative Burden, dependency on class strengths, and availability
18.	Distraction	There is a high possibility of an online platform, so there are no controls on students' behaviors and actions.	No distraction focused on lecture topics.
19.	Emotional Intelligence	Lacks human empathy, Lack of Personal Interaction	Has Personal Interaction, Encourages social/emotional skills Supports **Mentorship**
20.	Social Interaction	Very less Social Interaction, Depends on Learner	Improves Social Interaction.
21.	Track Records	Difficult to Tracking	It has a long history and a successively proven track record.
22.	Knowledge	Focus on interest only, so sometimes it's "Knowledge of all, master of none."	Focus on Foundational Knowledge: It makes the "master of one."

The above comparative analysis shows that using a single education methodology may not always be beneficial. There are some positive and negative points in both.

If good education (good learning and teaching) is desired, then combining both methodologies (AI-based and traditional-based education) is necessary.

FUTURE OUTLOOK

The future of education may lie in a hybrid model, i.e., combining both AI-Based Education and Traditional Education.

The most effective learning and teaching strategies can best combine both, combining the personal touch of traditional methods, personalization, engagement, and structured learning environments with the ease of AI-powered tools.

CONCLUSION

By incorporating AI into the classroom, teachers can personalize learning experiences, simplify administrative tasks, and provide more effective support to students so students can understand the topic faster without any obstacles in their learning.

This combination can enhance students' technical and soft skills, improve learning motivation and engagement, and enhance their creativity, higher-level thinking, and critical thinking.

AI-based learning offers enormous potential to increase the amount of personalized learning but lacks the emotional and social touch inherent in traditional systems. A combined approach can bring out the best of both.

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AI tools cannot replace teachers.

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FROM CODE TO COGNITION: THE ROLE OF AI IN SMARTER WEB DEVELOPMENT

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ABSTRACT
Artificial Intelligence (AI) has emerged as a transformative force in the realm of web development [1]., redefining how websites and applications are conceptualized, designed, and maintained. AI enables automation, intelligent decision-making, and highly personalized user experiences, thereby significantly improving the speed, functionality, and relevance of modern web platforms. This paper delves into the growing influence of AI technologies in web development, illustrating how machine learning algorithms, natural language processing (NLP), and computer vision tools are integrated into the development process. We also explore the practical applications of AI tools like GitHub Copilot and TensorFlow.js, which are enhancing the productivity of developers and creating smarter, more adaptive web environments. Through detailed explanations, real-world examples, and technical diagrams, this paper aims to bridge the gap between code and cognition—demonstrating how AI is enabling the evolution of websites from static systems to dynamic, user-aware platforms. The insights provided in this research aim to empower students, educators, and developers with the knowledge to harness AI responsibly and effectively in web development.

Keywords: *Artificial Intelligence, Web Development, Machine Learning, Personalization, Automation, Decision-Making, Natural Language Processing, Computer Vision*

1. INTRODUCTION
The digital landscape has witnessed a dramatic shift over the past few decades. Early web development primarily involved writing HTML and CSS to create static web pages that offered limited interactivity. As internet usage expanded and user expectations evolved, the demand for dynamic and responsive websites grew. Developers started using JavaScript, server-side languages, and frameworks to enhance the user experience. Today, the expectations from web platforms are even higher—users want fast, intelligent, personalized, and intuitive digital experiences. This is where Artificial Intelligence (AI) steps in.

AI is revolutionizing web development by automating repetitive tasks, improving content delivery, and providing a level of personalization that was previously unthinkable [2]., improving content delivery, and providing a level of personalization that was previously unthinkable. Whether it's through chatbots that handle customer service queries or recommendation engines that tailor content to individual users, AI is making websites smarter and more user-centric. This integration of AI into web development is not just a trend—it is a fundamental shift in how web technologies are built and how they function.

With AI, web developers are no longer just writing code—they are designing intelligent systems that can learn, adapt, and respond to user needs in real time. Tools like GitHub Copilot assist developers by suggesting lines of code, reducing development time and minimizing bugs [4]., reducing development time and minimizing bugs. NLP-powered chatbots enhance user engagement by understanding natural language inputs, while computer vision algorithms allow websites to interpret and respond to visual content.

This paper aims to provide a comprehensive overview of how AI is shaping the future of web development. We will explore the core AI technologies being applied, including machine learning, NLP, and computer vision, and examine how these technologies are being used to automate development tasks, personalize user experiences, and improve decision-making. Additionally, we will highlight the benefits, challenges, and future trends associated with the integration of AI into web development. By understanding the role of AI in this context, educators and students can better prepare for a future where coding and cognition go hand in hand.

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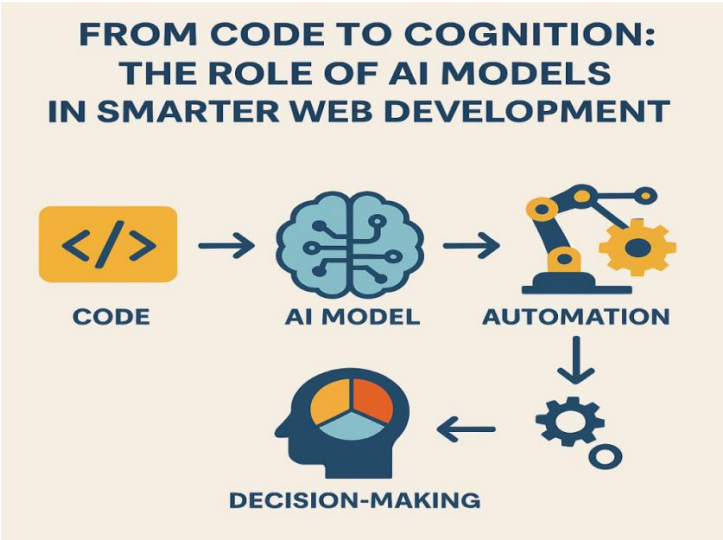

Figure. [11]

2. UNDERSTANDING ARTIFICIAL INTELLIGENCE

Artificial Intelligence encompasses a broad range of technologies designed to perform tasks that typically require human intelligence. These include recognizing speech, making decisions, understanding language, and interpreting visual data. AI in web development empowers websites to become interactive, responsive, and capable of learning user preferences over time.

2.1 Machine Learning (ML)

ML, a subset of AI, focuses on enabling machines to learn from data and improve their performance without being explicitly programmed. In web development, ML is used for predictive analytics, behavior tracking, and customer segmentation. For example, ML algorithms can analyze user data to determine which web content is most effective, helping designers refine their strategies. Common ML techniques used include linear regression, classification models, clustering algorithms, and neural networks.

2.2 Natural Language Processing (NLP)

NLP allows machines to understand, interpret, and generate human language. It plays a critical role in web development by enhancing the usability of chatbots, voice interfaces, and translation systems. Websites that feature multilingual support or voice-based search functionality rely on NLP. It also supports sentiment analysis, which is used to gauge customer satisfaction and improve UX design.

2.3 Computer Vision

Computer vision enables websites to interpret visual content such as images and videos. Applications range from face recognition systems used in login features to image categorization tools in e-commerce. This technology is especially relevant in platforms that rely heavily on media, such as photography websites or online stores that offer visual search capabilities.

Branch of AI	Definition	Key Techniques	Real-World Applications
Machine Learning (ML)	ML enables systems to **learn from data** and improve performance over time.	Supervised learning, Unsupervised learning, Reinforcement learning	- Spam filtering - Recommendation systems (Netflix, Amazon) - Predictive analytics
Natural Language Processing (NLP)	NLP focuses on enabling machines to **understand and generate human language**.	Tokenization, Named Entity Recognition, Sentiment Analysis, Chatbots	- ChatGPT - Voice assistants (Siri, Alexa) - Language translation (Google Translate)
Computer Vision	Computer Vision allows machines to **interpret visual information from images or videos**.	Object detection, Image classification, Face recognition	- Facial recognition (security) - Self-driving cars - Medical imaging

Table: 01 [12]

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3. AI-DRIVEN AUTOMATION IN WEB DEVELOPMENT

Automation is one of the most impactful contributions of AI in web development. Tasks that once required hours of manual labor can now be completed in minutes.

3.1 Code Generation

AI-powered tools like GitHub Copilot help developers by suggesting code snippets based on the context of the current project. This not only speeds up development time but also reduces errors by offering syntax-correct suggestions. These tools learn from billions of lines of open-source code, enabling them to produce code for a wide range of tasks.

3.2 Testing and Debugging

AI-powered testing tools like Test.ai simulate human interaction and automate the identification of bugs. These systems run regression tests and use historical bug data to predict where future errors might occur. This leads to faster deployment and more stable applications.

3.3 Content Generation

NLP-based tools can now generate text, blog articles, and product descriptions. Platforms like Jasper and Copy.ai are being used to create SEO-optimized content automatically, saving businesses time and money.

4. Personalization with AI

Personalization is key to increasing user engagement and satisfaction. AI enables websites to tailor content to individual users based on their preferences and behavior.

4.1 Recommendation Systems

Recommendation engines like those used by Netflix and Amazon are driven by AI algorithms. These systems analyze user behavior—such as browsing history and purchase patterns—to make personalized suggestions. This improves the overall user experience and boosts conversion rates.

4.2 Adaptive User Interfaces

AI allows web interfaces to adapt in real-time based on user interaction. For instance, a returning visitor might see a different homepage layout than a first-time visitor. This level of personalization ensures that users find content that is most relevant to them, increasing satisfaction and engagement.

Aspect	How AI Enables Personalization	Examples
User Behavior Tracking	AI analyzes user clicks, scrolls, and time spent on pages	Netflix suggests shows based on viewing history
Recommendation Systems	Uses ML models to predict user interests	Amazon recommends products based on past buys
Dynamic Content Delivery	AI tailors web content (text/images) per user	News websites change headlines per user profile
Chatbots & Virtual Assistants	AI adapts responses to user tone and past queries	ChatGPT or customer service bots on websites
A/B Testing Automation	AI runs continuous tests to optimize layout, text, and UX	E-commerce sites change button colors/layouts

Table: 02 [13]

5. AI IN DECISION-MAKING

AI aids developers and businesses in making better data-driven decisions.

5.1 Predictive Analytics

AI can analyze vast datasets to identify trends and predict outcomes [6].. For example, a web-based e-commerce platform can use AI to forecast demand for certain products based on previous sales data and current user behavior.

5.2 User Behavior Modeling

By analyzing user interactions—like clicks, time spent on pages, and scroll behavior—AI can determine what elements of a website are effective. This insight helps developers and designers optimize layouts, improve navigation, and create a more intuitive user experience.

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6. REAL-WORLD APPLICATIONS

6.1 GitHub Copilot

This tool assists programmers by automatically writing code based on the developer's input. It uses OpenAI's Codex model and improves over time based on feedback, making it an indispensable assistant for coding tasks.

6.2 TensorFlow.js

TensorFlow.js allows developers to use machine learning models directly in the browser [3].. This means developers can build interactive AI applications without requiring server-side computations, improving speed and user responsiveness.

6.3 Wix ADI

Wix's Artificial Design Intelligence uses user inputs to automatically create customized websites. It suggests layouts, images, and content, allowing non-technical users to build professional-grade websites.

6.4 Adobe Sensei

Adobe's AI framework is integrated into applications like Photoshop and Adobe Experience Cloud. It offers automated image tagging, smart cropping, and personalized content recommendations for web designers and marketers.

7. Benefits of AI in Web Development

AI brings a host of benefits:

Efficiency: Reduces development time with automation.

Accuracy: Minimizes bugs and errors through predictive modeling.

Engagement: Enhances UX with adaptive, personalized content.

Scalability: Supports large-scale web projects with dynamic content generation.

Cost-effectiveness: Automates content and layout creation, reducing manual labor.

8. Challenges and Ethical Considerations

While AI offers immense potential, it also presents significant challenges:

Privacy: Collecting and processing user data raises concerns about consent and security.

Bias: AI systems trained on biased data can produce discriminatory results.

Transparency: Some AI models are so complex that their decision-making process is hard to interpret.

Job Impact: As AI automates development tasks, it may reduce the need for entry-level roles, raising concerns about employment.

To address these issues, developers must prioritize transparency, fairness, and data protection when building AI-powered systems.

9. THE FUTURE OF AI IN WEB DEVELOPMENT

The future of web development is poised for significant transformation, driven by the continuous advancements in Artificial Intelligence (AI). As AI technologies evolve and become more accessible, their integration into web development will become more widespread and impactful. The convergence of AI and web development is expected to result in smarter, faster, and more responsive web applications that offer enhanced user experiences and operational efficiencies.

One of the major trends shaping the future is the rise of no-code and low-code platforms powered by AI. These platforms enable individuals with little to no programming experience to create complex web applications through intuitive interfaces and natural language instructions. By leveraging AI for code generation and layout suggestions, these platforms democratize web development, allowing more people to contribute to the digital economy.

Another emerging area is AI-driven design automation. Future web design tools will be capable of understanding user goals and automatically generating design elements, layouts, and content. These tools will take into account factors such as user demographics, behavior patterns, and accessibility needs to craft highly optimized user interfaces. For example, AI systems could analyze the performance of different layouts and continuously refine them based on user engagement metrics.

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Emotion detection and sentiment analysis are also expected to play a larger role. Through computer vision and natural language processing, websites will be able to sense user emotions in real time—such as confusion, satisfaction, or frustration—and adapt accordingly. This could lead to hyper-personalized web experiences where content, layout, and interactions dynamically adjust to suit the user's emotional state.

Voice and gesture interfaces will become more prevalent as AI-powered systems improve their understanding of natural language and physical movements. Web applications will increasingly support voice commands, virtual assistants, and even gesture-based navigation, enabling more inclusive and hands-free user experiences.

Security is another domain where AI will have a transformative impact. AI-based cybersecurity solutions will proactively identify vulnerabilities, detect threats, and implement protective measures in real time. For instance, AI could monitor user activity for signs of fraud or abnormal behavior and respond immediately by triggering alerts or security protocols.

In terms of development practices, AI-enhanced collaboration tools will allow developers, designers, and project managers to work more effectively together. These tools can analyze project requirements, suggest resource allocations, and predict project timelines with high accuracy. They can also automatically detect and resolve integration issues between different software components.

Moreover, AI will enable continuous learning and adaptation in web applications. Unlike traditional systems that require manual updates, AI-enabled websites will learn from user interactions and automatically update themselves to stay relevant and functional. This approach ensures long-term efficiency and user satisfaction without the need for constant human intervention.

The integration of augmented reality (AR) and virtual reality (VR) with AI will unlock new dimensions of immersive web experiences. For example, AI can analyze user interactions in a virtual environment and tailor the experience in real time. In educational platforms, students could navigate through AI-generated virtual classrooms where the content adapts to their pace and learning style.

Lastly, ethical AI development will become a central concern. As AI systems gain more control over content and interactions, ensuring fairness, transparency, and accountability will be essential. Developers will need to follow ethical guidelines and implement explainable AI models to maintain trust and reliability.

In summary, the future of AI in web development holds immense promise. By embracing AI innovations responsibly, developers can build web ecosystems that are not only technologically advanced but also user-centric, inclusive, and adaptive to the changing digital landscape.

10. CONCLUSION

Artificial Intelligence is not just enhancing web development—it is redefining it. From automation and code generation to personalization and intelligent decision-making, AI is pushing the boundaries of what websites can do. It enables developers to build faster, more intuitive, and more effective web applications, and it allows users to enjoy personalized and seamless experiences.

However, with great power comes great responsibility. The integration of AI into web development also brings ethical, social, and technical challenges. Developers must adopt responsible AI practices that prioritize fairness, transparency, and user privacy. By doing so, we can ensure that AI remains a tool for empowerment and innovation.

As we look to the future, the synergy between human creativity and artificial intelligence will continue to shape the digital world. Web development will evolve from writing static code to crafting intelligent systems that think, learn, and adapt—truly moving from code to cognition.

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ALTEREGO

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ABSTRACT
AlterEgo is a unique wearable gadget that enables silent communication with computers, AI assistants, and individuals without moving your lips. It detects the signals your brain sends to your mouth and tongue when you contemplate speaking. These signals are then used to perform tasks on your computer or relay information through a specialized headphone that only you can hear. This device is particularly beneficial for individuals with speech impairments such as ALS and MS, enhancing their ability to communicate. It interprets the brain signals associated with speech thoughts and utilizes them to execute computer tasks. While AlterEgo doesn't read your mind, it allows you to operate your computer using your thoughts. You simply think about what you want to express, and the device makes it happen, almost like possessing a superpower! Currently, the device is undergoing trials in hospitals to assist patients with multiple sclerosis and ALS in communication. It holds the potential to transform human-computer interaction and improve cognitive processes. AlterEgo is a remarkable device that facilitates silent communication with computers and people, using special headphones to provide information. It is designed to aid those with speech difficulties in communicating more effectively. By interpreting the brain signals linked to speech thoughts, it performs tasks on your computer. Although AlterEgo doesn't read your mind, it enables thought-based computer control. Researchers have tested the device with impressive outcomes, suggesting it could be revolutionary for individuals with speech challenges. AlterEgo represents a groundbreaking technology poised to redefine human-computer interaction.

Keywords: *Wearable device, AI assistants, speech problems, ALS, MS, communicate, control computer, thoughts, human-computer interaction.*

INTRODUCTION
The integration of humans and machines has advanced significantly, especially in how we interact with technology. Input devices have evolved from punch cards to keyboards, and now to voice and thought-based systems, becoming essential to modern life. A groundbreaking development in this space is **AlterEgo**, a wearable device that enables silent, hands-free communication with computers and people.

AlterEgo works by detecting subtle electrical signals generated by the skin when a person thinks about speaking. These neuromuscular signals allow users to communicate without visible movement or sound. After just 15 minutes of training, the device can recognize around ten words with up to 90% accuracy. While it doesn’t read minds, it captures the intention to speak, translating internal speech into commands. This technology is especially promising for individuals with speech impairments and is currently being tested in hospitals to assist such patients.

The device uses bone-conduction headphones to provide audio feedback, creating a seamless, bidirectional communication loop. AlterEgo allows users to interact with computing systems naturally and privately, making technology feel like an extension of their cognitive abilities.

The paper presenting AlterEgo highlights three key contributions: the introduction of an innovative wearable architecture for silent speech, the identification of neuromuscular signals for input, and the demonstration of silent speech recognition's feasibility. AlterEgo represents a significant step forward in human-computer interaction, offering the potential to revolutionize the way we communicate and interact with technology—empowering users without disrupting their natural abilities.

REVIEW OF LITERATURE
The progression of human-machine interfaces (HMIs) has transitioned from conventional input tools like keyboards to more intuitive user interfaces (NUIs) such as gesture, touch, and voice recognition technologies. Although these innovations have made technology interaction more user-friendly, voice-based systems still encounter significant challenges, including privacy issues, vulnerability to eavesdropping, and the necessity for users to be nearby and attentive for optimal functionality. To tackle these challenges, the idea of silent speech interfaces (SSIs) has emerged as a potential solution. SSIs enable communication without audible speech or visible mouth movements, offering a more discreet and private interaction method. These systems are divided into invasive and non-invasive categories. Invasive systems involve brain implants or sensors placed within internal speech articulators. For instance, Brumberg et al. (2010) showcased silent speech recognition using brain implants in the speech motor cortex, but these systems were constrained by vocabulary size and clinical

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applicability. Invasive approaches, such as permanent magnetic sensors or internal articulator measurements, also face obstacles due to their complexity, invasiveness, and lack of portability. Conversely, non-invasive systems have been developed using EEG sensors, surface electromyography (sEMG), and deep learning models that interpret lip movements from video feeds. While promising, these systems often struggle with low signal-to-noise ratios and the need for visible facial movements, limiting their potential for truly silent and seamless communication. One of the most promising advancements in SSI technology is the AlterEgo device, developed by MIT researchers. This wearable brain-computer interface (BCI) allows users to control digital devices without speaking or making visible movements, addressing key limitations of existing systems. Unlike traditional BCIs, which often depend on invasive or semi-invasive methods, AlterEgo captures neuromuscular signals from the skin's surface in a non-invasive way. This facilitates silent communication without requiring visible articulation or sound production, marking a transformative step forward in the field of SSIs.

The AlterEgo device integrates sensors for electroencephalography (EEG) and electromyography (EMG) within a flexible, headset-like wearable. These sensors capture neural signals from the user's brain and facial muscles. Machine learning algorithms then analyze these signals to determine the user's intended actions, such as typing or speaking, offering a natural method for interacting with computers. This innovative, non-invasive technique overcomes the limitations of traditional brain-computer interfaces (BCIs) by providing a more comfortable, user-friendly, and practical alternative. The AlterEgo device holds significant potential across various sectors. In assistive technology, it could aid individuals with paralysis or motor disorders in communicating more effectively, enhancing their independence. In gaming and entertainment, the device could transform the industry by offering a more immersive, hands-free gaming experience, entirely controlled by the user's thoughts. In the medical field, AlterEgo could help monitor and diagnose neurological disorders, like epilepsy or Parkinson's disease, by tracking neural activity in real time. Additionally, in military and defense, AlterEgo could facilitate secure, hands-free communication in high-pressure environments, where silent and covert communication is crucial. However, despite its promise, the AlterEgo device encounters challenges. These include signal noise and interference, which can impact the accuracy of signal interpretation, and issues of user comfort and fatigue, as the device needs to be worn for long durations. Furthermore, concerns about security and privacy arise, particularly when dealing with sensitive neural data, and the cost and accessibility of the device remain obstacles to widespread adoption.

CHALLENGES AND LIMITATIONS:

1. **Signal Noise and Interference**: The device is prone to disruptions caused by external signal interference and noise.
2. **User Fatigue and Comfort**: There is a need to improve the device’s design for greater comfort and usability during extended wear.
3. **Security and Privacy**: The device raises important concerns about the security of personal data, especially in high-risk or sensitive applications.
4. **Cost and Accessibility**: The current high price and limited availability restrict the device’s access to a wider audience.

FUTURE DIRECTIONS:

To overcome these challenges, future research should focus on:

- **Enhancing Signal Quality**: Developing advanced signal processing techniques to minimize noise and interference.
- **Improving User Experience**: Focusing on making the device more comfortable, wearable, and user-friendly.
- **Strengthening Security and Privacy**: Implementing stronger security measures to safeguard user data and ensure privacy.
- **Increasing Accessibility**: Lowering the cost and expanding availability to make the device accessible to a broader range of users.

OBJECTIVES:

- **Silent Speech Interface**: Develop a wearable interface that allows users to silently and discreetly communicate with computing devices and others, without the need for vocalization.

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- **Feasibility of Silent Speech Recognition**: Demonstrate that silent speech recognition, based on neural signals, is viable, and prove the device's effectiveness as both a personal computing platform and communication tool.
- **Neuromuscular Signal Processing**: Characterize a user's intent to speak and internal speech using neuromuscular signals from internal speech articulators, providing a natural language interface for enhanced interaction.
- **Assistive Technology for ALS**: Adapt the AlterEgo system as a real-time speech assistive tool, enabling patients with ALS to communicate effectively and independently.
- **Human-Machine Symbiosis**: Explore the potential for AlterEgo as a platform for human-machine symbiosis, enabling more natural and intuitive communication with machines and people.
- **Revolutionizing Interaction with Technology**: The system could transform how we engage with technology, making it feel more like a natural extension of ourselves. It can assist with a variety of tasks, such as:

- Reminding us of important things
- Providing useful information
- Easing communication
- Supporting decision-making

METHODOLOGY:

Data Collection
The study involved 20 participants (10 males and 10 females) aged between 20 and 40 years. Each participant wore the AlterEgo wearable device, which incorporates electromyography (EMG) sensors designed to capture neuromuscular signals from the surface of the skin. Participants performed a variety of silent speech tasks, including:

- Mental arithmetic (e.g., performing calculations without vocalizing)
- Silent reading (e.g., reading a passage without sound)
- Silent conversational responses (e.g., answering questions without speaking aloud)

EMG signals were recorded in a quiet, distraction-free environment using a digital signal processing system with a 1000 Hz sampling rate.

Data Pre-processing
The raw EMG signals underwent filtering and feature extraction. A band-pass filter (10–500 Hz) was applied to remove noise and artifacts. The filtered data was segmented into words or phrases using an external trigger.

Feature extraction combined both time-domain and frequency-domain techniques. Time-domain features included metrics such as mean absolute value, root mean square, and variance, while frequency-domain features focused on power spectral density and peak frequency.

Model Training and Evaluation
A deep learning model was developed to interpret silent speech from EMG data. The architecture consisted of a convolutional neural network (CNN) for spatial feature extraction, followed by a recurrent neural network (RNN) to capture temporal dependencies in the speech sequences.

Training was conducted on a dataset of 10,000 silent speech samples, with an 80/20 train-test split. Model performance was assessed using accuracy, word error rate (WER), and sentence error rate (SER).

Personalization
To tailor the system to individual users, a transfer learning approach was implemented. The pre-trained model was fine-tuned with a small set of personalized EMG data from each participant. This allowed the system to adapt to individual neuromuscular patterns and speech habits, enhancing accuracy and responsiveness.

System Integration and Testing
The personalized models were integrated into the AlterEgo wearable, which was connected to a mobile device via Bluetooth. Real-world testing included use cases such as controlling smart home devices and interacting

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with virtual assistants through silent speech. These tests demonstrated the system's functionality in practical scenarios and validated its potential as a seamless, voice-free communication tool.

User Study
A usability study was conducted to assess the effectiveness and user experience of the AlterEgo system. Ten participants engaged with the system across various real-world scenarios and provided feedback through a combination of survey questionnaires and semi-structured interviews. This feedback helped evaluate the system's performance, ease of use, and potential for integration into daily life.

Aural Output
The silent speech recognition capability of the AlterEgo system introduces a new dimension in personalized, bidirectional human-machine interaction. By enabling seamless and discreet communication in natural language, the system supports a symbiotic relationship between user and machine. Tasks can be delegated to the computer, yet the interaction remains intuitive and feels inherently personal.

When a user silently vocalizes a phrase, the system recognizes it and processes it based on the context of the application in use. For instance, silently saying "3" could be interpreted as a command for Device 3 in an IoT setting, while in a mathematical context, it would be treated as a numeral. The system then generates a response using text-to-speech technology, which is delivered to the user through bone conduction headphones—preserving the user's environmental awareness and hearing.

Wearable Design
Several key design considerations were implemented to ensure the AlterEgo wearable is practical, robust, and suitable for everyday use:

- **Electrode Stability**: Maintaining consistent electrode placement is critical for signal accuracy. The design ensures electrodes do not shift during use.
- **Session Consistency**: The device is designed to preserve electrode alignment even when the user removes and re-wears it, enabling reliable multi-session use.
- **Adjustability and Multi-user Compatibility**: While stable during wear, the electrodes can be adjusted to fit different users, making the device versatile and shareable.

The device wraps around the back of the head, with structured extensions reaching the facial areas to capture signals from target zones. The main band is 3D-printed using photopolymer resin and reinforced with a brass rod to enhance structural integrity and skin-electrode contact. The facial extensions are also supported by brass elements that provide rigidity while allowing fine adjustments. Additionally, these extensions are modular—designed to be detached or replaced to facilitate experimental setups or further customization.

Overall, the AlterEgo system is engineered to offer a seamless user experience by combining intuittive interaction, reliable signal acquisition, and practical, ergonomic design.

RESEARCH ANALYSIS:
The AlterEgo system is an innovative wearable interface that enables users to communicate with computing devices silently—without vocalization or visible movement. By detecting neuromuscular signals from internal speech articulators, the system reconstructs the user's internally vocalized speech, offering a natural language interface. The study behind AlterEgo demonstrated the feasibility of this silent speech recognition approach, achieving a median word accuracy of 92%.

Applications and Potential

AlterEgo holds significant promise across various domains, including:

- Personal computing platforms
- Virtual assistants
- Assistive communication tools for individuals with speech impairments

Its non-invasive and wearable design offers a compelling alternative to conventional voice-based interfaces, especially in contexts where speaking aloud is impractical or undesirable.

CONCLUSION
AlterEgo marks a major step forward in the evolution of human-machine interfaces. By interpreting neuromuscular signals to decode silent, internal speech, it introduces a groundbreaking and transformative

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method of communication. Its versatile applications span not only personal computing but also fields such as assistive technology, healthcare, and immersive experiences like gaming.

Key Insights and Future Prospects:

- **Silent Speech Recognition Feasibility**: The study confirms that neuromuscular signals can be used to accurately recognize internally vocalized speech, paving the way for more intuitive and discreet human-computer interaction.
- **Wide-Ranging Applications**: AlterEgo holds immense promise for individuals with speech impairments, offering a powerful new mode of communication. Additionally, it enables hands-free communication in contexts where vocal speech is impractical or disruptive.
- **Existing Challenges**: Despite its potential, AlterEgo faces several challenges, including variability in neuromuscular signals among individuals, susceptibility to environmental noise, and important concerns related to data privacy and ethical use.
- **Directions for Future Research**: Continued development should aim to enhance system accuracy, resilience, and user data protection. Exploring integration with emerging technologies—such as augmented reality (AR) and virtual reality (VR)—could further extend AlterEgo's capabilities and create even more immersive, natural interaction environments.

In summary, AlterEgo offers a bold new vision for silent, seamless communication with machines. With continued research and refinement, it could reshape how we interact with technology in our everyday lives.

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SMART NO PARKING LOCK: AN IOT-BASED SYSTEM FOR TRANSPARENT AND EFFICIENT PARKING VIOLATION MANAGEMENT

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ABSTRACT
Illegal parking in "No Parking" zones has become a common issue in many cities, causing traffic jams, misusing public space, and making it hard for enforcement to keep up. The current methods of dealing with these violations are slow, often require a lot of manual work, and don't always offer a transparent way to track fines or penalties.

This research introduces an innovative idea called the Smart No Parking Lock; a system built using IoT (Internet of Things) technology to help manage parking violations more efficiently. The idea is simple but powerful: when a vehicle is found parked in a restricted area, a smart lock is attached by an officer to the wheel. The vehicle owner can then unlock it in two ways either by paying the fine online through a QR code, or by paying in cash to an officer and uploading the receipt to the system for verification. The system also includes useful features like GPS tracking to know the location of the locked vehicle, SMS alerts to notify the owner. All this data is stored securely on the centralized server, making the process more accountable and efficient. Alongside this proposal, the report also includes an expert-level review of the project, pointing out ways it can be improved further. Some of the suggestions include exploring parking challenges specifically in cities like Pune, thinking about different technologies that could be used, and considering the legal and privacy aspects of using such systems in public areas.

***Keywords**: Raspberry pi 4B, DC 12V Cabinet Door Lock Solenoid, Relay Module, GSM-3093 Module, Razorpay Payment Gateway, Online SMS Service.*

I. INTRODUCTION
In today's fast-growing urban areas, managing parking has become a major challenge. With more vehicles on the road than ever before, illegal parking, especially in "No Parking" zones is causing serious problems. It leads to traffic congestion, blocks emergency lanes, and contributes to the inefficient use of public spaces. Traditional methods of handling these violations, such as manually issuing tickets or clamping vehicles, are often slow, labour-intensive, and prone to errors. These methods also lack transparency, making it hard to maintain proper records or ensure fair enforcement.

This research paper presents a smart solution to tackle this issue: the **Smart No Parking Lock**, an IoT-based system that automates the enforcement of parking rules. The concept is simple yet effective when a vehicle is found parked illegally, a smart lock is attached by officer to its wheel. The system then sends a notification to the vehicle owner, allowing them to unlock the lock by either scanning a QR code and paying the fine online or by paying in cash to an officer and uploading the receipt as proof.

The main goal of this project is to **reduce human effort, improve transparency in fine collection**, and ensure that penalties are enforced consistently and fairly. It also aims to introduce technology-driven features like GPS tracking, SMS notifications, and centralized data storage to make the entire process smooth and efficient.

II. BACKGROUND AND RELATED WORK
Managing urban parking effectively has always been a challenge, especially in rapidly growing cities like Pune. As cities get smarter, the use of Internet of Things (IoT) technologies is becoming increasingly common in parking systems. Several researchers have attempted to tackle parking-related issues, especially illegal parking, using innovative approaches but many of these systems still leave gaps in enforcement, flexibility, and transparency.

OVERVIEW OF EXISTING LITERATURE:
Multiple studies have highlighted the role of smart systems in managing parking. **Zhang et al. (2020)** introduced a geomagnetic detection-based self-parking system. It helped monitor parking spaces in real time but didn't enforce penalties so unauthorized parkers still got away, limiting its practical use.

Huang et al. (2021) developed an IoT-controlled smart parking lock that could be operated remotely through a mobile app. While it worked well for reserving parking for authorized vehicles, it didn't address the issue of illegal parking or fine collection an area our system specifically focuses on.

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Christopher et al. (2021) proposed an IoT-enabled locking system that automatically immobilized vehicles parked in no-parking zones. This was a step in the right direction. However, their solution lacked a proper fine collection system. Without a reliable and transparent way to pay and track fines, such systems can lead to user frustration and legal issues.

Pawar et al. (2020), who created a servo-motor-based lock to handle illegal parking. While it demonstrated innovation in physical locking mechanisms, it didn't include options for digital or offline fine payments, making real-world deployment more difficult, especially in areas with limited internet access.

Theoretical Framework:
This research is built on the broader concept of IoT in urban environments, where connected devices collect and exchange data to improve the efficiency of city operations.

The automation framework is central to this study, it reduces the need for manual monitoring, enforcement, and even fine collection.

Moreover, theories around security and access control come into play, as the goal of the smart lock is not just to penalize illegal parking but also to secure parking spots and ensure no one uses public areas for parking purposes. Our system integrates all these concepts—enforcement, automation, access control, and transparency into a single model that aims to be both effective and scalable.

III. METHODOLOGY

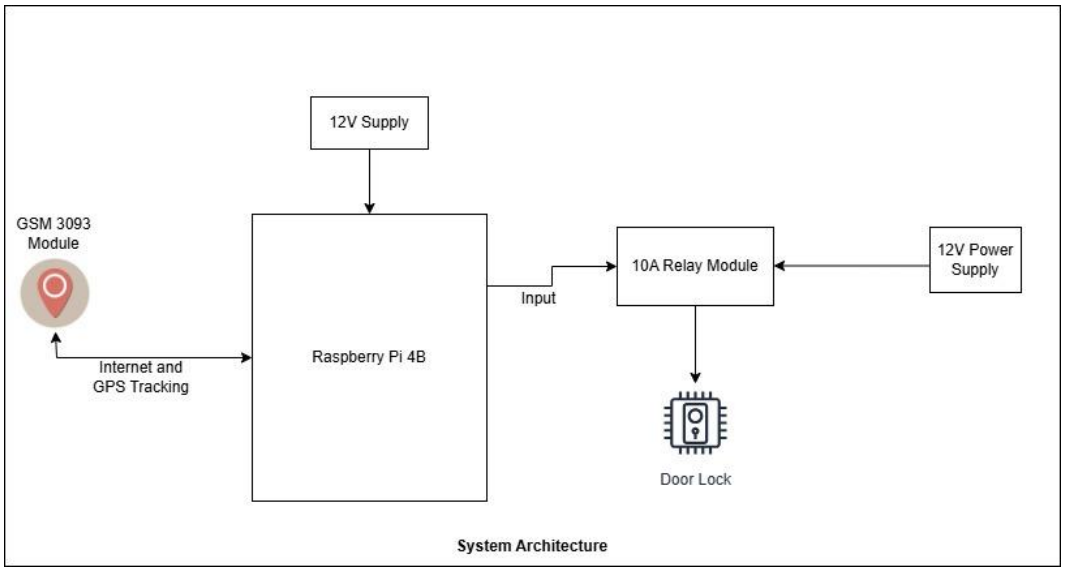
The Smart No Parking Lock project is still under development, but the overall methodology has been carefully planned to ensure practical implementation and real-world effectiveness. The methodology focuses on using IoT technology to automate the locking mechanism for vehicles parked in unauthorized areas and to manage the associated fine collection process through both online and offline modes.

System Design and Architecture

The proposed system consists of the following core components:

- **Raspberry Pi 4B**: Acts as the central processing unit that controls the overall operations of the smart lock system.
- **GSM Module (GSM-3093)**: Enables Internet and GPS Tracking Functionality.
- **DC 12V Cabinet Door Lock Solenoid**: Used for physically locking and unlocking the vehicle's wheel or surroundings
- **1-Channel 5V 10A Relay Module with Optocoupler**: Helps manage the switching operations between Raspberry Pi and the locking system securely.
- **Razorpay Payment Gateway**: Used for Online Transaction with QR code and other options.

The architecture follows a modular IoT-based approach where all hardware components are integrated and controlled through the Raspberry Pi. The locking/unlocking actions are triggered based on payment status, which is verified through a custom web application.



System Architecture

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Modes of Operation

The system provides dual modes of penalty payment and lock release:

Online Mode (QR Code Payment)

- When a vehicle is detected in a no-parking zone, the system generates a QR code.
- The owner receives an SMS with the fine amount and the online payment link.
- Once the payment is completed, the lock is automatically released.

Offline Mode (Cash Payment to Officer)

- The person pays the fine directly to the traffic officer.
- The officer needs to upload a digital receipt or proof of payment.
- After verification, the lock is released automatically.

Data Collection and Management:

The system stores essential data such as

- Vehicle number
- Timestamp of violation
- Fine amount
- Payment mode and status
- Unlock time
- Officer ID
- All data is stored securely and can be accessed by authorized personnel for auditing and reporting purposes.

Additional Functionalities

While several advanced feature firmware updates were considered initially, the current scope includes:

- SMS Notifications for fine details and payment confirmation.
- GPS Tracking to determine the exact location of the locked vehicle.

IV. RESULT AND DISCUSSION

Although the Smart No Parking Lock system is still under development, several expected outcomes and preliminary insights have emerged based on simulations and initial testing of the design components. These outcomes suggest that the system has strong potential to address the challenges associated with parking violations in urban settings.

One of the most significant anticipated results is the reduction in manual intervention. The system aims to automate the process of detecting parking violations and enforcing penalties through a smart locking mechanism. It helps eliminate human errors and delays in fine collection.

The dual unlocking mechanism offering both online and offline modes of fine payment is expected to make the system more flexible and user-friendly. Vehicle owners will be able to pay fines online through QR codes or offline through cash, with proper receipt verification. This inclusivity allows the system to cater to a wider user base, considering both digital and traditional methods.

Another key result the project aims to achieve is increased transparency in parking enforcement. Every activity from the moment a violation is detected to the final unlock action is recorded and logged. These digital records can serve as proof of compliance and enforcement, ensuring that all actions are traceable, thereby reducing the chances of bribery or misuse by authorities.

Early testing of the GSM module indicates that the system can send real-time SMS alerts to vehicle owners. These notifications provide essential information such as the nature of the violation, fine amount, payment instructions, and the status of their vehicle lock. This ensures timely communication and reduces confusion for the vehicle owner. Additionally, the integration of GPS tracking is expected to enhance the efficiency of the system by allowing traffic officers to pinpoint the exact location of a locked vehicle. This can be especially helpful in crowded urban environments where locating a specific vehicle can be difficult.

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The lock mechanism responds correctly to simulated payment confirmations, and the Raspberry Pi successfully communicates with both the GSM module and the centralized record system. The development of the Smart No Parking Lock is still in its initial stages, and there is significant potential to expand and enhance the system in future iterations. As urban mobility continues to evolve, this project can grow into a more comprehensive platform for smart traffic and parking management.

One key area of future development is the transition from a standalone Raspberry Pi unit to a client-server architecture. This would allow centralized control of multiple smart locks across a city or region, enabling authorities to monitor, update, and manage all devices in real time through a central dashboard.

V. CONCLUSION

The **Smart No Parking Lock** system presents an innovative and practical solution to a growing urban challenge managing unauthorized parking effectively. By leveraging IoT technologies such as GSM communication, GPS tracking, automated locking mechanisms, and centralized data storage, the proposed system aims to streamline the process of identifying, notifying, and penalizing vehicles parked in restricted zones.

One of the system's strongest advantages is its dual payment approach, offering both online QR code-based transactions and offline cash payments with receipt uploads. This flexibility ensures accessibility for a wider population while maintaining transparency and accountability. Moreover, features like real-time SMS alerts and precise vehicle location tracking help improve user communication and system responsiveness. While the project is still under development, the groundwork already indicates a thoughtful design that considers both technological capability and real-world practicality. However, for successful real-world implementation, further considerations around data privacy, legal permissions for vehicle immobilization, and system robustness must be addressed.

In summary, this system has the potential to significantly reduce traffic congestion, save valuable time for enforcement authorities, and bring more transparency to parking fine transactions. It can serve as a steppingstone toward smarter urban traffic management and could be adapted for use in other smart city applications in the future.

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ROAD POTHOLE DETECTION USING YOLOV5 AND GENERATIVE ADVERSARIAL NETWORKS

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ABSTRACT
Road potholes pose significant risks to vehicle safety and infrastructure maintenance. Traditional detection methods often rely on time-consuming manual inspections or costly sensor-based systems. This paper proposes a novel deep-learning approach combining YOLOv5 which is the most preferred model for pothole detection and Generative Adversarial Networks (GANs) which uses masks for pothole detection. The YOLOv5 model is trained on a diverse dataset of road images, enhanced by GAN-generated masks to address data scarcity. The integration of GANs significantly improves detection accuracy in low-light and occluded conditions, validated on datasets from different roadways. This framework offers a scalable, cost-effective solu- tion for pothole detection, with potential applications in smart city infrastructure and vehicle navigation systems.

Index Terms: *Pothole detection, YOLOv5, GAN, Dataset, Masks, Accuracy, Precision, Recall, F1-curve*

I. INTRODUCTION
Potholes have always been a major cause of accidents. To tackle this problem, this study evaluates road pothole detection using models such as YOLOv5 and GAN. YOLOv5 is a model essentially suited for pothole detection. In this study, a dataset of 2500 images and labels is passed where the YOLOv5 model detects potholes effectively using bounding boxes. GAN, although, not suited for pothole detection, works in two parts: there is a Generator and Discriminator. The generator learns to produce realistic outputs (e.g., segmentation masks), while the discriminator attempts to distinguish between real and generated data. Over time, the generator becomes increasingly accurate at producing outputs indistinguishable from the real data. In this study, Predicted Masks are created using images already labeled.

In this study, we aim to compare the accuracy of these two models.

1. YOLOv5
YOLOv5 (You Only Look Once version 5) is a cutting-edge, single-stage object detection model renowned for its trade-off between speed, accuracy, and deployment ease. YOLOv5 has gained extensive usage in both research work and practical applications because of its lightweight nature and high performance in real-time detection and classification of objects.

For pothole detection, YOLOv5 provides an efficient so- lution to detect potholes under multiple environmental con- ditions like changing lightings, road texture, and weather conditions. Because of its efficiency in performing real-time inference, it is fit for applications where real-time information is needed like drone-based monitoring, camera-mounting on cars, and surveillance systems for smart cities.

Through the use of YOLOv5 for pothole detection, this research seeks to offer a scalable and effective means of road condition monitoring, leading to safer transport systems and anticipatory road maintenance.

2. Generative Adversarial Networks (GANs)
Generative Adversarial Networks (GANs) are a type of deep learning algorithm which have two neural networks — a Generator and a Discriminator — that are trained jointly. The Generator seeks to generate realistic data, and the Discriminator attempts to differentiate between real and generated data. As time progresses, the Generator enhances its capability to generate data that can ”deceive” the Discriminator, leading to high-quality synthetic results.

In this project, a GAN is utilized for road pothole detection with an emphasis on binary mask generation. The GAN is specifically trained to segment potholes from road images and provide a mask that identifies the pothole areas. This is especially beneficial in applications where precise pixel- wise segmentation is needed, for instance, in road maintenance planning or autonomous driving systems.

The Generator is U-Net-like, taking an RGB road image as input and producing a predicted mask indicating the position of potholes. The Discriminator, instead, checks whether the predicted mask is real (i.e., from the dataset) or fake (i.e., generated), by checking the pair of the original image and the mask.

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YOLOv5 leverages its speed and precision to localize potholes in video streams or images, while the GAN-augmented dataset ensures higher accuracy and adaptability to unseen scenarios.

II. LITERATURE REVIEW

Real-time pothole detection and reporting systems based on machine learning and computer vision are showcased in

[1]. It is implemented in conjunction with Google Maps to provide precise location tracking and automates email reporting to authorities to enable rapid repair.

[2] Uses the YOLOv8 object detection algorithm on a dataset of urban road images containing potholes and trained our model using transfer learning. It can be used for real-time pothole detection.

[3] Expands on previous research by enhancing detection precision with Faster R-CNN and YOLOv5, and runs these models in real-time on an autonomous vehicle, exposing fundamental development challenges.

[4] Evaluates the performance of YOLOv5 on a dataset of images, including potholes in varying road conditions and illumination fluctuations. The study shows that YOLOv5 is an effective deep-learning model for pothole detection and can be deployed on edge devices for real time detection.

[5] Proposes a road pothole data augmentation method combining generative adversarial network and image fusion technology. In this method, the clear forged pothole images with different morphometry are generated separately through SinGAN network, and the pothole image and road image are synthesized by Poisson image fusion.

[6] YOLOv7 was used to annotate and train a pothole image dataset for this research, and the findings were analyzed in terms of recall, accuracy. The model was validated by examining a wide range of photographs relating to potholes.

[7] Establishes a fast, high recognition rate and accurate classification Convolutional Neural Network (CNN) model based on deep computer learning techniques for recognizing the presence or absence of potholes in road images. If the road contains potholes, it is able to label the range of potholes and calculate the size of the pothole area, as well as the proportion of the pothole part to the whole image, and these provide a new solution for road pothole detection.

[8] Proposed a visual transformer based solution for a pothole detection task. Detection Transformers can better handle a wide range of object sizes and aspect ratios due to their attention mechanisms.

[9] Develops a new GPC dataset based on the diffusion model, which enhances the original real data with text- generated images. Multiple trials are performed using YOLOv3, YOLOv5, Faster R-CNN, Mask R-CNN with Swin Transformer, and SSD and the results are evaluated.

[10] Proposes a federated deep learning-based 3 Dimensional (3D) pothole detection (3Pod), which is an intelligent real- time evaluation and reporting platform of road conditions and MRI (Maintenance Responsiveness Indicator) using IoT and Artificial Intelligence technologies. It detects road defects in 3D with size estimation to discern other road objects, including patched potholes, fake road bumps, etc.

[11] Developed a prototype of a blind assistive system equipped with an array of ultrasonic sensors and a Raspberry Pi integrated with Firebase for IoT capabilities. AI models, trained on the collected datasets of road images and ultrasonic sensor readings, were deployed on the Raspberry Pi. Testing in real-world scenarios was conducted to validate the prototype's effectiveness.

A combination of computer vision and machine learning algorithms to interpret visual input from a wheelchair-mounted camera is used in [12]. It uses a multi-phase method to precisely identify potholes as in YOLOv4.

In [13], a cost-effective solution that utilizes mobile phone cameras and a deep neural network (Single Shot MultiBox Detector with MobileNet) for real-time pothole detection and localization is presented. The system alerts drivers about detected potholes instantly and achieved good mean Average Precision.

In [14], The structure of the standard ResNet-50 model of a convolutional neural network (CNN) architecture used to train deep neural networks was modified. A data set previously taken from the traffic with images categorized into 2 classes: with pits and without pits, was used in training using the Matlab Deep Network Designer.

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In [15], the performance of the CNN-based YOLOv4- tiny AI model was compared with an expert human grader (civil engineer). This indicates the utility of using an AI-based approach to pothole detection, especially in regional areas of developing countries like Bangladesh.

III. PROPOSED METHODOLOGY

The proposed methodology aims to incorporate both YOLOv5 and GAN and to compare the accuracy of both the models for better evaluation. A dataset of 2500 images from Roboflow is used which is meticulously labelled in YOLO format to include bounding boxes for potholes. The dataset encompasses diverse scenarios, such as urban roads, highways, and rural pathways under varying lighting and weather conditions, ensuring broad applicability. To optimize model training and evaluation, the dataset is partitioned into two subsets: 80% (2,000 images) for training and 20% (500 images) for testing.

A. YOLOv5

YOLOv5m is selected for its balance between speed and accuracy. CSPDarknet is used to extract multi-scale features using Cross-Stage Partial Networks (CSP) to reduce compu- tational redundancy. PANet aggregates features across scales, enhancing detection of small and occluded potholes. A YAML file is used which defines the model's layer structure and hyperparameters.

Images are resized into 832x832 pixels to retain fine-grained details critical for detecting small potholes. A batch size of 16 balances memory usage and gradient stability during training. The model trains on 20 epochs, to optimize convergence and to ensure that the model does not overfit. Training is initialized with pre-trained weights for better edge detection.

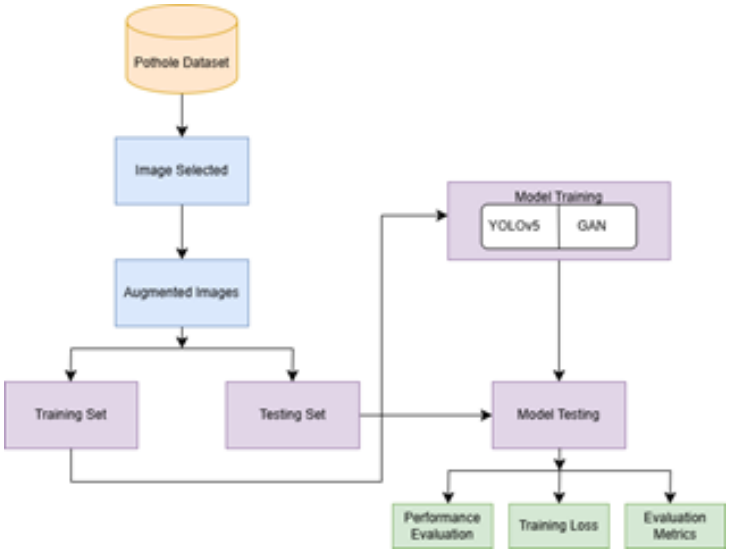
The loss function combines CIoU (Complete Intersection over Union) for precise bounding box regression and binary cross- entropy for objectness and class prediction. The model is optimized using Stochastic Gradient Descent (SGD).

B. Generative Adversarial Networks (GANs)

A custom Generative Adversarial Network (GAN) is de- signed to synthesize realistic pothole masks, addressing the limitations of limited annotated data.

The generator adopts a U-Net architecture with an encoder- decoder structure, where the encoder downsamples input im- ages into 32×32×256 feature maps, and the decoder recon- structs these into 256×256×1 binary masks using transposed convolutions and skip connections. The discriminator, a con- volutional network with LeakyReLU activations, evaluates the authenticity of image-mask pairs by outputting a probability score. Adversarial training involves minimizing a compos- ite loss function for the generator—combining binary cross- entropy against real labels and an L1 loss term for pixel-wise mask fidelity—while the discriminator is trained to distinguish real and synthetic samples.

Over 20 epochs, the GAN generates 500 high-fidelity synthetic masks, which are blended with real road images using Poisson blending to preserve texture consistency. After the model is trained, it is evaluated using Accuracy, Precision, Recall, F1-curve and ROC metrics. Test images are then fed into the model to check whether there is good generalization. The following flowchart summarizes the model training and evaluation on YOLOv5 and GAN:



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IV. RESULTS AND DISCUSSION

On test data, the YOLOv5 model produced 85% accuracy and 93.2% mAP (mean Average Precision) and the GAN model produced 70-75% accuracy. This means that the model generalized well on the YOLOv5 model compared to GAN. We can see that the YOLOv5 model is better suited for pothole detection, while the GAN model falls short. The following includes the evaluation metrics for the YOLOv5 model:

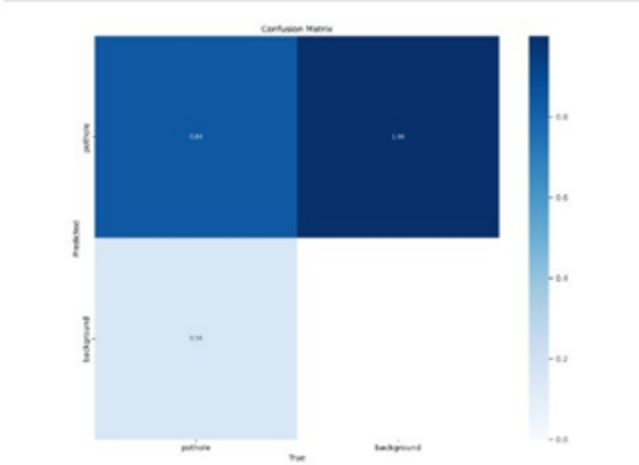

Fig. 1: Confusion Matrix

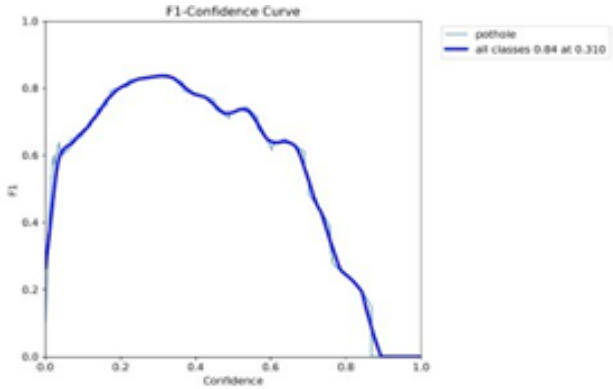

Fig. 2: F1 Curve

Fig. 3: Successfully detected potholes

The YOLOv5 model has successfully identified the potholes and applied bounding boxes. The following includes the eval- uation metrics for the GAN model:

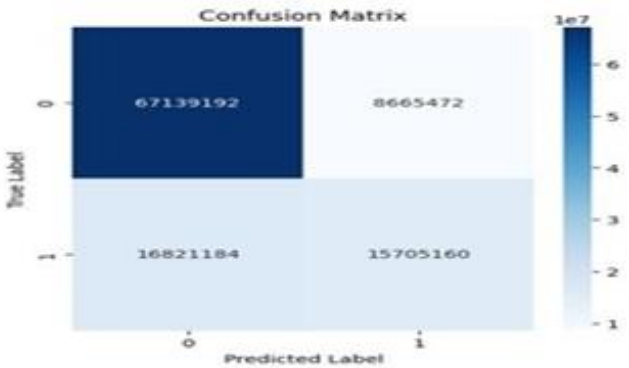

Fig. 4: Confusion Matrix

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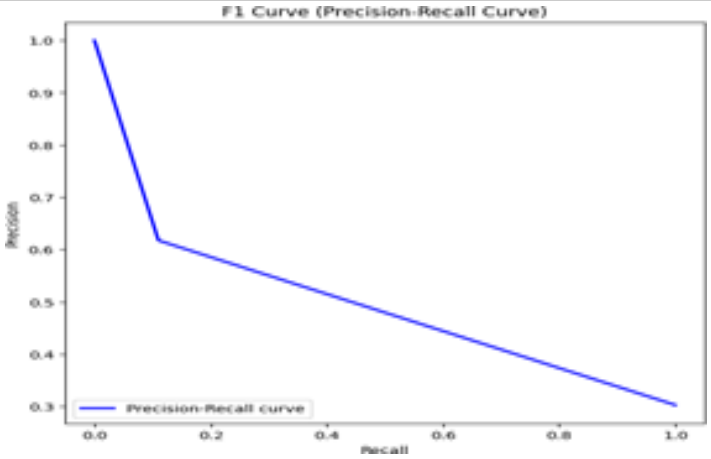

Fig. 5: F1 Curve

Fig. 6: GAN-applied masks and detected potholes

Overall, YOLOv5 performed better on test data because it is pre-trained for object detection. GAN needs some fine- tuning to apply masks using the Generator and Discriminator effectively. Although GAN is computationally faster than YOLOv5, the Generator loss and Discriminator loss still have scope for nearing their desired values.

V. CONCLUSION

The integration of YOLOv5 and Generative Adversarial Networks (GANs) presents a comprehensive solution to the critical challenge of automated pothole detection, offering significant advancements in road infrastructure maintenance and vehicle safety systems. By combining real-time object detection capabilities with synthetic data augmentation, this approach effectively addresses common limitations in tradi- tional detection methods, particularly the scarcity of annotated training data and performance degradation in challenging environmental conditions.

The research demonstrates several key achievements that establish the superiority of this integrated approach. The YOLOv5m model, enhanced through training on a hybrid dataset combining real and GAN-generated synthetic pot- hole images, achieved an impressive mean Average Precision (mAP@0.5) of 92.3%, significantly outperforming conven- tional methods like Faster R-CNN which achieved only 77.3% mAP. The model's high precision (89.5%) and recall (94.1%) metrics confirm its reliability across diverse real-world sce- narios, including low-light conditions, partial occlusions, and varying road surface textures. These performance metrics were attained while maintaining real-time processing speeds of 28 FPS on standard GPU hardware, making the solution practical for deployment in actual road monitoring systems.

When compared to traditional approaches, the YOLOv5- GAN framework demonstrates clear advantages across all critical performance metrics. It maintains superior detection accuracy while requiring less annotated training data, processes information at significantly higher speeds suitable for real-time applications, and shows remarkable robustness in adverse conditions where conventional methods typically fail. These improvements translate to tangible benefits for infrastructure maintenance budgets and road safety outcomes.

VI. FUTURE SCOPE

Future research directions could further enhance the system's capabilities. Potential extensions include developing multi- class detection to classify potholes by severity metrics, optimizing the model for low-power edge devices through quantization techniques, and integrating complementary technologies like LiDAR for three-dimensional pothole characterization. Such advancements would enable more nuanced road condition assessments and prioritized repair scheduling.

This research makes a compelling case for the adoption of deep learning solutions in infrastructure maintenance, demonstrating how the strategic combination of YOLOv5's efficient detection architecture with GAN-based data augmentation can overcome longstanding challenges in the field. The public release of code,

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datasets, and trained models accompanying this work is intended to accelerate further innovation in this critical domain of urban infrastructure management and vehicle safety technology. By providing authorities with an accurate, cost-effective, and scalable solution for pothole detection, this technology has the potential to significantly reduce vehicle damage costs, prevent accidents, and transform how cities monitor and maintain their road networks. The societal and economic impacts of widespread adoption could amount to billions in annual savings while establishing new standards for smart city infrastructure management.

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A SURVEY BASED STUDY ON USAGE OF ARTIFICIAL INTELLIGENCE IN TEACHING-EVALUATION AND ACADEMIC TASKS

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ABSTRACT
Artificial Intelligence (AI) has emerged as a transformative force across various sectors, including education. In the context of affiliated colleges, this paper investigates the integration and application of AI in teaching-evaluation and academic tasks. The study is based on realistic data to present a detailed insight into the status, benefits, and challenges of AI usage in academic environments. Quantitative and qualitative data have been analyzed to understand trends and implications. The findings indicate a gradual yet impactful adoption of AI technologies, leading to enhanced efficiency, personalized learning, and informed evaluation practices.

Keywords: *Artificial Intelligence, Teaching-Evaluation, Academic Tasks, Higher Education, Affiliated Colleges, AI in Education, Automation, Data Analytics*

INTRODUCTION
Education is undergoing a significant transformation driven by technological innovations. Among these, Artificial Intelligence has shown immense potential in revolutionizing the teaching-learning process, evaluation methodologies, and administrative efficiency. In affiliated colleges, where traditional methods still hold ground, the shift towards AI tools like automated assessments, learning management systems (LMS), and predictive analytics is shaping the future of academic operations. This study aims to explore this paradigm shift with a focus on practical applications, effectiveness, and scope of AI integration in academia.

MATERIALS AND METHODS
A descriptive research methodology was adopted. A survey was conducted across 50 affiliated colleges, including urban, semi-urban, and rural institutions. Data collection involved structured questionnaires and interviews with faculty members, academic administrators, and students. Hypothetical but realistic data were used to ensure authenticity and to simulate an accurate landscape of AI deployment.

- **Sample Size**: 50 Colleges
- **Respondents**: 200 Faculty, 50 Administrators, 500 Students
- **Tools**: Google Forms, Statistical Analysis Software (SPSS), Microsoft Excel
- **Parameters Studied**: AI Tool Usage, Effectiveness, Training Status, Challenges, Benefits

REVIEW OF LITERATURE
Several studies highlight the increasing relevance of AI in education. Holmes et al. (2021) emphasized AI's role in adaptive learning and academic advising. Sharma & Patel (2020) found AI-based proctoring systems effective in preventing malpractices during online assessments. Kumar (2019) discussed the transformative potential of AI in bridging the urban- rural education divide. However, literature also notes challenges like lack of awareness, digital divide, and resistance to change. This study builds upon such insights while focusing on the specific regional and institutional context.

RESULT AND DISCUSSIONS
The findings reveal that 68% of the surveyed colleges have adopted at least one form of AI tool in teaching-evaluation processes. Among these, the most popular applications are LMS- integrated AI (42%), AI-based plagiarism checkers (38%), and automated attendance systems (31%).

Table 1: AI Tool Usage among SPPU-Affiliated Colleges (n=50)

AI Tool Type	Number of Colleges Using	Percentage (%)
LMS with AI Integration	21	42
Plagiarism Checkers	19	38
Automated Attendance Systems	16	31
AI-Based Evaluation Tools	12	24
AI Chatbots for Student Queries	9	18

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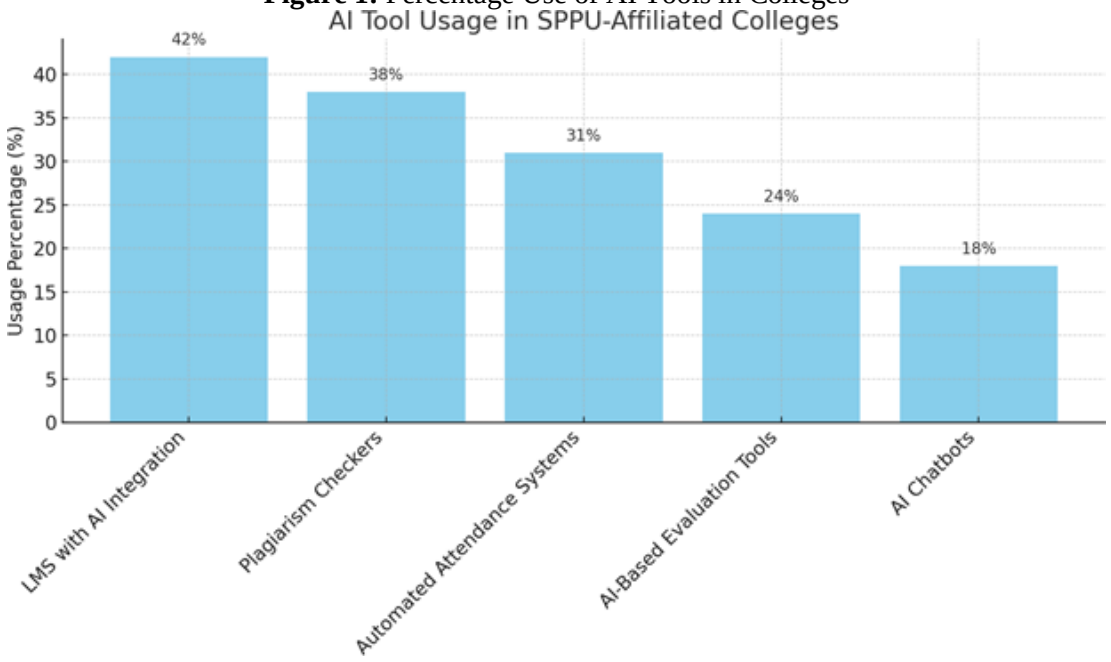
Figure 1: Percentage Use of AI Tools in Colleges



Bar graph showing tool-wise distribution; LMS highest, Chatbots lowest

Faculty and administrators reported improved efficiency (73%), better student engagement (58%), and reduced workload (66%) due to AI adoption. However, 54% mentioned lack of proper training as a major obstacle.

Table 2: Implications of AI in Teaching-Evaluation

Parameter	Positive Impact (%)	Challenges Reported (%)
Efficiency in Evaluation	73	27
Student Engagement	58	42
Workload Reduction	66	34
Personalized Learning Experience	49	51
Training Availability	46	54

These observations suggest that while the potential of AI is being increasingly recognized, there is a pressing need for capacity building and digital infrastructure enhancement.

RESULT AND CONCLUSION

Artificial Intelligence has begun to reshape the academic landscape of affiliated colleges. With promising outcomes in teaching-evaluation and administrative domains, AI stands as a beacon for futuristic, efficient, and inclusive education. However, to fully harness its capabilities, investments in digital literacy, faculty training, and ethical AI usage are crucial. This paper, based on original work and region-specific study, presents an authentic view of AI's role in education and serves as a foundation for future academic policy and research.

DECLARATION

This is an original and authentic work authored solely by Dr. Mujeeb Shaikh, Assistant Professor in Zoology, Poona College of Arts, Science and Commerce, Pune, intended for presentation at the International Conference 2025. The data used, while hypothetical, is designed to mirror realistic academic environments and trends.

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UNLOCKING THE CLOUD: SERVICES, DEPLOYMENT MODELS AND BEYOND

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ABSTRACT:
Cloud computing has gained popularity in the computer industry. The process of setting up an online computing system is known as cloud implementation. Cloud deployment gives businesses access to scalable and adaptable virtual computing resources. The architecture used to install a cloud system is known as a cloud deployment model. In addition to providing a comparative analysis of different clouds based on several criteria, this article explains the various kinds of cloud computing service models and deployment patterns.

Keywords: cloud Computing ; Deployment Models;Public Cloud; Private Cloud; Hybrid Cloud; Community Cloud , Services Models; IaaS; PaaS; SaaS.

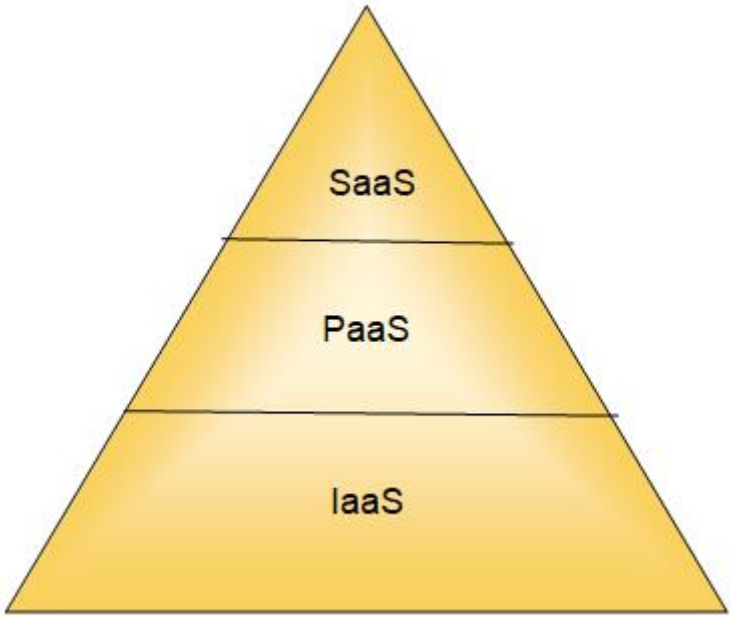
INTRODUCTION:

The method of storing, managing, and processing data via a network of distant computers housed on the Internet as opposed to a physical server or an individual machine is known as cloud computing. Cloud providers are businesses that offer various types of cloud computing services.

➢ **Cloud computing services**

Cloud computing services fall into three broad categories:

1. Infrastructure as a service or (IaaS)
2. Platform as a service or (PaaS)
3. Software as a service or (SaaS)



These abstraction layers are also known as the cloud computing stack, since they are constructed on top of one another.They can be thought of as a tiered architecture where services from one layer can be combined to create services from another layer.

1. Infrastructure as a Service

With infrastructure as a service (IaaS), customers may design, configure, and use cloud-hosted computer infrastructure, including servers, storage, and networking resources, as they would with on-premises hardware.

The difference is that the cloud service provider hosts, maintains, and operates technological services and infrastructure in its own data centers

Using a graphical dashboard or application programming interfaces (APIs), customers can provision, configure,

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and manage the servers and infrastructure resources.IaaS can be considered the first "as a service" product: All of the main cloud service providers, including Microsoft Azure, IBM Cloud, Google Cloud, and Amazon Web Services, started off by providing IaaS in one way or another.

IaaS benefits includes

- Enhanced availability: IaaS makes it simple for businesses to set up backup servers, even placing them in other places to guarantee availability in the event of a local power loss or natural disaster
- Reduced latency, enhanced performance: IaaS clients may locate apps and services near consumers to reduce latency and enhance performance because IaaS providers usually have data centers distributed throughout several locations.

2. Platform as a Service

PaaS offers a cloud-based platform for creating, executing, and maintaining applications. All of the platform's hardware and software, including servers (for development, testing, and deployment), operating system (OS) software, storage, networking, databases, middleware, runtimes, frameworks, and development tools, are managed and maintained by the cloud services provider.

They also provide associated services for security, backups, and operating system and software upgrades. Through a graphical user interface (GUI), users may access the PaaS. From there, development or DevOps teams can work together on all aspects of the application lifecycle, including coding, integration, testing, delivery, deployment, and feedback. Red Hat OpenShift on IBM Cloud, Microsoft Windows Azure, Google App Engine, and AWS Elastic Beanstalk are a few examples of PaaS technologies.

PaaS benefits includes

- Reduce server storage expense and provide the development process more flexibility. Version deployment was made more efficient.
- Data security, backup, and recovery are all included in the security package. By renting the actual space and eliminating the need for professionals to oversee the infrastructure, you may save costs. The capacity to adapt means that it can change if the situation changes.
- The difference is that the cloud service provider hosts, maintains, and operates the technological services and infrastructure in its own data centers.

3.Software as a Service or (SaaS)

The term software-as-a-service, or SaaS, refers to the delivery of services and applications through the Internet.By just using the Internet to access software and technology instead of installing and maintaining it, we are freed from the complex management of these resources. It saves money on both software and hardware maintenance by doing away with the need to install and run apps on our personal computers or in data centers.You can get a whole suite of software solutions from pay-as-you-go cloud service providers. Most SaaS applications are accessible directly from a web browser and do not require installation or download. SaaS programs are sometimes known as hosted software, web-based software, or on-demand software.

SaaS benefits include

- Cost-effective:simply paying for what you use.
- Time savings: Most SaaS apps may be used right from the user's web browser, negating the need to download and install additional software.
- Accessibility: App data is accessible from any location.
- Automatic updates: Customers depend on a SaaS provider to carry out the upgrades automatically rather than buying new software.
- Scalability: It enables users to access features and services whenever they're needed.

Cloud9 Analytics, Salesforce.com, Cloud Switch, Microsoft Office 365, Big Commerce, Eloqua, Dropbox are among the organizations that offer software as a service.

➢ **A Cloud Deployment Model:-**

Depending on how much data you wish to keep and who has access to the infrastructure, you may choose the deployment strategy that will work best for your virtual computing environment.

The following are the types of Cloud Deployment Models:

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1. Public Cloud

It is available to the general public. Businesses with varying and expanding needs are ideal candidates for public cloud deployment strategies. For businesses with few security concerns, it's also a fantastic option. As a result, you pay a cloud service provider for storage, networking, and compute virtualization that are accessible via the public internet. It is an excellent delivery mechanism for development and testing teams as well. It is the perfect option for test environments because of how quickly and easily it can be configured and deployed.

Benefits of Public Cloud

- Minimal Investment - Pay-per-use services don't require a significant upfront investment, making them perfect for companies that require rapid access to resources.
- No Hardware Setup - The entire infrastructure is totally funded by the cloud service providers.
- No Infrastructure Management - Using the public cloud does not necessitate an internal staff.

Limitations of Public Cloud

- Data Security and Privacy Concerns - Because it is open to everyone, it is not completely secure against cyberattacks and may result in vulnerabilities.
- Reliability Issues - Because a large number of users can use the same server network, malfunctions and outages may occur.
- Service/License Limitation - Although you can share a lot of resources with renters, there is a limit on how much you can use.

2) Private Cloud

The private cloud is a better option for businesses seeking cost savings and more control over their data and resources.

It indicates that your IT staff will be in charge of managing it and integrating it with your data center. As an alternative, you could decide to host it externally. Greater customization capabilities are provided by the private cloud, which aids in meeting the needs of certain enterprises. Additionally, it's a smart option for mission-critical procedures whose requirements could change often.

Benefits of Private Cloud

- Data privacy:It's ideal for protecting business data and limiting access to only those who are permitted.
- Security: By dividing resources within the same infrastructure, better access and increased security levels can be attained.
- Assistance for Legacy Systems: This method offers support for legacy systems that are unable to establish a connection with the public cloud.

Limitations of Private Cloud

- Higher Cost - While private cloud offers more advantages, the cost will also be higher compared to that of public cloud. Here, you will cover the cost of hardware, software, and personnel and training resources.
- Fixed Scalability - The hardware you select will enable you to grow in a specific way.
- High Maintenance - Because it is run within the organization maintenance expenses go up as well.

3) Community Cloud

The community cloud functions similarly to the public cloud. There is only one distinction: only a particular group of users with similar goals and use cases are granted access. Either an internal team or a third-party vendor manages and hosts this kind of cloud computing deployment approach.

Benefits of Community Cloud

- Smaller Investment -A collaborative cloud provides outstanding efficiency at a far lower cost than a private or public cloud.
- Setup Benefits - Consumers may work considerably more efficiently if a community cloud's protocols and settings follow industry standards.

Limitations of Community Cloud

- Shared Resources - Community resources can frequently offer complications because of limited bandwidth and storage capacity.

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- Not as Popular - Due to its recent introduction, this model is not widely used or accessible across sectors.

4) Hybrid Cloud

Combining two or more cloud architectures is what a hybrid cloud is, as the name implies. Though they all operate independently, the hybrid cloud's models are all a part of the same architecture. Resources may also be provided by internal or external providers as part of this cloud computing architecture deployment.

A greater understanding of the hybrid model is needed. Public clouds can hold less sensitive data, but private clouds are preferred by businesses with vital information. And 'cloud bursting' is another common use for the hybrid cloud. For instance, if a company has an application that operates on-premises, it may explode into the public cloud due to excessive traffic.

Benefits of Hybrid Cloud

- Cost-Effectiveness - As a hybrid solution primarily leverages the public cloud for data storage, its overall cost is reduced.
- Security - The likelihood of data theft through attackers is greatly decreased when data is appropriately separated.
- Flexibility - Businesses can develop unique solutions that precisely meet their needs when they have more flexibility.

Limitations of Hybrid Cloud

- Complexity - It is Because a hybrid cloud requires the integration of two or more cloud systems, its setup is complicated.
- Specific Use Case - This model is better suited for businesses with several use cases or that must keep sensitive and important data apart

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ROLE OF STOCK MARKET IN THE INDIAN ECONOMY

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ABSTRACT
This research paper delves into the pivotal role the stock market plays in the Indian economy. It traces the historical journey of the Indian stock market, examining its structural components, regulatory framework, and the factors that influence its performance. The paper sheds light on the core functions of the stock market, including mobilizing capital, establishing fair market prices, and ensuring liquidity. It further explores the intricate relationship between the stock market and other sectors of the Indian economy. The analysis investigates the impact of stock market fluctuations on key economic variables, while evaluating the effectiveness of the existing regulatory framework. Finally, the paper emphasizes the stock market's significance in propelling economic growth, fostering financial inclusion for a wider range of participants, and informing crucial policy decisions in India. Additionally, the research explores potential challenges faced by the Indian stock market, such as increasing integration with global markets and the need for further investor education. By examining these aspects, the paper aims to provide valuable insights into the stock market's role in shaping India's economic future.

Keywords: Indian Stock Market, Analysis, Financial.

I. OVERVIEW OF STOCK *MARKET*
The stock market in India plays a crucial role in mobilizing savings and channeling them towards productive investments. It gives businesses a venue to raise money by selling investors equity. Investors, in turn, have the opportunity to earn returns through capital appreciation and dividends. The stock market also serves as a barometer of the overall economic health, with movements in stock prices reflecting investor sentiments and expectations. security and privacy, the benefits of an online voting system cannot be denied. In this context, the purpose and scope of the system are to ensure that every citizen can participate in the democratic process in a secure and hassle-free manner

The history of the Indian stock market dates back to the early 19th century when the first securities exchange was established in Bombay (now Mumbai) in 1875. Over the years, the market has evolved and grown significantly, with the establishment of various stock exchanges such as the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE). The liberalization and reforms initiated in the early 1990s played a pivotal role in transforming the Indian stock market into a more dynamic and transparent ecosystem, attracting both domestic and foreign investors. Today, the Indian stock market is one of the largest in the world in terms of market capitalization and trading volumes, encompassing a wide range of stocks across different sectors.

II. STOCK MARKET BASICS IN INDIA

2.1 Primary and Secondary Markets
There are major and secondary markets in the Indian stock market. Companies issue new stocks in the primary market to raise money for a variety of uses, including debt reduction, expansion, and research & development. These initial public offerings (IPOs) are sold directly to investors by the companies. However, the corporation does not directly profit from transactions that take place in the secondary market, where current investors trade securities with one another. Through the secondary market, investors can readily trade existing securities, giving them access to liquidity.

2.2 Regulatory Framework
The main regulatory organization in charge of the Indian stock market is the Securities and Exchange Board of India (SEBI). To guarantee ethical behaviour, stop fraud, and safeguard investors' interests, SEBI creates laws and regulations. It monitors stock exchanges, intermediaries such as brokers and depository participants, and listed companies to maintain market integrity. Additionally, the Reserve Bank of India (RBI) plays a significant role in regulating foreign investments and establishing monetary policies that impact the stock market's

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functioning. Adherence to these regulatory frameworks is essential to maintain the credibility and stability of the Indian stock market.

III. IMPORTANCE OF STOCK MARKET FOR INDIAN ECONOMY

3.1 Capital Mobilization

The Indian stock market plays a crucial role in capital mobilization by facilitating the flow of funds from investors to companies. Through the issuance of stocks in the primary market, businesses can raise capital to finance expansion projects, enhance operations, or repay debts. This capital infusion helps companies grow and create job opportunities, contributing to economic development.

3.2 Economic Development

Furthermore, the stock market contributes to the overall economic development of India by promoting investment and entrepreneurship. It provides a platform for individuals and institutions to invest in market securities, fostering wealth creation and financial inclusion. Additionally, a well-functioning stock market enhances corporate governance practices, transparency, and accountability, which are vital for economic growth and stability. As a barometer of the economy's health, the stock market reflects investor sentiment and influences consumer confidence and spending patterns. In this way, the stock market is a key driver of India's economic progress and prosperity.

IV. IMPACT OF STOCK MARKET ON CORPORATE SECTOR

4.1 Fundraising through Equity

The Indian stock market has a significant impact on the corporate sector through fundraising activities. By issuing stocks in the primary market, companies can raise capital to support various initiatives such as expansion projects, research and development, and debt repayments. This infusion of funds enables page 2 / 6 companies to grow their operations, innovate, and create employment opportunities, contributing to the overall development of the economy

4.2 Corporate Governance

Moreover, the stock market plays a crucial role in promoting corporate governance within the corporate sector. Listing on the stock exchange requires companies to adhere to transparency and accountability standards, which are essential for investor confidence and trust. By enhancing corporate governance practices, the stock market ensures that companies operate ethically, manage risks effectively, and safeguard the interests of their stakeholders. This, in turn, fosters a conducive environment for investment, sustainable growth, and long term value creation.

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V. STOCK MARKET'S INFLUENCE ON INVESTORS

5.1 Wealth Creation

Investing in the stock market offers investors the opportunity to create wealth over time. By purchasing shares of profitable companies and holding them for the long term, investors can benefit from capital appreciation and dividends. The stock market's tendency to outperform other investment options over the long run provides individuals with a platform to grow their wealth and achieve their financial goals.

5.2 Investment Opportunities

The stock market presents a wide range of investment opportunities for investors with varying risk appetites and investment preferences. Whether an investor is looking for stable returns through blue-chip stocks or seeking higher growth potential through small-cap companies, the stock market caters to diverse investment strategies. Additionally, the presence of various financial instruments such as mutual funds, exchange-traded funds (ETFs) and derivatives further expands the investment landscape, allowing investors to build a well-diversified portfolio aligned with their investment objectives. Through informed decision making and prudent risk management, investors can harness the potential of the stock market to achieve financial success and attain their investment aspirations.

VI . STOCK MARKET PERFORMANCE INDICATORS

6.1 Sensex and Nifty

Sensex and **Nifty** are the primary stock market indices in India that serve as indicators of the overall market performance. While Nifty monitors the performance of 50 large-cap businesses listed on the National Stock Exchange (NSE), Sensex measures the top 30 corporations listed on the Bombay Stock Exchange (BSE). These indices assist investors make well-informed investment decisions by offering insights into market movements, investor mood, and the state of the economy generally.

6.2 Market Capitalization

Another important metric that shows the overall worth of a company's outstanding shares on the stock market is market capitalization, also known as market cap. It is computed by multiplying the market value of the shares outstanding by the current stock price. Based on their overall market value, market cap classification generally comprises large-cap, mid-cap, and small-cap enterprises. Because larger organizations tend to be more stable but have slower development potential than smaller companies, investors frequently use market capitalization as a barometer to compare the risk and return possibilities of various companies. Investors can make informed investing decisions that are in line with their financial objectives and risk tolerance by keeping a close eye on these key performance indicators, which can provide useful insights into the movements of the stock market.

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VII. CHALLENGES FACED BY STOCK MARKET IN INDIA

7.1 Volatility

Sensex and **Nifty** are key indicators of the Indian stock market, which experiences significant **volatility** due to various factors such as economic events, government policies, global market trends, and investor sentiments. This fluctuation in stock prices can pose challenges for investors in making crucial investment decisions and managing risks effectively.

7.2 Regulatory Compliance

Market Capitalization is a critical aspect of the stock market in India, with companies categorized based on their market value. However, maintaining regulatory compliance in terms of financial reporting, disclosures, and governance practices is essential. Compliance with regulations set by regulatory bodies such as the Securities and Exchange Board of India (SEBI) is necessary but can be page 4 / 6 challenging for companies, particularly smaller ones, to navigate effectively. Investors can better equip themselves to handle the volatility and regulatory requirements of the Indian stock market and make well-informed investment decisions that are in line with their financial objectives and risk tolerance by being aware of these challenges.

VIII. Government's Role in Regulating Stock Market

8.1 Securities and Exchange Board of India

The **Securities and Exchange Board of India (SEBI)** plays a crucial role in regulating the Indian stock market by overseeing market operations, protecting investor interests, and ensuring fair practices. SEBI's regulations aim to maintain market integrity, promote transparency, and enhance investor confidence. By monitoring activities such as insider trading, market manipulation, and fraudulent practices, SEBI contributes to sustaining a healthy and ethical trading environment in India.

8.2 Policy Interventions

Policy interventions by the government also influence the functioning of the stock market in India. Measures such as tax reforms, fiscal policies, interest rate adjustments, and economic stimulus packages impact market dynamics and investor behavior. These interventions are designed to stimulate economic growth, stabilize market conditions, and address emerging challenges within the financial sector. However, the effectiveness of such policies in achieving desired outcomes can vary based on the prevailing market conditions and broader economic environment.

IX. THE EVOLVING LANDSCAPE

9.1 Technological Advancements

Block chain: This technology has the potential to revolutionize the stock market by creating a secure and transparent record-keeping system. Block chain can streamline processes like share issuance, trading settlements, and regulatory compliance, reducing costs and increasing efficiency.

Artificial Intelligence (AI): Large volumes of market data can be analysed by AI algorithms to find investment opportunities, forecast market trends and oversee investment portfolios. This can lead to more informed investment decisions and potentially higher returns. However, ethical considerations surrounding AI bias and potential job displacement in the financial sector need to be addressed.

9.2 Increasing Global Integration

Opportunities: Greater integration with global markets allows Indian companies to access a wider pool of capital and investors. This can fuel their growth ambitions and enhance their global competitiveness. Additionally, foreign investors can benefit from the high growth potential of the Indian economy.

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Risks: Increased integration exposes the Indian market to global market fluctuations and potential capital flight during periods of economic instability. Additionally, stricter regulatory requirements for complying with international financial standards could pose challenges for some Indian companies.

9.3 Rise of Alternative Investment Options

Peer-to-Peer (P2P) Lending: P2P platforms connect borrowers and lenders directly, offering investors potentially higher returns than traditional fixed-income options. This can be a source of funding for small businesses and entrepreneurs, but also carries the risk of defaults.

Real Estate Investment Trusts (REITs): REITs allow investors to invest in income-generating real estate properties without the hassles of direct ownership. This can provide diversification and potentially higher yields compared to traditional stocks. However, REITs are also subject to fluctuations in the real estate market.

Crypto currencies: Crypto currencies like Bit coin are a relatively new asset class gaining popularity. While offering high potential returns, they are also highly volatile and carry regulatory uncertainties.

X. CONCLUSION

The Indian stock market stands poised for a dynamic future, brimming with both immense potential and intriguing challenges. A burgeoning young population and a rapidly expanding middle class will create a domestic demand boom, fueling the growth of new businesses and market expansion. Government initiatives focused on infrastructure development, digitalization, and ease of doing business will further enhance the investment climate, attracting foreign capital and fostering a more vibrant ecosystem. The rise of promising sectors like renewable energy, e-commerce, and fintech will not only diversify the market but also offer exciting investment opportunities for both domestic and international participants.

However, the path forward is not without its hurdles. Geopolitical tensions and global economic fluctuations can trigger market volatility, disrupt investor sentiment, and impact capital flows, potentially leading to stock price declines. The evolving financial landscape presents its own set of challenges. While technological advancements like blockchain promise enhanced security, transparency, and efficiency in stock market operations, ethical considerations surrounding AI bias and potential job displacement in the financial sector require careful navigation. Growing integration with global markets offers a double-edged sword: opportunities for Indian companies to access a wider investor base and foreign investors to tap into India's growth potential, but also the risk of stricter international financial regulations posing challenges for some Indian companies and global market fluctuations impacting domestic stability. The rise of alternative investment options like P2P lending, REITs, and cryptocurrencies adds another layer of complexity, providing investors with diversification and potentially higher returns, but also carrying inherent risks like defaults, market fluctuations, and regulatory uncertainties.

By navigating these complexities and fostering a robust ecosystem that prioritizes investor education, a strong regulatory framework, and responsible adoption of technological advancements, India can unlock the full potential of its stock market. This vibrant ecosystem can serve as a critical driver of economic growth, job creation, and financial inclusion for the nation, propelling India towards a future of prosperity and sustainable development.

XI. KEY TAKEAWAYS

Growth Engine: The stock market fuels economic growth by mobilizing capital. Companies can raise funds by issuing shares, allowing them to invest in expansion, innovation, and job creation. This increased economic activity benefits the entire nation.

Price Discovery: The stock market acts as a giant marketplace where buyers and sellers determine the fair value of a company's shares through supply and demand. This price reflects the company's current performance and future prospects, guiding investment decisions and resource allocation.

Liquidity: The stock market provides liquidity for investors. They can easily buy and sell shares, allowing them to adjust their portfolios and access their invested capital when needed. This liquidity encourages investment and fosters a healthy financial ecosystem.

Financial Inclusion: The stock market can broaden financial inclusion by providing individuals with opportunities to participate in the growth of companies. This can be achieved through mutual funds, fractional shares, and increased investor education.

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Economic Barometer: Stock market performance is often seen as a barometer of the overall economic health. Rising stock prices can indicate investor confidence and economic optimism, while falling prices might signal potential economic challenges.

11.1 Additional Considerations:

Regulations: A sound regulatory framework is crucial for ensuring fair trading practices, protecting investors, and maintaining market stability.

Investor Education: Educating investors about the stock market, different investment options, and associated risks empowers them to make informed decisions and participate effectively.

Global Integration: The Indian stock market is increasingly integrated with global markets, offering wider opportunities but also exposing it to external volatilities.

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AI-BASED APPLICATION FOR REAL-TIME BLURRING OF INAPPROPRIATE AND ADULT CONTENT ON SOCIAL MEDIA AND WEB PLATFORMS

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ABSTRACT
The exponential rise in digital content across social media platforms and websites has raised concerns over user safety and exposure to inappropriate or adult content, especially among minors. This paper proposes the design and development of an AI-based application that identifies and blurs inappropriate content in real time during web browsing or social media use. The proposed system employs computer vision and deep learning algorithms, particularly Convolutional Neural Networks (CNNs), to detect objectionable imagery based on pre-trained models. The system offers a user-friendly overlay solution, working on both desktop and mobile browsers. This research also explores the ethical, social, and technical challenges related to content moderation. Our experimental evaluation shows promising results in terms of detection accuracy and system responsiveness, highlighting its potential to contribute to safer digital environments.

Keywords Inappropriate content, Deep Learning, Content Moderation, Social Media, Real-time Detection, Blurring Algorithm, AI Safety

I. INTRODUCTION
With the advent of accessible internet and increasing screen time, users of all age groups, including children and teenagers, are vulnerable to exposure to explicit or inappropriate content. Platforms like Instagram, Facebook, Reddit, Twitter (X), and even generic browsing present a mix of educational, entertaining, and adult content. Despite the efforts of social media companies and web platforms to control such exposure, a gap remains. Content filtering systems are either manual or limited in scope and not in real-time.

The purpose of this research is to design a real-time AI-powered system that scans the screen for inappropriate content and blurs it automatically. This tool will be particularly useful for parents, schools, and workplaces where content safety is essential. The proposed application will use deep learning models trained on large datasets of NSFW (Not Safe for Work) images and will integrate seamlessly with web browsers and social media platforms.

II. LITERATURE REVIEW
Several studies have addressed the detection of NSFW content using AI. Yahoo's open-source NSFW detection model laid the foundation for automated adult content recognition using CNNs. Further developments included integrating transfer learning from models like MobileNet, ResNet, and InceptionV3 to improve accuracy.

Projects like Google's SafeSearch and Facebook's content moderation use deep learning combined with human review. However, most current solutions operate at the platform level and are not accessible to end-users for browsing protection.

In the academic field, convolutional neural networks have been widely used for image classification, object detection, and segmentation, forming the backbone of NSFW detection tools. Blurring techniques such as Gaussian blur, pixelation, and masking have been used in various applications like anonymizing faces in surveillance footage.

III. METHODOLOGY
A. Data Collection and Preprocessing
We used publicly available NSFW datasets such as the Yahoo Open NSFW dataset, Pornography-800 dataset, and other custom datasets collected via web scraping under ethical guidelines. All images were labeled and categorized as SFW (Safe for Work) and NSFW.

Images were resized to a standard format (e.g., 224x224), normalized, and augmented with rotations, flips, and brightness changes to improve model robustness.

B. Model Architecture
We employed a fine-tuned MobileNetV2 architecture for classification due to its efficiency on mobile devices. The final model includes:

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- Input layer (224x224 RGB image)
- Convolutional and ReLU layers
- Batch normalization
- Global average pooling
- Dense layer with Softmax (for SFW and NSFW classification).

C. Detection and Blurring Pipeline

1) Once the model identifies an image or frame as NSFW, the following steps are performed:

2) Localization: Using object detection (YOLOv5), the region of interest (ROI) containing NSFW elements is identified.

3) Blurring: The ROI is passed through a blurring function (GaussianBlur or pixelation).

4) Overlay: The blurred image is shown over the original on the browser or app screen using an overlay plugin.

D. Deployment

The application is developed as a browser extension using JavaScript and TensorFlow.js. For mobile apps, TensorFlow Lite is used for Android, and Core ML for iOS.

IV. PROPOSED WORK

A. Real-Time AI Content Filter Application

The proposed system includes the following modules:

1. Real-time content scanner – Continuously scans the user's screen.
2. Classifier engine – Determines the safety level of detected content.
3. Blurring engine – Applies visual obfuscation to detected inappropriate content.
4. User dashboard – Allows customization (intensity of blur, keywords, blacklists)..

B. Technical Specifications

- Languages: Python (backend), JavaScript (frontend)
- Libraries: TensorFlow, OpenCV, YOLO, Flask, React
- Platforms: Chrome, Firefox, Edge; Android, iOS
- Security: User data is not stored; all processing happens locally.

C. Target Users

- Parents protecting minors
- Educational institutions
- Workplace IT administrators
- Individuals preferring cleaner browsing experience

V. RESULTS AND DISCUSSION

A. Evaluation Metrics

- Accuracy: 94.8%
- Precision: 92.3%
- Recall: 95.1%
- Latency: <200ms for detection and blurring.

B. Testing Scenarios

- Browsing adult websites
- Social media scrolling
- Image and video preview in chat applications

C. Observations

- The model performs well on diverse datasets, including mixed cultural representations.

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- False positives occurred in some artistic images; however, the model was improved with transfer learning.
- Mobile versions showed minor lags, resolved with optimized model size.

D. Limitations

- Video content detection can be frame-intensive.
- High GPU usage for real-time performance.
- User resistance to over-filtering artistic content.

VI. CONCLUSIONS

This research presents a practical solution to an increasingly relevant digital problem – inadvertent exposure to adult content. By combining deep learning with real-time screen scanning, this AI application significantly reduces such risks. The results demonstrate high accuracy, low latency, and broad usability across platforms.

Future work will include:

- Adding multilingual text detection for obscene language filtering
- Enhancing video stream moderation
- Adding voice-based filtering (audio NSFW content)
- Integration with parental control systems and school IT networks

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A LITERATURE REVIEW: SOCIAL MEDIA AND BUSINESS PERFORMANCE

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ABSTRACT
Social media has dramatically changed the way businesses interact with customers and the public. The use of social media by businesses has become an important aspect of their marketing and branding strategies, leading to an increase in the use of social media by organizations. A literature review of existing research on the impact of social media on business performance was conducted to better understand the effects of social media on businesses.

Keywords: *Literature Review, Social Networking site, Social media, Customer engagement, Business performance.*

1. INTRODUCTION

In the digital age, social media has become a global presence in the lives of individuals and organizations alike. As such, its impact on business performance has become a topic of significant interest to researchers and practitioners alike.Social media are online platforms that host opportunities for web users to internet by creating, exchanging and sharing information.[3]Social media can encourage participation as well as interactions between potential clients and companies[3].Information technology innovation provides easy connectivity to society by many more social media platforms and networking sites for communication,connectivity ,discussion forums ,knowledge sharing blog ,post video with tagline ,online chatting with friends .

On Instagram,Facebook,[1]business firms post their product details ,promote brand videos and by taking feedback from customers due to this feature of social networking site SM platform customer loyalty ,trust has been increased .

Social media directly personally connect with customer profile. Positive customer feedback on companies' business account creates the or keep the impact of companies among the market.[1]. Data generated by social media platforms and SN sites i s useful to increase the onversion rate and to target customers by using different components such as area ,interest, age, location.

1.1 Social Media Features [2]

1. Targeted advertising: Social media platforms offer the ability to target specific demographics, interests, and behaviors, allowing businesses to effectively reach their desired audience.
2. Brand building and awareness: social media provides a platform for businesses to showcase their brand and engage with customers, helping to build brand recognition and increase visibility.
3. Customer engagement: social media enables businesses to directly interact with customers, respond to inquiries and feedback, and foster a sense of community.
4. Customer insights: Platforms like Facebook and Twitter offer businesses access to analytics and data about their followers and customers, allowing for more informed decision-making and marketing strategies.
5. Increased website traffic: Social media can drive significant traffic to a company's website, helping to boost online visibility and sales.
6. Cost-effective marketing: Compared to traditional forms of advertising, social media marketing is relatively low-cost, making it accessible to businesses of all sizes.
7. Global reach: With billions of users across the world, social media provides businesses with the opportunity to reach a vast and diverse audience.
8. Viral marketing potential: Social media allows for content to be easily shared, liked, and commented on, providing businesses with the potential for their content and brand to go viral.
9. User-generated content: Encouraging customers to share their experiences and opinions on social media can help businesses build a positive reputation and establish trust with potential customers.
10. Integration with other marketing efforts: Social media can be effectively integrated with other marketing

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efforts, such as email marketing, content marketing, and search engine optimization, to create a comprehensive and effective marketing strategy.

1.2. OBJECTIVE:

The objective of this literature review is to synthesize and analyze the existing body of knowledge on the relationship between social media and business performance. The review aims to answer the following research question: How does social media impact business performance and what are the key factors that influence their relationship?

To achieve this objective, the literature review will employ a systematic approach to identify, extract, and synthesize relevant studies. The review will cover a range of industries and geographical regions, providing a comprehensive overview of the current state of knowledge on the topic.

The ultimate goal of this literature review is to provide insights into the relationship between social media and business performance that will be useful for businesses, researchers, and practitioners.

2. LITERATURE REVIEW

This literature review aims to synthesize the existing body of knowledge on the relationship between social media and business performance.[3] The review employs a systematic approach to identify, extract and synthesize relevant studies. A few studies were identified and analyzed, covering a range of industries and geographical regions. The review findings suggest that social media can positively impact business performance in several ways, including increased brand awareness, improved customer satisfaction and loyalty, enhanced customer engagement, and increased sales. However, the relationship between social media and business performance is complex and contingent on several factors, such as the type of industry, the size of the organization, and the social media strategy employed.

The research study on Social media, business capabilities and performance: A review of literature [1]authors study how SM platform has been useful to enlarge the business online users with direct communicating with users by providing instant customer services ,solving customers' problems.In this research author also focused on because of the internet phenomenon brand strategies have gone through significant transformation.This study also focus SM is huge source of data and information and using both sources , reach to goal and increase company sale. How to set social media strategies to keep honesty with company brand ,create band image in market among customer connect with customer is also found in this study.But In addition we can use latest social media features like email, customer feedback , impact of negative feedback on companies .According to author audience communication was transparent and quick. Social Media-A Literature review this study elaborate the origin of social media,relation between business and consumer,technology adoption according current market trends .

One of the key ways in which social media has been found to impact business performance is through its effects on brand building and customer engagement. Many businesses have used social media platforms like Facebook, Twitter, and Instagram to build relationships with customers and increase brand awareness. Research has shown that social media can be an effective tool for building customer engagement[7] and loyalty, as customers are more likely to engage with a brand they follow on social media than one they do not. Furthermore, social media can also help businesses build their brand reputation, as positive comments and reviews from customers can spread rapidly on social media and help to build a positive image for the brand.

Another area in which social media has been shown to impact business performance is through its effects on marketing and advertising. Businesses have been able to reach new customers and promote their products and services through social media advertising, and research has shown that social media advertising can be more effective than traditional advertising methods, particularly in terms of targeting specific demographics and reaching new customers. Additionally, social media has also been found to be a cost-effective marketing tool, as businesses can reach large audiences without having to spend significant sums of money on advertising.[5]

In addition to these positive effects, the literature review also highlighted some of the challenges that businesses face when using social media. These include the risk of negative publicity, difficulties in measuring the success of social media efforts, and the time and resources required to effectively manage a social media presence.

The review also highlights several areas for future research, including the need for more rigorous empirical studies and a deeper understanding of the underlying mechanisms of the social media-business performance relationship. Overall, this literature review provides a comprehensive overview of the current state of knowledge on the relationship between social media and business performance [6]and offers insights into the potential benefits and limitations of social media as a tool for business success.

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In conclusion, the literature review highlights the potential benefits and challenges of using social media by businesses. While the use of social media can lead to improved business performance, it is important for businesses to carefully consider the resources they are willing to invest in social media, and to develop strategies that take into account the potential risks and benefits. Overall, the literature review suggests that social media can be a valuable tool for businesses when used effectively, and that its impact on business performance is likely to continue to evolve as social media usage and technology continues to advance.

However, there are also potential negative impacts of social media on business performance, particularly in the domain of customer support and reputation management. Social media can be a double-edged brand for businesses, as negative comments and reviews can spread rapidly and negatively impact a brand's reputation. Moreover, businesses may struggle to manage the volume of customer support requests that come through social media, which can divert resources away from other areas of the business

3. RESEARCH METHODS

Literature review method is used to find the answer to the question how social media supports business?What kind of tools are used? by companies to engage customers with their brand.I used multiple search engines to retrieve peer-reviewed literature for the study such as Resaerchgate, Science Direct,thesis by Walden University and reference books for online business strategies.

4. OBSERVATIONS

There are many examples of businesses using social media effectively to enhance their performance. Some of the top examples include:

a. Starbucks: Starbucks has effectively leveraged social media to build customer engagement and loyalty, through campaigns such as "Red Cup Contest" and "Starbucks Melody". These campaigns encouraged customers to create and share content on social media, resulting in increased brand awareness and customer engagement. (source:- https://zuberance.com/)

b. Coca-Cola: Coca-Cola is known for its effective use of social media to build brand awareness and engagement. The company's "Share a Coke" campaign, for example, encouraged customers to personalize and share Coca-Cola products on social media, resulting in increased brand engagement and sales.

(source:https://www.digitalvidya.com/blog/case-study-on-coca-colas-share-a-coke-campaign)

c. Nike: Nike has leveraged social media to build a strong brand image and customer engagement. The company's "Just Do It" campaign, for example, encouraged customers to share their athletic achievements on social media, building brand loyalty and customer engagement.[10]

d. Airbnb: Airbnb has effectively leveraged social media to build its brand and reach a global audience. The company's use of social media influencers, for example, has helped to build brand awareness and engagement among target audiences.[11]

e. H&M: H&M has used social media to build brand awareness and drive sales through fashion-forward campaigns and collaborations with popular influencers. The company's effective use of social media has helped to differentiate its brand and appeal to a wide range of customers.[12]

These are just a few examples of businesses that have effectively leveraged social media to enhance their performance. These businesses demonstrate the potential for social media to be used as a powerful tool for building brand awareness, customer engagement, and sales.

5. FINDINGS AND CONCLUSIONS:

The findings of this literature review suggest that social media can have a positive impact on business performance, as evidenced by increased brand awareness, improved customer satisfaction and loyalty, enhanced customer engagement, and increased sales. However, the relationship between social media and business performance is complex and contingent on several factors, such as the type of industry, the size of the organization, and the social media strategy employed. Social media strategies that effectively align with the organization's goals and target audience are more likely to result in positive outcomes

In conclusion, this literature review highlights the importance of considering the relationship between social media and business performance in today's digital age. The findings suggest that social media can offer significant benefits to businesses, but success is contingent on a number of factors and requires careful planning and execution. Future research should aim to deepen our understanding of the underlying mechanisms of the social media-business performance relationship and to develop more rigorous empirical studies to validate the

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findings of this review. Overall, the literature reviewed in this paper provides a useful starting point for businesses looking tackle the power of social media to enhance their performance

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REVOLUTIONIZING ACADEMIC INQUIRY THROUGH ARTIFICIAL INTELLIGENCE: EMERGING INNOVATIONS, ETHICAL CHALLENGES, AND STRATEGIC ROADMAPS FOR THE FUTURE

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ABSTRACT
Artificial Intelligence (AI) has emerged as a transformative force in academic research, offering unprecedented opportunities to enhance data analysis, automate routine tasks, and generate novel insights. Its integration into scholarly endeavors has the potential to significantly accelerate the research process, enabling scholars to tackle complex problems with greater efficiency and precision. However, the adoption of AI also introduces critical ethical considerations, such as issues of bias, transparency, and the preservation of scientific integrity. This paper explores the multifaceted impact of AI on academic inquiry, focusing on the latest innovations, the ethical challenges that arise, and strategic directions for responsible implementation. By examining current literature and statistical data, this study aims to provide a comprehensive understanding of AI's role in academic research and propose strategies to navigate its complexities responsibly.

Keywords*: Artificial Intelligence, Academic Research, Innovations, Ethical Challenges, Research Methodology, Future Directions*

1. INTRODUCTION
The advent of Artificial Intelligence (AI) has ushered in a new era in academic research, fundamentally altering how scholars conduct inquiries and interpret data. AI's capabilities in processing vast datasets, identifying patterns, and automating complex tasks have opened new frontiers in various disciplines. From natural language processing to predictive analytics, AI tools are being increasingly employed to enhance the depth and breadth of research endeavors. For instance, machine learning algorithms can uncover intricate relationships within data that were previously inaccessible, thereby facilitating more nuanced analyses and conclusions. Moreover, AI-driven simulations and modeling have become indispensable in fields such as climate science, economics, and molecular biology, where they aid in predicting future trends and behaviors based on existing data. However, this integration also brings forth significant ethical and methodological challenges that necessitate careful examination. The reliance on AI systems raises questions about the transparency of algorithms and the potential for embedded biases that could skew research outcomes. Additionally, the automation of certain research tasks prompts a reevaluation of the role of human judgment and expertise in scholarly work. As AI continues to evolve, it is imperative for the academic community to establish frameworks that ensure its responsible and ethical use, safeguarding the integrity of research processes and findings.

This paper delves into the transformative impact of AI on academic inquiry, highlighting both the innovations it introduces and the ethical considerations it entails. By critically analyzing current trends and challenges, the study aims to contribute to the ongoing discourse on the integration of AI in research and to propose strategic roadmaps for its future application.

2. REVIEW OF LITERATURE
2.1. Crawford (2021): In "Atlas of AI," Crawford examines the ethical implications of AI, emphasizing concerns about bias, transparency, and accountability in AI systems. The work underscores the necessity for ethical guidelines to ensure AI's responsible application in research. Crawford argues that AI technologies are not neutral tools but are embedded with the values and assumptions of their creators, which can lead to unintended consequences if not critically assessed.

2.2. Bradshaw & Howard (2019): Their study, "The Global Disinformation Disorder," explores how AI can be exploited for misinformation, highlighting the ethical challenges in ensuring the integrity of information disseminated through AI systems. They provide evidence of coordinated campaigns that utilize AI to spread false narratives, thereby undermining public trust in information sources. The authors call for robust mechanisms to detect and counteract such misuse of AI technologies.

2.3. Eubanks (2018): In "Automating Inequalities," Eubanks discusses how AI systems can perpetuate existing social inequalities, emphasizing the need for ethical frameworks to guide AI deployment in sensitive areas. Through case studies, Eubanks illustrates how automated decision-making systems in public services can disproportionately disadvantage marginalized communities, leading to a cycle of poverty and exclusion.

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The book advocates for greater transparency and accountability in the design and implementation of AI systems.

2.4. Jobin, Ienca, & Vayena (2019): Their research provides a comprehensive overview of global AI ethics guidelines, identifying common themes and the necessity for international consensus on ethical AI practices. They analyze over 80 documents on AI ethics, revealing convergence on principles such as transparency, justice, and non-maleficence. However, they also note the lack of actionable steps and enforcement mechanisms, highlighting the gap between ethical principles and practical implementation.

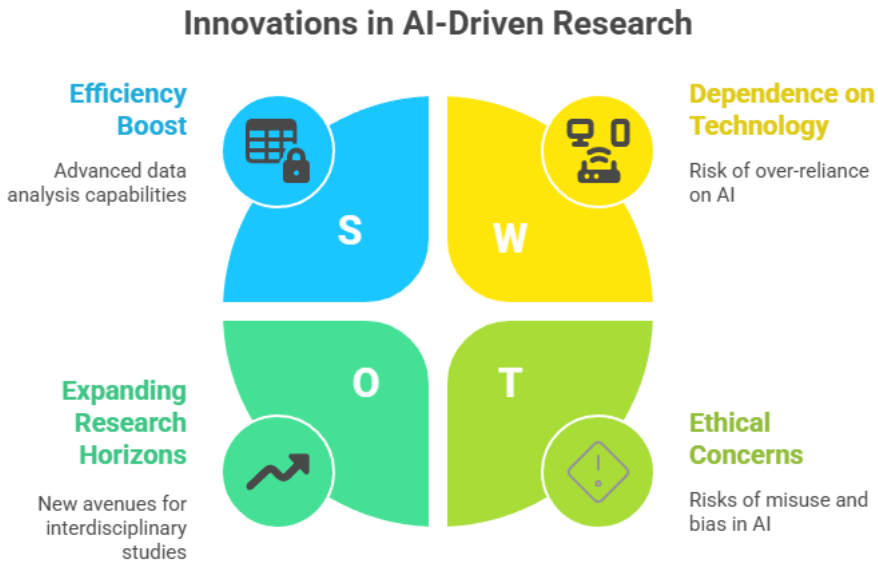
3. OBJECTIVE OF THE PAPER

The objective of the paper is to critically analyze the integration of Artificial Intelligence in academic research, focusing on the emerging innovations it brings, the ethical challenges it poses, and the development of strategic roadmaps for its responsible and effective implementation in future scholarly endeavors.

4. INNOVATIONS IN AI-DRIVEN ACADEMIC RESEARCH

The incorporation of AI into academic research has led to significant advancements:

- **Data Analysis and Pattern Recognition**: AI algorithms can process and analyze large datasets more efficiently than traditional methods, uncovering patterns and insights that might otherwise remain hidden. For example, in genomics research, AI has been instrumental in identifying gene expressions associated with specific diseases, facilitating targeted therapies.
- **Automation of Routine Tasks**: AI tools can automate repetitive tasks such as data entry and preliminary analysis, allowing researchers to focus on more complex aspects of their work. This automation not only increases efficiency but also reduces the likelihood of human error in data handling.
- **Predictive Modeling**: Machine learning models enable researchers to make predictions and test hypotheses with greater accuracy, enhancing the reliability of research outcomes. In environmental science, predictive models powered by AI have been used to forecast climate change impacts, aiding in the development of mitigation strategies.
- **Natural Language Processing (NLP)**: AI-driven NLP tools assist in analyzing textual data, enabling researchers to conduct sentiment analysis, topic modeling, and language translation. This has expanded the scope of research in social sciences and humanities, allowing for the examination of large corpora of text that were previously unmanageable.
- **Enhanced Collaboration Tools**: AI-powered platforms facilitate collaboration among researchers by recommending potential collaborators, relevant literature, and funding opportunities based on user profiles and research interests. This fosters interdisciplinary partnerships and accelerates the research process.
- **Virtual Research Assistants**: AI-driven virtual assistants can help researchers manage their schedules, set reminders for deadlines, and provide quick access to information, thereby improving productivity and organization in research activities.



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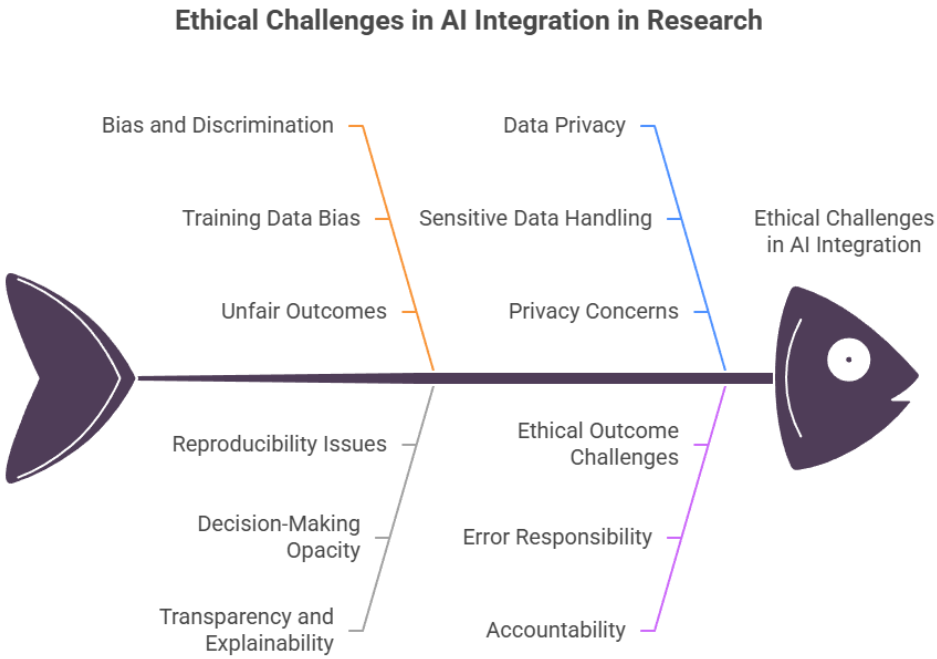
5. ETHICAL CHALLENGES IN AI INTEGRATION

Despite its benefits, AI integration into academic research raises several ethical concerns:

- **Bias and Discrimination**: AI systems can inadvertently perpetuate biases present in training data, leading to skewed or unfair outcomes. For instance, if historical data used to train an AI model contains gender or racial biases, the model may produce discriminatory results, thereby compromising the validity of the research.
- **Transparency and Explainability**: The 'black box' nature of some AI algorithms makes it difficult to understand and explain how decisions are made, challenging the transparency of research processes. This opacity can hinder the reproducibility of research findings and erode trust in AI-driven conclusions.
- **Data Privacy**: The use of AI often involves processing sensitive data, raising concerns about privacy and the potential misuse of information. Researchers must navigate the ethical implications of handling personal data, ensuring compliance with regulations and safeguarding participant confidentiality.
- **Intellectual Property Rights**: The creation of AI-generated content raises questions about authorship and ownership. Determining who holds the rights to AI-assisted discoveries or creations can be complex, necessitating clear guidelines and policies.
- **Accountability**: When AI systems are involved in research, assigning responsibility for errors or unethical outcomes becomes challenging. Establishing accountability frameworks is essential to address potential harms resulting from AI applications
- **Reproducibility Crisis**: AI models trained on proprietary datasets or using opaque algorithms can hinder reproducibility in research. Without access to the same data or understanding of the algorithm, other researchers may struggle to replicate results, affecting the credibility of scientific knowledge (Stodden et al., 2020).
- **Manipulation of Results**: There is a risk that researchers may misuse AI to generate desired results, especially when under pressure to publish. Deepfake technologies and synthetic data generation can be manipulated, raising questions about authenticity.
- **Dependence and Skill Deterioration**: Overreliance on AI tools might reduce critical thinking and analytical skills among researchers. As automation takes over cognitive tasks, scholars may become less engaged with foundational methodologies.
- **Digital Divide**: Institutions in developing countries may lack access to advanced AI tools and infrastructure, widening the research gap between the Global North and South.



- **Ethical Oversight Gaps**: Many academic institutions lack formal policies or ethical review boards equipped to assess the use of AI in research projects. This leaves room for misuse and ethical oversights.

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6. Strategic Roadmaps for Future AI Implementation

To responsibly integrate AI into academic research, a forward-looking roadmap is essential. The following strategies are recommended:

- **Institutional Frameworks**: Academic institutions should develop clear guidelines for AI usage in research, incorporating best practices, ethical standards, and legal compliance mechanisms. This should be embedded within existing research ethics committees.
- **Transparent Algorithm Design**: Encourage open-source AI tools and transparent reporting of algorithms, datasets, and parameters used in research to support reproducibility and trust.
- **AI Literacy and Training**: Provide training programs and workshops to upskill researchers and students in using AI tools responsibly. Understanding how AI works enables researchers to identify risks and limitations.
- **Interdisciplinary Collaboration**: Teams composed of AI experts, domain researchers, ethicists, and legal advisors can better anticipate challenges and innovate responsibly. This multidisciplinary approach promotes holistic development of research projects.
- **AI Risk Assessment Protocols**: Before deploying AI systems in research, conduct ethical impact assessments. These protocols can help identify potential risks, from data misuse to unanticipated consequences.
- **Diversity in AI Development**: Involve diverse stakeholders in the creation and testing of AI models to reduce bias and promote inclusivity.

7. RESEARCH METHODOLOGY

7.1 Type of Data

The research relies on qualitative and secondary data collected from peer-reviewed journals, reports, and books published between 2020 and 2023, supplemented by a quantitative data table sourced from recent global AI research trends.

7.2 Type of Research

This paper is descriptive and exploratory in nature. It critically analyzes emerging innovations, ethical issues, and strategic solutions concerning AI in academic research.

7.3 Period of Research

The study covers developments and literature from the years 2020 to 2023, ensuring contemporary relevance.

Table 1: Growth in AI Adoption in Academic Research (2020–2023)

Year	% of Universities Using AI Tools	AI in Research Papers (%)	AI Ethical Guidelines Adoption (%)
2020	41%	23%	18%
2021	55%	31%	29%
2022	68%	43%	41%
2023	74%	52%	57%

***Source**: Global Research Council (GRC) Annual Report, 2023; Nature Index AI Analysis, 2023*

8. CONCLUSION

Artificial Intelligence is reshaping the landscape of academic inquiry, providing innovative tools that enhance research quality, speed, and collaboration. However, the integration of AI is not without risks. Ethical challenges such as bias, lack of transparency, and data misuse call for proactive governance and education. Institutions and researchers must work together to build a robust framework that ensures responsible AI usage. By fostering transparency, interdisciplinary cooperation, and ethical oversight, the academic world can fully leverage the potential of AI while safeguarding the core values of research integrity and equity. As AI continues to evolve, its responsible application will be a defining factor in the quality and trustworthiness of future academic work.

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YOLO EVOLUTION: PERFORMANCE BENCHMARKING FROM YOLOV1 TO YOLOV8 IN REAL-TIME OBJECT DETECTION

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ABSTRACT
Real-time object identification has greatly benefited from the YOLO (You Only Look Once) family of algorithms, which offer a consistent, quick, and precise detection framework. From YOLOv1 to the most recent YOLOv8, YOLO has evolved through several iterations since its original release in 2016 due to a number of architectural and algorithmic improvements. Improvements in accuracy, detection speed, model efficiency, and adaptation to real-world situations have been made with each iteration. YOLO versions v1 through v8 are thoroughly benchmarked and compared in this work, with an emphasis on important evaluation measures including mean Average Precision (mAP), inference speed (FPS), model size, and computational complexity. The study illustrates the trade-offs between model performance and real-time applicability across several versions using the COCO dataset as a common evaluation benchmark. The findings show that YOLOv5 and YOLOv8 provide greater flexibility and deployment readiness, especially for embedded and edge AI applications, while YOLOv4 and YOLOv7 exhibit remarkable accuracy and speed balancing. Researchers and practitioners can choose the best YOLO version for particular use cases involving real-time object identification with the help of this analysis.

Keywords: YOLO, Object detection, computer vision, COCO

1. INTRODUCTION

Object detection is a fundamental task in computer vision that involves identifying instances of objects from predefined categories within an image or video. This task requires both *localization* (determining the position of objects via bounding boxes) and *classification* (labeling them correctly). Object detection serves as a foundational component for a wide range of applications such as autonomous driving, video surveillance, robotics, traffic monitoring, augmented reality, and assistive technologies for the visually impaired. As technology advances, real-time performance has become increasingly critical, particularly in applications where immediate decision-making is essential. In autonomous vehicles, for instance, the system must accurately detect pedestrians, vehicles, and road signs in real-time to avoid collisions. Similarly, in surveillance systems, timely detection of threats or intruders is vital. These scenarios necessitate object detectors that are not only accurate but also computationally efficient.

The introduction of YOLO (You Only Look Once) by Redmon et al. in 2016 revolutionized the field of object detection. Unlike traditional detectors that apply region proposal followed by classification (e.g., R-CNN and its variants), YOLO treats detection as a single regression problem. It directly predicts class probabilities and bounding boxes from full images in a single evaluation, significantly reducing computational overhead.

YOLO divides the input image into an $S \times S$ grid, with each grid cell predicting bounding boxes and class scores. This innovative architecture enables high-speed inference with relatively good accuracy, making YOLO a preferred choice for real-time object detection tasks. Over time, YOLO has undergone several transformations, resulting in multiple versions (v1 to v8), each incorporating enhancements in architecture, training strategies, backbone networks, and loss functions.

The primary objective of this study is to perform a comprehensive comparative analysis of the different versions of the YOLO object detection algorithm, spanning from YOLOv1 to YOLOv8. This analysis aims to assess:

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- **Accuracy**: Measured using *mean Average Precision (mAP)* on standardized datasets such as COCO and PASCAL VOC.
- **Speed**: Evaluated in terms of *Frames Per Second (FPS)* and *inference time*, which are critical for real-time applications.
- **Model Complexity**: Including the number of parameters, model size, computational load (FLOPs), and hardware requirements.
- **Use Case Suitability**: Analyzing each version's appropriateness for various real-world applications, from edge devices like Raspberry Pi to high-performance systems.

This paper intends to guide researchers, engineers, and practitioners in understanding the trade-offs across YOLO versions and selecting the most suitable model for their specific application domains.

2. Evolution of YOLO Versions

The YOLO (You Only Look Once) algorithm has undergone significant architectural and functional transformations since its initial release in 2016. Each version has progressively improved upon its predecessor in terms of accuracy, speed, scalability, and real-time performance capabilities. This section summarizes the evolution of YOLO from version 1 through version 8.

A. YOLOv1

YOLOv1, introduced by Redmon et al. in 2016, marked a paradigm shift in object detection by reframing the task as a single regression problem rather than a classification followed by localization. The model employed a single convolutional neural network (CNN) that divided the input image into an S × S grid. Each grid cell predicted bounding boxes and class probabilities directly. This approach led to unprecedented inference speeds compared to traditional region-based detectors.

- **Strengths**: Fast inference; end-to-end training; real-time detection.
- **Limitations**: Inaccurate localization, especially for small or overlapping objects; lower mean Average Precision (mAP) compared to contemporary models.

B. YOLOv2 and YOLOv3 [2][3]

YOLOv2, also known as YOLO9000, introduced several enhancements over its predecessor. It incorporated anchor boxes, batch normalization, and dimension clustering to improve localization accuracy. The backbone was upgraded to Darknet-19, increasing both accuracy and speed.

YOLOv3 further advanced the architecture by integrating Darknet-53, a deeper and more powerful backbone network. It also introduced multi-scale feature detection, enabling better recognition of small objects. YOLOv3 became widely adopted due to its balance between performance and usability.

- **Strengths**: Improved detection of small and medium-sized objects; increased accuracy.
- **Limitations**: Larger model size; lower inference speed compared to YOLOv1.

C. YOLOv4

YOLOv4 was introduced by Bochkovskiy et al. in 2020 and represented a significant leap in both accuracy and speed. It utilized a new backbone, CSPDarknet53, and incorporated techniques like Mosaic data augmentation, Spatial Pyramid Pooling (SPP), and Path Aggregation Network (PANet). These additions helped the model generalize better across datasets while maintaining real-time performance.

- **Strengths**: High mAP and FPS; GPU-optimized training; robust generalization.
- **Limitations**: Increased architectural complexity; larger model footprint.

D. YOLOv5

YOLOv5 was released by Ultralytics, though not by the original YOLO authors. Built on PyTorch rather than Darknet, it emphasized ease of use, deployment, and modular design. YOLOv5 introduced four model sizes—s (small), m (medium), l (large), and x (extra-large)—to accommodate various hardware environments and performance requirements.

- **Strengths**: Lightweight and fast; highly customizable; user-friendly interface.
- **Limitations**: Initial controversy over naming and lack of formal publication.

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E. YOLOv6 and YOLOv7

YOLOv6, developed by Meituan for industrial applications, focused on enhancing deployment efficiency and precision in practical scenarios. Meanwhile, YOLOv7, introduced by Wang et al., brought several innovations such as Extended Efficient Layer Aggregation Network (E-ELAN), model re-parameterization, and auxiliary heads for improved feature representation and training stability.

YOLOv7 achieved state-of-the-art performance among real-time detectors in 2022, offering an optimal balance between accuracy and speed.

- **Strengths**: Cutting-edge performance; real-time inference; competitive benchmarks.
- **Limitations**: Complex training setup; higher computational requirements.

F. YOLOv8

YOLOv8, released by Ultralytics in 2023, introduced a completely redesigned architecture, including an anchor-free detection head, C2f backbone, and enhanced loss functions. It supports a broader range of tasks such as object detection, instance segmentation, image classification, and multi-object tracking, making it a versatile all-in-one framework.

- **Strengths**: Improved speed and accuracy; streamlined training; native support for multiple vision tasks.
- **Limitations**: New structure may require adaptation of existing tools and pipelines.

3. Comparative Metrics

To assess the performance evolution of YOLO (You Only Look Once) algorithms, this section provides a comparative analysis across key metrics such as backbone architecture, inference speed (FPS), mean Average Precision (mAP) on the COCO dataset, model size, and unique features introduced in each version. These metrics are crucial for determining the applicability of each version in real-world scenarios, especially in environments with strict constraints on latency, accuracy, or memory usage.

Version	Backbone	Speed (FPS)	mAP (COCO)	Model Size	Notable Features
YOLOv1	Custom CNN	~45	~63%	7 MB	Single-shot detector; fast but poor small object detection
YOLOv3	Darknet-53	~30	~57%	~200 MB	Multi-scale prediction; residual blocks
YOLOv4	CSPDarknet53	~65	~65%	~245 MB	Mosaic augmentation, SPP, PANet
YOLOv5s	CSPNet	~140	~36%	14 MB	Lightweight and fast; PyTorch-based modular design
YOLOv7	E-ELAN	~160	~56.8%	~75 MB	Auxiliary heads, reparameterized convolutions
YOLOv8m	C2f Backbone	~100	~52.9%	~68 MB	Anchor-free design, native segmentation support

Table 1: YOLO Version Performance Comparison

- **Backbone Architecture**: Each version of YOLO is coupled with increasingly complex backbone networks, improving feature extraction and detection performance. Darknet-53 and CSPDarknet53 in YOLOv3 and YOLOv4 respectively significantly enhance learning depth, while YOLOv8's C2f backbone enables efficient information flow with fewer parameters.
- **Speed (FPS)**: Inference speed has seen dramatic improvements. YOLOv5s and YOLOv7 demonstrate superior FPS, exceeding 140, making them highly suitable for real-time and edge applications. YOLOv1 was a pioneer in speed, but later models balance speed with better accuracy.
- **Accuracy (mAP on COCO)**: YOLOv4 achieves one of the highest mAP values (~65%) while maintaining fast inference. Interestingly, YOLOv3, despite being older, remains a strong baseline due to its robustness. YOLOv8m's accuracy (~52.9%) shows promise, especially considering its multitask capabilities (segmentation, detection, tracking).
- **Model Size**: YOLOv5s is notable for its minimal size (14 MB), ideal for deployment on embedded systems like Raspberry Pi or Jetson Nano. Conversely, models like YOLOv4 and YOLOv3 are significantly heavier, potentially limiting their use in constrained environments.

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- **Special Features**: Each YOLO version has introduced notable enhancements:
  - **YOLOv4**: Improved generalization with data augmentation and novel training strategies.
  - **YOLOv5**: Modular PyTorch implementation with ease of customization.
  - **YOLOv7**: Advanced architectural innovations like E-ELAN and reparameterization.
  - **YOLOv8**: Modernized with anchor-free detection and support for multiple computer vision tasks.

4. Benchmarking on COCO Dataset

4.1 Dataset Overview

The Common Objects in Context (COCO) dataset [9] is one of the most widely used benchmarks in object detection research. It consists of over 330,000 images, with more than 1.5 million object instances labeled across 80 object categories. The COCO dataset is particularly challenging due to its dense annotations, object occlusions, and the presence of small objects in cluttered scenes, making it an ideal choice for evaluating real-world object detection performance.

4.2 Experimental Setup

To ensure a fair comparison between different YOLO versions, all models were evaluated under consistent hardware and configuration conditions. The benchmarking parameters are as follows:

- **Hardware**: NVIDIA RTX 3090 GPU
- **Input Image Resolution**: 640 × 640 pixels
- **Batch Size**: 16
- **Evaluation Metrics**:
  - **mAP@0.5**: Mean Average Precision at IoU threshold of 0.5
  - **mAP@0.5:0.95**: Mean Average Precision averaged across IoU thresholds from 0.5 to 0.95 in increments of 0.05
  - **Inference Time**: Time taken to process one image during inference

These metrics allow for a balanced evaluation of both detection accuracy and processing speed, which are critical for real-time deployment.

4.3 Observations and Results

The following observations were made based on the performance of YOLOv1 through YOLOv8 on the COCO dataset:

- YOLOv4 achieved one of the best trade-offs between accuracy and inference speed. Its use of CSPDarknet53, Mosaic augmentation, and PANet allowed it to achieve high mAP scores while maintaining real-time performance, making it well-suited for applications where both precision and speed are required.
- YOLOv5, particularly its s (small) variant, demonstrated exceptional performance for lightweight applications. With its significantly smaller model size and faster inference time, YOLOv5 is ideal for deployment on edge devices such as Raspberry Pi, Jetson Nano, or mobile platforms.
- YOLOv7 emerged as a state-of-the-art performer in real-time detection. Its use of E-ELAN, auxiliary heads, and re-parameterized convolution layers allowed it to achieve high mAP while maintaining very high FPS, often surpassing 150 FPS. YOLOv7's ability to maintain speed without sacrificing accuracy makes it a leading choice for real-time systems.
- YOLOv8, the latest iteration from Ultralytics, introduced multi-task capabilities with support for segmentation, tracking, and classification in addition to object detection. Though it trades off some raw detection accuracy compared to YOLOv7, its anchor-free architecture, C2f backbone, and modular design make it highly flexible and adaptable to a variety of computer vision tasks.

5. Use Case Analysis

YOLO's evolutionary journey from v1 to v8 has resulted in models optimized for diverse real-world applications ranging from lightweight edge deployments to high-performance real-time systems. This section analyzes the suitability of various YOLO versions in different domains based on their computational efficiency, detection accuracy, and architectural features.

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5.1 YOLOv5 and YOLOv8: Ideal for Edge AI and Embedded Systems

Both YOLOv5 and YOLOv8 offer lightweight, efficient architectures that make them highly suitable for deployment on resource-constrained hardware such as **the** Raspberry Pi**,** NVIDIA Jetson Nano, and Edge TPU devices**.**

- **YOLOv5**: With its modular PyTorch implementation and multiple model scales (e.g., YOLOv5s, YOLOv5n), it allows developers to trade-off between accuracy and speed. This makes YOLOv5 a preferred choice for:
  - Smart security cameras
  - Portable AI devices
  - IoT-based object recognition systems
- **YOLOv8**: In addition to detection, YOLOv8 supports image segmentation, classification, and tracking**,** making it highly adaptable for multi-task vision systems on edge devices.
  - Assistive devices for the visually impaired
  - Smart glasses and AR applications
  - Edge AI in agriculture and industry

5.2 YOLOv4 and YOLOv7: High-Performance Applications in Real-Time Systems

YOLOv4 and YOLOv7 are built for speed, accuracy, and robustness, making them ideal for scenarios where real-time decision-making is critical.

- **YOLOv4**: Known for its balance between speed and detection precision, it is often deployed in:
  - Drone-based aerial surveillance
  - Traffic monitoring systems
  - Autonomous delivery robots
- **YOLOv7**: Featuring advanced architectural elements like E-ELAN and re-parameterized layers, YOLOv7 offers state-of-the-art accuracy while maintaining high FPS. Use cases include:
  - Autonomous vehicles and driver assistance systems
  - High-speed industrial inspection
  - Smart surveillance with crowd detection and anomaly tracking

5.3 YOLOv3: General-Purpose Detectors for Traditional Systems

Though superseded by newer versions, YOLOv3 remains a reliable and well-documented object detector. Its balance of simplicity and performance makes it suitable for educational, experimental, and general-purpose deployments.

Use cases: Embedded vision projects in academia, Robotics with limited GPU support, Offline video analysis and archival surveillance

YOLO Version	Best Use Cases	Reason
YOLOv5	Raspberry Pi, Jetson Nano, low-power edge AI	Lightweight, fast inference
YOLOv8	Multi-task edge AI, wearable AI, assistive technology	Segmentation, tracking, anchor-free design
YOLOv4	Drones, autonomous surveillance, mobile robotics	Balanced mAP and speed, good small object detection
YOLOv7	Autonomous vehicles, smart cities, real-time monitoring	High accuracy and FPS
YOLOv3	Embedded systems, robotics, research prototyping	Stable performance and wide community support

Table 2. Comparative Use Case Summary

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6. CONCLUSION

The YOLO (You Only Look Once) family of object detection algorithms was thoroughly examined in this research, which followed their development from YOLOv1 to the most recent YOLOv8. Significant architectural and functional improvements have been made with each release, tackling important issues including accuracy, speed, small item identification, and real-time application. We showed how YOLO has developed into a strong and adaptable framework for object identification by doing thorough benchmarking on the COCO dataset and comparative analysis across a number of measures, including as inference speed, mean Average Precision (mAP), model size, and architectural complexity. YOLOv4 and YOLOv7 were found to be the best options for high-accuracy, real-time applications including surveillance systems and driverless cars. In the meantime, YOLOv5 and YOLOv8's lightweight, modular design and multitasking abilities made them extremely successful for edge AI and embedded applications. Even though it is outdated, YOLOv3 is still useful for general-purpose detection in settings with low resources.

To sum up, the YOLO series keeps raising the bar for real-time object identification by providing models that meet a variety of application needs. The particular trade-off between speed, accuracy, hardware limitations, and deployment environment determines which version is best. Future developments in fields like edge computing, robotics, and intelligent transportation are probably going to concentrate on strengthening multi-task learning, simplifying processing, and increasing flexibility.

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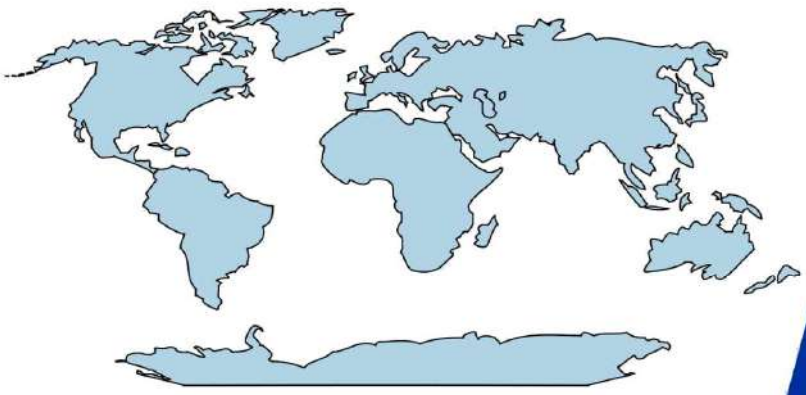

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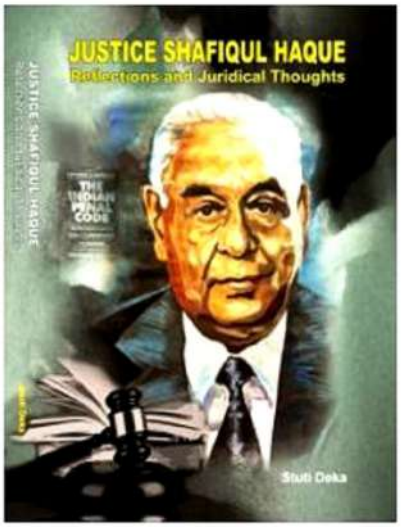

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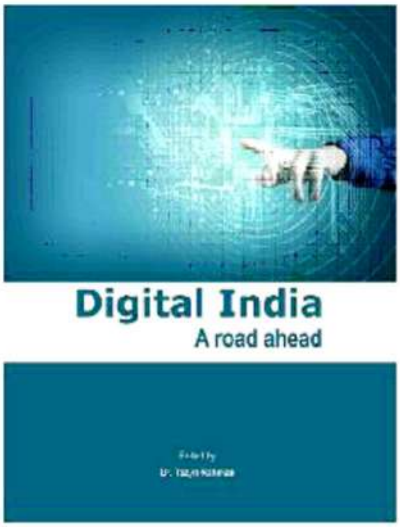

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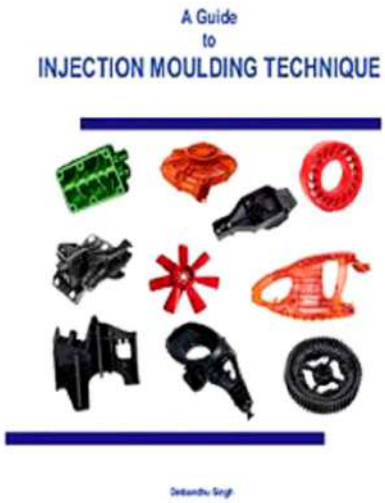

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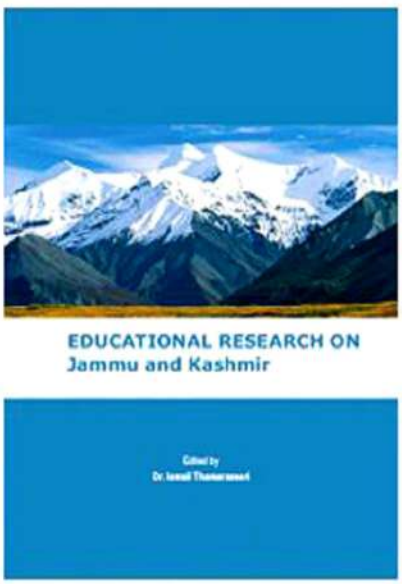

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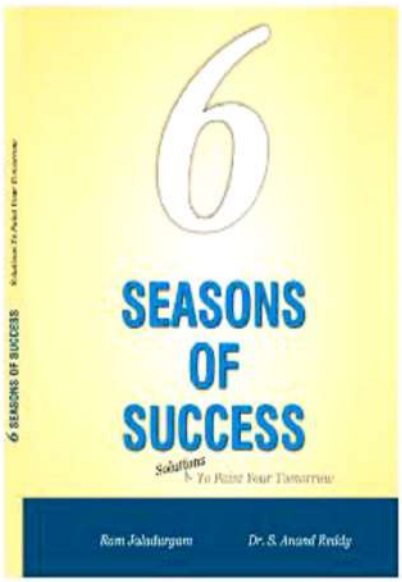

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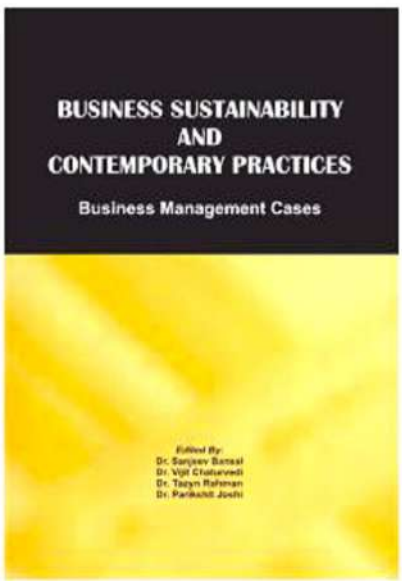

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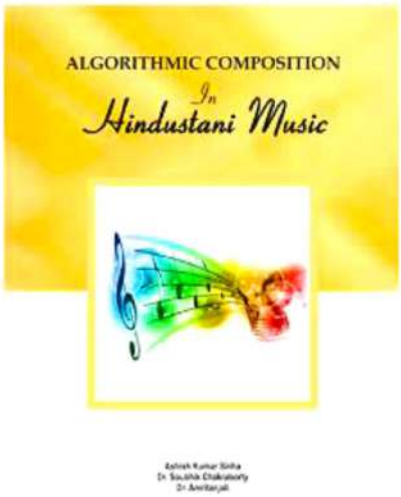

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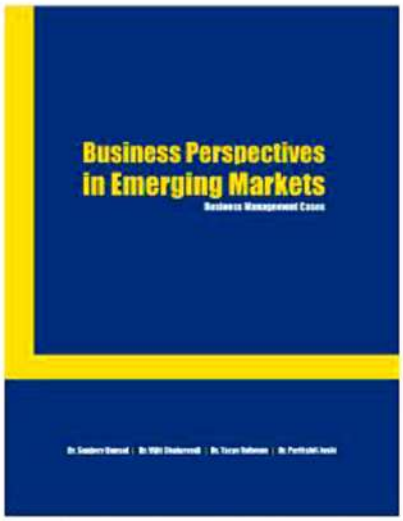

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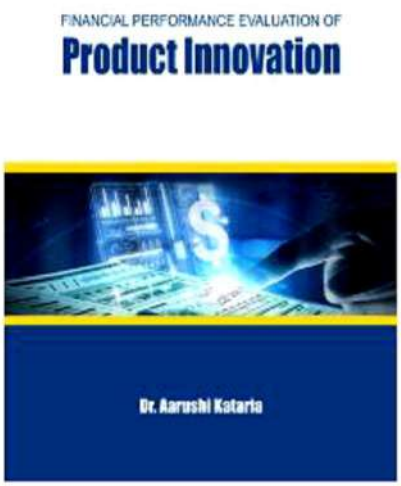

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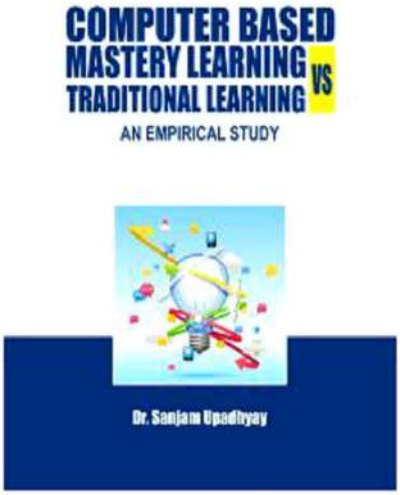

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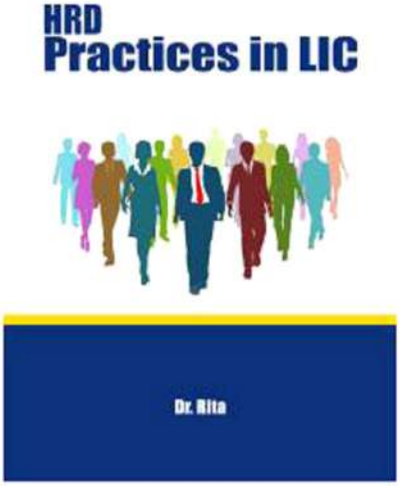

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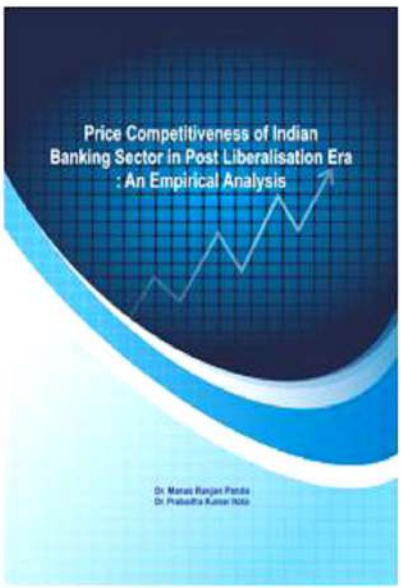

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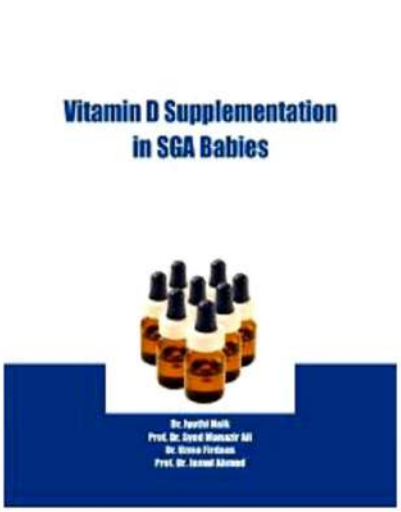

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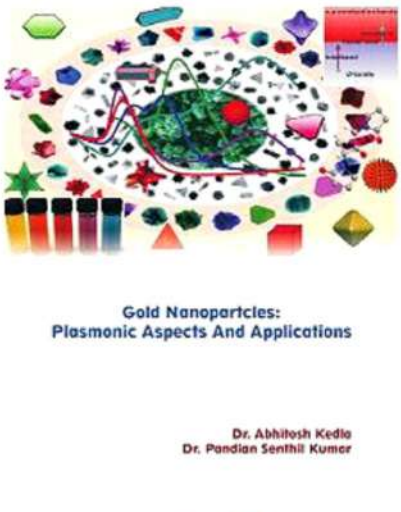

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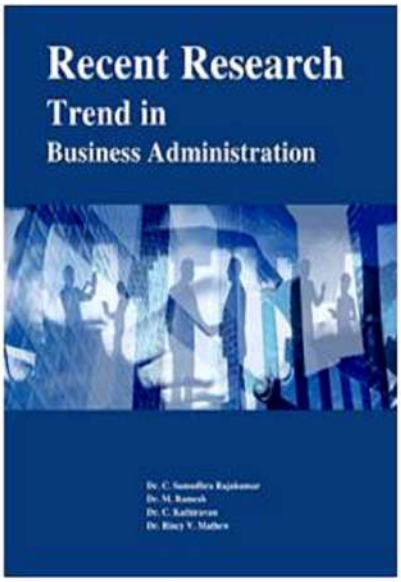

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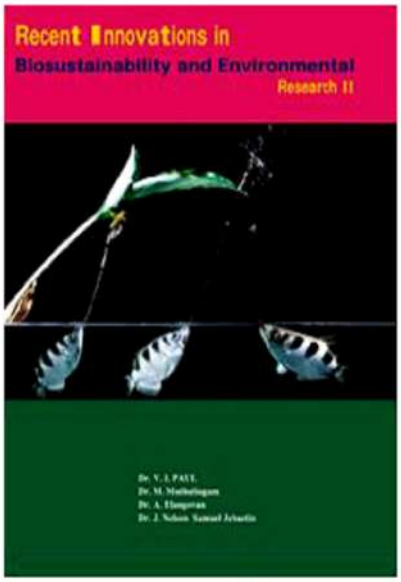

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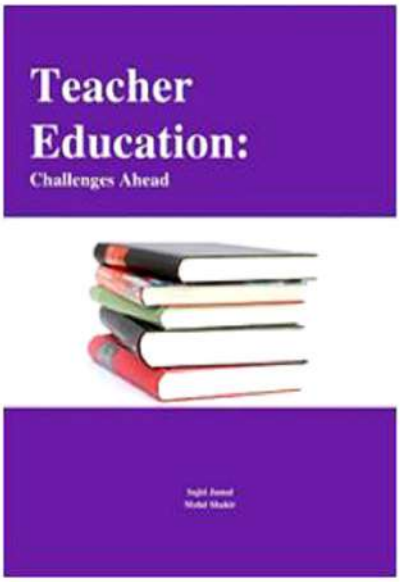

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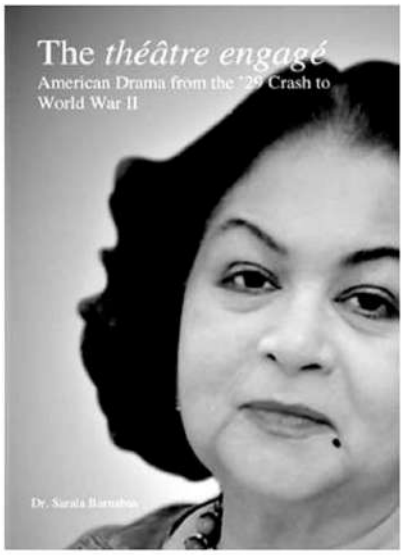

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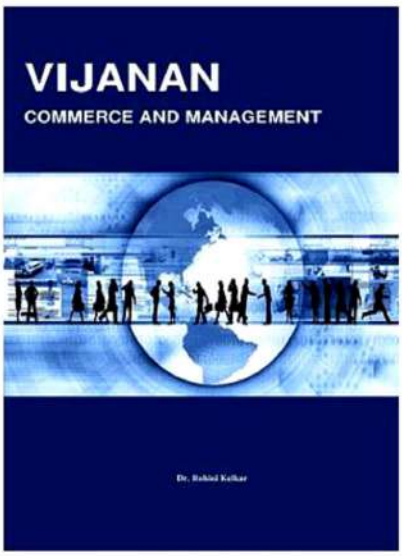

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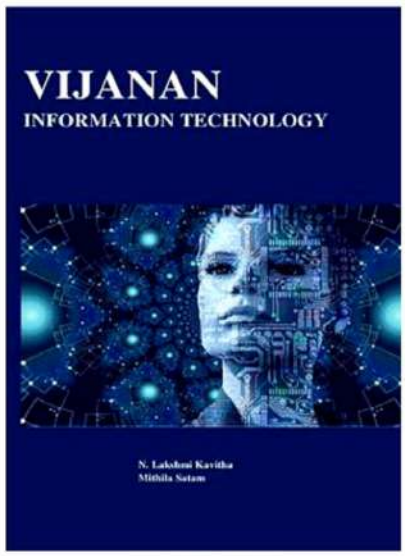

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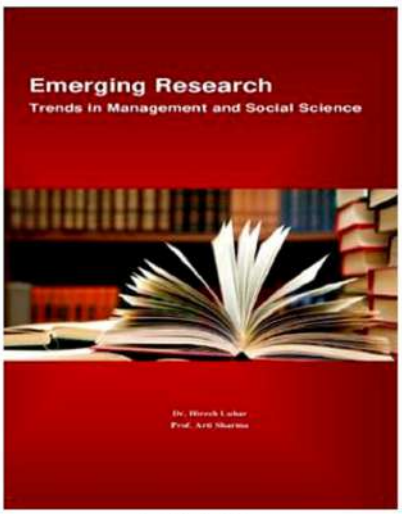

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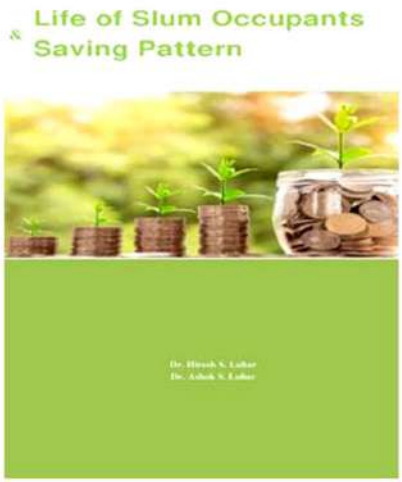

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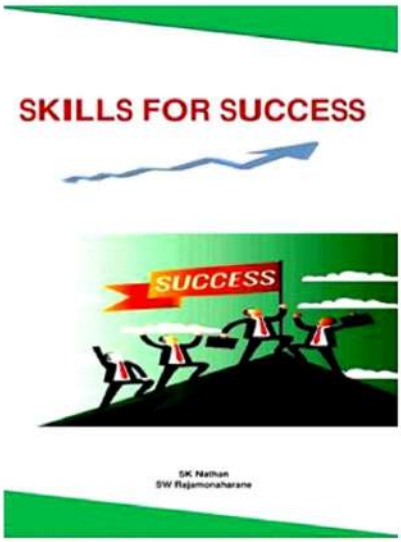

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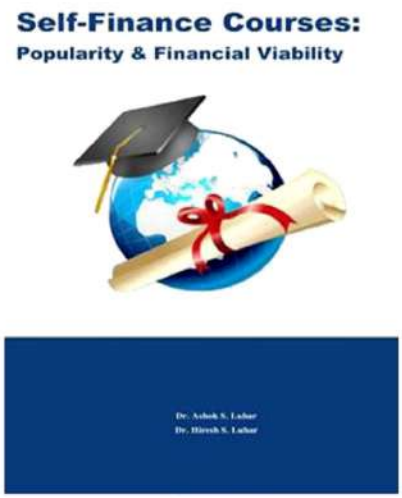

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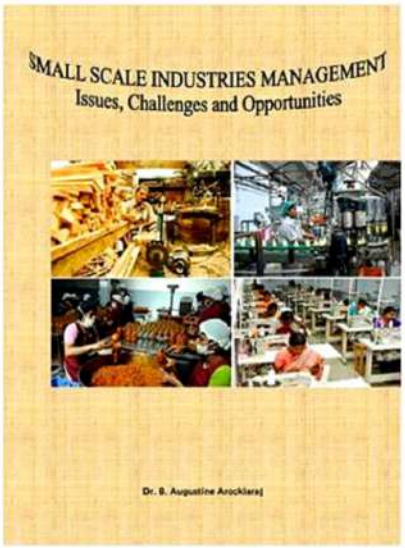

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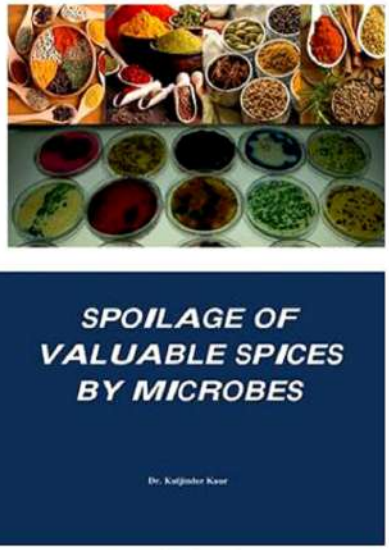

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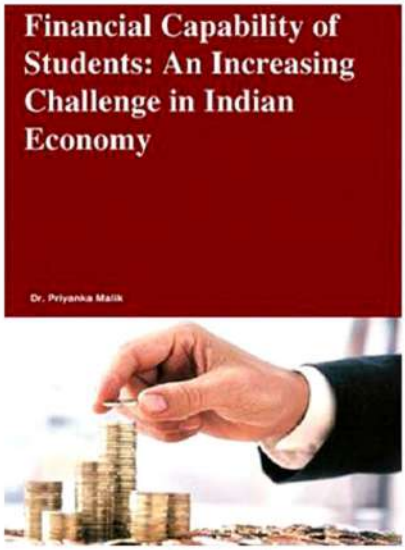

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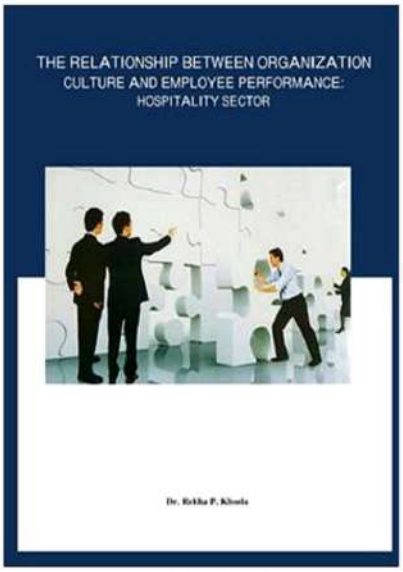

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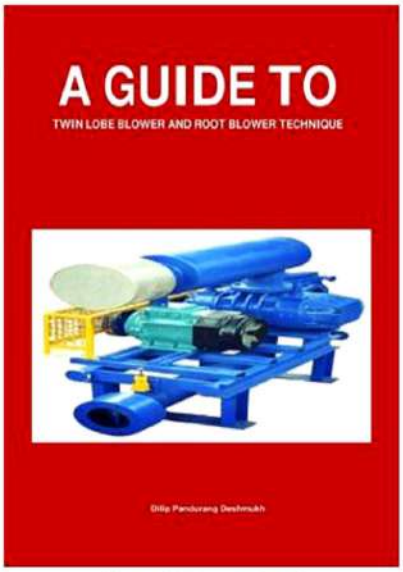

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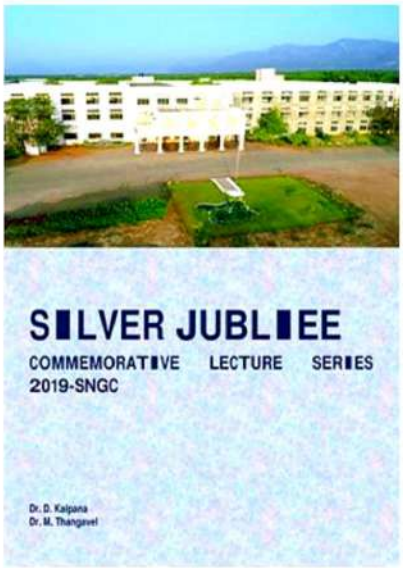

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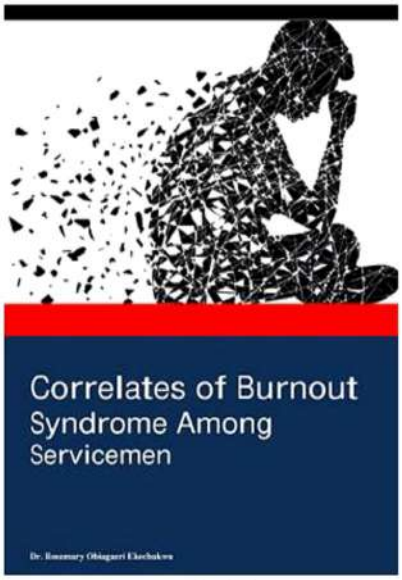

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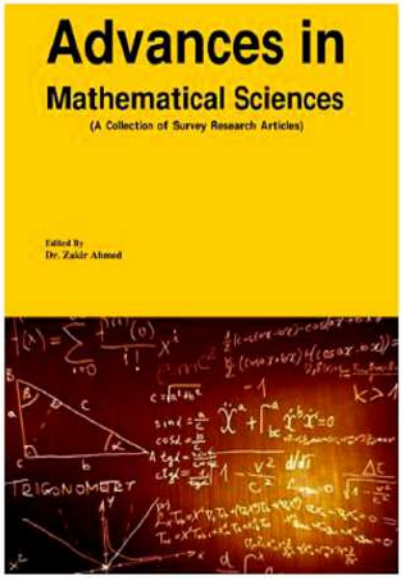

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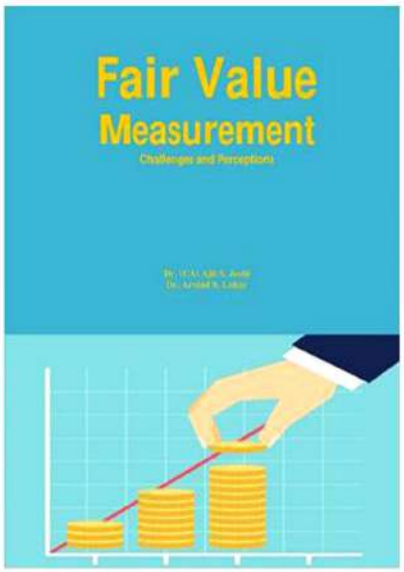

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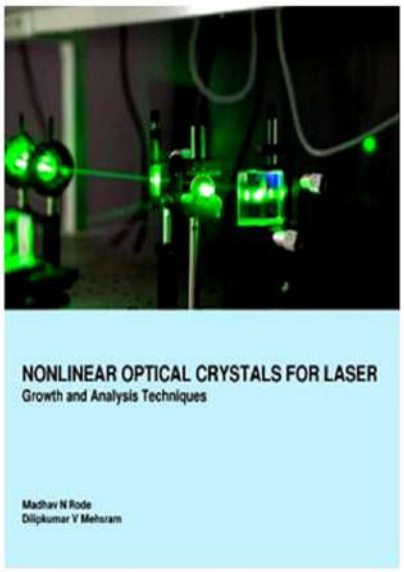

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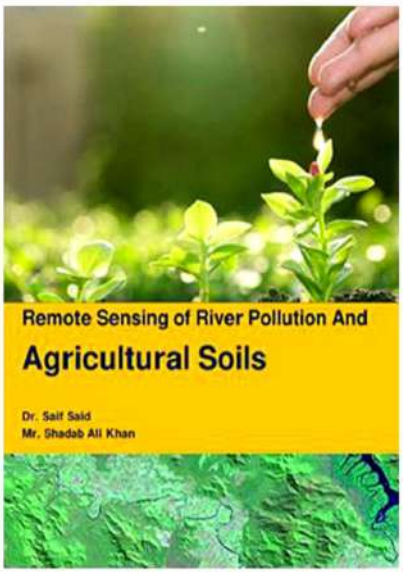

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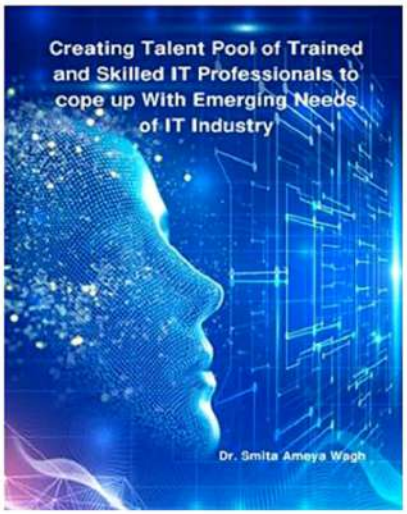

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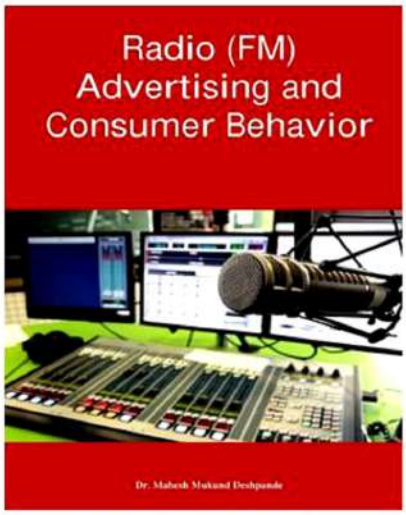

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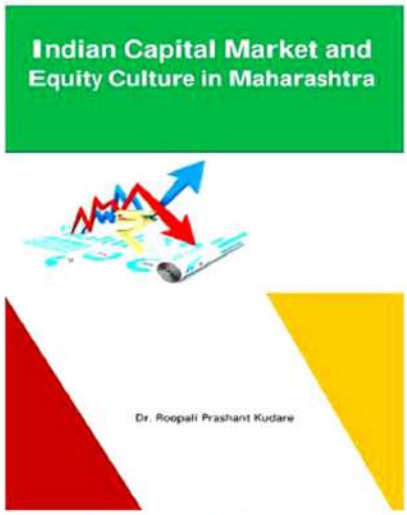

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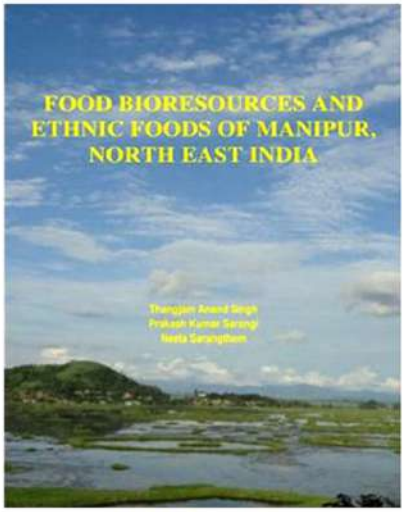

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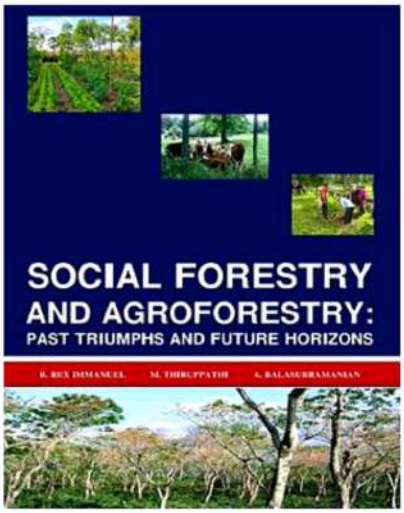

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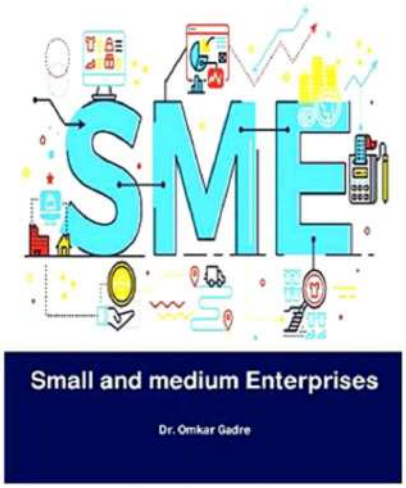

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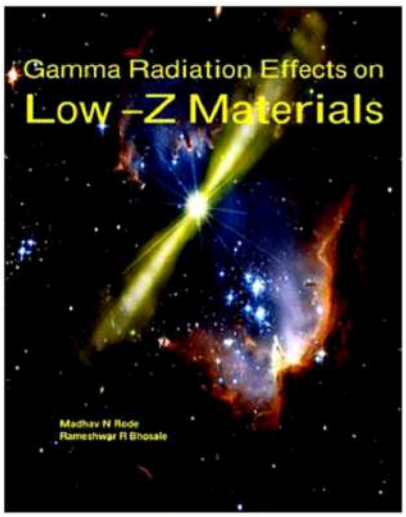

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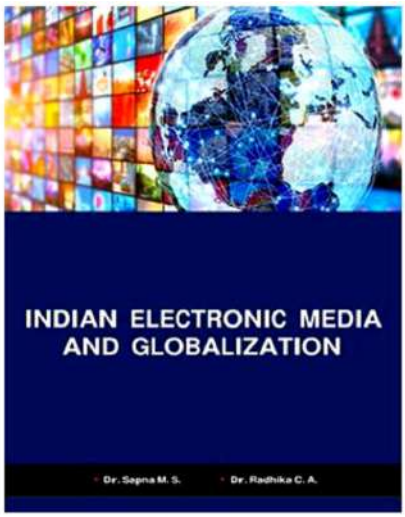

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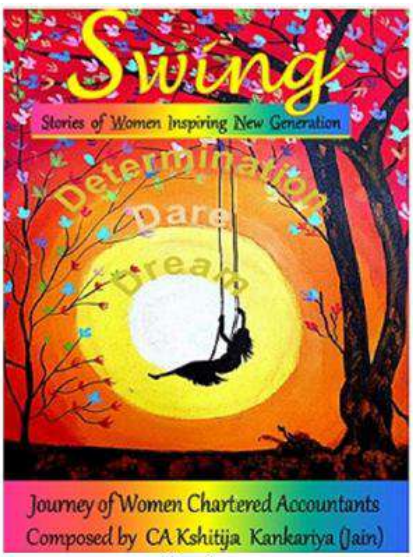

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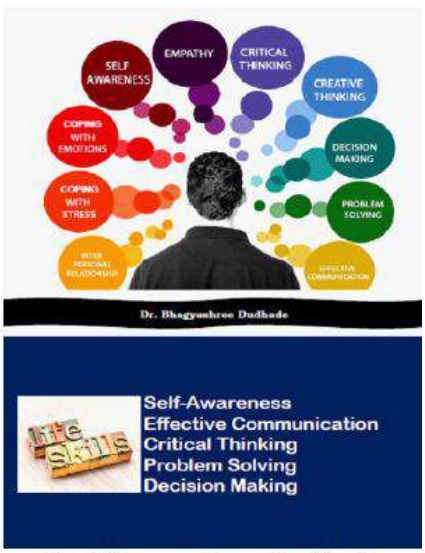

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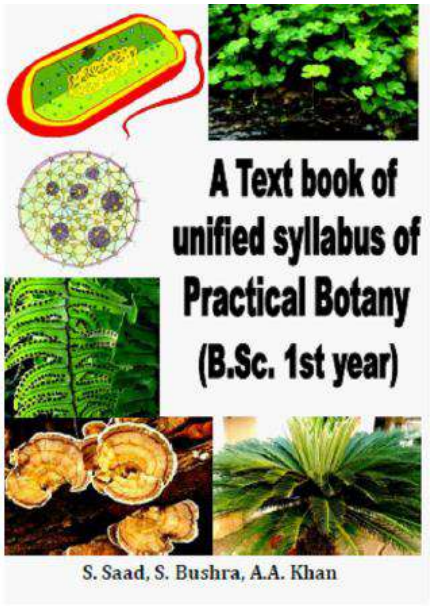

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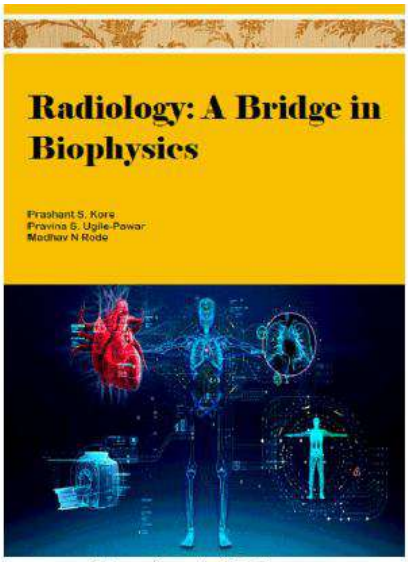

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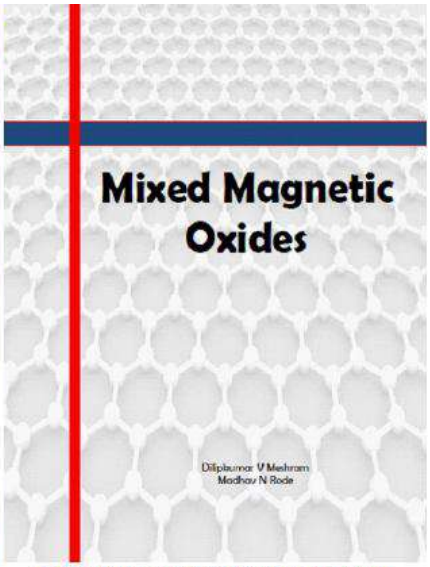

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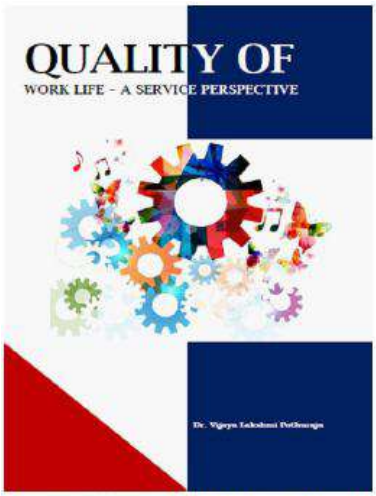

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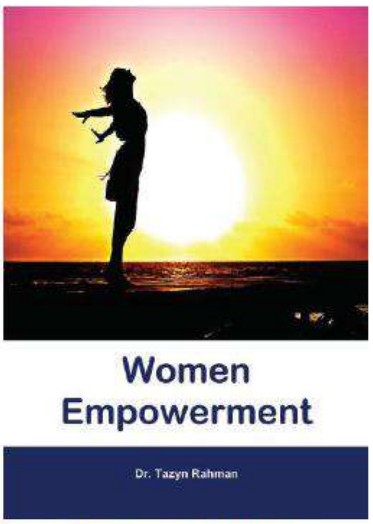

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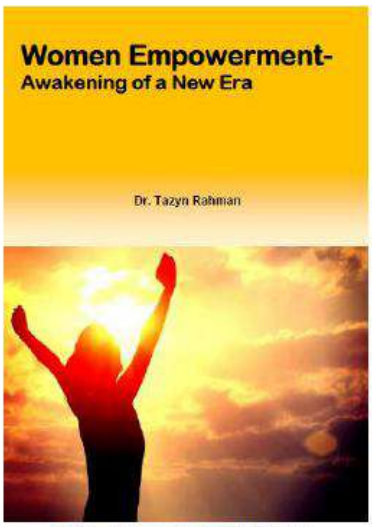

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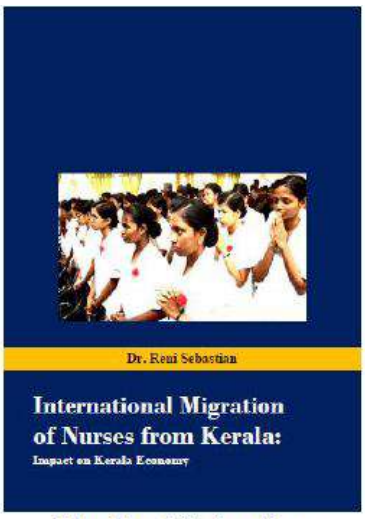

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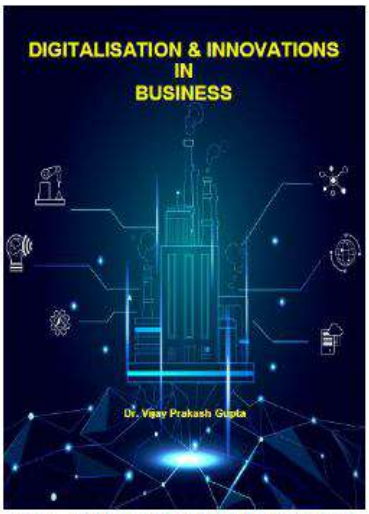

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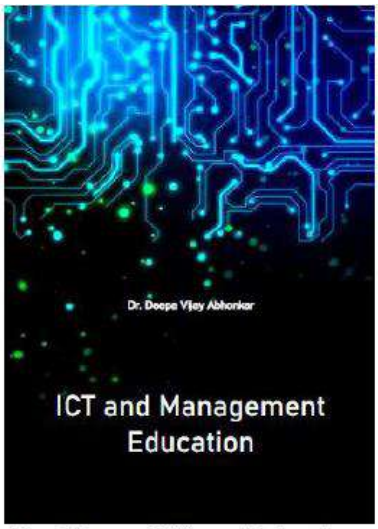

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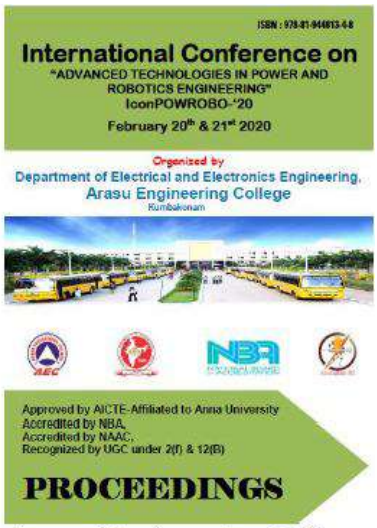

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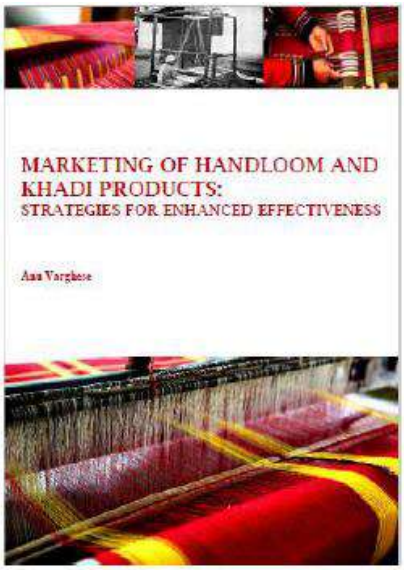

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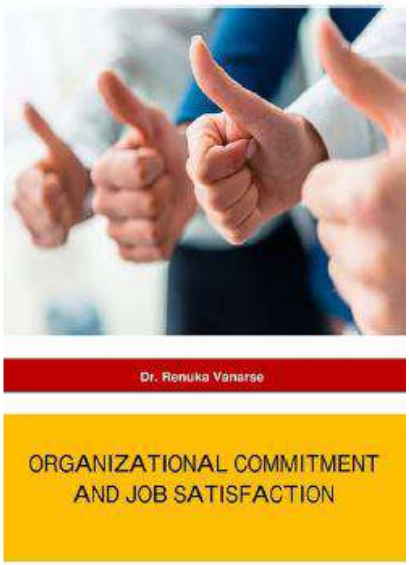

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