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Industry 5.0 for Society 5.0 a new Transformation

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Abstract:

Industry 5.0 represents a transformative approach within Society 5.0, leveraging advanced technologies like AI, IoT, Robotics, and Blockchain to enhance productivity, automation, and decision-making across various sectors. This abstract examines how privacy, security, and ethical issues are addressed by modern technologies to create a societal structure that is morally and humanely sound. IoT improves smart city infrastructure and environmental monitoring, while AI enables tailored education and predictive healthcare. Blockchain guarantees safe and transparent data transfers, while robotics helps with accurate healthcare operations. Collectively, these technologies support Society 5.0's sustainability, inclusivity, and resilience. They also hold out hope for a time when technological breakthroughs will preserve strict ethical standards and cybersecurity safeguards while prioritizing the needs of people and society.

Keywords: Industry 5.0, Society 5.0, AI, IoT, Robotics, Blockchain

Introduction

1.1 Overview of Industry 5.0 and Society 5.0- A paradigm change in the manufacturing and industrial sectors, Industry 5.0 emphasizes human-machine collaboration and the integration of cutting-edge technology like robotics, artificial intelligence, and the Internet of things to increase efficiency and flexibility[1]. Society 5.0, on the other hand, aims to tackle societal problems through technology while fostering sustainability and inclusivity. It is a human-centric society enabled by digital transformation[2]. Examining how Industry 5.0 and Society 5.0 interact is essential because it combines technological innovation with social progress, generating the kind of synergies that propel both social progress and economic expansion.

1.2 Importance of exploring their integration and transformation- The potential for this integration to completely transform the way industries function and increase their responsiveness to environmental and societal demands makes it crucial[3][4]. For instance, AI-driven urban management systems might minimize energy consumption, lessen traffic congestion, and improve public safety in smart cities powered by Industry 5.0 concepts coupled with Society 5.0 aims, all while enhancing the quality of life for inhabitants[5][6]. Similarly, advances in patient care and illness management may result from the fusion of Industry 5.0's advanced manufacturing technologies with Society 5.0's emphasis on telemedicine and tailored medicine.

1.3 The statement and research objectives- According to the statement, we can find revolutionary opportunities that benefit society and industry alike by investigating the intersection between Industry 5.0 and Society 5.0. The study aims to investigate the adoption trends of Industry 5.0, evaluate its influence on societal frameworks, and provide methods for optimizing the interplay between these two paradigms. The ultimate objective is to create the conditions for a peaceful coexistence in which the advancement of technology meets the demands of society and builds a future that is more resilient, egalitarian, and sustainable.

1.4 Background- Industry 5.0 is the next step up from Industry 4.0, which concentrated on data sharing and automation in industrial technologies. In contrast to its predecessor, Industry 5.0 places a strong emphasis on integrating cutting-edge technology like robotics, artificial intelligence (AI), and the Internet of Things (IoT) into industrial processes as well as human-machine collaboration[7][8]. This change recognizes that innovation and productivity are driven by human ingenuity, problem-solving talents, and decision-making capabilities in addition to technology improvements.

- **Evolution from Industry 4.0 to Industry 5.0**

To automate manufacturing processes, Industry 4.0 introduced cloud computing, cognitive computing, IoT, and cyber-physical systems[9][10]. But Industry 5.0 goes beyond these possibilities by highlighting the importance of human laborers in addition to machines. It focuses on developing cooperative work settings where people and robots cooperate to increase manufacturing processes' flexibility, customisation, and efficiency[11]. The goal of this evolution is to leverage human creativity and adaptability while addressing the shortcomings of completely automated systems.

- **Concept and Principles of Society 5.0**

A human-centered idea known as "Society 5.0" imagines a society in which modern technologies facilitate digital transformation, which helps to improve quality of life and solve social problems[12]. In order to build an inclusive and sustainable society where technology meets human needs including healthcare, education, and environmental sustainability, it integrates physical and virtual places. Principles include encouraging innovation and creativity, making sure technology is used ethically and responsibly, and balancing economic growth with societal well-being.

- **Key Technologies Enabling Industry 5.0**

Industry 5.0 makes use of a number of critical technologies to improve industrial operations and facilitate human-robot collaboration. Predictive maintenance and efficient manufacturing are made possible by IoT, which enables real-time data interchange between humans and machines[13]. While robotics permits flexible and agile manufacturing operations, artificial intelligence (AI) and machine learning algorithms improve decision-making abilities and automate repetitive jobs. The objective of Industry 5.0, which is to combine sophisticated automation and human abilities, is supported by all of these technologies.

- **Societal Goals and Technological Advancements Driving Society 5.0**

Through technical developments, Society 5.0 seeks to address societal concerns, improve quality of life, and achieve sustainable economic growth. Society 5.0 aims to improve healthcare services through

telemedicine and personalized medicine, develop smart cities, and encourage sustainable practices in energy and resource management by utilizing AI, IoT, and robotics[14][15]. By making effective and environmentally friendly solutions possible, technological developments in digital infrastructure, renewable energy, and autonomous cars are essential to achieving these societal objectives.

2 Literature survey

The study[16] explores, industry 5.0 encourages human-machine cooperation to increase productivity and speed, modernizing industry. Digital technology integration makes it possible to create customized products, improving customer happiness and transforming supply chain management. Large-scale manufacturing data is analyzed by artificial intelligence and machine learning to solve intricate challenges, providing businesses with a competitive advantage and spurring economic growth. It is imperative in today's tech-driven, international business climate to embrace Industry 5.0 and IoT. In industrial automation, robotics enhances precision and forecasting in conjunction with human intelligence. This is the age of smart manufacturing and mass customization, where robots augment human abilities. This examines the background of industrial revolutions, the effects of Industry 4.0 and 5.0 on manufacturing and society, as well as the salient characteristics and uses of these changes in the industrial landscape. It ends with a discussion of the differences between Industry 4.0 and 5.0.

The study[17] explores, numerous writers have come to the conclusion that the advancement of agricultural output and economic growth depend heavily on digital technology and applications. This progress is shown in the ongoing development of field work mechanization, machinery, and equipment. The usage of contemporary equipment in agriculture is growing, raising the industry's technical and technological requirements. The relationships between Industry 4.0 and Agricultural 4.0 are examined in this research. The study methodically investigates many domains, including Industry 4.0, "Smart Farming," Internet of Things (IoT), Cloud Computing, and Big Data, emphasizing their mutually reinforcing functions in the progression of agricultural methodologies.

The study[18] explores, society 5.0 seeks to put people back at the center of using technology for innovation in light of the growing need to take into account the social and environmental effects of these innovations. Although it has been acknowledged that people, sustainability, and resilience are important aspects of Society 5.0, the critical elements supporting Innovation 5.0 have not yet been evaluated. In order to (1) identify the essential domains and dimensions of Industry 5.0, (2) comprehend their impact on Innovation 5.0, and (3) discuss implications for research, management practices, and policy-making, this study employs a systematic literature review (SLR) and content analysis. The results suggest a multilayered paradigm that integrates technology and ICT with aspects that are knowledge-based, social, and human-centric. With an eye on data-driven, technological, and societal innovation, the study offers managers, business owners, and legislators recommendations for advancing knowledge management and human resources.

The study[19] explores, automation and digitization brought about by Industry 4.0 increase productivity but can result in job losses. Industry 5.0, on the other hand, overcomes these constraints by integrating humans and machines. Entrepreneurship in Society 5.0 places a strong emphasis on striking a balance between technology and humanistic values, whereas Society 4.0 is driven by digital technologies. Infrastructure and education need to be further developed as Industry and Society 5.0

adoption rises. In order to better entrepreneurship in this new context, this study constructs a theoretical model and investigates the idea of Entrepreneurship 5.0 inside Society 5.0.

The study[20] explores, industry 4.0 has helped the sector over the past ten years, but it has drawbacks that have made way for Industry 5.0. Although productivity has grown in smart factories, Industry 5.0 seeks to overcome these gains by focusing less on technology and more on human-machine collaboration. This study highlights Industry 5.0's role in improving consumer happiness through individualized products and explores its opportunities, limitations, and future research prospects. Industry 5.0 is necessary for competitive advantage and economic success in modern company. In addition to technologies like big data analytics, IoT, collaborative robotics, blockchain, digital twins, and upcoming 6G systems, the paper examines potential applications in healthcare, supply chains, and manufacturing. It also discusses the difficulties in combining people and robots on a manufacturing line.

3 Industry 5.0: Transformation and Impact

- **Definition and Characteristics of Industry 5.0**: Building on the groundwork laid by Industry 4.0, Industry 5.0 places a strong emphasis on human-machine cooperation and synergy[21][22]. Industry 5.0 places a greater emphasis on integrating human intellect and creativity with cutting-edge automation technologies than its predecessor, which was mostly focused on automation and data interchange in industrial technologies (IoT, AI, robots). Through human-machine cooperation, this integration seeks to improve productivity, streamline procedures, and stimulate creativity.

- **Integration of Human-Centric Approaches with Advanced Automation**: Industry 5.0 acknowledges that while automated systems are accurate and efficient, humans still possess special talents in areas like creativity, problem-solving, and decision-making. Through the use of technologies like augmented reality (AR), virtual reality (VR), and collaborative robots (cobots), workspaces and procedures are designed to enable employees to work productively with machines[23][24]. This improves human-machine interactions. Industry 5.0 attempts to increase worker satisfaction, safety, and overall operational efficiency by emphasizing human-centric design concepts.

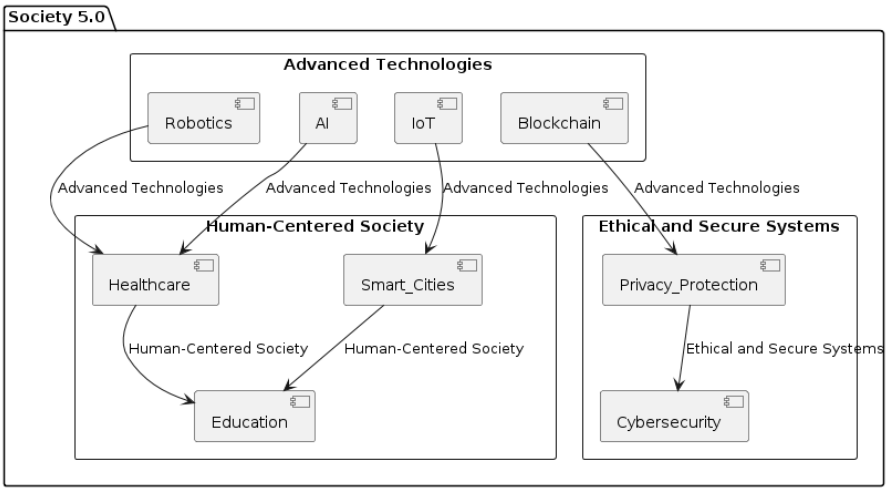
Figure 1 presents the architecture of Industry 5.0 in the context of Society 5.0, highlighting the ways in which cutting-edge technology support a morally and humanely sound social structure.

Industry 5.0 is built on advanced technologies, which include blockchain, robotics, IoT, and AI. These technologies boost productivity, automation, and data-driven decision-making in a number of industries. While IoT offers smart city infrastructure management and environmental monitoring, AI enables predictive healthcare diagnosis and individualized treatment plans. Due to its ability to support caregivers and assist surgeons, robotics is an essential component of healthcare. Blockchain technology guarantees transparent and safe data transfers, which is essential for maintaining anonymity during online exchanges.

These technologies are integrated into fields including healthcare, education, and smart cities by Human-Centered Society. Robotic aid in healthcare improves surgical precision, and AI-driven diagnostics improve patient outcomes. IoT-enabled solutions that optimize energy use, transportation networks, and urban planning are beneficial to smart cities because they foster sustainability and

livability. Technology is used in education to provide global connectivity and individualized learning experiences, which improves accessibility and educational outcomes.
In Society 5.0, ethical and secure systems solve important privacy and cybersecurity issues. Blockchain-powered privacy protection techniques guarantee safe data processing and user privacy during online transactions. By protecting digital infrastructure from threats, cybersecurity measures uphold the credibility and dependability of technical progress.

The way these elements are arranged in the diagram shows how they are interrelated in Society 5.0. It highlights the mutually beneficial interaction that exists between ethical concerns, human well-being, and cutting-edge technologies. Industry 5.0 seeks to create a sustainable, inclusive, and resilient society where technological breakthroughs serve human needs while guaranteeing privacy, security, and ethical standards are followed. It does this by integrating AI, IoT, Robotics, and Blockchain into important socioeconomic sectors. This all-encompassing strategy highlights Industry 5.0's revolutionary potential in creating a future where technology improves everyone's quality of life.



4 Case Studies/Examples Illustrating Successful Industry 5.0 Implementations:

Example 1: Volkswagen's Transparent Factory: The Dresden, Germany, Volkswagen factory uses transparent assembly lines where humans and robots coexist. This is an excellent example of Industry 5.0 ideas in action. As autos are put together, workers and robots work together to demonstrate efficient production while upholding high standards of craftsmanship.

Example 2: Siemens' Digital Factory: Siemens optimizes industrial processes by fusing human expertise with AI-driven digital twins. By enabling predictive maintenance and real-time monitoring, this method lowers downtime and improves operational efficiency.

Example 3: Smart Cities Initiatives: Beyond manufacturing, Industry 5.0 embraces urban settings where IoT, AI, and citizen-focused services are integrated to enhance quality of life. For example, Singapore's Smart Nation effort combines citizen feedback with data analytics to improve urban development and public services.

5 Economic, Environmental, and Operational Impacts of Industry 5.0:

- **Economic Impact:** By increasing productivity and innovation, Industry 5.0 stimulates economic growth[25][26]. Improved human-machine cooperation results in quicker production cycles and higher-quality products, which boost competitiveness in international markets.
- **Environmental Impact:** Industry 5.0 contributes to a smaller environmental footprint in industrial and urban areas by maximizing resource use and reducing waste through sophisticated automation and AI-driven efficiency[27][28]. These developments are mostly dependent on efficient energy management and sustainable practices.
- **Operational Impact:** By combining automation and real-time data analytics, Industry 5.0 improves operational efficiency and permits quick decision-making and preventative maintenance[29]. This leads to lower operating costs, more industry scalability, and higher safety.

In summary, Industry 5.0 is a paradigm change that uses technology to support human creativity and teamwork in addition to automation. Through creative human-machine partnerships, this change is altering industries, promoting sustainable growth, and enhancing societal well-being, as demonstrated by the instances and impacts highlighted.

6 Society 5.0: Enhancing Quality of Life

- **Goals and Principles of Society 5.0**

Society 5.0 is a concept of a human-centered society in which everyone's quality of life is improved via the use of technical breakthroughs. In order to accomplish sustainable development and successfully handle social concerns[30][31], it seeks to integrate cyber-physical systems (CPS), the Internet of Things (IoT), artificial intelligence (AI), and other technology into many parts of society[32][33]. Among the fundamental ideas are:

Human-Centric Approach: Using technology to put people's needs and wellbeing first. **Inclusivity and Accessibility:** Making sure that the positive effects of technology are felt by all facets of society.

Sustainability: Encouraging resource management and environmentally sound behaviors.

Innovation: Promoting innovative solutions to societal problems in order to raise living standards.

- **Technological Innovations Supporting Societal Integration and Well-being**

The following technological advancements form the foundation of Society 5.0: • Internet of Things (IoT): Linking physical things and systems to gather data and enable automation, improving daily convenience and efficiency.

Artificial Intelligence (AI): Facilitating automated and intelligent decision-making, enhancing public safety, transportation, and healthcare services.

Big Data and Analytics: Using enormous data sets to analyze and get insights for tailored services and well-informed decision-making.

Blockchain: Ensuring transparency and trust in digital interactions by safeguarding data exchanges and transactions.

- **Ethical and Social Implications of Society 5.0 Initiatives**

Putting Society 5.0 initiatives into practice brings up moral and societal issues:

Privacy Concerns: Informed consent and the right to privacy must come first in the collecting and use of data.

Equity: Preventing digital divisions and socioeconomic disadvantages by ensuring equitable access to technologies.

Job Displacement: Automation has the potential to upend established job markets, necessitating social safety nets and reskilling.

Ethical AI: Resolving biases in AI algorithms and guaranteeing impartiality and responsibility in the procedures leading up to decisions.

- **Case Studies/Examples Demonstrating Societal Benefits and Challenges**

Healthcare: Using Internet of Things devices for remote healthcare monitoring enhances patient care and lowers hospital visits.

Smart Cities: By incorporating IoT and AI technologies into urban design, energy efficiency, traffic congestion, and public safety are all increased.

Education: AI-driven tailored learning systems meet the demands of each student individually, enhancing academic results.

Difficulties: Data breaches, cybersecurity threats, and social opposition to technology adoption because of worries about privacy violations and job displacement.
The concept of "Society 5.0" is a revolutionary strategy that uses technology to promote sustainable development, raise standards of living, and solve societal issues. To make sure that technical innovations serve society while reducing dangers and obstacles, it is essential to strike a balance between innovation in technology and ethical considerations.

7 Integration of Industry 5.0 and Society 5.0

7.1 Integration of Industry 5.0 and Society 5.0

- **Synergies and Overlaps between Industry 5.0 and Society 5.0:** The paradigms of Industry 5.0 and Society 5.0 are closely related and seek to promote a mutually beneficial link between industry development and societal well-being[34]. In Society 5.0, digital transformation will enable a human-centered society where technology will be effortlessly integrated into day-to-day activities to address societal concerns and improve quality of life[35]. This idea is expanded upon in Industry 5.0, which emphasizes sustainable production techniques and human-machine collaboration in industrial settings[36]. Using cutting-edge technology like artificial intelligence (AI), the Internet of Things (IoT), and robotics to optimize manufacturing processes while making sure they favorably impact social demands like inclusion and sustainability is one way these concepts synergize.
- **Role of Advanced Technologies in Bridging Industrial Transformation with Societal Advancements:** Cutting-edge technologies are essential to connecting the goals of Society 5.0 with Industry 5.0. Artificial Intelligence (AI) improves efficiency and responsiveness by facilitating

intelligent decision-making in public services and industrial operations[37]. The Internet of Things (IoT) makes real-time data transmission possible, enabling community-based personalized healthcare and predictive maintenance in manufacturing. Robotics makes assistance devices for senior care possible while automating repetitive processes in production[38][39]. These technologies offer fresh approaches to persistent social problems, which not only expedites operations but also empowers people and communities.

7.2 Challenges and Barriers to Integrating Industry 5.0 Practices within the Framework of Society 5.0

- **Technological Integration Challenges:** Harmonizing disparate technological platforms and standards across industries and societal sectors is one of the main problems. Technology may be adopted by different industries at different rates, which can cause interoperability problems that impede smooth integration[40][41]. Furthermore, maintaining data security and privacy in the face of growing connectivity is still a major challenge that calls for strong cybersecurity defenses and legal frameworks to safeguard both private data and business activities.
- **Workforce Adaptation and Skills Gap:** Industry 5.0 necessitates a highly trained staff with the ability to operate and maintain cutting edge technologies[42][43]. It is crucial to close the skills gap that exists between developing digital skills and traditional manufacturing professions[44]. For employees to succeed in a technologically advanced workplace, they must be provided with ongoing education and training programs that provide them with the abilities required for roles in data analytics, AI programming, and human-robot collaboration.
- **Societal Acceptance and Ethical Considerations:** It is necessary to have broad acceptance and faith in technology breakthroughs to incorporate Industry 5.0 practices into Society 5.0. It is critical to address worries about automation-related job displacement, make sure that the advantages of technology are distributed fairly throughout society[45][46], and uphold ethical standards in the use of robotics and AI. Facilitating public participation and open dialogue regarding the advantages and drawbacks of Industry 5.0 technologies is crucial in building societal acceptance and averting possible opposition.

8 Future Directions and Opportunities

- **Emerging Trends and Innovations in Industry 5.0 and Society 5.0**

Industry 5.0 emphasizes human-machine collaboration on factory floors and beyond by fusing cutting-edge technology like artificial intelligence (AI), the Internet of Things (IoT), and robotics with human-centric principles. This change promotes more adaptable production systems that can quickly adjust to market demands and manufacture products to order. In contrast, Society 5.0 sees a digitally transformed human-centered society where technology improves quality of life in urban planning, transportation, and healthcare.

- **Research Gaps and Areas Requiring Further Exploration**

Considerable research gaps still exist despite the remarkable developments. Industry 5.0 requires more research on human-machine interaction optimization, cybersecurity frameworks for networked systems, and environmentally friendly production techniques. Research on the moral implications of

integrating AI and IoT, fair access to digital services, and the socioeconomic effects of digital transformation on marginalized communities must be expanded to meet the demands of Society 5.0.

- **Policy Implications and Recommendations for Stakeholders**

Realizing the full potential of Industry 5.0 and Society 5.0 requires effective policies. To guarantee the ethical application of AI and the security of personal data, governments should place a high priority on investments in digital infrastructure, encourage cross-sector partnerships, and erect strong regulatory frameworks. To equip the workforce for digital jobs, stakeholders need to push for inclusive policies that address technical disparities and encourage lifelong learning programs.

- **Long-Term Vision for the Evolution of Industry 5.0 and Society 5.0**

Future developments of Industry 5.0 and Society 5.0 aim to improve productivity, sustainability, and human well-being through the smooth assimilation of cutting-edge technologies into daily life. Industry 5.0 will persist in its development towards self-governing, networked industrial ecosystems, whereas Society 5.0 seeks to create a digitally inclusive community where technology breakthroughs benefit everybody. It will take constant innovation, accountable governance, and international cooperation to overcome obstacles and realize sustainable development objectives on this revolutionary path.
In summary, Industry 5.0 and Society 5.0 have a bright future ahead of them, one that will be shaped by innovation, research-driven understanding, inclusive laws, and a common goal of a future where everyone will have access to technology and be empowered by it.

9 Conclusion

In conclusion, Industry 5.0 embodies a pivotal transformation within Society 5.0, harnessing AI, IoT, Robotics, and Blockchain to revolutionize productivity, automation, and decision-making across sectors. In addition to advancing personalized education, predictive healthcare, and smart city infrastructure, these innovations use blockchain technology to guarantee ethical integrity, security, and transparency. Society 5.0 integrates these technological advances to prioritize human welfare, enforce strong ethical standards, and prioritize sustainability, inclusion, and resilience. This all-encompassing strategy highlights Industry 5.0's capacity to mold a future in which technology promotes societal well-being and human welfare.

References

[1] M. Fukuyama, “Society 5.0: Aiming for a New Human-Centered Society,” *Japan SPOTLIGHT*, no. August, pp. 47–50, 2018, [Online]. Available: http://www8.cao.go.jp/cstp/.

[2] J. Grosse Erdmann, J. Koller, S. Amir, A. Mihelič, and F. Döpper, *Simulation-Based Analysis of (Reverse) Supply Chains in Circular Product-Service-Systems*. 2023.

[3] P. Kiss, J. Hajdú, L. Máthé, J. Dobos, and L. Magó, “Analysis of the towed agricultural machinery manufacturers in Europe,” *Hungarian Agric. Eng.*, no. 33, pp. 5–10, 2018, doi: 10.17676/hae.2018.33.5.

[4] S. Sahu, R. Kumar, P. Mohdshafi, J. Shafi, S. Kim, and M. F. Ijaz, “A Hybrid Recommendation System of Upcoming Movies Using Sentiment Analysis of YouTube Trailer Reviews,” *Mathematics*, vol. 10, no. 9, pp. 1–22, 2022, doi: 10.3390/math10091568.

[5] M. Ghobakhloo, M. Iranmanesh, M. L. Tseng, A. Grybauskas, A. Stefanini, and A. Amran, “Behind the definition of Industry 5.0: a systematic review of technologies, principles, components, and values,” *J. Ind. Prod. Eng.*, vol. 40, no. 6, pp. 432–447, 2023, doi: 10.1080/21681015.2023.2216701.

[6] A. Saradha, “Industry 5.0 and Society 5.0,” *Ind. Revolut. Metaverse Ind. 5.0*, no. December, pp. 1–7, 2023, doi: 10.54368/qpbc.2023.1.1.
[7] N. Jefroy and M. Azarian, “Implications for Smart Logistics ?,” pp. 1–27, 2022.
[8] P. N.Mahalle, N. Rashmi Prasad, and R. Prasad, “Object Classification based Context Management for Identity Management in Internet of Things,” *Int. J. Comput. Appl.*, vol. 63, no. 12, pp. 1–6, 2013, doi: 10.5120/10515-5486.
[9] D. Paschek, A. Mocan, and A. Draghici, “Industry 5 . 0 – The Expected Impact of Next Industrial Revolution,” *Manag. Knowl. Learn. Int. Conf.*, pp. 125–132, 2019.
[10] S. S. Damre, B. D. Shendkar, N. Kulkarni, P. R. Chandre, and S. Deshmukh, “Smart Healthcare Wearable Device for Early Disease Detection Using Machine Learning,” *Int. J. Intell. Syst. Appl. Eng.*, vol. 12, no. 4s, pp. 158–166, 2024.
[11] S. Gupta, “Industry 5 . 0 : Spectrum or Entity ?,” no. July, 2023, doi: 10.48165/gmj.2023.conf8.
[12] E. G. Carayannis and J. Morawska-Jancelewicz, “The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities,” *J. Knowl. Econ.*, vol. 13, no. 4, pp. 3445–3471, 2022, doi: 10.1007/s13132-021-00854-2.
[13] V. M. Banholzer, “Technological and Social Innovations – Aspects of Systemic Transformation,” *Work. Pap.*, no. February, p. 48, 2022, [Online]. Available: www.th-nuernberg.de/innovationskommunikation.
[14] V. Babica and D. Sceulovs, “Business Processes in the Artificial Transformation of Industry 5.0,” *Proc. IMCIC - Int. Multi-Conference Complexity, Informatics Cybern.*, vol. 2024-March, no. Imcic, pp. 170–176, 2024, doi: 10.54808/IMCIC2024.01.170.
[15] J. Kotwal, D. R. Kashyap, and D. S. Pathan, “Agricultural plant diseases identification: From traditional approach to deep learning,” *Mater. Today Proc.*, vol. 80, no. xxxx, pp. 344–356, 2023, doi: 10.1016/j.matpr.2023.02.370.
[16] D. A. K. V. D. A. G. Dr. TR Pandey and D. R. K. S. P. R. S. Himanshu Sharma, “The Development of Manufacturing Industry Revolutions from 1.0 to 5.0,” *J. Informatics Educ. Res.*, vol. 4, no. 1, pp. 1230–1242, 2024, doi: 10.52783/jier.v4i1.710.
[17] I. Kovács and I. Husti, “The role of digitalization in the agricultural 4.0 – how to connect the industry 4.0 to agriculture?,” *Hungarian Agric. Eng.*, no. 33, pp. 38–42, 2018, doi: 10.17676/hae.2018.32.38.
[18] O. Troisi, A. Visvizi, and M. Grimaldi, “Rethinking innovation through industry and society 5.0 paradigms: a multileveled approach for management and policy-making,” *Eur. J. Innov. Manag.*, vol. 27, no. 9, pp. 22–51, 2023, doi: 10.1108/EJIM-08-2023-0659.
[19] L. Đorđević, D. Ćoćkalo, M. Bakator, and B. Novaković, “Entrepreneurship in Society 5.0: Integrating technology and humanistic values for a sustainable future,” *Industrija*, vol. 51, no. 1, pp. 29–45, 2023, doi: 10.5937/industrija51-45802.
[20] A. Adel, “Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas,” *J. Cloud Comput.*, vol. 11, no. 1, 2022, doi: 10.1186/s13677-022-00314-5.
[21] T. S. Karthik, B. L. S. Bizotto, and M. Sathiyanarayanan, “Industry 5.0: an Overall Assessment of Using Artificial Intelligence in Industries,” *J. Theor. Appl. Inf. Technol.*, vol. 101, no. 24, pp. 8163–8181, 2023.
[22] D. Dhotre, P. R. Chandre, A. Khandare, M. Patil, and G. S. Gawande, “The Rise of Crypto Malware: Leveraging Machine Learning Techniques to Understand the Evolution, Impact, and Detection of Cryptocurrency-Related Threats,” *Int. J. Recent Innov. Trends Comput. Commun.*, vol. 11, no. 7, pp. 215–222, 2023, doi: 10.17762/ijritcc.v11i7.7848.
[23] M. Ghobakhloo, M. Iranmanesh, M. F. Mubarak, M. Mubarik, A. Rejeb, and M. Nilashi, “Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values,” *Sustain. Prod. Consum.*, vol. 33, pp. 716–737, 2022, doi: 10.1016/j.spc.2022.08.003.
[24] N. Ambritta P, P. N. Railkar, and P. N. Mahalle, “Proposed Identity and Access Management in Future Internet (IAMFI): A Behavioral Modeling Approach,” *J. ICT Stand.*, vol. 2, no. 1, pp. 1–36, 2014, doi: 10.13052/jicts2245-800x.211.
[25] S. Malik and A. Rana, “Green Computing : Issues , Challenges & Suggestions,” pp. 18–21.
[26] B. Gadekar and T. Hiwarkar, “A Critical Evaluation of Business Improvement through Machine Learning: Challenges, Opportunities, and Best Practices,” *Int. J. Recent Innov. Trends Comput. Commun.*, vol. 11, no. 10s, pp. 264–276, 2023, doi: 10.17762/ijritcc.v11i10s.7627.
[27] M. Borchardt, G. M. Pereira, G. S. Milan, A. R. Scavarda, E. O. Nogueira, and L. C. Poltosi, “Industry 5.0 Beyond Technology: An Analysis Through the Lens of Business and Operations Management Literature,” *Organizacija*, vol.

55, no. 4, pp. 305–321, 2022, doi: 10.2478/orga-2022-0020.
[28] P. Chandre, P. Mahalle, and G. Shinde, “Intrusion prevention system using convolutional neural network for wireless sensor network,” *IAES Int. J. Artif. Intell.*, vol. 11, no. 2, pp. 504–515, 2022, doi: 10.11591/ijai.v11.i2.pp504-515.
[29] S. Saniuk, S. Grabowska, and A. Thibbotuwawa, “Challenges of industrial systems in terms of the crucial role of humans in the Industry 5.0 environment,” *Prod. Eng. Arch.*, vol. 30, no. 1, pp. 94–104, 2024, doi: 10.30657/pea.2024.30.9.
[30] S. Rajumesh, “Promoting sustainable and human-centric industry 5.0: a thematic analysis of emerging research topics and opportunities,” *J. Bus. Socio-economic Dev.*, vol. 4, no. 2, pp. 111–126, 2024, doi: 10.1108/jbsed-10-2022-0116.
[31] M. Trstenjak, M. Mustapić, P. Gregurić, and T. Opetuk, “Use of Green Industry 5.0 Technologies in Logistics Activities,” *Teh. Glas.*, vol. 17, no. 3, pp. 471–477, 2023, doi: 10.31803/tg-20230518185836.
[32] A. Behera, B. K. Ratha, and S. Sethi, “Green cloud computing: A survey,” *Ijseat*, vol. 4, no. 12, pp. 763–767, 2017.
[33] B. Gadekar and T. Hiwarkar, “International Journal of INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING A Proposed Business Improvement Model Utilizing Machine Learning: Enhancing Decision-Making and Performance,” *Orig. Res. Pap. Int. J. Intell. Syst. Appl. Eng. IJISAE*, vol. 2024, no. 1s, pp. 557–568, 2023, [Online]. Available: www.ijisae.org.
[34] R. Verdecchia, J. Sallou, and L. Cruz, *A systematic review of Green AI*, vol. 13, no. 4. Association for Computing Machinery, 2023.
[35] S. Nahavandi, “Industry 5 . 0,” *Sustainability*, vol. 11, pp. 43–71, 2019.
[36] B. Masoomi, I. G. Sahebi, M. Ghobakhloo, and A. Mosayebi, “Do industry 5.0 advantages address the sustainable development challenges of the renewable energy supply chain?,” *Sustain. Prod. Consum.*, vol. 43, no. April, pp. 94–112, 2023, doi: 10.1016/j.spc.2023.10.018.
[37] S. Ghosh, S. Member, T. Dagiuklas, and S. Member, “A Cognitive Routing Framework for Reliable,” vol. 18, no. 8, pp. 5446–5457, 2022.
[38] P. Söderholm, “The green economy transition: the challenges of technological change for sustainability,” *Sustain. Earth*, vol. 3, no. 1, 2020, doi: 10.1186/s42055-020-00029-y.
[39] P. R. Chandre, P. N. Mahalle, and G. R. Shinde, “Machine Learning Based Novel Approach for Intrusion Detection and Prevention System: A Tool Based Verification,” in *2018 IEEE Global Conference on Wireless Computing and Networking (GCWCN)*, Nov. 2018, pp. 135–140, doi: 10.1109/GCWCN.2018.8668618.
[40] I. Taj and N. Z. Jhanjhi, “Towards Industrial Revolution 5.0 and Explainable Artificial Intelligence: Challenges and Opportunities,” *Int. J. Comput. Digit. Syst.*, vol. 12, no. 1, pp. 285–310, 2022, doi: 10.12785/ijcds/120124.
[41] A. Iravani, M. H. akbari, and M. Zohoori, “Advantages and Disadvantages of Green Technology; Goals, Challenges and Strengths,” *Int. J. Sci. Eng. Appl.*, vol. 6, no. 9, pp. 272–284, 2017, doi: 10.7753/ijsea0609.1005.
[42] A. Raja Santhi and P. Muthuswamy, “Industry 5.0 or industry 4.0S? Introduction to industry 4.0 and a peek into the prospective industry 5.0 technologies,” *Int. J. Interact. Des. Manuf.*, vol. 17, no. 2, pp. 947–979, 2023, doi: 10.1007/s12008-023-01217-8.
[43] V. Bidve *et al.*, “Use of explainable AI to interpret the results of NLP models for sentimental analysis,” *Indones. J. Electr. Eng. Comput. Sci.*, vol. 35, no. 1, pp. 511–519, 2024, doi: 10.11591/ijeecs.v35.i1.pp511-519.
[44] S. S. Kankekar, S. S. Dadwal, and A. Ali, “Investigating the factors, challenges, and role of stakeholders in implementing industry 5.0 and its impact on supply chain operations: A study of the global agri-food supply chain,” *Oppor. Challenges Bus. 5.0 Emerg. Mark.*, pp. 124–150, 2023, doi: 10.4018/978-1-6684-6403-8.ch007.
[45] S. Gupta, “Industry 5 . 0 : Spectrum or Entity ?,” vol. 2, no. 2, 2024, doi: 10.48165/gmj.2023.conf8.
[46] M. Ghobakhloo, H. A. Mahdiraji, M. Iranmanesh, and V. Jafari-Sadeghi, *From Industry 4.0 Digital Manufacturing to Industry 5.0 Digital Society: a Roadmap Toward Human-Centric, Sustainable, and Resilient Production*, no. 0123456789. Springer US, 2024.