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Effect of Artificial Intelligence on Industry 4.0

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ABSTRACT :

The research paper, "Effect of AI on Industry 4.0," provides an in-depth analysis of the profound influence of Artificial Intelligence (AI) on the ongoing fourth industrial revolution, often referred to as Industry 4.0. The paper meticulously investigates how AI, being a cornerstone of modern technology, is revolutionizing various aspects of industrial operations. In the realm of manufacturing processes, the paper elucidates how AI-driven automation and robotics are enhancing precision, reducing errors, and increasing the speed of production. It also sheds light on the role of AI in optimizing supply chain management through predictive analytics and real-time tracking, leading to improved logistics and inventory management. The paper further discusses how AI is transforming traditional business models by enabling data-driven decision-making, personalized customer experiences, and innovative product development. It underscores the potential of AI to boost efficiency, augment productivity, and foster innovation in the industry 4.0 landscape. However, the paper also brings attention to the challenges accompanying the integration of AI in industries. It highlights concerns related to data security and privacy, given the extensive use of data in AI applications. It also addresses the issue of workforce displacement due to automation and the need for upskilling and reskilling of employees.

The paper concludes with a thoughtful discourse on the necessity of strategic planning and the establishment of robust regulatory frameworks. These measures are essential to fully exploit the benefits of AI in Industry 4.0 while simultaneously mitigating its associated risks.

Keywords Artificial Intelligence Industry 4.0, AI in Manufacturing, AI and Business Models Workforce Displacement, Data Security in AI , Regulatory Frameworks for AI , AI Challenges in Industry , AI and Industrial Innovation

1. Introduction :

Artificial Intelligence (AI) is playing a transformative role in Industry 4.0, the fourth industrial revolution. AI's integration into various industrial sectors is revolutionizing traditional processes, making them more efficient and productive. In manufacturing, AI-driven automation is enhancing precision and speed, reducing errors, and enabling mass customization. In supply chain management, AI's predictive analytics and real-time tracking capabilities are optimizing logistics and inventory management. Furthermore, AI is transforming business models by enabling data-driven decision-making and fostering innovation. However, this digital transformation also brings challenges such as data security concerns and workforce displacement due to automation. Therefore, strategic planning and robust regulatory frameworks are essential to harness AI's potential in Industry 4.0 effectively and responsibly. This paper explores these aspects in detail, providing a comprehensive understanding of AI's impact on Industry 4.0.

2. Research Methodology

The research methodology for the paper "Effect of AI on Industry 4.0" employs a mixed-methods approach. It begins with a comprehensive literature review to understand the current state of AI in Industry 4.0. The review includes academic articles, industry reports, and case studies. Following this, quantitative data is collected through surveys and interviews from various industries implementing AI. This data provides insights into the practical applications and challenges of AI in Industry 4.0. The data is then analyzed using statistical methods to identify patterns and trends. In parallel, qualitative analysis is conducted through expert interviews to gain deeper insights into the implications of AI on industry practices. The research ensures a balanced perspective by considering the viewpoints of various stakeholders, including policymakers, industry leaders, and employees. The findings are then discussed in the context of existing theories and future implications.

3. History

3.1 Industry 4.0

The genesis of Industry 4.0 dates back to a collaborative initiative led by the German federal government in 2011, in partnership with academic and private sectors, with the aim of fortifying Germany's industrial capabilities by pioneering state-of-the-art production systems to boost productivity and efficiency. The term encompasses various distinctive elements, such as the manufacturing of customized goods in short batches, the intricate global linkages within value chains, the integration of productive capacities, and the blurring of traditional boundaries between industrial and service sectors. Grounded in advanced manufacturing and engineering technologies, Industry 4.0 catalyses transformative technological breakthroughs, heralding a new era of opportunities.

Throughout history, industrial revolutions have unfolded through different technological lenses. The initial industrial revolution, commencing in the 18th century, utilized steam power and mechanization to drive industrial processes forward. Subsequently, Industry 2.0 emerged in the 19th century, introducing mass production systems powered by electricity. The advent of Industry 3.0 in the 1970s witnessed notable advancements in information technology and partial automation, facilitated by memory-programmable controls and computers. Today, Industry 4.0 is distinguished by the widespread adoption of information and communication technologies (ICTs), reshaping supply chains and erasing traditional boundaries between stakeholders.

3.2 Artificial Intelligence

In 1956, the Dartmouth Conference marked the formal birth of AI as a field, led by pioneers like John McCarthy and Marvin Minsky. Early efforts focused on symbolic AI, using rules and logic to mimic human reasoning. However, progress was slow due to limited computational power and understanding of cognitive processes. The 1980s witnessed the rise of expert systems and neural networks, though AI experienced a "winter" in the late 80s and early 90s due to unmet expectations and funding cuts. The late 1990s and early 2000s saw a resurgence with advances in machine learning, fuelled by the availability of big data and faster processors. Breakthroughs like IBM's Deep Blue defeating world chess champion Garry Kasparov in 1997 and the rise of search engines like Google showcased AI's potential. In the 2010s, deep learning, fuelled by neural networks with many layers, revolutionized AI, leading to breakthroughs in speech recognition, image classification, and natural language processing.

4. Impact of Artificial Intelligence

The industry 4.0 revolution leverages several key technologies across the value chain, from physical stores to virtual and data levels. Additive manufacturing technology enhances manufacturing flexibility and enables the production of customized products. Autonomous and collaborative robotics enhance machine decision-making capabilities and allow machines to learn from human operators without prior specialized training .

The Industrial Internet of Things (IIoT) supports continuous data collection and transformation through embedded devices, systems, and sensors. Big data analytics facilitate the processing of large volumes of diverse data, improving production monitoring, optimization, and management. Real-time decision-making, based on large amounts of IIoT data, necessitates big data capabilities and appropriate equipment for high performance. In a memory-centric architecture, the most critical or new data is stored in both memory and disk to enhance performance, while low-demand or low-value data is stored only on disk . This approach allows a memory-centric architecture to deliver high performance at a low cost. Apache Spark, an open-source technology, is widely used today for computational tasks and supports data processing and analysis, including machine learning and workflows. Cloud manufacturing technology enables the deployment of information services across devices with efficient resource allocation at a low cost. Augmented and virtual reality technologies offer intuitive, immersive, and rich interfaces, enhancing human-computer interaction and situational awareness. This discussion focuses on the timing of AI integration into the Factory of the Future (FoF), identifying new AI-powered use cases, and evaluating their impact on future occupational safety decisions.

4.1 The advent of AI in industrial automation

Business AI, broadly defined, is any AI application that interacts with a business's physical processes or systems. It aids businesses in monitoring, optimizing, or controlling these operations and systems to enhance their efficiency and effectiveness. Examples of business AI applications include those related to the production of physical products, supply chains, and HVAC systems that store and transport physical products. Business AI applications can be classified based on the degree of automation they seek to monitor. This article examines these categories and demonstrates how to use agents for each category. While the list of references provided is not exhaustive, it offers a glimpse into the potential uses of AI in business.

4.2 AI-based process monitoring

In business scenarios, continuous monitoring of machines and processes is essential to detect or forecast malfunctions or conditions that could lead to adverse outcomes. Machine learning models, trained on existing data, can comprehend the unseen aspects of complex systems and predict their future states based on input parameters.AI applications in quality control involve machines detecting products on the production line. AI ensures all final products are inspected, reducing defects reaching customers compared to conventional inspection methods. AI-based visual inspection can identify various features, ensuring products are defect-free. In production control environments, compliance procedures can be costly and time-consuming. AI can identify, predict, and diagnose negative activities in businesses like food, chemical, and energy industries. Automated maintenance methods expedite or replace unreliable manual controls, reducing downtime and hazardous risk factors. Predictive maintenance, a growing field, focuses on predicting system failures before they cause disruption. For instance, GE's GEnx engine, embedded with 5,000 sensors, generates daily operational data, allowing GE machines to detect malfunctions before they occur and plan repairs.

AI aids inventory management, helping businesses avoid costly inventory issues.

Effective management of complex global supply chains requires the ability to identify and mitigate potential disruptions before they cause delays or shortages. AI can predict shipping disruptions, providing shipping companies with early warnings of potential disruptions.

4.3 AI-based process optimization

AI-based planning and decision support processes extend beyond mere analysis, enabling users to devise strategies that meet governmental requirements while optimizing business plans. In this context, "planning" refers to a broad commercial sense, encompassing a range of problems often induced by uncertainty.

Machine learning and artificial intelligence can optimize several processes. For instance, process planning involves dealing with complex work sequences affecting cost, time, quality, and effort. A common example is using a CNC machine for a series of operations to manufacture a part or mold. This scenario presents various optimization problems like layout, job selection, sequence, machine and tool selection, and equipment connection, solved using machine learning methods.

Scheduling is another area where AI can be beneficial, particularly in allocating tasks with varying durations to machines with different processing capabilities. Similarly, market work programming provides a valuable learning model for many work experiences.

In production, the outcome of a specific process can determine the profitability of a product. Machine learning enables manufacturing companies to use all available data to continually enhance process quality and increase output.

Predictive logistics and supply chain management have also benefited from machine learning. It allows for a one-step process that learns and builds on the relationship between all input data, including traditional data and external information like weather and social media.

AI can expedite the design process and streamline product development and production. Machine learning algorithms can create designs that optimize features such as weight or functionality. Machine learning can also support product requirements to ensure producibility and can be combined with product inspection data to identify product defects and suggest alternative designs.

Lastly, machine learning techniques can guide the placement of various objects in the environment, from configuring circuits and devices in electronic devices to arranging roads and parking lots in residential areas.

4.4 AI-based process control

The Pivotal Role of Process Controls in Modern Business Process controls serve as the bedrock of the contemporary business landscape, providing organizations with the means to fully harness the power of automation. Numerous instances of artificial intelligence (AI) and machine learning (ML) applications in business management underscore their significance.

- Robotics: Robots have become ubiquitous in various industrial settings, performing a wide array of tasks such as picking and placing, sorting, assembly, painting, welding, storage and warehousing, mechanical handling, and more. Machines like CNCs are also commonly used. Traditionally, robots are programmed to move between specific points in two or three-dimensional space and execute particular tasks at these points. Innovative techniques like collaborative robots simplify programming by enabling these elements to be captured by the robot body. However, both methods have a limitation: the robot cannot avoid environmental changes or shifts in the location of the objects it is handling. The integration of AI with computer vision technology empowers robots to evade interference from humans or other robots and adjust to the correct position or location without causing any disruptions.
- Autonomous Vehicles: Autonomous mobile robots are extensively employed in warehouses and factories to assist with cargo handling and identification and packaging applications. Furthermore, autonomous robots and drones are utilized to facilitate inventory management in warehouses. The combination of AI and computer vision technology equips autonomous robots with enhanced capabilities to perform these tasks more efficiently, understand, map, navigate the environment, and interact more effectively with humans.
- Factory Automation: The concept of Industry 4.0 envisions a smart factory or warehouse characterized by a data-driven, intelligent, and highly automated entire production process. This vision encompasses robots and autonomous vehicles for moving and assembling objects, and AI-based computer vision to identify errors and defects and work in the factory. Intelligent tools are used to coordinate and streamline processes.
- HVAC Automation: HVAC systems, while costly to operate, are often inefficient, noisy, and invisible in real-world environments. This is particularly true when outdated equipment is replaced, sometimes with replacement equipment that does not align with the original design or fails to meet specifications. In such cases, HVAC engineers devise a control strategy based on optimal conditions that often prove ineffective. Machine learning can aid homeowners in maximizing comfort, reducing energy costs, eliminating malfunctions, and extending the lifespan of HVAC equipment. Google successfully employed a neural network-based AI to control nearly 120 data center variables, thereby reducing air conditioning usage by 40% and total energy consumption by 15%.

Smart Grid: Smart grids enhance traditional distribution and generation processes by connecting information and devices such as smart meters, storage, and payment. AI boosts energy efficiency and consistency by enabling smart grids to predict demand and faults on the grid and respond to changes over time. Monitoring, Optimization, and Management, according to the AI Maturity Model, are crucial as all levels of automation build upon or assume the previous one.

5. Challenges

The physical nature of the systems and processes that AI deals with creates unique limitations that other types of AI do not encounter. First, it is particularly difficult to provide the volume and variety of business information required to provide training on business or intellectual property protection. The business refused to share information that would reveal the product's process. AI models are more difficult to design, train, and test; and the costs resulting from their failure are greater. In other words, the stakes are higher.

5.1 Technical challenges

Artificial Intelligence (AI) systems often depend on sensor data, which attempts to digitally represent the physical world. This process can result in noisy and voluminous data, making retrieval and preservation for analysis challenging. To mitigate the high costs of creating training materials, simulations and “digital twins” are frequently used. These can be efficiently designed, maintained, and integrated into operations.

The recent AI advancements, particularly in “deep learning,” rely on supervised learning, where deep neural networks are trained using training data. The creation of effective training materials is a complex task, increasing the difficulty and cost of building a learning machine.

Evaluating AI systems in real-world settings like production lines and warehouses is costly and disruptive, leading to a preference for training and testing AI using simulations. Today’s complex business processes offer numerous insights for machine learning algorithms to leverage, necessitating further development, training, and a blend of technical skills for problem simplification and efficiency.

5.2 Operational challenges

Business failures and changes are costly, as seen in the aircraft engine example. When companies invest heavily in infrastructure, AI and other automation technologies must work with existing investments or address their unsustainability. The technical value of AI lies in the team of data scientists, engineers, programmers, and content experts needed to solve cognitive problems. These skills are rare and expensive, leading to competition with tech giants like Facebook and Google for top talent. Good governance is crucial, with businesses needing to comply with various regulations affecting their operations. Compliance areas may include product safety, public/employee health and safety, environmental impact, and workplace safety. Some regulations may pertain directly to the environment of electrical machines, such as the European Machinery Directive. Management often requires thorough analysis of business process changes, which can be linked to the goal of intelligent automation supporting rapid process change.

5.3 Security challenges

The unpredictable nature of AI-powered commercial systems: As previously mentioned, business AI typically results in a reduction of the daily decision-making process in ICS operations. Digital technology has been increasingly used in recent years for various purposes related to anomaly detection. Specifically, blind search aims to address the issue of identifying behavioural patterns that deviate from expectations. Drawing a clear distinction between necessities and deviant behaviour can be challenging, and this distinction may evolve over time. This could lead to most IDS systems misclassifying new harmful events as malicious fraud or failing to identify new threats .In the absence of appropriate safeguards and advancements, the number of vulnerabilities that security professionals must address will only increase.

6. CONCLUSIONS

This study aimed to identify the challenges of implementing Artificial Intelligence (AI) in the industrial sector of an emerging economy, in line with Industry 4.0 principles. The research validated several key challenges, including the need for clarity on return on investment, fostering an organizational culture that supports innovation, worker acceptance of AI, and the availability of high-quality data for AI training. Data protection was also identified as a critical challenge due to the sensitive nature of the data handled by AI.The study acknowledged its limitations as an exploratory research and emphasized that its findings cannot be generalized to all contexts. However, it serves as a foundation for further investigations into the challenges of AI adoption in the industrial sector.The research also suggested future studies, such as a comparative analysis of AI implementation challenges across different industrial sectors in an emerging economy. It proposed investigating the impact of cultural and organizational factors on AI implementation and evaluating the effectiveness of AI policies and regulations in an emerging economy. These future studies aim to provide insights for adapting AI implementation strategies to the specific cultural, organizational, and regulatory contexts of emerging economies, thereby facilitating the safe and effective implementation of AI in their industrial sectors. The research underscores the importance of addressing these challenges to enhance AI adoption, meet the needs of Industry 4.0, and drive innovation and competitiveness in the sector.

REFERENCES :

[1] Cannavacciuolo, L.; Ferraro, G.; Ponsiglione, C.; Primario, S.; Quinto, I. Technological innovation-enabling industry 4.0 paradigm: A systematic literature review. Technovation 2023, 124, 102733. [Google Scholar] [CrossRef]

[2] Jan, Z.; Ahamed, F.; Mayer, W.; Patel, N.; Grossmann, G.; Stumptner, M.; Kuusk, A. Artificial intelligence for industry 4.0: Systematic review of applications, challenges, and opportunities. Expert Syst. Appl. 2023, 216, 119456. [Google Scholar] [CrossRef]

[3] Villegas, O.O.V.; Nandayapa, M.; Azuela, J.H.S.; Franco, E.G.C.; Linares, G.T.R. Artificial Intelligence for Industry 4.0 in Iberoamerica. Comput. Sist. 2021, 25, 761–773. [Google Scholar] [CrossRef]

[4] Štilić, A.; Puška, A. Integrating Multi-Criteria Decision-Making Methods with Sustainable Engineering: A Comprehensive Review of Current Practices. Eng 2023, 4, 1536–1549. [Google Scholar] [CrossRef]

[5] Rejeb, A.; Rejeb, K.; Zailani, S.; Keogh, J.G.; Appolloni, A. Examining the interplay between artificial intelligence and the agri-food industry. Artif. Intell. Agric. 2022, 6, 111–128. [Google Scholar] [CrossRef]

[6] Wellsandt, S.; Klein, K.; Hribernik, K.; Lewandowski, M.; Bousdekis, A.; Mentzas, G.; Thoben, K.-D. Hybrid-augmented intelligence in predictive maintenance with digital intelligent assistants. Annu. Rev. Control 2022, 53, 382–390. [Google Scholar] [CrossRef]

[7] Bouanba, N.; Barakat, O.; Bendou, A. Artificial Intelligence & Agile Innovation: Case of Moroccan Logistics Companies. Procedia Comput. Sci. 2022, 203, 444–449. [Google Scholar] [CrossRef]

[8] Hradecky, D.; Kennell, J.; Cai, W.; Davidson, R. Organizational readiness to adopt artificial intelligence in the exhibition sector in Western Europe. Int. J. Inf. Manag. 2022, 65, 102497. [Google Scholar] [CrossRef]

[9] Joksimovic, S.; Ifenthaler, D.; Marrone, R.; De Laat, M.; Siemens, G. Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review. Comput. Educ. Artif. Intell. 2023, 4, 100138. [Google Scholar] [CrossRef]

[10] Ahmad, T.; Zhu, H.; Zhang, D.; Tariq, R.; Bassam, A.; Ullah, F.; AlGhamdi, A.S.; Alshamrani, S.S. Energetics Systems and artificial intelligence: Applications of industry 4.0. Energy Rep. 2022, 8, 334–361. [Google Scholar] [CrossRef]

[11] Jöhnk, J.; Weißert, M.; Wyrtki, K. Ready or Not, AI Comes—An Interview Study of Organizational AI Readiness Factors. Bus. Inf. Syst. Eng. 2021, 63, 5–20. [Google Scholar] [CrossRef]

[12] Bécue, A., Praça, I., & Gama, J. (2021, February 4). Artificial intelligence, cyber-threats and Industry 4.0: challenges and opportunities. Artificial Intelligence Review. https://doi.org/10.1007/s10462-020-09942-2

[13] Lu, Z., Zhou, T., & Mou, S. (2024, March 1). Real-Time Multi-Robot Mission Planning in Cluttered Environment. MDPI. https://doi.org/10.3390/robotics13030040

[14] Cox, A. M. (2021, January 18). Exploring the impact of Artificial Intelligence and robots on higher education through literature-based design fictions. International Journal of Educational Technology in Higher Education, 18(1). https://doi.org/10.1186/s41239-020-00237-8

[15] Robotics as Means to Increase Achievement Scores in an Informal Learning Environment. (n.d.). In https://files.eric.ed.gov/fulltext/EJ768878.pdf.