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Review Article

Advancements in Artificial Intelligence, Machine Learning and Deep Learning, Robotics and Industry 4.0: A Systematic Review on Application, Issues, and Electronic Markets

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Abstract *- This systematic review discusses state-of-the-art techniques utilizing AI derivatives: machine learning (ML) and deep learning (DL). In the current paper, five selected sources are discussed to demonstrate the significant transition brought by ML and DL in application fields such as robotics, Industry 4.0, and electronic markets. As the review highlights, these technologies improve existence's independence, effectiveness, and decision-making in intricate procedures. Top issues, including data issues, model explainability, and ethical issues, are noted, stressing the importance of future research and the creation of the Post-RAE-XAI systems. The findings of this research propose new avenues for future investigations on the current state-of-the-art and prospects of AI applications unified by ML and DL to improve human lives across the globe.*

Keywords *- Applications of Machine Learning, Artificial Intelligence, Challenges in Machine Learning, Deep Learning, ML Algorithms.*

1. Introduction

Machine learning (ML), a significant subset of artificial intelligence (AI), has brought about unprecedented transformation in different industries and research areas by training systems to evolve from data inputs. [1] This shift in the paradigm has not only improved the algorithmic performance but has also contributed to the development of new solutions in sectors including robotics, industrial automation, and even electronic commerce. Such sectors as healthcare and e-learning have embraced ML and DL technologies to revolutionize the sectors and achieve levels of development otherwise considered impossible. Industry 4.0 has its foundation in AI, and its implications are witnessed across industries. A category of AI, machine learning, enables systems to find ways of learning through data without being coded by people. [2] This capability is most relevant when working with large volumes of data within the financial, healthcare, and manufacturing industries to improve efficiencies, prediction, and client services. Artificial Intelligence (AI), which has expanded beyond ML, employs artificial neural networks imitating the human brain to analyze data and patterns. [3] DL is most useful for jobs like picture identification, voice recognition, and natural language comprehension to improve industries such as self-driving cars, diagnosis, and city technology. DL algorithms are ideal for predictive maintenance, fraud detection, and dynamic pricing in electronic markets because they can identify small patterns in large data. [2] Robotics are one of the leading key elements of this technological revolution. [4] In the past, robots were applied only in manufacturing for line operations; however, AI and ML improved robots' capacity to work in complex, changeable, and high-precision operations. It has become possible to have sub-human robots in operations with human operators in "robotic systems" that increase output, safety, and versatility. [4] Lithium-ion batteries are central in industrial applications such as automobile production, healthcare, and manufacturing goods requiring high precision and speed. It also applies to autonomous systems in sectors including farming and several storing and packaging industries. These systems have sensors and actuators and are enabled by artificial intelligence models to move, see problems, and solve problems in real-time, thus promoting intelligent production lines and self-organizing logistics systems under Industry 4.0. Industry 4.0 is a term used to describe an ongoing fourth industrial revolution mainly characterized by the integration of machines, systems, and data. [2] It entails the integration of AI with ML, DL, and robotics with IoT, making factories smart with machines that work with minimal human interference. The consequence is that manufacturing has evolved into an efficient, adaptable system sensitive to inputs and adjustments. Consequently, Industry 4.0 practices also affect electronic markets regarding supply chain management, real-time decision-making, and general efficiency. [3] The potential of applying AI-driven prediction introduces new approaches to inventorying, saving time, and understanding consumers, therefore improving traditional business. Overall, today's trends and achievements of ML in the context of AI show considerable improvements and applications. Advanced robotics has witnessed significant developments in self-navigating robots, machine vision, and industrial robots using ML and DL. In the same way, visual data and AI tools have also improved the level of autonomy and tasks accomplished by mobile robotics. In Industry 4.0, especially in the case of AI models used in industrial processes, utilizing methods from the XAI field is necessary to provide transparency and accountability. [5] Moreover, progressing toward the third generation of AI, which supports the integration of symbolism and connectionism, will eventually build effective and complex AI systems. Last, applying ML and DL in electronic markets sheds light on the effectiveness of those techniques in data pre-processing and decision-making based on big data and establishing efficient ways towards automation. Consequently, this article aims to deliver a systematic review of selected ML and DL studies in the context of AI and identify promising future developments in the field. These studies cover various applications and show how diverse and promising ML technologies are. The analysis of the current literature on such studies will enable us to evaluate state of the art, point out the existing research gaps, and suggest potential developments to parlay the power and potential of ML to AI.

1.1. Hypothesis

In this study, the author hypothesizes that "intelligent behavior in robotics and Industry 4.0, and electronic markets arises out of the role of machine learning and deep learning systems as symbolic processors. These systems employ syntactic structure for processing data, and the obtained results are also syntactically based. However, they are meaningful regarding actions and decisions in the available world." These hypotheses will be proved in subsequent sections of this paper.

2. Materials and Methods

2.1. Systematic Analysis Approach

This study uses a systematic analysis approach to assess all the relevant literature on machine learning within the field of artificial intelligence. Some stages of the systematic analysis approach include the preliminary search, comparison and elimination, comparison and inclusion, and finally, evaluation and selection of articles for further analysis.

2.2. Search Strategy

The first step in identifying the literature was to search significant academic databases such as IEEE Xplore, PubMed, ACM Digital Library, and Google Scholar. The search focused on articles, conference papers, and important technical reports found in peer-reviewed scholarly journals over the past five years, from 2019 to 2024, to consider the recent innovations in the subject.

2.3. Screening Process

The initial search produced a large pool of articles, and the articles that were further considered were screened based on the title and abstract. Nine articles that passed the eligibility criteria were obtained to check their suitability for the study. After searching all the articles for the selected terms, the articles were screened for extraction of full-text articles and later assessed against the inclusion and exclusion criteria.

2.4. Data Extraction and Synthesis

Specific to each identified study, important data contained within a study focused on the inclusion criteria, including the study's objectives, methodological approach, findings, and conclusions. These extracted data were then analyzed qualitatively to look for similarities, patterns, and research voids existing in the literature. These syntheses offered a clear perspective on the accomplishments of most recent studies along with the future directions of machine learning. Applying the method of systematic analysis with precision guarantees that this study will provide a comprehensive and meaningful analysis of machine learning algorithms in the context of artificial intelligence, offering beneficial knowledge to the field.

2.5. Analysis Methodology

To accomplish his purpose, the author incorporated an elaborate process of reviewing and synthesizing the results of the chosen studies. Keywords and phrases used to extract the relevant data included objectives, methods, major findings, and implications, as stated in each article. The collected data were subsequently encoded and made amenable to comparative analysis regarding themes, patterns, and issues on ML use in AI. Information relating to the quantitative findings for the multiple studies regarding performance profiles and statistical results were collated before being compared for the effectiveness of different ML and DL methodologies. To understand both the current state and future directions of ML technologies, the perceptions of stakeholders and future research directions and applications of the current technologies were also collected and analyzed. After presenting the findings, the results and discussions section gives a comprehensive view of the study. It can be seen as a conclusive part of the paper that brings the discussion about ML development within AI to a summary. This approach guarantees a critical assessment of the chosen papers and provides significant findings for the AI and ML domain.

3. Results and Discussion

3.1. Overview of Selected Studies

Collectively, this section summarises the review of five representative sample studies that expose the diverse and multifaceted nature of machine learning and its place in the field of artificial intelligence. These publications understand

ML technologies' developments, status, and trends in different areas, focusing on sophisticated robotics, mobile robots, and Industry 4.0. It concludes that machine intelligence has reached zero, the development of the third generation of AI, and the application of ML and DL in electronic markets.

3.1.1. Advanced Robotics

In their study, Mohsen et al. look into the AI, ML, and DL technology in the development of advanced robotic systems where they reveal its applicability in the self-navigation of the robots, the recognition of objects, the use of natural language in communication, and the predictive maintenance of the robotics systems. [6] The paper also shows how these technologies have boosted the performance of robots by developing better, smarter, and flexible robots for complex tasks and challenging conditions. One is collaborative robots, which implies that they interact with humans with the ability to change tasks and environments. [6] Further, AI, ML, and DL are essentials for modern transportation, manufacturing assembly robots, and aviation, leading to efficiency, safety, and customer satisfaction.

3.1.2. Mobile Robotics

On the other hand, Cebollada et al. offer a detailed overview of the mobile robotics system while focusing on incorporating Artificial Intelligence and Visual Data. [7] The sort that study revolves around how mobile robots achieve those tasks on their own through the help of visual sensors and AI tools in ways such as mapping, localization, and navigation. [6] Upgrades in computer vision hardware and algorithms have been crucial to this success. The review concludes that although AI can offer real, non-fragile solutions for many tasks in the framework of mobile robotics, attempts are still being made to develop more integral solutions for movement in space.

3.1.3. Industry 4.0

Ahmed et al. elaborate on the role of AI, particularly the ML and DL, and how they are evolving in the context of Industry 4. 0. [8] The work focuses on the shift from the black box AI system, the generalization of AI, to the Explainable AI (XAI), the generation of human-reasonable interpretations of AI systems' decisions. This transition is fundamental for increasing the deployment of AI solutions in high-impact industrial processes, where the explanation and traceability of results are essential. Looking at the general features of the survey, one discovers the AI and XAI techniques used in Industry 4. 0 related to functions like maintenance prediction, self-organizing features, and diagnostics, all increasing production capabilities and minimizing time losses.

3.1.4. Third Generation AI

Zhang et al. suggest that the next generation of AI should combine two significant paradigms of AI, namely symbolism and connectionism. [9] The study posits that the human mind is mimicked from the perspective of a single model that can hardly encompass actual human-level behaviours in the existing AI paradigms. Unfortunately, the authors never quite state which new AI paradigm they like the sound of, yet they are keen on developing new technologies and systems that are safe, reliable, and extensible. This approach proposed the design of AI systems that could produce decisions on a higher abstraction level.

3.1.5. The Application of Machine Learning and Deep Learning in Electronic Markets

Janiesch et al. present a demystifying overview of ML and DL and stress that these concepts are crucial in designing smart systems for EMs. [10] The research focuses on the differentiation of the concepts of ML and DL to elucidate the mechanisms of the construction of analytical models using automated tools.

They also explain the difficulties in regard to the utilization of intelligent systems, including human-automation cooperation and the formation of AI sterilization. The authors also explain the applicability of ML and DL for analyzing different kinds of data commonly found in electronic markets, such as time series, image, and textual data.

3.2. Efficiency and Sustainability of AI Systems in Industry 4.0.

To ground the hypothesis, the author bases his arguments on the process industry that turns input materials, which are not parts of a whole or integrated unit, into pre-defined recipes or formulas to products. It includes the supervising and regulation of the process, the supervising and care of the equipment, planning and organization of the production, as well as the enhancement of the production process, for example, by changing recipes or improving the control processes, using people and AI systems in synergy to guarantee dependability as well as stability of production is the next logical step.

Therefore, for the process of AI adoption, the first stage of engaging in teamwork is classifying the goals, intentions, and conclusions of the AI system so that they can be understandable to the users, who are the ecosystem's inhabitants. To build the structure of such XAI, one can distinguish the key elements of the methodology and start forming the principles of people and automation working 'together'.

In this contribution, we present the typical industrial applications of AI, the data and the users involved or required. Finally, we propose XAI's research requirements and research orientations in the process industry. The model is illustrated in Table 1 below. The hypothesis for this paper implies that intelligent human behaviors are global instances of physical-symbol processors.

Table 1. AI applications in process industry operations with associated users, data, and methods (RNN: Recurrent Neural Network; KNN: K-Nearest Neighbour

Application	End Users	AI Methods	Relevant Data
Process Monitoring	Operator, Process Engineer, Automation Engineer	RNN, KNN	Process Signals
Fault Diagnosis	Process Engineer, Automation Engineer, Operator, Maintenance Engineer	ANN, SVM, Bayes Classifier	Process Signals, Alarms, Vibration
Event Prediction	Operator	ANN	Process Signals, Acoustic Signals
Soft Sensors	Operator	SVR, ANN, RF	Process Signals
Predictive Maintenance	Operator, Maintenance Engineer, Scheduler	RNN, IF	Vibration, Process Signals

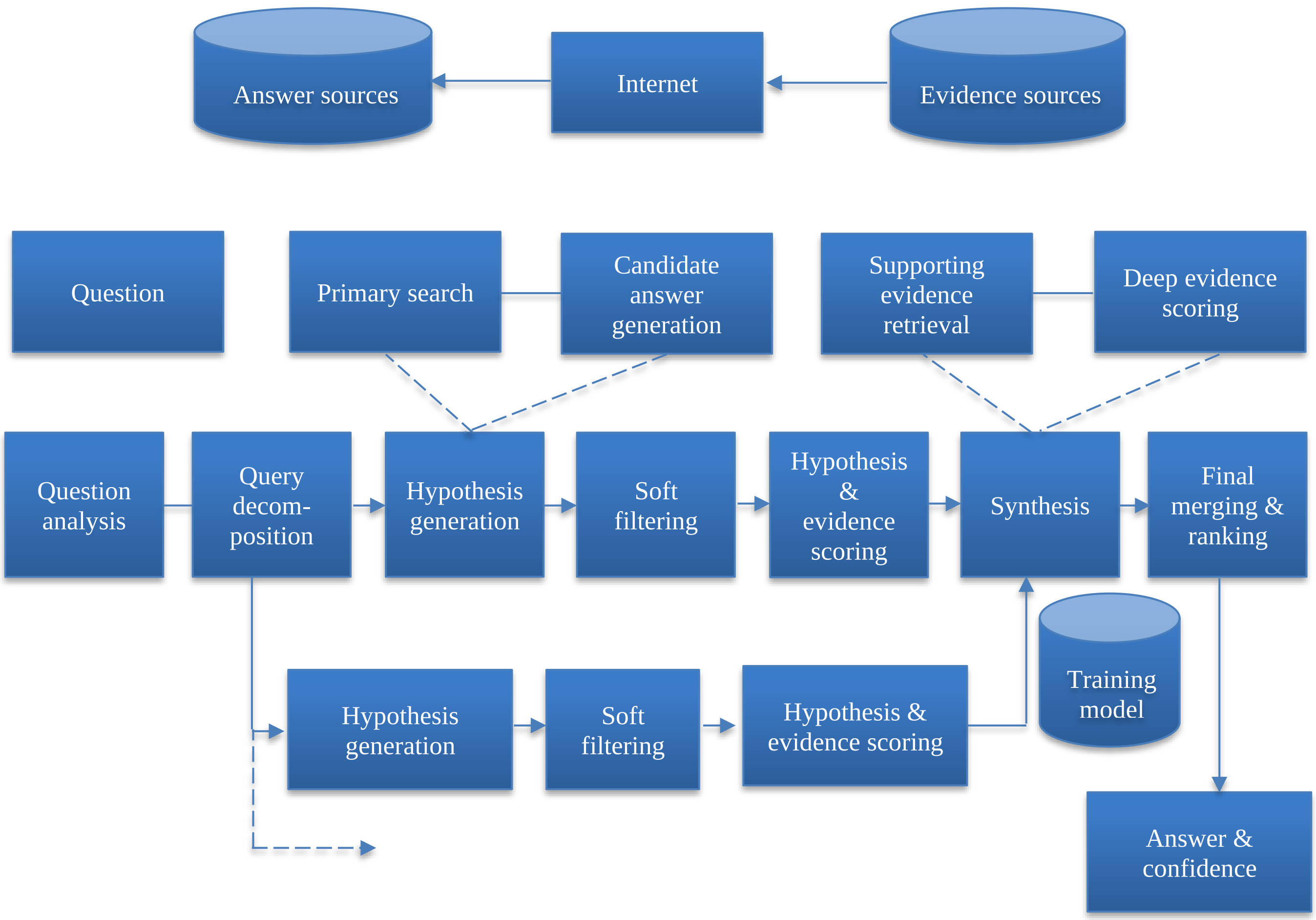

Fig. 1 IBM Watson System

These are (1) A set of symbols that are arbitrarily chosen and working rules that operate on these symbols; (2) The operators solely work on the syntactic structure of the symbol system, i.e. they are syntactic and not semantic; (3) The syntax of the symbol string is systematically related to its semantics in that the symbol is connected Rational behaviors are as a result of knowledge (including common knowledge) and reasoning. AI, concerned with logical knowledge and inference, has advanced much in the first generation, using symbolic models for such human activities. Nevertheless, it is necessary to continue the analysis of difficulties and mistakes in knowledge representation and reasoning methods. The following experience of the Watson dialogue system may be helpful to review in terms of the knowledge representation and reasoning methods: The system comprises (1) a procedure for raising a large number of unstructured texts for structured knowledge representation, (2) representation of the uncertain knowledge depending on a quality of knowledge score, (3) uncertain knowledge reasoning depending on the integration of multiparty reasoning models. The system is shown in Figure 1. The hypothesis is best spelt out by IBM Watson, which employs machine learning and deep learning algorithms to parse tremendous amounts of data syntactically. Cognitive intelligence recognizes patterns, produces understanding, and makes choices in various spheres. Although it engages in syntax, its outputs are semantic. They are always in context, so semantic interpretation can be considered systematic in Watson in healthcare, finance, and customer service.

3.3. Discussion of Key Themes

3.3.1. Advanced Robotics: Enhancing Efficiency and Adaptability

The use of AI, ML, and DL in advanced robotics is well illustrated by Mohsen et al. [6]. These technologies work together to allow robots to perform complicated missions independently, thus improving their capability. Self-navigation and object detection are perfect instances in which robots are becoming more intelligent due to the utilization of ML algorithms and structures like CNNs. Further, natural language processing (NLP) allows robots to understand and obey the commands uttered by man, and it can be used in different aspects of society. Another important use case is predictive maintenance, in which the ML and DL models learn from mountains of sensor data to predict equipment failures before the actual failure happens. These measures reduce the likelihood of a breakdown to the extent that they can keep robotic systems from working for long periods and, of course, the cost of attending to the system. The study further recommends a need to assert the development of more AI, ML, and DL applications on robotics to improve productivity in many sectors, as is commonly seen in the transportation, manufacturing, and aviation industries. [8]

3.3.2. Mobile Robotics: Autonomy Using Visual Information

Cebollada et al. have also focused on analyzing visual sensors and AI instruments to improve mobile robotic techniques. [7] Computer vision coupled with algorithms in artificial intelligence has been used to make mobile robots navigate and perform mapping and localization. Some techniques used in these developments include simultaneous localization and mapping (SLAM) and deep reinforcement learning. A new important application of SLAM algorithms consists of constructing a map of the robot environment and estimating the robot's position in this environment simultaneously. The other category is much deeper in reinforcement learning, which allows robots to learn the correct navigation procedures through trials. However, the study does not deny the difficulties of attaining complete autonomy in a complex and heterogeneous world. Due to the difference in illumination, shadows, and occlusion, the data visualization is quite challenging. Thus, future research has to address the necessity for enhancing the algorithms, which will have to be more resistant to these variations to increase the robots' performance in various environments.

3.3.3. Industry 4.0: Towards Explainable AI

Ahmed et al. point out that the ability to explain results (Known as explainable AI or XAI) is crucial for Industry 4. 0. Since AI systems are slowly being integrated into industries, it has been a question of how the decision-making process of such systems is done. [8] Explainable AI is intended to inform people about the AI system's decisions and, thus, build trust and facilitate the ethical utilization of AI systems in various and diverse fields. The study covers several Explainable AI techniques, such as Local Interpretable Model-Agnostic Explanations (LIME) and Shapley Additive Explanations (SHAP), which are useful in determining the contribution of features to AI. These methods are beneficial when used in areas that require prognosis and quality control, in which it is critical to comprehend why an AI system has made a specific decision. Moreover, the shift towards XAI resolves an ethical issue of AI applications in industries to ensure that AI systems work fairly, transparently, and responsibly. Such a shift is essential to apply AI technologies in areas where they are engaged in decision-making, and their decisions have a degree of impact.

3.3.4. Third Generation AI: Synthesizing Paradigms

In their paper titled Integrating the Symbolism and Connection Paradigms for AI Development, Zhang et al. commend themselves for presenting a new way of developing AI. [9] The authors claim that the contemporary AI paradigms that rely on symbolic reasoning or neural networks do not fully allow human intelligence. Symbolism is based on definite constraints and logical procedures, and connectionism relies on associative structures and networks; each has its prospect. Thus, being native to one paradigm deprives an AI of opportunities.

The third generation of AI, the Hybrid AI, is proposed as a combination of the first and second-generation AI. Such an integrated approach would enable better results in implementing reasoning and learning paradigms in AI systems, making it possible to develop Intelligent Technologies that are also safe, reliable, and extensible technologies. Such a concept of a third-generation AI is one of the significant steps towards creating fully cognitive artificial systems.

3.3.5. Machine Learning and Deep Learning in Electronic Markets

Janiesch et al. further discuss how ML and DL technologies can be applied in the electronic markets, especially due to the large and diverse data. [10] This work demonstrates how the ML and the DL models can handle different formats of data, time, image, and text to arrive at informative data for business automation and decision-making. For instance, in the financial markets, time series analysis utilizing Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) means making correct market trends and price predictions. In e-commerce, implementing image recognition can be helpful in product suggestions. It can boost customers' satisfaction by evaluating image information extracted from product images. Automating in analyzing text gives businesses a clue about what consumers feel and need so that the business can adjust to that and capture more of that market. The paper also explains the various limitations of the adoption of ML and DL systems, including the issue of data protection, the ability to understand DL models, and the issue of model retraining. Overcoming these challenges is important for properly implementing intelligent systems in electronic markets and their fair functioning.

3.4. Synthesis and Implications

The selected studies and this research emphasize the revitalization impact of AI, ML, and DL in different fields. These technologies are the main advancement enablers, from improving the competence of autonomous or assistive robots and mobile robots to the transformation of industrial processes in Industry 4.0 and the ability to perform various complex data analyses in electronic markets. Nonetheless, several common themes and issues can be identified through the analysis.

3.4.1. Data Quality and Integration

Both ML and DL require high-quality data to function properly and achieve the best outcome. Despite improvements, the main data quality issues of accuracy, completeness, and integration remain problematic in all domains.

3.4.2. Model Interpretability and Explainability

Demand for explainable AI can be seen when the decisions derived from the models have to be justified for activities with critical consequences. To gain public trust and ensure the ethical use of AI, some focus has been placed on making AI models more explainable.

3.4.3. Robustness and Adaptability

AI systems should also be able to be residual in complex environments that are constantly changing. This makes it necessary to continue conducting studies to construct efficient algorithms that could process fluctuations within the information and the environmental conditions.

3.4.4. Ethical and Societal Implications

Many ethical and social issues involve the general use of AI technologies, including data privacy, biased results, and loss of job opportunities. Solving these problems is crucial to the proper implementation of AI solutions.

3.4.5. Continuous Improvement and Innovation

The AI, ML, and DL fields are growing very fast, which always requires enhanced development. Users have to update themselves in the present day to be able to use new methods and tools optimally. As such, the chosen articles help to describe the current status and development trends of machine learning in the field of artificial intelligence. It also underlines how these technologies have become influential in different fields to the same point, as well as potential limitations and future research directions. By solving these challenges and using additional AI, ML, and DL opportunities, we can advance progress in the sphere and reveal more options for intelligent systems.

3.5. Features of the Research

The contribution of this research is derived from the fact that it presents a structured study of how ML/DL systems that can be embodied in forms such as AI frameworks like IBM Watson act as symbolic processors in intelligent decision-making processes in advanced robotics, Industry 4.0 and electronic market. In contrast to other works that consider AI to be the successful deployment onto chosen spheres, this paper pays primary attention to the syntactic transformation of data and systematic semantic matching of data with real-world actions.

Unlike other studies where the ML/DL applications are examined independently for each domain (e.g., predictive maintenance in Industry 4.0 or autonomous navigation in robotics), this paper connects these domains to illustrate their similarities in their theoretical structure. In addition, by comparing AI systems with human-like symbolic reasoning, this work provides insight into a new method for interpreting AI outputs and a fresh approach to exploring the adaptability of machine learning and deep learning approaches in other complex environments. The author achieved a state-of-the-art study through proper planning and execution of the research process. The author focused on an in-depth analysis of the key thematic issues and narrowed it to the subject matter, which forms the basis of the novelty of this study. Furthermore, the reliance on peer-reviewed materials to conduct this research renders a state-of-the-art study.

4. Conclusion

Concisely, the discussion of the applicability angle of Machine Learning (ML) in the sphere of Artificial Intelligence (AI) reveals its capacity for positive changes in various fields. The studies analyzed in this paper underscore the functions of ML and DL in improving robotics and mobile robotics and spearheading Industry 4. Technological advancement, better customer relations, increased order size, supply quality, better computer service, decreased cost of goods, and enhanced electronic markets to 0.

Such technologies have enhanced the instrumentality of self-sustaining operations, object identification, predictive maintenance, and analytics capabilities, decisively proving the adaptability of today’s technologies. However, several challenges, such as data quality issues, model interpretation, model robustness, ethical issues, and the constant need to develop new models, are some of the challenges that need to be dealt with fully to harness their capabilities. In the future, to develop reliable and human-like AI, it will be important to popularize integrating different paradigms and creating xAI systems. This systematic process has thus helped to produce a clear and coherent understanding of current trends and future directions, thus making a notable contribution to AI and ML.

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