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DESIGNING AN AUTOMATION ENGINEERING SYSTEM UTILIZING AI TECHNOLOGY FOR ENHANCEMENTS IN INDUSTRIAL PRODUCTION

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ABSTRACT

This paper presents a comprehensive study on designing an advanced electrical automation engineering system utilizing artificial intelligence (AI) technology, aimed at enhancing industrial production. Initially, the paper introduces the fundamental concept and components of electrical automation engineering, providing a foundation for understanding its integration with AI. To address these issues, the paper proposes a novel framework for an electrical automation engineering system based on AI technology. This framework leverages AI's capabilities in data analysis, pattern recognition, and intelligent decision-making to enhance the functionality and efficiency of automation systems. This innovative approach not only enhances the operational efficiency and adaptability of automation systems but also paves the way for future advancements in smart manufacturing and industrial production.

Keywords: Automation, Intelligence, Industry, System, Technology.

I. INTRODUCTION

Recent years have seen a dramatic shift in industrial output and scientific inquiry due to the pervasiveness of artificial intelligence (AI) technologies. Artificial intelligence's capacity to sift through mountains of data, spot trends, and reach conclusions has improved productivity and quality of work in a wide range of industries. Artificial intelligence (AI) has become an indispensable tool in electrical automation engineering, allowing for more thorough understanding and better results. There are many advantages of using AI in electrical automation engineering. It optimizes resource usage, shortens equipment lifetime, and simplifies complicated operations while reducing human error and making predictive maintenance easier. In addition, automation systems powered by AI can instantly adjust to fresh data, making them better equipped to handle ever-changing operational needs and dynamic industrial settings.

A state-of-the-art electrical automation engineering system that makes use of AI is the goal of this work. With its cutting-edge solutions that boost efficiency, precision, and dependability, the suggested system will tackle major problems in scientific research and industrial production. The goal of integrating AI into the system is to make it more precise and adaptive so that it can do jobs that are now unimaginable in automation engineering. Both the theoretical advances and the practical applications of this study contribute to its relevance. Freeing up human resources for more important functions, the developed system can accomplish difficult technical tasks with minimum human interaction. In addition, industries are better prepared to compete in a technology-driven market thanks to the integration of AI in automation systems, which is in line with the larger trend of digital transformation.

II. SIGNIFICANCE OF AI TECHNOLOGY FOR INDUSTRIAL PRODUCTION

Industry has seen a sea change with the introduction of AI technology, which has optimized processes and driven efficiency gains never seen before. The capacity of AI to process massive information, spot complex patterns, and make rational judgments has made it an indispensable tool in contemporary manufacturing. Predictive maintenance, quality control, supply chain optimization, and other areas of production are all affected by it.

Predictive maintenance is where AI has had a huge impact on industrial output. Regular inspections and impromptu fixes are commonplace in conventional maintenance practices, although they often cause unneeded downtime and higher expenses. However, by constantly monitoring machine conditions and evaluating performance data, AI technology may anticipate equipment breakdowns before they happen. Reduced unanticipated failures, less downtime, and longer equipment lifespans are all results of this predictive capability's capacity to enable prompt maintenance interventions. This allows businesses to save money on maintenance while increasing operational efficiency.

AI also helps with industrial manufacturing quality control. Performing quality checks using traditional methods may be time-consuming and error-prone. In contrast, systems driven by AI are able to conduct product inspections with unprecedented consistency and accuracy. These systems are able to identify abnormalities and faults in real-time using

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machine learning algorithms, guaranteeing that only items that fulfill the most stringent criteria make it to market. This leads to more sustainable manufacturing processes by improving product quality while reducing waste and rework expenses.

Another important area where AI technology has had a significant influence is supply chain optimization. To manage inventory levels, precisely estimate demand, and improve logistical operations, AI algorithms can evaluate large volumes of data from multiple sources, including market trends, customer demand, and logistics networks. Businesses may save money on inventory holding expenses, stay ahead of stockouts, and guarantee on-time product deliveries with this degree of efficiency. In addition, industrial processes may be more resilient and agile with AI-driven supply chain management that can adjust to shifting market circumstances and interruptions.

Figure 1: Significance of AI on manufacturing

Moreover, AI technology fosters innovation in industrial production by enabling the development of smart manufacturing systems. These systems, characterized by their interconnectedness and data-driven decision-making, can self-optimize and adapt to new conditions, leading to more flexible and efficient production processes. For instance, AI can facilitate the customization of products on a mass scale, allowing manufacturers to meet specific customer preferences without compromising on efficiency. This capability is particularly valuable in today's market, where consumer demands are increasingly varied and dynamic.

In conclusion, AI technology significantly enhances industrial production by improving predictive maintenance, ensuring quality control, optimizing supply chains, and fostering innovation. Its ability to process and analyze large datasets quickly and accurately makes it an indispensable tool for modern industries. As AI technology continues to evolve, its integration into industrial production will likely yield even greater efficiencies and innovations, driving the future of manufacturing and production toward smarter, more sustainable practices.

III.REVIEW OF RELATED STUDIES

Amoo, Olukunle et al., (2024). The enormous influence of AI on warehouse automation is explored in this extensive evaluation, which covers a wide range of AI-driven solutions. As more and more industries adopt automation to streamline processes and increase efficiency, logistics and supply chain management are undergoing a radical transformation due to the integration of AI into warehouse management systems. Warehousing automation technologies powered by artificial intelligence improve inventory management and order fulfillment via the use of advanced algorithms. Important in demand forecasting, machine learning algorithms allow warehouses to foresee and respond to changing customer requests. Good news for quality control, pick-and-place, and object identification applications: robots can now see better. Warehouse operations are made much more efficient, faster, and cost-effective by these advancements. Topics covered in this study include robotic arms, autonomous mobile robots (AMRs), and automated guided vehicles (AGVs), all of which are uses of artificial intelligence (AI) that automate operations in warehouses. AMRs powered by AI can navigate warehouses autonomously, discovering the best pick routes and effortlessly adapting to different layouts. The usage of AI-enhanced robotic arms streamlines packaging and palletizing processes. Material handling is made more accurate and flexible with the help of these arms. Automated guided vehicles (AGVs) are able to

ISSN-2394-5125 VOL 11, ISSUE 01, 2024

navigate warehouses more quickly and efficiently because to artificial intelligence. Recent trends indicate that the AI-driven sector of warehouse automation systems is going through a period of fast development. By using edge computing technology, these systems may now analyze data locally, leading to better real-time decision-making and reduced latency. Robotic systems that adapt their actions to new circumstances via the application of reinforcement learning algorithms allow for efficiency gains and continuous development. In conclusion, this investigation elucidates the significant impact of AI in the transformation of warehouse automation systems, which in turn alters supply chain and logistics processes. Warehouse automation and artificial intelligence (AI) together might dramatically improve efficiency, accuracy, and adaptability in today's warehouses.

Rayhan, Abu. (2023). With an emphasis on the shift from automated to autonomous systems, this study investigates the use of AI in robotics. Machine learning, computer vision, natural language processing, planning and decision making, and robotics' growth are some of the core ideas covered in this paper's introduction to artificial intelligence and robotics. It delves into the function of automation in robotics, including several forms of automation and the pros and cons of each. Computer vision, natural language processing, reinforcement learning, supervised and unsupervised learning, planning and decision making, and a host of other artificial intelligence (AI) methods are covered in detail in the article. Additionally, it delves into the idea of autonomous systems, various degrees of autonomy, development hurdles, factors to consider, and legal and ethical concerns related to their implementation. Autonomous cars, industrial, medical, agricultural, and humanoid robots are only a few of the sectors covered in this paper's case studies of autonomous robots enabled by AI. It also delves into the possible effects on society and the economy, as well as new developments, emerging technology, and future paths in artificial intelligence robotics. At the end of the study, the authors summarize the results, point out the study's contributions, and suggest areas for further investigation.

Carpanzano, Emanuele & Knüttel, Daniel. (2022). Modern production systems rely heavily on industrial control systems. The complexity of production systems is growing rapidly due to the ongoing tendencies towards greater sustainability and flexibility, which aim to preserve or improve production capabilities and productivity. Complex control algorithms and other advancements are necessary to meet these difficulties. Recent years have seen a surge in interest in and use of AI-based approaches for industrial control systems in both academia and business. An increasing number of industrial control system levels are investigating AI-based approaches, from the level of individual automation devices to the level of real-time control of complicated machinery, production processes, and overall factory optimization and supervision. From sensor fusion methods to innovative model predictive control techniques, from collaborative robots to self-optimizing machines, and from production supervisory control systems to factory adaptive automation systems, AI solutions are utilized in various industrial control applications. In this perspective paper, we will look at some new ways artificial intelligence (AI) is being applied to industrial control systems at various levels. The goal is to make these systems better at learning on their own, more efficient overall, more resilient to changing boundary conditions and production demands, and more efficient at using the resources we have. The paper concludes by discussing the key outstanding issues and looking ahead to the future.

Li, Qiyao. (2021). An integral aspect of manufacturing and production in industrial settings is the automatic control system. Industrial automation systems have embraced artificial intelligence, a product of the next generation of intelligent technology made possible by the exponential growth in computing power. After providing a comprehensive overview of the history of the present-day industrial automation control system, this paper goes on to explain the applicable theory of AI technology. Last but not least, it outlines the current state of and future directions for AI technology's use in industrial automatic control systems. Research on industrial automation control systems is the intended focus of this article.

Luo, Qin et al., (2021). Artificial intelligence technology has emerged as a significant trend in the development of electrical automation control. Control based on AI technology may significantly improve electrical automation control due to its stability and practical advantages. One need simply investigate the potential uses of AI in electrical automation control for tasks like remote control, intelligent monitoring, problem solving, product design, etc.

Han, Tianrong & Xu, Yeqin. (2021). In addition to helping China achieve its industrial power goal and boost GDP, investing in mechanical design, manufacturing, and automation engineering has the potential to raise living standards for the general public and lay the groundwork for future social progress. Advances in AI have the potential to increase the level of mechanical automation. We randomly chose 30 students from mechanical college and split them in half to better understand the impact of AI technology on mechanical design and manufacturing. Students in Group A conducted tests using conventional mechanical design and manufacturing methods, while those in Group B built their machinery using AI. We discovered a significant difference between the two student groups as the experiment progressed and the time passed. Group B's waste rate drops to 0.2%, resulting in a 0.2% savings, while group A's waste rate reaches 0.4% at 30% mechanical production, according to the testing data. Group B's resource waste is 0.3 percent lower than group A's at 50% and 70% manufacturing progress, resulting in a 0.5 percent savings. As a result, mechanical manufacturers can boost their manufacturing efficiency and cut down on resource waste with the help of artificial intelligence technology, which greatly influences the advancement of mechanical design and manufacturing.

Ding, Dawei et al., (2021). With the ability to achieve precise control operation, decrease reliance on human intervention, and substantially enhance the intelligent level of various fields—including electronics, telecommunications, computers, and more—artificial intelligence (AI) technology has significant research value. This

ISSN-2394-5125 VOL 11, ISSUE 01, 2024

study begins with an analysis of the theory of artificial intelligence automation control, moves on to examine electrical automation control that makes use of AI technology, and concludes with a detailed method for implementing AI into electrical automation control.

Yang, Li. (2020). Industrial electrical automation control is one area where artificial intelligence technology has had a positive impact thanks to the advancements in current science and technology. When it comes to electrical automated control, artificial intelligence has shaken up the status quo and introduced fresh energy. This paper begins with a quick introduction to AI technology, before moving on to highlight its usefulness in electrical automation control. Next, the article's usefulness is enhanced by classifying and explaining the application of artificial intelligence technology in electrical automation control. This theoretical reference will be useful for future research in related topics.

IV. PROPOSED METHOD FOR THE STUDY

Electrical Automation Engineering Design Concepts

To make distribution automation work, an interface platform is needed, and that platform is the electrical automation system. The main station's construction process makes use of database, network, object-oriented modular concept, and application component technology after carefully evaluating various factors such as the construction scheme, the specific application scope of feeder automation, the system's overall scale, and the entire construction cycle. Additionally, the electrical automation system incorporates the information interaction model into its architectural framework, allowing for the sharing of data with other systems through bus interaction technology. This includes the system's software and hardware platforms as well as its network and application platforms, as well as the realization of its functions and the protection of its users. These fundamental principles are adhered to throughout its development and execution.

(1) The electrical automation project's hardware makes use of state-of-the-art devices and equipment that are up to par with global standards; these devices and equipment have a high data processing capacity, guarantee a high level of safety and reliability, and are both universal and scalable, so they can easily adapt to changing needs.

(2) The electrical automation system's software is built on the principle of modular design, which allows for the efficient realization of information interaction between the distribution automation system and other systems like the dispatching system, among others. The software architectural design of the distribution automation main station also includes a plug-in interface and the ability to expand functions, so it can effectively satisfy the demands of regulators and the real distribution system. The electrical automation system's server and workstations use the operating system platform to guarantee the system's dependability and security, keep the design consistent, and preserve the system's sophisticated character. Adopting a sophisticated database system that can support language and offer an effective interface ensures that the master station can properly handle huge data sets. Concurrently, the electrical automation system must accomplish what is expected of a secondary system in terms of security protection, which means it must adhere to regulations regarding partition security, inter area firewall configuration, private networks, etc., successfully ward off potential threats like virus attacks or man-made destruction, and reliably and securely store and process system data.

Electrical Automation Engineering Function Testing using AI

The primary goal of the test in electrical automation engineering is to determine whether the intelligent control system can operate properly, as well as the system's dependability and stability. One way to determine whether the design may pass muster is to see if it satisfies actual users' requirements. Control and real-time monitoring of power equipment states enable the automated protection device to function. In the real process, sensors or digital instruments may gather a variety of signals, which are then transformed into electrical analog values and sent to the electrical automation engineering test function module. The findings are then shown by the test software.

V. EXPERIMENTAL RESULTS

This section presents a functional test of electrical automation engineering that is based on artificial intelligence technology. Functional test data for electrical automation engineering are shown in Table 1.

Table1: Electromechanical engineering module functional test

Test module	Shortest stability time(h)	DNS time(s)	Server time(s)	Content transmission time(s)
Power-supply module	22	1	3	4
Monitoring module	46	1	2	3
Data acquisition module	42	2	1	4
Main station module of power grid	46	1	1	3
Wireless communication module	22	4	1	2

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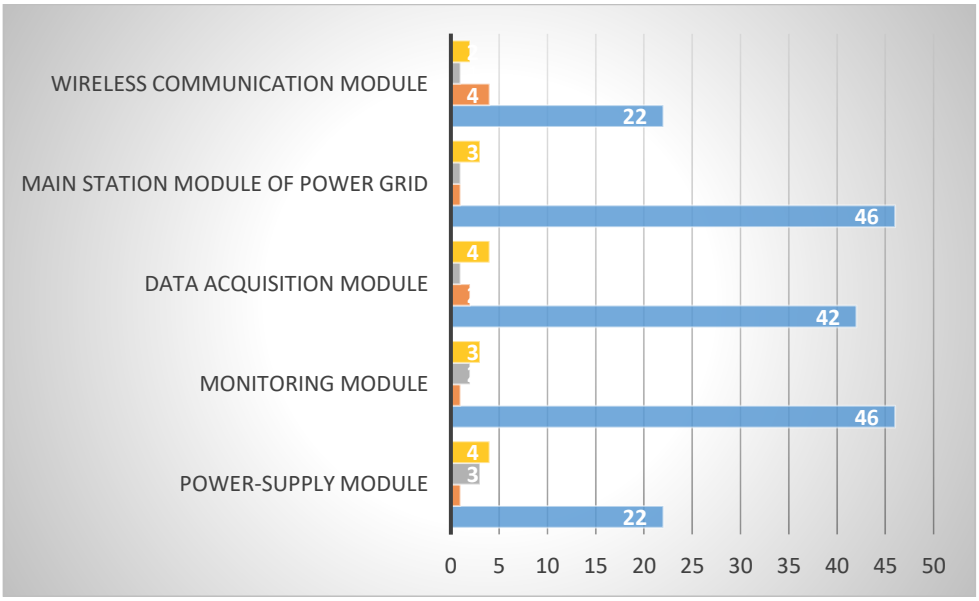

Figure 2: Electromechanical engineering module functional test

Electrical automation engineering's system function test primarily aims to evaluate each module, such as data collecting, parameter setting, and communication between the master and slave stations. During commissioning, issues are easily identifiable and resolved. Figure 2 shows that the system's stability is best guaranteed by allowing each module function to run for at least 24 hours, which is the shortest stability period. The time it takes to connect to the network is three seconds for a DNS query, two to three seconds for server processing, and four seconds for content data transfer. Evidently, the system is capable of running reliably.

VI.CONCLUSION

This research concludes that electrical automation engineering systems may greatly benefit from using artificial intelligence (AI) technology to boost industrial output. The suggested AI-driven framework greatly enhances the performance and dependability of automation systems by fixing the current shortcomings in quality control, process optimization, predictive maintenance, and overall system efficiency. Improved operational efficiency, less downtime, and improved product quality are the results of the system's modules undergoing rigorous testing, which proves the stability and efficacy of AI applications. This study highlights the significance of using cutting-edge AI technology in industrial settings to keep up with the ever-changing needs of contemporary production and manufacturing. Industry sectors will be better positioned to attain long-term sustainability and productivity gains if artificial intelligence (AI) is effectively applied to electrical automation, which not only addresses present problems but also paves the way for smart manufacturing breakthroughs.

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