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# Significance of AI in Electrical Control Systems and Automation

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**Abstract**: This article's primary purpose was to investigate the usage of artificial intelligence in electrical automation control systems (EACS). With the advancement of current science and technology, artificial intelligence technology has steadily impacted most elements of people's lives, notably in electrical and electronics automation control, with positive effects. Electronics and instrumentation tools and applications have much potential to perform better usingArtificial intelligence (AI) and its related applicability. AI advancements have transformed earlier modes of operation and infused new life into electrical automated control systems. The use of AI in electrical automation control signifies a paradigm shift from the traditional to the intelligent mode of operation, security, and innovation. Electrical automation control systems took many years to develop. Even if AI has a sophisticated technical framework, there is still much opportunity for improvement in these areas, which this article discusses in detail.

**Keywords:** Electrical automation control systems, AI, Technological adaptability, Automation, Fault detection, Cyberthreats

## I. INTRODUCTION

In this contemporary world, we can't imagine a day without electricity; thus, improved generation, operation, and security are required in this area.Regarding better-automated operation and security, we can't proceed without AI. AI is a new technological science that investigates and develops the theory, technology, and application systems for imitating and expanding human intellect, bringing together disciplines such as psychology, cognitive science, thinking science, information science, systems science, and bioscience. Artificial intelligence is the simulation of the data interaction process of human thinking, with the objective of discovering the nature of human intelligence and developing a clever computer that can respond and deal with problems in the same manneras people do [1]. Artificial intelligence has provided great potential and space for electrical engineering optimization, resulting in significant economic gains, safety, and real-time operational control.

The technology of electrical automation control has grown into a technological system, and artificial intelligence technology expands the field's potential. Artificial intelligence (AI) can increase control efficiency and broaden the system's range of applications when used in electrical automation. Integration of big data with cloud computing technology and electrical automation may optimize the economic potential of relevant data by allowing cloud computing technology to manage data information issues while also allowing accurate and objective data analysis [2].

## II. PROBLEM STATEMENT

The main focus of this paper will be the use of artificial intelligence in enhancing electrical automation control systems. As market competition heats up, businesses that wish to stay viable must continually increase their competitiveness. Artificial intelligence may improve a company's competitiveness by lowering operating expenses and increasing operational quality [4]. Intelligent assessment is often used in two ways: to provide early warning of a problem occurs and to provide a diagnosis once the issue has happened. Intelligent monitoring tools, real-time tracking of anomalous data, and identifying defective equipment or networks indicate all key indicators that an electrical engineering network, whether hardware or circuit design, has a problem [2,3].

The problem is that applying AI is more expensive and raises company losses once a fault has occurred. This research tackles how to effectively use AI in diagnosing problems and alerting issues using AI before they arise. To ensure the dependable and predictive operation and maintenance of electrical automation equipment, the predetermined intelligence level of the equipment must be consistently improved.

  

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## III. DIRECTION OF AI IN EACS RESEARCH

### A. Central Expert System

A central expert system (CES) is a software system in an electrical ecosystem that captures human expertise to aid decision-making: this is useful when dealing with problems that involve incomplete information or large amounts of complex knowledge [1]. Expert systems are beneficial for online operations in the control field because they incorporate symbolic and rule-based knowledge related to situations and actions. They can also justify and explain a line of thought. As shown in the figure below, the CES consists of a knowledge base, database, reasoning machine, interpretation mechanism, knowledge acquisition, and user interface (see Fig 1).

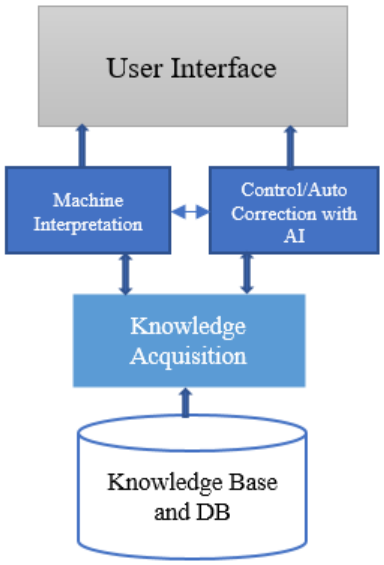


**Fig 1**. Electrical expert system with AI control measures

### B. Machine Learning

Machine Learning (ML), a subset of AI, investigates how a computer simulates human learning behavior, reorganizes existing knowledge structures with new knowledge and skills, and continuously improves its performance with reinforcement learning. Expert system implementation frequently uses machine learning techniques to address the knowledge acquisition (KA) bottleneck [2]. Because experts are better at collecting and archiving cases than explicitly expressing their experience and encounteringissues in production rules, the KA bottleneck occurs [3]. In this world of Bigdata, cloud, and streaming data, when machine intelligence techniques are used to address this bottleneck, knowledge is automatically extracted from data to study the system behavior patterns [4]. A piece of symbolic information can be incorporated into an artificial neural network learning algorithm, and the learning system can support knowledge model building and extraction.

### C. Pattern recognition and image processing

Pattern recognition is a very significant piece of innovation when it comes to heavy industries or electrical systems. Due to the assumed relationship between data patterns and fault classes, pattern recognition approaches are applicable to process monitoring while ignoring internal process states or structures [1, 5]; artificial neural networks are a widely used pattern recognition approach (ANN). Pattern recognition research is divided into two parts: the method of object perception, which belongs to the scientific understanding category, and pattern recognition with a computer under the condition that the task of the case is determined.

Image processing is a component of modern artificial intelligence that assists in identifying an object, image, or live animal. Image processing is manipulatingideasto extract relevant information or improve their quality. Image processing is beneficial, and its popularity is steadily increasing [6]. It is critical in physical systems to recognize an image or object based on logic to determine if it is a bottleneck in the end-to-end flow. It is essential for automation, resilience, and performance in central processing and complex systems.

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### D. Deep Learning

Deep Learning (DL), a machine learning discipline, is a solid and durable advanced computational subject that has seen great success in several study fields. Because its applications are always in demand, DL significantly influences people's lives and society. It propels advancements in daily technology like self-driving cars, picture and speech recognition, and natural language processing. For predictive modeling and complicated pattern recognition, deep learning algorithms rely heavily on artificial neural networks [7]. Deep Neural Networks (DNNs) have an input layer, hidden layers, and an output layer, similar to Artificial Neural Networks (ANNs).Some representations, such as neural coding, attempt to define a link between different stimuli and associated neuronal responses in the brain [1, 8]. The research aims to create efficient systems for learning these representations from large, unlabelled data sets.

Deep learning architectures such as deep neural networks, deep belief networks, and recurrent neural networks have been used in fields such as computer vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, and bioinformatics, yielding results comparable to, and in some cases superior to, human experts.

### E. Automation in Power Systems

The power system concept of the design is straightforward. The traditional classical controller is frequently required to design by the controlled object model. Still, the model construction will typically include many uncertain factors, such as changing parameters and numerical type, making the design more complex. Artificial intelligence control is simple, and the AI function approximator does not need to control the object's model; it contains the software brain of the system [9].

Improving performance is another field that demands automation and continuous monitoring. Performance can be quickly enhanced by properly adjusting related parameters. For example, the fuzzy logic controller responds faster than the optimal PID controller, and the overshoot is more minor[3, 10]. The artificial intelligence controller is more adaptable to new data or situations than the traditional controller.

## IV. APPLICATIONS OF AI IN ECS

There are many practical implementations of AI in the electrical and electronics field. In this industry, 4.0, from small devices to large, heavy equipment, all are equipped with AI and Internet of Things chips. Some of the applications are outlined below.

### A. AI in Electrical Equipment

The first appearance of artificial intelligence is in the electrical design for electrical automation control. As we all know, the structure of electrical equipment is complex. In the actual design process, it is necessary to understand not only electronics, circuits, electromagnetic fields, motors, automation, and other disciplines related to knowledge but also generators, sensors, and other components of the role and mechanism. It has high requirements for the designer's professional level and work experience, making electrical equipment design a complex project [10, 11]. The operation of the electrification system in electrical automation equipment is a highly complex problem because it involves many disciplines and fields. Its operation and control requirements necessitate a high level of knowledge reserves and expertise.

Artificial intelligence technology is an excellent way to ensure that electrical automation equipment usually operates. It is possible to realize the automatic operation of electrical equipment and replace human labor through computer programming and process, thereby significantly reducing labor costs. Simultaneously, using artificial intelligence technology improves the work's speed and precision.

### B. AI in Electrical Fault Diagnosis

Artificial intelligence in the logic of a fuzzy "neural network" expert system can be used to detect faults in a timely and accurate manner, to determine the cause of the failure, the type and location of the failure, and to control fault repair promptly, which is a perfect guarantee of electrical equipment for long-term operation. Artificial intelligence-based fault diagnosis techniques include rule-based reasoning (RBR), case-based reasoning (CBR), and fault-based tree fault diagnosis. The traditional expert system's composition and basic principle are used to build a mechanical fault diagnosis expert system based on RBR and CBR reasoning. The overall structure is depicted in Fig 2 [11].

  

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When an electrical equipment issue arises, it can be challenging to judge whether using an artificial intelligence system will be effective because the symptoms and problems real-world of relevance are so complex. Artificial intelligence technology is already being used by fuzzy logic, expert systems, and neural networks to evaluate fault systems. There has been much research on the transformer because it is widely used in power systems and is both popular and common. Gas decomposition in transformer oil is the primary method to diagnose transformer faults. Artificial intelligence-based generator fault diagnosis is a common practice in generators and motors.

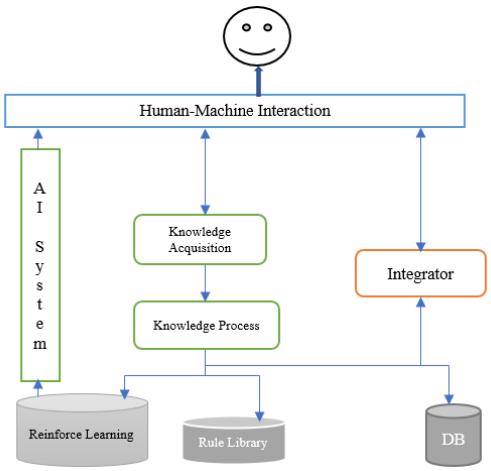


**Fig 2**. The overallarchitecture of an electrical fault system. Adopted from [2]

### C. Detection of Cybersecurity Threats in Power Systems

Electrical power system and their controlare crucial to the electrical industry; when it is successfully automated, production efficiency can be effectively increased, lowering production costs and human resource costs. But several times, these are easy targets by hackers to destroy them using cyber-attacks. This scenario is prevalent in developed countries for all innovative city projects [12, 13].

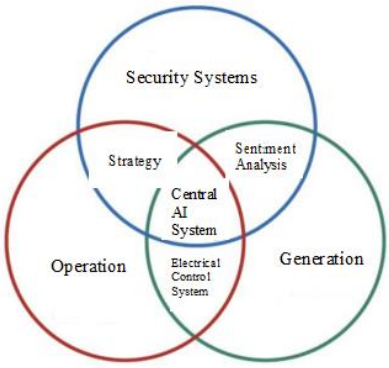


**Fig 3**. AI and a 360-degree view of Electrical-Automation (EA)

In the field of EACS, innovation requires the support of artificial intelligence, using artificial intelligence technology to enhance human consciousness of mechanical ability, detect cyber threats and strengthen automatic electrical control [13]. Artificial intelligence in the development of automation and cyber control can promote the overall progress in the field of the electrical industry and more to promote the development of automatic control of progress. In addition, the failure of the power system will be ruled out, promoting the development of artificial intelligence technology constantly forward, carving out a new direction in electrical automation control through the theory of all aspects of application of intelligent technology, making the people's living standards continue to improve[14, 15]. Fig 3 shows a 360-degree view of AI applicability on electrical power systems.

  

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## V. FUTURE RECOMMENDATION IN THIS FIELD

The following years are the era of electrical engineering with the innovation of cloud computing and Electrical Autonomous Vehicles (EAVs). Electrical automation system control is crucial to the electrical industry; when it is successfully automated, production efficiency can be effectively increased, lowering production costs and human resource costs. Fuzzy control, electrical expert systems, neural networks, and other techniques are used in electrical automation control as applications of artificial intelligence technology [16]. In the field of electrical automation control, innovation requires the support of artificial intelligence, using artificial intelligence technology to enhance human consciousness of mechanical ability and strengthening automatic electrical control. Artificial intelligence in the development of automation can promote the overall progress in electrical automation control and more to promote the development of automatic control of progress.

AI will assist energy suppliers in obtaining real-time consumer feedback for sentiment analysis using AI and Natural Language Processing (NLP), hence increasing service quality and operationality [17].The USA department of electrical engineering (DOE) forecasts that by 2030, 80% of the power generated will be used for transportation [18]. Transportation will be utilized by power electronics-based devices both domestically and internationally. This demands more control and automation in this niche for better power generation, management and security. There are some benefits to using power electronics more frequently on the grid. System inertia has traditionally been produced by rotating machinery. Power electronics can replace and even improve a lot of the system inertia. However, the growing reliance on power electronicshasseveral disadvantages [15, 18] to this electrification and distribution. Power electronics have exceptional stability and failure mechanisms that need to be assessed, looked into, and possibly reduced.To reduce prices, AI can balance power supply and demand in real-time, as well as optimize energy usage on demand and storage. AI technology will be required to govern decentralized networks as the globe transitions to renewable energy very fast.

## VI. CONCLUSION

This research paper discussed the use of artificial intelligence in the automation control of electrical and electronic systems. This research provides an overview of artificial intelligence and its applications to electrical equipment, electrical power, and problem diagnosis. Artificial intelligence applications are evolving with advances in science, technology, and the social economy. Businesses can gain advantages in operational efficiencies, dependability, and problem detection by incorporating artificial intelligence into their electrical automation system, which can help them save money and time. Artificial intelligence is now widely used in electrical automation control, raising the field's profile. The application process still has some issues, as the system is not mature enough. As a result, experts in the area should continue researching and developing new applications of artificial intelligence technology to accelerate further progress and advancement.

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