Journal of Artificial Intelligence Practice (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/jaip.2024.070219
ISSN 2371-8412 Vol. 7 Num. 2

Analysis of artificial intelligence technology in electrical automation control

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Keywords: Artificial intelligence technology; electrical automation control; application

Abstract: With the rapid development of artificial intelligence technology, innovative applications in the field of electrical automation control are constantly emerging, from intelligent recognition and decision to predictive maintenance, and then to voice and image recognition, these technologies have greatly expanded the possibility of electrical automation. The development of optimized energy management and adaptive control systems fully reflects the contribution of AI to the realization of efficient and energy-saving operations. It explores how machine learning, neural network and deep learning improve the precision of automation, and highlights how the combination of big data and Internet of Things technology can lead the future trend, this paper puts forward the cutting-edge research direction, focusing on the deep integration of technology and innovation breakthrough.

1. Introduction

In the past, the degree of automation of electrical appliances was limited by technical boundaries, and it was often difficult to strike a balance between efficiency and intelligence. And with the addition of artificial intelligence has brought a new vitality to the field. The learning ability of machines coupled with the connectivity of the network drives the transition from static rules to dynamic learning, providing deeper intelligence for automated devices. This change is moving beyond the traditional mechatronics, breaking the inherent shackles of thinking, towards a more complex but also more predictable control strategy. While unlocking the potential of electrical automation, it must also explore and solve new problems such as technology integration, data security and operational reliability.

2. Overview of artificial intelligence technology in electrical automation control

With the exponential growth of computing power and the breakthrough progress of machine learning algorithms, electrical automation equipment has acquired great data analysis and decision execution capabilities. After the high-speed analysis of large amounts of data, the artificial intelligence technology discovers the potential patterns in the operation process, and accordingly optimizes the performance of the equipment to achieve precise control. And these intelligent systems can also monitor and adjust the functional state in real time, constantly adapt to the changes

of the external environment, to ensure the optimal performance of the equipment operation.

The application of artificial intelligence technology in the segmentation field has brought a deeper understanding of the nature of equipment automation control. Taking neural networks as an example, their simulation and prediction of complex nonlinear relations provide an accurate real-time feedback mechanism for the running state of electrical appliances. In such feedback loops, the appliance automation control system becomes an entity that can be learned and adapted, rather than a pre-programmed fixed response set. At the same time, artificial intelligence technology is also constantly promoting the development of sensor technology, cloud computing infrastructure and data mining methods and other related fields. Therefore, artificial intelligence is not only an extension of functions, but also a comprehensive upgrade covering hardware and software, theory and methods. Such a deep and wide cross-border integration can promote the birth of personalized intelligent control system oriented by user needs, so as to improve energy utilization efficiency and equipment service life.

3. Application of artificial intelligence technology in electrical automation control

3.1 Intelligent identification and decision-making

In the current electrical automation control, the core of intelligent identification technology is through a variety of data collected by sensors, such as temperature, humidity, sound, etc., after the analysis and learning of deep learning model, fast and accurate or the working state of the environment itself, such as in intelligent air conditioning system, not only for indoor and outdoor temperature difference adjust cooling or heating mode, more through the activity of the user mode and historical data to predict the user's demand, take the initiative to adjust the ambient temperature to the most comfortable state. It can also combine facial recognition technology to enable intelligent recognition to identify the number of people in the room and optimize the energy consumption efficiency. Such a system can continuously learn and self-optimize through the feedback loop, showing the intelligent characteristics beyond the traditional automation products.

At the level of intelligent decision-making, it is mainly reflected in how to deal with abnormal conditions and risk management in the intelligent system. In some key electrical equipment, such as medical equipment or heavy industry machinery, intelligent decision-making technology can continuously monitor the running status of the equipment. Once the potential failure or efficiency decline is detected, the system can start the early warning program and send notification to the maintenance team, and provide possible troubleshooting guidance or automatic adjustment equipment setting to avoid faults[1]. This proactive and adaptive decision making greatly reduces the need for human intervention and improves the reliability and safety of the equipment. Intelligent decision-making also shows great potential in energy efficiency management. Through a real-time data-driven decision-making process, the system can optimize energy use and achieve the dual effect of saving energy and reducing operational costs.

3.2 Predictive maintenance

Predictive maintenance uses algorithms and machine learning models to deeply analyze the operating status of the equipment, allowing risks to be foreseen and arranging repair or replacement of parts before problems occur. In this application, sensors provide a massive input of raw data, which are deployed on key components to continuously monitor parameters such as temperature, vibration, noise level, current, and voltage. The core data analysis platform collects the information captured by the sensor and feeds it back into the advanced artificial intelligence models. These models combine the historical maintenance records, the specifications and performance indicators

of the equipment manufacturer, compare and analyze the real-time and historical operation data of the equipment, identify the small deviation from the normal operation mode, and effectively warn of the imminent failure. From robotic arms in industrial production lines to air purifiers in smart home systems, they can benefit from predictive maintenance.

At the same time, the learning capabilities of artificial intelligence, such as neural networks, decision trees, and other machine learning technologies, can iterate on themselves, learn from each maintenance activity, and continuously optimize the accuracy of the prediction model. When a mode is repeatedly confirmed as a fault precursor, the system will automatically adjust the threshold value, and even suggest the appropriate maintenance operation process and schedule. In this way, predictive maintenance will jump out of the limitations of human perspective and use the unremitting computing and logical reasoning ability of machines to promote the identification and response of potential problems in the automatic control of electrical appliances[2]. This is particularly evident in the management of complex systems such as power stations and substations, in which real-time monitoring and analysis of electrical status has gradually evolved into an important guarantee of the reliability of the power grid.

3.3 Speech and image recognition

In the field of electrical automation control, voice recognition technology allows the user through simple password or instructions, especially in the need for quick response or environment is not easy to manual operation, voice commands become a safe and efficient operation, such as security monitoring system, emergency only through the sound command immediately close or adjust the related equipment, this design significantly improve the speed and accuracy of emergency treatment. At the same time, with the maturity of deep learning technology, the accuracy of speech recognition has been greatly improved, and it can understand and execute more complex and changeable commands. This understanding ability covers a variety of languages and dialects, greatly promoting its global application prospects.

In terms of image recognition technology, through the real-time analysis of the camera to capture the image data, the system can identify the environment change or equipment abnormal state, so as to make corresponding adjustments, such as in the production line, image recognition can be used to detect the product quality, such as identifying product defects or defective products, in mass production this technology can ensure the unity of product quality and high standards[3]. Combined with machine vision, image recognition technology can enable robots to better navigate and operate in complex environments, such as accurately positioning and handling goods in automated warehouses, which not only improves the accuracy of operation, but also significantly optimizes resource allocation.

3.4 Improving energy management

The application of artificial intelligence technology in energy management is an in-depth understanding and prediction of the use of electrical appliances. For example, by analyzing historical data, the artificial intelligence system can predict the energy demand of various electrical appliances in a certain period of time, so as to make scheduling in advance and meet the operation needs of key equipment first. At the same time, using machine learning technology, the system can identify the non-efficiency mode in the operation of the equipment. If the high-power equipment is run during off-peak hours, the system will put forward adjustment suggestions or automatically convert to a more energy-saving operation mode. And with the help of big data analysis, the use habits of electrical appliances can be summarized, further refine the energy regulation strategy, to achieve the maximum reduction of energy consumption under the premise of ensuring the use of

demand.

With the electrical automation system of the development of sensors, artificial intelligence can according to the environmental changes, the user behavior factors dynamically adjust energy allocation, such as after detected the user home automatically reduce the energy supply of household appliances, or in the night trough automatically start energy-intensive operation[4]. Through such intelligent adjustment, it can not only improve the efficiency of energy use, but also promote the effective combination of renewable energy and traditional energy, and promote the optimization and upgrading of the energy consumption structure of the whole society.

3.5 The adaptive control system

In the field of electrical automation control, adaptive control is the result of self optimization in dynamic environment interaction, this strategy is essentially with the aid of advanced data analysis framework, real-time collection of operational data related to the control object, through the feedback mechanism to evaluate the effect of the current control model, and according to the real-time data continuously adjust the model parameters. The core algorithms of adaptive control systems often integrate fuzzy logic, genetic algorithms, neural network or enhanced learning technologies, which provide nonlinear mapping capabilities, giving the control system a high degree of adaptability and stability in the face of temperature fluctuations, load changes and other situations.

At the same time, the adaptive control system will adopt the most appropriate strategy after the iteration process, which can achieve the optimal energy efficiency ratio and the best performance index. In this process, the iteration of the algorithm not only simplifies the preset requirements of complex models, but more importantly, makes the system show unprecedented sensitivity to subtle changes in practice; and the self-learning characteristics of the algorithm reduce the burden of daily maintenance, and enables the system itself to respond to and handle prominent problems for the first time. For resource allocation and energy allocation, the system uses the optimization algorithm to effectively reduce waste and ensure the normal operation of key equipment[5]. In practice, the introduction of adaptive control system greatly improves the stability of the power system, which can ensure the continuity and security of key tasks, and presents a win-win situation of ensuring continuity and reducing cost for industrial and commercial users.

4. Frontier research and future trend of artificial intelligence technology to improve electrical automation control

4.1 Innovative application of machine learning in electrical automation control

In the field of electrical automation control, machine learning can not only achieve accurate prediction of electrical behavior, can also optimize the control strategy, such as in the case of automatic regulating air conditioning temperature, using machine learning algorithm analysis the user activity mode and indoor and outdoor temperature difference changes, can dynamically adjust equipment operation strength and mode, rather than simply depends on the predetermined temperature setting. This high personalization and scene adaptability can improve users' comfort and energy utilization efficiency, and then achieve the goal of energy conservation and emission reduction.

At the same time, the application of machine learning technology in electrical automation control is tending to deep, systematic development, the fusion based on time series prediction model, for example, the model through continuous collecting power consumption data, supplemented by environmental factors such as temperature, humidity, training that electrical use peak and trough

pattern. This forecast not only enables appliance manufacturers to develop more accurate production and supply chain plans based on the forecast data, but also provides energy supply companies with strategies to adjust the grid load. With the continuous progress of complexity and accuracy of machine learning methods, the real smart home ecosystem can be realized through more fine-grained consumer behavior analysis, as well as cross-device and cross-scene linkage optimization. This paradigm change also pushes the automation control of electrical appliances to a new stage of development, making the equipment not only a tool to execute commands, but also an intelligent partner to understand user needs and actively serve life.

4.2 Neural network and deep learning to promote automatic control accuracy

Neural networks, especially the deep learning networks with multiple hidden layers, independently capture the complex nonlinear relationship between input and output in a data-driven way, and the training results are abstracted layer by layer, finally forming effective feature representation and decision paths. In the field of electrical automation control, this means that small changes in environmental parameters such as temperature, humidity and pressure can be accurately perceived and used as the basis for automatic adjustment, so as to achieve the goals of power supply stability, energy efficiency optimization and even foresee faults.

Deep learning framework at the same time provides a more accurate and elastic decision structure, adaptability and autonomy, such as in load prediction, energy consumption management, etc., using convolutional neural network (CNN) analysis history and real-time data flow, electrical control system can predict the use of the future mode, for expected peak resources optimization configuration. In addition, with the help of the recurrent neural network (RNN) to consider the time series factors, the electrical control system can adjust the operation rhythm more finely, to avoid the excessive response or lag adjustment of the equipment under the dynamic load changes.

4.3 The integration trend of big data and the Internet of Things in electrical automation control

In the development process of electrical automation control, the Internet of Things technology makes more and more electrical equipment connected to the network to realize the real-time exchange and response of information, while the big data technology mines the value in the complex data flow to guide the equipment operation and management decisions. Therefore, with the application of Internet of Things technology, electrical equipment can be regarded as sensing nodes, and continuously collect multi-dimensional data such as use status, environmental influence factors and user interaction information. When these data gathered into huge amounts of data sets, big data analysis technology began to use advanced algorithm for deep learning and analysis of data, extract mode, predict the future trend and feedback to electrical control system, such as through the household electrical frequency, operation efficiency and energy consumption analysis, the system can according to the actual demand electrical working state, achieve energy conservation and emissions reduction goals at the same time, improve the user experience.

At the same time, the automatic control driven by big data and the Internet of Things endows the electrical system with great intelligent ability. This change is not limited to the electrical appliances of a single household, but also extends to the level of urban infrastructure, involving many fields such as energy management and traffic regulation. At the macro level, the government can monitor and allocate urban energy consumption based on this technology to promote the construction of smart city. At the micro level, home users can monitor and control various electrical appliances at home in real time through smart mobile devices to enjoy a convenient and efficient modern life. Future research may explore how to reduce the error response rate of the system, improve the

accuracy of prediction through the continuous iteration and optimization of the algorithm, and more likely to strengthen the collaborative ability of the work between devices, to achieve more refined management of electrical appliances. And security issues as the focus of the Internet of Things and big data fusion applications, how to ensure the privacy of data transmission and the anti-interference ability of the system, will have a direct impact on the popularization of electrical automation control and user trust.

5. Conclusion

To sum up, the application and development of artificial intelligence in the automatic control of electrical appliances not only meets the pursuit of efficiency, but also touches the boundary of innovation, which not only brings a far-reaching impact on the energy management and production efficiency of modern society, but also paves the way for the future intelligent manufacturing. In addition, artificial intelligence will continue to develop in the electrical industry and guide the progress of the industry. At the same time, in this process, it will continue to optimize and evolve, and move toward the ultimate automatic control.

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