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Recent Advances in Artificial Intelligence Theory and Technology and its Application Prospects in Power System Fault Diagnosis

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Abstract

In recent years, the development of artificial intelligence (AI) theory and technology has attracted wide attention. AI has become a new focal point in international scientific and technological competition and is considered by countries worldwide as a disruptive technology that will lead major transformations in future military science and technology. This paper first introduces the concept of AI, its development history, classification, and industrial chain structure. It then analyzes the current development and application status of AI in key fields, focusing on intelligent robotics, computer vision, natural language processing, and machine learning. Finally, it discusses the prospects of applying deep learning to enhance power system fault diagnosis.

Keywords

Artificial Intelligence; Industrial Chain; Deep Learning; Power System Fault Diagnosis.

1. Introduction

Artificial intelligence (AI) is an interdisciplinary technology that encompasses various fields such as philosophy, mathematics, economics, neuroscience, psychology, and computer engineering. Its goal is to study and develop technological systems that simulate and extend human intelligence [1-2]. Since the concept of artificial intelligence was born in 1956, it has undergone more than half a century of development, influenced by factors such as intelligent algorithms, computational power, and storage technology. The development of AI has shown a pattern of alternating peaks and troughs [3-4]. Its development can be broadly divided into three stages [5-6]:

①Initial Stage (1950s-1980s): This was the initial period of artificial intelligence, marked by the rise of symbolism that drove research based on abstract reasoning. However, due to the inability of models to address complex real-world tasks, AI development faced a bottleneck.

②Middle Stage (1980s-late 1990s): During this phase, expert systems became the focus of research, achieving significant progress in mathematical modeling. Nevertheless, the high development costs of expert systems and challenges in knowledge acquisition limited their application, leading to another downturn in development.

③Modern Stage (21st century-present): With the rapid advancement of big data, sophisticated algorithms, and computational capabilities, artificial intelligence has entered a golden period of rapid growth, achieving significant breakthroughs in multiple fields.

Currently, artificial intelligence has become a strategic priority for global technological and economic development, with countries recognizing it as a core driving force for the next round of industrial transformation [7-9]. This paper reviews the concept of artificial intelligence and its developmental stages, providing a detailed analysis of the current applications in key areas such as intelligent robotics,

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computer vision, natural language processing, and machine learning. Finally, it looks ahead to the broad application prospects of AI technology, particularly in fault diagnosis within power systems.

2. Levels of Artificial Intelligence

Artificial intelligence (AI) is a technology that completes specific tasks by mimicking the human knowledge processing process. Throughout its development, AI has been categorized into weak AI and strong AI based on its ability to reason, think, and solve problems [10-12].

①Weak AI: This is the form of AI that is currently widely used, excelling in executing tasks within specific domains but showing limited effectiveness when crossing domains. Weak AI relies on data-driven approaches, enabling computers to exhibit behavior that resembles "intelligence" in particular tasks. It has achieved significant success in applications such as speech recognition, image processing, object segmentation, and machine translation, sometimes even surpassing human performance. However, weak AI lacks reasoning abilities and cannot solve complex cross-domain problems.

②Strong AI: In contrast, strong AI possesses human-like cognitive abilities, allowing it to generalize across various fields and handle general tasks. However, research progress in strong AI has been slow due to humanity's limited understanding of the brain's intelligent mechanisms [13]. Achieving strong AI requires addressing the "zero to one" problem, and our current understanding of the mechanisms behind brain intelligence generation remains in its infancy. Traditional approaches, including symbolism, connectionism, behaviorism, and statistics, even when supported by stronger computational power and large-scale data, struggle to achieve this goal [14-16].

To tackle this challenge, simulationism proposes a new pathway. By developing advanced brain detection tools to analyze the neural network structure of the brain, engineers can simulate these structures and build brain-like devices. These devices can then achieve human-like intelligence through environmental stimulation and interactive training. This "structure first, function later" approach [14, 17] is considered more technically feasible than directly understanding the mechanisms of brain intelligence. Simulationism is closely related to traditional schools such as symbolism and offers new directions toward achieving strong AI. In the future, in-depth research on brain-like computing and brain science, along with a close integration with information technology, will become key forces driving the development of strong AI.

3. Structure of the AI Industry

The artificial intelligence (AI) industry chain can be divided into three main levels: the foundational layer, the technology layer, and the application layer [18-22]. Serving as the basis for the entire industry's development, the foundational layer primarily provides data and computing resources. This layer includes essential hardware facilities such as chips, development and compilation environments, as well as data resources, cloud computing, and big data platforms. These elements offer the necessary support for the development and operation of AI technologies, making them an indispensable cornerstone of the industry chain. Technology layer is the core part of the AI industry, focusing on the development of technologies that mimic human intelligence. The technology layer encompasses various algorithms and deep learning techniques, constructing a technological pathway from theory to application. Through deep learning frameworks and open platforms, this layer can encapsulate different algorithms and technologies, enabling rapid commercialization and promoting the swift advancement of AI. The application layer represents the practical implementation of AI technologies, integrating foundational technologies to develop software and hardware products or solutions tailored to specific application scenarios. The goal of the application layer is to meet the specific needs of industries or users, transforming technology into practical applications and driving widespread adoption and implementation across the industry. These three levels of the AI industry chain interact with one another, collectively driving the continuous development and commercialization of AI technologies.

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3.1 Foundational Layer

The foundational layer of artificial intelligence (AI) is the core of industrial development, primarily encompassing AI chips, data resources, and cloud computing platforms, which provide the data and computing power support for AI [23-24]. Chips, as the infrastructure for computing power, are crucial for driving industrial growth. However, they have a high technical barrier, and the ecosystem is largely established [24, 25]. Currently, international tech giants like Nvidia, Mobileye, and Intel dominate this field, while China's capabilities in the foundational layer are relatively weak [26-27].

With advancements in AI algorithms, there has been a surge in computing power demand in areas such as video image analysis and speech recognition. Traditional hardware architectures struggle to meet the intensive computing requirements of AI, and the lack of standardized hardware designs across different scenarios leads to low utilization and poor compatibility issues.

3.2 Technical Layer

The technology layer of artificial intelligence is the core of the industry, primarily simulating human intelligence features and relying on computing platforms and data resources to perform massive recognition training and machine learning modeling to solve specific problems [28-29]. Its applications encompass fields such as speech recognition, natural language processing, and computer vision [30]. Tech giants like Google, IBM, Amazon, Apple, Alibaba, and Baidu have made significant investments in this area. In recent years, China's technology layer has developed rapidly, focusing mainly on computer vision, speech recognition, and language processing, with innovative companies such as SenseTime, Megvii, and iFlytek emerging.

3.3 Application Layer

The application layer of artificial intelligence represents the extension of the industry, integrating foundational technologies to form software and hardware products and solutions tailored to specific scenario needs, such as in finance, security, transportation, and healthcare. Companies in this layer embed AI technologies into products and services to achieve industry intelligence. In the future, industries with complete data and clear feedback mechanisms are expected to realize large-scale commercialization ahead of others. Global tech giants like Facebook and Apple have made significant strides in areas such as speech recognition and image recognition. In China, the number of enterprises in the application layer is vast, making it the largest segment of the AI industry.

4. Key Areas of Artificial Intelligence Development and Current Applications

Driven by new theories and technologies such as mobile internet, big data, supercomputing, the Internet of Things, and brain science, artificial intelligence has made significant progress in areas such as reinforcement learning, deep learning, and machine learning, exhibiting a trend of diversified development. This encompasses multiple research fields, including intelligent robotics, computer vision, and natural language processing [31-33].

4.1 Intelligent Robots

Entering the 21st century, robotics technology has become one of the high-tech fields drawing global attention [34-35], playing an important role in the future industrial development. The European Union's Seventh Framework Programme, the U.S. National Robotics Initiative, Japan and South Korea's service robot research programs, and China’s 863 Program and National Natural Science Foundation have all placed significant emphasis on robotics technology [36-39]. The level of intelligent robotics technology and its industrialization is an important indicator of a country's technological innovation [40], promoting the transition of production and consumption towards intelligence, and being widely applied in industrial, educational, and service fields, profoundly impacting human life.

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4.1.1 Core Elements of Intelligent Robots

Intelligent robots possess three core elements: perception, movement, and decision-making. Perception is used to recognize the state of the environment; movement responds to external conditions; and decision-making determines the action path based on perceptual information [40-41]. These elements rely on the synergistic development of technologies such as automatic positioning and navigation, perception technology, bionic materials, modeling, and control technology [42-44]. For example, intelligent perceptual materials can enhance environmental awareness, providing more accurate information for control system decision-making, making the actions of intelligent robots more precise and efficient.

4.1.2 Domestic and International Fundamental Research and Cutting-Edge Technologies

International Technology Development: In the fields of new materials, structures, modeling, and control technology, the United States has made significant breakthroughs in bionic materials, applying them to artificial skin and artificial muscles [45-48]. Intelligent piezoelectric fiber composite materials and shape-memory alloys have also seen development [49-50]. Japan leads in smart materials such as piezoelectric and electrostrictive materials. Countries like the U.S., Japan, France, and Sweden have made rapid advancements in bionic structures and control, exemplified by multi-legged and humanoid robot models [51-52]. Germany has developed a 21-degree-of-freedom robot that closely mimics human hand movements [53].In the field of perception technology, the U.S. excels in ultrasonic sensors [54-55], radar [56-57], 3D laser scanning [58-59], and depth cameras [60-61], while also developing multi-sensor fusion technology that advances autonomous driving and environmental perception. Companies like Bosch in Europe and Germany also lead in accelerometer and MEMS technology. Japan has miniaturized and smartened perception technology, integrating it with nanotechnology and biochemical sensors.In cognitive technology, the U.S. is at the forefront in areas like fuzzy semantic recognition and machine vision in unstructured environments, while the UK's DeepMind has developed strong self-learning capabilities [61-63]. In human-robot collaboration, the U.S. has launched the first commercial collaborative robot, whereas European collaborative robots have been widely applied in industrial settings [64-66].

Domestic Technology Development: In recent years, China has made significant progress in the foundational and cutting-edge technologies of service robots, with some achievements reaching international advanced levels. China ranks third in the world for the number of patents in new materials, structures, modeling, and control technology. Shanghai Jiao Tong University has achieved results in shape-memory alloys, piezoelectric ceramics, and bio-inspired materials [67-71]; Tsinghua University has made breakthroughs in bionic hydrogels, bone composite materials, and nanomaterials [72-75]; Beihang University leads in soft structural materials and control technologies for robots; and Shandong University has established dynamic models for gait robots, achieving multi-legged robot locomotion [76-77].In the field of perception technology, the Shanghai Institute of Ceramics at the Chinese Academy of Sciences has broken foreign monopolies, and several domestic companies have made breakthroughs in laser sensing and 3D depth camera technology. Although the cognitive algorithm field has started later, it is developing rapidly, with domestic companies widely applying technologies in semantic and visual recognition.

4.1.3 Comparison of Domestic and International Technology Development

China overall lags behind foreign countries in new materials, structures, modeling, and control technology. Although it has reached international advanced levels in the application of structure and control, fundamental technologies still exhibit gaps. In perception technology, while applications are widespread, there is insufficient autonomy and controllability, with core technologies and equipment reliant on imports. The development of autonomous perception technology is crucial for enhancing the overall level of service robots. Although research in machine learning and intelligent cognition is on par with international developments, China remains at a disadvantage in core algorithm and platform development, and robotic collaboration technology lacks systematic research.

4.2 Computer Vision

Computer vision is a technology that integrates multiple disciplines, including computer science, neurophysiology, physics, and signal processing [78]. Its aim is to simulate human vision through computers to achieve understanding and recognition of the three-dimensional world [78-79]. This technology utilizes cameras and computers to replace human eyes, granting computers the abilities to segment, classify, recognize, and track objects. Leveraging high-performance computing and intelligent algorithms, computer vision can quickly process large volumes of data and has found widespread applications in areas such as facial recognition and autonomous driving, significantly enriching people's life experiences.

4.2.1 Components of Computer Vision Systems

Computer vision systems mainly consist of three parts: image acquisition, image processing and analysis, and output and display [80-81]. The core components include cameras, lenses, light sources, controllers, image acquisition cards, computers or embedded systems, image processing software, input-output controls, and execution mechanisms.

4.2.2 Development of Computer Vision Domestically and Internationally

Computer vision is characterized by diversity and imperfection. Although research in this field dates back to early times, it did not gain significant attention and development until the late 1970s, when computer performance began to improve. Currently, computer vision technology encompasses various aspects, including image enhancement and restoration, object detection and recognition, image segmentation, object tracking, image generation, pose estimation, 3D reconstruction, and stereo vision [82].

①Image Enhancement and Restoration

Image enhancement and restoration are classic research problems in image processing [83], primarily addressing quality degradation caused by external factors during imaging, transmission, and storage [84-85]. Image enhancement aims to improve visual effects and is often used as a preprocessing step for subsequent processing, while image restoration focuses on recovering the original appearance of images, considering degradation models. Common issues include denoising, deblurring, defogging, and super-resolution.Early methods often employed filtering techniques, such as median filtering and Wiener filtering, to process noise and content across different frequency spectrums. With the rise of sparse coding and regularization methods [86-90], these approaches have gradually become mainstream, as sparse coding-based regularization methods effectively characterize image priors and offer superior performance. In recent years, data-driven deep learning methods, especially the application of Generative Adversarial Networks (GANs), have transformed the image restoration problem into an image generation task, unifying the handling of various types of enhancement and restoration issues.The challenges in image enhancement and restoration lie in solving inverse problems and representing and learning image priors in high-dimensional spaces, driving research advancements in image coding and regularization learning. As effective means to improve visual quality, these technologies have been widely applied in areas such as text recognition, object tracking, and facial recognition.

②Object Detection and Recognition

Object detection and recognition are critical tasks in computer vision and pattern recognition, laying the groundwork for more complex tasks such as object segmentation and behavior analysis [91]. Object recognition predicts the category of objects in images or videos, while object detection identifies both the category and location of objects in the image. Traditional object recognition typically follows a two-stage process: first, local features are extracted and encoded [92], commonly using methods like SIFT, Gabor, and LBP, with representative encoding methods including Bag of Words (BOW) and sparse coding. Next, classifiers (e.g., SVM) or metric learning techniques are used for category prediction [93]. This approach operates feature extraction and classification independently, leading to lower efficiency.Since the rise of Convolutional Neural Networks (CNNs)

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in 2012, deep learning models (e.g., AlexNet, VGGNet, ResNet) have achieved end-to-end feature learning and classification, significantly enhancing object recognition performance, even surpassing human capabilities [94]. Modern object recognition methods increasingly focus on lightweight models [95-97], such as MobileNet and ShuffleNet.Early object detection methods, like Adaboost [98], were mainly used for face or pedestrian detection and employed a sliding window strategy, which was inefficient. With the introduction of R-CNN in 2014, the field of object detection entered the deep learning era. Two-stage algorithms based on object proposal boxes (e.g., Fast R-CNN, Mask R-CNN) offer high accuracy but are slow [99-100], whereas single-stage algorithms (e.g., YOLO, SSD) are faster but slightly less accurate [101-103]. In recent years, research combining these two categories of algorithms has been widely applied in fields such as biomedical image analysis and traffic safety.

③Image Segmentation

Image segmentation is a more challenging and rapidly developing task in the field of computer vision compared to object detection and recognition. Its goal is to segment different regions in images or videos to extract the target of interest and delineate its contours. Image segmentation can be viewed as an extension of object detection, requiring higher accuracy and refinement in segmentation. Current image segmentation tasks mainly include the following four types [104-105]:

Ordinary Segmentation: Separates different target areas in the image without classifying categories, such as segmenting dogs from grass.

Semantic Segmentation: Builds on ordinary segmentation to identify the category of each region, including countable "things" (e.g., cars) and uncountable "stuff" (e.g., grass).

Instance Segmentation: Further distinguishes different instances of the same category, such as labeling different cars.

Panoptic Segmentation: Combines semantic and instance segmentation, segmenting both uncountable stuff and countable things while numbering them.

Traditional segmentation methods primarily rely on pixel values, colors, textures, and other features, including thresholding, region growing, watershed algorithms, Normalized Cut, and active contour models [106]. However, these methods tend to produce incomplete segmentations and missed segments when dealing with complex visual content [107]. To address these issues, active contour models (e.g., Snake and Level Set) and segmentation methods based on probabilistic graphical models (e.g., MRF, CRF) were widely used before the deep learning era [108].

Since the emergence of deep learning in 2012, CNN-based models have begun to be applied in image segmentation, with fully convolutional networks (FCN) being a landmark model. This model replaces fully connected operations with convolutions, enabling efficient per-pixel category prediction [109]. To balance accuracy and resolution, subsequent models like U-Net, SegNet, and DeepLab have gradually improved segmentation results. To enhance segmentation efficiency, models like ICNet and BiSeNet employ multi-branch structures to improve inference speed.

The key model for instance segmentation is Mask R-CNN, which adds a segmentation branch based on Faster R-CNN but still faces challenges related to the precision of ROI operations. To overcome this, methods such as FOCS and SOLO eliminate the ROI framework, directly outputting more precise segmentation results. Panoptic segmentation combines semantic and instance segmentation, with models like Panoptic FPN and UPSNet being applied to this task.

Despite the ongoing research in image segmentation technology, its applications have expanded to areas like pedestrian segmentation and lesion segmentation. As a preprocessing step for complex visual tasks like gait recognition and person re-identification, it holds significant application value. Improving segmentation robustness in complex backgrounds and occlusion conditions remains a pressing issue..

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4.3 Natural Language Processing (NLP)

Natural Language Processing (NLP) is an important research direction in the fields of computer science and artificial intelligence, aimed at achieving effective communication between humans and computers through natural language [110-111]. The core tasks of NLP include natural language understanding and generation: the former enables computers to comprehend the meanings of natural language texts, while the latter allows computers to express specific intentions and ideas using natural language.

4.3.1 Development Stages of Natural Language Processing

The development of Natural Language Processing (NLP) has gone through three major stages [112]:

①Early Stage (1960s–1980s): Rule-based methods were employed to construct systems for lexical, syntactic, and semantic analysis, as well as question-answering, chatting, and machine translation. Although these approaches quickly leveraged human knowledge, their coverage was limited, and rule management and scalability were major bottlenecks.

② Statistical Stage (1990s Onwards): The rise of statistical machine learning began, utilizing annotated data and human-defined features to build systems. This approach was successfully applied in areas like machine translation and search engines [113].

③Neural Network Stage (Post-2008): The application of deep learning in NLP emerged, initially for feature computation and later evolving into end-to-end models. This shift propelled advancements in tasks such as machine translation, question-answering, and reading comprehension, leading to a surge in deep learning applications [113].

4.3.2 Current State of Natural Language Processing

In recent years, advancements in Natural Language Processing (NLP) technology have led to the emergence of several application systems, such as IBM's Watson, which defeated human champions in television quiz shows, and smart assistants like Apple’s Siri, as well as those from Google, Microsoft, and Baidu. NLP covers a wide range of fields, primarily including machine translation, semantic understanding, and dialogue systems. However, it faces four major challenges [114-115]:

①Uncertainty at Lexical, Syntactic, and Semantic Levels: There is inherent uncertainty in these layers of language.

②Unpredictability from New Vocabulary, Terminology, and Grammar: The introduction of new language elements can be challenging to handle.

③Limited Data Resources: There is a scarcity of data to tackle complex linguistic phenomena.

④Semantic Ambiguity and Complex Associations: These are difficult to describe using simple models.

In dialogue systems, deep learning has become a core technology, with end-to-end frameworks gradually gaining popularity in task-oriented and conversational systems, though many imperfections remain. Additionally, semantic recognition requires precise syntactic analysis, which plays a crucial role in dialogue systems and information extraction. The main existing issues include [116]:

①Syntactic Analysis is Often Limited to Isolated Sentences: There is a lack of systematic research into context.

②Computers Struggle to Store and Utilize Large Background Knowledge: This limitation restricts the scope of understanding.

Despite these challenges, NLP is in a phase of rapid development. An abundance of lexicons, corpus resources, and advancements in part-of-speech tagging and syntactic analysis technologies have fueled the prosperity of NLP. The widespread use of the Internet and globalization have created an urgent demand for NLP, driving its market applications. Furthermore, NLP research not only promotes the development of emerging disciplines such as bioinformatics but also gradually

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influences the evolution of computer architecture. Enhancing natural language processing capabilities will become a core objective for the next generation of computers.

4.4 Machine Learning

Machine Learning, proposed by Arthur Samuel in 1959 [117], is a scientific discipline that integrates various fields such as probability theory, statistics, and algorithm complexity. Its core principle is to simulate or implement human learning behavior by using algorithms to analyze data, learn from it, and make predictions and decisions about events in the real world. Machine learning algorithms are mainly classified into three categories: supervised learning, unsupervised learning, and semi-supervised learning [118].Supervised learning involves training a model using known input and output data.Unsupervised learning relies solely on input data, allowing the model to categorize the data independently.Semi-supervised learning combines both known and unknown sample data for training to enhance generalization capabilities and avoid overfitting.

Machine learning is a core technology for the development of artificial intelligence and is widely applied in various fields, including DNA sequence sequencing, securities market analysis, and data mining..

4.4.1 Model Structure and Network Design

Liu et al. [119] proposed a semi-supervised identifiable deep belief network algorithm (ccbRD) for image classification.Luo et al. [120] introduced the Sparse Group Restricted Boltzmann Machine (SGRBM), which improved local feature extraction and recognition rates.Yu et al. [121] developed a Deep Convex Network (DCN) for speech classification.Huang et al. [122] applied local convolutional deep belief networks to learn the global structural features of facial images.Zhou et al. [123] proposed a Semi-Supervised Convolutional Deep Network (CDN) that was successfully applied in image classification.Mrazova et al. [124] developed a growing CNN, which can automatically adjust the network structure to handle high-dimensional data.

4.4.2 Advances in Learning Algorithms

Wong et al. [125] proposed a regularized deep learning algorithm based on the Fisher criterion (RD-FM), demonstrating stronger feature recognition capabilities compared to kernel methods.Collobert et al. [126] introduced a fast natural language parsing algorithm based on a deep convolutional recursive graph transformation network (GTN), improving efficiency.Hinton et al. [127] enhanced neural network performance by constraining the weight interactions of feature detectors.Duchi et al. [128] developed an adaptive subgradient method for online learning and stochastic optimization.Sun Zhijun et al. [129] proposed a deep learning feature extraction algorithm based on the marginal Fisher criterion.Zhou et al. [130] proposed a semi-supervised active deep network (ADN) algorithm to address the issue of insufficient labeled data in sentiment classification.TOM et al. [131] introduced an advanced deep learning algorithm for sentence sentiment classification.Schaul et al. [132] developed an adaptive learning rate method.

4.4.3 Challenges

While deep learning, as a frontier technology in machine learning, has made significant progress and driven advances in artificial intelligence, it still faces many challenges. Many conclusions in the field are still based on experiments and empirical evidence, lacking a solid theoretical foundation.

Yann LeCun, one of the pioneers of CNNs and a professor at New York University, pointed out in the 2015 IEEE Conference on Computer Vision and Pattern Recognition that the key limitations of deep learning include: lack of a solid theoretical basis and reasoning mechanism, lack of short-term memory capabilities, and inability to perform unsupervised learning [133].

Moreover, although deep learning is inspired by the layered workings of the human cortex, current deep networks still differ significantly from the human brain in terms of structure, function, and mechanisms. The human brain consists of over 10 billion neurons, and accurately simulating this complex neural system remains a distant goal. Thus, research in computational neuroscience still has a long way to go. Finally, the increasing complexity of deep learning models and algorithms requires

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vast amounts of data and computational resources to train precise models, which raises the bar for deployment and application.

5. Application Prospects of AI Theory and Technology in Power System Fault Diagnosis

The application prospects of artificial intelligence (AI) theory and technology in power system fault diagnosis are broad and significant. As the complexity of power systems increases, traditional fault diagnosis methods are gradually struggling to cope with modern challenges such as large-scale distributed energy, complex grid structures, and the growing volume of sensor data [134-140]. AI, particularly machine learning and deep learning technologies, can effectively enhance the ability of power systems to detect, predict, and repair faults. The following are the key applications of AI in power system fault diagnosis:

①Intelligent Fault Detection and Diagnosis: AI can rapidly identify and diagnose fault types through real-time sensor data and historical data, reducing the need for human intervention. For instance, deep learning and neural networks can accurately detect equipment faults, automating the diagnosis of fault locations and types.

②Fault Prediction and Early Warning: AI, combined with machine learning techniques, can predict potential faults and issue early warnings. By analyzing equipment operating data, AI can detect fault precursors, thereby reducing the risk of power outages and enabling preemptive countermeasures.

③Self-Healing Grids and Smart Dispatching: AI facilitates grid self-healing, allowing for automatic isolation of faulted areas and the restoration of power supply. At the same time, AI can optimize power resource dispatching, preventing grid overload or secondary faults, ensuring a stable power supply.

④Big Data and Deep Learning Applications: Through big data and deep learning, AI can process complex power system data, monitor equipment status in real time, and identify potential fault patterns, improving the accuracy of fault diagnosis.

⑤Equipment Health Management and Lifetime Prediction: AI helps assess equipment health, predict remaining service life, and schedule maintenance in advance, reducing equipment failures and enhancing the reliability of power systems.

⑥Intelligent Maintenance and Operational Optimization: AI enables predictive maintenance and optimizes the operation of power systems, minimizing equipment downtime and improving system efficiency and stability.

The application of AI technologies in power system fault diagnosis shows great potential and prospects. From intelligent fault detection and fault prediction to grid self-healing and smart dispatching, AI enhances the intelligence, automation, and reliability of power systems. As AI continues to evolve, fault diagnosis and maintenance in power systems will become more precise and efficient. AI will play an increasingly critical role in future power systems, driving the industry towards greater intelligence and automation.

6. Conclusion

Artificial intelligence has deeply integrated into daily life and will trigger significant changes in social structures. The academic community generally agrees on three major development directions for AI: first, algorithmic breakthroughs, with ongoing advancements in foundational theories for small-sample, unsupervised learning, and personalized problems; second, the integration of brain intelligence and AI, merging mathematical statistical modeling with brain science; and third, human-machine coupling, exploring ways for AI systems to collaborate with human behavior.

In the future, driven by societal needs and market forces, AI will continue to evolve to better serve human development and will exhibit the following trends:

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①AI's understanding capabilities will continuously improve, and with enhanced computing power and algorithm optimization, technologies such as computer vision and natural language processing will advance further.

②The advancement of the Internet of Things (IoT) will drive demand for AI technologies and products across various sectors, such as manufacturing, home automation, finance, education, transportation, security, healthcare, and logistics. Intelligent products will gradually develop towards personalization, encompassing smart clothing, home appliances, and automobiles.

③Various industries have accumulated vast amounts of sector-specific data, laying the foundation for the integration of AI technology with business applications. For example, public information resources and dynamic data on human behavior from the security sector can further promote AI applications in related fields, driving the continued development of these industries.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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