The application of artificial intelligence in electrical automation control

Han FENG
School of Automation, Chongqing University of Posts and Telecommunications, Chongqing, Chongqing 400065, China
18883994714@163.com

Abstract. With the development of science and technology, artificial intelligence and electrical automation control technology is innovating and developing. The application of artificial intelligence technology in the electrical automation control is more and more extensive, which provides the development of automation control technology a solid foundation and strong support. In this paper, artificial intelligence is introduced with their research directions, including expert system, machine learning, pattern recognition, artificial neural network and deep learning etc. At last, the applications of artificial intelligence are analyzed from several perspectives. Hopefully, this paper can provide some instruction to AI researchers.

1. Introduction
Artificial intelligence is an emerging technology science that studies and develops the theory, technology and application systems for simulating and extending human intelligence, involving disciplines such as psychology, cognitive science, thinking science, information science, systems science and bioscience. The Artificial intelligence is in fact the simulation of the process of data interaction of human thinking, hoping to understand the essence of human intelligence and then produce a smart machine, this intelligent machine can be the same as human thinking to respond and deal with the problem.

Artificial intelligence has provided great potential and space for the optimization of electrical engineering, and it will bring about great improvement not only in economic aspect, but also in safety and actual operation control.

Since the advent of artificial intelligence, it has been widely applied in all fields of life, and achieved notable application effect, its emergence has even pointed out the direction for the development of many fields, the field of electrical automation control is no exception. In reality, the application of artificial intelligence technology has greatly promoted the progress of the concrete practice of electrical automation, and should be paid full attention to by related enterprises and staff. This paper aims to summarize the emergence and development of artificial intelligence and its components, and finally summarize the advantages and functions of artificial intelligence in electrical automation control.

2. The Research Direction of Artificial Intelligence

2.1. Expert System
An expert system (ES) is a software system that captures human expertise for supporting decision-making; this is useful for dealing with problems involving incomplete information or large
amounts of complex knowledge [1]. Expert systems are particularly useful for on-line operations in the control field because they incorporate symbolic and rule-based knowledge that relate situation and actions, and they also have the ability to explain and justify a line of reasoning. The ES basically consists of knowledge base, database, reasoning machine, interpretation mechanism, knowledge acquisition and user interface, which is shown in Figure 1.

2.2. Machine Learning
Machine Learning (ML), which mainly focuses on how the computer simulates human learning behavior, reorganizes the existing knowledge structure with the knowledge and skills learned, and continuously improves its performance. Machine learning techniques are often adopted for addressing the knowledge acquisition (KA) bottleneck in implementing expert systems [2]. The KA bottleneck arises due to the fact that experts are better at collecting and archiving cases than in expressing their experience and encountered cases explicitly into production rules [3]. In using machine intelligence techniques to tackle this bottleneck, knowledge is automatically extracted from data [4]. Symbolic information can be integrated into an artificial neural network learning algorithm, and the learning system supports knowledge modeling and extraction.

2.3. Pattern Recognition
Pattern recognition approaches are applicable to process monitoring because of the assumed relationship between the data patterns and fault classes while ignoring the internal process states or structures [1]; a widely adopted pattern recognition approach is that of the artificial neural networks (ANN). Pattern recognition research mainly includes two aspects: one is the method of perception of the object, which belongs to the understanding of scientific category; the other one is to achieve pattern recognition with the computer under the condition of the task of the case is determined.

2.4. Neural Network
The artificial neural networks (ANN) approach involves a nonlinear mapping between input and outputs, which consist of interconnected neurons arranged in layers. The layers are connected so that the signals at the input layers of the neural network are propagated throughout the network. The overall nonlinear behavior of the neural network is determined by the choice of network topology and the weight of connections between neurons [5]. In the process industries, ANNs have been applied for fault detection and diagnosis. For example, Cubillos and Lima [6] described an adaptive hybrid system built upon prior knowledge and neural networks to model process control strategies and uncertain parameters in a highly non-linear CSTR and a four-stage floatation unit. Tsai et al. [7] developed a
robust model predictive control architecture using artificial neural networks. The regional knowledge
analysis method was proposed and incorporated in the analysis of dynamic artificial neural network
models in process control. The resulting analysis method and the modified model predictive
architecture have been applied to a neutralization process. Power and Bahri [8] described a two-step
supervisory fault diagnosis framework using neural networks. Based on this framework, a fault
detection system was implemented to identify the exact location of faults and diagnose them in a pilot
plant case study. [1]

2.5. Deep Learning
Deep learning (also known as deep structured learning or hierarchical learning) is the application of
artificial neural networks (ANNs) to learning tasks that contain more than one hidden layer. Deep
learning is part of a broader family of machine learning methods based on learning data
representations, as opposed to task-specific algorithms. Learning can be supervised, partially
supervised or unsupervised. The concept of deep learning comes from artificial neural network
research, belonging to a new field of machine learning [9].

Some representations are loosely based on interpretation of information processing and
communication patterns in a biological nervous system, such as neural coding that attempts to define a
relationship between various stimuli and associated neuronal responses in the brain [1]. Research
attempts to create efficient systems to learn these representations from large-scale, unlabeled data sets.

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

3. Advantages of Artificial Intelligence in Electrical Automation Control

(1) The design idea is simple. The traditional classical controller often needs to design according to
the controlled object model, but the model construction will usually have many uncertain factors, such
as changing of parameters and the numerical type, so that to make the design more difficult. Artificial
intelligence control is not difficult, and the AI function approximator does not need to control the
model of the object

(2) Performance enhancement. By properly adjusting related parameters, performance can be
improved quickly. For example, the fuzzy logic controller reacts faster than the optimal PID controller,
and the overshoot is smaller

(3) More convenient to use. The artificial intelligence controller is easier to adjust than the
classical controller, and is more adaptable to new data or new information.

(4) Good consistency. The traditional control algorithm is designed according to the specific
object, so the control effect is very good only for the specific object, but the effect of other control
objects will not be consistent. The artificial intelligence control algorithm, whether for the specified or
unknown input data, can get good consistency estimation.

4. Application of Artificial Intelligence in Electrical Automation Control

4.1. Application of Artificial Intelligence in Electrical Equipment
Artificial intelligence is first reflected in the electrical design for electrical automation control. As we
all know, the electrical equipment structure is complex. In the actual design process, it not only needs
to use the electronics, circuits, electromagnetic fields, motors, automation and other disciplines related
knowledge, but also needs to understand the generators, sensors and other components of the role and
mechanism, and it has high requirements for the designer's professional level and work experience,
and thus electrical equipment design is a complex project [10]. In the operation of electrical
automation equipment, the operation of the electrification system is a very complicated problem, for it
involves a lot of disciplines and fields. Its operation and control requirements requires a high degree of knowledge reserves and higher quality.

In order to realize the normal operation of electrical automation equipment, artificial intelligence technology is a good way for it. Through programming and operation by the computer technology, it can realize the automatic operation of electrical equipment and to replace human labor as to greatly reduce the labor cost. At the same time, by using the artificial intelligence technology, it greatly improves the speed and precision of the work.

4.2. Application of Artificial Intelligence in Electrical Control

Electrical automation control plays a very important role in the electrical field, if the automation of electrical control is achieved, production efficiency can effectively be improved, reducing production costs and human resources costs. The application of artificial intelligence technology in electrical automation control is focused on fuzzy control, expert system, neural network and so on.

Artificial intelligence in the development of the automation not only can promote the overall progress in the field of electrical automation control, more to promote the development of automatic control of progress, so in the field of electrical automation control, innovation needs the support of artificial intelligence, using artificial intelligence technology to improve human consciousness of mechanical ability, strengthen the electrical automatic control. In addition, the failure of the power system of will be ruled out, promoting the development of the artificial intelligence technology in constant 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. [11]

4.3. Application of Artificial Intelligence in Fault Diagnosis

Artificial intelligence can be used in the logic of fuzzy "neural network" expert system timely and accurately detect the faults, it is used to determine the cause of the failure, type and location of the failure, and timely control of fault repair, which is very good guarantee of electrical equipment for sustainable operation.

In general, artificial intelligence-based fault diagnosis techniques include rule-based reasoning (RBR), case-based reasoning (CBR), and fault-based tree fault diagnosis. Based on the basic composition and basic principle of the traditional expert system, a mechanical fault diagnosis expert system based on RBR and CBR reasoning is constructed. The overall structure is shown in Figure 2. [12-14]

![Figure 2 The overall structure of the system](image-url)
Electrical equipment once appear problem, its symptom and the practical problems of its relevance is very complex, it is difficult to judge and determine, if the use of artificial intelligence system is solved this difficult problem. Already using artificial intelligence technology to judge fault system are: fuzzy logic, expert system and neural network. In power system, the transformer is very common and popular, also has a lot of research about it. At present mainly through decomposition of gas in the transformer oil for transformer fault diagnosis, determining the extent of the fault. In the generator and the motor, generator fault diagnosis using artificial intelligence technology is also very common.

5. Conclusion
With the development of economy, electrical automation is also facing new challenges. The traditional manual control has been difficult to adapt to the current social environment. The introduction of artificial intelligence technology has promoted the innovation of electrical automation control, which is of great significance to the development of electrical automation. This paper summarizes the components and the applications of artificial intelligence including its application in electrical equipment, electrical control and fault diagnosis. At present, artificial intelligence technology has been widely used in the field of electrical automation control, which has promoted the level of this subject. However, in the specific application process, there are still some problems. Therefore, relevant technical personnel should continue to study and innovate, as to promote the level of application of artificial intelligence technology to achieve innovation and improvement

Reference
[1] V Uraikul, CW Chan, P Tontiwachwuthikul. Artificial intelligence for monitoring and supervisory control of process systems [J]. Engineering Applications of Artificial Intelligence, 2007, 20(2): 115-131.
[2] DE Goldberg, JH Holland. Genetic algorithms and machine learning [J]. Machine Learning, 1988, 3 (2): 95-99.
[3] AKC Wong, Y Wang. Pattern discovery: a data driven approach to decision support [J]. IEEE Press, 2003, 33 (1): 114-124.
[4] BR Bakshi, G Stephanopoulos. Representation of process trends-III. Multiscale extraction of trends from process data [J]. Computers & Chemical Engineering, 1994, 18 (4): 267-302.
[5] MH Hassoun. Fundamentals of artificial neural networks [J]. Proceedings of the IEEE, 1996, 84 (6): 906.
[6] FA Cubillos, EL Lima. Adaptive hybrid neural models for process control [J]. Computers & Chemical Engineering, 1998, 22 (12): S989-S992.
[7] PF Tsai, JZ Chu, SS Jang, SS Shih. Developing a robust model predictive control architecture through regional knowledge analysis of artificial neural networks [J]. Journal of Process Control, 2003, 13 (5): 423-435.
[8] Y Power, PA Bahri. Integration techniques in intelligent operational management: a review [J]. Knowledge-Based Systems, 2005, 18 (2): 89-97.
[9] Y Lecun, Y Bengio, G Hinton. Deep learning [J]. Nature, 2015, 521 (7553): 436-444.
[10] WG Ji. Application of artificial intelligence technology in the analysis of electrical automatic control [J]. Electronic Test, 2014 (3): 137-138.
[11] SQ Xiao, JC Peng. The application of artificial intelligence technology in electrical automation control [J]. Automation & Instrumentation, 2013, 530:1049-1052.
[12] H Yang, J Mathew, L Ma. Intelligent diagnosis of rotating machinery faults-A review [M]. Pattern Recognition & Data Mining, 2002.
[13] LB Jack, AK Nandi. Fault detection using support vector machines and artificial neural networks, augmented by genetic algorithms [J]. Mechanical Systems & Signal Processing, 2002, 16 (2-3): 373-390.
[14] A Siddique, GS Yadava, B Singh. Applications of artificial intelligence techniques for induction
machine stator fault diagnostics: review [J]. IEEE International Symposium on Diagnostics for Electric Machines, 2003, 49 (3): 29-34.