Applications of Intelligent Artificial and Communication Technologies in Intelligent Buildings

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Abstract. With the development of society and the progress of science and technology, more and more technologies are being applied to the intelligent building system. The study summarizes and analyzes the development status of intelligent buildings, then analyzes and generalizes the advantages, disadvantages, and applications of several artificial intelligence and communication technologies in the intelligent building system. Results show that this paper introduces the three applications of artificial intelligence systems in intelligent buildings, including expert control systems, artificial neural systems, and intelligent decision systems, as well as the application of communication technology in intelligent buildings, including virtual LAN technology, communication network technology and broadband network technology. Artificial intelligence technology can reflect the current situation of buildings to people in real-time, judge emergencies instead of experts, and make the best choice to prolong the service life and stability of buildings. Communication technology can help users realize remote offices and home offices. The application of these technologies in intelligent buildings may not be mature at this stage, but the development and application potential are still very considerable.

Keywords: Intelligent buildings, Artificial intelligence, Communication technology.

1. Introduction

1.1 Intelligent buildings summary

Intelligent building refers to the optimal combination of building structure, system, service, and management according to the needs of users, so as to provide users with an efficient, comfortable and convenient humanized building environment [1]. It is the product of modern science and technology. The rise and development of intelligent building originate from the needs of social informatization and the global economy. The technical basis of the intelligent building is mainly composed of modern building technology, modern computer technology, modern communication technology, and modern control technology, which makes the building always follow the people-centered service concept, promotes the development of intelligent building towards high automation, high controllability and high integration, and promotes the service level of building management.

1.2 Intelligent buildings developing

Since the first intelligent building in Hartford was built in 1984, intelligent buildings have blossomed all over the world in the past 30 years. By 1995, tens of thousands of intelligent buildings had been built in the United States, and the proportion of intelligent buildings in American buildings was increasing day by day; Japan has also built thousands of intelligent buildings of all kinds. Before 2000, the proportion of intelligent buildings in Japan will reach more than 65%. The United States founded the American Architecture Association Aibi as early as the beginning of 1985 and put forward the concept "intelligent building refers to the four basic elements of building structure, system, service and management, and combine an optimal solution through the internal relationship between them, so as to provide a building with matching investment, high efficiency, comfort, safety and convenient environment, and provide a production place for human production activities."[2]. Closely following the United States, Japan established the "national intelligent building professional committee of the Ministry of construction" at the end of 1985 to give policy support to intelligent

buildings; The "Japan Intelligent Building Research Association" was also established. In 1886, China's State Planning Commission and the State Science and Technology Commission jointly approved the "Seventh Five Year Plan" national key scientific and technological research project: "feasibility study of intelligent office building". The official project approval of the Chinese government also shows that China's research and development in the field of intelligent building have officially entered the track. Today, there are hundreds of intelligent buildings in the Pudong District of Shanghai alone.

Whether in Europe, Russia, or Asia such as Japan and China, governments all attach great importance to the development of the intelligent building industry and actively formulate policies and standards on the application of intelligent building technology. All kinds of signs show that intelligent building technology is one of the leading development directions of the construction industry in the 21st century and a hot technology that countries all over the world are competing to catch up with. It has broad development prospects [3].

Deep learning intelligent decision-making systems, expert systems, smart homes, and communication network technology all reflect the great scientific and technological experience brought by the combination of artificial intelligence (AI) and communication technologies in intelligent buildings. However, at present, the application level of these combined technologies is still at the low-end level. Considering the current studies have an insufficient discussion about the advantages and disadvantages of technology, this paper emphasizes the applications of AI and communication technology in detail, and at the same time evaluates the advantages and disadvantages of several technologies.

2. Application of artificial intelligence technology in intelligent building

2.1 Eexpert control system

Expert control system (ECS) is a new system that can use expert experience and knowledge to judge or solve practical questions. As an important part of the application of AI in intelligent buildings, the core content of ECS is the construction of an expert data information database. With the support of ECS knowledge database, it uses the expert knowledge and experience of control objects and control laws in relevant fields to determine and deal with practical problems [4]. This operation method is equivalent to the processing ability of experts in the same professional field, and can judge and solve the corresponding professional problems.

The ECS uses the data information database to find the content of relevant problems through input comparison, matches the corresponding measures for simulation, integrates the knowledge model and mathematical model, combines the information collection and technology with the decision control system, and finally outputs the most reliable solution (Figure 1) [5]. The central regulator of the ECS can connect each control subsystem of the intelligent building and connect with the data information database, which can provide optimal control for the building equipment automation system of the intelligent building (including strong current equipment control automation, safety prevention automation, fire protection automation, etc.). In life, it can be applied to the property services of intelligent buildings. Through the establishment of the user information database, it can provide intelligent support for personnel access, automatic payment, business consultation, and other management and services, so as to achieve the goal of intellectualization, which is the embodiment of the application of ECS in daily life.

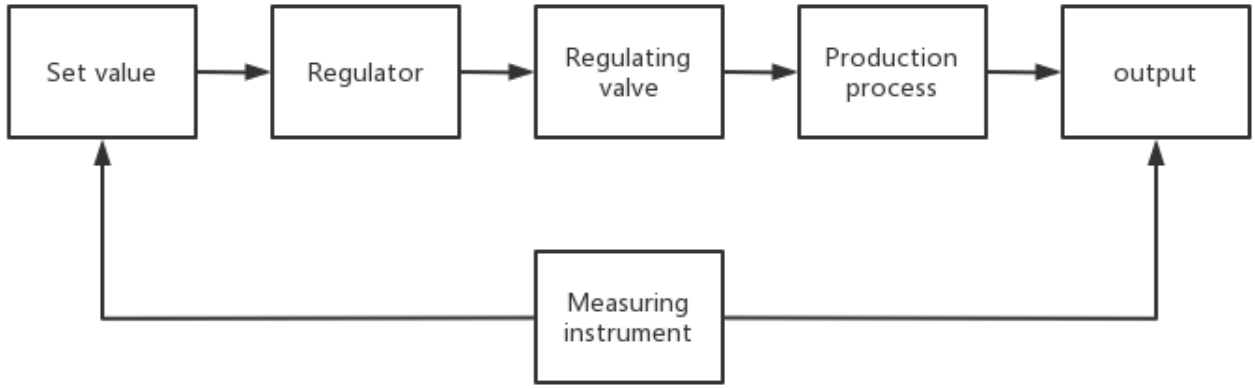


Figure 1. The working principle of the expert control system

The ECS also has some insufficient, which can only give advice or a schedule. when accomplishing tasks, it needs the decision-maker to make the decision. ECS needs working personnel to achieve its value. when the ECS encounters some rare cases, it can not give a correct or reasonable answer.

2.2 Artificial neural network control system

As the core part of the intelligent building control system, an artificial neural network control system (ANNCS) plays an important role in the automatic operation of intelligent buildings. It can ensure the self-optimization of system capability and improve the control response capability of the system [6].

The ANNCS has the ability of self-detection, which can make the intelligent building maintain the understanding of the operation state of each part of the building, give early warning at the fastest speed when the problem occurs, and connect the ECS for disposal (Figure 2) [7].

ANNCS can strengthen the automation ability of intelligent buildings. Through simulation analysis of the simulation model, the ability of the control system can be upgraded in the process of dynamic simulation, to make the control system more accurate, sensitive, and adaptable, including image processing, speech recognition, and biometrics [8]. It widens the information receiving ability and recognition ability of ANNCS, and greatly improves the overall level of intelligent building. The ANNCS can complete the remote-control task with the help of computer network technology. In remote monitoring and operation, it can achieve the goal of not being limited by time and distance, such as achieving remote office, operating according to the existing relevant instructions, and dealing with emergencies timely and effectively. For example, during the period of COVID-19's prevention and control, it can avoid the risk of virus transmission during the epidemic period, and it will be very helpful for the prevention and control of the epidemic.

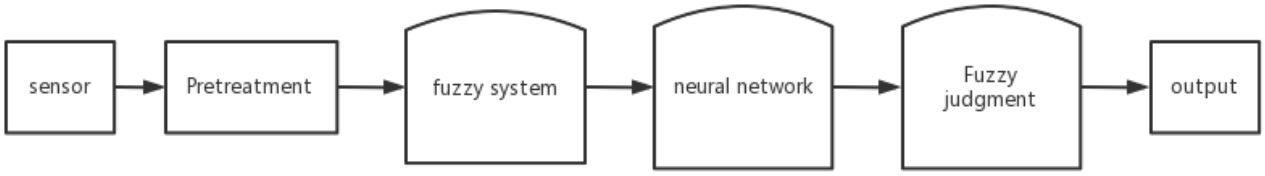


Figure 2. Working principle of the artificial neural network control system

ANNCS also has some insufficient in this stage, for example, the intelligence application function is simple, with several useful functions. Some only have the ability of logical judgment, not enough self-learning ability. It indicates that these artificial neural networks need to be improved at this stage. On the whole, the potential of the artificial neural network is infinite, it needs to be improved by latecomers.

2.3 Intelligent decision-making system

The intelligent building contains the application of an intelligent decision-making system (IDMS), which is an important embodiment of the application of AI technology in the construction industry [9]. The IDMS is a new intelligent management technology composed of computer technology, AI technology, and management science. It takes the scientific knowledge of management, operations research, and control theory as the theoretical basis, and computer technology and information technology as the means to help decision-makers carry out higher-quality decision-making activities, establish and modify decision-making models, provide various alternatives, and optimize various schemes. It can also help decision-makers improve their decision-making ability, level, quality, and benefits, so as to achieve the maximum economic and social benefits. The principle of IDMS is to collect, analyze and process the information generated in the operation process [10]. In this way, the problems of each control system can be handled, and the information data can be collected and analyzed more effectively. With the development of the internet, ANNCS could produce a large amount of information data every day. How to deal with this information data effectively is an effective problem that AI technology can solve. The effective use of IDMS can assist decision-makers in decision-making, which can improve the smoothness of building operations and prolong the service life of buildings.

3. Application of communication technology in intelligent buildings

3.1 Virtual local area network

A virtual local area network (VLAN) is a new technology to realize virtual workgroups by logically rather than physically dividing the devices in the local area network into network segments [11]. Through the application of communication technology, VLAN can be easily formed in intelligent buildings.

Different VLANs are like local area networks (LAN) connected through bridges. In addition, the network administrator can form a local area network of equipment between the same department. The LAN is not centralized and is connected to different hubs. In this way, the physical location of the network segment can no longer affect its logical subnet. It has the following characteristics: (1) Each department can have its VLAN, which is not affected by the network communication of other departments; (2) The host and server at any location on the communication network move from one VLAN to another without any physical change; (3) The network devices with physical changes can also remain unchanged on the same VLAN; (4) It improves the efficiency of network management, and it is very convenient for users to add, delete and move; (5) Users can add logical workgroup members on any physical network segment through VLAN, which is not limited by the workplace, and thus the security of LAN is improved [12].

Table.1. Points number and belonging network of VLAN

No.	System	Points number	Belonging network
1	Generic cabling system	2600	Management network, guest room network
2	Computer network system	112	Management network, guest room network
3	Telephone communication system	30	Management network, security net
4	Video monitoring system	168	Security net
5	Access control system	24	Security net
6	Cost system	14	Management network
7	Time Attendance	7	Management network

8	Background broadcasting system	150	Security net
9	Information guidance and release system	53	Management network
10	Room control system	526	Guest room network
11	Wireless WiFi system	325	Guest room network

Information in different VLANs is isolated from each other during transmission, that is, users in one VLAN cannot communicate directly with users in other VLANs. To control the broadcast storm, members of departments or branches can share the same "Lan" in the virtual workgroup mode, limit most network traffic in the VLAN, avoid propagation, narrow the broadcast range, and control the generation of the broadcast storm [13]. Construction costs have been reduced. There are often some situations in actual construction. VLAN technology can reduce the use of switches, optical fiber modules, and other equipment on the premise of ensuring the function, so as to reduce the construction cost.

VLAN technology can also be operated remotely. In the maintenance phase, the operator can operate remotely, to save personnel transportation, accommodation, and other costs. This is very advantageous for smart building rental users.

3.2 Communication network technology

The application of a communication network system in intelligent building design is to establish a generic cabling system to realize the sharing of information resources and the transmission requirements of customers for voice, data, image, and other information through the perfect combination of advanced twisted pair and optical cable technology [14]. A generic cabling system connects voice and data communication facilities, switching equipment, and other information management systems to form an integrated open system. On the basis of network access, the system can realize the transmission of image data such as analog and digital voice system, data transmission, fax machine, video signal acquisition of video conference and safety monitoring system, and signal detection of building security system (Figure 3) [15].

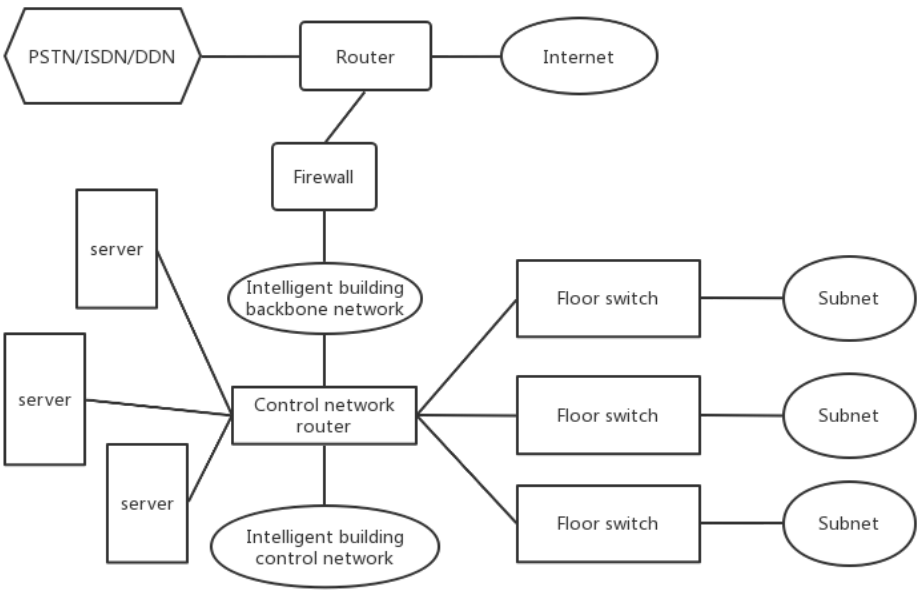


Figure 3. Intelligent building intelligent system working principle

The combination of communication technology and the intelligent building has promoted the common development of the two industries. The application of modern communication technology in intelligent buildings makes communication technology innovate and develop continuously according to the development needs of intelligent buildings. At the same time, the development and

progress of modern communication technology also promote the improvement of intelligent buildings and make them more humanized and intelligent.

3.3 Broadband network access

With the rapid development of computer technology, modern communication technology, and automatic control technology, intelligent buildings come into developed countries. One of the key technologies to realize intelligence is broadband network access. It refers to the unified internet access for internal decentralized users through a generic cabling system to realize building digitization [16]. Information transmission, exchange, and terminal are the three components of the communication network. According to the level, communication transmission can be divided into the access network, relay network, and long-distance network, which are the core networks in communication transmission. The access network mainly connects users to the core network and provides users with the connection to the nearest service point. At present, the more common network access technology is a broadband connection.

Different from traditional access methods, broadband access can realize the following basic functions: rapid access to the internet and broadband multimedia communication network; online stock speculation, shopping, and e-commerce; send and receive e-mail [17]. VOD services, online games; distance education; medical care; realize information sharing, mutual visits, and transmission in the community through LAN; and intelligent home service. Access network technology is divided into wired access and wireless access The wired mode can choose the optical fiber, twisted pair, and coaxial cable, while the wireless mode includes a cellular system, local loop, and communication satellite.

Nowadays, the number of broadband access network users is increasing, but there are some deficiencies in broadband access network technology innovation and infrastructure construction. For example, the current communication line technical conditions and network access technology are not perfect enough to meet the development needs of broadband services and balance the existing communication resources [18]. The communication quality needs to be improved. It is difficult to improve the communication transmission efficiency and meet the development needs of broadband services. In addition, there are great differences in the development strategies of technical products, lack of rich technical means, the current broadband products can not meet the needs of users, the construction of rate system is lack of refinement, and the overall construction level is relatively extensive. To sum up, the efficiency of the broadband access network is low, and there are many problems in equipment maintenance.

4. Conclusions

This study focuses on AI and communication technologies in intelligence architecture, and discusses and analyzes them from advantages and disadvantages, features and applications.

As for the applications of AI, ECS can replace or assist experts to judge problems and give solutions, and provide intelligent support for personnel access, automatic payment, business consulting, and other management and services. ANNCS can always understand the current state of the building, contact the ECS to make a judgment, and continuously update the system for self-learning. IDMS is a new intelligent management technology composed of computer technology, AI technology, and management science. It can assist decision-makers in decision-making, which can improve the smoothness of building operation and prolong the service life of buildings. VLAN technology is a new technology that divides the devices in LAN into network segments in a logical way rather than a physical way to realize virtual working groups. It can operate remotely and realize remote office to reduce costs.

Communication network system technology in intelligent building design is to establish a generic cabling system to realize the sharing of information resources and the transmission requirements of customers for voice, data, image, and other information through the perfect combination of advanced

twisted pair and optical cable technology. Broadband network access refers to the unified access of some scattered users to the Internet through the generic cabling system to realize building digitization, which can connect users to the core network and quickly access the Internet and broadband multimedia communication network.

In the future society, AI technology will emerge one after another. Higher-end AI technology will completely break the existing vision of mankind, and the application field of AI will be broader. At the same time, people pay more attention to green environmental protection, comfort, quickness, safety, and stability. The ability level is bound to cause researchers to think. Intelligent buildings are bound to become the mainstream way of buildings in the future, and social life will be more green and comfortable in the future.

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