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Application of Building Intelligence Systems in Engineering Based on Information Environment

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With the expansion of the scale of building intelligent systems (BIS) projects and the development of technology, people pay more and more attention to BIS and its projects. Professional enterprises mainly contract BIS due to its sizeable technical content and comprehensive coverage. With the arrival of the information age, the number of BIS projects in China is also increasing. This paper summarizes the relevant theoretical basis of BIS and introduces the applicable laws, experience, and development status of BIS. Therefore, the following work has been completed in this paper: (1) The research status of BIS at home and abroad is introduced, which provides a theoretical basis for the related methods proposed later; (2) The design framework of BIS in an information environment is proposed. Then, the basic principles of BPNN and PSO are introduced, and the PSO-BP model is built; (3) The best parameters of the model are selected through experiments after collecting experimental data sets. The experimental results obtained from the test data input model are compared with the real values, and it is found that the error between the evaluation value of the model and the real value is very small.

Keywords**:** building intelligent system, information environment, construction management, neural network

1. INTRODUCTION

The human living environment is always closely related to the development of science and technology. The emergence of intelligent buildings has profoundly impacted people's work and lifestyle, a milestone and inevitable result of the development of science and technology [26]. In the past, there was no unified definition of building intelligence. It was often adjusted, updated, and changed with the development of regions and countries, as well as the development of high-tech. The essence of the concept is consistent [9]. The definition of intelligent building given by the United States in the 1970s is to create a convenient environment integrating high productivity and low cost by optimizing the four basic elements of structure, system, service, and management and the relationship between them. It can be seen from the definition at that time that the design requirements for intelligent buildings were mainly mass production, convenience, and low cost. Intelligent building is the product of the combination of building technology and information technology. It is the optimal combination of the four basic elements of building structure,

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system, service, and management [23]. Intelligent building design is more complex than traditional projects because of the need for high safety standards, intricate system integration, detailed control requirements, advanced equipment functionality, and the field's interdisciplinary nature. Managing these complexities necessitates expertise across multiple disciplines and meticulous attention to detail throughout the design process. Suppose the principal work of the three major systems and several subsystems of the BIS is further refined. In that case, the main tasks and working methods in each planning and design stage, bidding, equipment selection, construction, commissioning, and trial operation can be more clearly defined. BIS engineering is based on buildings and is configured with various functional systems to provide people with an efficient, comfortable, and convenient environmental space to meet the needs of modern buildings [7]. Good application design and planning are essential to making an intelligent system with perfect functions perfectly reflected. Therefore, only by improving the technical application and management level of the building's intelligent system can the investment benefit of the construction unit be guaranteed, and the building can achieve the goal of safety, efficiency, comfort, and economy. As a marginal discipline, intelligent building includes all aspects of information and building technology [25]. The research of foreign developed countries in these two aspects is superior to or ahead of our country, and their information technology research has penetrated and refined into all aspects of architectural application. At the same time, foreign countries have formed a complete set of systematic and mature management systems at the technology and project management level, making the technology application and management implementation complete and efficient. Due to the difference in the scissors at the technical level, China has caught up with the times in terms of technology, and research at the technical level has roughly followed the pace of the times [5]. However, there is still a big gap in China's research and application status quo of technology application design management. Although the system and ideas of project management have been introduced in China, and people often say that project management should be realized, it is far from the requirements and effectiveness of real project management. BIS is a technology application based on system engineering. Its basic connotation is to use network and communication technology based on generic cabling engineering to organize the distribution of buildings and their sub-functions [22]. Realizing the automatic control functions of power distribution, network, communication, office, equipment management and security, and energy conservation management-related work is also smart due to the comprehensive investment and improvement of the use value. Through the collaborative management and comprehensive configuration of various resources, a unified, integrated building platform integrating intelligent software, hardware, and management is formed [25]. Integration is the method and principle of application system integration. It can effectively allocate, combine, and manage building resources to play a full role in the service performance of intelligent buildings. The intelligent building not only includes the hard-physical equipment environment but also includes the soft management and services. It is functionally involved in the humanities, economy, and society. The BIS can provide a building environment with comprehensive, complete, and advanced characteristics [3]. There are many opinions about the specific content of the BIS in the world. The rhetoric of Europe, America, Japan, Singapore, other countries, and the International Institute of Intelligent Engineering is different, but the overall connotation is the same. Among them, because the culture and situation of Japan are more similar to that of our country, we mainly refer to its formulation at present [3]. An intelligent building is a building environment that can provide comprehensive, complete, advanced, and other characteristics, and it is closely related to electrical power distribution and intelligent computer technology. The application of intelligent technology and computer technology, combined with power distribution, is to meet and improve the overall environment of the corresponding space through the technical creation of the control of various electrical equipment [30]. It integrates architectural engineering, intelligent engineering, electrical engineering, and other university disciplines, constantly adapting to technological progress and development. A set of normative building intelligence theories and related technical systems and standards have been gradually established and developed into a relatively independent and comprehensive discipline [24]. The society has more and more needs for building intelligence, and the requirements are gradually getting higher. The government also has high expectations for the construction of smart cities. Even various fields are full of enthusiasm and need for intelligent control technology and interaction technology, which need to be used to achieve better intelligence for buildings and products and meet more needs of people [16]. In addition, with the rapid development of relevant computer technology and intelligent technology and the convenience brought by the expansion and upgrading of communication technology, it has become a trend to use intelligent technology and information technology to upgrade and transform traditional industries. BIS focuses on all social needs and has an incomparably good development prospect [2]. Therefore, this paper summarizes the relevant theoretical basis of BIS and introduces the relevant laws, experience, and development status of BIS. Then, the BIS under the information environment is designed, and the application of BIS in the project is proposed. Finally, the project's application effect is evaluated using a neural network.

2. RELATED WORK

In the past decade, China's real estate has been in a period of take-off, and the demand for housing in China's large and medium-sized cities has soared. Intelligent buildings sprouted nationwide at this time. Today, ten years later, with the introduction of the concepts of digital city and smart city in geography, new possibilities and opportunities are provided for the development of intelligent buildings [21]. At the beginning of the new century, with the development of the real estate industry and the peak period of economic construction, the intelligent building industry has ushered in rapid and high-level development. During this period, many key projects emerged as the times required, forming an interdisciplinary and multi-state industrial chain. The industrial chain is characterized by intensive cross-professional talents, intensive technology, and emerging industries, making intelligent building from the originally imported vocabulary into the daily popularization technology [20]. The intelligent building is divided into three parts: a building automation system, an office automation system, and a communication automation system. These three systems are closely combined with people's daily lives, making people in the information vortex unable to leave the demand for intelligent buildings. So far, the development of intelligent buildings has been well-received [11]. In recent years, building intelligence in southeast China has developed rapidly. With the government's strong support, its achievements and level are at an advanced level. At the same time, China's smart communities have almost also made rapid progress [13, 14]. Intelligent building is an edge technology field that integrates the development of modern multi-disciplinary high-tech. With the continuous development of intelligent building technology, the functions of various modern advanced equipment installed inside buildings are constantly improved. However, an important problem is the lack of technical personnel to continue managing and maintaining many equipment after installation, commissioning, and training. The management level is low [6, 18, 19]. Most of the engineering technicians are experienced or changed from other industries. Only 7% have corresponding technical titles, and 3% have intermediate technical titles or above. Some managers lack understanding of the general use of equipment, and even the technicians in charge of the project lack understanding of the survey contents. Due to the lack of technicians at all levels, low management level, high maintenance costs, aging of some equipment, and lack of necessary maintenance, the operation of some equipment cannot reach the intended design goals [10]. The development of BIS integration technology is closely related to the development and demand of intelligent buildings. From the perspective of IT technology, the intelligent building is the specific application of computer technology, communication technology, and control technology in the construction field based on IT technology. The intelligence of intelligent buildings in the process of operation and maintenance is based on IT technology. The development of intelligent buildings for more than 20 years shows that IT technology is important in intelligent buildings and has always been the main technology. Therefore, the development of IT technology directly determines the development of intelligent buildings and makes intelligent buildings have different connotations and extensions in different IT technology periods [15]. Each functional subsystem in the single-function system stage of intelligent building operates in isolation and completes its functions independently. Such as closed-circuit television monitoring, fire monitoring, air conditioning equipment monitoring, *etc.* Lack of coordination and data sharing between subsystems. The system integration technology is at the initial stage, and the applications are relatively few [1]. In the multi-function system stage, some independent subsystems with similar functions are formed into multi-functional systems through simple system integration technology. For example, a comprehensive security system and building equipment automatic control system are formed to achieve functional integration and significantly reduce the number of subsystems [17]. The integrated system phase is no longer limited to function integration but extends to management and communication functions to achieve a wider range of integration. The integrated system includes a building management system, office automation system, communication network system, *etc.* In the integrated management stage, the computer network is core to realizing the systematic, integrated, and intelligent operation and management of the entire intelligent building system [29]. From the perspective of integration, intelligent buildings have developed from integrated functions to integrated systems and networks, from stand-alone applications to web-based collaborative applications, especially applications based on Internet and intranet network integration. From the perspective of information processing, it has developed from simple state information combination and monitoring-based processing to content-based processing and fusion, as well as human-computer interface based on virtual and multimedia technology [8]. Reference [12] believe that the owner's project management level in China's building intelligent system engineering needs to be improved. Because the project interests drive the whole process management level of the project management company, most project owners lack the enthusiasm to entrust professional companies to manage the project. The services provided by the construction supervision and consulting units are limited to a certain stage of the project and cannot provide the whole process of project management services. The increasing global population and resource consumption are creating a demand for sustainable urban environments. Smart cities strive to enhance resource efficiency by utilizing cutting-edge technologies like smart control systems, infrastructure monitoring, healthcare services, transportation, and energy production. There is a suggestion for a hybrid heating and cooling system using renewable solar and wind energy. This system utilizes optimized NARX-ANN and fuzzy controllers to assess energy usage according to user requirements, weather conditions, and distribution. The system provides enhanced robustness and a heightened control response compared to current systems, making energy conservation in smart city buildings easier [32]. Energy conservation and efficient infrastructures are essential for the sustainability of smart cities. Incorporating the Internet of Things in intelligent buildings enhances decision-making and energy management. An AI-powered sustainable decision support system (SDSS) utilizing deep learning has been suggested for categorizing buildings according to their energy efficiency. The algorithm gives decision-makers a framework for analyzing big data streams, reducing energy usage, and enhancing sensor data precision. The DLSDSS has proven to improve precision, processing time, data dispersion speed, power consumption, shedding of load, and energy effectiveness [31].

The business capacity of the design and construction units is insufficient, and their main work is still concentrated in a particular stage of the project life cycle. It is difficult to form the whole project process and manage the project's general contracting. Believes that the current concept of intelligent construction project management in China is weak and that the legal system is not perfect. The scope of project management has been expanded, and it is urgent to form the whole process management concept of the project. The role of price is overemphasized in the competition, the quality of project services provided by the project management unit is not considered enough, and the application of information technology in project management is not high.

3. METHOD

3.1 Design of Building an Intelligent System in an Information Environment

3.1.1 Comprehensive analysis of design scheme

The purpose of strengthening the design core of BIS is to provide support for the convenience of people's lives and work by improving the application of BIS to make the interior of intelligent buildings better meet people's basic needs. In this regard, it can be believed that when formulating the design scheme of BIS, we need to start from multiple perspectives. With the comprehensive consideration of office, living, and other details as the core, we need to meet the basic needs and, on this basis, design a perfect BIS scheme. The BIS design scheme itself needs to maintain the basic principles of feasibility and rationality to ensure that the proposed intelligent system is practical, achievable, and aligns with the objectives of the building project. By maintaining feasibility, the design scheme can be implemented effectively within the constraints of the project, considering factors such as budget, resources, and technical capabilities. Rationality ensures that the design is logical and sensible and meets the intended goals of enhancing building functionality, efficiency, and user experience. Overall, upholding these fundamental principles is essential to developing a BIS design that is realistic, effective, and capable of delivering the desired outcomes within the context of the building project. According to the basic requirements of intelligent buildings, at the initial stage of the design scheme, according to the relevant design of intelligent systems. Sort out schemes similar to building projects and intelligent system design and analyze the implementation and appropriateness of the design scheme. The design scheme of a Building Intelligent System (BIS) is characterized by its emphasis on feasibility, careful consideration of various perspectives, adherence to basic principles, evaluation for optimization, focus on safety and security features, incorporation of monitoring and control mechanisms, detailed equipment planning, quality control measures, and integration of multiple systems. These characteristics ensure that the BIS design is practical, efficient, and meets the diverse needs of the building occupants while prioritizing safety and functionality. In case of problems, the intelligent requirements of building electrical system design shall be clarified through re-analysis, and based on the above analysis results, the design scheme of building electrical and intelligent shall be optimized. Secondly, you did a good job designing the safety assessment. Intelligent building design is more complex than other building projects, and the BIS requires relatively high safety standards for the design scheme. Thorough control in the design stage is vital to avoid problems in the future. It guarantees specific demands, early problem recognition, uniformity, risk reduction, cost-effectiveness, enhanced communication, and efficient quality control. In general, it establishes the groundwork for project success by addressing possible issues ahead of time and encouraging improved results. At the same time, the basic schematic diagram and detailed installation diagram of the subsystem are respectively drawn to support building safety management.

3.1.2 Key link design

The quality of a building dramatically affects its service life and effectiveness. Similarly, the quality of BIS also affects its related practical effectiveness. To ensure the design quality of the BIS as much as possible, many aspects of quality control need to be done. First of all, regarding monitoring points, the BIS involves more types of work, and different types of work should be coordinated to ensure the construction efficiency and safety of the building project. To ensure the rationality of the Building Intelligent System (BIS), it is crucial to address both internal and external coordination of components during the design phase. This involves defining the monitoring function of the BIS and creating a control schematic diagram that aligns with the system's control object and content characteristics. The design's rationality and effectiveness can be guaranteed through strategic planning and coordination of monitoring points and control mechanisms. Based on the reasonable definition of the monitoring function of the building intelligent system, the corresponding control schematic diagram is designed based on the characteristics of the control object and control content of the BIS. Regarding the equipment plan, BIS will involve sensors, substations, and other links, which directly determine its complexity. In this regard, it is necessary to divide the substation and monitoring points during the plan design to avoid the design not meeting the requirements due to factors such as updating BIS requirements. Therefore, the distribution coverage can be designed during the design period based on the standard of 10% additional reservation. Therefore, Fig. 1 shows the architecture of the BIS under the information environment designed in this paper.

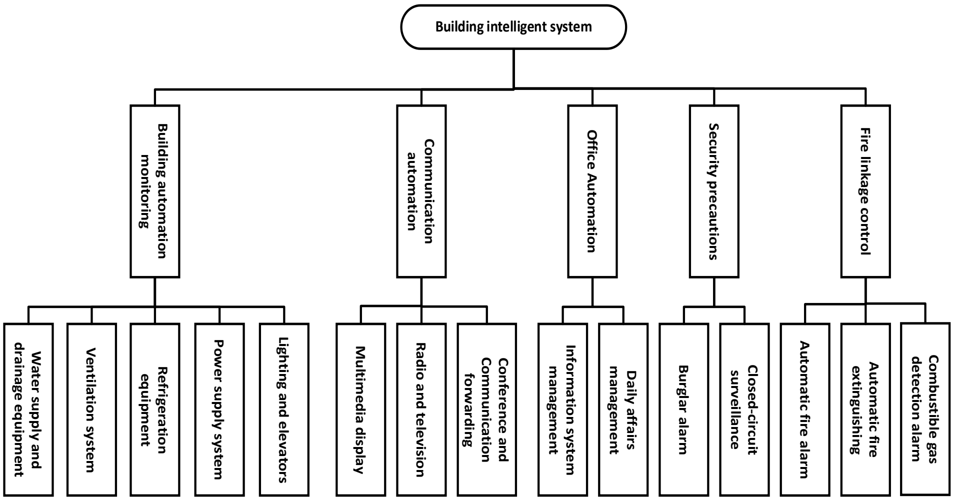

Fig. 1. Building intelligence system framework under the information environment.

3.2. Engineering Application of BIS under the Information Environment

1) Application of intelligent security system. Intelligent security system is an integral part of the intelligent era. To provide people with a comfortable, safe, and secure living space, it is necessary to protect the safety and performance of buildings. At present, construction projects need to ensure the use of intelligent security systems through high-tech electronic technology and BAS systems. The Building Automation System (BAS) is essential for integrating intelligent security systems using advanced electronic technology. BAS combines security components like access control and monitoring systems to improve operational efficiency and safety within buildings. Through BAS, managers can monitor security functions in real-time, enhancing safety measures. By incorporating high-tech electronic technology, BAS optimizes security features, such as access control systems, to manage personnel access effectively. This integration streamlines security management, enhances building safety, and provides real-time monitoring to mitigate risks efficiently. At the same time, managers can also monitor the dynamic effects in the building in real time through the intelligent security system to facilitate future work management and queries. The specific functionalities and components of intelligent security systems, including access control, anti-theft, and monitoring, comprise the technical framework that improves building safety and security. The access control system oversees the entry and exit to designated areas using keycards, biometric scanners, and PIN codes to restrict access to authorized individuals only. On the other hand, the anti-theft system is created to discourage and stop theft by using sensors, alarms, and surveillance cameras that identify and notify of any suspicious actions, thereby protecting valuable assets inside the establishment. Moreover, the monitoring system uses cameras, sensors, and devices to monitor activities

in and around the building, offering live video feeds, alerts for suspicious behavior, and the ability to record for future reference. By incorporating these three systems into an intelligent security system, buildings can enjoy complete protection from unauthorized entry, theft, and efficient surveillance, ensuring a safe and secure space for occupants and valuable items. Taking the access control system as an example, the primary function of the access control system is the security barrier function. During the use period, they will be identified once external personnel enter the management and control scope of the access control system. Combined with image information processing, access control is realized to achieve the purpose of security. In terms of security monitoring, an intelligent system can be introduced into the access control system to display the building security monitoring function using early entry of personnel information, and people without records in the system are prohibited from entering and exiting the building. Therefore, with the introduction of BIS, the safety monitoring function can be optimized to ensure the safety level of the whole work. Emphasizing the identification of potential safety hazards and ensuring timely responses results in significant improvements in building safety and management. These efforts result in improved safety measures, better risk mitigation, more accurate incident response, preventive maintenance practices, and higher occupant safety. Buildings can proactively manage risks, improve emergency preparedness, and provide a safe environment for occupants by prioritizing the identification and rapid correction of safety concerns.

2) Application of intelligent fire protection system. The intelligent fire protection system is based on strengthening building safety and conforms to the application characteristics of the current intelligent era. Its functional characteristics are similar to those of an access control alarm system. However, there are still differences in essence, and the access control system is to isolate the danger. The intelligent fire protection system detects and deals with risks promptly, reduces the losses caused by hazards, and promotes the safety guarantee function of buildings. BIS is used in various sectors like smart homes, commercial buildings, healthcare facilities, educational institutions, industrial settings, transportation hubs, retail spaces, government buildings, and the hospitality industry. In smart homes, BIS control systems for lighting, heating, and security for increased comfort and energy efficiency. Commercial buildings benefit from BIS by optimizing energy usage and security measures. Healthcare facilities use BIS to monitor patient care and ensure a safe environment. Educational institutions automate processes and improve security. Industrial settings use BIS for process monitoring and workplace safety. Transportation hubs manage passenger flow and enhance security with BIS. Retail spaces track customer behavior and manage inventory. BIS in government buildings streamlines operations and boosts security. In the hospitality industry, BIS automates guest services and enhances the guest experience. Sustainable buildings incorporate BIS to monitor energy usage and reduce environmental impact. As the green escape routes for government business, residential, and high-rise office buildings are narrow, evacuation and rescue work are challenging in a crisis. Therefore, intelligent application systems are critical when unexpected disasters come. The intelligent fire protection system can automatically trigger sensitive sensing devices for temperature, smoke, light, and other reactions through the fire monitoring in the building and self-sensing fire alarm intelligent fire protection system to form danger alarm signals. In emergencies, it is crucial to utilize community broadcasting, corridor lighting, and other equipment to evacuate individuals and reduce the number of casualties efficiently. Community broadcasting can give straightforward evacuation directions through loudspeakers, leading peo-

ple to safety. Good lighting in hallways is essential for visibility and assisting people in finding their way out of the building during evacuations. Emergency exit signs, lighting, and directional signage are crucial for directing people to safety. A comprehensive evacuation strategy can be established by strategically placing these elements, integrating them with community broadcasting and corridor lighting, and ensuring a swift and orderly evacuation throughout the building. This method decreases confusion and possible accidents, leading to fewer casualties and guaranteeing the safety of people inside buildings in emergencies.

3) Application of communication system. As the most obvious link between people's needs and dependence in the information age, in most modern office buildings, the quality of communication determines people's work level and office efficiency, and people's basic work needs can be met by BIS. Effective communication is crucial in evaluating individual performance and office productivity. When information is communicated correctly, tasks are more easily grasped, increasing efficiency. Also, it enhances cooperation within the team, promoting teamwork and synergy. Additionally, it simplifies decision-making processes, addresses conflicts, and increases employee involvement. Effective communication builds strong relationships with customers by creating trust and guarantees efficient meeting of customer requirements. Highlighting effective communication methods in the workplace can significantly improve productivity, teamwork, decision-making, conflict resolution, employee involvement, and customer interactions. In the specific building method, the intelligent system inside is built into a multi-repetitive and miscellaneous communication network system from inside to outside. Different office workers are provided with corresponding identity-setting permissions through the communication network system to meet the needs of people's personalized information applications. With the help of the internal and external networks of the BIS, query or obtain the corresponding information. In specific applications, the BIS is mainly built based on communication engineering, optimized and improved based on people's specific use needs, and fully applies the management mode of authority division to ensure the intelligent communication function of the building.

4) Application of electrical control system. Based on applying BIS in the information environment, an electrical system is the most typical application. The application of intelligent technology in electrical systems can promote the whole system's operation to maintain high efficiency and high controllability. Taking building automation system as an example, it is a significant development direction based on information environment applications in intelligent buildings. It means that there are air conditioning units, fresh air units, cold and heat pump units, exhaust fans, fan coil units, domestic water pumps, elevators, lighting circuits, and other electrical systems or equipment in a regional building, which can remotely monitor all system equipment to achieve the management, maintenance, statistics, analysis of operating data, as well as the supervision and control of failures. Its purpose is to maintain the remote data of the system, control the operation of corresponding equipment in case of a fault alarm, and assist professionals in achieving on-site connection. Maintaining remote system data yields significant benefits, including enhanced monitoring, operational efficiency, early fault detection, predictive maintenance, cost savings, and informed decision-making. These advantages contribute to optimized system performance and operational effectiveness. During specific applications, providing information integration data under these information environments has the following functions. First, it can

help the energy consumption of the building, that is, the optimal energy-saving control of power, lighting, air conditioning, and other equipment. Second, it can effectively extend the facilities and equipment connected to building automation management; that is, it will not cause damage to the equipment due to abnormal use due to long-time or overloaded operation. Third, it can improve management reliability; that is, the data collected in the information environment will not cause losses due to the non-standard and unreasonable operation of the electrical equipment of the building due to the negligence, fatigue, and misjudgment of manual management. Fourth, it can effectively reduce the building property or management team's labor management and labor costs. Without integrating BIS, it is difficult to achieve the above four points by manual control. The evaluation of the building's electrical system design revealed several challenges, including insufficient coordination and data sharing among subsystems, the early stages of system integration technology, a shortage of skilled technical personnel, and the need for optimized design schemes. These issues highlight the critical need for improved system integration, addressing the technical staff shortage, and refining design strategies to improve the overall performance of intelligent building systems.

3.3 BPNN Based on PSO

3.3.1. The Basic Principle Of BPNN

An input layer, an output layer, and one or more hidden layers are typical components of a BPNN, a supervised learning technique based on error backpropagation. The Backpropagation Neural Network (BPNN) employs the error backpropagation mechanism in a two-stage process. During the forward pass, the network receives input values from known training samples. It calculates the output of each neuron by adjusting connection weights and thresholds through the hidden layers to the output layer. Subsequently, in the backward pass, known as error backpropagation, the network evaluates the impact of weights and thresholds on the total error by comparing the target output with the actual error. Through this comparison, the network adjusts the connection weights and thresholds between layers to minimize the error, iteratively refining its parameters to enhance prediction accuracy. This iterative learning process enables the BPNN to learn from errors, adapt its weights and thresholds, and improve performance by converging towards the desired output. Nonlinear mapping is achieved by continually adjusting the weights and thresholds across nodes, reducing the error between the anticipated and ideal output. Implementing the backpropagation (BP) algorithm involves two steps, utilizing gradient descent to achieve convergence. In the first step, known samples are used as input values for the network. By setting the network structure and learning the connection weights and thresholds, the output of each neuron is calculated backward from the input layer through the hidden layer. In the second step, the influence of the weights and thresholds between layers on the total error is calculated from the output layer to the hidden layer based on the target output and the actual error. The connection weights and thresholds between the layers are then adjusted accordingly.

Fine-tuning connection weights and thresholds in a neural network is vital for optimizing training, improving convergence speed, preventing overfitting, enhancing generalization, avoiding local optima, adapting to data complexity, and boosting model robustness. These adjustments are crucial for shaping the network's learning process and overall performance. Through iterative refinements in two phases, the predicted output of the Backpropagation Neural Network (BPNN) gradually approaches the expected output until the network converges. The neuron's output calculation method is demonstrated in Eq. (1).

$$y_a = f\left(\sum_{b=1}^{n} w_{ab} x_b + \theta_b\right) \tag{1}$$

where y_a is the output value of neuron a, w_{ab} represents the connection weight between neuron i and neuron b, θ_b is neuron b's threshold.

3.3.2 Analysis and research of PSO algorithm

1) Mathematical model of PSO algorithm: Assuming that the particle coordinates of the i particle in the particle swarm are $X_a = (x_{a1}, x_{a2}, \ldots, x_{an})$, the best position is recorded as p_1, and the best-recorded position of all particles is p_2, the moving speed of the particle is $V_a = (v_{a1}, v_{a2}, \ldots, v_{ad})$. In particle search, in each iteration process, the trajectory of the particle in space is shown in Eqs. (2) and (3).

$$v_{ad}^{i+1} = v_{ad}^{i} + c_1 rand()(p_1^i - x_{ad}^i) + c_2 rand()(p_2^i - x_{ad}^i) \tag{2}$$

$$x_{ad}^{i+1} = x_{ad}^{i} + v_{ad}^{i+1} \tag{3}$$

where c_1 and c_2 are the acceleration constants, respectively, the purpose is to make the particles move faster to the best position and the best position of all particles; *rand*() is a random number of [0, 1]; the maximum value of the particle moving speed is V_{max}.

As soon as the particle's velocity reaches its maximum value (Vmax), it will stop increasing. Establishing a maximum particle velocity is crucial for enhancing overall search accuracy. In a given solution space, a particle moving too quickly might miss the optimal value, while a particle moving too slowly might settle at a local optimal solution. To improve overall search accuracy, the maximum particle velocity is determined using strategies such as setting limits, balancing speed and precision, incorporating acceleration constants, introducing randomization, and promoting search diversity. These approaches aim to optimize particle movements, balance exploration and exploitation, and improve the chances of finding optimal solutions during the search process. As a result, this configuration is required. The velocity of a particle comprises three elements. The first element is the particle's initial velocity, which defines its current state of motion. If no interference occurs, the particle's velocity remains constant. The second element simulates the particle's cognitive abilities, inspired by bird cognition. The final element is the sharing of information. During the optimization process, particles will interact, leading to the collective development of the entire particle swarm, thereby reflecting the social characteristics of particles.

2) The process of the PSO algorithm: PSO, in contrast to most other optimization methods, does not rely on gradient information. Probabilistic fuzzy search is a method used in Particle Swarm Optimization (PSO) that combines probabilistic and fuzzy logic concepts to improve the algorithm's search capabilities. This method introduces unpredictability and adjustability into the optimization procedure, resulting in a more robust and versatile approach. Probabilistic fuzzy search is known for its capability to manage uncertainty, incorporate fuzzy logic for imprecise data processing, and demonstrate adaptive

behavior influenced by feedback. Probabilistic fuzzy search is essential in PSO as it helps to enhance exploration by diversifying the search space, improve exploitation by effectively utilizing promising regions, and ensure robustness in handling complex optimization challenges with uncertain or noisy data. In general, probabilistic fuzzy search enhances PSO's ability to explore various solution spaces, make decisions based on fuzzy rules, and adjust its search strategy dynamically, ultimately improving its performance in solving complex optimization problems. However, many evaluation functions are necessary to estimate the fitness of particles; there are still numerous evident improvements over standard evolutionary algorithms in terms of the overall performance of the optimization process. High resilience is achieved in the process of PSO since individual performance will not impact the overall solution. Because the PSO's members do not directly communicate information, the whole system may be assured to remain scalable. Using distributed processing in the PSO's method improves computational efficiency by allowing parallel computation across multiple processors. This approach optimizes resource utilization, increases scalability, ensures effective processor coordination and communication, simplifies load balancing, and improves overall speed and performance. Distributed processing speeds up convergence, improves solution quality, and effectively handles complex optimization tasks by coordinating multiple processors for concurrent computation. The PSO method is more scalable than previous intelligent algorithms because it does not need the issue to be continuous. The general flow of the PSO algorithm is shown in Fig. 2.

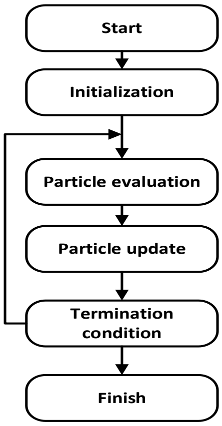

Fig. 2. General steps of particle swarm optimization.

3.3.3 Construction of PSO-BP model

1) The Back Propagation Neural Network (BPNN) estimates the cost module. Critical factors of the BPNN include the number of hidden nodes, the number of hidden layers, the activation function, the learning rate, and the momentum coefficient. Increasing the number of hidden nodes can reduce the "training sample" error but may also extend the convergence time. However, beyond a certain point, increasing the number of hidden nodes can lead to a sharp rise in execution time if the error level increases. The number of hidden layer nodes is calculated using Eq. (4).

$$H = \sqrt{r+s} + c \tag{4}$$

Number of hidden layers: The number of hidden layers significantly affects the convergence speed of the network. Typically, 1 to 2 layers are ideal for addressing most application problems, with one layer commonly used for training. The sigmoid function is employed as the activation function, and its calculation formula is shown in Eq. (5),

$$f(x) = \frac{1}{1+e^{-x}}. \tag{5}$$

Learning rate and momentum coefficient: The speed at which a neural network converges during training depends significantly on the learning rate, which dictates the magnitude of steps taken in optimization. If the learning rate is too high, there is a risk of overshooting the minimum of the loss function during optimization, which could result in oscillations or divergence. On the other hand, a minimal learning rate can considerably delay convergence, requiring additional training epochs to achieve the desired level of performance. Momentum is frequently incorporated into the learning algorithm to improve convergence speed and stability. This includes a momentum factor that includes a portion of the previous weight update in the current update. This method aids in reducing fluctuations in the optimization process and speeds up learning, especially in areas of the loss landscape with steady gradients or flat surfaces. By adjusting the learning rate and momentum with care, the training of neural networks can be improved to achieve quicker convergence and more effective learning.

2) Randomly generate the initial velocity and position of the particle swarm. Set $X_a = (x_{a1}, x_{a2}, \ldots, x_{an})$ as the initial position of particle a, set $V_a = (v_{a1}, v_{a2}, \ldots, v_{ad})$ as the initial velocity of particle a, $P_h = (p_0, p_1, \ldots, p_s)$ for all best position of the particle is recorded, that is, the local optimization position. The velocity and position vectors of the particle swarm in n-dimensional space are randomly generated at (0, 1).

3) Calculate the fitness of each particle. The fitness of each particle is evaluated using the problem-specific objective function. The fitness function value is then compared to the best function value stored in memory, and the particle adjusts its search speed for the next stage based on the best value in memory. The sum of squared errors (SSE) is represented in Eq. (6),

$$f(a) = SSE = \sum_{a=1}^{n} (T_a - E_a)^2 \tag{6}$$

where T_a is the data fitted by the algorithm, and E_a is the original data.

4) Take a reading of the particle's location and velocity vector. If the particle's best value is superior to the current global best value, update the global best value in memory. Simultaneously, adjust the location and velocity of each particle to ensure that the subsequent global search proceeds more quickly and accurately.

$$V_a^{i+1} = WV_a^i + c_1 rand()(s_a^{i1} - s_a^i) + c_2 rand()(s_a^t - s_a^i) \tag{7}$$

$$s_a^{i+1} = s_a^i + V_a^{i+1} \tag{8}$$

where c_1 and c_2 are learning factors, also known as acceleration constants, W is the inertia factor, $rand()$ is a uniform random number of [0,1], s_a^{i1} represents the i_1th dimension of the individual extreme value of the ith variable, s_a^t represents the *a*th dimension of the global optimal solution, s_a^i represents the *i*th dimension of the individual extreme value of the *a*th variable.

5) The PSO neural network technique may test the impact of translation. At this point, when network training is complete, the average error data from the training set is gathered, and error data from the sample set is received via testing.

4. EXPERIMENT AND ANALYSIS

4.1 Source and Pretreatment of Experimental Data

As a crucial element in implementing neural network algorithms, datasets play a decisive role in the credibility of model output results. After evaluating the characteristics of the application effect of building intelligent systems in engineering under an information environment, this paper designs a dataset for training and testing purposes. The dataset contains 1,000 data points. This dataset, obtained through the process above, ensures the highest possible accuracy of the experimental results. The data is then preprocessed using the following equation,

$$y_p = \frac{x - x_{\min}}{x_{\max} - x_{\min}}. \tag{9}$$

4.2 Model Parameter Selection

1) Selection of Activation Function: In this paper, three commonly used activation functions were compared, with the specific experimental results in Fig. 3. The results indicate that the ReLU function outperformed the others. Consequently, the ReLU function was selected as the activation function for this study.

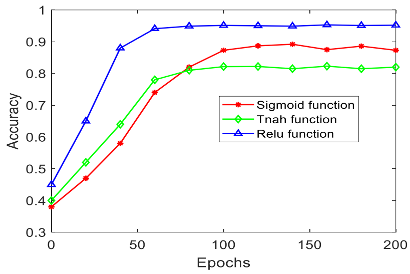

Fig. 3. The effect of different radial basis functions on model training.

2) This paper verifies the algorithm performance for the number of hidden layer neurons by setting the number of neurons from 5 to 15. The accuracy is calculated to obtain the optimal number of neurons. The experimental results are shown in Fig. 4. It can be seen that when the number of hidden layer nodes is 10, the accuracy rate is the highest. Therefore, the number of hidden layer nodes is 10.

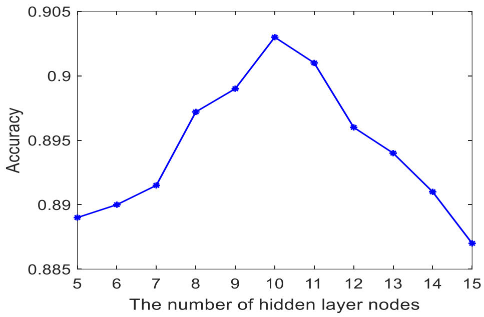

Fig. 4. The effect of different hidden layer nodes on model training.

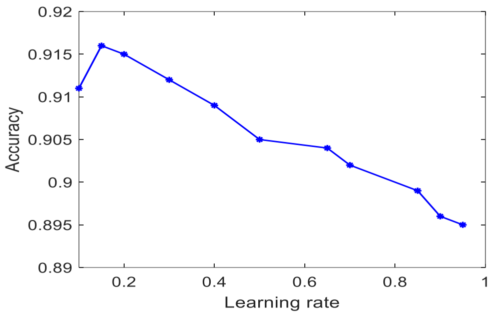

Fig. 5. The effect of different learning rates on model training

3) Selection of learning rate: Learning rate is also an important factor affecting the training effect of a neural network. This paper selects several commonly used learning rates in the range of [0.1, 1] for testing. The results are shown in Fig. 5. The training effect of the model is best when the learning rate is 0.15, so the selected learning rate is 0.15.

4.3 Model Performance Test

The prediction results can be obtained by importing relevant sample and test data into the BP and PSO-BP models. BP model converges after the iteration of 300 steps. In comparison, the PSO-BP model converges at 200 steps, as shown in Fig. 6. It is proved that the accuracy of the PSO-BP model is greatly improved, the convergence speed is faster, and there is no local optimization trap after optimization by the PSO algorithm. The comparison between the effect evaluation value of the PSO-BP model and the actual value is shown in Table 1. It can be seen from the figure that the error between the assessed value of the PSO-BP model and the actual value is tiny, indicating that the PSO-BP model has good performance.

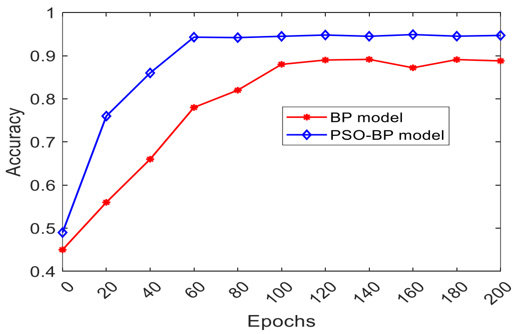

Fig. 6. Iteration times curves of different models.

Table 1. Experimental comparison between model output and expert evaluation results.

Number	1	2	3	4	5	6	7	8
Model output	0.648	0.719	0.732	0.781	0.859	0.864	0.882	0.735
Actual values	0.650	0.718	0.732	0.782	0.861	0.864	0.884	0.737

5. CONCLUSION

BIS is a combination of architectural art and high technology. With the rapid development of BIS in recent years, intelligent housing has gradually entered people's lives as a new building to improve the quality of life. Under the information environment, the design and application mode of the BIS has been significantly improved, with significant improvements and breakthroughs in technology maturity, usability, convenience, and other aspects. Therefore, discussing BIS's design and engineering application based on an information environment is of great practical and practical significance. Therefore, the following work has been completed in this paper: (1) The research status of BIS at home and abroad is introduced, which provides a theoretical basis for the related methods proposed later; (2) The design framework of BIS in an information environment is proposed. Then, the basic principles of BPNN and PSO are introduced, and the PSO-BP model is built; (3) The best parameters of the model are selected through experiments after collecting experimental data sets. The experimental results obtained from the test data input model are compared with the real values, and it is found that the error between the evaluation value of the model and the real value is very small.

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