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Research Article

Optimization of Electric Automation Control Model Based on Artificial Intelligence Algorithm

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To effectively solve the problems faced by modern electrical engineering, the design of an electrical automation control system based on artificial intelligence technology is realized. A model of electrical automation control system based on an artificial intelligence algorithm is presented. The control parameters are optimized by using the artificial intelligence algorithm control strategy. The research results show that when there is 20% load interference and 2.1 Hz frequency interference, the maximum failure rate of the turbine under system control is 0.02, indicating that the system has high anti-interference. Therefore, in the automatic control of electrification, the application of the artificial intelligence algorithm can greatly improve the control response time of the automatic control of electrification, save cost, and achieve efficient production.

1. Introduction

With artificial intelligence iterative growth and maturity as a component of modern information technology, it has been widely explored and popularized in a range of industries, notably in the field of electrical automation control, assisting in the evolution of electrical automation. AI technology naturally integrates the information and intelligent content of electronics, telecommunications, computers, and other fields and disciplines. In a multitude of areas, it can be utilized to simulate human awareness or thinking. Because AI technology has computer advantages, such as the ability to perform precise control operations, reduce reliance on human interaction, and efficiently prevent avoidable mistakes caused by human factors, its use in related sectors may significantly increase the level of intelligence in these industries [1, 2]. Social development makes economic production increasingly dependent on scientific and technological progress, be it agriculture, industry, or tertiary industry, which has been widely used in electrical automation control technology; in electrical automation control technology, artificial intelligence technology has become the core part of electrical automation technology research and application [3]. Artificial intelligence technology integrates many technologies, including computer technology, sensor technology, and GPS technology. Industrial production uses intelligent technology, which greatly reduces the work intensity of employees, greatly improves the production efficiency of enterprises, and effectively reduces the production cost, which makes enterprises more competitive in the market [4]. In particular, the use of artificial intelligence technology in dangerous areas can greatly reduce the damage to operators. In industrial and agricultural production, the introduction of artificial intelligence technology can reduce the unit cost and labor cost of production and improve the operation accuracy in the process of industrial and agricultural production; on the basis of minimizing manual operations, the safety of production activities is effectively improved, and production efficiency and enterprise benefits are improved [5]. Machine learning has expanded the capabilities and scope of electrical engineering optimization, resulting in major advances not just in terms of cost but also in terms of safety and real-time operation control [6]. Nguyen et al. robust adaptive strategy based on pseudofuzzy logic and sliding mode control (PFSMC) is proposed. Due to the robustness of the sliding-mode control technology, reduced sensitivity to uncertainty, and enhanced resistance to pseudofuzzy mechanism interference, the proposed control algorithm can not only guarantee the stability of the system but also improve the steady-state tracking error. To verify the design efficiency of PFSMC, simulations and laboratory tests of the proposed protocol and conventional PID schemes were performed and compared below. In a computer environment, test cases with and without certainty are implemented using two controllers to visualize comparative responses. Then, both control methods are integrated into a real hardware platform to obtain practical results [7]. With the continuous growth of power demand in China, the requirements of electrical control system are constantly improving; the traditional electrical control system cannot keep up with the pace of social development [8]. The electrical automation control system using artificial intelligence technology can effectively improve the level of control and finally achieve modernization and intelligence.

Electrical automation control is highly significant in the electrical industry; if electrical control automation is achieved, production efficiency can be effectively enhanced, lowering production costs including human resource expenses. Fuzzy control, expert systems, neural networks, and other artificial intelligence technologies are being employed in electrical automation control. Artificial intelligence in the growth of automation not only can promote the overall progress in the field of electrical automation control but also can promote the growth of automatic control of progress, so in the field of electrical industrial applications, innovation requires the support of artificial intelligence, using artificial intelligence technology to improve the consciousness of mechanical ability and strengthening the electrical automatic control [9, 10]. The manual technology in electrical automation control is analyzed. An efficient and precise control mode is an important basis of electrical automation control. Automation control mainly studies the application of computer data processing, the classification and identification processing of data digitalization, the structural optimization of system composition, the control of electrical automation, and all small branches [11]. On the basis of automation control technology, by combining with an artificial intelligence algorithm, the work efficiency of electrical automation control will be greatly improved to some extent, save the time consumed in the traditional electrical control, reduce the energy and human resources consumed in the operation of equipment, greatly improve the control of machine time, and control the accuracy of electrical automation control. Shi et al. proposed a clone selection optimization system based on the joint learning framework. The heuristic clone selection strategy in local model optimization was used to optimize the effects of joint training. First, the process improves the adaptability and robustness of the federated learning solution and improves the modeling performance and training efficiency. In addition, this study tries to improve the privacy security defense capability of federal learning programs through differential privacy preprocessing. Simulation results show that the clone selection optimization system based on joint learning has significant optimization capability for the basic performance, stability, and privacy of the model [12].

A single controller's automated running of a large electrical power distribution network can enhance efficiency and reliability while cutting maintenance costs. For the control to be most successful, the controller must have a general overview of the whole network to reason about the cause of the readings of the multiple sensing devices positioned across the network. Conventional power system control methods rely on a network of local devices that make choices based on the instantaneous reading of a single sensor. These single-parameter results may occasionally be incorrect due to sensor malfunctions [13, 14]. Based on this, a model of electrical automation control system based on the artificial intelligence algorithm is proposed. It is applied in the experiment; after testing in different working conditions, when there is 20% load interference and 2.1 Hz frequency interference, the control effect of the system is better than the traditional PID control system; under the control of the system, the output frequency fluctuation of the turbine system is small and has fast convergence to the optimal frequency, and under the control of the system in this paper, the maximum failure rate of the turbine is 0.02, which has high robustness; it is predicted that the electrified industry in the future will inevitably rely heavily on artificial intelligence algorithms. In the automatic control of electrification, the application of the artificial intelligence algorithm can greatly improve the control reaction time of the automatic control of electrification, save cost, and achieve efficient production.

2. Research Methods

2.1. Electrical Automation Control System Based on Artificial Intelligence Algorithm

2.1.1. Hardware Design. The electrical automation control system based on the artificial intelligence algorithm is around the turbine regulation, as the goal, through a single neural network-based PID intelligent controller module; based on the adaptive ant colony genetic artificial intelligence algorithm, the optimal control of PID intelligent controller is realized.

2.1.2. System Structure. The core components of the system include water turbine, pressure water inlet, and large motors, among which the PID intelligent controller module based on a single neural network is included, which belongs to the feedback control system. The structure diagram of the electrical automation control system based on the artificial intelligence algorithm is shown in Figure 1. In Figure 1, a represents a given rotational speed signal, b represents the output control signal, and c represents the load disturbance signal; for a parallel operating unit, its output power variation does not interfere with the frequency of the power system; based on this kind of situation, the function of the turbine regulating feedback system is 0; in this case, the PID intelligent controller module based on a single neural network can enable the follow-up system function. Figure 1 illustrates that the turbine governor has experienced the development process from the mechanical hydraulic governor to the process of analog circuit to the microcomputer electrohydraulic governor. Prior to the appearance of the microcomputer governor, the main mission of the governor (mainly machine governor and analog circuit governor) was to adjust the water guide mechanism/paddle mechanism (injection needle/converter mechanism) according to the unit frequency deviation of the rating, and the turbine governor is mainly a speed regulator.

2.1.3. PID Intelligent Controller Module Based on Single Neural Network. The core of the intelligent PID controller is a single neuron, which can complete self-learning and has good adaptability, and the structure is simple and can quickly adapt to the nearby environment, the field adjustment parameters are few and easy to adjust, which can ensure that the control system belongs to the optimal state in practical application, and its control effect is better than the ordinary PID controller. Based on using a single neuron, the adaptive PID controller can play a better role. For the converter input, it can make the turbine controlled process, and PID control settings can be optimized, such as setting $S(r)$; the output can be transformed into the number of relevant states required in neuron-based learning control; in the state coefficient Y_1, Y_2, Y_3 of the output of the converter, $Y_1(r)$ is equal to $\varphi(r)$, $Y_2(r)$ operates on $\varphi(r) - \varphi(r-1)$, $Y_3(r)$ operates on $\varphi(r) - 2\varphi(r-1) + \varphi(r-2)$, S describes the performance index, R describes the neuron proportional coefficient, and neurons using association retrieval can derive control signals $H_{\mathrm{p}}, H_{\mathrm{i}}, H_{\mathrm{d}}$; then, the control strategy of the artificial intelligence algorithm is used to realize the optimal adjustment control of three kinds of control signals, that is, the three kinds of control parameters.

2.2. Control Strategy Based on Artificial Intelligence Algorithm

2.2.1. Node and Path Generation. Set $H_{\mathrm{p}}, H_{\mathrm{i}}, H_{\mathrm{d}}$ as the three variables to be set in the PID, the controller suppose there are five significant digits for each of the three variables. Set the 5 digits of H_{p}, H_{i}, H_{d} according to the value condition in the PID controller 1 placed before the decimal point and 4 places after the decimal point, for example, 1.0025. Then, the ant path graph is optimized according to the ant colony algorithm with this parameter. For these three parameter values, they are abstractly described in the xOy plane; the method is to draw 15 equally spaced and equally long line segments $A_1, A_2, \cdots, A_{15}$ perpendicular to the x-axis; among them, $A_1 \sim A_{15}$, $A_6 \sim A_{10}$, $A_{11} \sim A_{15}$ describes the first to fifth digits of H_{p}, H_{i}, H_{d} in turn. Divide each line segment equally; that is, obtain 10 nodes from each line segment and describe the digit values represented by the line segment in turn. So far, there are 15×10 nodes in the xOy plane, and set 1 node as $a(x_j, y_{j,i})$, where x_j describes the x-coordinate of line segment A_j; $y_{j,i}$ describes the ordinate of node i on A_j, and the value corresponds to the ordinate value $y_{j,i}$ of the node. Suppose an ant starts at the origin O, and after crawling to a random point in segment A_j, implement a loop, and its crawling path can be described as $B = \{O, a(x_1, y_{1,i}), a(x_2, y_{2,i}), \cdots, a(x_j, y_{j,i})\}$, where $a(x_j, y_{j,i})$ node is in line segment A_j; then, the value described by this path is shown in

$$\begin{cases} H_p = y_{1,i} \times 10^0 + y_{2,i} \times 10^{-1} + y_{3,i} \times 10^{-2} + y_{4,i} \times 10^{-3} + y_{5,i} \times 10^{-4}, \\ H_i = y_{6,i} \times 10^0 + y_{7,i} \times 10^{-1} + y_{8,i} \times 10^{-2} + y_{9,i} \times 10^{-3} + y_{10,i} \times 10^{-4}, \\ H_d = y_{11,i} \times 10^0 + y_{12,i} \times 10^{-1} + y_{13,i} \times 10^{-2} + y_{14,i} \times 10^{-3} + y_{15,i} \times 10^{-4}. \end{cases} \tag{1}$$

2.2.2. Algorithmic Control Process. The control process based on the artificial intelligence algorithm is as follows:

(1) According to the parameter tuning method, namely, Z-N method, the calculated PID parameter is $H_{\mathrm{p},s-M}, H_{\mathrm{i},s-M}, H_{\mathrm{d},s-M}$

(2) The number of ant colonies is n, and each ant h has 15 ordinate values and crawling path attributes that are used to store the 15 nodes passed by ants

(3) Hybrid algorithm parameter initialization: put the ant at the starting point

(4) Set the value of variable j to 1; if the parameter $p < p_0$, then calculate the probability $Q_{ji}^h(t)$ of ants transferring each node in line segment A_j by formula (2). On the contrary, formula (3) is used to select the subsequent nodes through the wheel selection method, and the value of this node is introduced in the table, as shown in

$$\delta(t) = \begin{cases} 0.95\delta(t-1), & 0.95(t-1) \geq \delta_{\min}, \\ \delta_{\min}, & \text{else}, \end{cases} \tag{2}$$

where $\delta(t)$ describes local pheromone parameters, as shown in

$$Q_{ji}^h(t) = \begin{cases} \dfrac{\left[\psi_{ji}(t)\right]^1 \cdot \left[\vartheta_{ji}(t)\right]^2}{\sum_{h \in \text{allowed}_h} \left[\psi_{ji}(t)\right]^1 \cdot \left[\vartheta_{ji}(t)\right]^2}, & i \in \text{allowed}_h, \\ 0, & \text{else}, \end{cases} \tag{3}$$

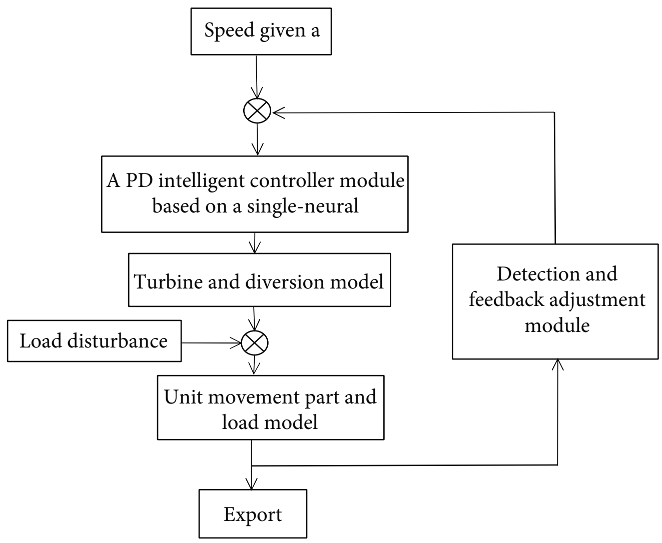


FIGURE 1: Structure of electrical control system based on artificial intelligence algorithm.

where allowed_h describes the nodes that ant h can select next, $[\vartheta_{ji}(t)]^2$ describe the importance of visibility factors, and $[\psi_{ji}(t)]^{-1}$ describes the importance of pheromone locus intensity

(5) When each ant finishes a node, equation (4) is adopted to refresh the local pheromone, and the local information volatility coefficient is adaptively transformed, as shown in

$$\psi_{ji} \longleftarrow (1-\delta)\cdot\psi_{ji} + \delta\cdot\Delta\psi_{ji}. \quad (4)$$

Type $\Delta\psi_{ji} = P_1/S_{\text{PID1}}$, S_{PID1} describe the node path passed; the value of local pheromone parameter δ is adaptive. $\Delta\psi_{ji}$ describe the track pheromone intensity per unit length.

(6) Set $j = j+1$, if the value of j is not greater than 15, jump to Step (3); otherwise, jump to Step (7)

(7) Following the path that the ant h has climbed (array G_h), calculate the PID parameter H_{p}^h, H_{i}^h, H_{d}^h corresponding to this path. Implement computer simulation to obtain the performance index s_z^h of the system, steady-state adjustment error d^h, and overshoot e^h. Calculate the corresponding objective function of ant h, record the best path and the best performance index in this cycle, and lead H_{p}^h, H_{i}^h, H_{d}^h into H_{p}^*, H_{i}^*, H_{d}^*

(8) Assuming $h \longleftarrow h+15$, all pheromones are refreshed according to equation (5), and the volatile coefficient of all information is adaptively adjusted. As shown in

$$\psi_{ji} \longleftarrow (1-\partial)\cdot\psi_{ji} + \partial\cdot\Delta\psi_{ji}, \quad (5)$$

where ∂ describes the volatilization coefficient of all pheromones

(9) Use the single point crossing strategy to cross (cross when crossing constraint variable $\theta < 0.000001$) and generate new individuals

(10) Using the basic mutation (mutation occurs when crossing the constraint variable $\theta < 0.01$) scheme, calculate each parameter value again; if the performance index obtained is close to the objective function F, so if the mutation is not removed, the pheromone is updated, and conversely, the mutation is removed

(11) If all ants do not converge to the same path, put all ants at the starting point again and jump to the step; otherwise, the loop stops and outputs the optimal path and the corresponding optimal PID parameters H_{p}^*, H_{i}^*, H_{d}^*

2.3. Functions of the Electrical Automation Control System. The function of the electrical automation control system is control; the premise of the control function is to analyze the data to provide a control basis.

(1) *Information Collection*. The electrical system is required to have relevant data terminal collection and software equipment; the main function of information collection is to provide a basic guarantee for the realization of the control function [15]. Terminal equipment and software are used to collect equipment, operation, and environment in the power system; it mainly includes operation time, equipment quantity, ambient temperature, fault condition,

and alarm system and signals using the data collected by the software and equipment with real-time information on the power system to provide operational information for the staff, so that the staff can effectively deal with the emergency

(2) *Information Transmission*. Information is two-way transmission, that is, terminal equipment and software collect information to the processing center for transmission, and the processing center is the transmission of control processing instructions to the execution terminal [16, 17]. Therefore, the process of information transmission is particularly important, and information transmission is also the main condition to realize the control and supervision of the control system. Transmission equipment of the power system mainly includes video cable, signal cable, coaxial cable, and optical cable; the corresponding transmission mode can be selected according to transmission distance and type, to ensure the quality and speed of information transmission and to avoid information loss, not timely transmission, coding disorder, and information confusion [18]. The controller is required to include a control module, power module, communication module, and editing module, to ensure the coordination of the system

(3) *Information Analysis*. Information analysis refers to the main process of control and monitoring of the control system; the control system should process and analyze the information collected by terminal equipment and software; after the collected information is sent to the database, the control system and software are displayed, and the system cannot be handled independently by the staff to use the system to help achieve the corresponding work [19]. In addition, the system should collect data to achieve storage, including the environment, equipment, and other real-time data, which can be printed through graphs, reports, etc., to facilitate staff analysis

(4) *Diagnostic Control*. Diagnostic control belongs to the main function of the electrical automation control system; after information collection and analysis, the control system should be able to diagnose autonomously, based on the analysis results, including computer, controller, and field terminal equipment diagnosis, so that the system can run stably [20]. In addition, the analysis and diagnosis results to achieve control include power system fault detection and operation detection, so that the power system can operate stably

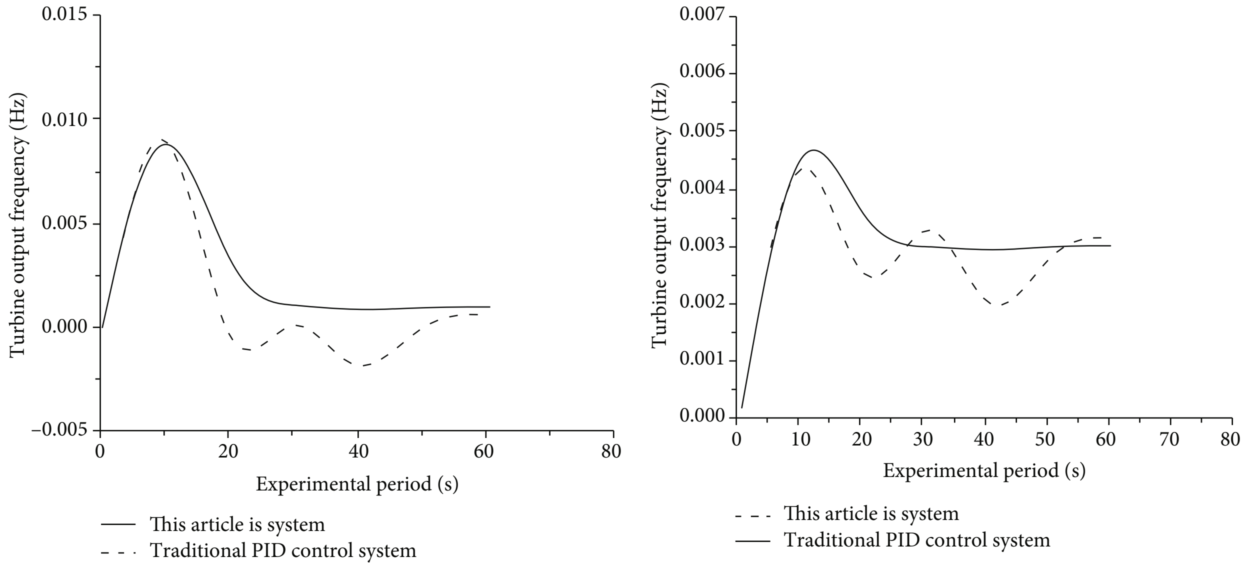
3. Result Analyses

The electrical automation system is more complex, including many disciplines and fields. For example, in terms of electrical automation equipment operation, the operators are required to have good comprehensive quality and perfect professional knowledge. In addition, the complexity of electrical automation focuses on operational effectiveness, which can reduce the shutdown or other accidents caused by operation errors or improper operation. Therefore, AI technology plays an important role in facing this real problem. Take the computer theory as the basis, write a program, which can realize the computer-based intelligent control. Intelligent operation of electrical equipment can replace the problem of insufficient human brain labor force, not only improving work efficiency but also reducing cost input. In addition, the use of artificial intelligence technology can improve the scientific operation of electrical automation equipment and realize the optimization of the real environment of equipment operation. The system is used in a hydropower station to realize the optimal PID control of the turbine in the hydropower station. A single machine sets the isolated load, setting two types of working conditions: working condition A is the design head rated power work; working condition B is the design head, working with partial load. Unit parameters are the following: runner model is HL220-LJ-410; single unit capacity is 102.7 MW; the hydrodynamic inertia time constant is 1.11 s, and the unit inertia time constant is 6.66 s. The parameters of the traditional PID control system are set as $H_p = 4.04, H_i = 1.23, H_d = 2.67$. The parameters of the turbine system in the experiment are shown in Table 1.

Table 1: Parameters of the turbine system in the experiment.

Parameter	Working condition of A	Working condition of B
Turbine transfer coefficient 1	-0.31	-0.27
Turbine transfer coefficient	0.75	1.28
Turbine transfer coefficient	1.47	0.93
Turbine transfer coefficient	0	0
Turbine transfer coefficient	0.78	1.07
Turbine transfer coefficient	0.48	0.36
Generator self-adjusting coefficient	0.21	0.21

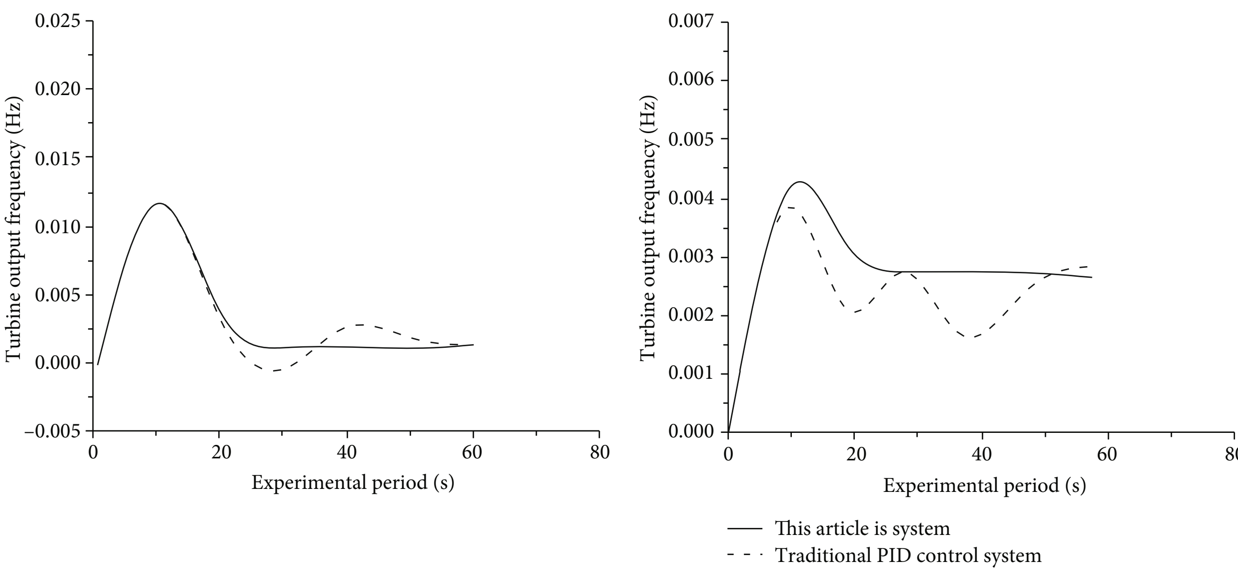
In working condition A, under the control of the system and the traditional PID control system, the response curve of the turbine system subjected to 20% load interference and 2.1 Hz frequency interference is shown in Figure 2. In working condition B, under the control of the system and the traditional PID control system, the response curve of the turbine system subjected to 20% load interference and 2.1 Hz frequency interference is shown in Figure 2. Analysis of the control results in Figures 2 and 3 shows that the control effect of the system in this paper is better than that of the traditional PID control system. Under the control of the system in this paper, the output frequency of the hydraulic turbine system fluctuates less and converges quickly to the



(a) 20% load interference

(b) 2.1 Hz frequency interference

Figure 2: Comparison of control effects under working condition A.



(a) 20% load interference

(b) 2.1 Hz frequency interference

Figure 3: Comparison of control effects under working condition B.

optimal frequency. The output frequency of the hydraulic turbine is stable at about 20 s and remains at 0.000~0.005 between; under traditional PID control, the output frequency of the hydraulic turbine system fluctuates greatly, especially in 20 s-40 s, the output frequency of the hydraulic turbine fluctuates up and down, and it can converge to the optimal frequency when the experiment takes about 50 s. It can be seen that the control effect of the system in this paper is the best.

When 20% load interference and 2.1 Hz frequency interference are tested, the failure rate of the turbine is shown in Figure 4 after the system control is adopted. In Figure 4, the maximum failure rate of the turbine under system control is 0.02 for both 20% load interference and 2.1 Hz frequency interference, indicating that the system in this paper has high anti-interference performance.

Set the input of the turbine system as a unit step signal. Set the number of ants to 30 and the number of iterations to 100. The range of PID control parameters is $H_p = H_i = H_d = [0.00001, 20]$; it is compared with the PLC electrical automation control system and electrical control system of conveyor controllable variable speed device. Figure 5 is the PID step response diagram of the turbine system under the control of three kinds of systems.

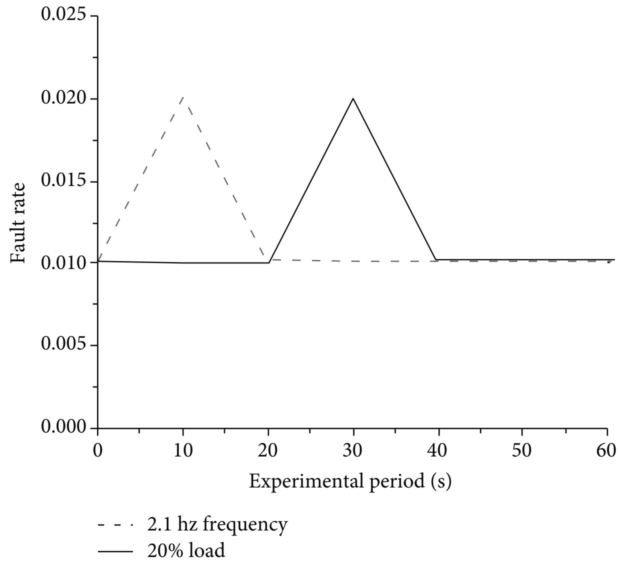


Figure 4: Failure rate of hydraulic turbine controlled by the system in this paper.

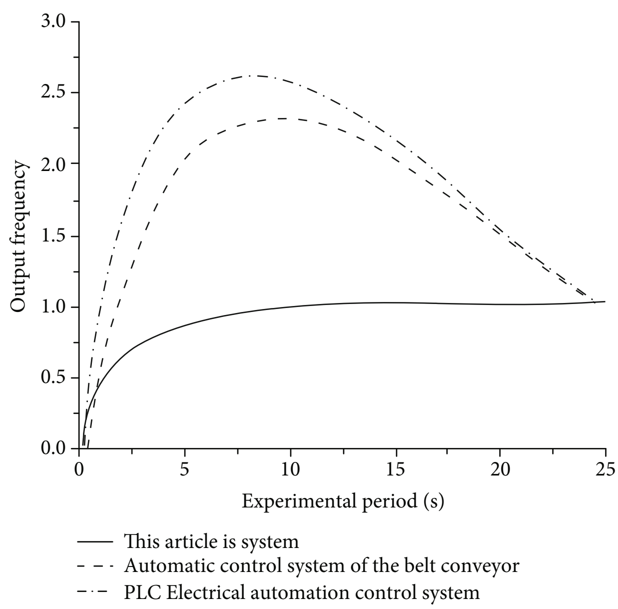


Figure 5: Unit step PID response of hydraulic turbine system.

Table 2 shows PID tuning parameters and system unit step performance indicators. Based on the data in Figure 5 and Table 2, it can be seen that the three PID parameters of the system control have the best effect. Compared with the other two systems, the adjustment time of the turbine system is only 10.26, while that of the other two systems is 37.36 and 16.59 which is much higher than the system. The steady state adjustment error and the number of overshoots are only 0.1677 and lower than the other two systems. Therefore, the system control performance is the best.

Table 2: Unit step performance index of hydraulic turbine system.

Indicators	System	PLC system	Belt conveyor controllable speed change device system
H_p	8.0031	4.59	10.1
H_i	0.0072	1.7	1.9945
H_d	0.6489	0.9	1.6879
Adjust the time	10.26	37.36	16.59
Steady-state adjustment error	0.1677	8.2575	4.4408
The number of overshoot	0.1677	35.9715	18.1964

4. Discussion

The function of the electrical automation control system is control, and the premise of the control function is to analyze the data to provide the control basis. (1) Information collection: the electrical system is required to have corresponding data terminal collection and software equipment, and the main function of information collection is to provide the basic guarantee for the realization of the control function. The terminal equipment and software are used to collect the operation and environment of the equipment in the power system, mainly including the operation time, equipment quantity, environmental temperature, fault situation, and alarm system and signal. Use the data collected by the software and equipment to provide operation information to the real-time information in the power system, so that the staff can effectively handle emergencies. (2) Information transmission: information is two-way transmission; that is, the terminal equipment and software collect information to the processing center for transmission; the processing center is to control the processing instructions to the execution terminal transmission. Therefore, the information transmission process is particularly important, and the information transmission is also the main condition for the control and supervision of the control system. Power system transmission equipment mainly includes video cable, signal cable, coaxial cable, and optical cable, to choose the corresponding transmission mode by transmission distance and model type, to ensure the quality and speed of information transmission, and to avoid information loss, untimely transmission, coding confusion, and information confusion. The controller is required to include the control module, power supply module, communication module, and editing module, to ensure the working coordination of the system. The control results of Figures 2 and 3 show that the control effect of the system is better than the traditional PID control system, and the output frequency of the turbine system fluctuates less and quickly converges to the optimal frequency. Under the traditional PID control, the output frequency of the turbine system can converge to the optimal frequency at about 50 s. Therefore, the system controls the best.

5. Conclusions

Under the background of the rapid development of modern science and technology, our life has been changed; artificial intelligence technology has promoted the development of modern civilization; as a new high technology, it has high use value in real life. Design an electric automation control model optimization based on the artificial intelligence algorithm, and apply it in the experiment, after testing in different working conditions; when there is 20% load interference and 2.1 Hz frequency interference, the control effect of the system is better than the traditional PID control system; under the control of the system, the output frequency of the turbine system fluctuates less, converges quickly to the optimal frequency, and has high robustness; it is predicted that the future electrification industry will inevitably rely on the artificial intelligence algorithm. In the automatic control of electrification, the application of the artificial intelligence algorithm can greatly improve the control reaction time of the automatic control of electrification, save cost, and achieve efficient production. Therefore, the application of artificial intelligence algorithms is very broad. The application of AI technology to electrical automation control systems is crucial to the development of various fields. At present, the electrical automation control system has been widely used in intelligent buildings and has achieved certain application results. When creating the electrical automation control system, people must fully consider the actual requirements, use appropriate methods to calculate the automatic control system parameters, and actively use artificial intelligence technology to improve the effect of electrical automation control. The design and development of the electrical automation control system must analyze the working environment interfering with the operation of equipment and the operation of equipment and pay great attention to the interference of external environment during design. In addition, to ensure that the system can complete a stable power transmission, based on the system research and development and design cycle, the system research and development personnel must accurately grasp the working principle of the system.

Data Availability

The data can be made available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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