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Optimization Model of Ship Engine Room Electrical Equipment Layout Based on Deep Learning

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Abstract

With the rapid development of computer technology and big data, algorithms such as deep learning and neural networks have been widely applied. Among them, deep learning has gradually become a hot topic and mainstream direction in intelligence. This computer model constructed using multiple processing layers has shown significant effects in aerospace, electrical engineering, automotive, and urban transportation industries. This paper uses genetic algorithms and particle swarm optimization algorithms in deep learning to study and optimize the layout of ship engine room electrical equipment. Firstly, we analyze the application of genetic algorithms to solve the layout planning of ship engine room electrical equipment. The arrangement of equipment and the utilization of ship's electrical wires are recombined through data analysis to understand the correlation of various factors affecting the layout fully. Secondly, we use particle swarm quantum algorithm to optimize the layout structure of genetic algorithms, establishing constraints to obtain the final objective function path. Finally, attention should be paid to equipment anomalies before the layout of ship engine room electrical equipment. Deep learning establishes a spectrogram anomaly detection database to explore the location of abnormal states through detection algorithms. The research results show that the optimization of ship engine room electrical equipment layout based on deep learning using particle swarm algorithms has achieved good results in terms of usage.

Keywords: Deep Learning, Particle Swarm Algorithm, Genetic Algorithm, Ship Engine Room

1. Introduction

With the proposal of the construction plan for China's golden waterway and the construction of a large number of large ports within the waterway range, the transportation volume in the southwest water area is the largest in the entire region. With the limitations of flow rate and water volume of each river, there are increasing constraints on the operation of ships in the waterway. Accelerating the modernization of port terminals, ports in the southwestern waters with Guangxi as the main region have become a core battleground. To meet the requirements of different waterways for ships, we have set new goals for the advancement of ship type standardization[1]. Constructing an efficient, green, and smooth modern water transportation system requires adjustments in the internal technical structure of ships. With the development of the Internet of Things and computer technology in recent years, the automation level of ship engine room electrical systems has also undergone significant changes. The electrical equipment of the entire ship's engine room has much higher demands for the electrical system than ordinary vessels[2]. Therefore, how to ensure a safe, green, efficient, and reliable ship power system has become the main goal of ship power system design both domestically and internationally[3].

The power system of many ships is automatically matched to meet the layout standards of their own navigation waters, and their characteristics are quite obvious. Therefore, when analyzing and designing the layout system, its uniqueness needs to be fully considered[4]. Currently, the electrical capacity of inland river ships is relatively small, mainly supplying various equipment on the ship itself, so the individual unit capacity is not large. The largest power station capacity of outer river ships is only a few tens of thousands of kilowatts, and the single-unit capacity is only a few kilowatts. It can be seen that the principle of the ship's power system is quite different from that of normal power distribution. In addition to the small electrical capacity, all large-consuming compressors and fire-fighting equipment need to occupy power. When the main equipment on the ship starts, the power and impact of the entire power grid will affect the voltage[5]. Therefore, the electrical equipment inside the ship's engine room should be stable and reliable. For the requirements of generators, the response time of the configured electric decoupling voltage regulator should be fast, short, and accurate, and it should also have a reasonable and intelligent layout to improve the performance of early-stage equipment. The ship's electrical equipment layout system should be able to provide reliable power under various navigation segments and water area restrictions, and ensure power quality during the changing and complex transportation process. In order to meet the above power grid requirements, ships not only need to configure reliable generators but also consider the overall impact of electrical equipment layout. Only by treating the ship's power system as a whole and planning and designing the electrical equipment structure can ensure the normal operation of each link[6].

2. Development Trends and Current Status of Deep Learning Technology

For a long time, ships have varied and complex designs, with relatively small average carrying capacity. This has imposed obvious limitations on the utilization of waterways and major navigational facilities [7]. Other factors that restrict the development of shipping include the use of electrical equipment and power systems. With the development of ships towards larger, standardized, and intelligent vessels, the establishment of ship engine rooms that meet the requirements of any navigation has become a major focus of research in various countries. China has drawn on the experience of standard ship engine room design in water bodies such as the Beijing-Hangzhou Grand Canal and the Three Gorges Reservoir, and has optimized their layouts to increase the frequency of electrical equipment utilization. Efforts have been made to encourage the use of technological ships and to eliminate unsafe, low-performance, and non-environmentally friendly vessels in demonstration layouts [8]. For other ship models that cannot meet the requirements for electrical equipment, methods such as natural elimination, transformation elimination, and adaptation elimination have been implemented. With the rapid development of computers and deep learning algorithms, there have been many in-depth studies on electricity usage in ship technology. Electricity, as the daily energy source in ship engine rooms, is a special energy source that requires high standards in terms of safety, reliability, and timely response [9].

After becoming a mainstream development direction in the field of artificial intelligence, deep learning, as a computational model composed of multiple processing units, has completed the optimization of machine technology at an abstract level [10]. This algorithm, which represents machine learning and artificial learning, has also brought revolutionary changes at the level of neural networks. Therefore, deep learning has become a representative term for artificial neural network intelligent technology, with unique processing units and complex structures. To address the need for large amounts of computational data in current deep learning technology, neural network parameters that are easy to obtain and determine are selected during the training process. Various methods such as neuron learning, transfer learning, and network architecture have gradually become indicators of the progress of deep learning technology. In the development of deep learning technology, the main focus has shifted from experience-based guidance to the promotion of new task-oriented models, where neural networks not only have the ability to learn but can also predict certain data results. Among them, deep learning fusion technology is a good way to change traditional transfer learning, and the basic idea is to adjust the network structure based on the support of object data and the similarity of the target data distribution. The main purpose of this method is to use the adjusted network layout to maximize the performance of the algorithm, enabling it to function normally with limited information data. Although deep learning technology has shown good research results in natural language processing and complex games, there are still shortcomings in its application to the optimization of ship engine room electrical equipment layout. These bottlenecks have become the main factors restricting the development of deep learning and ship electrical equipment layout technology. In summary, this paper starts from the use of genetic algorithms and particle swarm optimization algorithms in deep learning to optimize the layout structure of ship engine room electrical equipment.

3. Deep Learning Technology and Genetic Algorithm Optimization

3.1. Ship Engine Room Electrical Equipment Layout Model Based on Deep Learning and Genetic Algorithm

With the standardization requirements for ship types, the principle of ensuring that ships have individuality, commonality, and functionality is gradually expanding to various components. Currently, the use of ship electrical technology and intelligent devices has drawn extensive attention to electric propulsion, where both direct current generators and alternating current generators can maintain the normal operation of electrical appliances by charging batteries. In addition to considering stable power supply during work, higher standards are also required for the performance of electrical equipment during navigation. With scientific and technological innovations in electronic components' production, many shortcomings in ship engine room equipment have been successfully addressed. The main features of electrical equipment systems need to have high capacity and intelligence, with stable performance and complete functionality being secondary characteristics. Advanced computer technology and manufacturing processes have facilitated the friendly transformation of electrical equipment. In our research, we primarily focus on optimizing the intelligent layout of ship engine room electrical equipment. Many foreign researchers use multi-objective deep learning genetic algorithms and fuzzy reality to achieve overall design in structural design.

These algorithms involve the calculation of microelement data and the establishment of adaptive constraints based on the starting and ending points set according to each ship's navigation direction, serving as the mathematical model's basis. The similarity of the ship's electrical pipelines and valve layouts is adjusted according to the constraint method, using the installation principles of ship pipelines as the modification criteria to ultimately obtain the appropriate intelligent electrical layout path for ship engine rooms. The basic principle of the genetic algorithm can solve the problem of the optimal choice of the path of ship engine room electrical equipment by using several objective functions as candidate solutions. The mathematical functions and corresponding algorithms for evaluating the effectiveness of the entire population are established based on the objectives set by the genetic algorithm, and the results of the evaluation are adjusted according to the optimal layout selection. In the regular genetic algorithm, the layout schemes to be optimized are extracted for data extraction, and the constant of the target object is compared with indicators, and then taken as the positive function with the lowest coefficient. The target object refers to the spatial real problem to be dealt with in the search for the optimal layout and the calculation expression is obtained as follows:

$$Fit(x) = \begin{matrix} f(x) + D_{\min}, f(x) + Min > 0 \\ 0, f(x) + D_{\min} < 0 \end{matrix} \quad (1)$$

$$Fit(x)_2 = \begin{cases} f(x) - N_{\min}, D_{\min} - f(x) > 0 \\ 0, D_{\min} - f(x) < 0 \end{cases} \quad (2)$$

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In the equations, represents the maximum coefficient to be solved, and another variable represents the minimum coefficient. The optimal use threshold of the fitness function has a significant impact on the convergence of the genetic algorithm. When the algorithm performs the calculation initialization, the characteristic differences of each electrical path are relatively large. Therefore, selecting the obtained initial function can better meet the final expectations.

3.2. Ship Engine Room Electrical Equipment Layout Model Based on Particle Swarm Optimization Genetic Algorithm

Establishing a mathematical model for the design and layout of ship engine room electrical equipment is one of the main approaches to constructing intelligent ship engine room electrical systems. Compared with traditional ship engine room electrical equipment layout, it differs in drawing methods, layout routes, energy consumption, resource utilization, and many other aspects. Traditional ship engine room electrical equipment layout mainly relies on manual drawing on paper, making it difficult to quickly solve and analyze dynamically generated problems. On the other hand, the deep learning intelligent layout method for ship engine room electrical equipment utilizes advanced computer big data technology to collect and process design scheme features. To make computer technology more adaptable to the intelligent work of electrical equipment, we also need to establish corresponding accurate mathematical models based on real ship engine room structures. How to construct efficient and intelligent algorithms to explore the optimal layout path for ship engine room electrical equipment is a key challenge in the ship electrical industry, and more and more new intelligent algorithms have their advantages and disadvantages. The working principle of traditional genetic algorithms starts from a population and is updated through stages such as selection and crossover until each variable meets the final computational requirements.

In our previous research, we connected the internal space of the ship engine room with the genetic space and unfolded the mathematical encoding and binary algorithm. We randomly generated multiple independent individuals for the electrical equipment instruments and evaluated each object. However, the limitations of this traditional genetic algorithm are quite apparent, with efficiency reduction and poor precision appearing in the later stages of data optimization. The deficiency in the optimal layout structure can only be discovered when the computation terminates, resulting in reduced diversity in the later stages of each objective variable. As a result, the algorithm is unable to perform deep learning in the final solving process, and all resources consumed in the early stages of the algorithm become wasted. Therefore, we propose to use the particle swarm optimization algorithm to optimize the ship engine room layout design. Based on the heuristic characteristics of the layout algorithm, the particle swarm optimization algorithm combines multiple comprehensive solutions using its random search pattern. In general, the structure of the ship's engine room equipment needs to consider the design requirements of the compartments, and corresponding equations are established for this complex constraint problem:

$$\min F(X) = (f_1(x), f_2(x), ..., f_m(x)) \quad (3)$$

Among them, represents the diversity variable in the design. The coordinates of the variables correspond to the arrangement of components inside the ship's physical interior. Next, the imbalance function is redefined from the perspectives of balance, maintenance, and ship's power circulation:

$$f(x) = \sum_{i=1}^{m} f_i \times p_i \quad (4)$$

In the formula, represents the number of ship's equipment, and represents the quality of the equipment. Next, based on the ship's engine room electrical equipment layout structure provided by the particle swarm optimization algorithm, the monitoring system inside the engine room is completed.

From Figure 1, it can be seen that the terminal system of the ship's electrical equipment is installed with a central control center. Through data transmission from sensors to various distributed systems, the flow of current between each interface follows the rules of intelligent layout.

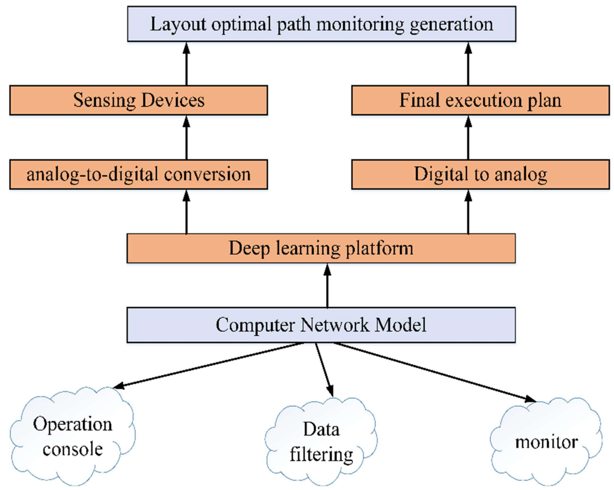

Figure 1. Ship Engine Room Electrical Equipment Layout Structure

4. Results of Ship Engine Room Electrical Equipment Intelligent Layout Model

The changes in ship's electricity consumption are influenced by technological development and local economic support, and the research on electrical equipment has a certain history. In the early days, electricity in the ship's engine room was only for meeting normal requirements, and later it gradually applied to navigation signal command and power auxiliary direction. In our research, we used two algorithms based on deep learning technology to discuss and analyze the optimization of ship's engine room electrical equipment layout. First, in the traditional genetic algorithm, we found that the entire computation process must consider how to adopt the parameters of ship's electrical changes. The composition parameters are related to the calculation results and the final efficiency of the entire algorithm. The traditional particle swarm optimization algorithm can optimize the nonlinear fitting problem brought by the genetic algorithm in a parallel and random way. It reduces the low accuracy, low efficiency, and high cost of the genetic algorithm in the actual research of ship's engine room electrical equipment layout. This particle swarm optimization algorithm is easy to implement, with a simple structure, and does not require cumbersome operations such as guided optimization of the target to be optimized. We compare and analyze the accuracy of the results of the genetic algorithm and the particle swarm optimization algorithm in the final design of ship's engine room electrical equipment layout, as shown in Figure 2.

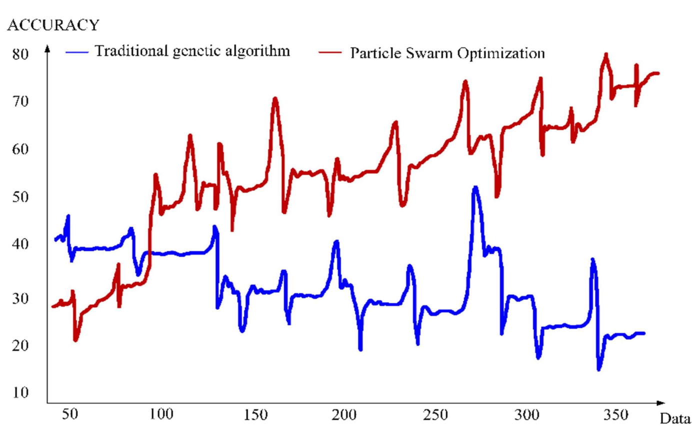

Figure 2. Comparison of Accuracy between Two Algorithms

From Figure 2, it can be seen that the accuracy of the traditional genetic algorithm is significantly inferior to the particle swarm optimization algorithm. Therefore, the particle swarm optimization algorithm further validates its effectiveness. By setting weight coefficients and velocity limits in population optimization and parameter initialization, updating the best position of each particle in each generation, the generation of the optimal layout path is ultimately achieved. In addition to the differences between algorithms, engine room layout optimization also has different choices in dimensions. Two-dimensional and three-dimensional layouts can both obtain the orientation of equipment and paths. Based on different dimensions and the requirements of ship's engine room, the most reasonable engine room layout structure is chosen. In order to better represent this complex process, we made some simplifications in the layout. When arranging the ship's engine room electrical circuits, the impact on the ship's normal life and navigation performance needs to be considered. The power required by complex equipment is simplified, and the layout path is shown in three dimensions through projection technology. Finally, we compared the utilization rate before and after optimizing the layout of ship's engine room electrical equipment, as shown in Figure 3.

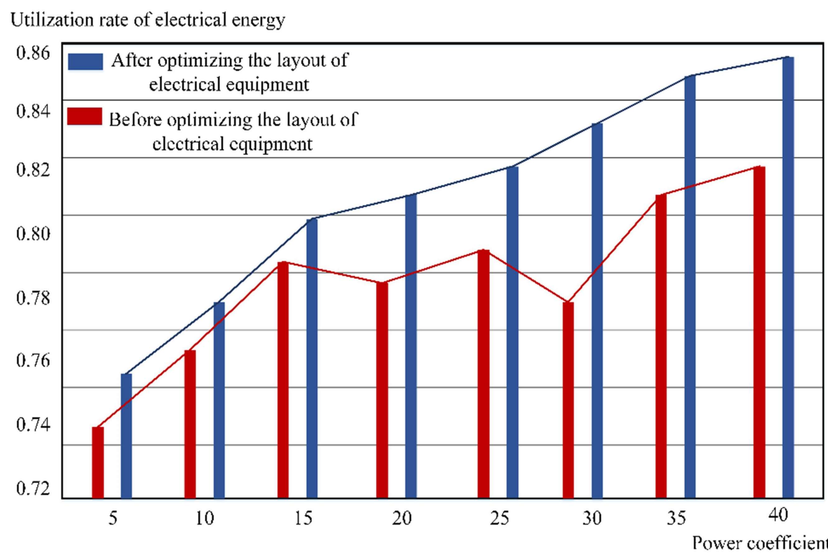

Figure 3. Changes in Utilization Rate before and after Optimizing the Layout of Ship's Engine Room Electrical Equipment

From Figure3, it can be seen that the utilization rate of ship's engine room electrical energy significantly increased after optimizing the electrical equipment layout. From this result, we found that the factors affecting the capacity and utilization rate of ship's engine room electrical equipment are mainly reflected in the layout path of electrical equipment.

5. Conclusions

In this paper, we first briefly discussed the layout path schemes of ship's engine room electrical equipment obtained by two intelligent algorithms under deep learning technology. We compared the effectiveness of the obtained layout structures quantitatively and qualitatively. By comparing the numerical values of the objective functions in the computations of the two algorithms, we further proved that the particle swarm optimization algorithm is more suitable for obtaining the optimal solution of ship's engine room electrical equipment layout than the genetic algorithm. Secondly, we analyzed and designed the power equipment system of ship's engine room, adjusted the configuration of internal engines in the ship's system, and connected the electrical consumption with energy utilization. According to the specific sailing conditions of each ship, we chose the layout design scheme that is suitable for the ship's body. Finally, we compared the two algorithms in terms of effectiveness and accuracy and chose to use the particle swarm optimization algorithm to optimize the subsequent layout scheme. The results showed that the ship's engine room electrical equipment layout based on deep learning technology significantly improved in actual bearing capacity and utilization rate after being optimized by the particle swarm optimization algorithm.

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