Design System of Refrigerator Drive Control Circuit Based on Deep Learning Algorithm

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Abstract: Refrigerators play an important role in modern life, as they are used to maintain indoor temperature comfort and freshness of food. The traditional design methods for the drive control circuit of refrigerators usually use traditional control algorithms, such as PID control, but these methods often fail to meet the efficient and intelligent requirements of modern refrigerators. Therefore, a refrigeration machine drive control circuit design system based on deep learning algorithms has emerged. Deep learning algorithm has powerful pattern recognition and adaptive learning capabilities, which can extract features, predict and control by learning a large number of data. Applying deep learning algorithms to the design of refrigeration machine drive control circuits can more accurately predict and control the working state of the refrigeration machine, improving the performance and stability of the control system. The function of the refrigeration machine drive control circuit design system based on deep learning algorithm is to achieve intelligent control of the refrigeration machine. Through experiments, it can be seen that the command response speed of the refrigeration machine drive control circuit design system based on the deep learning algorithm was within 15 seconds, the fault handling capacity was over 47, and the fault handling speed was within 24 seconds. From this, it can be seen that the design system of refrigeration machine drive control circuit based on deep learning algorithm plays an important role. It can improve the control accuracy, energy efficiency, and intelligence level of refrigerators, meeting the requirements of modern refrigeration needs.

Keywords: Deep Learning, Refrigeration System, Drive Control, Circuit Design, Process Optimization

1. Introduction

With the development of technology and the improvement of people's living standards, the demand for refrigeration systems is also increasing. In recent years, the application of refrigeration systems has become increasingly widespread [1]. However, in actual operation, there may be fluctuations or decreases in fault diagnosis performance [2]. Therefore, this requires diagnostic models to have the ability to relearn to adapt to on-site data. Among them, drive motor control is a key link in system development and design [3]. However, in the face of complex environments,

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circuit systems are prone to faults, and existing redundant fault-tolerant technologies cannot effectively improve the reliability of the system [4]. Traditional circuit fault diagnosis methods have low accuracy and cannot accurately detect circuit faults [5-6]. Therefore, it is necessary to find new solutions. The success of deep learning provides new ideas for these problems, and the increase in correct calculation methods and degrees has a positive effect on target recognition [7]. Therefore, the design of a refrigeration machine drive control circuit system based on deep learning algorithms can improve the accuracy of fault diagnosis and the reliability of the system.

In the face of potential fluctuations or degradation in fault diagnosis performance of refrigeration systems in actual operation, it is necessary to seek new solutions. Among them, the application of deep learning algorithms provides new possibilities for improving the accuracy of fault diagnosis and the reliability of the system. By designing a refrigeration machine drive control circuit system based on deep learning, it is expected to improve the existing diagnostic model and better adapt to on-site data, thereby improving the stability and efficiency of the refrigeration system.

2. Traditional Refrigerator Drive Control Circuit and Improvement Assumption

2.1 Defects in Traditional Refrigerator Control Algorithms

Thanks to the progress of manufacturing technology and the development and improvement of heat and mass transfer theory, refrigeration systems have continuously evolved and developed, and in recent years, many forms of refrigeration systems have emerged [8]. The traditional refrigeration machine control algorithm usually uses a fixed PID controller to control the operation of the refrigeration machine. However, this fixed control algorithm cannot adapt to different working conditions and load changes, resulting in poor control performance. In addition, traditional refrigeration machine control algorithms often have significant response lag, which means that the controller responds slowly to system changes. This would result in significant temperature fluctuations in the system and a longer adjustment time, and has strong research value and practical research significance in the drive controller of ice makers [9].

The refrigeration system is an important part of daily life [10], and traditional refrigeration machine control algorithms often aim to maintain a constant temperature while neglecting the optimization of energy consumption. This leads to excessive operation of the refrigerator at some times, resulting in energy waste. In addition, traditional refrigeration machine control algorithms often only consider a single control objective and cannot cope with complex operating conditions and the needs of multiple control objectives. This leads to poor adaptability of control algorithms and difficulty in meeting the needs of practical applications. The specific defects and impacts are shown in Figure 1.

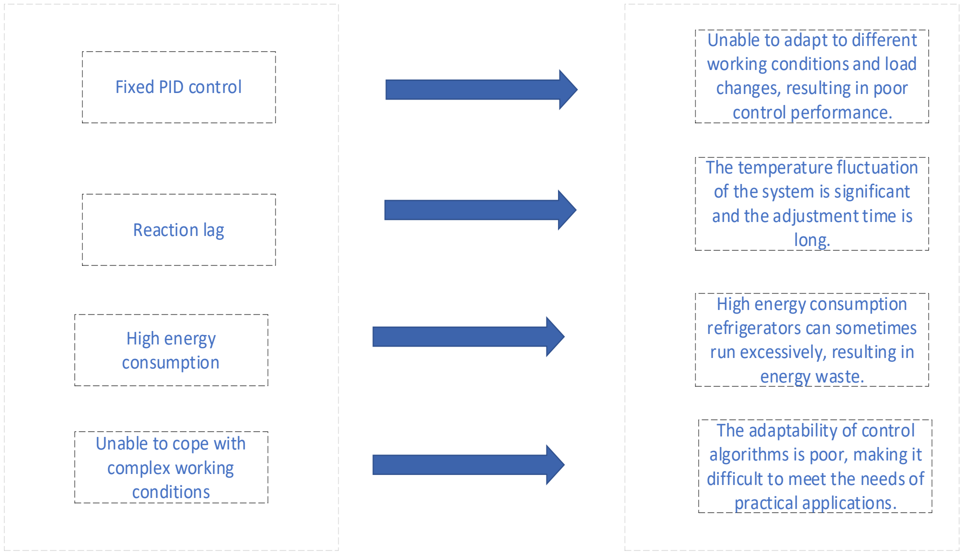

Fig.1 Defects and impacts of traditional control algorithms

The regulation of environmental temperature by refrigeration systems plays an important role in production and daily life [11]. Based on the analysis of Figure 1, it can be seen that traditional refrigeration machine control algorithms have defects such as fixed PID control, delayed reaction, high energy consumption, and inability to cope with complex working conditions. In order to improve the control performance and energy utilization efficiency of refrigerators, more advanced control algorithms and strategies need to be adopted.

2.2 Improvement Aspects

With the rapid development of the social economy, electrical equipment has been widely used. As the basic energy source for people's lives and work, the power system's operational quality and efficiency have attracted attention from various fields [8]. However, traditional refrigeration machine control algorithms have some shortcomings, which limit the performance of refrigeration machines in efficient and intelligent requirements. Traditional algorithms often only consider a single control objective and cannot cope with complex operating conditions and the needs of multiple control objectives, resulting in poor adaptability of control algorithms and difficulty in meeting the needs of practical applications. In summary, in order to improve the control performance and energy utilization efficiency of refrigeration machines, more advanced control algorithms and strategies need to be adopted to improve the shortcomings of traditional refrigeration machine control algorithms.

To address the shortcomings of traditional refrigeration machine control algorithms, the following improvement measures can be taken:

(1) Dynamic PID control: The traditional fixed PID control algorithm can be improved to a dynamic PID control algorithm. By monitoring the working conditions and load changes of the refrigeration system in real-time, the parameters of the PID

controller can be adaptively adjusted to improve control performance and response speed.

(2) Predictive control: the Model predictive control algorithm is introduced; the dynamic model of the refrigeration system is used for prediction in the control process, and the operating parameters of the refrigerator are adjusted according to the prediction results. This can reduce control lag, improve control accuracy and stability.

(3) Energy consumption optimization control: Taking energy consumption optimization as one of the control objectives, optimization algorithms (such as fuzzy control, genetic algorithm, etc.) are used to find the optimal operating strategy of the refrigeration machine. By dynamically adjusting the operating parameters of the refrigerator, it is possible to reduce energy consumption while maintaining a constant temperature.

(4) Multi objective optimization control: Considering the complex changes in operating conditions and the needs of multiple control objectives, multi-objective optimization control algorithms can be adopted. By balancing the weights between different objectives and finding the optimal control strategy, the refrigeration machine can maintain efficient operation while meeting multiple objectives.

(5) Algorithm based on artificial intelligence: An intelligent refrigeration machine control algorithm has been constructed using artificial intelligence technologies such as neural networks and deep learning. By learning and optimizing the process, the algorithm can automatically adapt to different working conditions and load changes, improving control performance and energy utilization efficiency.

Based on the above analysis, the system can effectively improve the shortcomings of traditional refrigeration machine control algorithms by adopting dynamic PID control, predictive control, energy consumption optimization control, multi-objective optimization control, and artificial intelligence algorithms, thereby improving control performance and energy utilization efficiency.

3. Deep Learning Algorithm Combined with Refrigeration Machine Drive System

3.1 Combining Deep Learning with the Advantages of Ice Makers

The traditional control algorithms for refrigerators have some shortcomings, and the emergence of deep learning algorithms provides new possibilities to solve these problems. By training models with a large amount of data, the control performance and energy utilization efficiency of refrigerators can be improved. Moreover, as an important component of communication systems, data centers play a significant role, especially in refrigeration systems [9].

Deep learning algorithms can extract complex relationships and nonlinear features hidden in refrigeration system by learning and analyzing a large amount of real-time data. Compared to traditional fixed PID control algorithms, deep learning algorithms can better adapt to different working conditions and load changes, thus achieving more accurate control. The operational framework is shown in Figure 2.

Secondly, deep learning algorithms have fast response speed and low lag effects. Deep learning algorithms can accurately predict future system trends through learning and predicting historical data, thereby achieving faster control responses. This can greatly reduce temperature fluctuations in the system and improve the stability and accuracy of control.

In addition, deep learning algorithms can optimize the energy consumption of refrigerators by optimizing control strategies. Deep learning algorithms can automatically adjust the operating parameters of refrigeration machines based on real-time data and environmental conditions, ensuring that they maintain a constant temperature while minimizing energy consumption. This can effectively reduce the energy consumption of the refrigerator and improve energy utilization efficiency.

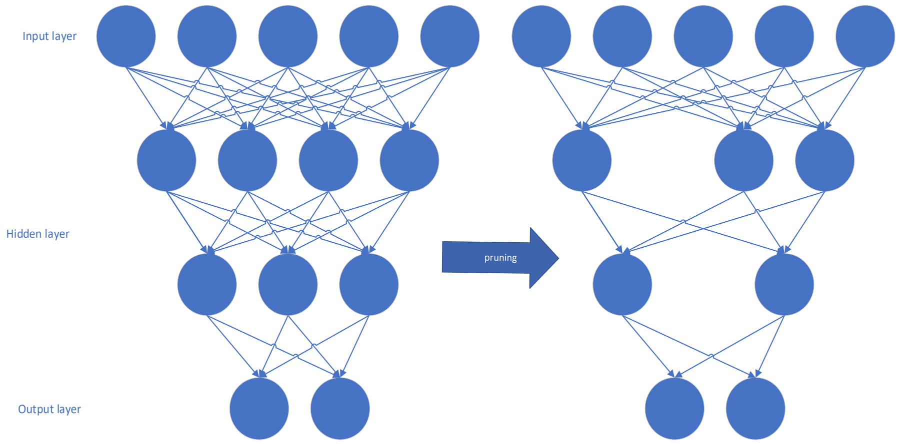

Fig.2 Working principle of deep learning algorithm

Finally, deep learning algorithms have strong adaptability and flexibility. Deep learning algorithm can meet the requirements of complex working conditions and multiple control objectives through multi-objective optimization and Adaptive learning. This makes the control algorithm of the refrigerator more intelligent and flexible, and can better adapt to the needs of practical applications. It can be seen that deep learning methods have become a powerful driving force for technological progress [10].

3.2 Data Collection and Preprocessing

Combining deep learning algorithms with data acquisition and preprocessing of refrigeration drive systems is a method of applying artificial intelligence technology to refrigeration system optimization. Refrigeration systems typically include multiple sensors and monitoring devices for collecting parameter data such as temperature, pressure, and flow rate. These data can be analyzed and processed through deep learning algorithms to improve the efficiency and performance of refrigeration systems.

Through data collection, data preprocessing, data analysis and modeling, prediction and optimization, and establishing accurate models for predicting refrigeration system performance, fault status, and energy consumption, the deep learning process is comprehensively summarized in Figure 3.

From the above analysis, it can be seen that deep learning algorithms combined with data acquisition and preprocessing of refrigeration drive systems can provide effective solutions for the optimization and intelligent management of refrigeration systems. By using Big data and artificial intelligence technology, intelligent monitoring, prediction and optimization of the refrigeration system can be realized, and the system performance and energy efficiency can be improved. Moreover, as an important branch of machine learning,

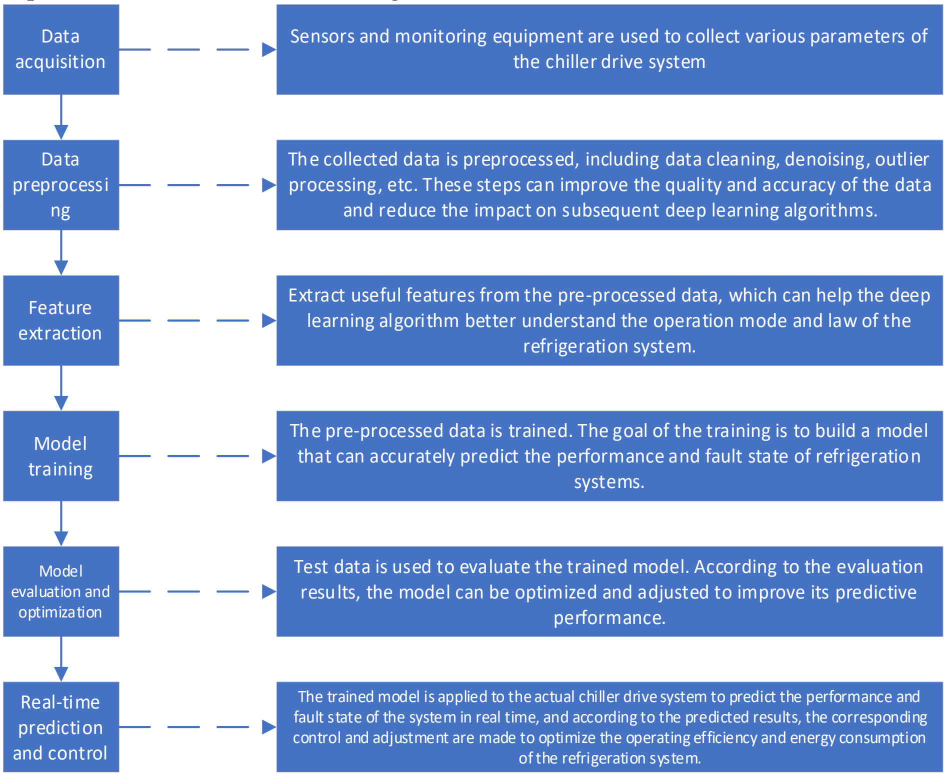

Fig.3 Deep learning algorithm data collection and preprocessing

3.3 Model Training and Optimization

Before designing deep learning algorithms combined with refrigeration drive systems, it is necessary to first start and initialize the refrigeration drive system. The refrigeration machine drive system is a key system used to control and regulate the operating status of the refrigeration machine, ensuring that the system can effectively provide cooling and cooling functions. The introduction of deep learning algorithms can provide more intelligent control and optimization strategies to improve the performance and efficiency of refrigerators. Therefore, in the entire process design, system power on and initialization are essential steps, laying the foundation for the operation of deep learning algorithms and the driving of refrigeration machines. Through reasonable startup and initialization operations, the stability and reliability of the system can be ensured, providing a good environment and conditions for subsequent deep learning algorithm processing and refrigeration machine control.

So model training should focus on this aspect. When the system starts, initialization settings are carried out, followed by initialization of deep learning algorithms, including model selection, parameter initialization, etc. In the process of initiating the deep learning algorithm, data from the refrigeration machine drive system is received as input, and then the motor unit of the refrigeration machine is controlled based on the output of the deep learning algorithm to adjust the operating status of the refrigeration machine. Finally, the status of the refrigeration machine drive system is monitored. When a fault or abnormal situation occurs, the processing of the deep learning algorithm is interrupted and the corresponding fault handling program is executed, as shown in Figure 4.

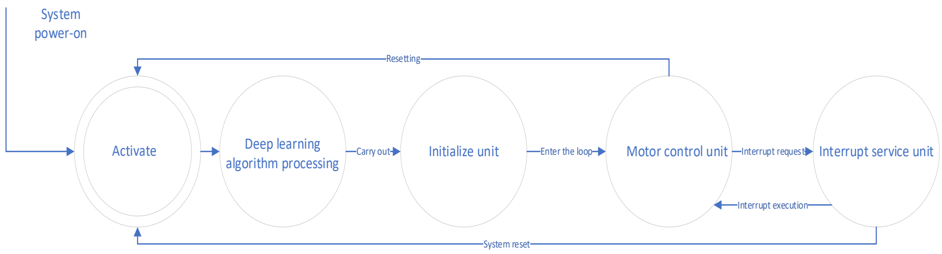

Fig.4 Operation process of deep learning algorithm combined with refrigeration machine drive system circuit

4. Formulas and Experiments

4.1. Formula

Formula (1) predicts the output temperature y of the refrigerator assuming an input feature x (representing the environmental conditions of the refrigerator). The prediction formula can be established by using an exponential smoothing model:

$$y\_t = \alpha \times x\_t + (1 - \alpha) \times y\_\{t-1\} \quad (1)$$

Among them, y_t represents the predicted temperature at the current time, and x_t is the input feature of the current time; y_{t-1} represents the predicted temperature within the previous unit of time, and α represents the smoothing coefficient, which is responsible for controlling the weight of the current time. By adjusting the value of α, it is possible to balance historical and current data.

Formula (2) determines the control operation A of the refrigerator based on the current temperature value y. Using the fuzzy control strategy, the control operation can be calculated according to the fuzzy set and control rules of the current temperature:

$$A = \sum (W \times A) \quad (2)$$

In Formula (2), W is the membership degree of the fuzzy set corresponding to the current temperature value y, and A is the control operation corresponding to the control rule. The control strategy based on fuzzy logic is realized by defining fuzzy sets and control rules, and calculating the weight of membership and control operations.

4.2. Experiment

In order to test the performance of the refrigeration machine drive control circuit design system using deep learning algorithms, the testers conducted 100 usage experiments on four control systems, namely Group A, Group B, Group C, and Group D. The following four aspects were tested and evaluated: system response speed, system failure frequency, average failure processing speed, and number of crashes.

System command response speed: In each experiment, the response speed of the system can be tested by introducing temperature changes in the environment. It can record the temperature changes of the refrigerator and the response time of the system control circuit. By analyzing statistical data on response time, the response speed of the system can be evaluated.

Number of system failures: During the experiment, 50 common fault situations were randomly simulated, such as sensor failures, circuit failures, etc. The number of times the system successfully processed faults was recorded, and the types of faults were classified and counted. The reliability and stability of the system were evaluated by comparing the number of failures of different systems.

Average processing speed of faults: When a system fault occurs, the time from the occurrence of the fault to the completion of fault handling was recorded. The average time for troubleshooting was calculated and compared with other systems. This can evaluate the system’s fault handling efficiency and responsiveness.

Number of crashes: This recorded the number of times the system crashes during the experiment. Crash refers to a situation where the system cannot operate normally or stops responding. By comparing the number of crashes in different systems, the stability and reliability of the system can be evaluated.

The experimental data is shown in Figure 5.

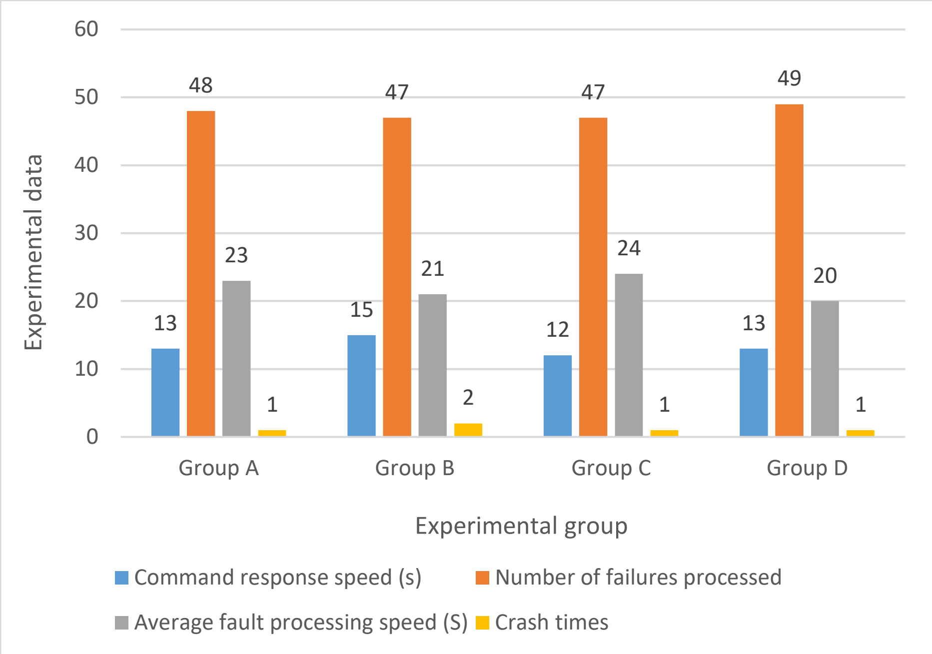

Fig.5 Experimental data of the refrigerator drive control circuit design system for deep learning algorithm

Through the analysis of experimental data in Figure 5, it can be seen that the system command response speed of each group was within 15 seconds, and the fault handling capacity was over 47; the fault handling speed was within 24 seconds, and the number of crashes was less than 2. Overall, the system's overall corresponding speed, fault handling capacity, and fault handling speed were relatively excellent.

5. Conclusion

Based on the analysis above, it can be seen that the design system of the refrigeration machine drive control circuit based on deep learning algorithm has certain advantages in response speed and stability. According to the analysis of experimental data, it can be concluded that the system had a fast response speed and can respond promptly to changes in environmental temperature; the fault handling ability was relatively efficient, but the difference in fault frequency was not significant, and further evaluation of the system's reliability and stability was needed; the system had fewer crashes, demonstrating a certain degree of stability and reliability. In the future, the design system for refrigeration machine drive control circuits based on deep learning algorithms can further optimize system performance, such as improving algorithm and hardware design, and explore the combination of deep learning algorithms with other intelligent technologies such as the Internet of Things and cloud computing, thus achieving more efficient, reliable, and intelligent refrigeration machine drive control circuit design systems. Through these efforts, the performance and user experience of the system can be further improved to meet the needs of modern refrigeration machine control.

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