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Intelligent Monitoring of Cabin Temperature Based on Recurrent Neural Network

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Abstract: The engine room of a ship is the heart of the cabin. The power plant and electrical facilities located in the engine room provide all kinds of energy for the ship to ensure the normal operation of the ship, ensure the normal life of the crew and help the crew to complete various operations. The engine room is an important place for the generation, transmission and consumption of all kinds of energy on the ship, and is the core of the whole ship. The generalized regression neural network is a kind of radial basis function neural network, which has great advantages in solving nonlinear problems and is not affected by multiple collinearity. The purpose of this paper is to study the intelligent monitoring of cabin temperature based on recurrent neural network. In the experiment, the temperature detection system of the ship engine room is designed, the resistance temperature sensor is calculated, and the data of the ship engine room temperature prediction system design and model training process are investigated.

1. Introduction

The temperature detection and acquisition system of the ship's engine room mostly uses thermal resistance or thermocouple as the temperature sensor. In order to meet the requirements of accurate measurement, the analog signals collected by the sensor must be subject to corresponding temperature compensation. In addition to power devices and electrical facilities, there are a large number of combustibles such as oil and other combustibles in the engine room. Once the operation is wrong or forgotten, it is easy to cause engine room fire [1]. Different from conventional land accidents, ship fires have certain time domain characteristics and regional limitations.

With the improvement of computer technology, communication technology, automation technology and other new technologies, the marine engine room monitoring and alarm system has gradually improved from the earliest manual monitoring to automatic, intelligent, networked and unmanned monitoring. Ngo Y H indicated that the quality of breathing air in commercial airline cabins has been increasingly reviewed due to the identification of volatile organic compounds from the engine bleed air used to provide oxygen to the cabin. Ideally, the sensor will be placed in the air bleed pipe itself to detect before it penetrates and contaminates the entire cabin. Current gas sensors have selectivity problems, do not have proper dimensions, or are too complex for commercial deployment. Here, we choose isopropanol, which is the main component of deicing spray used in the aviation industry, as the target analyte: isopropanol exposure is assumed to be the key component of the gas toxicity syndrome before, during and after flight. The mechanism of action proposed by isopropanol is anesthetic and central nervous system inhibitor [2]. Pollack I B studied the closed-circuit quantum cascade tunable infrared laser direct absorption spectrometer. It is equipped with an inertial inlet for unfiltered particle separation and several custom designed components, including an aircraft inlet, a vibration isolation mounting plate and a system for optionally adding active continuous passivation, for studying the ammonia phase measurement of aircraft. The instrument was then deployed on the aircraft during research flights and test flights related to the chemistry of western wildfire clouds, aerosol absorption and nitrogen field activities. The instrument is configured to measure gaseous ammonia, smoke, boundary layer, cloud and hot engine room within a certain height range. The important design objective is to minimize motion sensitivity and maintain reasonable detection [3]. The theoretical basis of the generalized regression neural network is nonlinear regression analysis, and the smoothing parameter is the only parameter that needs to be optimized in the training process.

According to the research background and significance, this paper studies the generalized regression neural network and the functional module analysis of the ship engine room temperature detection and acquisition and intelligent prediction system. According to the functional structure, it can be divided into three modules, mainly including temperature detection module, temperature acquisition module and temperature prediction module. In the experiment, the temperature detection system of the ship engine room is designed, the resistance temperature sensor is calculated, and the data of the ship engine room temperature prediction system design and model training process are investigated.

2. Research on Intelligent Monitoring of Cabin Temperature Based on Recurrent Neural Network

2.1. Research Background and Significance

The engine room of a ship is the core part of the ship. The power plant and electrical equipment in the engine room provide and use all kinds of energy for the ship to ensure the normal navigation of the ship, the normal life of personnel and the completion of various operations. The safety design of the ship's engine room is one of the important criteria for the whole shipbuilding level [4]. The power device in the engine room of a ship is the power equipment set to ensure the normal operation of the ship. The electrical equipment in the engine room is the electrical device that provides lighting and other navigation and living needs for the ship. Both power devices and electrical equipment are responsible for the power supply and energy conversion functions of ships during navigation, and there is a heating phenomenon in energy transmission and conversion. The temperature in the engine room of a ship is an important detection index for the safety of the engine room of the ship. Excessive temperature will lead to the failure of the ship's power system and affect the normal navigation of the ship, and even cause sudden disasters such as fire. The electrical equipment in the engine room of the ship is easy to overheat the conductors of electrical equipment due to the confusion of wiring methods, poor ventilation in the engine room, overload of equipment and other problems, resulting in the temperature risk of electrical equipment. When the temperature of electrical equipment exceeds the allowable range of the environment and lasts for a long time under such conditions, or there are combustibles near the equipment, it is easy to cause fire in the ship's engine room [5].

To sum up, the fire in the engine room of the ship caused by the high temperature of the equipment is difficult to put out and destructive, which poses a major threat to the safe operation of the ship and the life safety of the staff on board. Therefore, the dynamic detection of the temperature in the engine room of the ship and the prediction of the dangerous temperature under the working condition are of great significance to the safe navigation of the ship and the protection of the life and property of the personnel. Therefore, the research and improvement of a complete engine room temperature dynamic detection, acquisition and prediction system has very important practical value and significance for ship design and safe navigation [6-7].

2.2. Overview of Generalized Regression Neural Network

Generalized regression neural network is an algorithm improved on the basis of mathematical statistics, which is an improvement of radial basis function network. The generalization precision converges to the global optimal value, that is, the model finally converges to the regression line with more training samples. There are only four layers in the neural network structure diagram of GRNN, and there is only one unknown free parameter, namely the smoothness factor of radial basis function. Based on the numerous advantages of GRNN, the generalized regression neural network has been widely used in many fields, such as mural repair research, ZigBee indoor positioning algorithm, aircraft transmitter temperature prediction, and the prediction of explosive quantity, etc. GRNN is based on the theory of nonparametric regression, and uses training set as a posterior condition. Its basic idea is to use Parzen nonparametric estimation method to estimate the joint density function f (x, y), and use the estimated joint density function f (x, y) to predict the final result output of test samples. It is the ranking model of the final network based on the maximum probability [8-9].

2.3. Functional Module Analysis of the Ship Engine Room Temperature Detection and Acquisition and Intelligent Prediction System

The ship engine room temperature detection, acquisition and intelligent prediction system mainly realizes the detection, acquisition and prediction of the temperature of power equipment and electrical equipment in the ship engine room. According to the functional structure, it can be divided into three modules, mainly including temperature detection module, temperature acquisition module and temperature prediction module. The functions of these three modules are analyzed below, and different principles of temperature detection, temperature acquisition and temperature prediction are described respectively [10-11].

(1) Temperature detection module

The temperature detection module is the primary component of the whole system, which is mainly responsible for detecting the temperature of the engine room power plant and electrical facilities. Using virtual instrument technology, a remote multi-channel temperature detection system can be realized to monitor the temperature changes of power equipment and electrical facilities in different areas of the engine room. Through the communication function of the LAN, the real-time and reliable monitoring of the ambient temperature of the ship's engine room can be realized [12-13]. The technology of high-speed transmission method is used to realize the high-speed release and exchange of temperature data. Even if the staff is not on site, they can learn the environmental temperature conditions of various locations in the engine room on the monitoring host of the engine room monitoring room, and know the real-time changes of the environmental temperature in the engine room at any time. The application of virtual instrument and computer network in temperature detection system makes the system have good versatility and flexibility.

(2) Temperature acquisition module

With the improvement of modern shipbuilding technology and navigation technology, the ship engine room has improved more and more different uses and functions, and the structure of the ship engine room has become more and more complex. The original temperature acquisition system is difficult to achieve the multitask synchronous processing function, real-time data signal transmission function, online data signal accurate processing function required by modern ships [14-15].

In the process of temperature data acquisition, the test software is an important part of the system. Test software is the key to control data acquisition and data processing. With the improvement of new technology, testing software based on VB has shown more and more limitations. The virtual instrument is composed of software system and hardware system. The software system is composed of the panel design of virtual instrument and the driver of I/O interface instrument. The hardware system is based on the combination of computer and various I/O interface devices.

(3) Temperature prediction module

As an important physical quantity, temperature plays an important role in the daily navigation, transportation and maintenance of ships, and the measurement and prediction of temperature is of great guiding significance for the safe navigation of ships, the daily maintenance of cabins and the early warning of ship fires. After years of research and improvement in relevant fields at home and abroad [16-17]. Nowadays, most of the main methods of temperature prediction are to mine a large number of data, effectively process and analyze the temperature data collected by the temperature acquisition system, and then to achieve the temperature prediction by establishing a temperature prediction model and inputting samples to obtain the prediction results. At present, the commonly used temperature prediction models are mainly established through time series analysis, artificial neural network and other data prediction methods [18].

Figure 1. Process of temperature prediction

3. Investigation and Research on Intelligent Monitoring of Cabin Temperature Based on Regression Neural Network

3.1. Design of Intelligent Inspection and Monitoring System for Engine Room Temperature

The temperature detection system is the basis of the temperature detection, acquisition and prediction system of the ship's engine room. It is mainly responsible for the detection of the internal temperature of the ship's engine room, laying the groundwork for the temperature acquisition system and the temperature prediction system. The accuracy of the temperature monitoring position of the temperature detection system and the detection sensitivity to the temperature are particularly important for the entire system. It mainly compares different types of temperature detection elements, selects appropriate temperature detection elements according to the design requirements of the system, simulates the temperature field of the engine room of DWT9200 product oil tanker, and completes the layout of temperature measurement points.

3.2. Resistance Temperature Sensor

Resistance temperature sensor is the most commonly used temperature detection device for medium and low temperature measurement. It measures temperature by using the linear relationship between the resistance of metal, semiconductor materials and alloys and temperature. Where R_t is the resistance value at temperature t; R_{to} is the corresponding resistance value at temperature t_0 (usually t_0 =0 ℃); α Is the temperature coefficient. For linear thermal resistance, the relationship between resistance value and temperature is as follows:

$$R_t = R_0[1+\alpha(t-t_0)] \tag{1}$$

$$\Delta R_t = \alpha R_{to}\Delta t \tag{2}$$

4. Analysis and Research on Intelligent Monitoring of Cabin Temperature Based on Recurrent Neural Network

4.1. Design of Intelligent Monitoring System for Engine Room Temperature

The recurrent neural network can be learned through the error back propagation algorithm, according to the direction of reducing the target output and actual error, correct the connection weights between output layers and output layers layer by layer, and constantly improve the mathematical model, so that it can realize the function of temperature monitoring. On the other hand, based on various prediction theories, it is a software system to analyze the collected temperature data and establish a certain model for temperature monitoring and early warning,

This temperature prediction model collects the data of temperature measuring points in the engine room of the ship through the temperature acquisition system to obtain the original data samples. Through the analysis and selection of the measured and saved temperature data, the temperature data of one of the many temperature measuring points is selected as the original sample data. The five temperature data continuously measured at the temperature measuring points near the host are taken as a group, the first group is used as the training sample, and the second group is used as the prediction sample for immediate output. The original data samples are shown in Table 1 and Figure 2:

Table 1. Raw sample data table

	First group	Second group
1	35.1	35.5
2	36.1	36.7
3	35.4	36.4
4	35.2	36.2
5	35.3	35.8

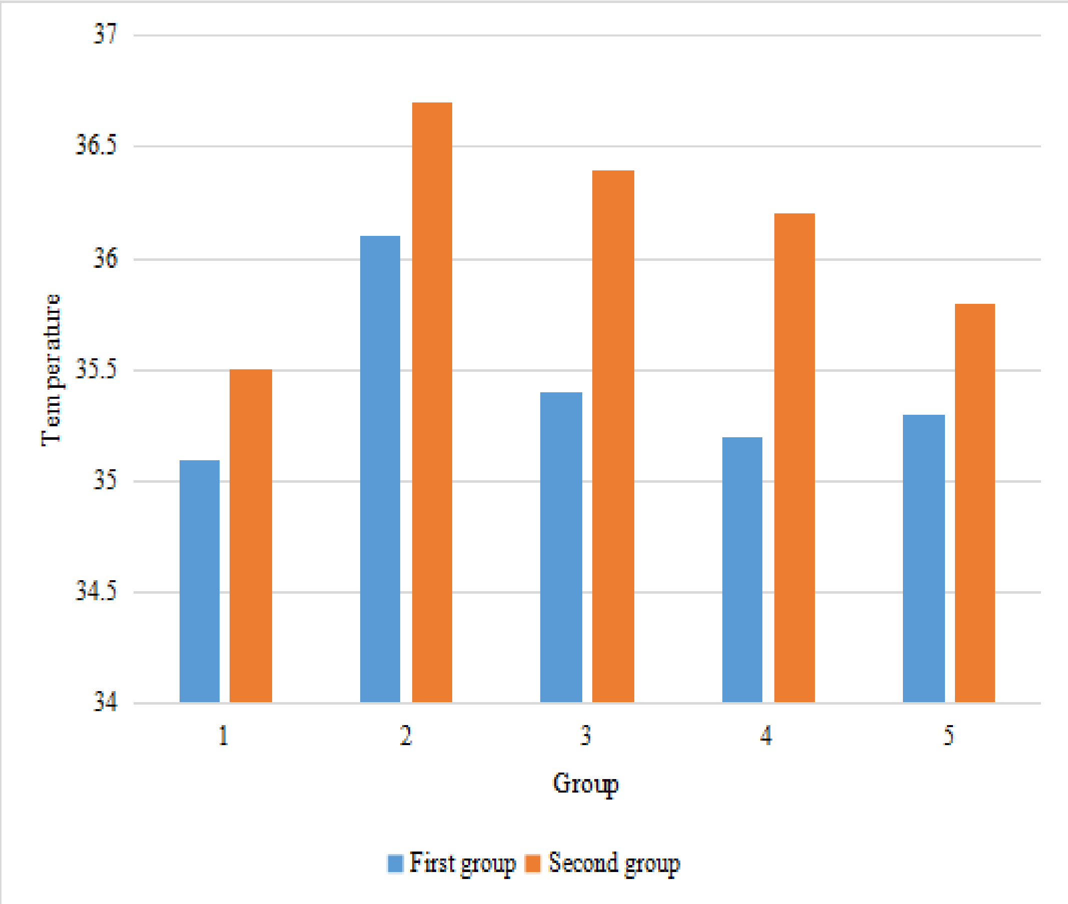

Figure 2. Temperature data comparison diagram

4.2. Model Training Process

The complete neural network program first reads the initial values of the system's input samples, output expected samples and hidden layer's input and output weights, and then obtains the trained hidden layer's weight parameter values through systematic operation, as shown in Table 2 and Figure 3:

Table 2. Weights after training

	First group	Second group
1	0.5174	0.8421
2	0.5142	0.0745
3	0.6214	0.3684
4	0.3687	0.6974
5	0.0574	0.6847

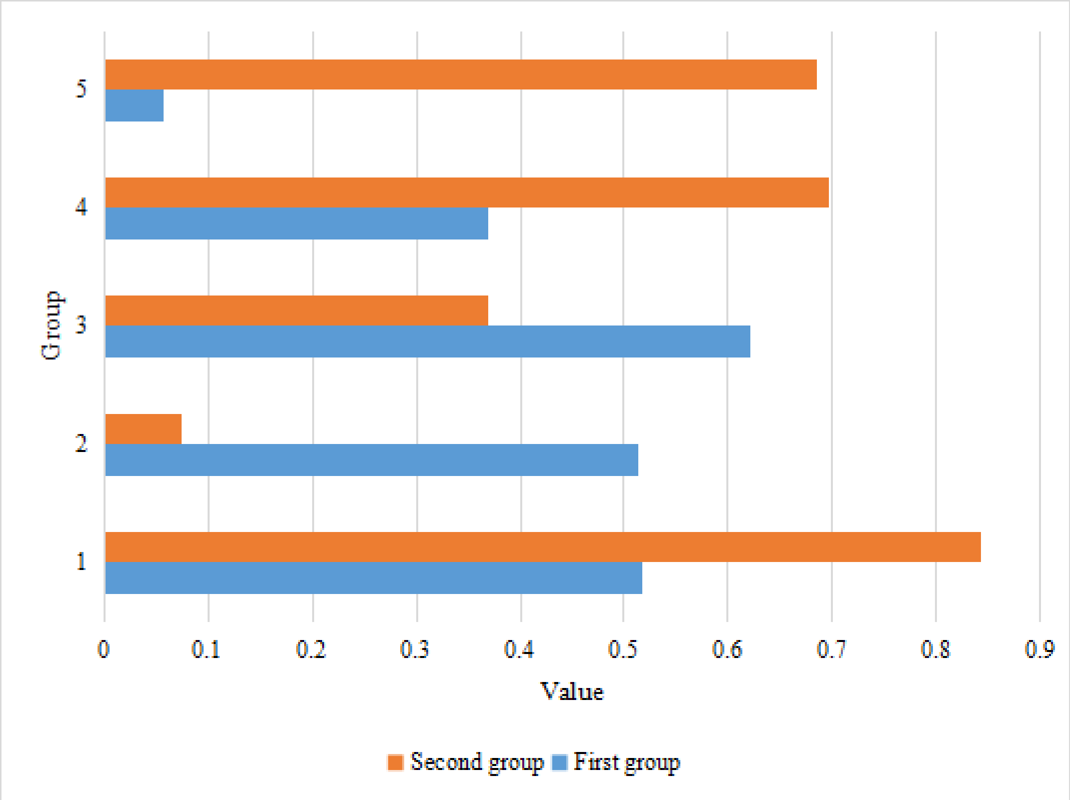

Figure 3. Comparison diagram of the hidden layer weight parameter value data

Based on the temperature prediction system of regression neural network, the temperature prediction model of ship engine room is established by using the regression neural network, and the temperature prediction program is completed by using the graphic programming function of LabVIEW. The recurrent neural network has good identifiability and high precision prediction performance for the system. In this system, the neural network can predict the temperature of the key temperature measuring points in the ship engine room, ensuring the safe, reliable and economic operation of the ship engine room system. It is worth noting that if we want to get a more accurate prediction for a certain object. We should ensure the number of training samples for that object and the accuracy of training samples.

5. Conclusion

With the rapid improvement of science and technology, machine learning technology is constantly improving and perfecting, and the ranking learning model also needs to be constantly improved and perfected. New technologies or algorithms are used in the sorting learning model to achieve higher effect and efficiency. With the continuous improvement of the ship, the cabin environment has become more and more complex, and the temperature detection and acquisition system also needs more and more data acquisition channels. Therefore, in the design process of the temperature acquisition system at this stage, we need to first consider how to expand the temperature acquisition channel more simply and conveniently. The ranking learning model based on generalized regression neural network has many other aspects of research. Due to the time and energy reasons, the research results of this paper at this stage still have many deficiencies that need to be improved and perfected.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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