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RESEARCH ON AUTOMATIC MONITORING AND FAULT DIAGNOSIS SYSTEM OF UNMANNED CABIN

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Abstract:-

Based on the theory of virtual instrument, test technology, fuzzy neural network and ant colony algorithm, this paper studies the design, fault feature extraction and diagnosis method of engine room monitoring module, Optimization of Fuzzy Neural Network Based on Group Algorithm. This is researched on Fault Diagnosis of Marine Diesel Engine Based on LabVIEW. In order to solve the shortcomings of the traditional development software (VB, VC ++, C language, etc.), Developing the long developing period, slow running speed, debugging and maintenance difficulty and difficult to realize system redundancy in the engine room monitoring system, The engine room monitoring and fault diagnosis system is designed. To achieve the cabin parts of the signal acquisition, processing, centralized display, alarm control.

Key words: - *engine room monitoring; LabVIEW; ant colony algorithm; fault diagnosis; fuzzy neural network*

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1 INTRODUCTION

With the rapid development of electronic science and technology, ship automation equipment increasingly toward large-scale, complex, integrated, and other highly intelligent direction. It is resulting in more and more complex marine equipment, a wide range of various parts and the relationship between the more closely. Any part of the failure, a direct impact on the operation of the ship's safety, reliability and mobility, and may cause huge economic losses or even lead to casualties accidents.

The paper takes marine diesel engine as the research object, uses computer technology and virtual instrument technology to realize the data acquisition, storage and analysis as well as the function module design. And then, it is on the fault diagnosis part of the line optimization discussion. In the traditional fault diagnosis, fuzzy rules of fuzzy diagnosis library lack of self-learning and associative energy, because the controlled object often changes, resulting in reduced diagnostic effect. With the rapid development and extensive application of neural network technology, fuzzy neural network (FNN), which combines fuzzy logic system and artificial neural network technology, has the characteristics of both fuzzy information and self-organizing learning. It is single and inadequate, more suitable for fault diagnosis system. Generally speaking, this kind of fault diagnosis algorithm is based on BP algorithm, but this algorithm is most slow in convergence and often leads to local minimum. Therefore, this paper adopts the latest ant colony algorithm to optimize the parameters of fuzzy neural network. The ant colony algorithm has faster convergence and flexibility, so it has great potential and development in fault diagnosis. It is very feasible and effective to improve the fault diagnosis technology of marine diesel engine.

2 Design of Function Module of Marine Engine Room Monitoring System

With the vigorous development of the world shipping industry, the requirements of information integration of ship system are becoming higher and higher. To this end combined with Internet technology and satellite communication technology, the full realization of data and knowledge sharing, the design of network-based ship engine room monitoring system.
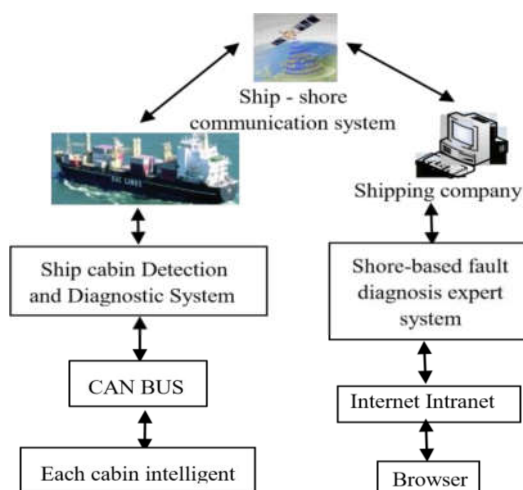

Figure 1 Based on the wireless network cabin monitoring system

As shown in Fig. 1, the data and alarm information from the engine room are stored in the shipboard engine room detection and diagnosis system and shore-based fault diagnosis expert system. Design CAN bus and cabin intelligent monitoring unit connected to the field data to ensure the anti-jamming; design of the Internet Browser communication to improve the data communication and information collection capabilities, and to achieve the intelligent monitoring unit parameter settings and Response, the completion of all parts of the cabin real-time monitoring.

In the traditional cabin automation monitoring system, all subsystems are vertically arranged side by side, which inevitably has the function of duplication, redundancy shortcomings. In order to ensure that the structure of a certain layer does not affect the other layers, a hierarchical system is proposed, which includes the personnel layer, the software layer, the computing backbone layer, the sensor and the actuator layer. As a result, the hierarchical structure of the system is more good operability and scalability, improve the reliability of the system.
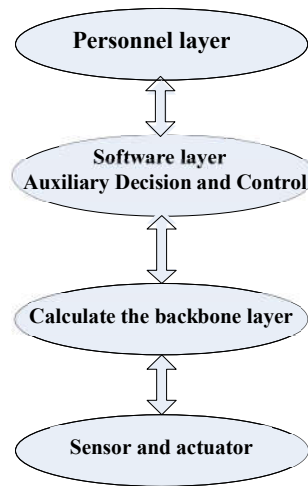
Figure 2 System design transverse hierarchical structure

The design of the system software is divided into three parts according to the network nodes: data preprocessing, analysis of the operating state of the cabin and display of the results of the running state fault prediction.

The system uses a modular design, so as to provide a great convenience for the development. Modular programming designs, through the division of functional modules, the design of the data flow between the various modules shown in Figure 3.
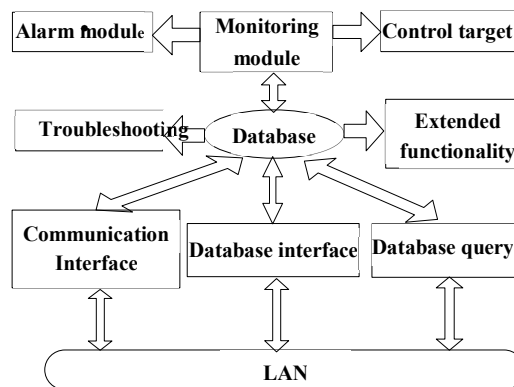

Figure 3 The data flow between the various modules

In the cabin monitoring system software, the users input the monitoring interface, the system through the acquisition of the analog and switch the amount of the corresponding analysis and processing; the results will be stored in the database. When the system is abnormal, start the alarm module provides multi-level alarm; the alarm information is recorded to the alarm database for query, analysis and use. In addition, the system can also be drawn into the curve of the analysis of the parameters of trend monitoring. System software flow is shown in Figure 4.
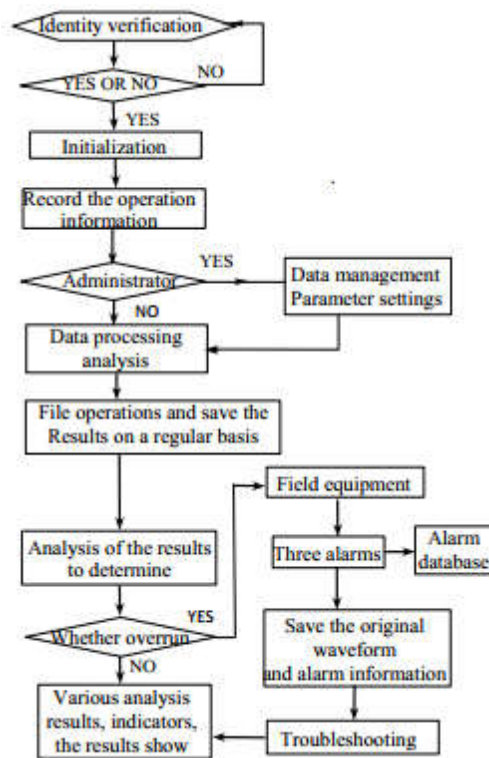
Figure 4 Software program flow chart

3 Fault Diagnosis of Marine Diesel Engine Based on Fuzzy Neural Network

Fault diagnosis of marine diesel engine, often more complex failures, cannot rely on simple "yes" and "no" to diagnosis. Through the fault diagnosis rules and methods of FNN neural network, some faults can be expressed in fuzzy form, and then the training samples of FNN can be created according to the rules of fuzzy theory to achieve the expected purpose.

Table 1 Troubleshooting Rules

parameter		malfunction					
T_r	P_z	F_1	F_2	F_3	F_4	F_5	F_6
H	H	B	D	D	D	D	B
H	L	D	D	D	D	A	D
N	H	D	D	B	C	D	A
N	L	D	C	D	D	D	D
L	H	A	D	A	A	D	D
L	N	D	D	D	B	D	D

A, B, C, D in the above table are translated into corresponding failure confidence. According to the information in the table above, the fault diagnosis training samples based on fuzzy neural network are as follows: A = 0.9, B = 0.6, C = 0.2, D = 0.05.

The structure of the fuzzy neural network (FNN) is shown in Fig.5. The input variables are the highest burst pressure and exhaust temperature of the fault parameters. They are Pz and Tr respectively, and each parameter is divided into three fuzzy Sub-sets {high, low, normal} = {H, L, N}, which use Gaussian function to represent the membership degree:

$$\mu_j(x) = \exp\left[-\frac{(x_i - a_{ij})^2}{\sigma_{ij}^2}\right] \qquad (1)$$

Where i = 1, 2; j = 1, 2, 3. Each of the above membership functions x can be normalized to the real variables, expressed as the center of the membership function, expressed as the width of the membership function. The fuzzy outputs can be generated by the corresponding inputs.
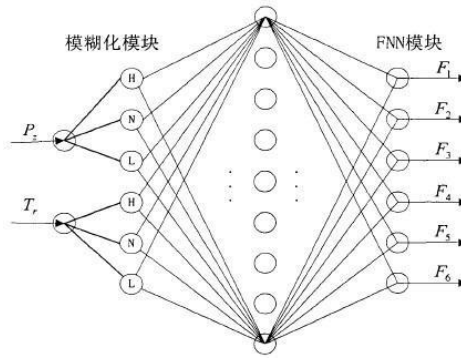
Fig.5 The structural model of fuzzy neural network

In this paper, a multi-layer feedforward fuzzy neural network with serial structure is adopted. The network consists of two parts: fuzzy quantization and neural network. Fault signal pressure and temperature are connected with the input layer, and the fuzzy vector is transformed into a fuzzy vector into the neural network for training and learning. Then, the fuzzy rules are obtained and the logic operation of the rule and the reliability value of the fault diagnosis are obtained. Many of the input and output information are related to nine hidden layer nodes. Therefore, the structure of this fuzzy neural network is 2-6-9-6.

1) The first layer for the input layer that variable fuzzy input signal, this layer only two nodes, that is, the normal temperature and pressure of the real input.
2) The second layer is fuzzy layer, this layer has 6 nodes, and the output of each node is the corresponding membership function value.
3) The third layer is the fuzzy rule layer. There are nine nodes in this layer, which is the number of fuzzy inference rules of the system. The nonlinear function of this layer of neurons for the hyperbolic tangent function, set the hidden layer input for the output, the formula is:

$$s_i = \sigma\left(\sum_{j=1}^{6} w_{ij} x_j + b_i\right) \quad 1 \le i \le 9 \quad (2)$$

Among them is the input layer - the hidden layer of the connection weights, hidden layer neurons for the threshold.

4) The fourth layer is the output layer, the nonlinear function of this layer of neurons for the S-type function: Let the output () that:

$$y_k = f\left(\sum_{j=1}^{9} s_{kj} x_j + b_{k0}\right) \quad 1 \le k \le 6 \quad (3)$$

Among them the current hidden layer the connection layer output layer weight, the threshold for the output layer neurons. There are 6 output nodes in this layer. In this fuzzy neural network, the adjustable parameters for the 2 to 3 layers, 3 to 4 layers of weight and 3, 4-layer threshold. They are the object [1-2] of optimization training of ant colony algorithm in fault diagnosis.

4 Fault Diagnosis of Marine Diesel Engine with FNN Optimized by Ant Colony Algorithm

In this paper, the ant colony algorithm is used to optimize the fuzzy neural network, the basic train of thought and optimization are: In this paper, the diesel engine fault diagnosis system has 108 weights and 15 thresholds, which need to train the parameters, M=123,, expressed as P_1, P_2,..., P_M, and P_i ($1 < i < $ M).than the non-zero number range is formed as a set I_{pi} .Then according to the basic idea of the ant colony algorithm, let a certain number of ants in the nest start to find food. Let the total number of ants h, each ant from the first set of departure, according to each element in the collection P_j（I_{pi}）

One element is selected randomly from each set I_{pi}（$1 \le$ i $\le$ According to the pheromone of each element I）in the set, and the pheromone of the corresponding selected element is adjusted. In each time step, the ant can only choose a pheromone. For different ants, at each time step, the selected elements should not be in the same set. When the ants choose all the elements in the collection after the completion of, even if it is to find food sources, that is, choose a complete set of FNN weights and thresholds, then adjust the collection of elements in the amount of information. This process is iterated until the evolution trend is not significant or reaches the set number of convergence times [35].

The steps of searching for the optimal parameters within the error limit are as follows: 1) initialization: Let the time t =0 and the number of loops N_c = 0, Set the maximum number of loops to N_{cmax}, Let the amount of information τ_j（I_{p_i}）= C, $\Delta\tau_j$（I_{p_i}）=O, for each element. The ants are all placed in the nest, where C is a constant.

2) Start all ants, for collections I_{pi}, ants K (k =1, 2…， h） , the state transition probability is calculated according to the following equation

$$\Pr(\tau_j^k(I_{P_i}))=\frac{\tau_j^k(I_{P_i})}{\sum_{g=1}^{N}\tau_g(I_{P_i})} \qquad (4)$$

3) Repeat Step (2) until all the ants in the nest reach the food source.
4) Let t value and the error of the neural network are calculated by the weights chosen by the ants, and the current optimal solution is recorded. The output value and error of the neural network are calculated by the weights chosen by the ants, and the current optimal solution is recorded. After m units of time, the ants arrive at the food source from the nest, and the information on each path is updated according to Equation (5).

$$\tau_j(I_{P_i})(t+m)=(1-\rho)\tau_j(I_{P_i})(t)+\Delta\tau_j(I_{P_i}) \quad (5)$$

$$\Delta\tau_j(I_{P_i})=\sum_{k=1}^{40}\Delta\tau_j^k(I_{P_i}) \qquad (6)$$

$$\Delta\tau_j^k(I_{P_i})=\frac{Q}{e^k}$$
Denotes the element

$$P_j(I_{P_i})$$

Iteration, and 0 otherwise $P_j(I_{Pi})=0$. e^k the set of weights selected by the kth ant is used as the output error of neural network weights,

which is defined as follows $e^{k^{?k}}=\left|O-O_q\right|.1$ and 2 represent the actual output and expected output of this fuzzy neural network, respectively. The smaller the error (e^k) is, the more the corresponding pheromone increases. □□0□□□1□ Pheromone persistence, represents the rate of adjustment is a constant pheromone [6].
5) If the entire ant colony converge to a path or loop number, $N_C \square N_{max}$, the loop ends, and the result is output; otherwise, go to step (2).

5 Design of each function module based on LabVIEW
5.1 data acquisition program design
The data acquisition function of the system is mainly realized by NI driver acquisition module DA . A large number of sensors, such as temperature and pressure sensors, are installed in the cabin monitoring system. These sensors will be different types of signals into 4-20mA standard analog signal into the data acquisition module; through the CAN bus processing, the results into the host computer and provide alarm and data printing and other functions, as shown in Figure 6 data Acquisition program schematic shown[7].
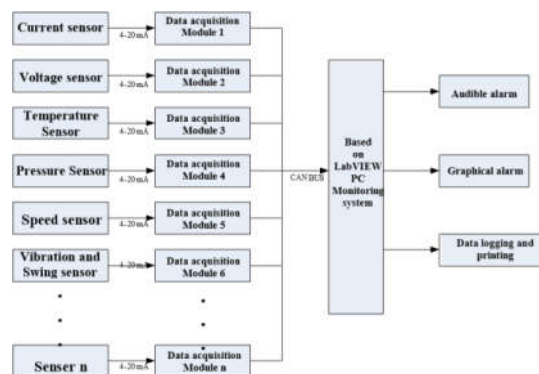

Figure 6 Schematic diagram of the data acquisition program

Among them, the sensor acquisition principle and acquisition procedures are shown in Figure 7, Figure 8 shows.
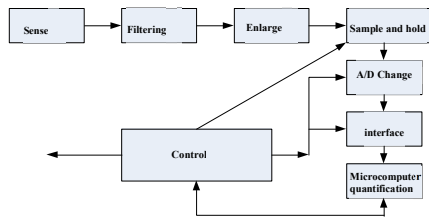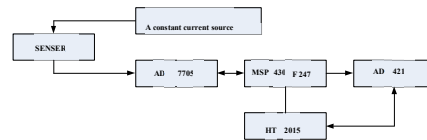
Figure 7 Sensor acquisition principle

Figure 8 Sensor acquisition step diagram

As shown in Fig. 9, Fig. 10 and Fig. 11, the acquisition parameter setting interface chart, the data acquisition and recording program block diagram.
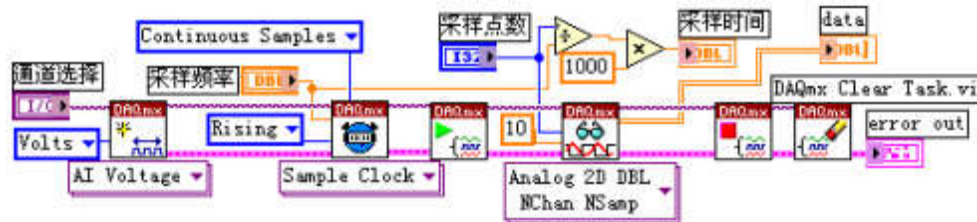

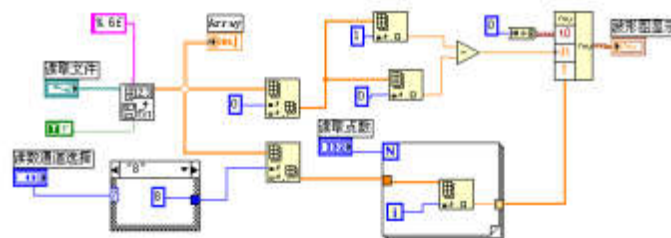**Figure 10 Data acquisition and recording procedures**

Figure 11 Shows a block diagram of a recorded file and displayed as a waveform

4.2 Menu setting program design

According to different identities can operate the different permissions, the system a total of five identity, respectively, administrators, engineers, operators, inspectors, non-cabin staff, and the lower the level of operation can be less authority. If the administrator can access all the interfaces in the program, and even shield the parameters and other levels of the user's login, and engineers have only the configuration parameters of the right; non-staff almost cannot see the actual operation. There are eight menu items, such as "System", "View", "Configuration", "Data", "Window" and "Trouble Diagnosis". There are several command options under each menu. Command will pop up the corresponding dialog box or function interface.

In the ship engine room monitoring system, the data and the information quantity are very big. Simply recording these parameters does not account for cabin operation. In order to reflect the real-time trend of nacelle operation, we need to draw real-time curve for some parameters [8]

In the ship engine room monitoring system, the real-time parameters and data, alarm information can be displayed in detail in the LabVIEW-based PC monitoring interface, but we cannot do 24-hour duty, otherwise it will cause human and financial resources pole Big waste. Therefore, the historical storage function for the system, it is particularly important. We can through the historical data waveform window will be out of the past information and data for analysis [9]
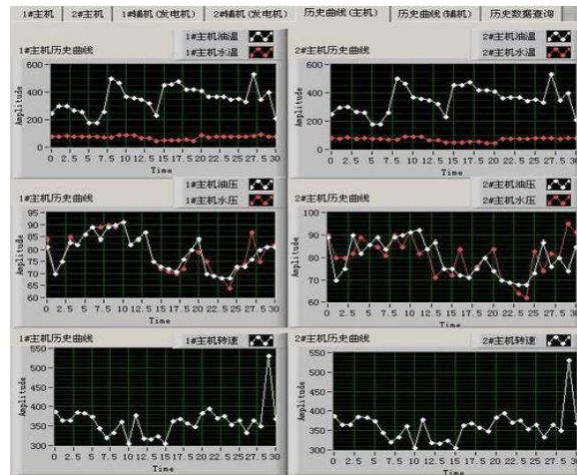
Figure 12 Historical data waveform display.

Alarm function is the core function of cabin monitoring. Through the alarm information integrated interface, the attendant can see the cabin operating conditions and the emergence of the failure, such as generator failure, host stop failure, fire alarm. At the same time set the mute button in order to eliminate the alarm sound and clear the fault information record. Select the three-level alarm interface as shown in Figure 13, the front panel display, this selection of green, yellow, red three colors, corresponding to the normal, alarm, dangerous three required state.

Figure 13 Three-level alarm interface effect display

5 Completion

1）This paper focuses on the design of the LabVIEW software platform based on the engine room monitoring system software module functions and implementation. In this paper, the modules of data acquisition, processing, centralized display, alarm control, parameter configuration and program management are realized.

2) The fuzzy neural network formed by the combination of fuzzy logic system and artificial neural network has the advantage of using fuzzy information effectively, and has the characteristics of neural network parallel processing and highly self-organizing self-learning information, which overcomes the limitation of single system And can be better adapted to the marine diesel engine intelligent fault diagnosis system. And selects a kind of fuzzy neural network to carry on the breakdown diagnosis to the marine diesel engine, has obtained the better breakdown diagnosis result;

3) For the first time, the ant colony algorithm is applied to the parameter optimization training of the intelligent fuzzy neural network diagnosis system of the marine diesel engine. Compared with the fuzzy neural network based on the BP algorithm learning, the ant colony optimization training network has the advantages of good convergence speed and good diagnostic effect. And avoids the drawback that network training falls into local extremum. The ant colony algorithm optimization training fuzzy neural network has the good intelligent fault diagnosis application prospect.

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