On line monitoring method of forklift truck working condition based on multi sensor

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Abstract: Aiming at the problems of poor timeliness and poor monitoring accuracy of domestic forklift working condition monitoring, a multi-sensor online monitoring method for forklift condition is proposed. Analyze the relevant factors that affect the status of the forklift truck, optimize the structure of the forklift truck condition monitoring platform, design the main control algorithm for forklift truck condition monitoring, and obtain the loading status and monitoring parameters of the forklift in the warehouse in real time. Status online monitoring. In order to verify the monitoring performance of this method, a comparative experiment is designed. The results show that the method in this paper can effectively shorten the monitoring delay and improve the detection accuracy, which is of great significance for the realization of network, intelligence and modularization of electric forklifts.

1. Introduction
As a flexible mode of transportation, forklift is widely used in the loading and unloading and storage of goods in warehouses, stations, ports, docks, factories and mines. Forklifts work frequently, work intensity is big, the working environment is bad, it is inevitable that there will be failures. But at present, the forklift maintenance is still in the planned maintenance stage, which is not conducive to the timely detection and elimination of potential faults of forklift trucks, which affects the working efficiency of forklifts, shortens the service life of forklifts and brings losses to users. On this basis, the working principle of forklift condition monitoring terminal is studied, and the overall design of the module is given. This module is composed of monitoring platform and vehicle terminal[1]. The vehicle terminal includes weighing module and GPS positioning module. This module takes STM32 microcontroller as the core, completes data acquisition through weighing, GPS positioning and other modules, and data transmission is completed by DTU module[2]. The software is mainly composed of MCU software and monitoring platform software, which realizes the real-time acquisition and update of monitoring data. Through the comprehensive test, the vehicle mounted terminal realizes the real-time collection of forklift working condition data and the real-time update of relevant data on the monitoring platform, which fully meets the design requirements.

2. On line monitoring method of forklift working condition

2.1 structure optimization of forklift on-line monitoring platform
Starting from the technical characteristics of the sensors on the forklift working condition online monitoring platform, the key technologies such as equipment compatibility, sensor identification, information processing, data calculation and safety are mainly developed.
In the forklift industrial and mining status detection platform, it is necessary to automatically collect the forklift industrial and mining status data, which is completed by digital or analog device[3-5]. The data of forklift industrial and mining state detection platform includes physical phenomena of forklift, such as temperature, sound, pressure, voltage, current, etc. The data acquisition module is composed of signal processor, sensor, data acquisition device and application software. Through data acquisition, conversion, calculation and analysis of monitoring equipment of forklift industrial and mining state detection platform, the measurement module can be customized and the data measurement can be realized[6]. Using STM32 single chip microcomputer, the ADC composed of 16 channels of external and 2 channels of internal measurement signals adopts 12 bit successive approaching forklift industrial and mining state detection platform, and realizes three data conversion modes of single channel, intermittent, single measurement and single measurement. There is a data register in the ADC of MCU in forklift industrial and mining state detection platform. The ADC converter stores the result data after single channel conversion. The register is 16 bits, but the converted data will be stored in the first 12 bits in a left-right alignment. But multi channel conversion is different from single channel conversion. After the ADC signal is converted, the converted data is uploaded and stored in the memory. Finally, the conversion result is transmitted to MCU through the corresponding serial port. Based on this, the platform monitoring information is standardized as follows:

| Parameter                           | Specification                  |
|-------------------------------------|--------------------------------|
| Sensitivity                         | 1-2±0.1mV/V                    |
| Creep                               | ±0.03±0.05%F·S/30min           |
| Nonlinearity                        | ±0.05%F·S                      |
| Lag error                           | ±0.05%F·S                      |
| Repeatability error                 | ±0.03%F·S                      |
| Output temperature effect           | ±0.03F·s/10[UNK]               |
| Zero temperature                    | ±0.03F·s/10[UNK]               |
| Input impedance                     | 385±10                         |
| Insulation resistance               | 700±15                         |
| Supply bridge voltage               | 9≥5000MQ                       |
| Operating temperature range         | proposal10VDC(12V-24V)         |
| Permitted Overload                  | 20+0                           |
| Texture of material                 | 150%F·S stainless steel        |

When the scan bit is set in the ADC register of the forklift on-line monitoring platform, the scanning mode of the ADC can work normally. The ADC converter scans each group of channels in ADC jsqr register (for injection channel) or ADC sqrx register at runtime, and converts each group of channels in ADC jsqr register. After setting the con bit of the ADC CR1 register, the conversion restarts the first channel of the selection group without stopping the conversion of the last channel. This method uses the built-in detection method. By setting the detection bit of register ADC CR2, the quasi precision error caused by the change of capacitor bank in ADC is minimized. After the verification, the hardware is reset for normal data conversion. According to the calibration chart, the ADC converter must maintain at least two ADC clock cycles to start calibration, i.e. Adon = 0. In addition, it is best to calibrate the ADC at each charge. After the check, the check code is saved by ADCDR register.

### 2.2 Main control algorithm of state information monitoring

In the forklift condition monitoring, the upper monitoring node is the information terminal of the system. Its task is to receive the data from the bus, collect and store it, and give alarm according to the preset alarm value. The main function of this system is the realization of master node, including 16 bit microprocessor, Iflash data storage, clock circuit, can communication module and LCD. The forklift status detection method based on CAN bus is composed of upper monitoring node and several field collection nodes. At this time, the process of monitoring node data judgment is shown in Figure 1.
Further, taking the remote detection method of forklift status as the design goal, through the research of GPS, GPRS and data acquisition technology, the practical application situation is analyzed, and the solution is proposed. Most of the warehouse forklift monitoring work is based on LAN, which can complete the status monitoring and diagnosis, and has the function of Internet expansion. The basic capacity of the monitoring interface can reflect the carrying capacity of forklift truck safety monitoring model at a certain time point, and also can preliminarily determine the basic width condition of information flow, which is generally expressed by \( u \), while \( y \) is the core memory condition of database mechanism. The standard physical quantity of forklift operation flow comprehensive treatment is put forward, the basic form of monitoring equipment can be planned, and the safety level of the model can be determined. The results of forklift workflow integration can be expressed as follows:

\[
\lambda = \left[ \int_{w} (T - w)^2 dw \right]^{1/2} \leq \left[ \int_{e} y \| f + \| dtdj \right]
\]

(1)

Where \( p \) is the maximum width range of information flow, \( t \) is the influence coefficient of hierarchical protection system, \( W \) is the random test data of forklift operation status, \( e \) is the lower limit coefficient of monitoring equipment, \( a \) is the upper limit coefficient of application, \( F \) and \( j \) are two different grid safety vector data. On the basis of the above theories, the model of forklift condition safety monitoring is successfully improved based on the improved level protection. The vector expression weighted by input data is as follows:

\[
a = (Q_1(a^*, b^*)a_1^*, Q_2(a^*, b^*)a_2^*, \ldots Q_n(a^*, b^*)a_n^*)'
\]

(2)

\[
b = (Q_1(a^*, b^*)b_1^*, Q_2(a^*, b^*)b_2^*, \ldots Q_n(a^*, b^*)b_n^*)'
\]

(3)

By weighting the input data, the corresponding vector formula is obtained. In the process of data preprocessing, due to the influence or interference of external signals, large errors of forklift operation data are caused. In this paper, the non sensitivity loss function support vector machine is optimized and improved to make the monitoring results sensitive to various disturbances, and the calculation formula of error function is given.

\[
S = \begin{cases} 0, & |a - b_n| \leq \lambda \\ \frac{1}{2} (b - a_n + \lambda)^2, & b - b_n < -\lambda \\ \frac{1}{2} (a - b_n - \lambda)^2, & a - b_n > \lambda \\ \end{cases}
\]

(4)
Further development of monitoring platform software program, data analysis and platform display; forklift information module can display forklift status information, convenient for managers to monitor forklift in real time. The data storage module can store the relevant information of forklift. When you query the historical data or track of the car, all the data you need can be obtained from the database. The realization of electronic map module based on Baidu map can query the location and driving track of forklift, so as to monitor the working condition.

2.3 Realization of forklift working condition monitoring

The main function of the monitoring platform is to display the data sent by the vehicle terminal to the server, so as to provide more intuitive data information and operation platform for managers. Data exchange between monitoring platform and server, data exchange between server and vehicle terminal, monitoring and connection using socket. The monitoring platform browser will receive the data.

The following is the specific interaction process between the server and the monitoring platform: Firstly, the status information master control module of electric forklift is initialized, which mainly includes: initialization of application program, clock, configuration of command-line interface, and then initialization of status information master control module to make it become state node. Through setting parameters to connect AP station (router node), identity information is stored in database through forklift login server. In the design process, the following main control module of state information is adopted. In order to carry out real-time detection of forklift working condition and ensure the detection effect, based on this, the detection steps of forklift working condition are optimized as follows:

![Figure 2. optimization of forklift condition monitoring steps](image)

After the monitoring equipment is initialized, the server establishes a connection with the module, and the module sends the data to the port designated by the server, and the status information data is sent to the server as a message. By analyzing the information contained in XML structure, the server can get the real-time status information of forklift. The client carries out real-time communication, receives message information, judges the need to enter real-time monitoring, and establishes TCP session. When the communication is interrupted, the main module reinitializes the status information, so that the server can obtain it in real time.

The node variables on the monitoring platform are represented by A, B and C respectively. The normal state is 1 and the abnormal state is 0. S1, S2, S3, S4 are the conditional probabilities of P (c = 1 /
a, b), which are determined according to the actual situation. When a and b in the monitoring image are set as two loading points respectively, the number of other users is $m_a$ and $m_b$. C indicates that the node is composed of two loading points a and b, and its value is 0, indicating that the user has not obtained the status of this loading point. Therefore, S3 and S4 are the values of S2:

\[
\begin{align*}
    s_1 &= 0 \\
    s_2 &= m_b / (m_a + m_b) \\
    s_3 &= m_a / (m_a + m_b) \\
    s_4 &= 1
\end{align*}
\]

During the monitoring, it is found that node A and node B are the load points caused by actual forklift movement, and node C is the load point caused by actual motion sickness. The module node C represents the steps for calculating the working probability under normal conditions, as follows:

\[
P (c=1) = \sum S(a \cdot b \cdot c)
\]

\[
= \sum S(a) \left[ S \left( (c=1) \cdot a \right) S(b) \right] \\
- \sum S(a) S \left[ S \left( (c=1) \cdot b=0 \right) S(b=0) \right] \\
+ \sum S(a) S \left[ S \left( (c=1) \cdot b=1 \right) S(b=1) \right] \\
= S(a=1) S(b=1)
\]

Based on the above algorithm, the forklift working condition is optimized, which can better achieve the monitoring effect. The remote online real-time monitoring of forklift operation status is carried out by using multi-sensor principle to ensure the accuracy and effectiveness of monitoring.

3. Analysis of experimental results

Furthermore, the practical application effect of the multi-sensor on-line monitoring method of forklift working condition is compared and tested. Using frc15 electric forklift storage tank covered wireless network as the test environment, the practical application effect of the multi-sensor forklift condition online monitoring method is further compared and tested. Real time display of data acquisition on remote PC client. After processing, the display status information collected by the steering controller is displayed in the table, and the experimental parameters are further standardized as follows.

| Parameter                  | Numerical |
|---------------------------|-----------|
| Signal input channel      | 2, 4, 6, 8 |
| Input interface level     | 2.5Vp/2.8Vp |
| Supported formats         | PAL/Message mode |
| Sampling rate             | 10-12KHz  |

Based on the above parameters, the monitoring results of the literature [4] method, literature [5] method and the method in this paper are compared and recorded to obtain the accuracy of the monitoring status of the operation status of the forklift, as shown in Figure.3.

![Comparison of monitoring accuracy](image)

Figure 3 Comparison of monitoring accuracy
Analysis of Fig. 3 shows that the monitoring accuracy of the working conditions of the forklift is different under different methods. When the time is 2h, the monitoring accuracy of the method [4] is 55%, the monitoring accuracy of the method [5] is 35%, and the monitoring accuracy of the method in this paper is 93%. When the time is 8h, the monitoring accuracy of the method [4] is 50%, the monitoring accuracy of the method [5] is 36%, and the monitoring accuracy of the method in this paper is 82%. The monitoring accuracy of the method in this paper is always high, which proves that the monitoring effect of this method is good.

The monitoring delays of the above three methods are tested, and the specific results are shown in Figure 4.

Figure 4 Monitoring delay of different methods

Analysis of Figure 6 shows that different methods have different monitoring delays. When the number of experiments is 200, the monitoring delay of the method of [4] is 129ms, the monitoring delay of the method of [5] is 112ms, and the monitoring delay of the method in this paper is only 4ms. When the number of experiments is 800, the monitoring delay of the method of [4] is 532ms, the monitoring delay of the method of [5] is 256ms, and the monitoring delay of the method of this paper is only 12ms. The method in this paper has always had low latency and high monitoring efficiency.

4. Conclusion

This paper proposes a method for monitoring the working condition of the forklift. In this paper, the structure of forklift condition monitoring platform is optimized, and the main control algorithm of forklift working condition information monitoring is designed. The forklift working condition on-line monitoring is realized by multi-sensor. The experimental results show that the method can realize real-time monitoring of the working condition information of the forklift and can help the management personnel to comprehensively manage the forklift.

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