ISSN 2616-5767 Vol.5, Issue 11: 26-32, DOI: 10.25236/AJETS.2022.051104

Design of AGV Fault Diagnosis Data Acquisition System Based on Cloud Platform

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Abstract: *With the development of industrial Internet of Things technology, online fault diagnosis system has become an important part of remote operation and maintenance. Aiming at the problem that the AGV online fault diagnosis system requires higher real-time data, more data volume and faster transmission rate, this paper proposes a cloud platform-based AGV fault diagnosis data acquisition system. The system uses the STM32 single-chip microcomputer to collect the sensor data carried by the AGV, uses the wireless WIFI module to upload the data to the cloud server, and finally saves the data to the cloud database after conversion and verification, which provides a test platform for the Web remote real-time monitoring and online fault diagnosis system. By building an AGV test platform to conduct experiments, the results show that the throughput rate of the system is 90PPS, and the packet loss rate is within 0.1%. The system can meet the data requirements of the online fault diagnosis system, and has good real-time performance and stability.*

Keywords: *Automatic Guided Vehicle (AGV), Cloud platform, Data acquisition*

1. Introduction

After years of development, the current fault diagnosis technology is more and more used in factories to assist the normal production, thereby improving the production efficiency of enterprises and reducing the incidence of accidents. With the continuous upgrading of my country's manufacturing industry, the use of AGVs has become more and more popular and widespread in enterprises, and the AGV logistics transportation system is an important part of the production process of enterprises. If the AGV car fails, it will be reduced. The production efficiency of an enterprise can seriously endanger the safety of personnel. Therefore, the application of remote fault diagnosis technology to AGV cars is an inevitable trend [1].

According to the characteristics of the dynamic movement of the AGV car, the method of remote data transmission can only be wireless transmission. Compared with the wired transmission data stored in the local database for fault diagnosis, the fault diagnosis system of wireless transmission data has a certain effect on the data transmission rate and data storage location. higher requirement. this paper proposes a cloud platform-based AGV fault diagnosis data acquisition system design.

2. Overall system architecture

The entire data acquisition system consists of three parts, namely the AGV car data acquisition and transmission platform, the gateway data transfer module, and the cloud data processing module. The overall system architecture is shown in Figure 1, the AGV car data collection and transmission platform uses the controller to complete the data collection of each sensor of the AGV car, and uses the car to be equipped with a wireless WIFI module to upload the collected data. The gateway [2] data transfer module is based on the intelligent gateway, which can process the data upload of multiple AGV cars at the same time, and complete the data upload to the cloud server through the MQTT protocol. The cloud data processing module processes the received intelligent gateway data and stores it in the database, and then the Web monitoring interface and the fault diagnosis system complete the AGV remote status monitoring and AGV remote online fault diagnosis by extracting the database data.

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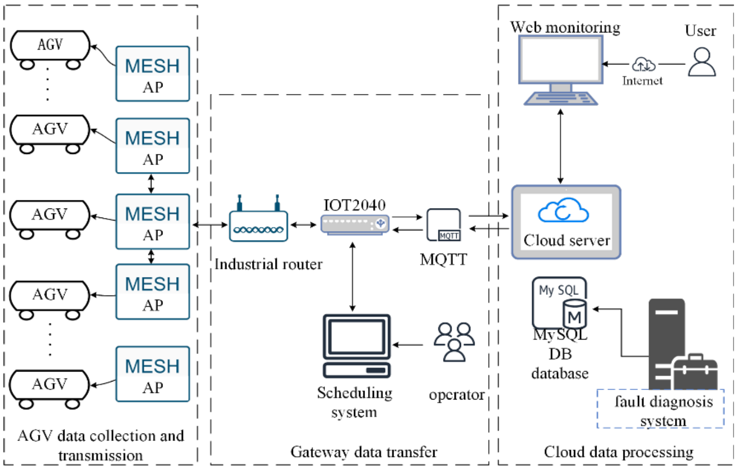

Figure 1: System frame diagram.

3. AGV car data collection and transmission platform

3.1. AGV car platform construction

The AGV car is composed of STM32 controller, magnetic navigation sensor, DC gear motor, incremental encoder, motor drive board, Mecanum wheel, ultrasonic obstacle avoidance sensor, RFID reader, gyroscope, 24V power supply, WIFI communication module, etc. Hardware composition, the hardware structure diagram of the car is shown in Figure 2.

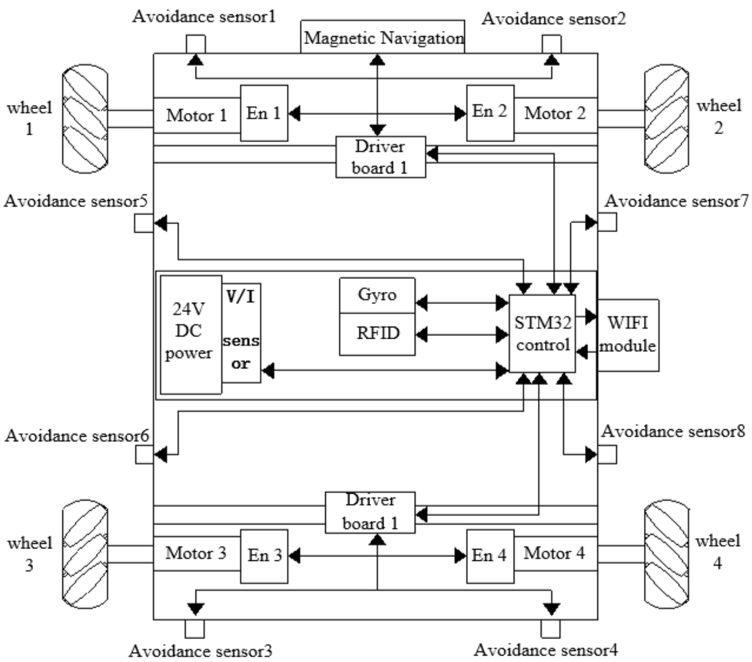

Figure 2: AGV car hardware structure diagram.

It can be seen from Figure 2 that the magnetic navigation sensor is installed on the baffle at the front end of the vehicle, its sensing point is 25mm from the ground, the distance between the magnetic points is 10mm, and the width of the magnetic strip is 30mm; the RFID reader is installed on the AGV car at the bottom of the center position, 35mm from the ground, the car realizes the navigation and positioning functions of the AGV through the magnetic navigation sensor and RFID reader [3].

The motion control part of the AGV consists of a DC gear motor, an incremental encoder, a motor drive board, and hardware such as a Mecanum wheel and a gyroscope. The STM32 controller outputs four PWM pulse widths corresponding to the speed of the wheat wheel to the drive board, and uses the

BTN7971B chip of the drive board to form an H bridge to realize the control of the forward and reverse rotation of the motor; the incremental encoder with 500 lines measures the speed feedback of the motor Give the controller to realize the closed-loop control of the movement speed of the AGV car. Regarding the rotation control part of the car, it is realized by using a gyroscope (installed near the center of the AGV car) and closed-loop control.

Considering that the AGV needs to achieve translation and rotation motion [4], the obstacle avoidance part of the AGV adopts ultrasonic obstacle avoidance sensors. In order to avoid the blind spot of obstacle avoidance, the car is designed and installed with 8 ultrasonic obstacle avoidance sensors, and the obstacle avoidance distance is set to 150mm-200mm.

The wireless data transmission WIFI module adopts the ALK8266 high-speed WIFI module of Anylinkin Company. Compared with the serial data transmission with a baud rate of 4Mbps, the SPI communication with a baud rate of 21Mbps ensures the high-speed and high-efficiency transmission of sensor data.

3.2. AGV data collection needs analysis

According to the requirements of the AGV trolley online fault diagnosis system, it is necessary to collect operating status data such as magnetic navigation sensors and obstacle avoidance sensors [5]. The AGV trolley is a four-wheel-drive Mecanum wheel, and the use of a gyroscope can ensure the accurate all-round movement of the AGV trolley. At the same time, the damage of the hub, the stuck hub and the inability to rotate [6] will affect the life cycle and control effect of the AGV car. Therefore, it is necessary to extract these fault features through the fault diagnosis system and then use intelligent algorithms to train them. When a fault occurs, the Faults can be found quickly [7]. The demand analysis is shown in Table 1.

Table 1: AGV sensor data collection requirement analysis.

Diagnostic needs	Failure form	Data collection content
mechanical failure	Broken wheels, installation errors and encoder damage.	The speed signal output by the encoder.
mobile function	Motor overheating and motor driver board damage	Fault current of motor driver chip
Rotation function	Gyroscope data is lost.	The angle of the gyroscope.
Guide function	Magnetic navigation sensor data loss, magnetic stripe demagnetization.	Magnetic navigation sensor sensing points.
security function	Data loss and obstacle avoidance.	detection distance.
Positioning function	RFID reader data is lost and insensitive.	RFID reader coordinate data.

3.3. The realization of data acquisition and transmission

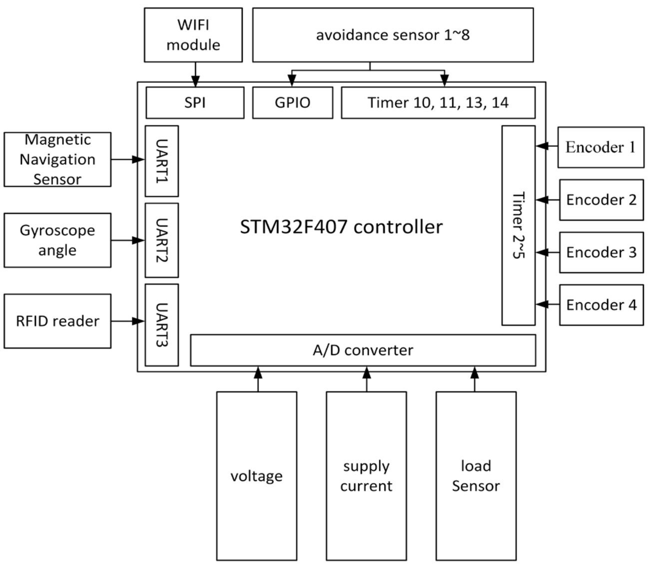

Figure 3: Block diagram of data acquisition part.

According to the demand analysis proposed in Table 1, the STM32 controller is used to complete the

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data acquisition, and its data acquisition block diagram is shown in Figure 3. Among them, when the controller processes the data, if the ASCII code is used for transmission, 125 bytes are required, and the 2-byte hexadecimal conversion transmission requires only 45 bytes, and the data volume is reduced by three times. Therefore, the system uses hexadecimal to process data.

In order to ensure the requirements of AGV data collection, the controller needs to process all data and store it in the array every 10ms, then the controller transmits the data to the WIFI module, and the WIFI module is connected to the wireless AP local area network in STA mode, so as to realize the AGV car and the wireless AP. Remote data exchange. However, because the frequent interruption of the sending data timer is easily interrupted by other interrupts, causing errors in the sending of sensor data, an improved method for sending data is proposed, that is, keeping the collection frequency of 100Hz unchanged, and expanding the sending array to 5 times the original. That is, the array is filled with 5 groups before sending the message packet.

4. Gateway data transfer module

4.1. Siemens IOT2040 intelligent gateway

The intelligent gateway carries the transfer function of AGV data upload and cloud command delivery, so it must ensure the rapidity of AGV data upload and the stability of communication with the cloud.

The IOT2040 intelligent gateway selected in this system, equipped with an open Linux system, provides a foundation for various industrial control devices to access the Industrial Internet of Things [8]. The IOT2040 gateway and the AGV wireless WIFI module use sockets as a bridge for data transmission, which can establish a stable and fast TCP connection.

4.2. MQTT protocol

The MQTT protocol is an instant messaging protocol based on the publish/subscribe model. A topic is established through the message server, the publisher will publish messages to the topic, and the subscriber can subscribe to the topic from the message server, the message server will forward all messages published by the publisher to the subscribers. This protocol can avoid the confusion of data processing by the gateway caused by the simultaneous upload of data from multiple AGVs, and allow the gateway to process data in an orderly manner without interfering with each other.

4.3. Realization of Gateway Data Transfer Module

Based on the MQTT protocol, the IOT2040 intelligent gateway is used to realize the data transfer function between AGV and the cloud platform. The block diagram of the module is shown in Figure 4.

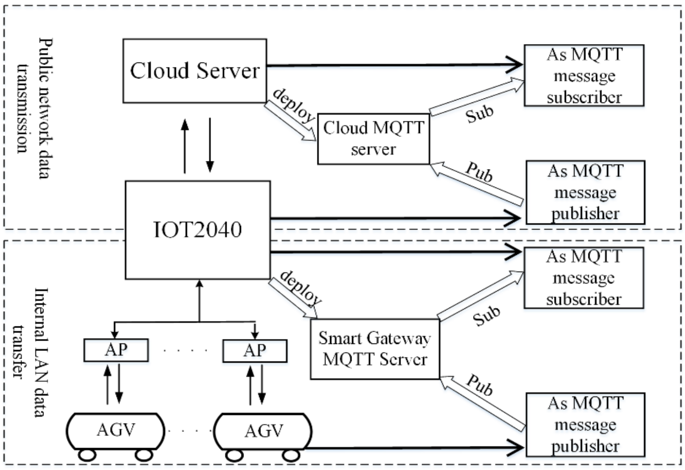

Figure 4: Structure block diagram of gateway data transfer module.

As can be seen from Figure 4, the AGV car and the intelligent gateway complete data communication through the internal local area network, and the IOT2040 gateway exchanges data with the cloud server through the public network. The data transfer steps are as follows:

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(1) The intelligent gateway installs the MQTT message server and establishes the topics of multiple AGVs.

(2) As the publisher of the gateway MQTT message server, each AGV car transmits the sensor data to the gateway MQTT message server in the MQTT protocol format through the WIFI module.

(3) The gateway MQTT message server parses the sent message and publishes the data carried by the message to the corresponding topic. At the same time, the gateway, as a subscriber of the MQTT topic, receives the data published by each AGV.

(4) The cloud server side also deploys the MQTT message server to establish the same topic as the smart gateway.

(5) As the publisher of the cloud MQTT message server, the gateway re-publishes the AGV data to the cloud MQTT message server through the network. At this time, the AGV data upload to the cloud is completed.

5. Cloud data processing module

5.1. Node-RED programming tool

Node-RED is a visual programming tool built on Node.js in Linux systems that allows developers to connect various code blocks (called "nodes") to form a "flow" to achieve specified functions, Its visual programming interface is shown in Figure 5. Node-RED also has a wealth of UI nodes, which support visual display of data, and use various UI nodes to form different monitoring screens to realize web-side AGV remote data monitoring.

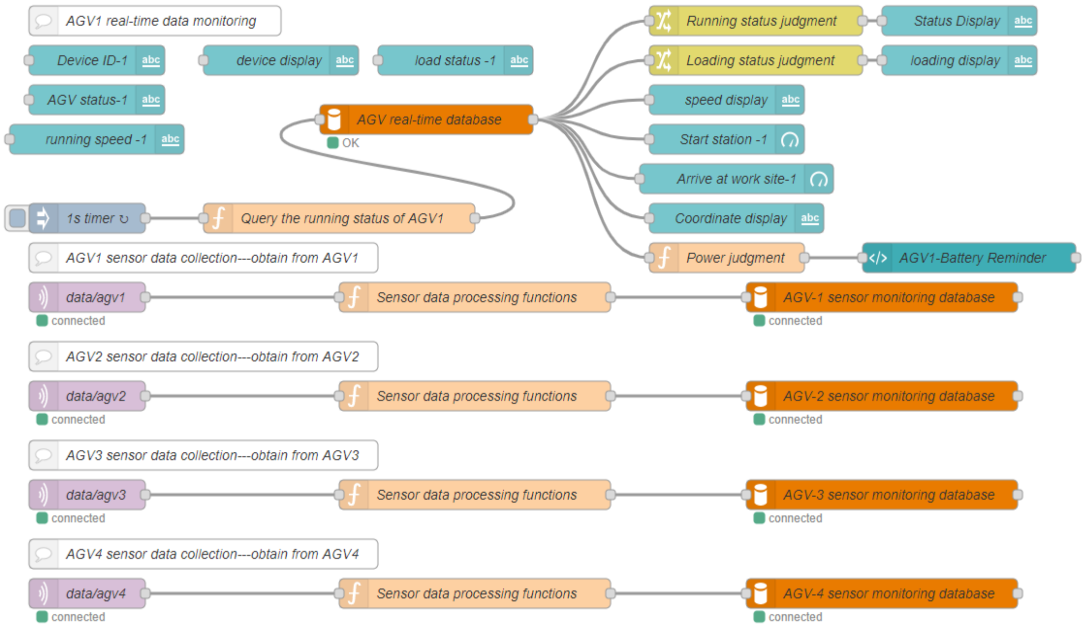

Figure 5: Node-RED visual programming.

5.2. Cloud data processing

The processing flow of cloud data is as follows:

(1) Use the MQTT node in the Node-RED tool to subscribe to the corresponding topic to receive the message published by the gateway.

(2) Use a text editor to create a conversion function, and re-convert hexadecimal numbers into floating-point numbers and integers according to the rules through JavaScript programming to realize data conversion.

(3) Connect the data processing function to the mysql database node to complete cloud data storage.

(4) The AGV data is regularly retrieved from the database, and various UI nodes of Node-RED are

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used to visualize the AGV running status, form different monitoring screens, and realize the remote data monitoring of the AGV on the Web side.

6. System test

6.1. AGV real-time data acquisition and transmission test

AGV real-time data acquisition and transmission test mainly test two indicators of system throughput rate and transmission packet loss rate. Among them, the throughput rate refers to the amount of data that is successfully transmitted per unit time when data is uploaded to the cloud; the packet loss rate refers to the ratio of the number of packets lost during data transmission to the number of packets sent.

In order to test the above two indicators of the system, the performance test of the AGV upload intelligent gateway and the performance test of the AGV upload cloud platform were carried out. The experimental test is shown in Figure 6.

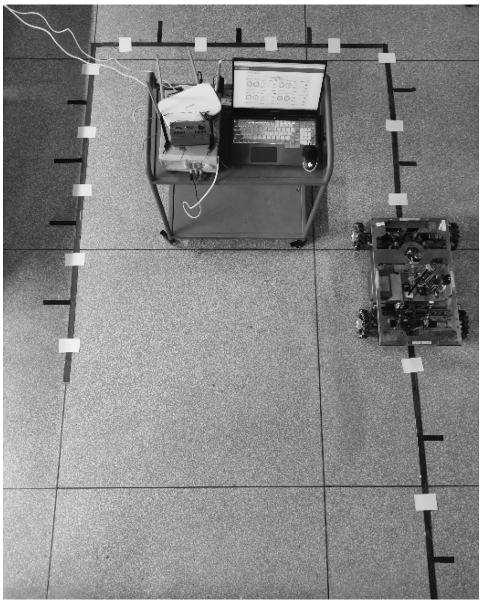

Figure 6: Experiment of uploading AGV data to cloud server.

6.2. AGV data upload intelligent gateway performance test

Connect the AGV car and the gateway to the same internal local area network for communication. By calculating the bytes used by the sensor data and the bytes used by the MQTT protocol format, the length of a set of data packets sent is 59 bytes, and the AGV car saves five bytes every time. After grouping the data packets, they are sent to the intelligent gateway. Carry out the experimental test, hang the AGV car in the air to execute the forward command, and count the time required for the MQTT subscriber of the gateway to receive 10,000 groups of data packets; carry out the packet loss rate test of the AGV data again, by setting the transmission on the STM32 controller side There are 60,000 groups of data packets, and the gateway IOT2040 side counts the number of received data packets at the same time. The experimental results are shown in Table 2.

Table 2: AGV upload data to gateway IOT2040 test.

Numble	Send packets	Receive packets	testing time/s	Throughput/PPS	Packet loss rate
Test 1	10000	10000	102	98	0%
Test 2	60000	59985	632	95	0.025%

From the test results in Table 2, it can be seen that the throughput rate and packet loss rate of the AGV car data uploading intelligent gateway can meet the actual needs, and the MQTT message server of the gateway IOT2040 can process five consecutive sending messages at the same time, which proves that the AGV car collects five groups of packets at the same time. The method of sending the data once works.

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6.3. Upload AGV data to the cloud server for performance testing

On the basis of the above experiments, the broadband is connected to the Ethernet port of the gateway IOT2040 through a network cable, and the gateway IOT2040 can be connected to the MQTT message server of the cloud server by operating the gateway background, and also 10,000 groups and 60,000 groups of data packets are handled respectively. The test results of the rate and packet loss rate are shown in Table 3.

Table 3: AGV upload data to cloud test.

Numble	Send packets	Receive packets	testing time/s	Throughput/PPS	Packet loss rate
Test 1	10000	10000	102	98	0%
Test 2	60000	59985	632	95	0.025%

Based on the test results in Table 2 and Table 3, the throughput of the system's data transmission is 90PPS, and the packet loss rate can also be kept below 0.1%. The data acquisition and transmission system can better satisfy the AGV online fault diagnosis system. Real-time, stable transmission requirements.

7. Conclusion

In order to solve the problem of data acquisition in AGV fault diagnosis based on cloud platform, this paper designs a data acquisition system for AGV fault diagnosis based on cloud platform. By analyzing its failure mechanism and proposing a method for AGV multi-sensor data acquisition, the intelligent gateway is used to realize the data transfer to the cloud server, and the Node-RED programming tool is used to realize the storage of AGV sensor data into the cloud database. Through the test of the designed and built AGV car data acquisition test platform, the throughput rate of the data acquisition system is 90PPS, and the packet loss rate is within 0.1%. At the same time, the system can realize real-time monitoring of the AGV status through the Web remote, indicating the proposed data acquisition The system meets the requirements and can provide stable and reliable diagnostic data for the online fault diagnosis of AGV.

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