Research on Intelligent Monitoring Method of Medicine Delivery Vehicle Based on Internet of Things Technology

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Abstract— Solving the puzzle of cross-infection between doctors and patients now seemed a distinct possibility due to the continuous progress of artificial intelligence technology represented by autonomous driving. A medicine delivery vehicle is designed to complete the transportation task autonomously. Utilizing the Internet of Things (IoT) technology, it can be remotely monitored and commanded through the WeChat mini program based on the Message Queuing Telemetry Transport (MQTT) protocol. The vehicle platform is constructed with Radio Frequency Identification (RFID) device, STM32 single-chip microcontroller, GM65 camera and other auxiliary hardware modules. To communicate with the cloud platform, ESP8266 Wi-Fi module is configured in the vehicle. The vehicle, cloud platform, and applet correspond with each other employing the MQTT protocol on software level. The OpenAPI interface and Topic subscription function are operated in the applet for transmitting monitored data and remote control instructions to the cloud and vehicle. The experiments in a simulated environment verify the effectiveness of system solutions and provide a technical solution for reducing the contact between doctors and patients.

Keywords-component; Internet of Things;MQTT protocol; Intelligent monitoring; medicine delivery vehicle; cloud; WeChat mini program

1. INTRODUCTION

The world has been ravaged by various infectious viruses strongly in recent years. The rate of infection among medical staff is exacerbated by the frequent contact between medical staff and patients in the fight against the virus. It is not conducive to the effective control of infectious diseases. The SARS epidemic broke out on a large scale around mid to late April 2003. Until May 25th, 2003, a total of 5,316 clinically diagnosed cases of SARS were reported nationwide, and yet the infection rate of medical staff reached 18.13% [1]; More than 2,000 medical staff were infected in less than two months in the early stages of the outbreak of COVID-19 in 2020 [2]. In order to reduce the contact between doctors and patients and reduce the risk of infection of medical staff, human beings are also constantly exploring.

In recent years, the development of human society has been transformed into the fourth industrial revolution known as the "Smart Age"[3],in which the integration and development of artificial intelligence technology and medical treatment has become a current research hotspot, such as new medicine research and development, portable robots, rehabilitation assistance robots wait[4]. In order to reduce doctor-patient contact, many scholars have conducted research on medicine delivery robots, such as Zhang Han et al who realized face recognition and autonomous navigation in the development of intelligent medicine delivery robot [5], and Jiang Longtao et al, developing an intelligent medicine delivery robot that realized door tag recognition and automatic medicine delivery [6]. In a broader sense, medicine delivery vehicles also belong to the category of intelligent driving, and intelligent interaction is one of the major challenges in the development of intelligent driving technology [7], which requires robots to have self-learning and self-awareness capabilities [8], which is a difficult research area in the current artificial intelligence research field.

In this context, this paper designs an intelligent monitoring system based on IoT technology for medicine delivery vehicle, which consists of three parts: the device perception layer, the network transport layer and the system application layer. First, hardware modules such as RFID, STM32 single chip computer, and GM65 are used to build the robot platform and obtain its operation and status information, and communicate data with the cloud platform by ESP8266 wireless WiFi controller. Then, the medicine delivery vehicle is connected to the Ali Cloud IoT platform through MQTT protocol to realize connecting hardware and sending and receiving data. In addition, the system client uses WeChat Mini Program, which is connected to the cloud by OpenAPI and the AliCloud IoT platform's Topic subscription function. The back-end of the Mini Program mainly uses Python and MySQL is selected as the database of the system. The application of the applet improves the efficiency of the monitoring system. The system applies IoT technology to the medical logistics system to monitor the operation status of medicine delivery vehicles, and through the software and hardware interconnection realized by MQTT protocol, users can remotely detect and control the status of medicine delivery vehicles through their mobile phones. The use of medicine delivery vehicles to perform medicine delivery tasks can effectively reduce the contact between medical staff and patients, and reduce the risk of infection for medical staff.

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2. System Overall Design

2.1. Overall architecture

Referring to the design idea of the Internet of Things, this system is mainly divided into device perception layer, network transport layer and system application layer [9]. The system architecture is shown in Figure 1.

The device perception layer is mainly used to obtain vehicle status data, using multiple groups of position, speed and weight sensors to detect the location information, running speed and weight of the medicine delivery vehicle, and using WIFI network to connect and communicate with the network transport layer.

Network Transport Layer is responsible for data transmission. Ali Cloud is selected as the cloud platform of the IoT, and MQTT protocol is used to realize the communication between the cloud and device sensors, system application layer. On the one hand, the data received from the device sensor can be transferred to the application layer of the system. On the other hand, the control commands from the application layer of the system can be transferred to the device sensor, so as to achieve monitoring and remote control.

System application layer carries out data monitoring and information processing, using MySQL database to store user information and vehicle information. Data monitoring on the WeChat applet side to realize the control of hardware modules.

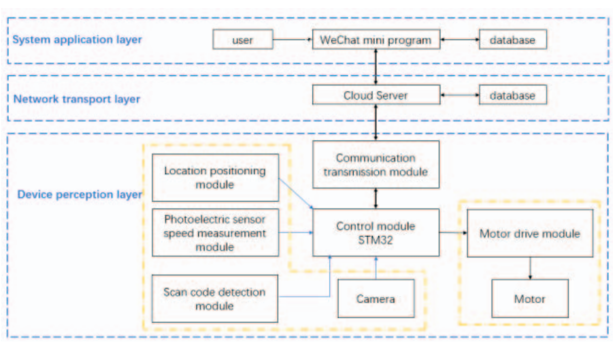

Figure 1. System structure diagram

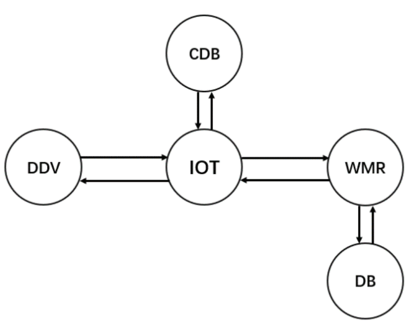

Figure 2. System DFG model

2.2. Transport Protocol

The system completes data transmission and reception through the MQTT protocol, which is built on top of the TCP/IP protocol and uses the published subscribe message transmission mode. It is suitable for connecting hardware devices with poor network signals and most commonly used in small devices. The MQTT protocol architecture is divided into three identities. The first one is the publisher. The second type of identity is the agent. The third identity is the subscriber [10].

Based on the MQTT protocol, the data flow graph model of the system operation is established, as shown in Figure 2. In the figure, the node MDV (Medicine Delivery Vehicle) is the device sensor part of the medicine delivery vehicle, and the node IOT (Internet of Things) is the Ali Cloud IoT platform, the node CDB (Cloud Database) is the server database in the cloud, the node WMR (WeChat mini program) is the WeChat mini program, and the WeChat mini program has its database DB (Database) for storing user information. The system operation process involves transferring data from device sensors to cloud servers, which store the data in the cloud database and forward it to the WeChat mini program. After receiving the information, the WeChat mini program displays it and stores the backend data in the data library of the WeChat mini program. The MQTT protocol uses JSON format to control the specification of message data input and output, matching the exact Topic by field name. After successful matching, specific topics can receive data and transmit it. To ensure the safe and stable transmission of system data streams, QoS technology is adopted during the communication process. The vehicle transmit data through wireless WiFi with the Ali Cloud IoT platform and stores device data in the cloud server database. The mini program obtains the cloud platform's ternary group information through the MQTT protocol. After successfully subscribing to the message, the cloud platform forwards the stored vehicle data to the mini program, achieving intelligent interaction between the vehicle and the user.

3. System Hardware Design

The hardware part of the vehicle uses STM32F103C8T6 as the overall control chip and ESP8266 wireless WiFi controller for data communication with the cloud platform. Collect information through the RFID module, and use the RC522 module to read card information through radio frequency to obtain vehicle position information. Using an embedded reading sensor GM65 to scan QR codes and identify medicine information. A camera is used to detect the operation status of the vehicle and avoid pedestrians and other obstacles. The basic structural framework is shown in Figure 3.

3.1. Communication Transmission Module

The system makes it convenient for small robots to realize remote monitoring and data acquisition by using the ESP8266 module, which features low cost, low power consumption, and easy programming. It is connected to the wireless WiFi using

AT command, so that the courier vehicle can connect to the AliCloud IoT platform. During the development process, in order to control the connection of ESP8266 to Ali Cloud by STM32, the AT command was sent to ESP8266 through the USART1 serial port by rewriting the Print function. This enabled the medicine delivery vehicle to connect to the Ali Cloud platform and report and receive data.

3.2. Location Positioning Module

The positioning information of the medicine delivery vehicle is obtained by RFID module combined with WiFi technology. Their combination can further improve the range and accuracy of positioning. The RC522 module reads card information through radio frequency. It can identify the card and realize the determination of the robot's position after reading the card information and comparing the card number. Then, the location information is upload to the cloud platform through ESP8266 to update the location information of the medicine delivery vehicle.

3.3. Photoelectric Sensor Speed Measurement Module

The running speed of the medicine delivery vehicle is measured by a photoelectric sensor. This method has the advantages of high accuracy, fast response and non-contact, which facilitates the accurate acquisition of the running speed of the medicine delivery vehicle. When writing the control program, the EXTI interrupt of the STM32 pin is used to count the code plate grid. Then, the number of wheel revolutions in a fixed time period is calculated by outputting the number of counts for that time period through the timing interrupt. The speed of the medicine delivery vehicle is calculated and the speed information is reported to the cloud platform.

3.4. Scan Code Detection Module

Considering that the GM65 Bar 2D code recognition module can read barcode symbols very easily and accurately, and has the advantage of high scanning rate, the GM65 module is selected to scan the barcode on the medicine box to identify the medicine information carried by the medicine delivery vehicle. After connecting GM65 and STM32 through a serial port, the data is sent to STM32 through the serial port when GM65 scans medicine information. STM32 identifies the type of medicine through barcode information and sends the medicine information to the cloud platform, which updates the medicine information carried.

3.5. Motor Drive Module

The motor drive module uses LS911 to determine the level of the STM32 pin output and drive the motor to achieve different rotation situations. This enables STM32 to control the operation and stop of the medicine delivery vehicle, preparing for subsequent cloud platform commands to control the medicine delivery vehicle.

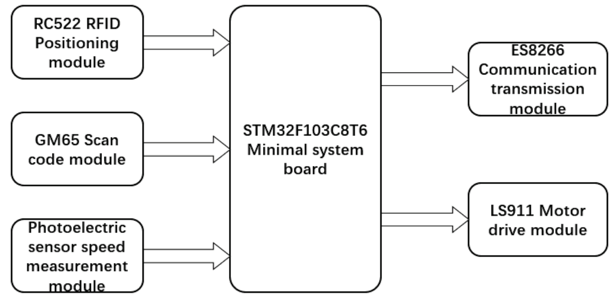

Figure 3. System hardware block diagram

4. System Software Design

4.1. IoT Platform Setup

The system adopts the Ali Cloud IoT platform, which has powerful server functions and supports hardware device access and communication. It also has a sea of OpenAPI interface for easy connection with software devices, and the platform has high security and confidentiality. Each device accessing the platform needs to obtain specific triplet group information (ProductKey, DeviceName, DeviceSecret) to connect with it. The platform configuration is relatively simple. The first step is to create a new product and set options such as product networking method and communication data format. The second step is to create a new device under the corresponding product and obtain the MQTT connection parameters of the device, that is, triplet group information. Data communication uses SQL statements to forward information to the subscribed topics in the system application layer. The statements are written in JSON data format. Realized the transmission of vehicle position information, driving speed, carrying weight, medicine information, and other data by corresponding settings. After the Ali Cloud IoT cloud platform is successfully connected to devices and mini programs, the platform devices will display online status. The specific configuration of the Ali Cloud IoT platform is shown in Figure 4.

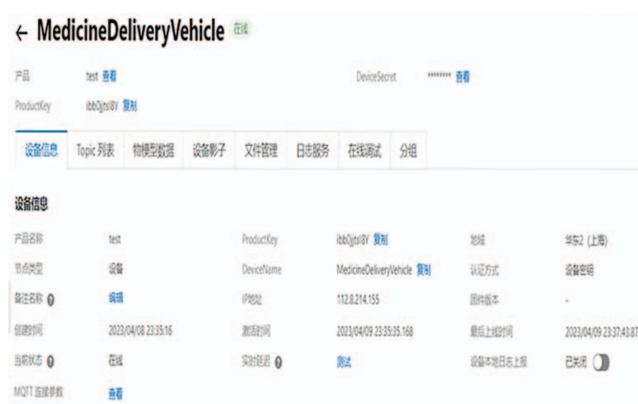

Figure 4. Alibaba Cloud IoT Platform configuration diagram

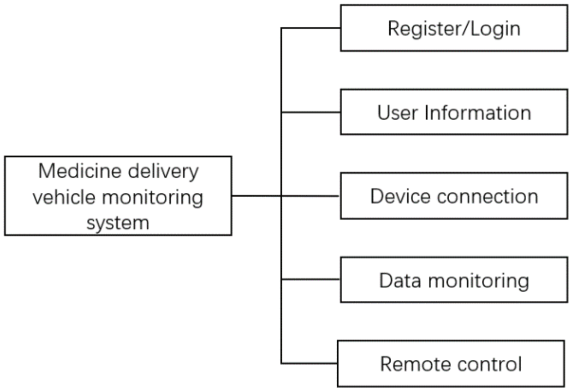

Figure 5. Mini program function module diagram

4.2. WeChat Mini Program Design

WeChat mini programs provide developers with one of the most convenient fast applications, relying on WeChat to provide users with flexible use on mobile devices without loading. The basic framework of system development is the MINA, which contains the basic functions provided by development tools, many components and APIs. The system uses WXML and WXSS which like HTML to interpret the layers. It is divided into logic layer, view layer, and system layer. The Python language is used to handle data transfer between layers in the logic layer. The main functional modules of the mini program are divided into personal center and monitoring data, including functions of login/registration, user information, device connection, data monitoring, remote control ,etc. The mini program functional module diagram is shown in Figure 5.

The storage and management of personal center information uses a MySQL database, which defines attributes such as name, phone number, room number, bed number, and medication information. The phone number is set as the primary key, and specific input formats are set to enhance information security. Data monitoring and remote control are connected to the Alibaba Cloud IoT platform through the MQTT protocol, and the device displays online status after successfully subscribing to the mini program.

5. SYSTEM TESTING

5.1. Testing Procedure

To test the feasibility of the actual operation of the medicine delivery vehicle, a simulation experiment was conducted to test it. The system testing was divided into two parts: hardware and software. The hardware testing mainly includes motion trajectory testing, runtime testing, and medicine recognition testing; The software testing includes whether the device can connect to the Ali Cloud IoT platform normally, whether device information can be uploaded to the cloud normally, whether the WeChat mini program can receive device information normally, whether the device can receive platform instructions normally, and whether the mini program can issue commands.

The medicine delivery vehicle was presumed to work mostly indoors, so on April 10, 2023, a virtual medical environment was built in the laboratory to test the vehicle. The simulation experiment was divided into two groups for 5 rounds of testing. The first group of wards was located in Ward 1, which distance was shorter, and the second group of wards was located in Ward 2, which was farther away. During the experiment, observe and record the actual operation status, travel time, running speed, and data reception between the cloud and the mini program of the vehicle.

Table 1 for example of hardware part running test.

Table 1. System hardware running state test *

Test Projects	**System Hardware Running State Test**
Test environment	Simulation Lab
Test process	Scan the code to identify medicines; carry medicines from the starting point for delivery; unload medicines after arriving at the destination; return to the pharmacy
Expected results	(1) Correctly identify the medicine; (2) Carrying medicines and transporting them from the starting point to the ending point; (3) Return to the ward after unloading the medicine.
test results	(1) Correctly identify the medicine; (2) Carrying medicines and transporting them from the starting point to the ending point; (3) Return to the ward after unloading the medicine.

Table 2 is an example of the software part running test.

Table 2. System software running status test *

Test Projects	**System Software Running Status Test**
Test environment	Ali Cloud Internet of Things Platform, WeChat mini program
Test process	After the device is started, it connects to the cloud platform; the device operation information is uploaded to the cloud platform; the cloud platform forwards the device information to the applet; the applet and the cloud platform send instructions to the device
Expected results	(1) The device is normally connected to the cloud platform; (2) The cloud platform normally receives the running status of the device; (3) The applet normally receives the running status of the device; (4) The instructions issued by the applet and the cloud platform can be received by the device normally;
test results	(1) The device is normally connected to the cloud platform; (2) The cloud platform normally receives the running status of the device; (3) The applet normally receives the running status of the device; (4) The instructions issued by the applet and the cloud platform can be received by the device normally;

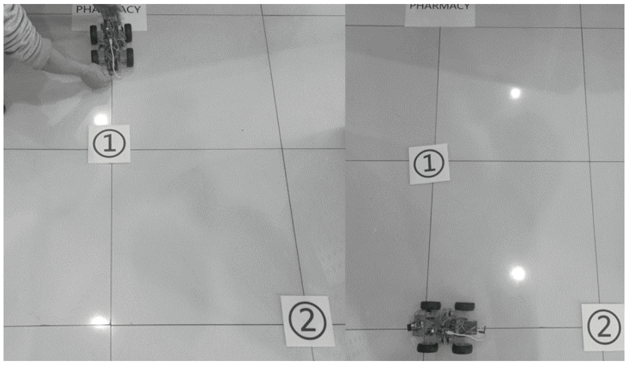

Figure 6. Actual vehicle delivery process

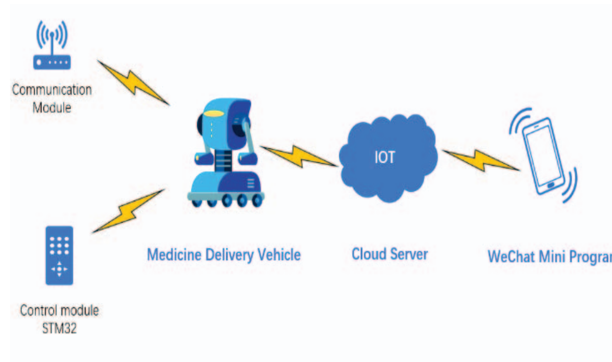

Figure 7. Monitoring method architecture diagram

5.2. Test Results and Analysis

The hardware test results are shown in Table 3. From Table 3, it can be seen that the average speed of the medicine delivery vehicle to complete the delivery task is about 0.2m/s, but there may be slight fluctuations with distance change. Overall, the operation is relatively stable. The actual delivery process of the vehicle is shown in Figure 6. The medicine delivery vehicle runs well in the specific practical scenario and can complete the medicine delivery task. Considering that the medicine delivery vehicle will be put into outdoor scenario application later, its hardware function must be further improved, such as using SLAM technology for positioning, but the cost will increase.

The test results of the software part are as follows. After the device is successfully connected to the cloud platform, the cloud platform interface will display that it is online. After this process the system completes the monitoring process, as shown in Figure 7. After receiving the device status information, the cloud platform forwards the data to the WeChat mini program. The applet interface shows that the subscription is successful, and the real-time location, speed, and weight are displayed on the home page, as shown in Figure 8(b). At the same time, the applet provides users with a registration and login function, which is convenient for users to upload personal information, and provides buttons to obtain user IDs and change parameters, as shown in Figure 8(c) below.

After testing, the user can normally enter through authorization after opening the WeChat mini program. On the homepage, the real-time data detection of the vehicle can be realized, the operating status of the device can be checked, and the communication between the device, the cloud platform, and the applet can be carried out, and the medicine delivery task can be realized.

Table 3. Hardware test results*

Num	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**
T/s	8.69	8.61	8.59	8.65	8.57	14.01	13.56	13.73	13.79	13.69
M/s	0.23	0.23	0.23	0.23	0.23	0.21	0.22	0.21	0.21	0.21

Figure 8. Mini program design interface

6. Conclusion

This paper introduces an intelligent detection method for the medicine delivery vehicle from the aspects of the overall system structure, hardware design and software design. The data transmission and remote control from the smart device to the cloud server to the mobile phone terminal realize the intelligent interaction between humans and robots. The system realizes the connection of each port through the MQTT protocol, and finally can realize the intelligent monitoring of the vehicle and the medicine delivery by the vehicle through the simple operation of the mobile phone software. However, due to the interface design of the system, there is still room for improvement in planning routes, medicine identification, and administrator authority settings. The medicine delivery vehicle has strong operability and stable operation during task execution. It can be further developed and put into market. Intelligent robots in logistics and transportation will have a broader development prospect in the medical field in the future.

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