Design of a vaccine storage and transportation system in remote areas based on Raspberry Pi

1st Jilin Qin
Shandong Institute of Commerce and Technology
Jinan, China
48270745@qq.com

2nd Jiong Zhang
Shandong Institute of Commerce and Technology
Jinan, China
21731416@qq.com

3rd Haitao Guo
Shandong Institute of Commerce and Technology
Jinan, China
457106895@qq.com

4th Fanxing Meng
Shandong Institute of Commerce and Technology
Jinan, China
276546941@qq.com

5th Xianwei Xue
Shandong Institute of Commerce and Technology
Jinan, China
376303164@qq.com

Abstract—**Vaccination can not only effectively protect individuals from infectious diseases, but also effectively prevent the spread of infectious diseases. The storage and transportation of vaccines have very high requirements on the environment. Generally, except for some high temperature resistant vaccines, the ambient temperature should be tens of degrees below zero. However, in some remote areas, due to weak infrastructure, unstable power supply and poor storage and transportation conditions, the vaccination rate of children there is very low. This paper designs an intelligent vaccine storage and transportation system based on Raspberry Pi. The system has the functions of process monitoring, storage and transportation traceability, temperature control and vaccine transfer. It combines software and hardware, and is suitable for remote areas. It aims to provide "last mile" service for children who need vaccination in remote areas.**

Keywords—Raspberry Pi; Relay; TEC Refrigeration Chip; Buzzer; Dht22 sensor

I. INTRODUCTION

In recent years, more and more attention has been paid to the importance of vaccination and the safety of vaccine storage and transportation. The National Health and Family Planning Commission and the State Food and Drug Administration made the following five requirements in the revision of the "vaccine storage and transportation management specification". First, it proposed the implementation of classified management of vaccine cold chain storage and transportation, and made it clear that the disease prevention and control institutions and vaccination units should verify the temperature records of vaccine transportation and the relevant information of vaccine products when receiving or purchasing vaccines; the second is to gradually improve the level of cold chain equipment; the third is to improve the level of cold chain temperature monitoring management, and put forward relevant requirements for temperature monitoring in the process of vaccine storage and transportation; the fourth is to standardize the management of vaccine storage and transportation, and put forward specific requirements for cold chain temperature traceability management procedures and data management;

fifthly, strengthen the management of abnormal temperature in the process of vaccine storage and transportation, and put forward the measures to deal with the abnormal temperature in the process of vaccine storage and transportation[1]. From the national requirements, we can see that there are higher requirements for temperature control monitoring and data traceability in the process of vaccine storage and transportation.

The impact of substandard vaccines on human safety is unimaginable. In addition to the problems of vaccines themselves, the deterioration and failure of vaccines during transportation and storage also become the main culprit of low vaccination rate. It is reported that the least vaccination rate is in underdeveloped areas with weak infrastructure and unstable power supply. Our country has a vast territory, and the hardware equipment in the third and fourth tier cities and towns is far from meeting the requirements. According to statistics, as many as 40% of the vaccine refrigerators are in a state of damage and no maintenance. Some of the vaccine refrigerators are unstable, and some health institutions in remote areas even have no refrigerators. Therefore, the vaccine in the "last mile" of storage and transportation is easy to lose its function due to the adverse environment outside.

In view of the above situation, this paper designs an intelligent vaccine storage and transportation system based on Raspberry Pi. The system combines software and hardware, and has the functions of process monitoring, storage and transportation traceability, temperature control and vaccine transfer. It aims to provide "last mile" service for children in remote areas who need vaccination. The system can set up two different temperature zones for storing and transporting vaccines with different temperature requirements. It has the advantages of simple operation, low cost and suitable for remote areas.

II. RESEARCH CONTENTS

The whole process of vaccine storage and transportation should be in the specified temperature environment, the cold chain storage should meet the requirements, and the temperature should be monitored and recorded in real time.

According to statistics, in the current market, the products that occupy more than 2 / 3 of the vaccine storage and transportation share include 2-8 degree vaccine transfer box, portable insulation box, vaccine transfer refrigerator, insulation transfer vehicle[5], etc. As shown in Table 1, portable transfer boxes usually use ice bags for heat preservation, but the constant temperature function is poor; professional equipment for transporting vaccines is often equipped with DC compressor refrigeration, which is affected by the power supply and is large and inconvenient for transportation; many equipment on the market do not have process visualization, monitoring and control functions, and as special equipment for vaccines, the market price is generally high.

TABLE I.   COMPARISON OF SIMILAR SYSTEMS

System name	2-8 degree vaccine transfer box	portable insulation box	vaccine transfer refrigerator	insulation transfer vehicle
Refrigeration source	*DC compressor*	*ice bags*	*AC compressor*	*DC compressor*
Volume	*medium*	*small*	*relatively large*	*large*
Visualization	*No*	*No*	*No*	*No*
Traceability	*No*	*No*	*No*	*Yes*
Monitor	*No*	*No*	*No*	*No*
Approximate price(¥)	*1000*	*200*	*3500*	*450000*

In view of the above problems, in order to reduce the cost of vaccine storage and transportation, expand the scope of users, and make the storage and transportation system have the functions of process monitoring, storage and transportation traceability, temperature control and so on, it uses Raspberry Pi, relay, refrigeration chip, temperature and humidity sensor and other hardware with high cost performance ratio to realize temperature control and real-time data transmission; HTML5 technology is used to develop the system interface, which can be installed on the user's mobile phone to view real-time data and realize contactless operation of vaccine storage and transportation box. The system also uses web crawler technology to collect the latest batch of vaccine information in real time, and calls the voice recognition interface of baidu API platform to realize the voice interaction function. As shown in Figure 1, the system mainly includes four modules: environment status, real-time monitoring, access record, and system setting, including seven sub functions, such as temperature and humidity detection, QR code scanning and warehousing, internal monitoring, warehousing record, one clic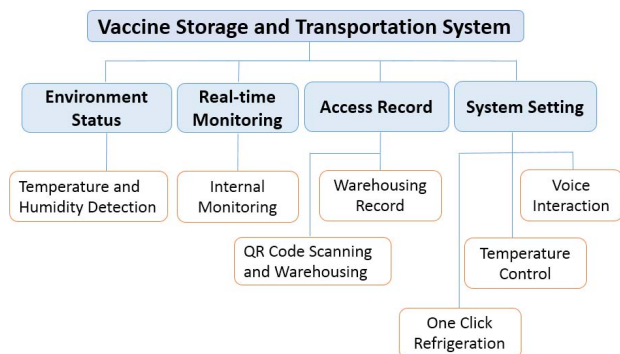k refrigeration, temperature control, and voice interaction. It can provide quality services for vaccine storage and transportation, especially in remote areas.

Fig. 1. System function frame diagram

III.   IMPLEMENTATION PROCESS

As shown in Figure 2, the system uses Raspberry Pi, relay, TEC refrigeration chip, temperature and humidity sensor, electric bolt lock and other hardware devices equipment to assemble the hardware part of the system; uses HTML5 hybrid technology to develop the software part of the system, and uses MUI framework and voice recognition interface of Baidu API platform to complete the system interface, refrigeration control, process control, voice recognition and other functions.
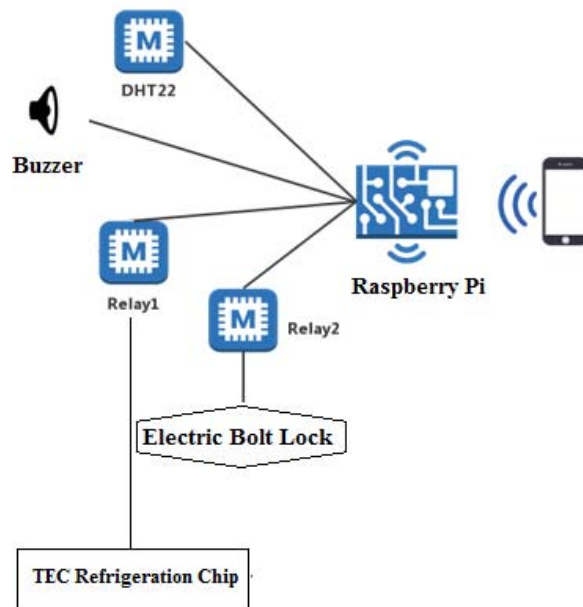

Fig. 2. Design schematic diagram

A.   Associated Equipment

The hardware technologies involved are as follows:

- Raspberry Pi:

It is a microcomputer motherboard based on ARM, with SD / microSD card as memory and hard disk. There are 1 / 2 / 4 USB interfaces and a 10 / 100 USB interface around the card motherboard Ethernet interface (type A has no network interface), which can be connected with keyboard, mouse and network cable[2]. At the same time, it has TV output interface of

video analog signal and HDMI high-definition video output interface. All the above components are integrated on a motherboard which is only slightly larger than credit card, and it has all the basic functions of PC.

- DHT22:

It is a temperature and humidity composite sensor with calibrated digital signal output. It consists of a capacitive humidity sensor and a NTC temperature sensor, and is connected with a high-performance 8-bit MCU. Therefore, it has the advantages of excellent quality, ultra fast response, strong anti-interference ability and high cost performance. It is a four pin module, including four pins of VCC, data, NC and GND. In actual use, only VCC, GND and data are used. The NC pin is empty, and the VCC voltage range is 3-5v. The principle of measuring temperature and humidity by dht22 is to measure the surrounding air through the built-in capacitive humidity sensor and thermistor. After obtaining the temperature and humidity values, a digital signal is sent to the main control board by the data pin[3].

Dht22 technical parameters:

1. Humidity measurement range: 0-100% RH

2. Humidity measurement accuracy: ± 2% RH

3. Temperature measurement range: - 40-80 ℃

4. Temperature measurement accuracy: ± 0. 5 ℃

5. Working voltage: DC5V

- Relay:

It is a kind of electronic control device, which has control system (also known as input circuit) and controlled system (also known as output circuit). It is usually used in automatic control circuit. In fact, it is a kind of "automatic switch" that uses smaller current to control larger current. Therefore, it plays the role of automatic adjustment, safety protection and conversion circuit in the circuit[4].

- TEC Refrigeration Chip:

Semiconductor refrigeration chip, also known as thermoelectric refrigeration chip, is a kind of heat pump. It has the advantages of no sliding parts, and can be used in some places with limited space, high reliability requirements and no refrigerant pollution. Using the Peltier effect of semiconductor materials, when the direct current passes through the couple formed by two different semiconductor materials in series, the heat can be absorbed and released at both ends of the couple respectively, which can achieve the purpose of refrigeration.

It is a kind of refrigeration technology with negative thermal resistance and high reliability. TEC refrigeration chip is an electronic module that controls the current direction and intensity through TEC. By using it, the temperature of an object can be precisely adjusted. The controller has small volume, modularization, high efficiency, low noise, accurate temperature control, and can be used for temperature control of related systems.

- Buzzer:

It is an integrated electronic buzzer, powered by DC voltage. As a sound device, it is widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products.

- **Electric Bolt Lock:**

Usually it consists of two main parts: lock body and lock hole. The key part of the lock body is the "lock tongue", which can realize two states of "closing" and "opening" by cooperating with the "lock hole". That is, the lock tongue is inserted into the lock hole to close the door, and the lock tongue leaving the lock hole is to open the door. It is precisely because of the retractable function of the lock tongue that it is named "plug-in lock". It is also because of this feature, the plug-in lock is often used in a variety of swing doors (two-way opening). At the same time, its "hidden" installation features are more suitable for places with higher requirements on the confidentiality of the lock body.

B. Operation Process

As shown in Figure 3, through the software app of the system, scan the QR code of the storage and transportation box, open the box, and record the information of the box in the background. Then scan the vaccine QR code, record the vaccine information in the background, and put the vaccine into the storage and transportation box. A camera is installed inside the box, which can automatically adjust the temperature to the temperature suitable for the storage of the vaccine through image recognition.
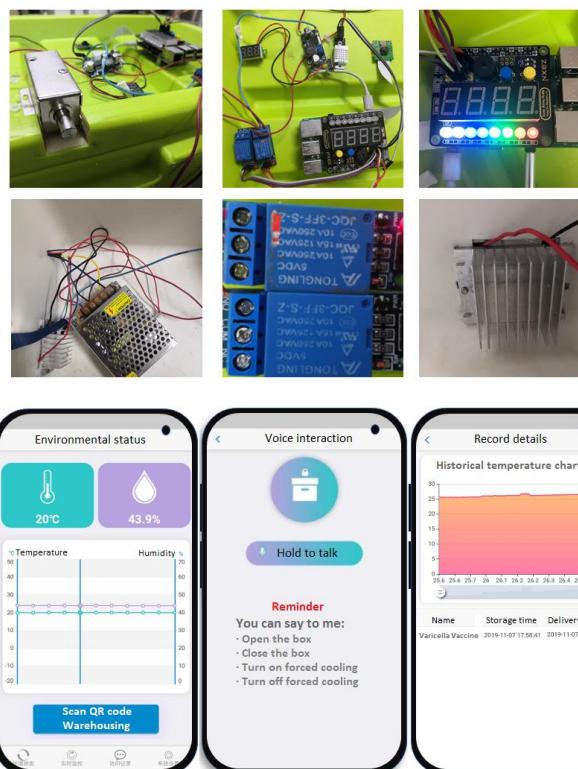

Fig. 3. Real object diagram of system

Transportation process management and control is to monitor the temperature and humidity in the storage and

transportation box in real time on the mobile phone through the system software app, and automatically generate charts from the data, so as to achieve the purpose of non-contact and visual observation. After the vaccine is put into the storage and transportation box, according to the image recognition results, view the detailed data of the vaccine on the system app, and prompt the user how long the vaccine can be stored at most. As shown in Figure 4, the box has four temperature zones, which can store vaccines with different temperature requirements. It makes it easier for users to operate.
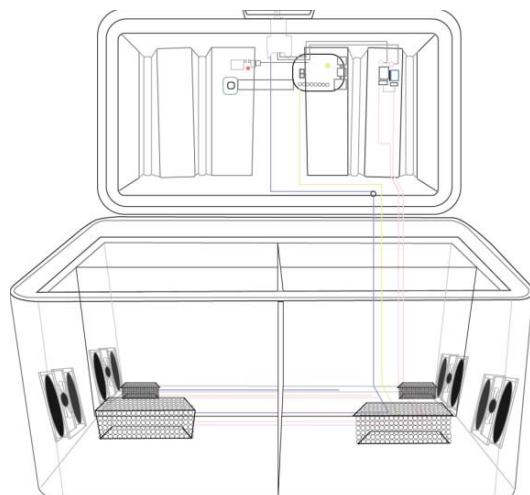

Fig. 4. Four temperature zones of the box

The system also supports voice recognition function. Through the system app, the command operation of vaccine storage and transportation box can be carried out, including voice unpacking, box closing, observation, etc. Speech recognition has high security, you can set instructions to complete the specified action.

IV. INNOVATION

When the system is moving, the built-in power supply is switched to ensure the constant temperature in the box. After scanning the QR code of the vaccine, the system will compare with the relevant data published by the State Food and drug administration. When the vaccine is detected in the recalled batch, it will give a prompt and refuse to be put into the warehouse. If it is not in the recalled batch, it can be put into the warehouse smoothly, so as to realize the safety traceability. When vaccines are transported in remote areas, the system can ensure the storage and transportation environment and monitor the availability of vaccines.

In short, the system is composed of software and hardware, which is easy to operate and low cost. It supports process monitoring, storage and transportation traceability, temperature control, voice interaction and vaccine transfer functions. It is very suitable for vaccine storage and transportation in remote areas.

V. CONCLUSION

This paper designs an intelligent vaccine storage and transportation system based on Raspberry Pi. The system combines software and hardware, and has the functions of temperature and humidity detection, QR code scanning and warehousing, internal monitoring, warehousing record, one click refrigeration, temperature control, and voice interaction. It can provide quality services for vaccine storage and transportation, especially in remote areas. The functional modules of the system can be added or removed according to users' needs. The interface is open and fully supports the secondary development. I hope more people who like to study can join us to provide "last mile" service for children who need vaccination in remote areas.

REFERENCES

[1] LE Imbelloni, IAN Pombo, GBDM Filho. NATIONAL GUIDELINES FOR VACCINE STORAGE AND TRANSPORTATION. EBSCO, 2015, 10. 5658/WOOD.2015.43.1.17.

[2] Yong Sun, Liqing Geng, Ke Dan. Design of Smart Mirror Based on Raspberry Pi. ICITBS 2018, 77-80.

[3] Zhang Jing. A simple calibration methods of relative humidity sensor DHT22 for tropical climates based on Arduino data acquisition system. IMAT, 2019.

[4] J Liu, M Tang, Y Geng, Adaptive Spray and Wait Routing Based on Relay-Probability of Node in DTN. International Conference on Computer Science & Service System, 2012.

[5] Liao Yingjun, Niu Lin, Cai Liulu. Design and implementation of vaccine storage and transportation system based on RFID Technology. Computer knowledge and technology, 2018. 1009-3044（2018）30-0071-03