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Design and Implementation of Human Health Monitoring Platform Based on Internet of Things Technology

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***Abstract*—Internet of Things (IoT) can provide interconnection of things, which can promote the achievement of the remote human health monitoring. In this paper, a human health monitoring platform is designed and developed under the application framework of body sensor network of IoT. The platform can collect the physical information of user by constructing the human state acquisition system. And then the collected human physiological data is transmitted to data processing platform through ZigBee wireless network for further data processing, preservation and display, with which real-time rescue and treatment can be sent out by guardian, doctors and healthcare caregivers.**

Keywords-remote Health Monitoring of Human; ZigBee; Sensor; Physiological Parameter； Electronic Care System

I. INTRODUCTION

With the continuous improvement of living standards and the rising proportion of aging population, people are paying more attention to health problems, which makes it with wide application prospects to spread the remote medical monitoring. In China, as the population aging is coming, necessary healthcare service is missed among the aging population. Meanwhile, the problem of difficulties in medical care becomes more and more prominent due to the phenomenon that medical services are far less than the actual needs of society. Therefore, it is an important research topic how to solve these problems through the means of remote medical monitoring [1-2]. It can save certain medical and service charges to allocate medical resources effectively and reasonably, as well as improving the efficiency of the hospital. Telemedicine [3-5] is helpful for medical workers to get the specific information of person under guardianship on time, so it is convenient for them to get timely and effective treatment.

Since the middle of the 20th century, the United States, Western Europe and Japan have made a lot of researches on remote medical monitoring. Before 1985, remote medical treatment developed slowly because of the limitation of the development of science and technology. But during the next ten years, the United States and Western Europe countries made great progress in remote consultation and long distance transmission of medical image. From then on, remote diagnosis began to be put into use. With the development of mobile communication technology and the progress of wireless sensor technology, remote medical detection system based on wireless sensor network technology have become the focus of many experts and scholars at home and abroad [6-10]. An MAC protocol was proposed by Shu et al. to deliver urgent data for body sensor networks (BSNs) with heavy traffic [11].

Based on the technology of Internet of things, this paper designs a human health monitoring platform. The design and implementation of the monitoring platform mainly includes the following four aspects.

Firstly, design and implementation of the human body physiological data acquisition module. The physical status of body temperature, blood pressure and fall detection of human being are monitored in this paper. Three modules including temperature measurement module, pulse measurement module and fall detection module are constructed to collect and monitor the physiological characteristics of human body by sensing the information of body temperature, pulse and human movement.

Secondly, threshold-based fall detection algorithm is proposed for fall detection research. The changes during the fall action of human body is fully analyzed, under which a third-level fall detection algorithm is proposed. The algorithm determines fall by analyzing the collision of human body, accumulated acceleration ΔSVM and the final state of human body.

Thirdly, design and implementation of the wireless transceiver module. This paper realizes the design of wireless transceiver module on the basis of the analysis of ZigBee technology and the characteristics of ZigBee network. Meanwhile, the conversion from ZigBee protocol to TCP/IP protocol is achieved by analyzing the gateway. Then the collected physiological characteristics data can be transmitted with the designed wireless transceiver module.

Fourthly, design and implementation of the electronic care system. The electronic care system mainly processes, stores and manages the collected human physiological characteristic data, which can also provide visualized human-computer interaction.

Finally, the main function and the reliability of the system and main function module are verified by setting a large number of experiments.

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II. HUMAN HEALTH MONITORING PLATFORM BASED ON INTERNET OF THINGS TECHNOLOGY

The design includes three parts, namely data acquisition module, wireless communication module and electronic supervision system.

A. Data acquisition module

Data acquisition module can collect many kinds of state data of the body by use of sensors. After the selection of main control chip and circuit design, it can get the physiological parameters, including temperature, pulse data and so on. If the user falls down, the alarm information will be sent out.

MCU of MSP430 series is a hybrid processor, with low power consumption, convenient development, strong processing power and many other advantages. This paper adopts MSP430F2 as main control chip to gather physiological indexes, including temperature, blood pressure, pulse and so on. It handles data through the A/D conversion ports, and communicates among multiple serial ports.

Below temperature acquisition and fall detection are mainly introduced

1) Temperature measurement

When it comes to temperature measurement, we choose a sensor named DS18B20. This sensor is a temperature sensor, which is widely used with great popularity. It has lots of features, such as small volume, low hardware overhead, strong anti-jamming capability, strong anti-jamming capability and high precision.

DS18B20 is a component with single wire digital interface, and it is convenient to connect with MSP430F2. MCU and the temperature sensor connect with each other by a series of digital I/O pins, which can be used to transmit data between them. Fig. 1 shows their hardware connection.

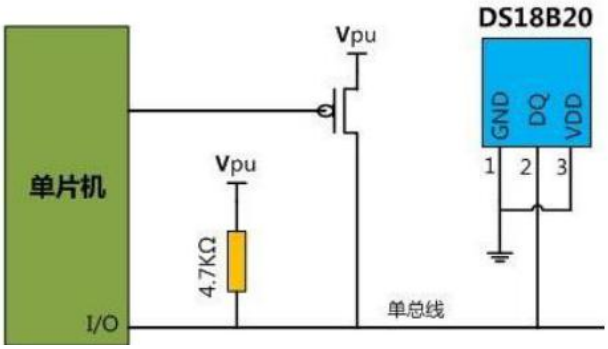

Figure 1. Hardware connection diagram.

The module carries on the system initialization, and then read the sensor data. If the sign bit is 1, it continues to read sensor data, or it reads the serial number. If reading serial number successfully, the module converts the data, and executes delay processing. Then it will read the register data, in order to obtain high bit and low bit of register data. If temperature sign value is positive, the module obtains the data in float type, then output the data after data analysis and processing.

2) Fall detection

MGA3110 (semiconductor three-axis magnetometer) and MPU6000 (three-axis gyroscope) are the major units to construct the module of fall detection. When the user falls down, inertial perception algorithm based on MEMS will extract the data from these two sensors, which can conclude human pose. Design of schematic circuit diagram is shown in Fig. 2.

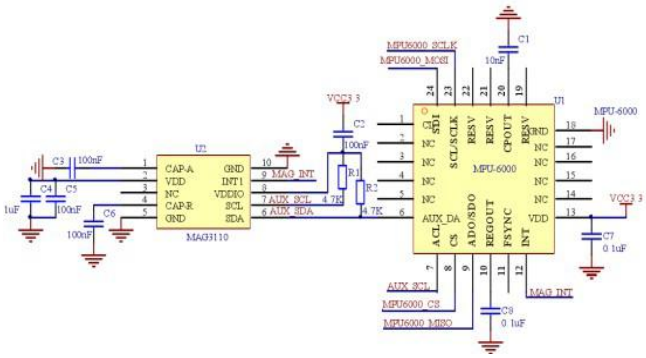

Figure 2. Design of schematic circuit diagram.

After working stably, the system's internal clock and the sensors' internal data of the module will be initialized. The device of data acquisition would continuously read information from three-axis magnetometer and three-axis gyroscope. Then the information will be transmitted to coordinated control unit. After transmission of the medium notes and analysis of various data interface, the information will be received by data process unit finally. If some data is beyond the preset threshold value, the data process unit will activate an alarm.

B. Wireless transceiver module

Wireless transceiver module is in charge of transferring the collected data to the data processing unit in software platform for processing. At the same time, the alarm information given by the platform will be transmitted to the patient's care workers. The main work of this module includes hardware selection and design of the wireless data transceiver module, wireless communication technology and the design of the gateway.

CC2530 is a kind of chip produced by TI. As the first chip to support ZigBee technology, it provides a system on chip (SoC) solution project.

The peripheral circuit of CC2530 is very simple, including power supply circuit, crystals circuit, wireless transceiver circuit and reset circuit and other parts. Thanks to the built-in module function integrated in chip CC2530, we use 32.768 kHz clock crystals and 32m Hz passive crystals in the master clock module when we design the circuit. When designing network matching of the RF module by use of wireless technology, we use 50 euro negative polarity whip antenna. The acceleration sensor and the RSSI positioning sensor are integrated into the intelligent terminal.

Due to some restrictions in terms of the performance, related chips of wireless transmission module cannot access data directly from the port of the coordinator. To solve the problem, a device must be used as transit equipment between

the coordinator and network. Here we choose W5500 as network interconnection equipment. After connection between CC2530 and W5500, we can send control data to W5500. We use SPI interface to implement the communication between MCU and W5500. CC2530 is wireless single chip, with 8051 kernel, two SPI interfaces in a single chip, reusing with USART serial port. In this paper, we select SPI1 as the control interface of W5500. After connecting every pins by winding displacement, we write program of the hardware drivers.

C. Electronic care system

Electronic care system is the interactive interface between human health monitoring platform and guardian person. In addition to constructing a database system for data receiving, data processing and data management, this system also designs a data display platform.

We choose MySQL database to manage data. After entering the main interface to the system through the login module, the user or the guardian can perform related operations according to their own needs. For example, the guardian can manage medical equipment, query the state information of person under guardianship and process alarm information and so on. Then the user can click the exit button to exit the system.

1) Login module

The user inputs the username and password, and clicks the login button. If the username or password is wrong, the login request will be denied.

2) Alarm center module

After entering the main interface of the system, the user can set alarm threshold value and receive short messages in alarm center module.

a) Alarm setting: According to the actual situation of the person under guardian, a threshold is set for the body data related to the guardian. When the collected data exceeds the threshold value, the system sends out an alarm

b) Short message receiving: This part is used to receive alarm information and reply information sent by guardians. For one thing, person under guardianship is informed to do necessary activities by the short messages. For another, the physiological data of person under guardian can be queried.

3) Guardian management

After logging in the system successfully as a manager, the user can select the guardian management module in the main menu of the system. In this page, the user can perform relevant operations, such as querying the information of guardians, adding new guardians, deleting existing guardians and modifying the information of the guardians.

4) Management module of person under guardianship

After logging in the system successfully as a manager or a guardian, the user can select the management module of person under guardianship in the main menu of the system. In this part, the user can perform relevant operations, such as querying the basic information of person under guardianship. The user also can add new person under guardianship, modify or delete existing person under guardianship.

III. TEST AND ANALYSIS

In this paper, we have conducted the system function test, the system accuracy test and the communication test separately.

A. System Function Test

In the human fall detection test, 20 participants of different age and gender were in accordance with the provisions of the experiment. The participants with sensors simulated the fall pose in different conditions, and the fall action needed to be repeated five times in one environment. At the end, everyone completed the fall action 25 times in five different environments, with a total of 500 times. The fall detection device issued a total of 454 alarm through the test system, which implied that the accuracy rate was up to 90.8%. So the system can meet the design requirements, but there is still much room for improvement.

Temperature monitoring and pulse measurements will be presented in the next part.

B. System Accuracy Test

In order to analyze the accuracy of temperature monitoring and pulse measurement, three volunteers were invited as the test object of the system. We measured their temperature and pulse, and respectively compared them with the test results of the medical mercury thermometer and the pulse tester. Table I and Table II are the comparison results.

It is not difficult to see that the measurement results of the system are consistent with the mercury thermometer. And the relative error value is small, as low as 0.3%. Therefore, it can be concluded that the system can be used to monitor body temperature. As shown in the temperature variance of the 3 sets of test data, we illustrate that the system is a relatively stable to measure temperature.

As we can see from Table II, the pulse results of the measured object are all in the normal range (normal adult pulse number is 60-100/min), and are basically same with the medical pulse test results, with the relative error 2.6%.

C. Communication Test

The communication test mainly includes two aspects, such as the test of communication distance and the test of transmitting and receiving.

Through the actual test, the ZigBee network transmission distance is as far as 80 meters, which is a stable and reliable signal transmission. The node can move freely within the transmission scope. Therefore, the transmission distance fully meets the needs of practical applications.

The system has also performed the communication test in sending and receiving the short message, using the water temperature instead of the body temperature. When the water temperature exceeds the set threshold value, the preset phone will receive a message from the SIM card, and there will be excessive temperature displayed on the phone. Therefore, the GPRS communication is normal.

IV. CONCLUSION

This paper have designed and implemented a human health monitoring platform based on IoT technology. We can

get real-time physiological data and body posture by human physiological data acquisition module. Then the collected data and alarm information will be transmitted to central monitoring platform by use of wireless communication to perform processing, storage, management and display. If the physiological data of person under guardian exceeds the threshold value, the alarm will be sent out, which ensures that the person of guardian can be diagnosed and treated timely and effectively.

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TABLE I. BODY TEMPERATURE TEST RESULTS

	Test results						
Tester	***First Time***	***Second Time***	***Third Time***	***Average Value***	***Variance Value***	***Mercury thermometer***	***D-value***
Tester 1	36.5°C	36.1°C	36.2°C	36.27°C	0.0289	36.4°C	0.13
Tester 2	36.5°C	36.2°C	36.2°C	36.3°C	0.02	36.4°C	0.1
Tester 3	35.9°C	36.0°C	36.1°C	36.0°C	0.0067	36.1°C	0.1

TABLE II. PULSE TEST RESULTS

	Test results (times/minute)						
Tester	***First Time***	***Second Time***	***Third Time***	***Average Value***	***Variance Value***	***Mercury thermometer***	***D-value***
Tester 1	71	75	72	72.7	2.89	74	1.3
Tester 2	83	79	82	81.3	2.89	79	2.3
Tester 3	82	86	79	82.3	8.2	85	2.7