Health monitoring system based on wireless personal area network

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ABSTRACT

With the rapid development of social economy, people pay more and more attention to physical health problems. Heart rate detection, blood oxygen detection and blood pressure detection are important basis for cardiac diagnosis, which can help people to carry out early medical diagnosis. Combined with Arduino, Android and Bluetooth technology, a simple and easy-to-use health monitoring system based on wireless personal area network is proposed in this paper. The system uses reflective photoelectric sensors to obtain heart rate signal, digital blood pressure modules to obtain blood pressure information and MAX30102 blood oxygen sensors to obtain blood oxygen information. The data acquired by the sensor is processed by Arduino, the heart rate and blood oxygen information are displayed on the LCD1602 in real time. Meanwhile, the smart phone APP is used to communicate with Arduino via Bluetooth to perform blood pressure measurement. The test results show that the system can obtain health parameters timely and accurately, and the overall operation of the system is stable and practical.

Keywords: Arduino, health monitoring, personal area network, android, bluetooth

1. INTRODUCTION

Recently, thanks to the increasingly pressure caused by working and studying, the heath problem is being more and more concentrated. Some of the main parameters of the body, such as heart rate, blood oxygen level and blood pressure have also become people's focus to know their health status quo[1]. Enough amount of oxygen is the material fundamental of all kinds of life activities, and the blood oxygen saturation is an important parameter that reflects blood oxygen level[2]. The decrease of blood oxygen saturation can cause serious hazards, such as hypertension, hypoxemia and coronary heart disease. In addition, due to the increasing number of hypertension patients, the cases of cardiovascular and cerebrovascular diseases have been growing so fast during recent years, making it a vital problem that threats people's health.

In order to meet the needs of healthy life of daily family, this paper proposes and implements a health monitoring system[3] based on wireless personal area network[4]. With Arduino as the main control core[5], the system uses blood oxygen sensors, blood pressure sensors and heart rate sensors to collect data on human physiological characteristics. The collected data is interacted with the smart phone through Bluetooth to realize real-time monitoring[6].

2. OVERALL SYSTEM FRAMEWORK

The general block diagram of the health monitoring system is shown in Figure 1. The main controller adopts ArduinoMega2560 based on ATMEGA2560 processor[7]. The heart rate measurement module based on photoelectric sensor, the digital blood pressure measurement module and the blood oxygen measurement module based on the MAX30102 blood oxygen sensor[8] are used to collect health-related parameters. After being processed by Arduino, the collected data is displayed through the display module. And the data can also be transmitted to the smart phone through the Bluetooth module for real-time monitoring.
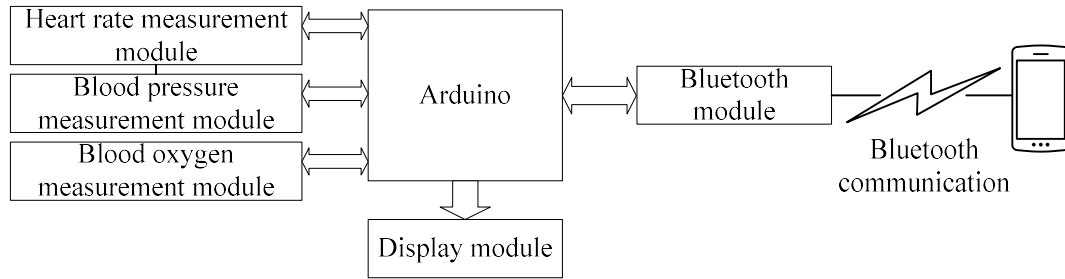
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Figure 1. Overall block diagram of the system.

3. HARDWARE DESIGN

3.1 Heart rate measurement module

The heart rate measurement module is shown in Figure 2, including the signal acquisition circuit, the filter amplifying circuit and the waveform shaping circuit.
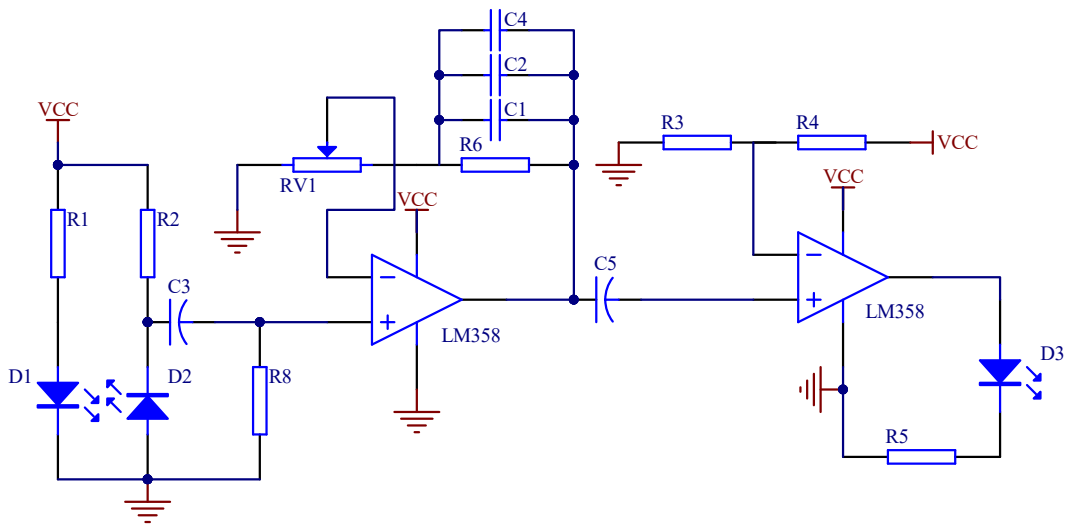

Figure 2. Heart rate measurement module circuit.

The signal acquisition circuit is composed of D1, D2, R1, R2, C3 and R8. And the reflective photoelectric pulse sensor adopts infrared pair tubes to detect the pulse signal[9]. Capacitor C3 is a coupling capacitor, which can isolate DC, pass AC and prevent the DC signal from interfering with the work of the next-level module.

The heart rate of normal people is generally relatively fixed and belongs to low-frequency signal, while the external interference is basically high-frequency signal. The filter amplifying circuit composed of C1, C2, C4, C5, R6, RV1 and LM358 is used to filter and amplify the heart rate signal. This reduces noise and interference from other signals.

The waveform shaping circuit is composed of R3, R4, R5 and LM358. The "+" terminal of the operational amplifier is connected to the amplified pulse signal, and the voltage of the "-" terminal is divided through R3 and R4. After the two voltages are compared, if the pulse signal is large, the output is 5V; otherwise, the output is 0V. In this way, regular pulse forms are obtained.

3.2 Blood oxygen measurement module

The blood oxygen measurement module based on MAX30102 is shown in Figure 3, including the optical sensor, the optical transmitter and the noise reduction circuit. The blood oxygen acquisition module uses I2C communication standard[10], which can be carried out by software operation and realize low power consumption. The luminous part includes two LEDs,

which can emit light of different wavelengths. The photodiode of the receiving part converts different light intensities into different electrical intensities, and then transmits the blood oxygen value to the main controller after filtering and ADC.
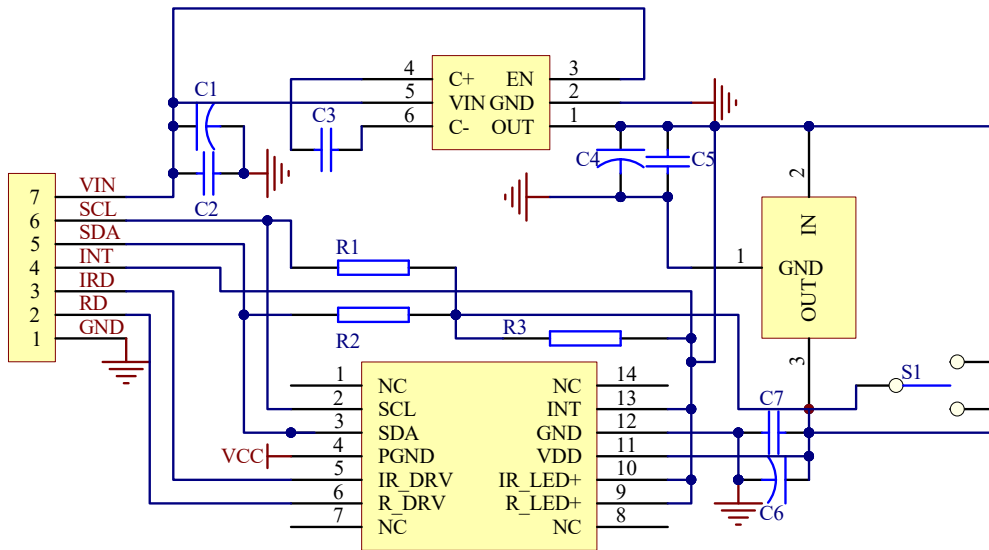
Figure 3. Blood oxygen measurement module circuit.

3.3 Blood pressure measurement module

The blood pressure measurement module adopts the digital blood pressure module kit, which is composed of digital blood pressure module, air pump, solenoid valve, air release valve, air route pipe fitting and cuff. The measuring range of digital blood pressure module is 0-299mmHg, the resolution is 1 mmHg, and the error is ±3 mmHg[11].

The TX and RX of the blood pressure measurement module are connected to the RX and TX of the Arduino respectively. The serial port connection is set through AT commands. In this design, the acquisition mode is selected and the serial port is used to transmit data.

3.4 Display module

The display module adopts LCD1602 liquid crystal display and uses I2C for communication. The display is easy to display numbers and letters, simple to control and low cost.

3.5 Bluetooth module

The Bluetooth module based on HC-05 adopts serial communication mode[12]. Users can modify the device name, baud rate, etc. through AT commands conveniently and flexibly. The circuit of Bluetooth module is shown in Figure 4. The TXD pin is connected to the RXD pin of the main controller, and the RXD pin is connected to the TXD pin of the microcontroller.
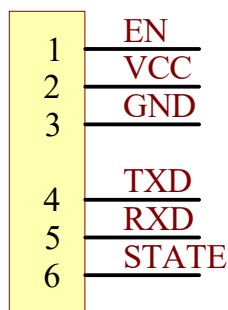
Figure 4. Bluetooth module circuit.

4. SOFTWARE DESIGN

4.1 Overall system software design

The overall programming of the system is shown in Figure 5. After system initialization, the main controller judges the measurement mode command. If Flag = 1, the heart rate and blood oxygen information will be collected and displayed through LCD. If Flag = 0 and the measurement instruction sent by the smart phone APP is received, the blood pressure information will be collected and returned to the smart phone for displaying through the Bluetooth module.
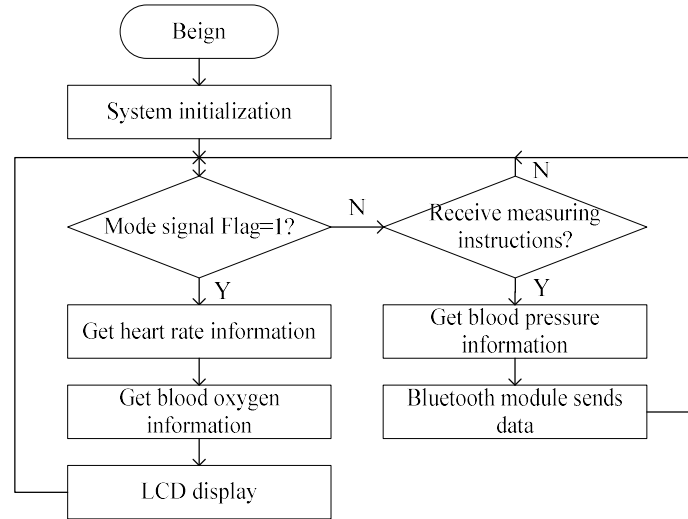

Figure 5. Overall programming of the system.

4.2 Heart rate measurement program design

The heart rate measurement program design is shown in Figure 6. After initializing the configuration, the old-time variable "old_time" and the new time variable "new_time" are updated. Then the 1 minute heart rate calculated by the formula is stored in the array "Data[ ]". When the array has five data points, it is sorted and the third value is fetched.
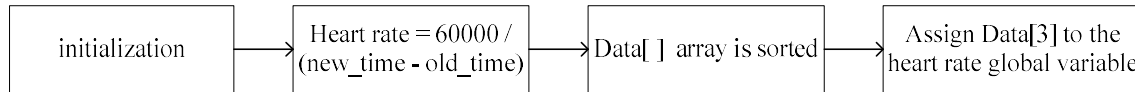

Figure 6. Heart rate measurement program design.

4.3 Blood oxygen measurement program design

Firstly, the I2C communication is established by initialization and the corresponding basic variables are configured. Then the corresponding reflected light value is acquired by obtaining the two functions of reflected infrared light and reflected visible light. Finally, the blood oxygen information is obtained by using the blood oxygen processing function, and the calculation result is shown in equation (1).

$$SaO_2 = \frac{C_{HbO2}}{C_{HbO2} + C_{Hb}} * 100\%$$

(1)

4.4 Blood pressure measurement program design

Firstly, the program is initialized. After receiving the AT command "AT+ST:1\r\n", the blood pressure measurement module starts the measurement. The main controller receives the blood pressure information through the serial port and sends the total data information including systolic and diastolic blood pressure information to the Bluetooth module.

4.5 Display program design

Firstly, the display module is initialized. Then, the backlight is turned on. Finally, the coordinates are selected and the data is displayed.

4.6 Bluetooth program design

The Bluetooth program design is shown in Figure 7. After the program initializes the serial port, if the serial port receives the control command, it will send the measurement control signal to the blood pressure measurement module; otherwise, it will continue to wait. When the blood pressure measurement module returns the blood pressure information, the data will be sent to the phone.
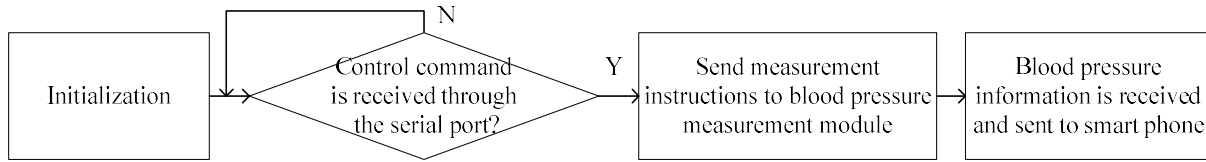

Figure 7. Bluetooth program design.

4.7 Smart phone app program design

The smart phone APP includes an information module, a user information configuration module, a Bluetooth module, a data receiving module, and a data storage and display module. The information module enters into different activities through three controls, namely configuration, query and detection. The user information configuration module is mainly used to configure user information, which is used to record names, smart phone numbers and other information. The Bluetooth module is used to configure Bluetooth search, connection and data transmission. The data receiving module is mainly used for data interaction between smart phone and Bluetooth module. The data stored and display module mainly displays the database data and displays the historical records.

5. SYSTEM TEST

The physical hardware picture is shown in Figure 8. In order to test the accuracy of the system, the method of repetition and comparison is adopted. The same tester measured continuously in the same period to observe the consistency and accuracy of the measurement results. At the same time, a relatively accurate electronic measuring instrument on the market is used for measurement. The results of the same tester are compared. The comparison table of measurement results is shown in Table 1.

It can be seen from Table 1 that the measurement results of this system have some errors compared with the electronic measurement instruments on the market, but they are all within a reasonable range and meet the measurement requirements. The results of multiple groups of measurements by the same tester show that the designed system has better measurement repeatability, consistency and good individual adaptability to testers with different physical conditions.
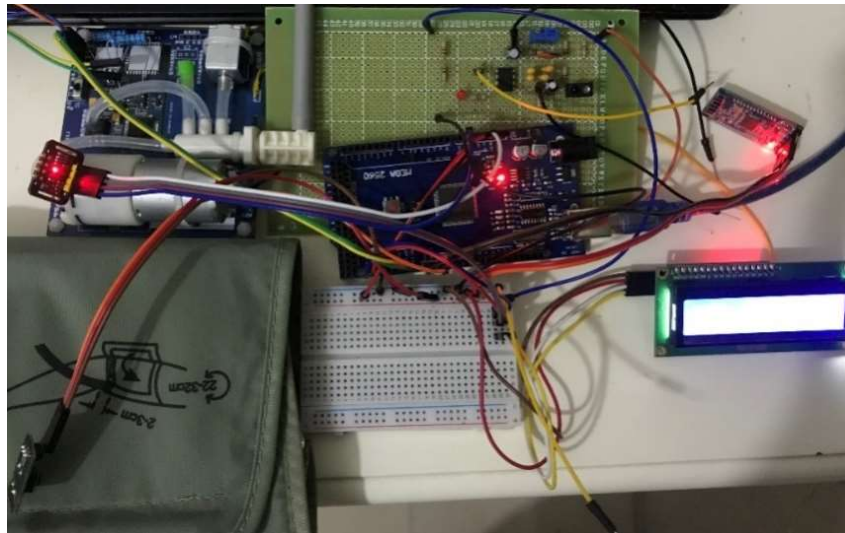

Figure 8. Physical hardware picture.

Table 1. Comparison of measurement results.

	The system proposed				The market product			
	HR (bpm)	SaO$_2$ (%)	SBP (mmHg)	DBP (mmHg)	HR (bpm)	SaO$_2$ (%)	SBP (mmHg)	DBP (mmHg)
Tester 1	89	96	134	87	87	97	133	83
	90	97	132	82	89	96	130	81
	92	96	130	85	90	96	131	84
Tester 2	72	97	125	79	70	97	127	78
	68	97	128	80	69	98	126	83
	69	98	124	82	67	98	122	81

6. CONCLUSION

In this paper, Arduino is used as the core control module, and the corresponding sensors are used to collect the information of heart rate, blood pressure and blood oxygen to realize a health monitoring system based on wireless personal area network. The measurement information can be displayed not only through LCD, but also transmitted to smart phone APP through Bluetooth. The test results show that the system can obtain health parameters timely and accurately. And the system runs stably, which can be widely used in families and other scenes requiring health monitoring.

ACKNOWLEDGMENTS

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