Design of Smart Bracelet Based on STM32 Microcontroller *

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Abstract

With the development of electronic information technology, the demand for high-precision and convenient electronic detection equipment for biomedical signals goes straightly high. Heart rate and steps counting are two important indicators of the human body. Based on this, this design studies an intelligent bracelet with health monitoring system, which can detect human movement state and steps counting, measure and analyze the heart rate, and connect wirelessly through Bluetooth module. A STM32 microcontroller is used to collect and analyze the information of motion state, heart rate and step quantity, and then send them to the APP, which is developed based on Android and displayed through Bluetooth module. The users can change their lifestyle by above parameters. Smart bracelets can play a role in reducing the risk of disease.

Keywords: STM32 microcontroller, smart bracelet, health detection, sensor

1. Introduction

Smart bracelet is a kind of wearable smart device. Today, with the rapid development of science and technology, smart wearable technology and Internet of Things technology are becoming more and more popular. Especially in the field of biomedicine, it promotes the progress and development of science and technology, and at the same time provides convenience for the medical treatment of people's health. Smart wearable devices are portable, accurate and functional, which brings a very good development prospect for smart bracelet in the future. Recently, the cooperation between smart wearable devices and the medical field has become increasingly mature. Using the Internet of Things technology and single-chip microcomputer for data collection and data analysis to improve the quality of life, network informatization is an inevitable development trend in today's society[1]. This paper designs and studies smart bracelets based on STM32 single-chip microcomputers by surveying the current social health status and general living habits, which are mainly used to detect the individual's exercise status and supervise the wearer's exercise.

2. Control system composition

The smart bracelet control system is composed of a microprocessor module, a heart pulse detection module, a motion state detection module and a Bluetooth module. The smart bracelet uses STM32 as the controller to receive the heart rate, exercise status and other data sent by the sensor, and process these data, analyze the human body’s exercise status and physical health, and display the results on the OLED display. At the same time, the data is uploaded to the computer through the Bluetooth module for storage, which serves as the basis for the user's health dynamic management. The structure diagram of the smart bracelet control system is shown in Fig. 1

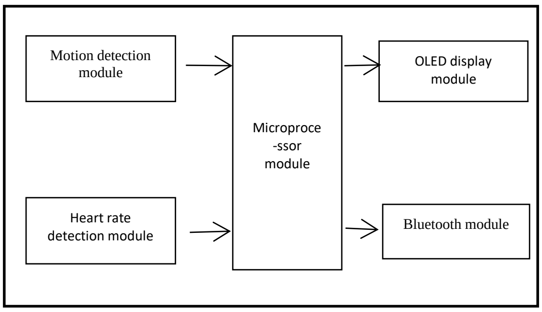

Fig. 1. The structure diagram of the smart bracelet control system

2.1. *Microprocessor module*

The STM32 series of single-chip microcomputers are a series of very powerful single-chip microcomputers with very high cost performance[2]. It is based on the ARM Cortex-M core designed for embedded applications that require high performance, low cost, and low power consumption. It has first-class peripherals: 1μs Dual-channel 12-bit ADC 4bit/s UART 18Mbit/s SPI, etc. In terms of power consumption and integration, STM32 microcontrollers also have a good performance, which is obviously slightly inferior to the power consumption of MSP430, but this does not affect the enthusiasm of engineers for it.

2.2. *Heart rate detection module*

The pulse measurement uses the heart rate pulse sensor module[3]. There are three main methods of pulse measurement: one is to extract from the ECG signal, the other is to calculate the pulse rate from the fluctuation measured by the pressure sensor, the third is the photovolume method. The basic principle of photovolumetric method is to use human tissues to make pulse measurement with different light transmittance caused by pulsation of blood vessels. The sensor used is composed of two parts: a light source and a photoelectric transducer, and is fixed on the patient's finger or earlobe through a band or a clip. The light source generally uses a light-emitting diode with a certain wavelength (500nm~700nm) that is selective to the oxygen and hemoglobin in the arterial blood. When the light beam penetrates the human peripheral blood vessels, the light transmittance of this light is changed due to the change of the arterial pulsation congestion volume. At this time, the photoelectric transducer receives the light reflected by the human tissue, converts it into an electrical signal and amplifies and outputs it. Since the pulse is a signal that changes periodically with the beating of the heart, and the volume of the arterial blood vessel also changes periodically, the change period of the electrical signal of the photoelectric transducer is the pulse rate. Most smart watches use photoelectric method to monitor heart rate. Their obvious feature is that the sensor part is equipped with a green LED light. There are many types of photoelectric sensors for this measurement principle. According to the different receiving positions of the light signal, the photoelectric method can be divided into two modes: transmission and reflection.

2.2.1. *Transmission photoelectric method*

The transmission photoelectric method refers to that the generator and photosensitive receiver on the wearable device are located on both sides of the measured part (usually fixed by a clip). The incident light passes through the skin and enters the deep tissues, except for the skin, muscle, blood, Outside of the absorption by bones, the remaining part of the light transmission is sensed by the photosensitive receiver. According to its principle, this method is suitable for measuring parts with relatively short distance between the two sides of the human body, such as earlobes, fingers, toes, etc., and representative smart wearable products are those ear clip heart rate monitors and nail oximeters Wait. Smart wearable products that adopt the transmissive photoelectric method are usually fixed with a clip. The product of this monitoring method usually adopts the structure of a sealed cassette in appearance, which can well reduce the external light interference, thereby improving the measurement accuracy and stability. Due to its high signal-to-noise ratio and stable signal, in addition to measuring heart rate, it can also analyze heartbeat function, blood flow and many other cardiovascular physiological information through waveforms. The disadvantage is that it is not suitable for use on smart bracelets and smart watches, and products used on earlobes, toes and other parts will feel uncomfortable to wear.

2.2.2. *Reflective photoelectric method*

Contrary to the transmissive photoelectric method, in the reflective photoelectric method, the emitter and the photosensitive receiver on the wearable device are located on the same side of the measured part, and the reflected light is mainly measured. The advantage of this method for measuring heart rate is that it is very simple and has low requirements for the measurement site. As long as the tissue is relatively smooth and there is less subcutaneous fat, it can almost be measured, such as the forehead and wrist. Therefore, most wearable devices such as smart bracelets and smart watches adopt this method to measure heart rate. Moreover, the appearance of smart bracelets or smart watches in the form of products also perfectly solves the dual requirements of transmission-type photoelectric method center rate monitoring and wearing comfort. However, although the reflective photoelectric method performs well in a stable state, when the device is worn on the end of the wrist, it will swing up and down like a pendulum as the user walks or moves irregularly. The centrifugal force will cause a large change in blood volume; The interaction of systolic pressure and centrifugal force in the blood makes it more difficult to distinguish the amount of blood in the blood vessels. Therefore, the accuracy of the heart rate data may be reduced. In addition, the tightness of the wearable device and the blood flow of the human skin will also affect the accuracy of the monitoring.

This article chooses the photoelectric reflection measurement method. The photoelectric reflection measurement method uses a photoelectric sensor for measurement. The photoelectric sensor is composed of a transmitting tube and a receiving tube. The transmitting tube emits a certain wavelength of light, which is transmitted back to the receiving tube through the refraction and reflection of the blood vessel. The cyclical contraction and relaxation of the heart cause regular contraction and dilation of venous blood vessels. The blood and hemoglobin in the blood vessels undergo regular changes in concentration and cause changes in blood transmittance. The light signal then fluctuates regularly and then returns. Receiving tube. The light signal received by the receiving tube is converted into an electrical signal and filtered and amplified to obtain the heart rate and pulse information. Among them, the absorption of light by the skin and muscle tissue remains constant throughout the blood circulation process. When the heart contracts, the blood content in the blood vessels is the highest at this time, the absorption of light is the highest, and the light intensity returning to the receiving tube is the smallest; On the contrary, when the heart relaxes, the blood content in the blood vessels is the lowest, the light absorbed is also the least, and the intensity of the light returning to the receiving tube is the largest. The intensity of the light received by the light receiver changes pulsatingly. The current method of measuring pulse wave with infrared sensors usually adopts photoplethysmography, which is a measurement method that uses optical means to indirectly obtain pulse information by detecting changes in blood volume. In the smart bracelet, the most widely used is the reflective measurement structure, so this article uses a photoelectric sensor for experiments. The analog information is converted into an analog voltage signal through the current-limiting resistor R4 and sent to the LM393 comparator, which can be divided by the pin 2 of the comparator chip. Comparing the analog voltages obtained by the voltage divider, a square wave can be obtained. The schematic diagram of the internal circuit of the pulse sensor and the LM393 comparator is shown in Fig.2.

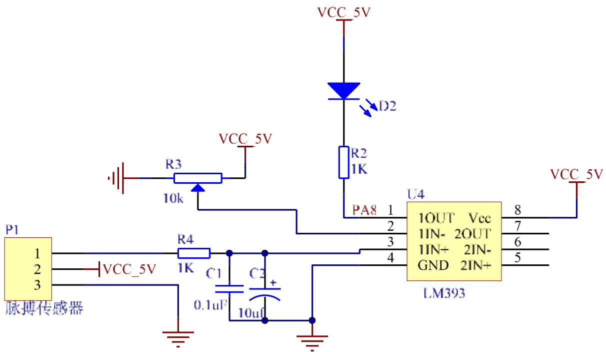

Fig. 2. The schematic diagram of the internal circuit of the pulse sensor and the LM393 comparator.

2.3. *Motion state detection module*

Devices such as accelerometers and gyroscopes are all inertial sensors. As the name suggests, accelerometers are devices that detect the acceleration of objects. The motion state of an object can be determined through accelerometers and gyroscopes. There are three types of acceleration sensors: piezoelectric, capacitive, and thermal. This article uses a three-axis capacitive acceleration sensor. The three-axis acceleration sensor has acceleration output in three directions of x-axis, y-axis and z-axis, and the output value forms a vector, which can detect the angle. A gyroscope is used to detect position information. The gyroscope is an angular motion detection device that uses a high-speed rotating body's momentum-sensitive shell relative to inertial space around one or two axes orthogonal to the rotation axis. The module has high accuracy and strong stability. The circuit corresponding to the gyroscope is shown in Fig.3.

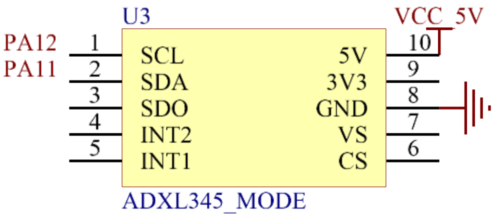

Fig. 3. The circuit corresponding to the gyroscope.

2.4. *Bluetooth module*

The embedded HC-05 Bluetooth serial communication module has two working modes: command response working mode and automatic connection working mode. AT commands can be executed when the module is in command response mode (or AT mode). Users can send various AT commands to the module, set control parameters for the module or issue control commands. In the automatic connection working mode, the module can be divided into three working roles: master, slave and loopback[4]. When the module is in the automatic connection mode, it will automatically connect according to the pre-set data transmission. Main mode: The module can actively search for and connect to other Bluetooth modules and receive and send data. Slave mode: It can only be searched and connected by other Bluetooth modules to receive and send data. Loopback: The Bluetooth module returns the received data to the remote master device as it is. The circuit connection schematic diagram of the Bluetooth module is shown in Figure 4.

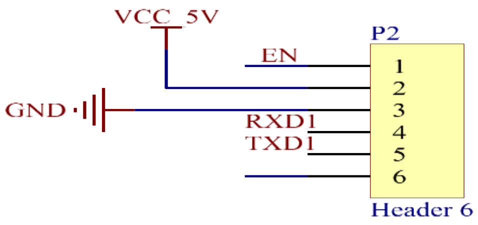

Fig. 4. The circuit connection schematic diagram of the Bluetooth module.

3. System total circuit design

This design is composed of STM32F103C8T6 microcontroller core board circuit + ADXL345 sensor circuit + heart rate sensor circuit + OLED circuit + Bluetooth module. The schematic diagram of the core board circuit is shown in Fig. 5.

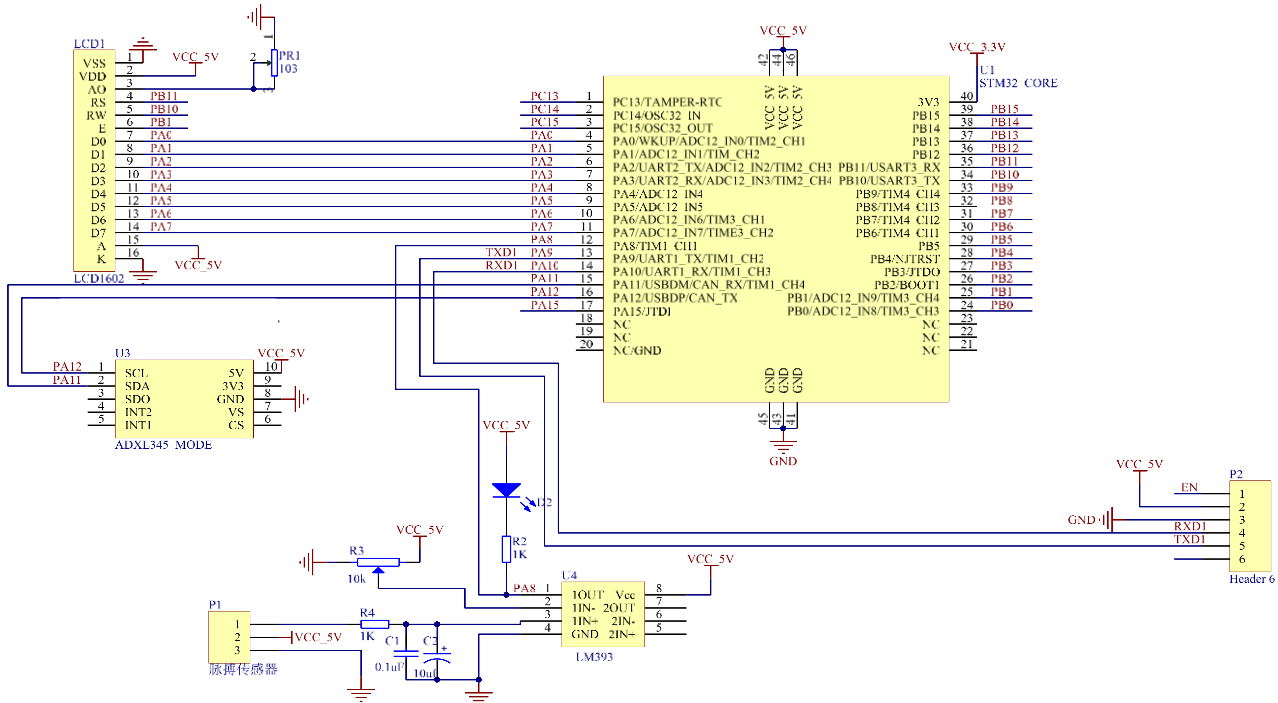

Fig. 5. The schematic diagram of the core board circuit

The actual product after circuit soldering is shown in Fig. 6.

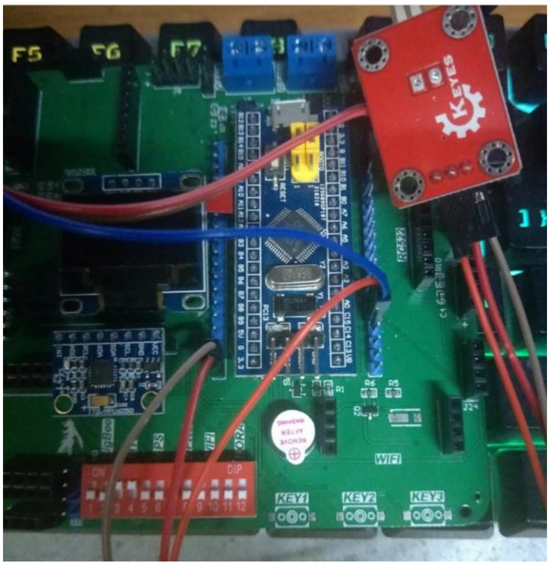

Fig. 6. The schematic diagram of the core board circuit.

4. Conclusion

The smart bracelet control system designed in this paper has been installed and debugged, and it has the characteristics of multiple functions, high data accuracy, and fast response speed, and has high use value.

References

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Authors Introduction

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