Design of Embedded-based Smart Bracelet

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***Abstract*—With the development of science and technology and continuous improvement of medical level, we pay more and more attention on our health. The smart bracelet is popular with more and more people due to small volume, portability, real-time monitoring of health status and other advantages. Here, the embedded-based smart bracelet is designed with STM32 as the main control chip, and equipped with the heart rate and blood pressure detection module, air temperature and humidity detection module, step count module, vibration module and OLED screen display module. The programming is realized through C language; finally the display of date and time, air temperature and humidity detection, heart rate detection, calorie detection, blood pressure detection, step count and other functions can be realized, and all detection data can be displayed on OLED screen. The smart bracelet has a strong design function and low price, and brings the better user experience to the user.**

Keywords*—*embedded, smart bracelet, data monitoring

I. Introduction

A. *Research background and significance*

The smart bracelet is one of the most representative products in the smart wearable devices. It can record the physical condition, exercise, calorie consumption and other data of the user every day in detail and synchronize these data to the mobile phone, tablet PC and other devices, so as to guide the healthy life, and they can formulate the scientific and healthy exercise plan according to their own exercise intensity

B. *Domestic and foreign research status*

The data show that the 2013-2017 transaction scale of the smart bracelet market tends to a growth trend, and currently, the technology and function of the smart bracelet can basically meet the use requirement of most people. However, if the manufacturers don't make breakthrough in technology or realize the product differentiation after 2018, the market turnover of the smart bracelet will substantially fall [1].

The United States is the first country which put forward the wearable smart detection equipment and design prototype in the world. The Media Laboratory in the United States proposed the multimedia, sensor and wireless communication and other innovative technologies in the beginning of 1960s, and implanted all detectors in the clothing worn usually to detect the physical condition of people. The American highly expected that the smart wearable technology could make better development, and also looked forward to appearance of more advanced technologies [2].

C. *Research content and significance*

The subject mainly includes the following research contents:

1) Display of the system time, including the design of accuracy and reliability of system time.

2) Accuracy of the set reminding time of alarm clock and design of vibration frequency of vibrating motor.

3) Design of the heart rate and blood pressure detection.

4) Design of the temperature and humidity detection.

5) Detection of the step count and calorie consumption.

Research significance:

The functions of the sports bracelet and medical bracelet are integrated on a smart bracelet in the design, so that the functions of the smart bracelet are more perfect, providing better usage experience for users, and other technological products may be also derived to promote the development of the intelligent industry.

II. General Design

The temperature and humidity detection and blood pressure detection are added based on the existing sports bracelet in the subject research, so that the functions of the smart bracelet are more perfect. The design of the smart bracelet is divided into the hardware design and software design. STM32F411 is used as the main control chip in the hardware design aspect, which is mainly used to collect the relevant data, analyze and process the relevant information and coordinate each module in the whole system. The program is written by C language through Keil 5 programming software in the software design aspect.
The whole block diagram of the system is shown in Fig.1.

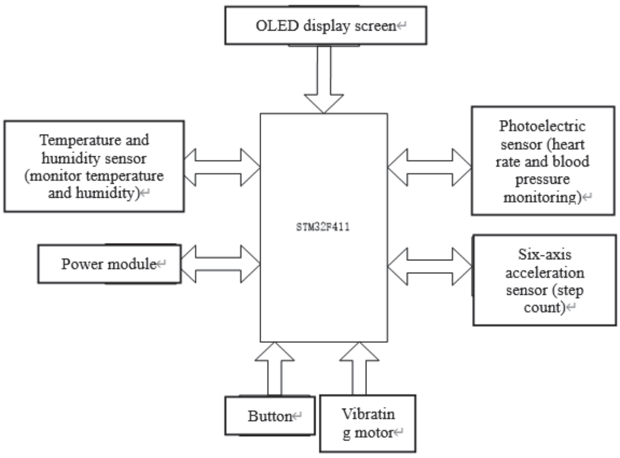

Fig.1. Whole block diagram of system

III. Hardware Design

A. Main control chip

The reasons for selecting STM32 as the main control chip in the design include:

- ARM core with extensive use.
- A lot of interfaces to expand the function module alone.
- Reasonable price of STM32.
- Low power consumption and high running speed.
- Support all embedded operating systems.

The schematic diagram of the main control chip is shown in Fig.2.

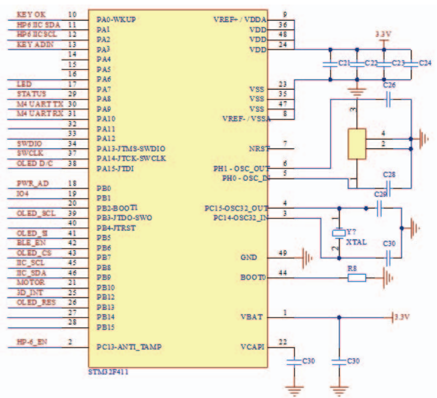

Fig.2. Schematic diagram of main control chip

B. Heart rate and blood pressure detection module

The heart rate and blood pressure are detected by the photoelectric sensor through Photo Plethyamo Graphy (PPG). The schematic diagram of HP-6 photoelectric sensor is as shown in Fig.3.

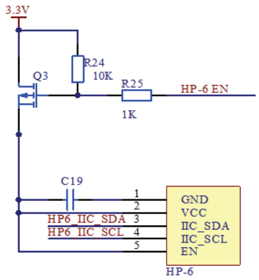

Fig.3. Schematic diagram of HP-6 photoelectric sensor

The heart rate and blood pressure are detected with the Photo Plethyamo Graphy (PPG) through reflection of visible light in the body.

The detected optical signal is converted to the electrical signal, and then is perfected, analyzed and calculated to obtain the heart rate and blood pressure.

C. Temperature and humidity detection module

The temperature and humidity integrated digital output sensor has a super small size, but its precision is very high. Therefore, it is extensively applied [5]. SHT20 temperature and humidity sensor belongs to one of them. The schematic diagram is as shown in Fig.4.

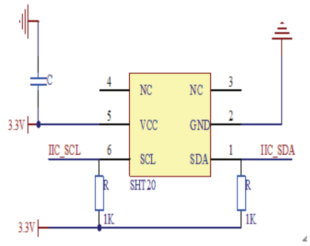

Fig.4. Schematic diagram of SHT20

D. Step count module

The step count function is realized by MPU6050 six-axis acceleration sensor. The schematic diagram of MPU6050 is as shown in Fig.5.

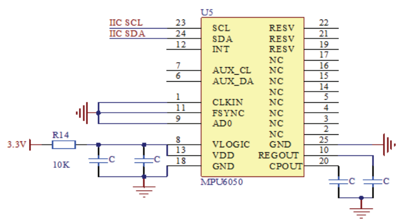

Fig.5. Schematic diagram of MPU6050

The user wears the smart bracelet on the wrist, then the value of acceleration of all axes of MPU6050 will be periodically changed obviously with the wrist shaking during exercise, and the data are recorded, analyzed and calculated to obtain the walking steps.

E. OLED display screen

The OLED display screen is selected in the design of the system upon comprehensive consideration. The schematic diagram of OLED display screen is as shown in Fig.6.

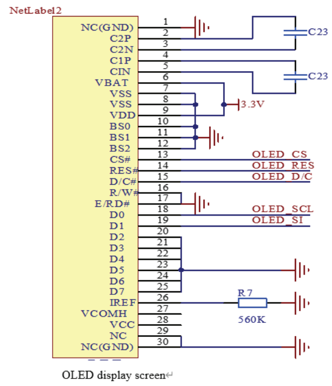

Fig.6. Schematic diagram of OLED resistive display screen

F. *Button design*

The buttons of the smart bracelet are mainly used to arouse the screen of the bracelet and switch between functions of the bracelet. The schematic diagram of buttons is as shown in Fig.7.

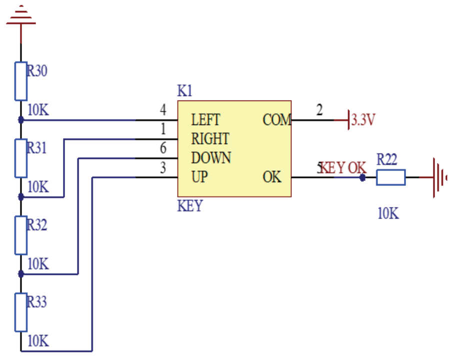

Fig.7. Schematic diagrams of buttons

G. *Vibrating motor*

The smart bracelet supports the setting of alarm clock in the design, which can be used for morning call or reminding. The schematic diagram of vibrating motor is as shown in Fig.8.

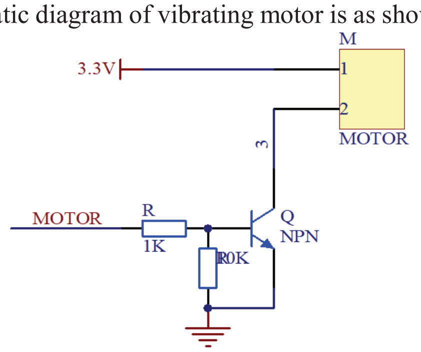

Fig.8. Schematic diagram of vibrating motor

IV. Software Design

The common programming languages include C language and assembly language. The assembly language has high programming efficiency and small memory, but it belongs to the low-level language, so the relevant hardware structure needs to be understood, and it has the difficult programming and poor portability. C language has some features of high-level language and low-level language, and owns an abundant callable function library. Therefore, C language is used in the system for program design and development, and the whole program is composed of the main program and all subprograms [7].

A. *Design of main program*

The main program is the main part of the whole program, and it is integrated with the program of all modules to complete the system initialization, information display, information processing, data transfer, emission of control signal and other functions. The flow chart of the general programming is as shown in Fig.9.

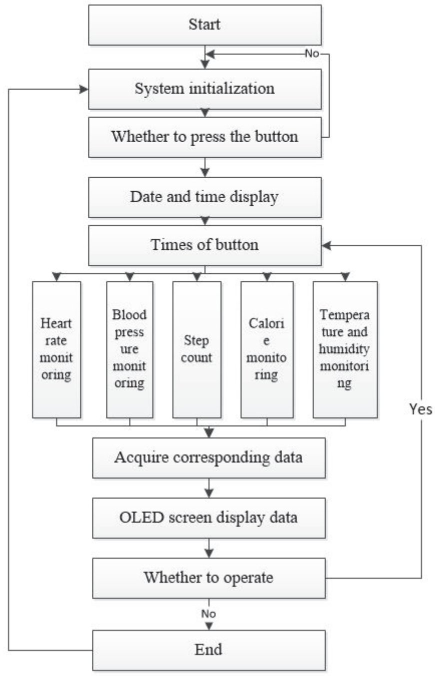

Fig.9. Flow chart of general program

B. *Design of subprogram*

C language programming is used in the system to realize the functions of all modules. C language has the powerful modular design characteristics, and promotes the implementation of modularization programming and calling [10].

- Temperature and humidity acquisition

  The system starts to work, and the temperature and humidity sensor waits for orders. When the temperature and humidity are detected, the main control chip arouses SHT20 temperature and humidity sensor. The flow chart of temperature and humidity acquisition is as shown in Fig.9.

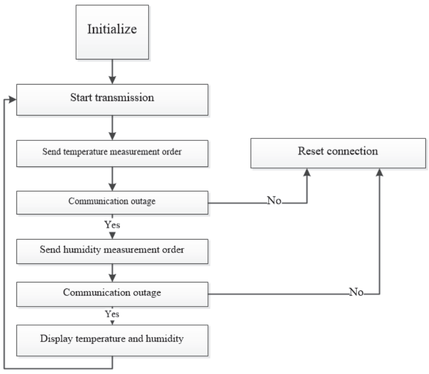

Fig.10. Flow chart of temperature and humidity acquisition

- Heart rate and blood pressure data acquisition

The system starts to work, and the heart rate and blood pressure sensor waits for orders. When the heart rate or blood pressure is detected, the main control chip arouses the heart rate and blood pressure sensor, and the heart rate or blood pressure detected is displayed on OLED display screen. The flow chart of heart rate and blood pressure data acquisition is as shown in Fig.11.

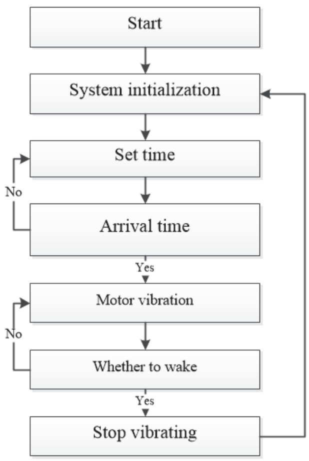

Fig.11. Flow chart of heart rate and blood pressure data acquisition

- Step count data acquisition

When the system starts to work, the acceleration sensor is started. During exercise, the acceleration values of all axes will be obviously changed, and the system records and analyzes the data to obtain the walking steps. If you want to watch the steps, you can turn the button to the step count function, and the current steps will be displayed on OLED display screen. The flow chart of the step count data acquisition is as shown in Fig.12.

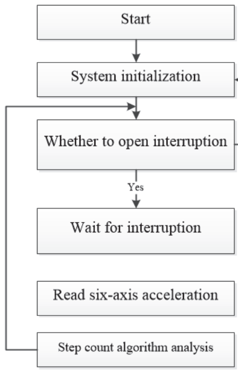

Fig.12. Flow chart of step count data acquisition

- Data display

When the system starts to work, the date and time will be displayed on the screen. If the further operation is not executed, the screen will be dimmed after 3-4s. The screen will be on after pressing the button; the different functions can be selected through pressing the button, and the detected data are displayed on OLED display screen.

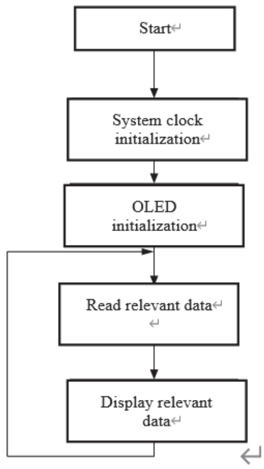

Fig.13. Flow chart of data display

- Setting of alarm clock

After the system powers on, the alarm clock time is set, and the vibrating motor waits for orders. Upon the appointed time, the main control chip will send the order of starting to the vibrating motor, and then the vibrating motor starts to vibrate. The flow chart of setting of alarm clock is as shown in Fig.14.

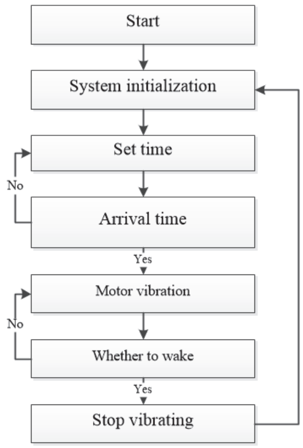

Fig.14. Flow chart of setting of alarm clock

V. SUMMARY

Here, the embedded-based smart bracelet is designed with STM32 microcontroller as the main control chip, and equipped with the heart rate and blood pressure detection module, air temperature and humidity detection module, step count module, vibration module and OLED screen display module. The programming is realized through C language; finally the display of date and time, air temperature and humidity detection, heart rate detection, calorie detection, blood pressure detection and step count of the smart bracelet can be realized, and the design expectation of all detection data displayed on OLED screen can be also improved in the time calibration, hand feeling optimization and other aspects. The smart bracelet appears on the market for a short time up to now, so it shall continue to be studied to make greater breakthrough in the technology, making the smart bracelet have stronger functions and more stable performance, and providing more services for users.

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