Arduino-based Wireless Heart Rate Detection Project

CE201-5 Individual challenge

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Context

Abstract

Heart disease has become a major problem, especially today when ageing continues to increase. Cardiovascular disease (CVD) is a general term for heart diseases, including rheumatic heart disease, congenital heart disease, hypertensive heart disease, coronary heart disease, myocarditis and other types of heart disease. [a)] Heart disease can be prevented at the initial stage by detecting ECG signals for this disease. Therefore I have created this small project based on the Arduino Nano development board, which allows for image monitoring of the heartbeat using the ECG sensor AD8232. In this article, I use two Arduino Nano development boards (referred to as AN1 and AN2).

AN1 is connected to the Bluetooth module HC-05, the AD8232 to obtain and send heart rate data, and to the SSD1306 OLED screen to display the Bluetooth connection status, BPM value, and current time. AN2 is connected to the Bluetooth module HC-05 and the dot matrix screen MAX7219. The MAX7219 is used to display the heart rate waveform. (Figure 1) All GIF images can be linked by clicking on the image.

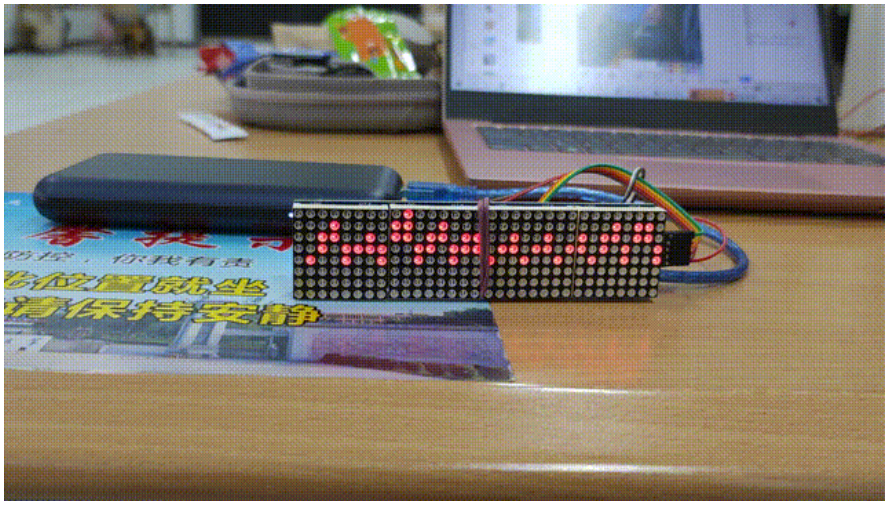

Figure 1 Project presentation GIF

Components required

- Arduino Nano *2；
- ECG sensor AD8232
- ECG electrode connectors 3.5mm
- MAX7219 Matrix screen
- DuPont wire
- Bluetooth module HC-05 *2
- Chip electrodes
- USB to TTL serial port
- SSD1306 OLED screen

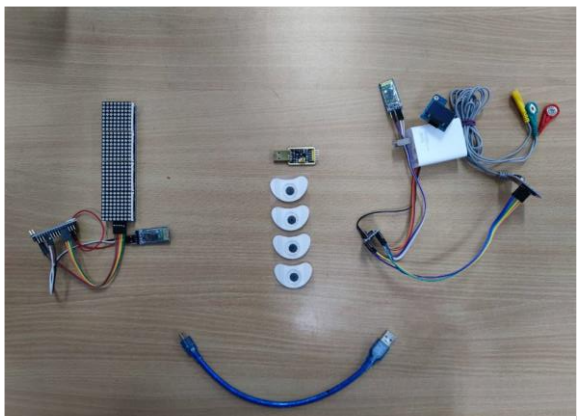

Figure 2 Components required

Data acquisition method

I wanted to collect ECG data via ECG sensors and transmit the data in real time via Bluetooth for the purpose of monitoring heart rate.

AD8232 ECG sensor

The sensor is an economical and efficient module for measuring the electrical activity of the heart. This electrical activity can be plotted as an ECG or electrocardiogram and output as an analog reading. An ECG can be very noisy, and a single-channel heart rate monitor, the AD8232, serves as an operational amplifier to help easily obtain a clear signal from the PR and QT intervals. (Figure 3)

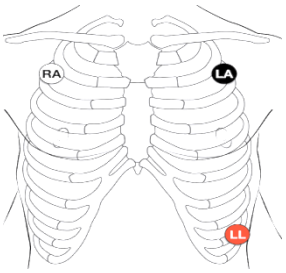

Figure 3 ECG sensor monitoring points [b)]

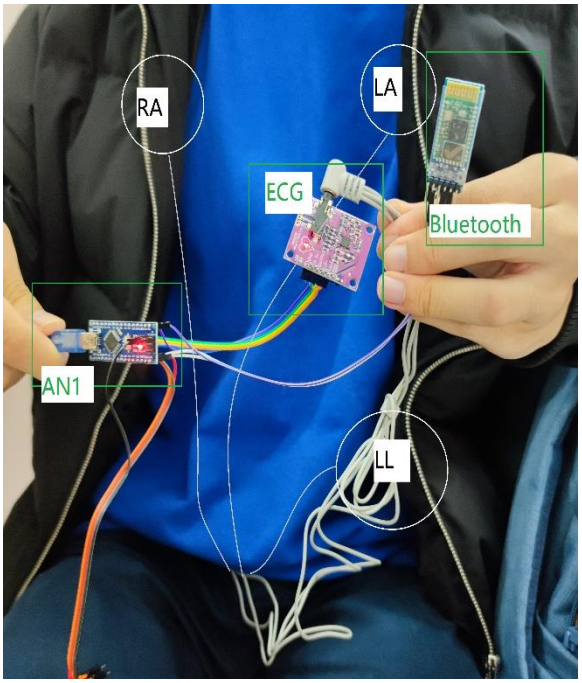

Figure 4 Diagram of the connected sensor

The AD8232 is an integrated signal conditioning module for ECG and other biopotential measurement applications. It is designed to extract, amplify and filter small biopotential signals in the presence of noise, such as those generated by movement or remote electrode placement.

The AD8232 module leads to nine connectors that you can Ild to pins, wires, or other connectors. SDN, LO +, LO-, OUTPUT, 3.3V, GND provide the necessary pins to operate this display through Arduino.

RA (right arm), LA (left arm) and RL (right leg) pins are also available on the board for connecting and using your own custom sensors. There is also an LED light that beats to the beat of the heart(Figure 4).

HC-05 Bluetooth communication module

UART has 4 pins (VCC, GND, RX, TX), TTL level used (Figure 5),low level is 0 (0V), high level is 1 (3.3V or above).

VCC: poIr supply pin, usually 3.3v.

GND: ground pin.

RX: receive data pin

TX: transmit data pin.

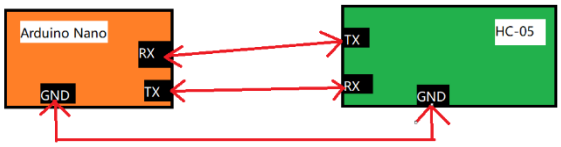

Figure 5 Arduino connect HC-05

To connect to the USB interface, you need the USB to TTL serial port (Figure 6), which converts the TTL level to the USB level.

Figure 6 USB to TTL serial port

To set up the main module：

1. Set PIO11 to high.
2. PoIr up the module and it will enter the AT command response state.
3. Use the serial port tool, set the baud rate 38400, data bit 8 bits, stop bit 1 bit, no parity bit, no flow control.
4. Serial port send the character "AT+ROLE=1\r\n", successfully return "OK\r\n", where \r\n is a carriage return（Figure 7）.
5. PIO set to low, re-poIr, the module is the master module, automatically search for slave modules, establish a connection.

Figure 7 Serial debugging software

Display design

I wanted to visualise the data collected to make it easier for the user to use and to get a clearer picture of the changes in their body. The display is divided into two areas: the OLED screen, which shows the current time, Bluetooth connection status and current heart rate (BPM), and the Matrix screen, which visualises the ECG data collected.

SSD1306 OLED Screen

SSD1306 is a single-chip CMOS OLED/PLED driver with controller for organic / polymer light emitting diode dot-matrix graphic display system. It consists of 128 segments and 64commons. This IC is designed for Common Cathode type OLED panel [c].

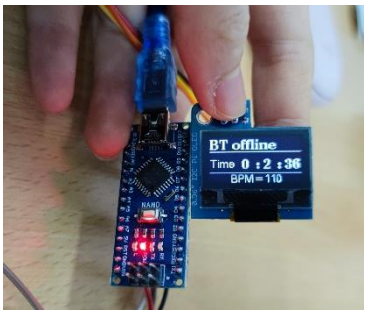

Figure 8 Drives OLED to display time, Bluetooth status, BMP.

To drive the OLED screen, I use the 'u8g2' library (available in the Arduino IDE's library manager). The 'u8g2' library has good platform support and basically supports most Arduino development boards. The 'u8g2' library has good platform support and basically supports most Arduino development boards, and the display controller has good support and many APIs (including the Matrix screen which I will mention next), especially for Chinese with different fonts.

MAX7219 Matrix Screen

The MAX7219 is an integrated serial input/output common cathode display driver that

connects a microprocessor to an 8-bit digital 7-segment digital LED display, or to a bar graph display or 64 individual LEDs. data. [d)]

In order to display more detail, I connected four MAX7219s together to make a large screen to display heart rate. Again I still use the 'u8g2' library to control it. (Figure 9)

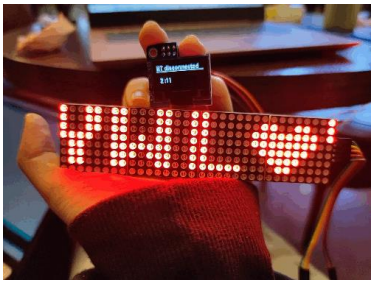

Figure 9 Matrix screen GIF

Performance demonstration

I split the project into two parts based on two Arduino's: the first part connects the Bluetooth module, the OLED screen and the ECG sensor via AN1（Figure 10） for data acquisition sending and display. The second part is connected to the dot matrix screen and Bluetooth via AN2（Figure 11） to transmit and visualise the data. The two parts communicate via the Bluetooth module and can be seen in the diagram as being wirelessly independent of each other.

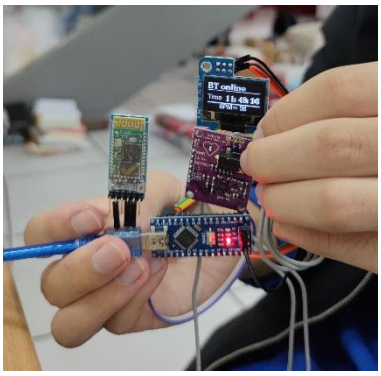

Figure 10 AN1 part

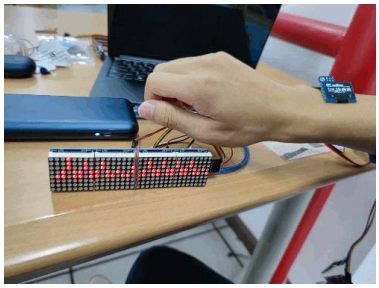

Figure 11 AN2 part GIF

The principle is as follows: the patch electrodes and ECG sensor transmit the signal to AN1 by collecting heart rate changes, and AN1 simultaneously transmits the signal to AN2 via the Bluetooth module and displays it in real time on the dot-matrix screen. At the same time AN1 controls the OLED screen to display the current BMP and Bluetooth status. (Figure 12)

The all code have be update in GitLab.(d4207e20346373ea8476acd3ae6f68754327ea4a)

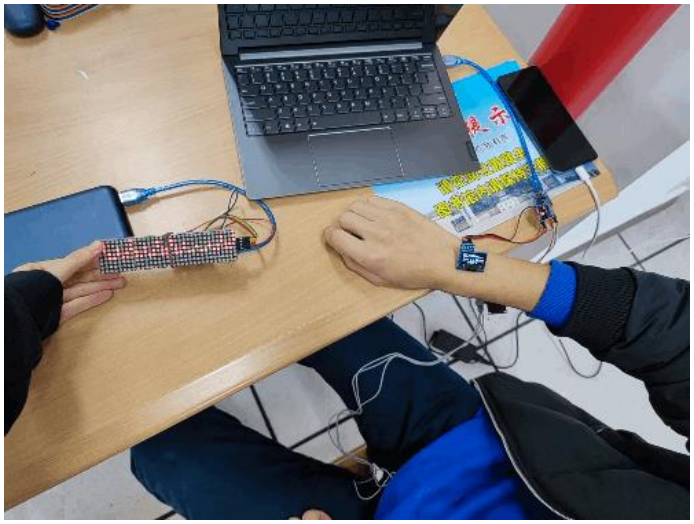

Figure 12 Real-time ECG display GIF

Reflection

Through this project, I learnt about IIC communication, Bluetooth communication protocols and how to use a microcontroller to drive some simple sensors, while project management was an essential tool to facilitate the development of the project. Of course, I also realised that when encountering difficulties Wiki and many forums or there are many experienced seniors who teach their experience carefully and patiently read their posts, many problems will be solved.

Finally, I would like to thank the Northwestern University labs for funding me to buy so many sensors and microcontrollers. I would also like to thank my boyfriend Ruben for being a human model for me and collecting all the heart rate data from him.

Quote

a) https://zh.wikipedia.org/wiki/%E5%BF%83%E8%84%8F%E7%97%85
b) Designing an Arduino-based ECG monitor using an AD8232 ECG sensor (engineersgarage.com)
c) SSD1780 (adafruit.com)
d) MAX7219 DS (sparkfun.com)