Smart Sock

Project in partnership with Aintree Hospital

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1. Introduction

The Smart Sock uses wearable technology to monitor heart failure (HF) patients, providing real-time data on key health indicators. It integrates advanced sensors and Bluetooth Low Energy (BLE) for real-time data transmission, providing real-time insight into patient health to reduce emergency admissions and improve patient care, addressing the critical need for timely medical intervention in high-frequency management. The project not only demonstrates the potential of wearable health devices in clinical Settings but also highlights the importance of interdisciplinary collaboration in advancing healthcare technology.

2. Hardware & Software Design

Core part of hardware:

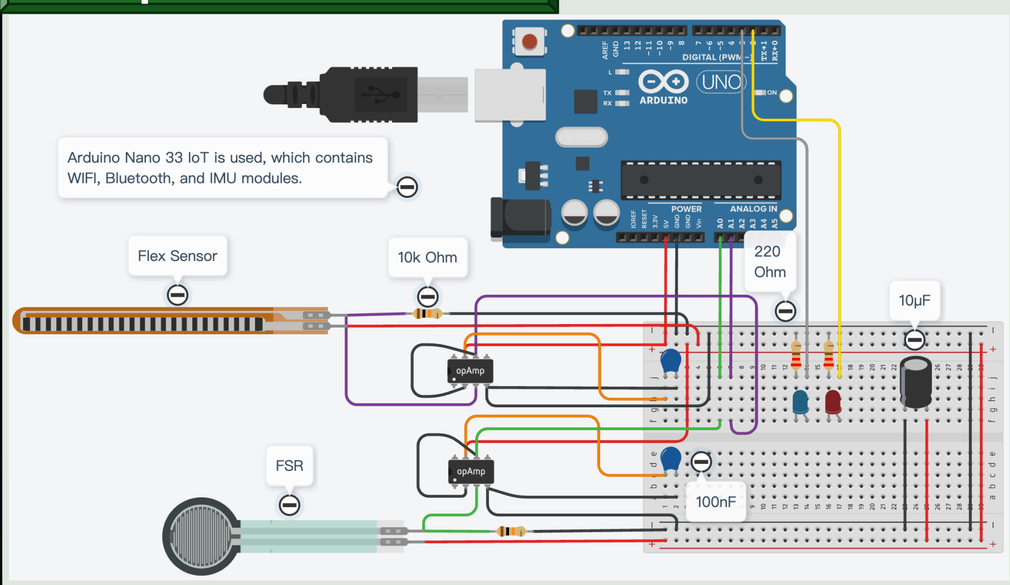
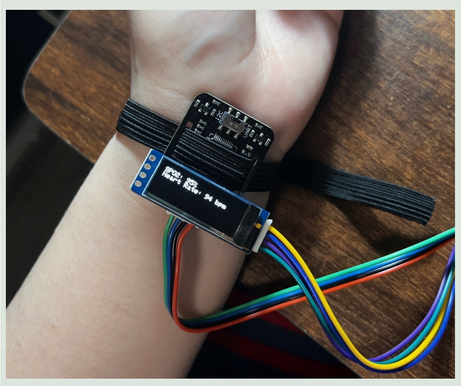


Figure 1: Circuit design of Anklet

$$V_{OUT\_FSR} = \frac{R_1 \times V_{IN}}{R_1 + R_{FSR}} \qquad V_{OUT\_Flex} = \frac{R_{Flex} \times V_{IN}}{R_1 + R_{FSR}}$$

When ankle swelling occurs:
For the FSR: Force $\uparrow \Rightarrow R_{FSR} \downarrow \Rightarrow V_{OUT\_FSR} \uparrow$
Flex Sensor: Bend $\downarrow \Rightarrow R_{Flex} \downarrow \Rightarrow V_{OUT\_Flex} \downarrow$
An Alert is issued when the amount of change exceeds the threshold.
When the IMU detects vigorous movement, the detection stops.



The MAX30102 uses PPG (PhotoPlethysmoGraphy) measurement data, which are converted into heart rate and oximeter values by the MCU and displayed on the OLED screen

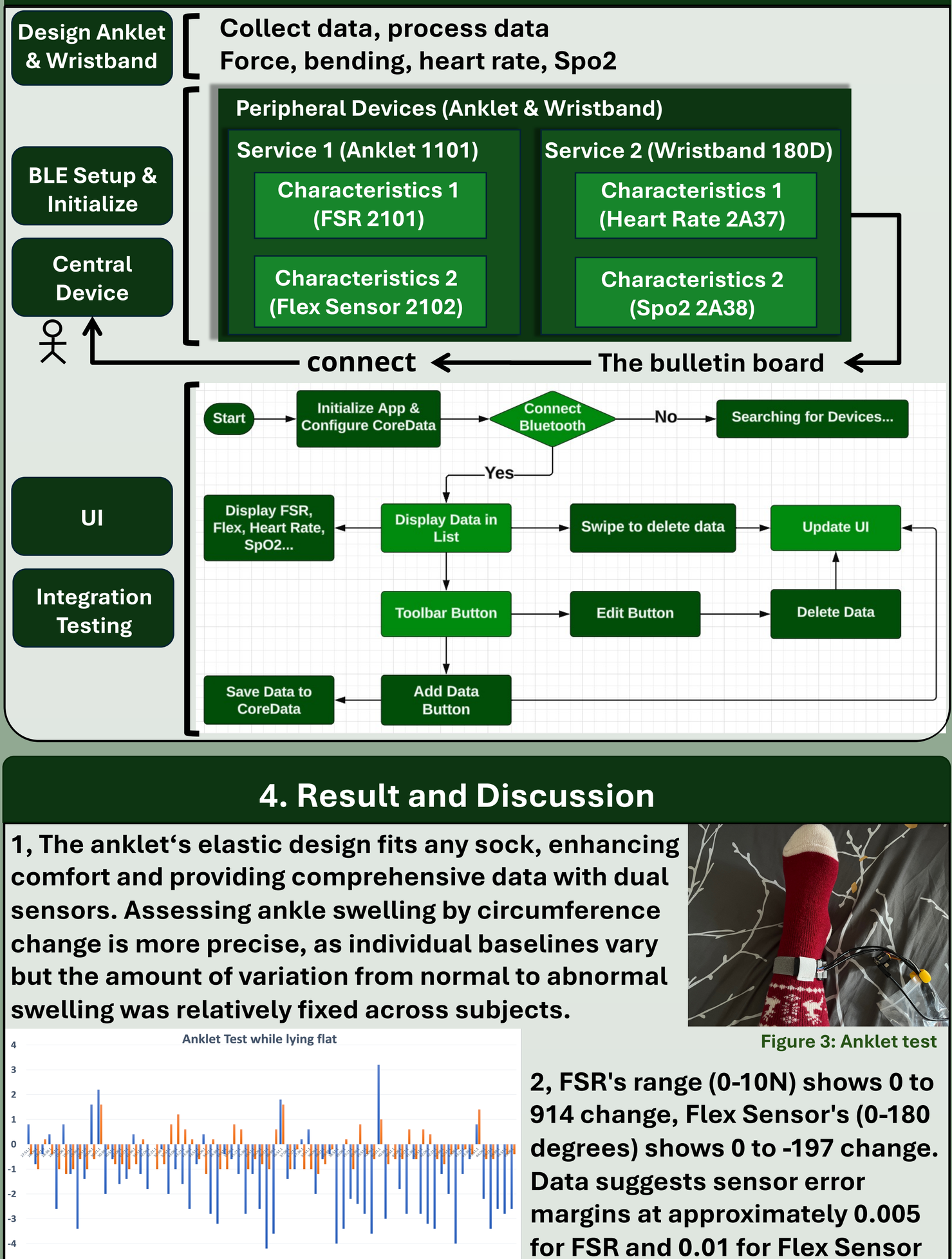
Figure 2: Wristband test

Core part of software:

Using BLE (Bluetooth Low Energy) technology, after data is transferred from the peripheral device to the central device via BLE, the application running on the central device is responsible for receiving, processing, and presenting the data.

Using Xcode to create an APP that displays data, logs data, edits data, and sends alerts.

3. Methodology



4. Result and Discussion

1, The anklet's elastic design fits any sock, enhancing comfort and providing comprehensive data with dual sensors. Assessing ankle swelling by circumference change is more precise, as individual baselines vary but the amount of variation from normal to abnormal swelling was relatively fixed across subjects.

Figure 3: Anklet test

2, FSR's range (0-10N) shows 0 to 914 change, Flex Sensor's (0-180 degrees) shows 0 to -197 change. Data suggests sensor error margins at approximately 0.005 for FSR and 0.01 for Flex Sensor

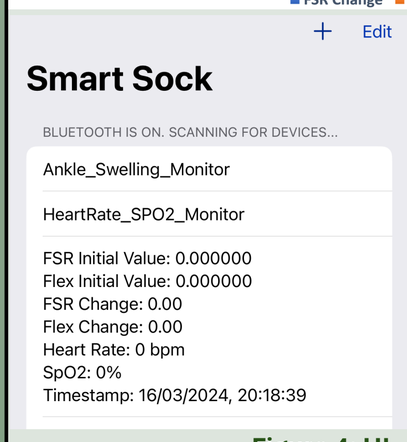


Figure 4: UI

3, The key to the project's success lies in managing Bluetooth communications and iOS data processing effectively. Issues concerning privacy rights, reference management, and ensuring continuous connectivity were addressed.
4, Testing on actual devices resolved issues with certificate verification, Bluetooth permissions, and device referencing. Zero-data displays may have resulted from decoding or protocol errors.

5. Conclusion and Future Work

Developed "smart socks" to advance heart failure patient monitoring through wearable technology that can track ankle swelling, heart rate and blood oxygen saturation in real-time, thereby reducing emergency hospitalizations and improving patient care. The project highlights the potential of BLE for data transfer and the importance of a user-friendly software interface.
Moving forward, I plan to integrate AI for predictive analytics, expand monitoring capabilities, enhance the user interface, and learn more about medicine to improve its effectiveness and ensure compliance.