GM1 - Team SpO2 - Interim Report

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1 Aim

The improvement our group aims to make on existing devices (such as an Apple Watch) are to have continuous measurements on patients (the Apple Watch requires you to keep a steady, horizontal hand). We wish to use the accelerometer readings to potentially improve the accuracy of the heart rate readings and therefore the SpO2 readings. We would also like to be able to factor-in temperature and moisture to either improve the readings or at the very least alert users to check the sensor. We believe it to be difficult to significantly improve the accuracy of the sensor, however we hope to achieve similar levels of accuracy as the current market, as well as further functionality, the primary goal being, long term trend detection and analysis. We will use L2S2 for the data communication and storage aspect of the project.

We aim to use this product on patients who may experience tremors and may have dementia, so a key goal is to have a sensor that is comfortable to wear and non-intrusive. For this we have chosen to place sensors on the chest area, as these are easily hidden and experience less movement. As tremors and coughing fits are likely unavoidable in our patients, we hope to utilise the accelerometer in cancelling out the effects these have on the readings, rather than Apple's method of ignoring the readings and giving an error message. This is because we could like to have continuous longer term readings.

We also aim to have a robust and user friendly app, that allows nurses and patients to adjust thresholds for alerts and customise alerts for different conditions that affect SpO2. The app would also, as previously mentioned, include alerts for sensors conditions, such as excess sweat, too high/low temperature and sensor battery life.

2 Work Done so Far

Over the past week I have worked on interfacing the MAX30102 sensor with both the Raspberry Pi Pico and the ESP8266 Micro-controller. After setting up the sensor with the Pico initially, as it had more processing capabilities, we found that there was no existing port of the SpO2 calculations from raw sensor data. I then spent a day attempting to edit the library to include a cycling buffer and give continuous SpO2 readings, eventually getting a very simple solution working using an existing ring buffer function for python and cycling my readings through that. However, the SpO2 calculation function required fine tuning and using an external library and lists would increase the delays of the device. Instead of spending further time improving this, I decided to switch to the ESP8266 board that had pre-written libraries by DFRobot. This worked much better, however it did not give consistently good readings, to improve this we found that it would have to be properly fitted to our sensing location, as this was the primary source of errors.

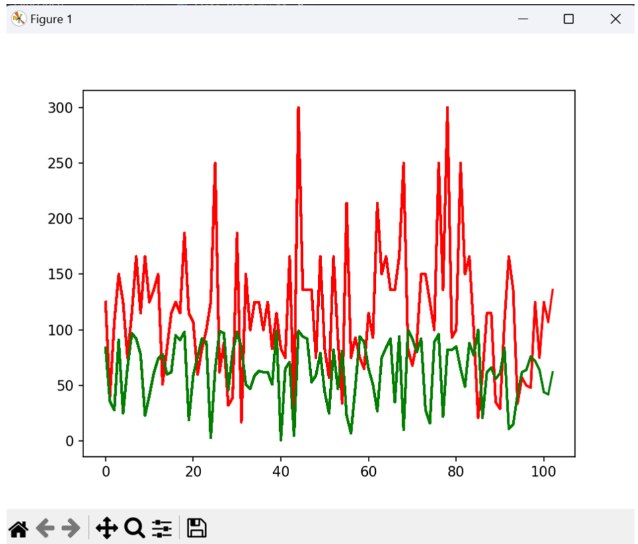

Figure 1: Initial MAX sensor readings (Red HR, Green SpO2

So, while waiting for the mechanical team to work on the prototype fitting, I assisted with conducting tests on potential locations of the sensor, testing the difference in values read on an Apple Watch, as it gave a good target accuracy for our sensor. We compared this with a finger sensor hospital unit we had. From this (Table 1) we found that, out of the positions we were considering, the ankle was the worst, the forearm (by the brachioradialis) was the best and rest of the locations were equally viable. We decided to finalise the position to be the chest, although the forearm gave better reliability. This was due to the fact that, our desired users include patients with dementia and similar conditions, in this case, they would be likely to remove sensors on the forearm or other places. This would make it harder to measure trends and get continuous readings, a key requirement for us. Sensing on the chest also allows for easier integration of multiple sensors, such as a accelerometer, a colour sensor, a moisture sensor and it allows for a bigger power supply, as well as potentially multiple sets of each sensors across the chest. The function of each sensor will be explained in the technical section of this report. The placement of the sensor on the chest also means there is a reduced affect from motion.

Placement	Control			Watch		
	Test 1 (%)	Test 2 (%)	Test 3 (%)	Test 1 (%)	Test 2 (%)	Test 3 (%)
Forearm (Brachioradialis)	98	98	98	98	98	98
Wrist	97	97	97	97	97	95
Chest	98	99	99	97	97	97
Ankle	98	98	98	98	94	100
Forehead	97	97	100	98	98	98

Table 1: Table of measurements of different sensor locations

We can see from this table that the forearm is the most accurate, and the accuracy of the chest, is worse than the wrist and the forehead. However the chest is more precise and has a constant error, this means it may be easier to work with and get accurate results, through an adjustment on the SpO2 calculation algorithm.

Finally, I worked on getting the accelerometer sensor readings, along with Misha, who also worked on the colour sensor.

3 Plan

Getting the SpO2 sensor working took longer than expected, but the plan from Monday is to now place all the sensors on a protoboard and begin working on a battery management system/unit and connection to the app with the L2S2 system. Alongside this we will make a full containment unit for the prototype to begin use case testing. I will work on the algorithm for SpO2 measurement, primarily on the cancellation of movement noise, and accuracy of SpO2 measurements. Additionally, I will work on integrating the colour sensor to give a confidence output on the readings (Initially I will do this using the measured error on different skin tones from existing papers). I would like to eventually be able to find a function that can factor in all the parameters (skin tone, temperature and moisture), however this will require a significant amount of user testing against a good control. I expect the algorithm to take up the majority of my time working on the project, as I will first have to make an algorithm to get an accurate heart rate reading. Then I will use that accurate heart reading to get improved values for the AC component of the red and infrared readings (by using a bandpass filter at the heart rate frequency). This should then give improved SpO2 readings that are robust against motion noise. This could potentially pose a challenge as I may have to edit the library for the sensor to factor in the heart rate adjustment and work on a buffer level on the sensor. This is something I have not done before. Then I will code the light sensor and temperature sensing alerts that can be sent to the app, this should be significantly easier, and should take 1 or 2 days.

4 Appendix

4.1 Time Sheet

Task	Start	End	Hours Spent
MAX Sensor Pi Pico Interaction	09/05/2024	11/05/2024	8
MAX Sensor ESP Interaction	11/05/2024	13/05/2024	6
ESP Sensor Testing	16/05/2024	16/05/2024	2
Team Meeting w/ Paul	16/05/2024	16/05/2024	1
Location Testing	16/05/2024	16/05/2024	3
Accelerometer Testing	17/05/2024	18/05/2024	2
Individual Report Writing	18/05/2024	19/05/2024	4
Protoboard of sensors	20/05/2024	20/05/2024	
Battery Management System	20/05/2024	22/05/2024	
Heartrate Calibration With Accelerometer	21/05/2024	27/05/2024	
Improved SpO2 Readings	27/05/2024	29/05/2024	
Confidence calculations based on peripheral sensor readings	29/05/2024	30/05/2024	

Table 2: Time Sheet