AUTOMATIC HEARTRATE MONITORING

[Document subtitle]

[DATE]

JAKE NEWALL
[Company address]

Project Description

The aim of this project is to select a suitable smartwatch/wrist mounted sensor that has a reliable photoplethysmography sensor, retrieve the live data and compare this data against clinically validated Real Time sensors.
At the time of writing I am currently researching the Empatica E4 sensor as the potential fit due to the sensitivity of the sensor and the 64Hz rate that is promised for PPG (Photoplethysmography) acquisition. If the data is not completely accurate when tested against the medical sensor, an algorithm will need to be designed to calibrate the watch and remove the outliers so that the data is as correct as possible. The main data which will be sent from the E4 is from the PPG. The heart rate can be calculated by detecting the peaks in this time series data and working out the distance between the peaks to get the duration between each heartbeat. Furthermore we can attempt to calculate any underlying issues by finding abnormalities between the peaks.

With this data we can create an automatic log in real time to an application developed for Android phones in Android Studio that will help us to evaluate the heartbeat of participants that wear the sensor. This will enable us to look out for irregularities in heartrate and changes during exercise.
At the end of this project we wish to have a smartwatch that is almost as reliable as a clinical sensor and that can give important insights to the user of the watch for both their fitness and health.

What needs to be learned/researched/tested

Watch selection

It is essential that I use the best sensor possible on the market inside of a smartwatch. The resolution of the heartrate data as well as the accuracy and reliability of that data is most important.
There are 2 types of sensors that we can choose from

1. IR-LEDs – "most commonly used for measuring the flow of blood that is more deeply concentrated in certain parts of body such as the muscles" ~ https://medcraveonline.com/IJBSBE/IJBSBE-04-00125.pdf
2. green LED's (most commonly used in smartwatches) - typically used for calculating the absorption of oxygen in oxyhemoglobin (oxygenated blood) and deoxyhemoglobin (blood without oxygen present) ~ https://medcraveonline.com/IJBSBE/IJBSBE-04-00125.pdf

Retrieving data from the smartwatch

Retrieving the data from the smartwatch and handling how the smartwatch saves data when a mobile phone cannot be accessed is of importance. If the phone cannot be accessed, we do not want data to be deleted. Bluetooth is the normal method that smartwatches connect to mobile phones

Validate watch against clinical sensor

Using real participants and certain exercises, the watch will need to be tested against the clinical sensor

Fix any issues after watch has been validated against clinical sensor

It is unknown at this point how the smartwatch will match up against a clinically tested sensor for measuring heartrate. Because of this there are plenty of unknowns when it comes to the reliability of data. It will be of importance to iterate through the data, removing variables which are outliers and recalibrate as the project progresses.

Data

How will data be stored? How will it be protected? How will data be transmitted but safe? These are all questions that I will have to deal with along this project

Skin sensitivity

My current smartwatch can cause issues with my skin if too tight. However if too loose the data that we retrieve is not as accurate. We want to make sure that the user does not experience any pain or rashes when wearing the sensor

Raw Data Or Not

Do I need to ascertain raw PPG data? Or will heart rate data be enough?

Project Deliverables

1. A smartwatch with relevant software
    a. That can access the heart rate data
    b. That can relay the heart rate data across to a mobile application
    c. That stores a limited amount of data on the device in case of an issue with the connection between smartwatch and phone
    d. That has a simple interface for the user to check their heartrate on the smartwatch
    e. That deals with most Motion Artifacts
2. An Android Application
    a. With a simplistic, User Friendly GUI
        i. Users can see their heartrate
        ii. Users can see time series data
        iii. Users will need to accept data agreements so that we can store their data
        iv. Users will need to accept push notification agreements
    b. That can send push notifications to the user
    c. That calculates data when it is sent from the smartwatch so that we have a time series to show to the user and to use for any relevant algorithms
    d. An algorithm that calculates when the user is running
    e. An algorithm to calculate when the user is walking
    f. That can send and receive data to a database which is located elsewhere (On a server / Cloud)

Research / Bibliography

Review on photoplethysmography devices - https://medcraveonline.com/IJBSBE/IJBSBE-04-00125.pdf

- “However, one of the major difficulties in using PPG-based monitoring techniques is their inaccuracy in tracking the PPG signals during daily routine activities and light physical exercises. This limitation is due to the fact that the PPG signals are very susceptible to Motion Artifacts (MA) caused by hand movements.”
- alternative factors such as environmental noise may also affect the PPG signal acquisition, which consequently affect the estimation accuracy of the HR
- Many studies have demonstrated that the second derivative of the PPG signal contains valuable health-related information.22 Investigation into this signal has shown strong potential to assist researchers and clinicians in evaluating various cardiovascular-related diseases, including atherosclerosis and arterial stiffness

Review on different wearable heartrate sensors - https://www.tomsguide.com/us/heart-rate-monitor,review-2885.html

- The results below are from a single person, so they're by no means scientific; however, we plan to test these devices on other individuals, as well as test newer devices as they come out.

Fitbits own OS - https://www.tomsguide.com/us/fitbit-ionic-os-vs-android-wear,news-25748.html

https://www.wareable.com/garmin/garmin-heart-rate-monitor-guide-230

Motion Artifact Reduction - https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6111474

Retrieving Raw PPG Data - https://stackoverflow.com/questions/47444302/android-wear-how-to-get-raw-ppg-data

Comparing watches – Clinical study - https://www.choice.com.au/health-and-body/diet-and-fitness/sportswear-and-shoes/articles/fitness-trackers-with-heart-rate-monitors-what-we-found

- Among the best performing were the monitors in bands from Garmin, Fitbit, Under Armour and Striiv, as these managed to produce readings within 95% accuracy – despite having to contend with motion and sweat.
- However, the Apple Watch Series 2, Samsung Galaxy Watch 4, Mio Alpha 2 and TomTom Touch return 99% accuracy even with movement, which makes them a much more effective training option

Fitbit app review - https://help.fitbit.com/articles/en_US/Help_article/2229

Fitbit accessing data - https://dev.fitbit.com/build/reference/web-api/heart-rate/