Sleep and Health Analytics Embedded

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Functional Description of Project

The goal of our project is to create a wristband that will provide information about the user's health. This wristband will perform reflectance pulse oximetry and activity level of the user. Pulse oximetry is a non invasive method of measuring blood oxygen saturation. We plan to use reflectance pulse oximetry to determine the blood oxygen saturation pulse rate, and we plan to use an accelerometer to measure the movement of the wearer. Using this Data, the project will provide analytics of the users activity levels, physical health, and sleep quality.

In addition to providing analytics on health and sleep, the device will also provide alerts. When the user enters a restless state of sleep, and has provided a desired time to be woken, the device will attempt to optimize sleep quality by prompting the user to wake up. When the user has been inactive for a predefined duration of time the device will alert the user of their inactivity. The device may use an onboard vibration module to alert the user or may communicate with an external device, which will provide the alert.

A possible stretch goal could be to visualize the user's heart rate in an application, in order to emulate the output of an EKG. Also, we think it would be interesting to the use the accelerometer to communicate with another embedded system within the user's environment, for example: allow the user to silence an alarm or manipulate lights by performing specific motions.

Initial Ideas for Implementation

In order to measure blood oxygen saturation the pulse oximetry sensor will need to be used. Reflectance pulse oximetry can be performed by measuring the change in absorbance of the wavelengths. Blood with high oxygen saturation has a bright red color, while blood with low oxygen saturation has a darker red. Pulse Oximetry uses measures the bloods reflectance or absorbance of light to determine the bloods level of oxygen saturation. By performing a Fourier Transform, blood oxygen saturation values can be converted into a frequency measurement and the pulse rate of can be derived.

An accelerometer will be used to measure the movement of a user. An algorithm will be used to determine what motion is considered a step. Determining activity levels during the day will then be executed by comparing movement and heart rate data. The accelerometer will also be used to monitor the users sleep patterns. During periods of sleep, when the user has not

moved, the device will assume that the user has entered a deeper sleep. The armband will transmit this data to a database backend, which will provide analytics on the users hours of REM and NREM sleep.

In order to save our analytical data for later analysis, we will need to off load our data to a phone capable of syncing with a server. This can be done either wirelessly or through a headphone jack. A variety wireless communication protocols are available. Many health analytics devices communicate over bluetooth, which has high power consumption. Bluetooth 4.0 is a low power possibility, but is not supported by many android devices. A number of Wi-Fi modules are also available for low embedded devices. A non-wireless solution is communicating over a 3.5mm headphone jack. While the headphone jack wouldn't provide the convenience of wireless communication, it would solve compatibility issues with different phone models. Communicating via the headphone jack would also reduce power consumption of the device.

Device alerts can be performed by interacting directly with the user using LED's or vibration modules or indirectly by alerting an external device such as a cell phone.

Initial Tasking

Much of the project development will involve research on procedures of pulse oximetry. The relationship between blood reflectance and blood oxygen saturation is non-linear and varies for different locations on the body. Much of the initial project research will be determining whether the development of our own blood reflectance device is feasible or whether we must use a third party solution. Additionally, in order to determine the users heart rate from blood saturation levels, a fourier transform must be performed, which will be a determining factor in choosing a microcontroller.

Communication and wireless protocols must also be evaluated before selecting a method of communication. Power consumption, device versatility, and protocol complexity must all be evaluated before our team can select a communication module.

Much of the projects value is determined by the analytics that it can provide to the user. One of the first application development tasks will be to determine what type of information we should provide. Key elements of the health analysis will be steps throughout the day, movement during sleep, and heart rate trends. Using this data we hope to provide the user with information and alerts about sleep quality, stress levels, quality of exercise, periods of inactivity, and blood oxygen circulation.

Alerts for this project will initially be cause by two types of triggers. A timed alarm that wakes the user up when they are in a light period of sleep, and an alert that vibrates on the users

wrist to notify them that they have been inactive for a predefined period of time. These predefined values will be set in the application and then loaded onto the wristband.

In addition to alarm triggers we must also determine methods of interacting with the user. LED's and vibration motors will be used for performing alarms, but we must also research available types of display screens and available packages which will allow the user to interact with the device.

Current Risks

Performing pulse oximetry from the wrist is non-ideal, and can have different values depending on the user. Due to the involvement of heart rate measurement in our projects analytics, pulse oximetry is a large risk in the project. While we would rather develop our own pulse oximetry peripheral, a variety of pulse oximetry devices are available which would offer a suitable alternative building our own.

Measuring the pulse accurately during high amounts of physical activity is very important for people that exercise. However, this can be very difficult to do from the wrist due to variability of blood oxygen levels during exercise and the nonlinearity of pulse oximetry sensors. If we are unable to develop a method of measuring heart rate during exercise, we may need to attach an additional sensor that will measure heart rate independent of blood oxygen levels.

Sources

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