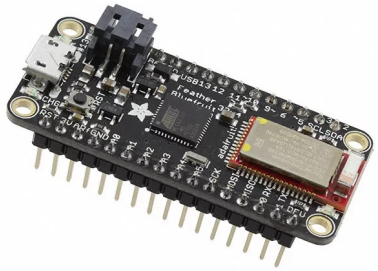
HEART RATE AND BREATHING MONITER

CHEST STRAP LAB



Wearable Technology Laboratory (BIOE 494/ CS 491)
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Materials:

1. Arduino Feather 32U4 BLE
2. Bread Board
3. Micro USB interface cable
4. Rechargeable Lithium Battery
5. AD8232 heart monitor
6. ECG leads
7. ECG gel
8. Conductive cloth
9. Buttons
10. ECG electrodes
11. Conductive Fabric
12. Resistor
13. Haptic motor
14. Elastic Band & Velcro

Background

As we discussed in the presentation, heartrate and respiratory-rate monitoring wearables could be used in the areas of mediation and fitness for both children and adults. Your goal is this lab is to develop a wearable elastic chest strap. The chest strap will have embedded electronics to collect Electrocardiograph (ECG) signal using the AD8232 heart monitoring board, and the respiratory signal using the conductive cloth sensor connected to the Arduino.

AD8232 Heart Monitor:

Let's get familiar with the AD8232 heart monitor board. The AD8232 chip is designed to collect a clean ECG signal. Go over the tutorial of this board using the link provided below. The tutorial will go over the basics for getting your AD8232 board up and running.

https://learn.sparkfun.com/tutorials/ad8232-heart-rate-monitor-hookup-guide?_ga=2.201433553.1187612062.1519059427-2036631182.1517865376

Using the board and the provided leads record the ECG signals from a group member and calculate their resting heart rate (beats per min). Now ask the group member to perform 20 jumping jacks and measure their heartrate after performing this activity.

Note: *Some post-processing steps might be required when dealing with biosignal. You could use time varying or frequency domain filters to reduce the noise. Also bare in mind that sometimes using FFT concepts is the best approach for calculating a rhythmic pattern such as the heart rate.*

Now that you are comfortable with using the AD8232 board, it's time to incorporate the board on the chest strap.

Device Assembly:

Follow the following steps in order to build the device:

Step 1. Measure the circumference around your chest and cut a piece of the elastic band of the appropriate size. Incorporate Velcro using hot glue at the end of the strap so that you could create a closed loop.

Step 2. Using the button insertion tool, embed 3 buttons on the elastic band. These buttons will be used to attach the Snap-On ECG electrodes, therefore; pick the location of the buttons wisely so that you have one electrode to the right of the heart and the other electrode to the left of the heart. Place the reference electrode furthest away from the heart on the right side of the body on the elastic strap.

Step 3. On the top side of the strap, wrap wires around the buttons and connect them to the AD8232 board. Once the ECG electrodes are connected to the buttons the ECG signal will be carried over to the board using these wires instead of the leads you purchased. Pay attention to the fact that the electrode on the right side of the heart needs to be connected to the RA pin of the board, and the electrode on the left side of the heart needs to be connected to LA pin. The reference electrode located to the right side, furthest away from the heart, needs to be connected to RL.
Step 4. Using the prototyping board provided connect the AD8232 board to the Arduino and attach device and the battery to top of the strap.
Step 5. Place electrodes on the buttons attached to the strap. In order to further reduce the noise, cover the electrodes with gel.
Step 6. Now start recording a live ECG signal from the user.
Step 7. Code should update the heart rate displayed on your interface every 30 sec.

Respiratory sensor:

In this section we will use a ribbon of conductive cloth as a sensor to gauge the respiratory rate. The conductive cloth changes in resistance as it stretches due to the expansion and contraction of the diaphragm during the inhalation and exhalation. This variation in resistance could be used to calculate the respiratory rate, and the inhalation/exhalation period. Incorporate this sensor on the elastic strap using the following steps:

Step 1. A strip of the conductive cloth will be provided to you.
Step 2. Using the multimeter measure the resistance of the sensor (R_{sensor}).
Step 3. Based on the R_{sensor} create a voltage divider that could be used to identify changes in voltage that results from the inhalation and exhalation.
Step 4. Place the sensor strip on the elastic strap in between the two buttons to the right of the heart. Secure the sensor strip by sewing the two narrow sides on to the elastic strap. Make sure the sensor is stretched and has tension while you sew it so that the tension on the sensor could change as one breath.
Step 5. Incorporate wires on each side of the sensor strip that could be connected to the prototyping board.
Step 6. Develop a code that would calculate the respiratory rate, the inhalation period, and the exhalation period.

Data Collection:

Congratulations, you developed your second wearable device! Time to put the device to test. The interface that you have developed for this lab should offer the user a selection between the following 3 different modes of operation:

1) Fitness Mode
2) Stress Monitoring Mode
3) Meditation Mode

For each of these modes of operation the interface should perform the following tasks:

Section I: Fitness Mode

1) For the Fitness Mode your interface should always collect a 30 sec bassline data from the user. The baseline data would display the resting heart rate and the resting respiratory rate of the user.
2) After the 30sec initial data collection, the interface should be capable of displaying the cardio zone the user is experiencing.
3) Ask the user to perform a physical task, like running up and down the stairs, this task should be challenging enough to change the user's cardio zone. Analyze the collected ECG signal and have the interface display an activity graph. This activity graph should color code the period of time that the user was at each cardio zone (consult Fig 1). The maximum heart rate for each user is roughly equal to the user's age subtracted from the number 220.

Fig 1: Heart rate zone as a percentage of the user's maximum heart rate.

4) For each cardio zone, your interface, should also display the change in the respiratory rate, and the inhalation and respiration duration for the user.

Section II: Stress Monitoring Mode

1) For the Stress Monitoring Mode your interface should always collect a 30 sec bassline data from the user. The baseline data will display the resting heart rate and the respiratory rate of the user.
2) Play a relaxing music for the user (Do not take more than 1 min to decide what song this would be!) and measure their heart rate and the respiratory rate during the entire duration of the song. Can you conclude if the music actually made the user more relax?
3) Now ask the user to do a difficult task or try to solve a hard riddle. Measure the user's heart rate and the respiratory rate during the entire duration of this activity. Can you conclude if the activity actually made the user anxious?
4) Now discuss with your team mates on how to improve your interface so that it could detect if the user is stressed or calm. Incorporate these steps into your interface so it would be able to automatically detect these two emotional modes.

Section III: Meditation Mode

1) For the Mediation Mode your interface should always collect a 30 sec bassline data from the user. The baseline data will display the resting heart rate and the respiratory rate of the user.
2) Now imagen the user wants to meditate. Ask the user to breath so that their inhalation period is one third of their exhalation period.
3) Have your interface to continually check to make sure if this breathing pattern is achieved. If for 3 consecutive breaths this criterion is not meet, have a Haptic motor that is also placed on the elastic band, buzz in order to notify the user to try to get back into their meditative state.

Section IV: Time to get creative!

Can you add any other application to this device in order to make it more interesting? If so the floor is yours.

Module Requirements:

You will be graded on:

- A working prototype at the end of the module which your group will present.
- A well organized and scientifically composed presentation in which you present the required presentation elements.
- Your presentation includes all required graphs and visuals with accompanying interpretations of results.
- All team members are knowledgeable and able to build and use the circuit and accompanying GUI system. Everyone needs to present a section of the work.
- Your creativity in representing and implementing your idea.