Emotional Intelligence Device

Project Proposal

ECE 445 Senior Design

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1. Introduction

1.1 Statement of Purpose

We live in a digital world where people can become lost in their devices, decreasing the daily amount of personable social interaction. As a result, their communication skills deteriorate; specifically, their ability to identify and express their own emotions in a constructive manner becomes more difficult. There are also people with medical disorders that are unable to identify emotions in their peers, such as people with autism.

We want to design a wearable device that will help people identify their emotions, give the option to display their emotions, and provide constructive suggestions to the users to help alleviate stressful social situations. Our device aims to help someone explore the root cause of their feelings as well as offer the ability to display his/hers broad emotional state to help others identify with him/her. We think this concept would allow people to effectively communicate their emotional state, leading to less conflict on a daily basis and a better quality of life for all involved.

1.2 Objective

1.2.1 Goals

a. Ability to identify emotions the user is experiencing
b. Helps the user communicate their emotions better
c. Allow the user to look at their emotional history to track the cause of their emotions
d. Give the user an option to display emotional state to other people

1.2.2 Functions

a. Process the audio received by the microphone and identify the tone that reflects emotion
b. Use biosensors to identify physiological signals
c. Classify emotions based upon spoken tone as well as physiological signals
d. Record and update average emotional state for a 24 hour period
e. Option of displaying their emotions or only showing it to the user himself/herself

1.2.3 Benefits

a. Help people quickly identify and manage their emotions
b. Increase effectiveness when communicating with other people
c. Decrease stress from social interactions with and for people that have medical disorders

1.2.4 Features

a. RGB LEDs for non-discrete display of emotional state

b. Button for discrete/non-discrete display selection
c. Rechargeable lithium ion polymer battery
d. Lithium-ion battery pack safety sensor and automated detach from user
e. OLED Display
f. Good microphone and high quality sampler
g. Temperature biosensor, heart rate sensor

2. Design

2.1 Block Diagrams

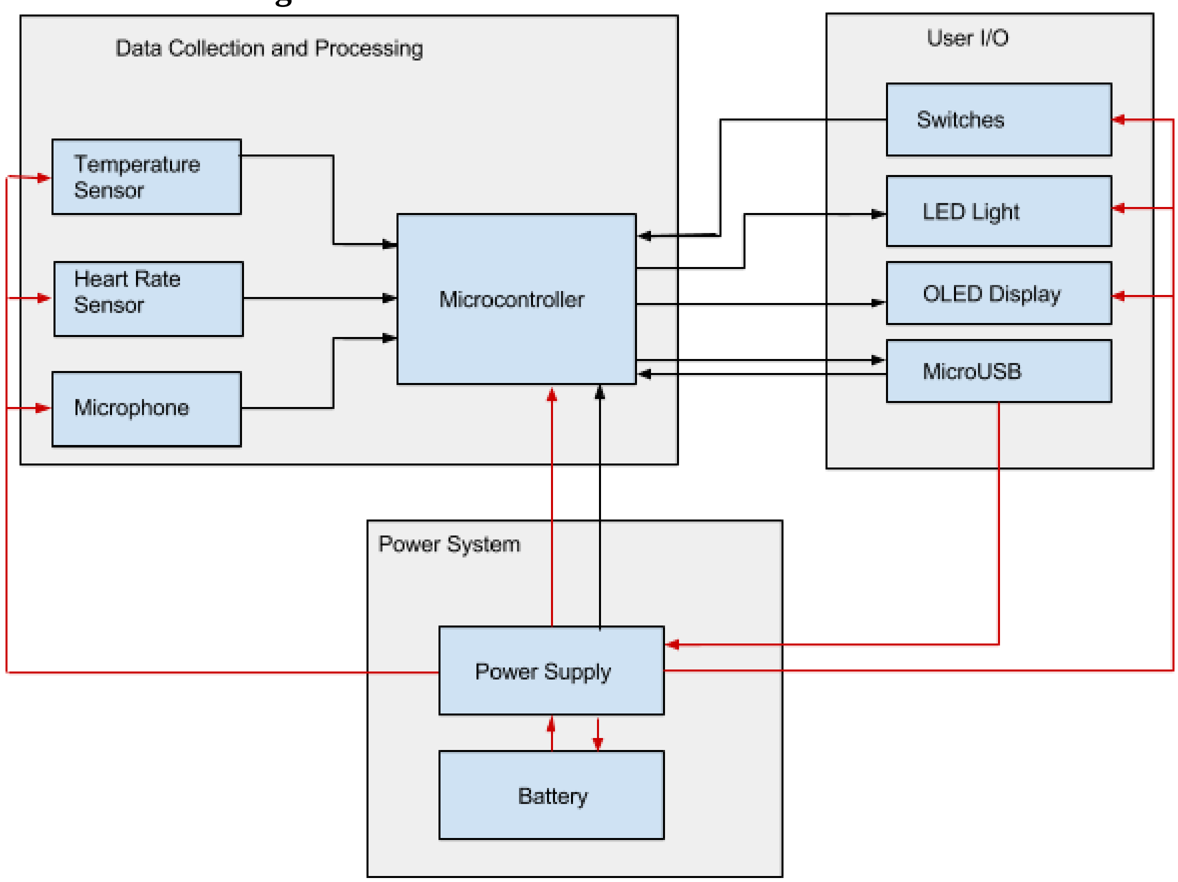

Figure 1. Block Diagram Overview

2.2 Block Descriptions

2.2.1 Data Collection and Processing Module

In order for the emotional state of the user to be measured, we choose to combine three methods of measuring the user's emotion and process that information with decision algorithms to arrive at the user's emotional state. The result is sent to the User I/O. The state of the overall machine is also monitored, such as battery power.

2.2.1.1 Temperature Sensor

Temperature sensor consists of a skin contact sensor in the wristband and a separate temperature sensor thermally insulated from the heat from the device that will measure the ambient temperature. This second sensor is required for false-positive determination when the ambient conditions will result in a raised temperature of the user. The data is sent to the Microcontroller. Both temperature sensors are digital. Power is received directly from the battery.

2.2.1.2 Heart Rate Sensor

The heart rate sensor measures the user's beats per minute. The sensor package required to accurately record this is a photodiode and LED placed at the bottom of the wrist band. Ideally, the LED shines a light and the photodiode records the reflected in mV. Operation of the BPM sensor will require an ADC as well as amplifiers before this signal is sent to the microcontroller (or we choose a different microcontroller with multiple ADC's).

2.2.1.3 Microphone

MEMS microphones can provide ~20 Hz to ~20kHz with sufficient signal to noise ratios to capture human speech as well as fulfill the requirements for small volume and power. The analog signal is captured and sent to the microcontroller.

2.2.1.4 Microcontroller

Microcontroller accepts the information from the sensors, I/O blocks, and battery pack. It will convert the analog voice signal to a digital signal and process/interpret the other signals with a decision algorithm to determine the emotional state of the user. In order to conserve power and to avoid constant flip-flops of emotional states due to minor fluctuations, we will analyze the user's emotional state only once every minute or so. The frequency of emotional measurement will be a design decision.

Based upon the I/O block input, it will determine whether to use the OLED display and LEDs for emotional state or simply use the OLED display. It will also display the battery power whenever the user activates the OLED display. The microcontroller program and data dump will occur through the I/O block with a micro-USB port. Power to the components will not be directly provided by the microcontroller.

The microcontroller is constrained firstly by power consumption, then area and processing power. It is marginally constrained by memory, but that may change with implementation of the algorithm.

2.2.2 User I/O Block

User I/O Block allows the user to set privacy setting, view current battery power, charge the device, see the current emotional state via OLED display and/or colored LEDs, and allow the user to program preset messages to be displayed for certain emotional states. Microcontroller programming capability for the designer.

2.2.2.1 OLED Display

OLED display will display the emotional state as well as any preset user messages in the form of scrolling text for the specific emotional setting. It will also display the current power percentage of the battery pack, which is sent from the microcontroller. Ideally, the light-up signal will come from the microcontroller as a result of a button press from the user or when a new emotional state has been identified.

2.2.2.2 LED Lights

RGB LED lights allow the user to display their emotional state to their peers. Different colors/intensities of each LED will determine the color projected onto the user's skin around the watch. This is controlled directly by the microcontroller and indirectly by the privacy setting switch which is part of the switches block.

2.2.2.3 Switches

There are two active user inputs during normal operation of this device. The first is a slider switch that determines privacy. When this slider is turned on, the LEDs will not turn on to display their emotion to their peers; only the display will show their emotion. This signal is sent to the microcontroller.

The second user input will turn on the display during the whole duration the button is pressed and will continue to show the display for 10 seconds after the button is de-pressed. This signal is also sent to the microcontroller.

The last switch is the on/off switch. The switch will need to be held for a second or more to power off and on.

2.2.2.4 MicroUSB

The Micro USB port has two functions; power for recharging the battery and data transfer to the MCU for programming the MCU. The power line from the Micro USB is routed to the battery through the power supply circuit, which regulates the charge current and voltage. The other function allows us to program the Micro USB to perform all of the functions necessary to detect and display emotion.

MicroUSB was chosen as the port due to the small dimensions and the current prevalence of Micro-USB to USB cords for modern smart phones.

2.2.3 Power System

The power system serves the function of providing voltage and current to all components as well as regulating the charging behavior of the lithium-ion-polymer battery. The power will not be directed from the MCU to all components, but directly from the power system.

2.2.3.1 Battery

The two most important criteria for selecting a batter come down to high energy density and very small volume. The type of batteries with this characteristic are the lithium-ion polymer batteries. They have serious safety concerns, though, and will require their own voltage and charge regulator for charging. We will also consider some mechanical safety device for the user should the battery malfunction unpredictably. We will also consider having a temperature sensor on the battery to monitor the heat and maintain it at a safe operating temperature by reducing the current draw on the battery (sensors and/or MCU to low power mode).

2.2.3.2 Power Supply

The power supply will regulate the voltage and current draw during charging as well as the current and power delivered to every component. Each LiPo cell is slightly different and the power supply will have to be designed or some off-the shelf power supply for the specific power cell. Safety is the highest concern with the power system, and this part will have to be extensively tested to ensure safe operation.

3. Requirements and Verification

3.1 Requirements and Verification

Module	Requirements	Verification
Power Supply	a. Power supply from the battery should be able to power the device for 8 hours b. Supply 5V with ripple of +/- 0.25V	a. Leave the device on and measure the time that it remains functional b. Use multimeter to measure the voltage difference across the power supply
Microcontroller	a. All components connected to the microcontroller must be able to work independently without affecting each other's functionality b. Correctly determines user emotion with an accuracy of 70% c. Correctly chooses suggestion words to user depending on the detected emotion d. Maximum microcontroller temperature will be 60℃	a. Test and record functionality of all individual components before and after connecting to the microcontroller b. Given clear tones of voice (for example, angry, sad, happy), send the correct emotion to the PC through the microUSB c. Program test cases into the Microcontroller with every possible emotion, then analyze the suggested words and determine relevancy d. Use an external temperature sensor to measure the temperature of the microcontroller when in use
Temperature Sensor	a. Determine temperature of skin with an accuracy of 80%	a. Compare temperature sensor readings with an external temperature sensor
Heart Rate Sensor	a. Determine the heart rate (Beats per minute) of user with an accuracy of 95%	a. Compare heart rate from sensor with an external heart rate monitor
Microphone	a. Able to listen and record sound from the wrist when the hand is far away from the mouth	a. Before mounting microphone to microcontroller, test it's ability to record sound at 1 meter distance
Display	a. OLED display words that are preloaded onto the microcontroller b. LED light display will be on or off depending on a signal from the Microcontroller	a. Program the display to show characters on every possible location of the display b. Send on and off commands to the LED to check if it turns on and off
Switches	a. Check to make sure ON states correspond to active high and OFF states correspond to active	a. Connect multimeter and oscilloscope across switch and record the voltage across switch at changing states

	low b. Switch should be debounced and only register one input per press	b. Connect oscilloscope across the switch and graph the voltage level during button press. There should be only one voltage spike when the button is pressed.

3.2 Tolerance Analysis

The most important aspect of the device is to consume the lowest amount of power possible during operation. The microprocessor's power can be minimized with a combination of low power settings and by setting the input voltage to 2.2 V DC. It's operating range is from 1.8 V to 3.6 V. Since the standard lithium-ion-polymer battery cell is between 3.7-4.1 V, a basic buck converter is needed to down convert the voltage and to illustrate the tolerance analysis, shown in Figure 2. Equations 1 and 2 are then derived from the model shown in Figure 2.

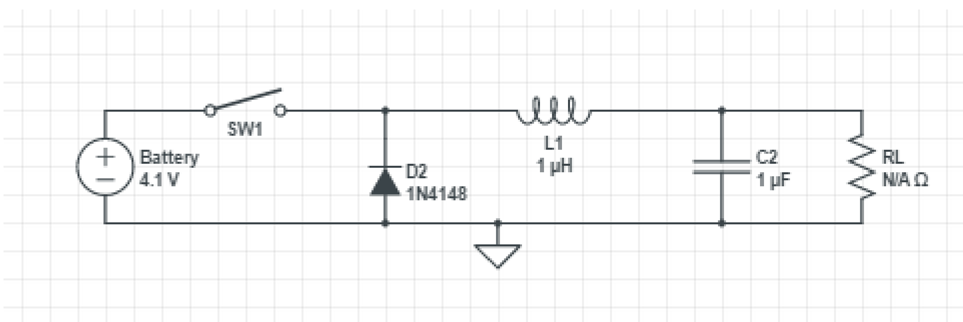

Figure 2. Basic Buck DC-DC Down Converter

$$L = (V_{IN_{MAX}} - V_{out})\left(\frac{V_{out}}{V_{IN_{MAX}}}\right)\left(\frac{1}{f_{sw}}\right)\left(\frac{1}{LIR * I_{OUT_{MAX}}}\right) \quad (1)$$

$$C = \frac{L(I_{OUT_{MAX}} + \frac{LIR * I_{OUT_{MAX}}}{2})^2}{(\Delta V + V_{OUT})^2 - V_{OUT}^2} \quad (2)$$

In equations 1 and 2, fsw is the minimum frequency switch which would be regulated by the user's power switch. That is approximately 1 Hz. The LIR is the current ripple to Ioutmax ratio. ΔV represents the maximum overshoot voltage. Since we are performing this analysis with a desired +/- 10% error in Vout, we will also set the overshoot voltage to 0.2 V. Note that the maximum desired error and overshoot voltage are both less than 3.6 V. Using this analysis, a 10% error in Vout will result from a 3% error in the inductor and a corresponding 20% error in the capacitor. Therefore, the device that requires the best tolerancing is the inductor.

4. Cost and Schedule

4.1 Cost

4.1.1 Parts

Item	Part Number	Quantity	Unit Price ($)	Total Cost ($)
IC Temperature Sensor	AD22100ARZ	2	4.00	8.00
Heart Rate Monitor Analog Front-End	AFE4403	1	8.42	8.42
LED Emitter and photodetector	DCM03	1	0.10	0.10
Microprocessor	MSP430G3	1	0.80	0.80
LED (Red, Green, Yellow)	HLMP3301 (R) HLMP3507 (G) HLMP3401 (Y)	3	0.15	0.45
Microphone	InvenSense ICS-40300	1	3.50	3.50
OLED Display	EA DOGM132	1	17.04	17.04
Resistors and Capacitors	-	20	0.10	2.00
Button/ Switch	JSX08001SAQNL	1	0.54	0.54
Lithium-Ion Polymer Battery	3.7V, some mAh	1	14.75	14.75
IC Charging Controller	MAX1555	1	1.95	1.95
Total				**57.55**

4.1.2 Labor

Name	Hourly Rate	Total Hours (hr)	Total ($) = 2.5*(Hourly Rate)*(Hours)
Jonathan Fouk	30	150	11,250
Matthew Palmer	30	150	11,250
Vivian Tseng	30	150	11,250
Total			**33,750**

4.1.3 Grand Total

Section	Total ($)
Parts	57.55
Labor	33,750.00
Grand Total	**33807.55**

4.2 Schedule

Week	Jonathan Fouk	Matthew Palmer	Vivian Tseng
2-9	Finalize and hand in proposal	Finalize Parts list Power Requirements for all parts	Prepare and sign up for Mock Design Review
2-16	Learn Eagle Order Parts Circuit design for biosensors and microphone	Schematic Design Review Draft Circuit Design for Battery Pack, Micro-USB interface	Learn Eagle Finalize and select components Design switch circuit for user interface
2-23	Test sensors and circuit for biosensors and microphone	Test Microprocessor, Verify Battery Pack Design and Micro-USB interface w/	Test OLED Display Test LEDs and size LED resistors, Test switch circuit for

	Learn audio processing Python/MATLab audio processing implementation	Microprocessor Learn audio processing	user interface Learn audio processing
3-2	Start Microprocessor Coding, continue Python/MATLab audio processing	Design audio, verify designed circuits	Validate design layout Test Microprocessor basic functions with all devices
3-9	Continue debugging/developing audio processing algorithm	Design PCB Layout(s), thermal analysis on battery, components	Start incorporating basic features to prototype design
3-16	Continue developing audio processing algorithm	Design Physical Watch, verify PCB layout and order	Second verification on PCB layout, biosensor implementation
3-23	Spring Break Implement audio processing in microcontroller	Spring Break Continue designing physical watch, verify watch layout with machine shop and order parts	Spring Break Implement microprocessor basic functions
3-30	Add decision making algorithm to blend audio processing and biosensor readings	Construct the PCB w/ components and add to watch Attach sensors/LEDs/switches to watch/PCB	Test connected display and overall watch functionality
4-6	Debug decision making algorithm	Test components and temperature @ worst case	Try optimizing if user response is slow
4-13	Mock Presentation Preparation	Demo Sign up	Mock Presentation Preparation
4-20	Presentation Sign Up	Final testing for demo	Final testing for demo
4-27	Presentation Preparation	Presentation Preparation	Final paper writeup
5-4	Lab Checkout	Finalize final paper	Finalize Presentation