A Multi-sensor Wearable that Bridges Communication Gaps Between Emotional Support Systems and Individuals with Anxiety Disorder

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Abstract: *Scientists and researchers have a tremendous responsibility to improve the quality and expectancy of life, particularly human life. The researcher has chosen the presented field for research to identify possible innovative and advanced definite system designs to save numerous endangered lives of Individuals with Anxiety Disorder. The paper displays compact board can then be incorporated into an easy-to-wear device, such as a ring, which focuses on the finger and collects the physiological signals of GSR, PPG, and 3-axis sensors. This way, the user is only wearing a compact sensor board that can efficiently communicate with the Arduino interface without being physically connected to it. The authors algorithm, states that the ranges for at least two of the variables represented, and should be satisfied, interprets this data and sends its corresponding emotional state to the support system. Author analysed real-time data across many scientific databases and analysed a variety of methodologies to determine risks and resolutions with valid evidences.*
Keywords: GSR, PPG, 3-axis accelerometer

I. Introduction

To accurately decipher the emotional state, three biomedical sensors collecting separate indicators of tension--high sweat rate, high heart rate, and trembling--must be combined into a printed circuit board (PCB) to form a cohesive interpretation of a user's emotional state. The PCB must interface with the Arduino, which interprets the data as either indicative of a resting, tense, or distressed emotional state. The three biomedical sensors used were galvanic skin response (GSR), photoplethysmography (PPG), and a 3-axis accelerometer.

The GSR sensor measures skin resistance and sweat rate, which is correlated with the emotional state, as demonstrated in Table 1. The PPG sensor measures blood volume changes that translate to heart rate through arteries on the finger, which is correlated with the emotional state, as demonstrated in Table 2. The 3-axis accelerometer sensor continuously measures the orientation of a user concerning the Earth and movements such as trembling, which is correlated with the emotional state as demonstrated in Table 3. These three sensors must be combined on a board with a maximum size of 2" x 2" and provide a reliable data stream. Figure 1 demonstrates the hardware build. Figure 2 illustrates how the PCB will interface with the Arduino.

II. Proposed Method

The GSR, PPG, and 3-axis accelerometer sensors require 3.3 volts, have a baud rate of 9600, and collect data through the fingertip to be integrated into one usable board. Figure 3, Figure 4, and Figure 5 include the data for each sensor corresponding with three emotional states: resting, tensed, and distressed.

For the 3-axis accelerometer, resting was simulated in a sitting position. Tensed was simulated through light trembling. Distressed was simulated by more vigorous shaking.
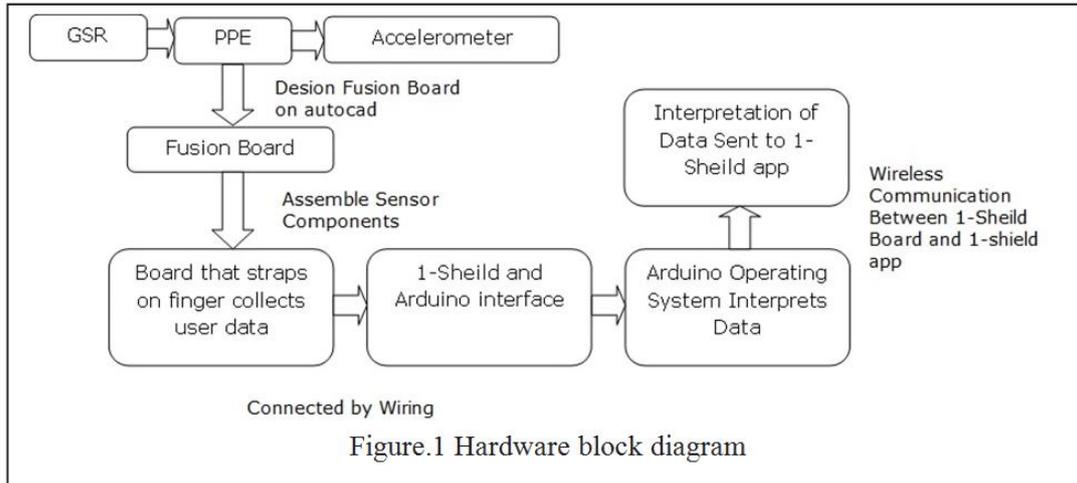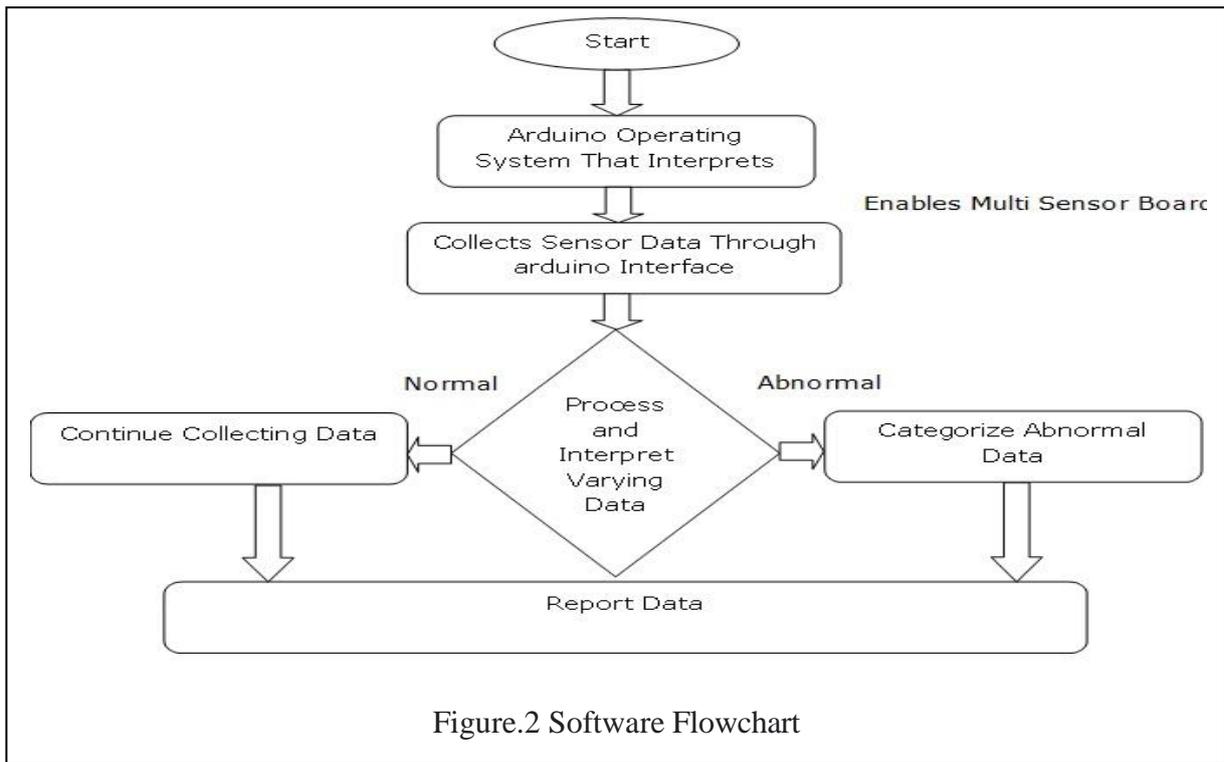
Figure.1 Hardware block diagram

Figure.2 Software Flowchart

III. Simulation Results

For accelerometer sensor resting was simulated based on varying emotional states. Table 1 shows the simulated results.

Table. 1 Axis accelerometer data based on varying emotional states

State 1	Resetting in sitting position		
X	Y	Z	Difference in Y
30	270	500	
32	275	500	5
30	271	500	-4
30	272	500	1
State 2	Tensed		
X	Y	Z	Difference in Y
30	253	500	
32	265	500	12
33	249	500	-16
30	263	500	14
State 3	Distressed		
X	Y	Z	Difference in Y

33	**240**	**500**	
30	**220**	**500**	**-20**
32	**274**	**500**	**54**
34	**231**	**500**	**-43**

In Table 2 results noted for the PPG sensor, resting was simulated in a sitting position. Tensed was simulated through a timed test. Distressed was simulated after an exercise.

Table.2 PPG data based on varying emotional states

Maximum PPG Measured Results	
State 1	**Resting in Sitting Position**
Heart Rate	Oxygen Level
85	98
82	98
83	98
85	98
State 2	**Tensed**
X	Y
98	95
95	97
97	97
100	96
State 3	**Distressed**
X	Y
105	95
108	96
110	95
106	95

For the GSR sensor, resting was simulated in a sitting position. Tensed was simulated through a timed test. Distressed was simulated after an exercise.

Table.3 GSR data based on varying emotional states

GSR Measured Results	
State 1	Resting in Sitting Position
	Arduino Count
	142
	173
	156
State 2	Tensed
	83
	91
	122
State 3	Distressed
	47
	32
	21

By combining the board schematics of the GSR and 3-axis accelerometer sensor, the first version of a board layout was created in a 38 mm x 30 mm board. All components were connected to the standard pins. Unnecessary pins were eliminated to conserve space, and standard circuits were routed to a single pin.
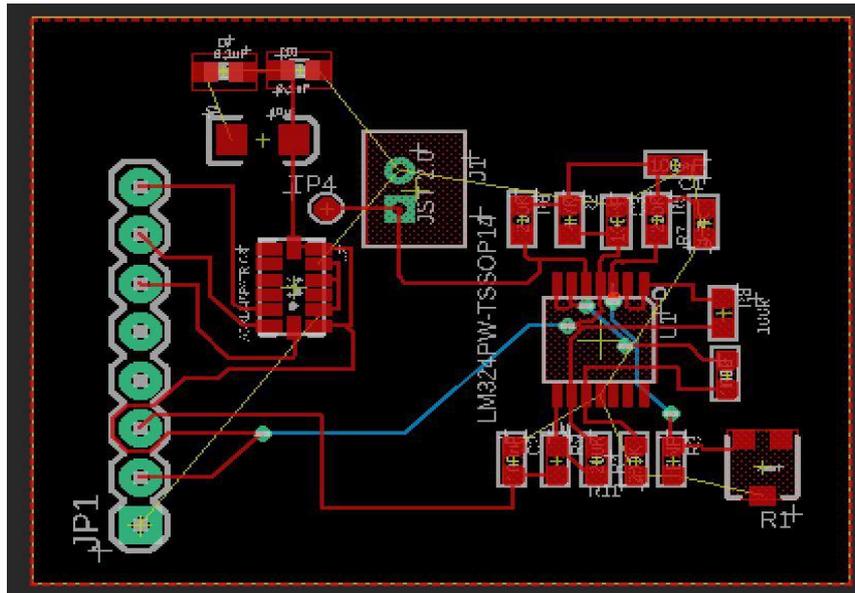
Figure 3 - GSR and 3-axis accelerometer board layout

The PPG sensor, which has both top and bottom layers, was then added to the schematic and was reorganized and incorporated into the circuits of the previous board. It is 38 mm x 47 mm.
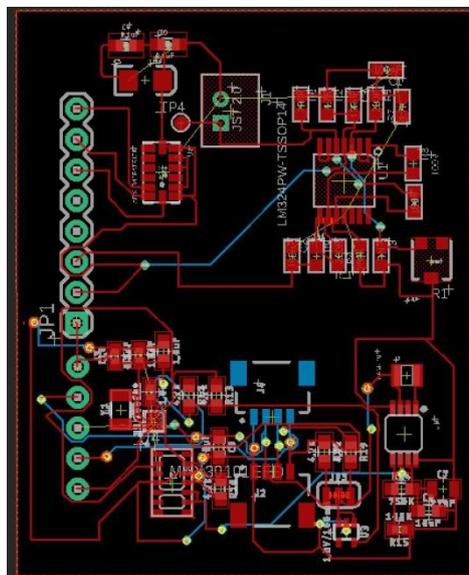

Figure. 4 GSR, PPG, 3-axis accelerometer board layout

The dimensions would be 38 mm x 47 mm. The components measuring physiological signals will be soldered on the PCB when fabricated.
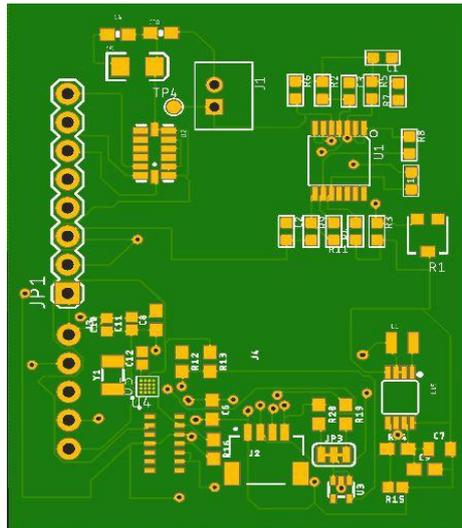
Figure 8 - The top layer of the designed PCB

When interfaced with the Arduino, the Arduino counts output would be three streams of data from each sensor. The algorithm, which states that the ranges for at least two of the variables represented in Figure 9 should be satisfied, interprets this data and sends its corresponding emotional state to the support system.

Table.4 Ranges for each emotional state for every sensor

	GSR			PPG			3 - Axis		
	Resting variable	Tensed variable	Distressed variable	Resting variable	Tensed variable	Distressed variable	Resting variable	Tensed variable	Distressed variable
Arduino Count	130-150	75-100	30-60	70-85	85-100	100-120	$\lvert 0 \rvert$ to $\lvert 5 \rvert$	$\lvert 5 \rvert$ to $\lvert 20 \rvert$	$\lvert 20 \rvert$ to $\lvert 60 \rvert$

If data is collected smoothly, the algorithm's interpretation would be notified to the 1sheeld app, or the support system, through the Arduino-1-shield interface.

IV.   Conclusion

The data can be sent and interpreted through the Arduino and 1-shield interface once the PCB is fabricated, populated, and tested with components. A second board will be revised depending on the performance to minimize space. The compact board can then be incorporated into an easy-to-wear device, such as a ring, which focuses on the finger and collects the physiological signals of GSR, PPG, and 3-axis sensors. The next step to increase wearability is to make the wearable wireless using a transceiver module. This way, the user only wears a compact sensor board that can efficiently communicate with the Arduino interface without being physically connected.

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Author

Shalini Rao is a rising senior at Monta Vista High School, Cupertino, USA. She is deeply involved in designing and developing a mental health wearable to bridge the communication gap between emotional support systems and individuals with anxiety disorder. Her product is expected to serve 300 million individuals globally. LivelyKit, an iOS application developed by Shalini, helps emotionally affected individuals immediately access helpful resources. She is the lead coordinator of Bring Change to Mind, a National Club in the USA. She plans to pursue Mechanical Engineering related to the aerospace track in the future.