Adaptive Wireless Wearable Neuro-Stimulator

DESIGN DOCUMENT

Team: 22
Client: Adan Cervantes
Advisor: Swamy Ponpandi
Patrick Walsh/Communications Manager, Kevin Wang/Meeting Facilitator, Kevin Simons/Test Engineer, Matt Stephenson/Report Manager, Brian Weber/Chief Engineer
sdmay18-22@iastate.edu
sdmay18-22.sd.ece.iastate.edu

Revised: Oct 9, 2017/0.1

Table of Contents

List of figures/tables/symbols/definitions

1 Introduction

1.1 ACKNOWLEDGEMENT

We would like to acknowledge Adan Cervantes, the client who brought this project to us, provided assistance in the form of recorded data, as well as significant advice in moving the project forward.

1.2 PROBLEM AND PROJECT STATEMENT

In 2015, there were 1,600 deaths due to SIDS (Sudden Infant Death Syndrome) alone, according to the Center of Disease Control. This accounted for almost half (43%) of infant deaths, many parents were left with the cause of their child's death unknown. The search for the cause and correlations to prevent SIDS is ongoing.

Through data analysis and development of a device to be worn on the ankle, our aim is to combat SIDS. Our goal is to find if there exists data correlation backing the suspicion that SIDS is caused by energy (lighting resonance) using information provided by radio stations. Additionally, the anklet will track infant movement and other health metrics. The anklet will provide a pulse (vibration) to induce reflexive movement as stimulus to the infant.

The anklet will be developed first as a proof of concept. With the anklet, an Android application will be developed to connect to the anklet and show data received from the anklet. The anklet should be able to send the pulse based on information input through the application, as well as send back metrics for the application to send notifications if infant status may be at risk.

1.3 OPERATIONAL ENVIROMENT

The environment in which the anklet is intended to be used is on an infant's ankle, indoors where the infant may sleep. Thus, the environment is not an extreme one, though the anklet should be comfortable to wear, as well as reliable in performance monitoring infant status.

1.4 INTENDED USERS AND USES

The intended user are parents concerned about monitoring and keeping track of their infant's health. The anklet will allow parents to be notified if the infant does not respond to the pulse from the anklet, as well as see other metrics in the application.

The other use is for researchers who may use data from the device in order to find correlations with SIDS rates.

1.5 ASSUMPTIONS AND LIMITATIONS

Assumptions:

- This device is intended to be used globally.
- Device will be used in research purposes. Data from device is to be sent to database which researchers may view in visualizations such as graphs. This also assumes enough parents would agree to have this (anonymous) data sent.

Limitations:

- Device must be small enough to fit on an infant's ankle. The device is designed to be a wearable on the ankle; the circuit design should lend itself to being able to made into a small enough board.
- Circuit needs to be done before the embedded code is developed. Embedded code relies on gathering data from sensors which depends on how sensors may be connected to the microprocessor.
- Due to schedule constraints and limited knowledge on PCB design, a custom PCB on a small scale was decided not feasible in the time frame. A prototype circuit is to be developed with an evaluation board as proof of concept.

1.6 EXPECTED END PRODUCT AND DELIVERABLES

End Product – Prototype of anklet: A prototype of the anklet able to connect to Android Application. Anklet should be configurable by application and send data back. Application should be able to visualize the data. Anklet needs to be able send pulse (vibrations) based on readings from sensors and the pulse periods based configuration (input from setup in application). Expected delivery is March-April 2018.

Graphs of data: Client gave us data to create graphs and see if the electrical energy in the atmosphere has any correlation the number of cases of SID. December 2017.

Software source code: The source code for the application, as well as the embedded code for the anklet. Expected delivery for all complete code: March-April 2018

Flow chart: An overall design of the software. Showing both software and hardware interactions. December 2017.

System diagram: diagram of the anklet connection, circuit diagram, etc. December 2017.

2 Specifications and Analysis

There are three distinct parts for this project. We need some way to record data from an infant during sleep, this data would include movement and heart rate. This data then needs to be available to alert parents in real time, in case they need to take action, as well as uploading the data to a secure server for review later by medical professionals.

2.1 PROPOSED DESIGN

As seen in *Figure 1* our design is to have an anklet, that has some customization setup steps, that will record data as the infant sleeps and upload this data to a phone in batches. This will allow the phone to see real-time data, and then we can upload the data from the phone to the secure server, which will save us having to make the anklet WIFI-enabled.

The anklet has a method to turn data recording on and off automatically. This was a requirement as we don't want to have to put more responsibility and another thing to remember onto the already busy parents. The way this will work is a temperature sensor and heart rate sensor will be running

continuously, and when they detect a rise in temperature and a heart rate, then the whole data recording, including the acceleration, and uploading data will turn on.

The data recorded is heart rate, temperature, and acceleration, this is all fed into our embedded code that monitors these readings and based on those readings, plus the data set in the config step, will send stimulating vibrations to the ankle. If no response is recorded for that or subsequent pulse trains, then the parents will be alerted.

The phone app is meant for parents to monitor their child as they sleep, as such, it contains mostly real-time data, with an easily consumable dashboard for main data notices. These notices include battery low, data full, child on back, and anklet connected. The app is easy to use and is mostly for answering the question "Is my child OK?".

The web app on the other hand is meant mainly for medical professionals looking into the causes of SIDS. It is able to correlate data from all devices around the world and see graphs of the data for that specific device. Because this information could be considered medical information, the user's information is hidden and just an ID is shown.

2.2 DESIGN ANALYSIS

So far, we have created a block diagram to visualize how the system will work. Put research into components that we will need for the anklet. This is a particularly challenging part as we have to make sure the anklet can run on battery power for extended periods of time, and have enough storage to handle becoming disconnected from the phone. We need parts that are extremely low power and produce accurate readings.

We have identified some parts that we believe will meet our requirements and discussed with our faculty advisor about the validity of them. We are in the process of placing an order for the parts. In the mean time we have started the design of our circuit. We will be using an evaluation board and a bread board to wire up the parts to produce our proof of concept. This design will be used once we receive the parts to assemble the circuit and get to testing faster.

For the visualizing side of things, we have created screen sketches for the app, as well as designed the server's database, and produced proof of concept graphs that had upwards of 480,000 data points. While the graph was created and you could view it, the large amount of data did make it hard to work with. Once we have real readings we will work on a way to produce more responsive graphs, possibly by using average data, or less data points, with the option to see more if you zoom in.

3 Testing and Implementation

3.1 INTERFACE SPECIFICATIONS

Wearable Device

As our device is going to be a proof of concept, the whole thing is essentially a test bench that we are creating. The hardware pieces will be placed into a solderless breadboard in the orientation

dictated by our circuit design, and connected to an evaluation board. This will allow us to test the circuit as though it is a final product, without having to create a printed circuit board to test off of.

Android Application

To test the android application before the circuit is done, we will need to spoof the Bluetooth input from the device. To do this, we will need to write code that enables us to use a different device to connect to the application and test the data transmission.

Web Application

Part of the testing for the web application is using the application itself to make sure that it works as intended. So, we will be developing the web application with the intention of building in the functionality to test it and see the information that we need to from it in the process of doing functionality testing.

3.2 HARDWARE AND SOFTWARE

Testing Hardware

To test the physical circuit, we will be using the various tools available to us in the Iowa State labs. We will be using a multimeter to test the various voltages and currents running through each portion of the circuit to ensure they have the proper current and voltage running through them to power the components without damaging them. We will also be using a variable power source to test the potential variations in voltage that could potentially run through the circuit. We would test the variation in voltage to make sure that our circuit will not malfunction or fail due to a slight variation in the power to the device.

Testing Software

We have multiple software based parts of our project that will need to be tested. For the android app, we will be doing the development in the Android Studio IDE. The software has its own built in error detection that we will use to avoid having any poorly written lines of code get into the final product. To ensure that all of the code that we write, regardless of its final destination (Web Application, Android application, and embbeded code), we will be using the Git application to check each other's work. Before anything is merged into the master branch, or any other time a merge is requested, we require that at least two other group members go through their code to make sure that everything works as it should.

3.3 PROCESS

For the software part of the project, as show in the Figure 1, we test incrementally as we build. Therefore, every time there is a new feature developed, we test it before it reaches the production level. All code that makes the main branch has 100% code coverage.

For the hardware, we will pick parts, design on paper, simulate and test, build and test. Then we will do a bunch of testing both on people as well as with meters. If things do not work, we can jump as far back as simulate and test if the circuit is not working.

3.4 RESULTS

As of October 12, 2017, we have drawn screen sketches, started the design of a circuit, and worked on analyzing a set of data. Our first run through on analyzing the data was on the incorrect set of data. Our test of this analysis was to present the data analysis to our client, but once he realized the miscommunication, he notified us that we had analyzed the incorrect portion of the data. The result of this test and test analysis was that we now know what specific data we need to analyze and how to read the data in a format that allows us to automate the analysis of it.

4 Closing Material

4.1 CONCLUSION

The goal of this project is to provide a way for SIDS researchers a way to study the effect of low energy radiation generated by lightning and its possible correlation to the rate of SIDS. The device and application suite we will be creating are all aimed at the accurate collection and display of biometric data gathered from the infant wearing our device. The end goal in the creation of the device is to have something that allows the parent to take active action towards increasing the survival of their infant in the years that SIDS has an effect.

The current progress of the team is focused on ensuring that each part of the project will be created to the specifications of the client. We have met with our advisor to discuss the feasibility of creating a complete packaged device with a custom printed circuit board that allows us to achieve our desired functionality in the time that we have, and with the skill set of the group. After our discussions with our advisor, we needed to reevaluate and change the full device creation to the creation of a proof of concept that does not involve the creation of a printed circuit board and packaging. After our decision that the creation of a complete, production ready device was not feasible, we met with our client to notify him of the infeasibility of creating such a device along with all other parts asked for. Once the device structure change was approved, we moved on to gathering a firm list of requirements for each individual piece of the project so that we could produce products that the client will be satisfied with and to help him get a better idea of what he wants the final products to look like.

Our plan to complete this project is best done by following the timeline we have set for ourselves. We believe this will best allow us to achieve our goals because it gives us a chance to manage our schedules so that we have enough time to work on each piece that we are assigned to do. This is the best solution for us because it gives us a structure to follow instead of randomly assigning tasks without a set timeline of what comes next. Our schedule gives an exact timeline of what needs to happen and when it needs to be done by. The schedule also has what follows the previous task, and

this allows the individual units in our team to progress after they finish with their current task without any delay because they know what comes next. Time will not be wasted trying to figure out what needs to happen next. Barring any significant delay or issue, following our timeline will allow us to finish all necessary tasks on time.

4.2 REFERENCES

SIDS Information and Statistics:

"Sudden Unexpected Infant Death and Sudden Infant Death Syndrome." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 17 Apr. 2017, www.cdc.gov/sids/data.htm.
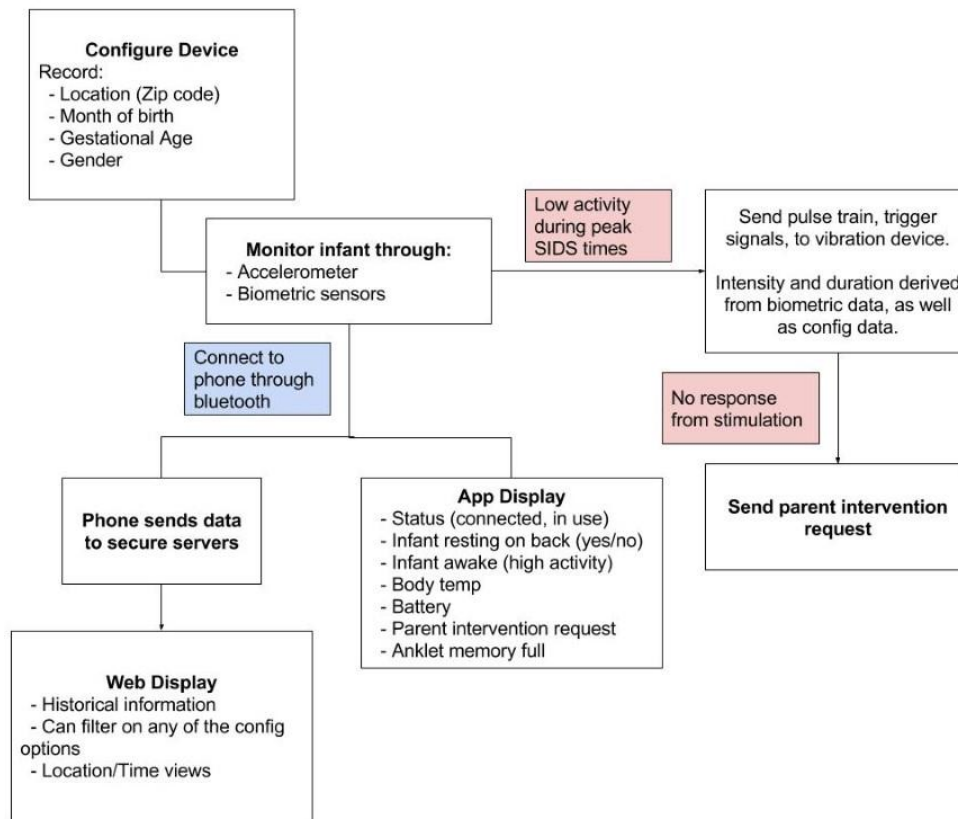
4.3 APPENDICES

Figure 1.

Figure 2.

Adaptive Neruostimulator

Legend: Period Highlig: 8 | Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete

ACTIVITY	Week start	Week Duration	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
First Group Meeting	3	1	3	1	100%
First Client Meeting	3	1	3	1	100%
First Faculty Mentor Meeting	3	1	3	1	100%
Analyze Data	4	1	4		20%
Create High level design	5	2	5	1	100%
Research Components	5	2	5	1	100%
Circuit Design	7	3	7		0%
Android App Design	7	2	7		0%
Database Design	7	2	7		0%
Web App Design	8	2			0%
Create Database	9	2			0%
Develop Android App	10	7			0%
Order Parts	10	8			0%
Develop Web App	10	7			0%
Test Database	11	2			0%
Fix and Re-Test Database	12	3			0%
Test Web App	17	2			0%
Test Android App	17	2			0%
Build Circuit	18	4			0%
Fix and Re-Test Android App	19	3			0%
Fix and Re-Test Web App	19	3			0%
Design Embedded Code	20	2			0%
Develop Embedded Code	22	6			0%
Test and Document Embedded Code	28	2			0%
Test Everything Together	28	2			0%

Weeks: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30