

Adaptive Wireless Wearable Neuro-Stimulator

Team:

- Patrick Walsh (Android App)
- Kevin Wang (Android App)
- Brian Weber (Hardware)
- Matt Stephenson (Hardware)
- Kevin Simons (Website)

Faculty Advisor: Swamy Ponpandi

Client: Adan Cervantes

<https://sdmay18-22.sd.ece.iastate.edu>

Adaptive Wireless Wearable Neuro-Stimulator : sdmay18-22

Problem Statement

- The search for the cause and correlations to prevent SIDS (Sudden Infant Death Syndrome) is ongoing with many avenues being explored to explain sudden deaths.
- Our client has been researching SIDS and possible causes, however research into this field is difficult due to the nature of the problem, and the lack of data
- The task we are taking on is development of an anklet prototype to monitor infant movement and other health metrics
- The anklet is also to provide a small pulse (vibration) to induce reflexive movement
- This recorded data then needs to be available to be easily consumed by researchers

Market Survey and Related Work

- Current devices on the market are exclusively monitoring
 - There is no recorded data that can be accessed for research
 - There are no found devices that will send stimulus back during dangerous situations, such as the infant laying on their face
- Baby Monitor | Official VTech® Audio and Video Baby Monitors
 - <https://www.vtechphones.com/products/baby-monitors>
- Sproutling Wearable Baby Monitor
 - <http://fisher-price.mattel.com/shop/en-us/fp/sproutling-sleep-wearable-fnf59>

Functional Requirements

Wearable Device

- Device has a temperature sensor, heart rate sensor, accelerometer, and vibration motor
- Device is able to send a vibration pulse of varying strength and length
- Device can store data in a buffer
- Transmit data

Android App

- Communicate with the database via wifi/cellular connection
- Require user to sign in
- Communicate with device over Bluetooth
- Display real-time information from the wearable device
- Upload data pulled from wearable to database

Functional Requirements (cont.)

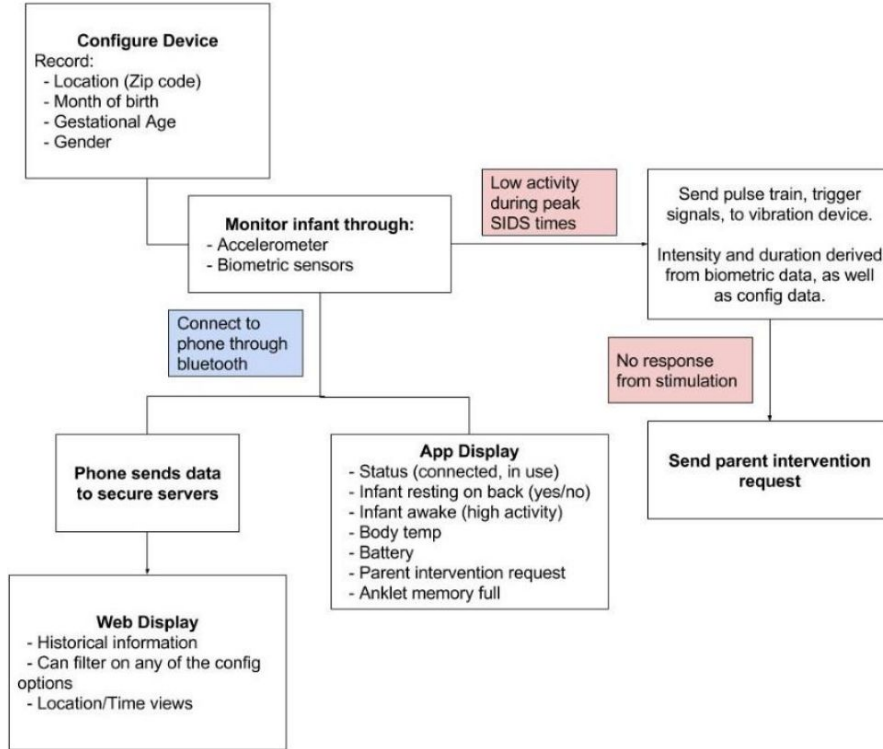
Web App

- Required login to view data
- Maintain a database of historical data, associated with devices
- Display data based on user input parameters
- Expose endpoints, to make developing new mobile applications easier
- Display contact information, and Terms and Conditions

Non-Functional Requirements

- Data presented by web application focuses on the needs of researchers
- The Android application will be easy to use for parents
- The device allows future developers to easily change parameters based off of further research
- All applications are user friendly and straightforward to use

Project Design



Project split into 3 main sections

- **Wearable Prototype**
 - Embedded device for recording biometrics
- **Android app**
 - Display overview of sensor readings
 - Display alerts from device
 - Upload data to database
- **Historical data website**
 - Input form for query parameters
 - Display graph of historical data

Technical Constraints and Other Considerations

- Limited experience with embedded code and circuit design
 - Parts of the original project proposal could not be accomplished
 - Prototype still developed with the marketable product in mind
- The device must record data even when disconnected from phone
 - Data will be stored locally on device
 - Vibration action will be decided on the device
- Must store large amount of historical data
 - Phone applications will upload to web database on regular intervals
- Must be able to display large amounts of data in a meaningful way
 - Users can specify date ranges for data, so they have control over how much they see
 - Graphs make it easy to see general trends, and outliers

Risks and Mitigation

- Data Server Loss
 - Deployment in multiple AWS regions provides the data redundancy needed
- Future HIPAA compliance requirements
 - This really can only be mitigated by continual monitoring of possible changes
- Lawsuits
 - Create terms of use and define clear lines of what the product is meant to do

Wearable Detailed Design

- Arduino Code
 - C code
- Array of sensors
 - Temperature sensor
 - Heart Rate Sensor
 - Vibration Motor
 - Accelerometer
- Bluetooth

Android Detailed Design

- Android Application
 - Android Studio (Java)
 - VOLLEY for web transactions
 - Room Persistence Library for local data storage
- Background Services
 - Rest communication
 - Bluetooth handler
- Real-Time UI updates from Bluetooth device

Website Detailed Design

- Website
 - PHP supporting a REST like API for app interaction
 - Form submissions and API calls all use the same database interaction code
 - Currently using a MySQL database, if the project expands in the future, Amazon RDS may be used
 - Using a javascript graphing library for our graphs (Chart.js)
 - After PHP fetches data from the database, it JSON encodes it, which is then decoded in javascript, in order to set up the graph constructor

Cost Estimations

- Wearable Prototype (\$40.50)
 - Heart Rate Sensor \$2
 - Temperature Sensor \$1.5
 - Accelerometer \$7
 - Vibration Motor \$2
 - Wireless bluetooth receiver \$3
 - Evaluation Board \$25
- Website (\$913 per year)
 - Amazon RDS for MySQL meeting HIPAA requirements with multi-AZ deployment (db.t2.medium 4GiB) \$795 per year
 - Frontend server (t2.small) \$118 per year
 - Scaling once memory is reached is then as easy as upgrading instance size

Functional Decomposition

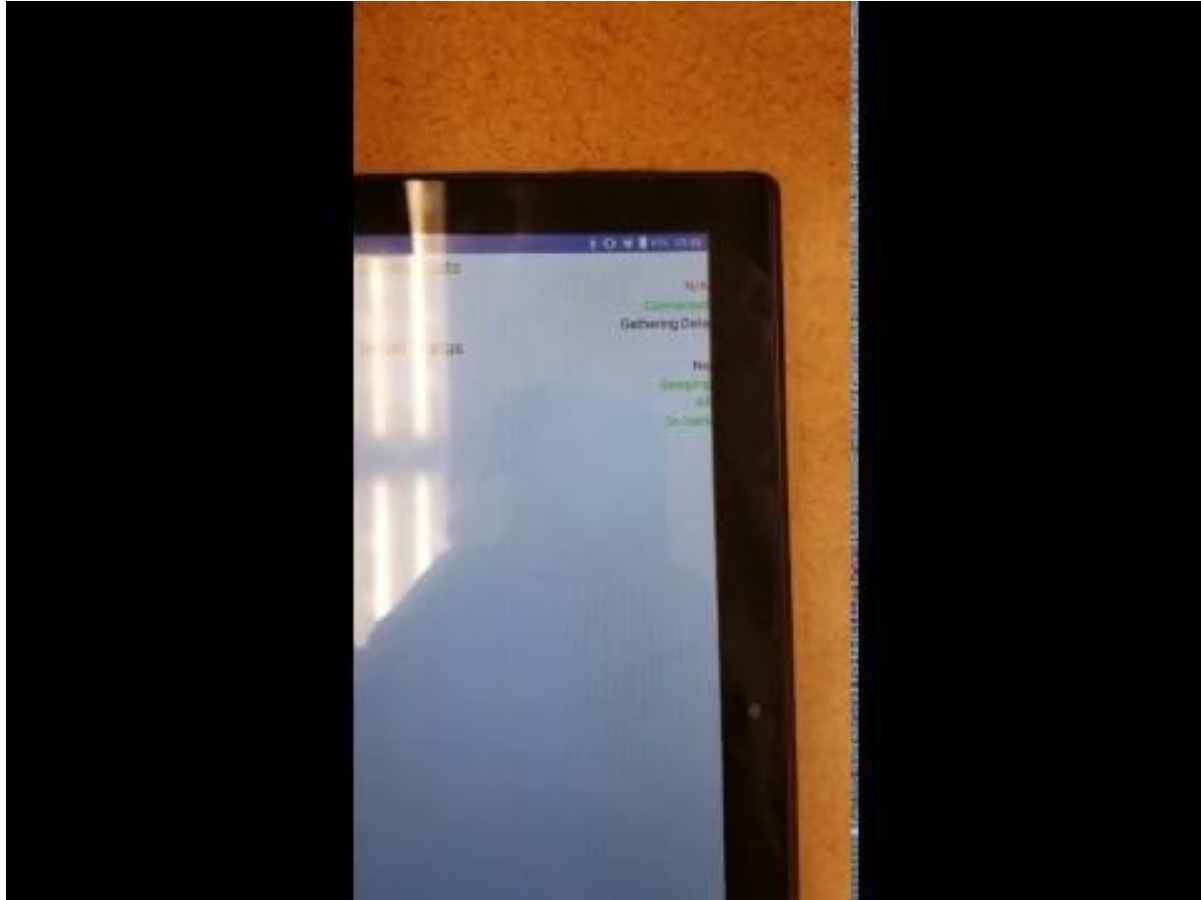
- Wearable Device
 - Records biometric data when worn
 - Uploads the data to the app
 - Emits small pulse to ankle to trigger movement
- Android Application
 - Will receive data packets from the wearable device
 - Displays real time data and connection status
 - Batch uploads historical data to the database
- Web Application
 - Displays historical data in graph format
 - Allows user input to filter the queried data

Testing

- Wearable
 - Manual functional tests
 - Unit testing
- Android Application
 - Manual functional tests
 - Integration tests with mocked out data
- Website
 - Automated functional tests for endpoints
 - Manual system integration tests for graphing



Full Pipeline Demo





Website Example



Historical Data

Refine the search by specifying the following values

Data Type

- ☒ Accelerometer
- ☒ Heart Beat

Date Range

04 / 18 / 2018 to 04 / 19 / 2018

Gender

- ☒ Male
- ☐ Female

Age (months)

0 to 24

Month of Birth

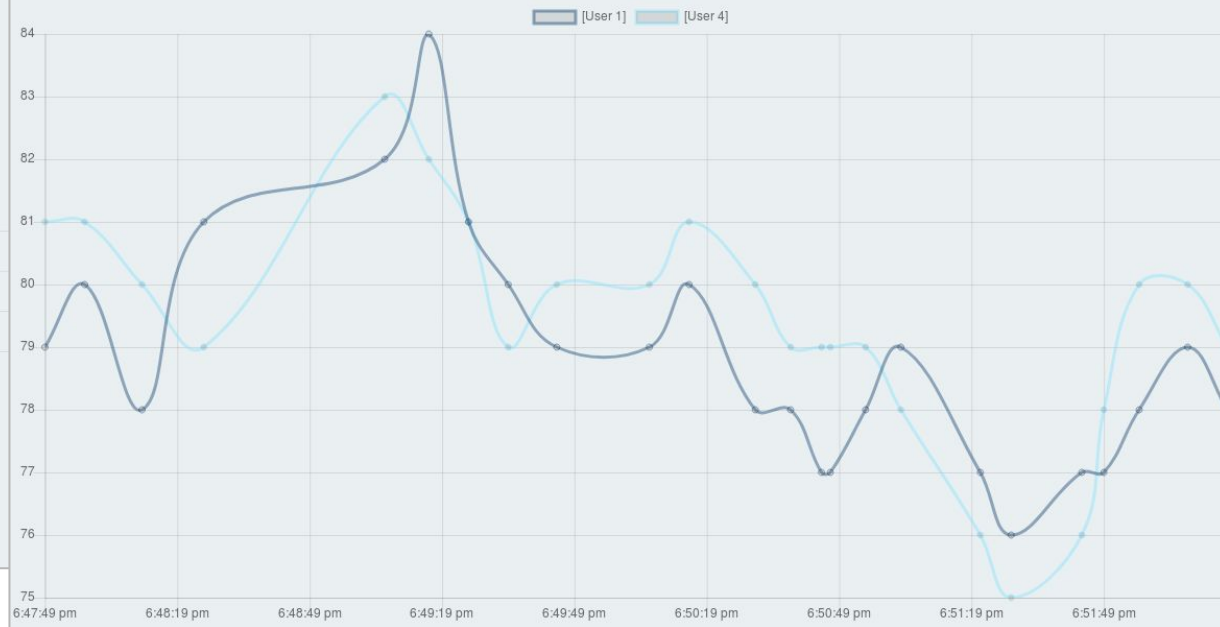
- ☒ January
- ☐ February
- ☐ April
- ☐ May
- ☐ July
- ☒ August
- ☐ October
- ☒ November

Location

- ☒ Northern Hemisphere
- ☐ Southern Hemisphere

Submit

HeartRate



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Client Feedback & Future Work

- Glad to see the full integration path is working
- Substantial progress has been made towards the end device and software

Future Work

- Refinement of all of the parts
- Creating an actual wearable
- Publishing the app

Lessons Learned

- Hardware was harder than expected and requires more initial design work
- Integrating sooner rather than later makes for a more cohesive end product
- Developing a clear API for communication is essential
- Having access to server logs can be very helpful in debugging



Questions

