Adaptive Wireless Wearable Neuro-Stimulator

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Client: Adan Cervantes

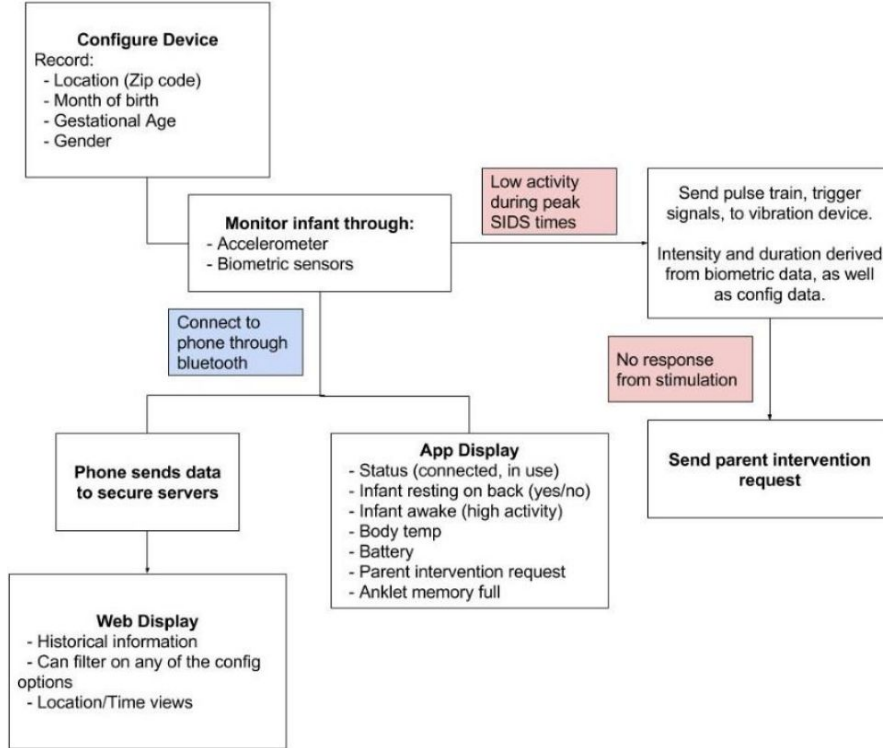https://sdmay18-22.sd.ece.iastate.edu

Project Plan

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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 correlations between low energy waves emitted from lightning and the rate of SIDS.

- The task we are taking on is development of an anklet to monitor infant movement and other health metrics. The anklet is to provide a small pulse (vibration) to induce reflexive movement as stimulus to the infant.

- Also, there is an aim to find if there exists data correlation backing the suspicion that SIDS is caused by energy (lighting resonance) using information provided by radio stations.

Conceptual Sketches

Configure Device
Record:
- Location (Zip code)
- Month of birth
- Gestational Age
- Gender

Monitor infant through:
- Accelerometer
- Biometric sensors

Low activity during peak SIDS times

Send pulse train, trigger signals, to vibration device.

Intensity and duration derived from biometric data, as well as config data.

Connect to phone through bluetooth

No response from stimulation

Phone sends data to secure servers

App Display
- Status (connected, in use)
- Infant resting on back (yes/no)
- Infant awake (high activity)
- Body temp
- Battery
- Parent intervention request
- Anklet memory full

Send parent intervention request

Web Display
- Historical information
- Can filter on any of the config options
- Location/Time views

Project split into 3 main sections

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

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Functional Requirements - Wearable Device

- Device has a temperature sensor
- Device has a heart rate sensor
- Device has an accelerometer
- Device has the ability to vibrate on command from android app
- Device can store at least 1 day's worth of data
- Device communicates with android device via Bluetooth
- Device is low power and rechargeable

Functional Requirements – Android Application

- The application communicates with the database via internet/cellular connection
- The application will require the user to log in
- The application will use Bluetooth to communicate with wearable device
- The application displays real-time information from wearable device
- The application will upload data received from wearable to database

Functional Requirements - Web Application

- The application will require the user to log in
- The application will display up to 6 months of past data
- The application will use data pulled from the database
- The application will allow the user to download the data in .csv format

Non-Functional Requirements

- Data presented by application focuses on the needs of researchers
- All information is stored securely
- When the algorithm deems it necessary, the device will be triggered to deliver 3 pulses of vibration by the android application
- All applications are user friendly and straightforward to use
- Android application will notify user of various events

Technical Constraints and Other Considerations

- Lack of experience with embedded code and circuit design
  - Parts of the original project proposal could not be accomplished
- The device must function and record data even when disconnected from phone, this data must be uploaded later
- Must store large amount of historical data with redundancy
- Must be able to display large amounts of data in a meaningful way
  - May have to limit the date range that data can be queried from

Market Survey

- Anklet is not just a monitoring device; it also gives a small pulse (vibration). The application gathers data from anklet to notify of potential concerns (infant not sleeping on back, for example).
- Anklet aims to serve research purpose (through data collection) in addition to monitoring health metrics. There could be value for research on SIDS.

Risks and Mitigation

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

Cost Estimations

- Wearable ($37.5)
  - Heart Rate Sensor $2
  - Temperature Sensor $1.5
  - Accleraometer $7
  - Vibration Motor $2
  - 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

Project Timeline

- Meet with group, client, and faculty advisor for first time
- Analyze data received from client
- Create a high-level design for each piece of the project
- Order parts for the circuit
- Develop at least half of the desired functions for the android application and web application
- Create the database

Second semester timeline

- Build circuit designed first semester when parts arrive
- Design and implement embedded code
- Do iterative testing on each project piece: android application, web application, circuit, and embedded code
- Tests all parts together and ensure that everything does what it is supposed to
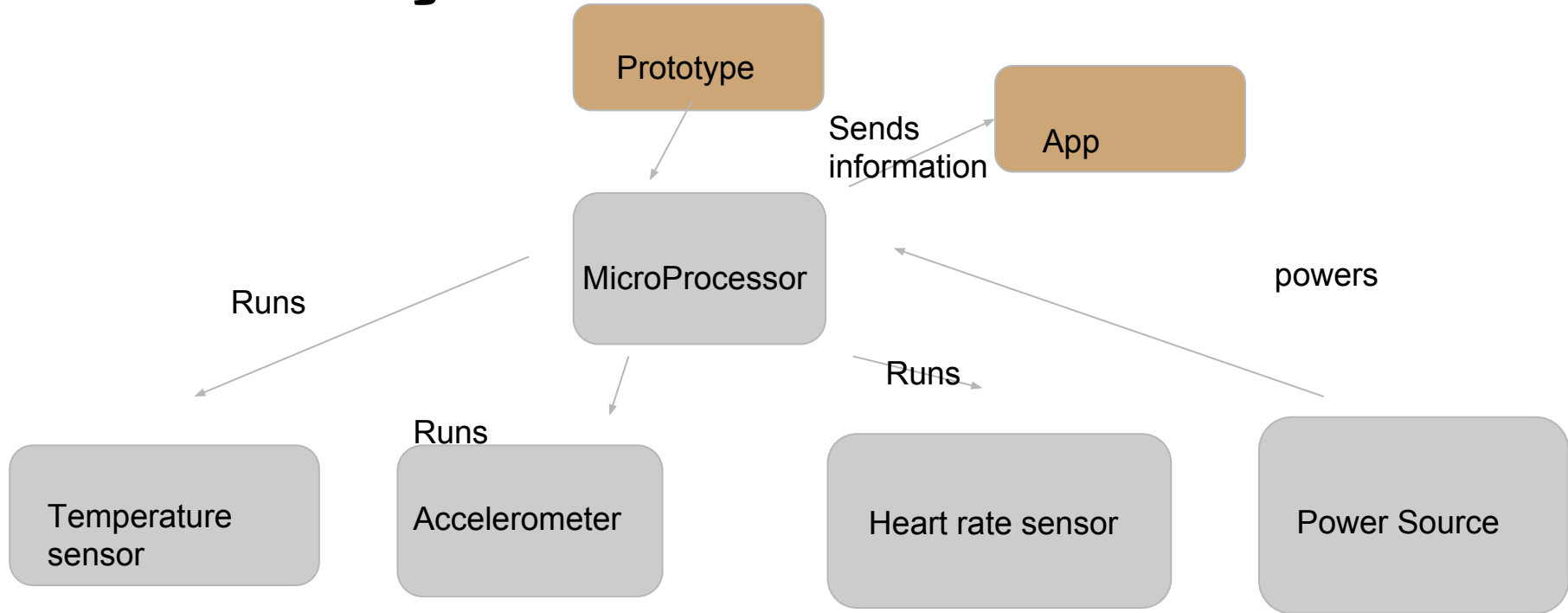- Present final product to client

System Design

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Ankle Device (Proof of Concept)

Detailed Design

Android Application

Detailed Design

- User interface
    - Connects all background modules together
    - Bluetooth, internet, and database communication tethered to buttons and processes
    - Controls what the user sees
- Bluetooth Module
    - Single point of contact for all Bluetooth communications
    - Modularizes the application to decouple from other unrelated functions
    - Allows for easy maintenance
    - All Bluetooth related functions are encapsulated in the module
- Internet Module
    - Single point of contact for all internet communications
    - All functions that require use of internet are encapsulated in this module
    - Modularizes the application and decouples it from other processes
    - Allows for easy maintenance

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Web Application

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Detailed Design

- User interface
  - Allows users to interface with the data in storage
  - Takes in user inputs for defined fields and executes database query
  - Displays the returned data in a graph for the user
- Database
  - Storage for all the recorded data as well as user information
  - Data stored in a database of SQL tables
  - Tables for User info, Accelerometer, and Heart Rate
  - Biometric data is linked to Users by their ID

Technology Used

Website - MySQL, Amazon RDS, <Some javascript graphing library>

Android Application - Android Studio

Test Plan

- Android Application + Website
  - Unit tests for methods
  - Integration/E2E tests for modules
  - UI automation tests for app
- Anklet
  - Unit tests for embedded code to verify functionality
  - Prototype anklet to verify recording and communication methods work
  - System testing to verify triggers
    - No movement for certain time triggers pulse
    - No response to pulses triggers alert
    - The sensors turn on when device is attached and turn off when detached

Prototyping

- Android Application Prototype V1
  - Basic UI created
  - Basic navigation
  - Bluetooth module partially implemented
  - Internet module partially implemented
- Database up and running
- Web Application Prototype V1
  - Basic UI created
  - User able to fill out certain fields

Conclusion

Current Project State

- Screen Sketches Completed
- Basic Android App UI Built
- Basic Web UI Designed
- Components for Circuit Selected

Individual Contributions -- Patrick Walsh

- Android Application
  - Created UI
  - Helped design application UI
  - Helped create software architecture
- Setting up meetings
- Main point of communication between group, client, and faculty advisor

Individual Contributions -- Kevin Wang

- Android Application
  - Helped design app UI
  - Screen flow of UI
- Arranged times for some additional group meetings

Individual Contributions -- Matt Stephenson

- Wearable
- Made sure necessary reports were submitted

Individual Contributions -- Brian Weber

- Wearable
- Research into raspberry pi.

Individual Contributions -- Kevin Simons

- Data visualization
  - Created MATLAB script to graph magnetic data from sensors around the world
  - These graphs used by client for his research and by us for confirmation
  - Worked with client, and his point of contact, to understand how to convert the raw data to a visual format
- Website
  - Created Database to store all the user and biometric information
  - Created screen sketches of UI

Spring Semester Plan

- Jump straight into development
  - Android App
    - Finalize UI
    - Create Backend Logic
    - Link To Database / Website
    - Link to Wearable
  - Web App
    - Create the user interface
    - Write the backend logic to execute the user's query
    - Link to Android App
  - Wearable
    - Add sensors to Arduino
    - Develop Sensor Interfacing Code
    - Link to Android App

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