Sensory Augmentation through Haptic Feedback Implants

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HARDWARE

Main Components of Proposed System
- Seeeduino Xiao nRF52840 microcontroller
  - BLE connections allow meshing with multiple instances
- Paired induction coils for power and data transfer
- 1.2v Linear Resonant Actuator
- 3.7v 1200mAh LiPo battery
- Repurposed CGM medical Adhesive

External Sensor Modules
- Ultrasonic rangefinder device
- GQ GMC 500 Dosimeter with speaker leads terminated into second Seeeduino Xiao
- MQ-9B CO and CH_4 gas detection sensor
- Compatible with Bluetooth CGMs present in market

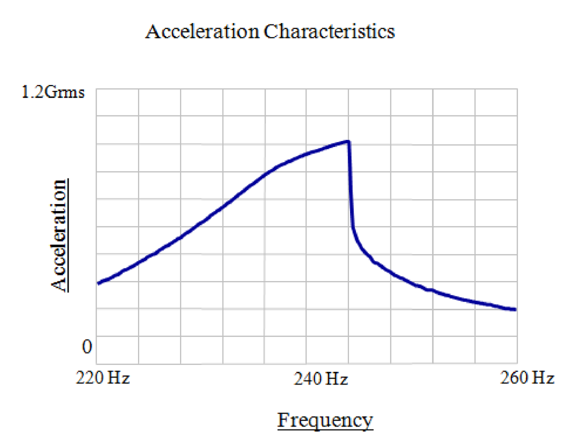

Figure 1: Frequency response curve of Vybronics LRA

- Prior experience with magnetic vibration implants confirm that variations in frequency and pattern can be utilized to communicate data.
- After a brief period of familiarization and learning, a user can correlate data points from sensor input to the vibration
- Eventually users will not have to focus on the sensation to derive the meaning behind it

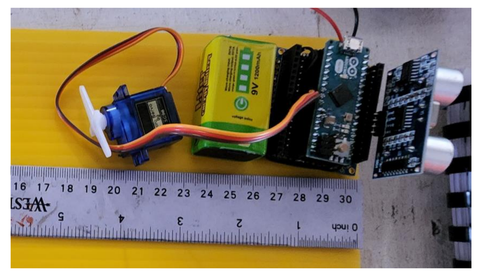

Figure 2: Prototype distance rangefinder

- The design for the shoulder mounted distance rangefinder uses an ultrasonic sensor currently
- This will allow a two-point triangulation system that allows for distance to be measured in the direction the user is facing
- Future work will entail the utilization of LIDAR to provide data for a full field of view

Figure 3: Mockup of future LIDAR grid design

ABSTRACT

The goal of this study is to introduce an implantable haptic feedback device that allows a user better interaction and feedback from various sensory modules. A thorough analysis of the design of the sensor is provided in this paper. The implantable nature increases the user's ability to integrate the vibrations into a more natural sense over time. Conscious training associating the vibrations with their meaning and the natural neuroplastic capacity of the brain will allow a user an intuitive and integrated understanding of the linked device. By using a standardized external battery module, design constraints surrounding internal power storage are avoided and present an opportunity for modular sensor packages. Current applications include blood glucose monitoring, radiation dosimetry, and pseudo-echolocation using an array of implants.

METHODOLOGY

- nRF52840 Seeeduino XIAO used in BLE Mesh mode allows for multiple implants to be networked together
- The user's personal mobile device acts as a bridge between the sensor suites and the haptic control board
- Eventual connection will use a mobile app to set up device initially for headless operation
- When data is received from the paired sensor it is converted into a value within the resonant range of the LRA
- Additional post processing of the data will allow for alerts using more noticeable patterns as well as layering of data through a combination of frequency, pulsing, and patterns that allow the communication of more complex information

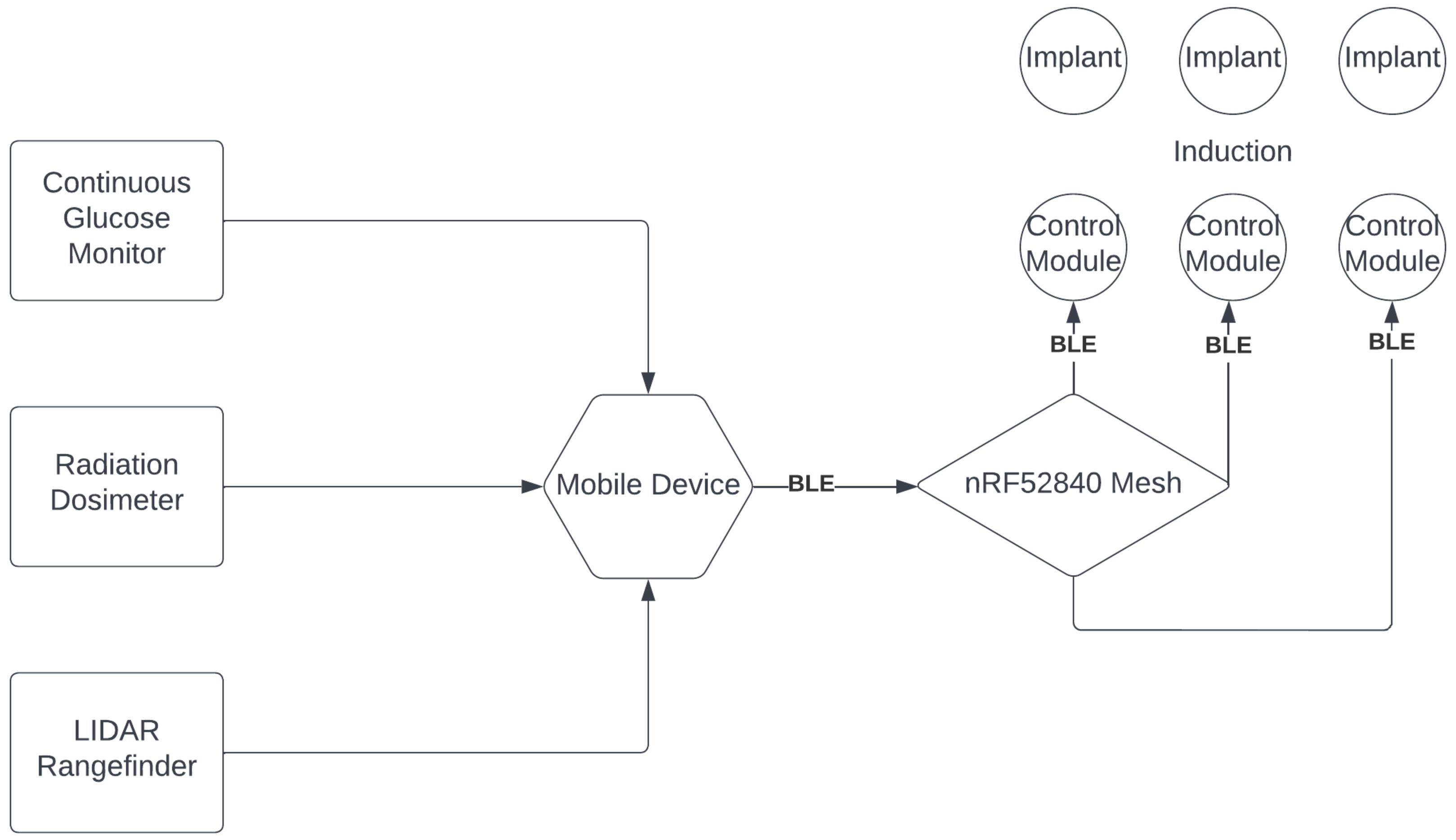

Figure 4: Block diagram of sensor and implant network

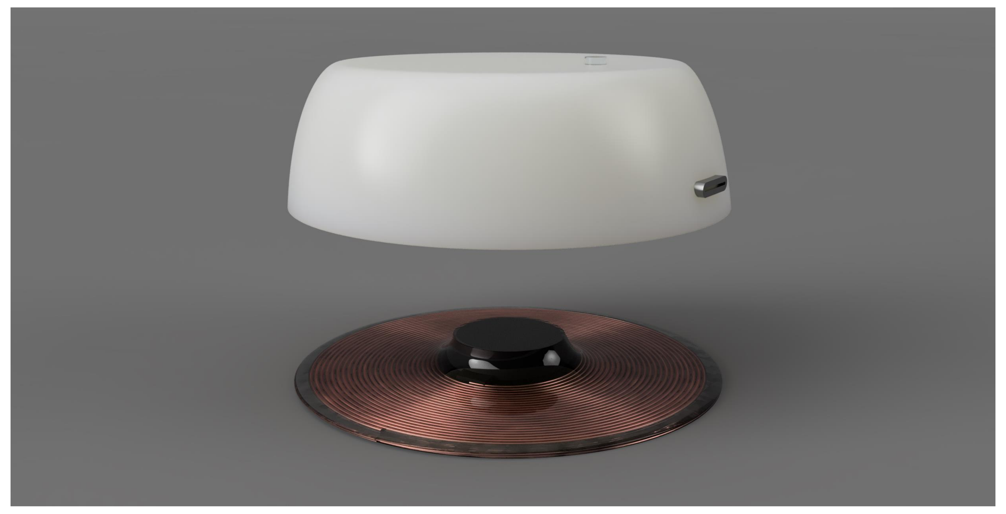

Figure 5: 3D model of proposed implanted package

POWER SUPPLY

- By using induction coils in the external and internal components of the design, it eliminates the need for batteries to be implanted
- This decreases cost, risk, and final implant size
- Future efforts will allow for a standardized external module, creating a common platform for additional internal components including biosensors
- The internal component, when not coupled with the external module is entirely passive
- This builds on work done using transdermal piercings to provide power and improves on this by reducing the risk of infection

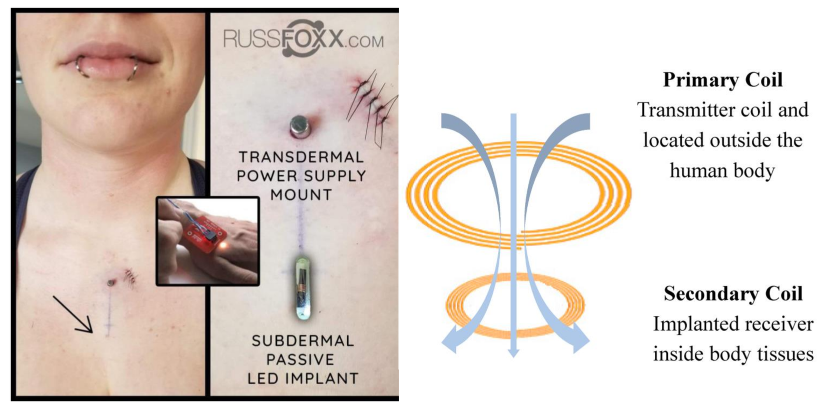

Figure 6: Previous efforts in transdermal power compared to inductive coupling

Figure 7: The Dexcom G6 CGM

- The external module will be paired with a continuous glucose monitor that communicates using Bluetooth
- This allows for a more closed loop system for users not without pumps as part of care efforts
- Vibration data will become integrated as a sense and users will be able to know their current glucose levels much like any other body sensation such as hunger or fatigue
- This can be done at the same time as other data is communicated such as phone alerts either using the same implant or with an additional unit
- Occupational hazards can be addressed similarly
- Efforts to allow for detection of hazardous gases through the same vibration-based communication can allow those with anosmia to detect hazards around them
- Radiation is also communicable by transferring the output from a digital dosimeter into vibrations allowing more granular monitoring

Figure 8: GQ GMC-500 Geiger Counter