Ese Bowry and Marissa Hsu

Development of a Wearable Intracranial Pressure Monitoring Device

Plan Proposal

3/1/2022

Overview

This project will work on the creation of a wireless, wearable intracranial pressure (ICP) monitoring device for monitoring of pressure inside the skull to aid physicians to continuously analyze a connected patient's pressure levels. This is a proof-of-concept (POC) based project where our central goals are comprised of

1. Prototyping a wearable monitoring device that can be embedded in a cranial implant for measuring a patient's intracranial pressure
2. Transferring the data to a remote PC/smartphone via Bluetooth/wifi
3. Live-tracking and feedback analysis

Ese Bowry (ebowry1@jhu.edu) and Marissa Hsu (mhsu17@jhu.edu) will be working as a team on this project with the guidance and aid of mentor Joshua Liu (jsliu@jhu.edu).

Widely used ICP monitoring methods are usually characterized by the placement of a catheter into the brain that monitors the patient for a limited period after a patient has encountered a severe head injury. Current ICP devices have worked to create a more compact design consisting of an implantable sensor and monitor that can aid in longer term ICP measurements. Our team plans to extend these current ICP devices by integrating a sensor that can be inserted into a 3D printed implant with an iOS application in order to wirelessly track data about the intracranial pressure. Our project will be guided as a proof-of-concept project but with the intention to create a device that is not only user-friendly but will also advance ICP telemedicine techniques.

Technical Approach

Since this project is in its proof-of-concept phase, we will be focusing on determining whether this idea of a wireless ICP monitoring device is feasible and will function as proposed. Our approach consists of two components: the implantable ICP device and the data interface.

Implantable ICP Device:

We will begin our POC testing by working with the FLORA Wearable Electronic Platform as the sensor device. We will perform initial testing using a wired connection to transmit data from the sensor to a connected PC. We will simulate controlled pressure movements by developing a controlled pressure reading device so that we can test our FLORA device with controlled pressures to monitor if data readings are as expected. After confirming the state of our sensor device, we will begin work with wireless connections, such as a Bluetooth transmitter. If we are able to develop a fully working wireless sensor device, we will plan to move on to testing in more variable settings.

Data Interface:

While working with the hardware components of this project, we will simultaneously be working on an iOS application that will receive data from the sensor and output the data in a readable format. Here we will focus on the graphical representation of the pressure readings as well as initiating components to support live data collection and displaying. After creating a working iOS app that can successfully receive and display data, we will move towards data analysis capabilities. For example, high or low-pressure readings, with respect to given threshold values, will be flagged and displayed on the iOS app to indicate concerning conditions to the user or physician.

Deliverables:

In order to achieve our goals, we have separated our goals into 3 categories (minimum, expected, and maximum). For our minimum goals, we plan to have a functional monitoring device using FLORA Wearable Electronic Platform and an iOS app for ICP monitoring. For our expected goals, we plan to work on the GUI, have specified pressure warnings pop up on the app, usability testing for UX/UI design, and documentation for the ICP monitoring process that we are designing. Our maximum goal is a submitted conference paper.

Key Dates:

- Preliminary Research on ICP/ Literature Review **due 2/25/2022: Ese Bowry and Marissa Hsu**

- Functional Monitoring Device **due 3/17/2022: Marissa Hsu**
- Functional IOS App **due 3/17/2022: Ese Bowry**
- Specified pressure warnings **due 4/5/2022: Ese Bowry**
- Usability testing **due 4/12/2022: Ese Bowry and Marissa Hsu**
- Creation of Fake Brain **due 4/12/2022: Ese Bowry and Marissa Hsu**
- Phantom Study **due 4/19/2022: Marissa Hsu**
- Submitted Conference Paper **due 5/5/2022: Ese Bowry and Marissa Hsu**

Deliverables:

Dependency	**Solution**	**Alternative**	**Expected Date**	**Status**	**Effect**
Obtaining Electronic Component	Purchasing FLORA Wearable Electronic Platform	Purchasing Bluefruit LE Module	2/21/2022	Completed	Unable to begin design of device
Data Transfer	Purchasing Bluetooth Transmitter	Purchasing Wifi Module	4/1/2022	Not Started	Wireless Transfer
3D Printer for Soft Materials	Molding	Fake Brain with Tissue Matter	4/12/2022	Not Started	Full Testing
Testing Environment	Fully Functional Device and App	Minimally Functional Device+App	3/17/2022	Not Started	Usability Testing and Improvements

Management Plan

Our team meets with our mentor every Monday at 3:00 pm and meets to work on the project on Wednesdays. We hold additional meetings as necessary. We manage communication through email, code exchange through GitHub, and project documentation through a shared Google Drive and the CIS project Wiki.

Reading List

Mitchell, K. S., Anderson, W., Shay, T., Huang, J., Luciano, M., Suarez, J. I., Manson, P., Brem, H., & Gordon, C. R. (2020). First-In-Human Experience With Integration of Wireless Intracranial Pressure Monitoring Device Within a Customized Cranial Implant. *Operative neurosurgery (Hagerstown, Md.)*, *19*(3), 341–350. https://doi.org/10.1093/ons/opz431

Velazquez Sanchez, V.F., Al Dayri, G. & Tschan, C.A. Long-term telemetric intracranial pressure monitoring for diagnosis and therapy optimisation of idiopathic intracranial hypertension. *BMC Neurol* 21, 343 (2021). https://doi.org/10.1186/s12883-021-02349-8

Evensen, K. B., & Eide, P. K. (2020). Measuring intracranial pressure by invasive, less invasive or non-invasive means: limitations and avenues for improvement. *Fluids and barriers of the CNS*, *17*(1), 34. https://doi.org/10.1186/s12987-020-00195-3

Zaghloul, N. A. E. M. S., & Abdel-Rasoul, R. (2016, May). Application and Implementation of Wearable Sensor for Real-Time Activity Tracking. In *The Third International Conference on Computer Science, Computer Engineering, and Social Media (CSCESM2016)* (p. 63).

J, P. (2021, May 27). Intracranial Pressure Monitoring Device and its critical applications. Retrieved February 17, 2022, from https://www.researchdive.com/blog/intracranial-pressure-monitoring-device-and-its-critical-applications

Wilcher, D. (2017, January 17). Low Cost Platform Allows Prototyping Wearables with Ease. Retrieved February 17, 2022, from https://globalsmt.net/technology_news/low-cost-platform-allows-prototyping-wearables-ease/

Kwon, Y.S., Lee, Y.H., & Cho, J.M. (2016). Early Experience of Automated Intraventricular Type Intracranial Pressure Monitoring (LiquoGuard®) for Severe Traumatic Brain Injury Patients. *Korean Journal of Neurotrauma, 12*, 28 - 33. https://doi.org/10.13004/kjnt.2016.12.1.28