PIECE OF MIND – A REMOTE EEG MONITORING SYSTEM

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Project Summary

The prevalent role that electroencephalography (EEG) plays in characterizing, diagnosing, and studying neurological disorders is consistent by the medical and academic communities alike, owing to its accurate real-time monitoring of brain activity and relative low-cost. Other industries have leveraged the Internet of Things (IOT) technology to meet growing demands by which a lateral distribution of smart devices/sensors are enabled to report more data to an end-user than previously possible. This project employs a combination of these two ideas to obtain a telemetric medicine model in which a custom-built "smart headset" detects the wearer's EEG signal and wirelessly uploads the data to central repository. This system's Arduino-powered gateway enables the use of remote EEG monitoring. The simple design of the headset does not require the need of a trained technician or neurologist to apply gel electrodes, and the wireless technology allows data to transmitted if the gateway is connected to an internet network.

Problem and Need

Over 12% of total global deaths are attributed to neurological disorders and are projected to increase over the next 10 years [1]. Current challenges surround brain injuries like concussions, carrying symptoms that are very subtle and can be misdiagnosed with today's subjective question test [2]. Moreover, neurological disorders and injuries can require a time-intensive monitoring schedule needed to gather sufficient data. In neurological healthcare and academics, electroencephalography has been used to address financial concerns of cerebral monitoring as it is among the lower-cost neurological tests that monitors the electrical activity of the brain. Specifically, its measured voltage differences have been noted to be an accurate diagnosis or classification tool for some neurological disorders, like epilepsy; and, it may soon be an important role for detection the early stages of others. The need to leverage the power of IOT to continuously monitor EEG data from a low-cost EEG headset is pervasive in the solution's ability to deliver more sets of data at a lower cost.

Significance

It should be noted that this project does not attempt to diagnose any neurological disorders or injuries. However, the low-cost, telemetric monitoring system detailed in this project can be used as a proof-of-concept by the medical and academic communities alike. It can be furthered to study the system's efficacy for diagnosing specific neurological disorders. Else, the platform can be combined with other state of the art tools or software (e.g. machine learning) to develop new diagnosis protocols.

Goal

The overall goal of the project was to leverage IOT technology in combination with a custom built, low-cost "smart headset" to enable a wireless telemetric EEG system capable of continuously monitoring a patient's signals from the comfort of his or her own home.

Customer/User Analysis

The end user primarily envisioned was determined to be a neurologist using the platform as a cost-effective solution to collect large amounts of reliable data remotely. The headset was designed using ergonomically fitting casings, elastic headband material, and non-intrusive electrodes to optimize comfort while EEG testing is in progress. The wireless capability was implemented so the wearer could, in theory, allow data to be collected from comfort of one's work or while using the device for a sleep study at home.

Deliverables

The center of our system features an adjustable "smart-headset" capable of detecting a single channel EEG from its electrode and reference node. On either side of the headset is a 3-D casing, each of which hold the band to the adjusted size. One casing contains a printed circuit board (PCB) used to detect the signal, reduce the nose, and converting the amplified output to a digital encoding that is then sent via Bluetooth to the Arduino-controlled Gateway. The gateway is coded with a graphical user interface (GUI), allowing the user to connect to the network of their choice and entering the corresponding password. The gateway also communicates with wearer about battery time remaining and connectivity issues. While no issues arise, the gateway continuously forwards the data to a centralized website. The repository accepts the data transmitted data over Wi-Fi and calls upon embedded MATLAB scripts to display the EEG to the end-user.

Terminal Objective

To achieve the project's goal of remote EEG monitoring, the system needed to be broken down and built to satisfy its subcomponents requisites. A circuit was first tested to satisfy each of the signal detection, noise reduction, and amplification specifications. Bluetooth and Wi-Fi testing were performed to ensure there was no loss of data occurring on either the receiving or sending end for the Arduino module.

Overview Diagram

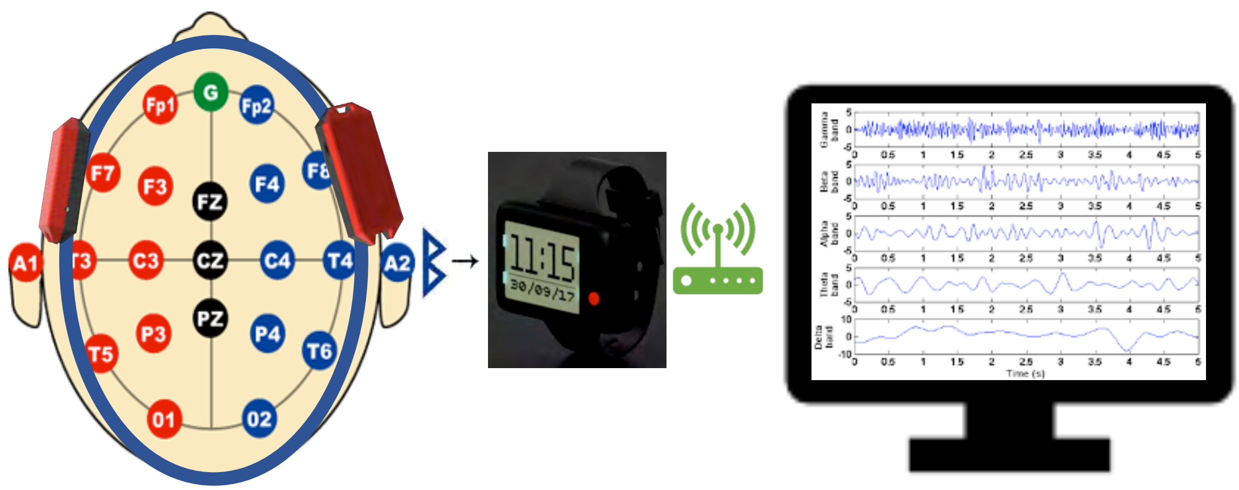

Fig. 1. An adjustable smart headset, outlined in blue, detects a wearer's EEG from an electrode located in range from Fp1 to Fp2 and a reference node located at A2. The PCB, enclosed in the 3-D printed casing on the right side of wearer's head, encodes a clean amplified signal outputted from its circuit via a 10-bit analog-to digital converter. The headset uses its HC-05 Bluetooth 2.0 module, also enclosed it casing, to send the converted digital data to the Arduino-powered watch, containing the receiving Bluetooth module. The watch forwards the signal over the user-designated wireless network to a centralized data repository site. On the website, an embedded MATLAB is embedded to continuously store the streaming data and allows the end-user to visualize general EEG patterns and waveforms.

References

[1] World Health Organization. "Neurological Disorders Public Health Challenges," pp. 33-35, 2015.
[2] Mez J. et al. "Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football," *JAMA*, 2017.