Electroencephalography (EEG) Minor Traumatic Brain Injury (mTBI) Detection Device

Agam Aulakh¹, Lisa Huang¹, Srishti Mathur¹, Mackenzie Morris¹, Christine Philip¹, Anastasiya Rybitska¹
Academic Advisor: Dr. Jay Carriere¹
¹Schulich School of Engineering, University of Calgary
²Garmin Canada

Project Purpose
Our team set out to create a portable, cost-effective, and accessible device capable of collecting an individual’s electroencephalography (EEG) data and providing information that can alert the individual of potential abnormal brain activity indicative of a minor traumatic brain injury (mTBI).

This device would be available for medical professionals in environments outside of a hospital, allowing for basic insight into a person’s brain activity.

Potential users:
- Sports team physicians
- Emergency medical professionals

Overall, our goal is to aid medical professionals in their decision-making by providing them with a cost-effective, accessible way to collect information regarding their patients’ brain health.

Hardware
The hardware component of our project is a custom, 4-layer Printed Circuit Board (PCB) with surface mount technology. The components include:
- A Texas Instruments ADS1299 chip, which is an 8-channel COTS AFE for denoising and amplifying EEG signals.
- A Nordic nRF534 MCU for handling signal processing and communication between components.
- Power management circuitry to regulate the voltage from 4xAA batteries, as well as a low battery sensing circuit.
- An LCD screen for displaying results.
- Status LEDs, a power switch, a buzzer, and control buttons.

We also designed and formally reviewed the schematics for an experimental custom AFE board, which can be explored in future work to further decrease the cost of the device. Table 1 depicts the cost breakdown of each option.

Our signal processing pipeline collects, cleans, and processes EEG data from the user. The algorithm focuses on computing the relative power of each EEG frequency band. The pipeline runs as follows:
- Raw EEG signals are collected via 8 electrodes placed on the user’s head according to the International 10-20 System as seen in Figure 5.
- Brain signals travel through copper-shielded cables, which reduce the 60Hz noise interference.
- The AFE amplifies and filters the analog signals at a sample rate of 250Hz
- For each epoch of data (every 2048 samples), the MCU:
  - Transforms the data from the time domain to the frequency domain
  - Computes the power spectral density (PSD) or periodogram of each electrode channel using the Welch method
  - Calculates relative band powers by averaging the Welch periodograms
- The LCD screen displays the relative power for each EEG frequency band

Outcome
These results will provide the user with information regarding their brain health. The data can be used by medical professionals to aid their decision-making and determine whether the patient needs further evaluation and treatment in a hospital. As it stands, our project can serve as a development platform in the future as it hosts a suite of sensors, has adequate memory for sophisticated algorithms, provides Bluetooth functionality, and can support professional use.