Electroencephalogram (EEG) Sensor and Subsequent Analysis System Optimization for Objective and Point-of-Care Concussion Diagnosis

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Concussion diagnostics rely heavily on subjective data and inconclusive tests resulting in undetected concussions. Undetected concussion lead to permanent brain damage if another concussion is sustained before recovery. This project optimized the electroencephalogram (EEG) sensor and subsequent analysis systems with seamless, in-helmet integration for practical (portable and inexpensive) and accurate concussion diagnosis in a point-of-care and objective manner. A capacitive electrode was designed to replace conventional, yet impractical wet electrodes. Bootstrapping techniques simulate expensive, ultra-high resistors; and guarding traces increase signal sensitivity. A silicone cap secures electrodes, preventing motion artefacts. Next, the signal is amplified and filtered using notch and bandpass filters – passing only alpha, beta, delta, and theta waves. Analog-to-digital conversion with a 16MHz sampling rate (adequate for brainwave sensing) occurs before transmission to the ATMega328 microcontroller, which analyzes the signal with a real-time fast Fourier transformation to derive brainwave power values. These values identify concussions when brainwave activity shifts from normal to concussive and wirelessly transmits diagnoses via a Bluetooth module. Printed circuit boards were designed and assembled to decrease cost (<$75) and size (comparable to marketed in-helmets attachments). Sensor validity and electrode accuracy was verified using event related potentials with accuracy also maintained during movement as tested by the experimenter. This practical and accurate concussion diagnostic tool will lower the risk of permanent brain damage by mitigating undetected concussions, and should, therefore, be implemented into athletic and military helmets.

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