

Senior Design I

Technical Review Paper

Over a million cases a year of mild Traumatic Brain Injury (mTBI) occur in just the United States where symptoms can be life long which can occur from high contact sports and the military. However, mTBI is hard to detect as most concussion protocols are about verbal and visual cues which can be falsified.

Our proposed Senior Design Capstone project is based on utilizing an electroencephalogram (EEG) to track and determine the electrical activity of one's brain and to implement it inside a sports helmet to look at brain waves and determine if the sports player has a concussion by looking at the brain waves provided by the EEG. The brain waves will provide a quantifiable result to let people determine if the sports player can continue playing or if the person should be held to the bench to decrease the percentage of a concussion. EEG typically look at brain waves through frequencies and an uptick in amplitude would by an undetermined margin could determine if the person has a concussion or mTBI. The technology that will be looked at in this technical review paper will be looking at the factors that need to be considered looking at which EEG is optimal, specifically how different types of EEGs, along with their electrodes, can be used for recreational use and determine what factors we would need to consider in terms of hardware such as power, feasibility and effectiveness.

EEG has an extensive background in bio-signals as it's cheaper than a functional magnetic resonance imaging hardware and has a powerful noninvasive method to look at brain activities. "Wet" EEG electrodes, where the electrodes are on the skin and need a direct application with a water-based gel, are the most popular choice of EEG to provide brain waves especially in scientific studies due to it being the first prominent stable EEG. However, a "wet" EEG would not be applicable for recreational use in sports but there does exist "dry" EEGs where there would be pins to connect with one's hair which creates a noninvasive method to read brain waves and has been shown to be able to detect seizures and epilepsy [1]. "Dry" EEGs have been shown to be an effective, rapid, accurate assessment at point of care for mTBI [2]. In order to determine if "dry" EEGs can be utilized in real time, a lot of factors are needed to be used in sports and in the military over a long period of time.

Since the EEG will be utilized over a long period of time, energy is a main concern to maximize the longevity of the EEG if possible. Connected to the antenna of the EEG, the most energy-drawing part of the EEG is the electrode to record modulations of the brain waves. There are many different architects

of an EEG with electrodes, however one method to create a low-powered EEG electrode is to have electrode surfaces connected to each other in successive manner with an amplifier along with an antenna and an individual battery for each electrode as only 3.3 volts was needed to supply it where the electrodes were a size of a coin [3] Other than the electrodes, the main power absorber is considered to be the System of Chip attached to the EEG's electrodes and there are many multiple systems to be considered [4].

It has been stated that a typical “dry” EEG, specifically the electrodes, as spiky which is non-ideal for recreational use, especially in high acceleration as it could create discomfort or puncture the skull. However, most EEG electrodes are rigid. Other types of polymers should be considered for the dry electrode could also be a thin-film metal embedded in the elastomer. Many other materials have been looked at to determine if different materials would affect the electrode sensitivity and ability to read brain waves from hair molecules along with comfortability as dry stretchable electrodes were able to measure relatively well in comparison to wet electrodes.

One material that has been looked at for electrode materials are silver-coated silica and silver flakes as a flexible silicone-based dry sensor. These electrodes of silver-coated silica had several uses and the conductivity of these sensors were reduced as holes appeared on the surface which would lead to poor electrical contact and reduced conductivity while the silver flakes were as stable as industry standard “wet” electrodes. These materials although show low impedance over the course of 7 days with repeated uses. However, salt influences typical electrodes' impedance with an exponential rise after 3 days, however silver flakes' impedance was shown to be constant over the course of a week. Overall, silver flake “dry” EEG sensors were found to be substitutes for “wet” EEG with looking at repeated uses and the effects of salt [5]. Another “dry” electrode was made as a flexible and wearable technology based on polydimethylsiloxane with similar contact impedance with the industry standard “wet” EEG as the material has low resistivity and high thermal stability. It also showcases similar phases from the contact impedance which shows that the overall output should be like a typical “wet” EEG. Overall, these “dry” electrodes were also shown to provide on par or more precise results compared to the standard “wet”. The “dry” electrodes have shown similar results also in received SNR, however high motion may cause inaccuracies [6]. Another approach was a dry electrode with electrically conductive polymer foam covered by a conductive fabric which allows for comfortability and keeps the electrode impedance low, especially under motion [3]. In conclusion, there has been many different types of EEGs and the dry EEGs have been shown to be a route for recreational use but different types of materials should be looked at further down the line to determine the tradeoffs between flexibility, comfortability and accuracy and precision of reading brain waves to determine which EEG would best fit inside of a sports player helmets.

Power, flexibility and effectiveness have all been considered for “dry” EEGs, especially if it’s used for a long time in high contact, and need to be considered in the Senior Design project on how it will effect electrically and connect to the embedded system to accurately measure the brain waves in high contact sports. Overall, it has been shown that flexibility of some “dry” EEG electrodes do not affect the accuracy and precision of EEGs and the power drawn from the electrode are not as big of a factor compared to the embedded system. However, there are a lot more factors that need to be considered for all possible “dry” EEGs such as salinity, compression, and longevity. These tests need to be streamlined to determine the optimal EEG flexible sensor for the most accurate reading along with drawing the lowest power.

References

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