COMP4801
Final Year Project
Project Plan

Brain-Computer Interface System

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Project Background

The technological era has led to various developments in the mode of interaction with machines, be it through touch in smartphones, voice in home assistants such as Alexa or biometrics in fingerprint scanners. This developments seemed nothing more than science fiction a few decades ago, and an interface linking thought to action seems like nothing less. However, Brain-Computer Interfaces (BCIs) are very real, with a variety of application not only in medicine but also mainstream entertainment such as video games.

This system however, is not without limitations. The accuracy of this system is sometimes questionable and hence requires an invasive approach of attaching the electrodes to the brain on many occasions. Moreover, a number of challenges arise while trying to classify these signals to perform a particular task, in terms of accuracy and responsiveness. Nonetheless, recent developments have led to EEG-based brainwave monitoring devices which do not require invasive techniques and are readily available for distribution as well.

The project aims to take advantage of these readily available headsets and create a Brain-Computer Interface that is accurate in its domain. Current systems making use of such technology do exist, however they do face issues in terms of classification accuracy. We plan to use tools such as Machine Learning to aid the mechanism of classification and employ statistical methods to extract the most useful information out of the produced signals. The project will also help us gauge the practically of building such systems with lower resource utilities (such as a 4 channel EEG headset). Moreover, we believe that the use of such technology is rather rare at a university level, and we want to enhance the ubiquity and awareness about such devices to promote further interest and development in this field.

A system such as this could aid disabled users in communication, providing an alternative to auditory or written communication. It could able people with muscular or neurological disorders to use computers with ease. If successful the project could have an impact not only on the lives of disabled users, but also help speed up the delivery of information to such an extent that the gap between thought and action is nullified.

Project Objectives

- To create a feasible system of interaction which translates thought to command to perform an action, with available resources.
- Develop an application that utilizes this system to demonstrate the power of brain-computer interfaces in real time.
- Employ recent developments in data science to improve the feature extraction and classification of signals obtained from the hardware.
- Design a product that could perhaps be modified to suit commercial use.
- Promote literacy about BCI systems and promote research and discussion about this technology at a university level.
- To ensure the system is non invasive and safe for use by the common population.

Project Methodology

1. **Signal Extraction Using EEG Headsets:**
   We aim to make use of the 4-channel OpenBCI EEG headset "Ganglion" to begin our signal extraction and prototyping. The first phase comprises of identifying whether the board can read brain waves to a certain degree of accuracy and attempt to derive meaningful information from the signals. If we find that the 4-channel board is not powerful enough for the purposes of the project then the team will consider investing in the 8-channel board, "Cyton". In addition, the raw signals produced by our brains may not be aligned well with the goal or task to be performed. In order to train our brains to produce the "right" signals, we would like to make use of the Emotiv headset to help us focus and align our thoughts in the right direction.

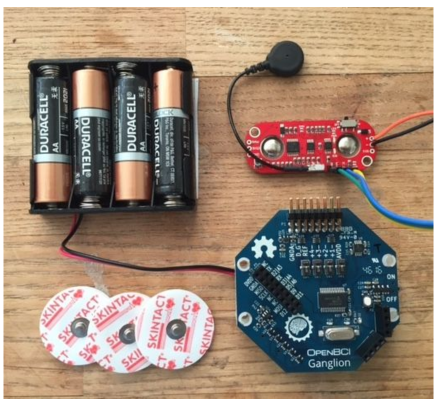

Fig 1: The OpenBCI Ganglion

Fig 2: The Emotiv Headset

2. **Data Preprocessing and Feature Extraction**
   This step is crucial in being able to operate an interface accurately. The signals obtained from the device are suspected to contain a large amount of noise and interference from various external and internal sources such as muscle movement. It is hence essential to process this signal data in order to extract meaningful data that can be used to map the thoughts to desired commands. We plan to port the signal data from the OpenBCI GUI into a more workable format and employee statistical techniques to extract relevant features from the same.

3. **Feature Classification**
   This phase involves using machine learning models and techniques to perform the classification of the signals, i.e map the signals to desired commands. This is also the

stage for feedback and improvements since our model accuracy depends on a range of factors originating from phases 1 and 2. We hope to create a classifier or engine which will be able to map the obtained signals to commands within our application domain.

4. **Application Layer**

Finally, we plan to connect our brain-computer interface engine to an application in order to demonstrate the system in real time. This would involve creating a simple application that would receive the signal input and perform the corresponding task displaying it as an output to the user. This phase would involve user testing to improve on the application as well as the training models. The diagram below summarizes the project lifecycle.

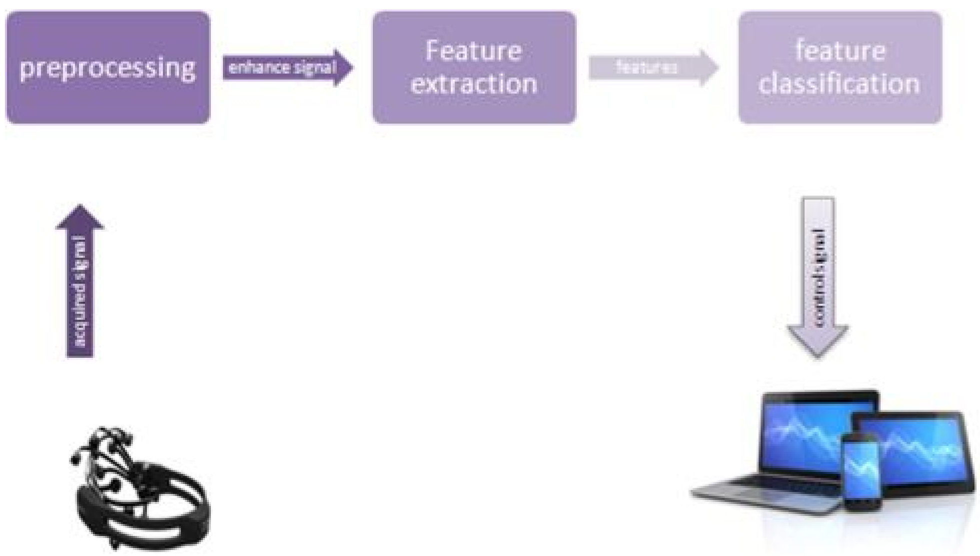

Fig 3: Project Methodology. Retrieved from https://ars.els-cdn.com/content/image/1-s2.0-S1110866515000237-gr3.jpg

Project Schedule and Milestones

October

- Literature Review
- Setting up device
- Signal Extraction (and ensuring brain signals can be obtained)
- Work on porting the data to workable form (using python or js)

November

- Attempt at using the Emotiv headset to train ourselves to produce better readings
- Decide on the application of the BCI system
- Start working with the signal data produced

December

- Continue working on feature extraction and signal processing
- Start identifying prospective machine learning models for classification

January

- Work on the application to demonstrate the BCI system
- Training classification models
- First round of user testing and feedback (including training users in signal production)

February

- Incorporate user feedback
- Continue working on application and training models
- Second round of user testing (inviting the same users as in Round 1)

March - April

- Resolve any issues and realign project accordingly
- Finalize application

References

Brain computer interfacing: Applications and challenges. (2015, July 06). Retrieved from https://www.sciencedirect.com/science/article/pii/S1110866515000237

Classification of EEG Signals in a Brain-Computer ... (n.d.). Retrieved from https://www.researchgate.net/file.PostFileLoader.html?id=56b9cf577eddd3a57d8b461b&assetKey=AS:327182586007553@1455017815785