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HKU Computer Science Final Year Project
Project Plan

Brain Computer Interface

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Overview

Brain-Computer Interface (BCI) is the concept that involves building a direct communication pathway between computer and human brain.
Brain activity is usually measured by an ElectroEncephaloGraphy(EEG) device. It is a physiological method for recording electrical activities of the brain with the help of electrodes.
This technology can be useful to people with motor disabilities and can also be applied to non-medical fields, such as gaming.
In this project, we will develop a simple computer game that can be controlled by mere human thoughts.

Project Background

History:

Various forms of BCI have been widely used to monitor human brain signals. These devices can be attached to our heads externally or implanted into our brain tissues.
Most BCIs available nowadays are used for medical purposes. Audio signals are translated into electrical pulses and are sent to human brain directly. Mind-controlled robotic limbs are developed to replace paralysed human limbs to improve patients' lives.

Trend:

Nowadays, the business sector and academia are paying attention to BCI more than ever. Elon Musk, founder of SpaceX and Tesla, invested 20 million on his new BCI company called Neuralink. It aims to develop a BCI that enhances the communication of human beings with the help of AI. Another Tech Giant Facebook also revealed similar projects regarding this technology.
As a matter of fact, electronic gaming, or eSports, are gaining much momentum in recent years, with VRs and ARs being the rising star. BCI games could bring a profound impact on the gaming industry in the near future, especially when paired with VR and AR.

Research Progress:

Researchers have made tremendous progress on BCI technology. One example is Brain-to-speech technology, which detects user's brain activities and convert them into speech. BCI is also particularly helpful for patients suffering from aphasia, an illness that causes difficulty in understanding and forming language after a stroke.
Scientists have also worked on gaming applications of BCI. Studies have introduced several BCI-implemented games, ranging from simple games like Pacman and Tetris, to complex ones like World of Warcraft(WoW).

Objectives

1. **To measure the brain activities:**

   To accurately measure brain activities of our test subjects using non-intrusive hardware. Precisely, we hope to find out:

   a. Which EEG device is most affordable while offering promising results
   b. How to optimize the measurement
   c. The origins of different electrical signals produced by the brain under different stimulations

2. **To analyse and understand the data:**

   After acquiring the raw data, analysis will be done with machine learning techniques. We hope to achieve the following targets in this project:

   a. Accurate classification of different thought patterns
   b. Real time processing of brain activities that is fast enough to make possible an interactive application

3. **To build an application using the analysis result:**

   The game is expected to take the result from the aforementioned analysis as game commands. In other words, different game commands will be formed by the classification of different brain activities i.e. interpreted “thoughts”.

Methodology

1. Test and obtain the right equipment and software

There are existing BCI equipment and software at HKU. We will first get familiar with these tools, and decide if these tools are suitable for our project. If necessary, we will purchase new BCI tools and run different trials so that we know how to make the best use out of them.

2. Collect brain data with experiment subjects

We will get approval from HKU before collecting any data from our test subjects.
Simple instructions will be given to our subjects, such as blinking and moving their eyebrows or limbs. Brain activities produced by these movements will be recorded and stored during the process.
They will also be asked to perform more complex actions such as imagining certain images, colours or concepts for further studies.

3. Analyse brain signals with Machine Learning

After preprocessing the data, a machine learning model will be built and fitted with the training data.
The model will then be trained and fine tuned repeatedly until a satisfactory result is obtained from the test set.
This model with help detect patterns and classify raw data into different categories of

thoughts.

4. Real-time classification of brain signals

In order to build a BCI game, the classification of brain signals should be performed in real-time. If it is accurate and fast enough, more refined and complex instructions can be carried out in the game. For example, the game character will be able to move and jump in specific directions as desired.

5. Build a simple BCI game model

Lastly, we will take reference from other suitable BCI game models and build a game with Unity.

Project Schedule & Milestones

1. September
    a. Meet with supervisor for brief ideas
    b. Conduct research on the device and past researches
    c. Submit detailed project plan and project website (29 Sep)
2. October
    a. Explore the EEG device in HKU (First to the second week)
    b. Choose and purchase a new EEG device if necessary (Second to the third week)
    c. Literature review (Whole month)
3. November
    a. Receive the device and experiment with its capabilities (First to the second week)
    b. Acquire data for analysis (Second to the third week)
    c. Design and prototype the machine learning model according to the data (Forth week)
4. December
    a. Preprocess the data for the model (Whole month)
    b. Build and train the machine learning model (Whole month)
5. January
    a. First presentation (13-17 Jan)
        i. Literature review
        ii. Experiments carried out on the equipment
        iii. Early analysis result
    b. Preliminary implementation (Whole month)

i. Real time classification model
ii. Comparison of real time classification and non-real time classification

6. February
    a. Preliminary implementation ready (Start of Feb)
    b. Interim report (2 Feb)
    c. Refine and enhance the real-time implementation
        i. Stability
        ii. Accuracy
    d. Design and build a simple BCI game model
7. March
    a. Incorporate EEG equipment with real time analysis (First week)
    b. Incorporate analyzer with the game model (Second week)
    c. Experiment on real-person test subject (Last week)
8. April
    a. Fine-tune and consolidate information gathered
    b. Final report (19 April)
        - Finalize tested implementation
    c. Final presentation (20-24 April)
        i. Summary of the project
9. May and June
    a. Project exhibition (5 May)