Self-Regulation of Alpha Waves as Difficulty Control Using Open-BCI

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# ABSTRACT

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## Keywords

Brain-Computer Interface, Gaming, Self-Regulation, Alpha waves

# INTRODUCTION

Our Brain Computer Interface (BCI) informed game relies on self-regulation of alpha waves to inform a game-wide experience. Using the high stress nature gaming induces allows us to exercise the users brain by encouraging them to relax and gain control of their brain waves. As the user regulates their brain activity the game will become easier, while unregulated sporadic brain activity will make the game more challenging. Employing techniques to smooth electroencephalogram (EEG) data such as sliding averages will allow the game to maintain a sense of responsiveness while not reacting to large changes too quickly in order to avoid jarring effects of a rapidly changing in game environment. Though this project focuses on gaming the model is easily transferred to a direct brain training exercise. Using a score metric for how often the player was able to maintain the desired state allows the users to attempt to improve on subsequent runs of the application. This is in addition to an overall score such as the amount of time to complete a task or number of tasks completed within an allotted time.

# Related Works

Research has been done into BCI for Games which finds that one of the advantages is early adoption.[1] This is desirable for our project as it shows that though other types of applications may solve more critical problems, a gaming application is more likely generate interest and be tested by others. Due to the ability to generalize the tasks we ask the user to do in our game, this allows our work to then be applied to more critical areas of research.

Our application does not employ the use of motor imagery for control, however research into continuous control using motor imagery still gives us insights into real time control systems using BCI.[2] The processing of the real time system in their paper employs multiple steps of different neural networks to converge on a final control to be sent to the game. Most important to our work is the use of predictive models as we likely won't design new neural networks for our application. Using predicted values could help us smoothly transition a game-wide variable towards its next value with less bounce back.

Other work has been done on modifying current popular titles to use BCI and finding the best way for a user to interact with the game for long periods of time.[3] Of particular interest to us is how actions were decided. Using a normalized range of frequencies, they then used one standard deviation in either direction as threshold values for when an action should take effect. This control scheme can help inform our game on how to use thresholds to avoid jarring and sudden changes. In Addition, one of the primary results of the paper was that BCI did not have an adverse effect on how long an individual would want to play a game which could be a concern when having to wear a headset.

To build upon this previous research we intend on incorporating design elements from the various papers. To ensure that our application is giving good real time interaction results we will use a predictive algorithm as was used in EEG-based continuous control of a game using a 3 channel motor imagery BCI [2]. Our application will build on the ideas by simplifying the predictive algorithm to be used for broader state variables rather than precise motor controls. We will build upon BCI for Games by exploiting the popularity of gaming that it found to market a brain training exercise as a game first and foremost. Experiencing BCI Control in a Popular Game [3] will be built upon by modifying the models for selecting an action based on input described in the paper to fit our own games control schematics.

# Approach

We plan on following a scrum-like procedure for this project which will mean going through multiple iterations in the coming weeks to ensure maximum functionality for the application. Although the implementation of all BCI applications can be complex, the underlying idea behind the project is a relatively simple one and should be able to fully implement the project with 3 sprints with significant benchmarks at each one, the third being the final finished product. In term of the software and API's we will use to code the project, we initially wanted to use Unity because it's very conducive to gaming environments but using it in collaboration with OpenBCI showed problems initially. Depending on initial tries at the basic coding involved we might have to switch to JavaScript, which people have had success with in the past. In terms of our team's collaborative approach, we plan to split up beginning responsibilities between the graphic interface engineering and the mathematical translation of the EEG data to the corresponding speed/difficulty of the game. The graphic interface will represent much of the work involved to make the application functional but the translation of EEG data will be critical to actual use of the application. Optimizing moving averages and handling volatile maximums and minimums will be important to gameplay and will likely take just as much, if not more time than the graphic interface to fine-tune. Balancing these the pillars through the sprints/iterations we be critical for being able to accurately test the application moving forward and is why collaboration will be a key role in this project.

# timeline

This project will take us about four weeks to complete. The first goal we plan to tackle is to identify the proper EEG data acquisition method. After this we will focus on filtering the acquired data into meaningful metrics through mathematical analysis. At this point, we will also begin to design the user interface using Unity. Finally, we will integrate the metrics derived from the EEG data into the gaming UI, such that the game adjusts difficulty level in response to real-time input from users’ level of self-regulation.

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# intellectual merit

Traditional BCI game applications use EEG as another communication device similar to a mouse or keyboard. Many EEG applications for business focus around the long term state of the brain. Our project targets the intersection of these two system types by using short term brain state as the trigger and game effects as the feedback. This specialized type of system can act as a training platform for your brain while still being enjoyable for the user.

# broader impacts

Our game focuses on self-regulation as opposed to direct control over a specific action allowing for a broader use of the system we designed. Though our game is made to be entertaining such that the player wants to take part voluntarily, it can also be used for training. The extensibility of our project comes from the generic design rather than the specific implementation built. A more direct version of training could be built by encouraging the user to regulate only at specific times rather than having regulation result in a positive effect regardless of the scenario. This would help to ensure they are actually regulating when they mean to. This could be continued until training results in their ability to reactively regulate to high stress situations. Given research that uses driving games as a way to measure frustration[4], the training could be tested by looking for a significant difference in their ability to regulate during the addition of the element intended to frustrate the user.

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