Controlling Player Avatars in Game Worlds using Multi-Modal Input Systems

Final Year Project Proposal: Final Proposal

# Abstract

This proposal covers the beginning of an investigation into the usages of BCI and myoelectric technologies for video games. The result of which is to aid in the creation of a system that can decipher multi-modal bio-physical input data, streamed from a user through the use of electroencephalography (EEG), electromyography (EMG) and eye-tracking. On creation of this system two game demo’s will be created, both attempting different to test for different uses of these technologies, seeing how plausible it would be to expect them as mainstays in the video game industry.

# Introduction and Rationale

Since the inception of the video game industry, different interaction modalities have been explored to design new experiences for the player. Recent examples are virtual reality (VR) controllers, Nintendo Switch’s Labo Toy-Cons, and the Wii’s motion controls.

One field the industry has been progressively advancing in is Brain-Computer Interfaces (BCI). BCI (Liarokapis, 2015)and myoelectric (Kristoffersen, 2021) based gaming and have become an important tool for researchers looking to understand how the brain can be used to interact with computers and the development consumer prosthetics.

Much like the modalities that came before them, non-invasive electroencephalography (EEG) and electromyography (EMG) could become accessible for consumers. Playable games have already been developed, though mainly only for the purpose of research (Liao, 2015). However, with the continued development of these technologies, their use for entertainment could become more realistic, allowing them to become mainstays in the industry. For this reason, this project will concentrate on the exploration into the potential of these technologies in creating new ways to interact and control virtual worlds.

# Literature Review

The interactive nature and the real-time feedback video games provide has made their use in BCI research invaluable. Their ability to influence the player in ways other media is unable, has allowed for otherwise inaccessible research to be completed. Even in cases where the inclusion of a video game is not required, trials including them were shown to alleviate the boredom of participants, while not negatively impacting the success of the sessions (De Castro-Cros, 2020). Similar examples can be drawn from their use with EMG systems. EMG based games have been used in rehabilitation and the aiding of vulnerable people, having been able to rebuild and maintain healthier lifestyles by encouraging exercise and feelings of safety when moving (Jitaree, 2012). A recent trend in BCI and myoelectric technology research has begun to put the focus of player experiences and the game’s first, rather than using them just as tools (Marshall, 2013).

BCI’s in gaming, particularly EEG, has been shown to accommodate various methods of interaction with the game worlds. From controlling the difficulty of Tetris (Liarokapis, 2015) and the accuracy of a bow through meditating (Liao, 2012), to moving and shooting bullets from a spaceship using motor imagery (Ndulue, 2019). Though these games work, they are limited by the technology they are designed around: EEG has an exceptionally high temporal resolution due to its high sample rate, over 1024Hz depending on the system, while its spatial resolution is lacking, due to individual sensors averaging the voltage potential across a region of the brain rather than that of singular neurons (Jing, 2000); fMRIs on the other hand have a very low temporal resolution, 4hz, while their spatial resolution is incredibly high (Huotari, 2019). Even when comparing with the same technologies different systems can outperform one another, the sensor count and quality of conduction largely influences the usage of EEG. It’s also worth considering the satisfaction a player has when given a system. Due to the cumbersome nature of curtain EEG systems, player satisfaction may favour the less effective system (Liarokapis, 2014).

Another use of these technologies in the games industry could be inspired by the technology behind prosthetics. Though individually EEG (Bright, 2016) and EMG (Salem, 2013) have both been used to control prosthetics, the use of a multi-modal system has been demonstrated to give greater results than when used independently (McMullen, 2013). By taking the same approaches used to drive prosthetics and mapping them instead to avatar rigs (i.e. virtual limbs), the control of animated characters will be made possible (Kristoffersen, 2021).

# Aims and Objectives

## Aims:

* Understanding the interaction between multimodal input system in games.
* Reading in and combining physio- and neuro input modalities.
* Creation of an interactive gaming experience using said interaction modalities.

## Objectives:

This proposition puts forth the investigation of a singular multi-modal input system, covering: the reading of multi-modal input data, including EEG, EMG, and eye tracking devices; processing their input streams; translating the data using machine learning; and returning a meaningful output, to be used within a game.

To accomplish this, the investigation will continue with how video games are currently being used in bio-physical research. By the further examination of these techniques, the desire is to find a method for synchronously tracking streams across multiple devices, aiming to have access to all of data from these streams, each describing the same events but from the context of different modalities.

A system will then be developed to process this data, with the intention of inferring what the user is thinking. This will be done through researching and development of a machine learning solution. Following this a game will be built, using this system as the focus for player interaction.

## Player Avatar Control

Using motor imagery data recorded from the users imaging movements, eye-tracking data, and the EMG data from them trying to mimic the movements of an animated avatar, the intent will be to train the system to allow for the control of in game avatars.

## Adaptive Game Worlds

By measuring a user’s state of mind, the system could potentially allow for adaptive difficulty, changing how systems within the game are affect based on players stress or enjoyment.

# Methodology

Due to the project requiring the creation of a game demo and it’s the reliance on VR development, the game engine Unity 3D will be used. This is due to its inbuilt support for VR, ease of use and heavy documentation. This will mean most of the code will be written in C# or called using bindings for other languages. The aim will be to have the system run on a semi-portable VR device. Two headsets of interest have been chosen, the HTC Vive Pro Eye, and the Pico Neo Eye, both supporting built in eye tracking system and both also allow the option of including the different modalities of EEG and EMG.

There is also a need to read the data streams from each input-modality, to handle this the Lab Streaming Layer (LSL) will be used, due to its built-in time-synchronisation and networking features.

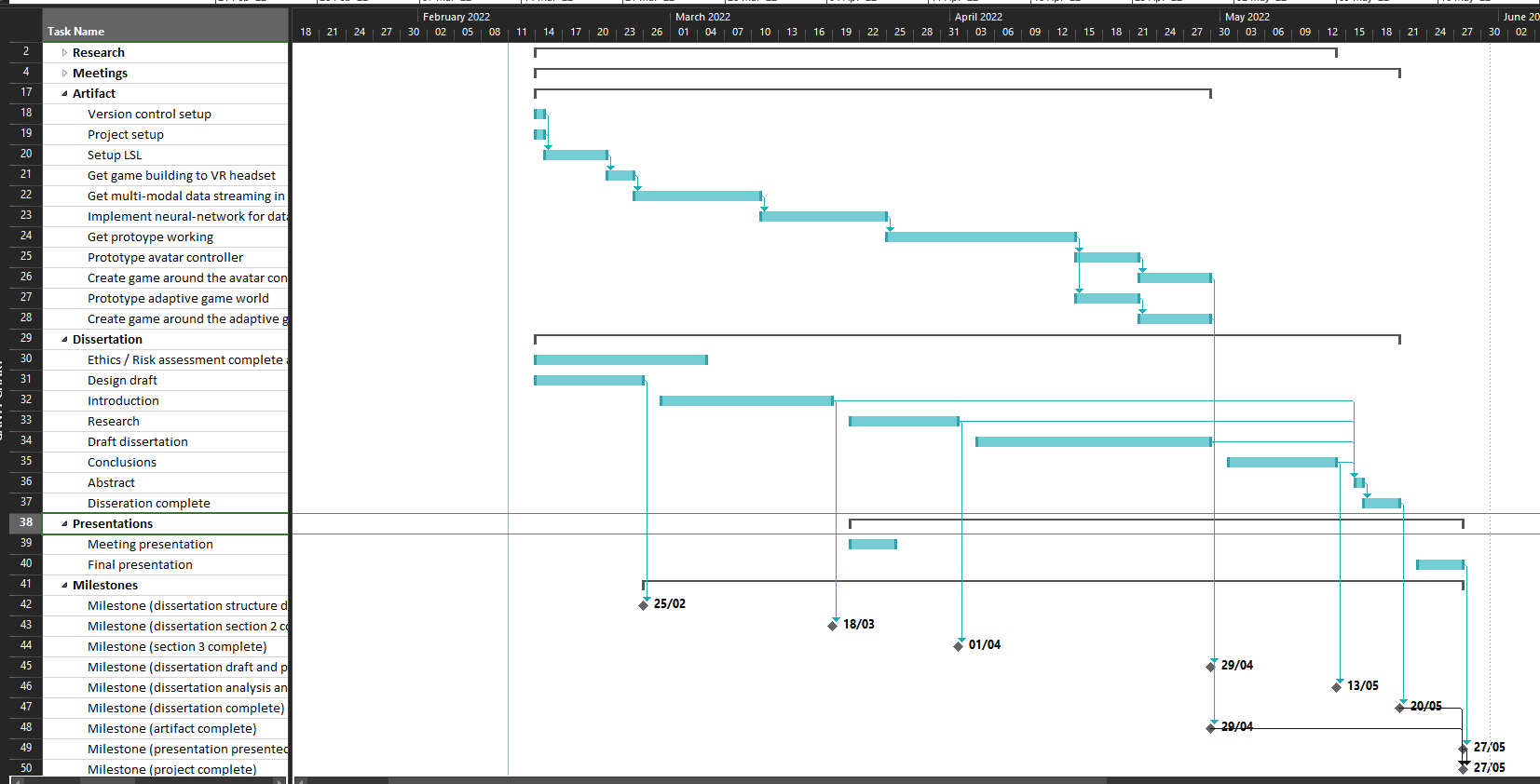
During the testing phases, a technician will be required to help the players into the equipment. When setting up the EEG, the participants head will need to be cleaned, measurements will then be taken of the skull, and the electrodes will be placed across there scalp. If using a wet EEG system, conductive gel will also be needed, this will be injected around the sensors using a blunt syringe boost the conduction. Each sensor will need to be connected into an amplifier, this will clean each signal of unwanted noise and convert the inputted signal from analogue to digital, from here they can then be passed in over an LSL stream and read into the program.

Setting up the EMG will require either the connection of emteqPRO to the Vive Pro Eye for facial EMG, or the attachment of EmotiBit sensors to the skin above the muscles of the participants. These sensors have in built amplifiers, so will be able to be read directly into an LSL stream.

For the system to be successful it will need to be able to translate its input data into viable outputs, for this machine learning will be required. Since Unity is programmed using C# the ML.Net framework can be used to train and process the data, or all processing can be left to LSL to train using OpenViBE.

The cleaning of these signals will need to be done to avoid external stimuli from influencing the recorded data, an example being the noise generated from powerlines, causing erroneous results. Following this, neural networks will be used for the analysis of the input data, these algorithms will be trained using motor imagery data generated from users imagining specified actions, and the myoelectric data resulting from performing movements. Using this, game prototypes demonstrating different mechanics will be developed. Each attempting to push the system to perform different tasks.

# Project Plan



## Structure Draft

The basic structure of the report will be designed, this will be what the dissertation will be structured from going forward.

## Introduction Complete

The introduction has been finished; this will introduce the topics discussed in this proposal.

## Research Complete

Marks the completion of the dissertations research section. Though I will be continuing to add to this throughout the report’s creation, this will be the point in which I can consider it somewhat finished.

## Dissertation Draft

The initial draft of the dissertation is complete, going forward will be clearing mistakes and polishing up the works foundations.

## Analysis Complete

The analysis of the artifact has been completed; conclusions gained from the results will be explained in detail.

## Dissertation Complete

The completion of the dissertation, the analysis of the results gained from the artifact have been completed and conclusions will have been made.

## Artifact Complete

The completion of the multi-modal input system, neural network translator and the game demos to go along side it.

## Presentation Complete

The presentation of the project has been completed.

# References:

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