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

Final Year Project Proposal: Final Proposal

# Abstract (150)

Summarise the document

# Introduction and Rationale (150: 158)

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 **[-------]** and myoelectric **[-------]** 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 [Gaming control using a wearable and wireless EEG-based brain-computer interface device with novel dry foam-based sensors**]**. 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 (300: 307)

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 [Effects of Gamification in BCI Functional Rehabilitation]. 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 [DESIGN OF EMG BIOFEEDBACK SYSTEM FOR LOWER-LIMB EXERCISES OF THE ELDERLY USING VIDEO GAMES]. 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. [Games, Gameplay, and BCI: The State of the Art].

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 [Examining User Experiences through a Multimodal BCI Puzzle Game] and the accuracy of a bow through meditating, [Gaming control using a wearable and wireless EEG-based brain-computer interface device with novel dry foam-based sensors] to moving and shooting bullets from a spaceship using motor imagery. [Driving Persuasive Games with Personal EEG Devices: Strengths and Weaknesses]. 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 [Low sampling rate induces high correlation dimension on electroencephalograms from healthy subjects]; fMRIs on the other hand have a very low temporal resolution, 4hz, while their spatial resolution is incredibly high [Sampling Rate Effects on Resting State fMRI Metrics]. 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. Its 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 [Comparing interaction techniques for serious games through brain–computer interfaces: A user perception evaluation study].

Another use of these technologies in the games industry could be inspired by the technology behind prosthetics. Though individually EEG [EEG-based brain controlled prosthetic arm] and EMG [The Development of Body-Powered Prosthetic Hand Controlled by EMG Signals Using DSP Processor with Virtual Prosthesis Implementation] 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 [Demonstration of a Semi-Autonomous Hybrid Brain–Machine Interface Using Human Intracranial EEG, Eye Tracking, and Computer Vision to Control a Robotic Upper Limb Prosthetic]. 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. [User training for machine learning controlled upper limb prostheses: a serious game approach].

# Aims and Objectives (300: 350)

Aims:

* Understanding multimodal interaction in the context of computer games
* How to potentially combine physio- and neuro- input modalities
* Generating an effective game experience for players to interact with

Objectives:

* Investigating EEG, EMG and eye-tracking technologies
* Generate ML solution to translate input data
* Evaluation of solution through user evaluation

This proposition puts forth the formation of a singular multi-modal system covering: the reading of multi-modal input data, including but not limited to EEG, EMG, and eye tracking devices; cleaning up these signals; translating the data using machine learning; and returning a meaningful output, to be used within a game.

To accomplish this, an exploration into how video games are currently being used in bio-physical research will be conducted. By examining these techniques and synchronously tracking all signals from across devices, the aim is to have access to multiple streams of data all describing the same events but from the context of different modalities.

The system will then be developed to process these data streams to allow for the calculation of a user’s intent. 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.

## 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 motion of in game avatar rigs.

## Adaptive Game Worlds

The final interaction that this system could potentially allow is adaptive difficulty, changing how the game plays based on player stress or enjoyment to affect the difficulty of game worlds.

# Methodology (300: 314)

The system proposed will be written in C#, inside of the game engine Unity 3D. The aim will be to have the system run on portable VR devices. Two headsets of interest include the HTC Vive Pro Eye, and the Pico Neo Eye, both supporting built in eye tracking system and allow the option of including the different modalities of EEG and EMG. To read these signals from each device, the use of 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.

# Project Plan (300)

## What’s the plan?

Work on other projects and get a feel for the technology, then in the process investigate ways of combining it and seeing what different output functions I can decipher from it.

# References:

1. Will add!!!