Proposal for Brain-Computer Interface (BCI) controlled racing competition

1 BCI System Overview
1.1 What is BCI?
Brain-computer interface (BCI) is a system that measures CNS activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output; it allows people to communicate directly with computers using their brain waves without physical action [1].

1.2 The purposes of designing a functional BCI
BCI can provide much utility. For instance, patients disabled by neuromuscular disorders, such as amyotrophic lateral sclerosis (ALS), can make use of BCI to control computers and electrical appliances to alleviate the restrictions imposed by their paralysis or even to restore motor function lost due to neuromuscular disorder [1].

2 Major Components and Mechanisms
2.1 Signal Acquisition
EEG conductive gel will be applied to decrease the impedance of the subject's head such that 32-64 AgCl electrodes embedded on the subject's head using the international 10-20 system can effectively collect post-synaptic signals from brain neurons [2].

2.2 Signal Processing
The EEG signal will be sampled at 256 Hz. Signals between 2-60 Hz will be isolated from the raw EEG data using a bandpass filter in combination with a notch filter between 45-55 Hz to weaken signal interference from the power source [3]. Independent Component Analysis (ICA) denoising will be implemented to remove unrelated signals, such as EMG.

2.3 Feature extraction
Activities within the desired μ-band (7.5-12.5 Hz) will be extracted for the BCI [4] by applying a bandpass filter on the processed EEG signal.

2.4 Device Output Command
The extracted signals are categorised using a tetraclass classification algorithm to determine the pilot's intent. A simple distance classifier can be used since we are only concerned with a small number of classes [5]. The corresponding input is piped to the game to generate the desirable outcome (idling/jumping/sliding/rotating).

3 Proposed Project Timeline

Week	Work Description
5	• Research EEG data pre-processing techniques and classification algorithms. • Have meetings with TAs to discuss the research findings.
6	• Finalise the pre-processing methods and procedures. • Collect eye-closed and eye-open EEG data and test the pre-processing methods.
7-8	• Design the classification algorithm using the data. • Test the algorithm and improve it.
9-12	• Design four tasks to collect data on four distinctive EEG patterns. • Design a tetraclass classification algorithm and improve it with testing. • Familiarise the pilot with the game through practice.
13-14	• Write up the final report.

Works Cited

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[3] M. Benda and I. Volosyak, "Peak Detection with Online Electroencephalography (EEG) Artifact Removal for Brain–Computer Interface (BCI) Purposes," *Brain Sciences,* vol. 9, no. 12, p. 347, 29 November 2019.

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