**EEG-Based Controller for Navigating a Virtual 3D Space**

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The idea of controlling objects in a 3D space using nothing but the mind has been fantasized by science fiction for decades. In addition to the unlimited potential of electroencephalogram(EEG)-based controllers in the medical field, these devices could be utilized in almost every industry. Applications include but are not limited to, neural cognitive prosthetics, operating robotics, and virtual realities such as the Metaverse.

Invasive EEG devices have been used in the past to allow monkeys to navigate 3-dimensional spaces. However, an invasive EEG comes with significant risks. Infections, and other damage to the subject’s brain are major problems associated with an invasive EEG, as well as the cost and complexity of creating a device capable of withstanding the environment within the scalp. For these reasons, a non-invasive approach is most practical and has greater potential to reach those who cannot afford expensive surgeries.

In the past, teams have achieved 3-dimensional navigation using non-invasive EEGs both in a virtual world and in the physical world. In these cases however, the object at hand had a constant forward velocity. This allowed users to be able to pay more attention to the direction of the object rather than its entire motion. For this project, we will give the user full control of the object’s movement.

The device we will deliver will utilize methodologies from electrical, mechanical, hardware and software engineering. The physical device will be a headset that have EEGs placed in specific locations around the user’s head. The location of these EEGs will be determined by where we can achieve the strongest readings for the targeted brain functions. From there, the information read by the EEGs will be passed into a machine learning algorithm that will determine the desired course of action from the user. Artifacts are signals read by the EEG that are not generated by the brain such as the user blinking their eyes. Precautions in the code will attempt to account for these artifacts and will be designed to limit the interruptions caused by said artifacts. Once an action is determined by the machine learning algorithm above a certain threshold of certainty, the 3D object will then perform the action desired by the user. The user will be able to watch the object move in real time on a screen, allowing for adjustments to be made. It will be crucial for the object to move in a continuous manner, rather than discrete robotic-like movements. Designing our code to accommodate for this will be one of the many challenges we will face moving forward. Nonetheless, this project will yield a cost-effective, technically efficient device capable of bringing science fiction into reality.

**Deliverables:**

* A headset containing a series of non-invasive EEG sensors that will:
  + Read neural activity from specific regions of the brain
  + Output data to a predictive algorithm
* An algorithm that:
  + Utilizes machine learning techniques to predict the users desired course of action.
  + Actions will include rotate clockwise, rotate counterclockwise, move up, move down, move forward, move backwards.
  + Each action will be associated with the user thinking about moving certain body parts in certain manners.
* Software to utilize information from the previous algorithm to control an object in a virtual 3D space.
* A virtual 3D space as well as a task for the user to complete (i.e. move object through a ring).

**Potential for improvement:**

* Allow control over a virtual human character in 3D space, rather than an inanimate object.
* Add capability of completing more complex tasks (i.e. walking, jumping, picking up items, etc.)
* Controlling a physical device like a drone.
* A program to improve the efficiency of the training process necessary to operate the device.

**Sources:**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3619112/#:~:text=Through%20EEG%20data%20acquisition%2C%20the,motor%20commands%20can%20be%20predicted>.

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