EEG-Based Dynamic Difficulty Adjustment

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The Premise:

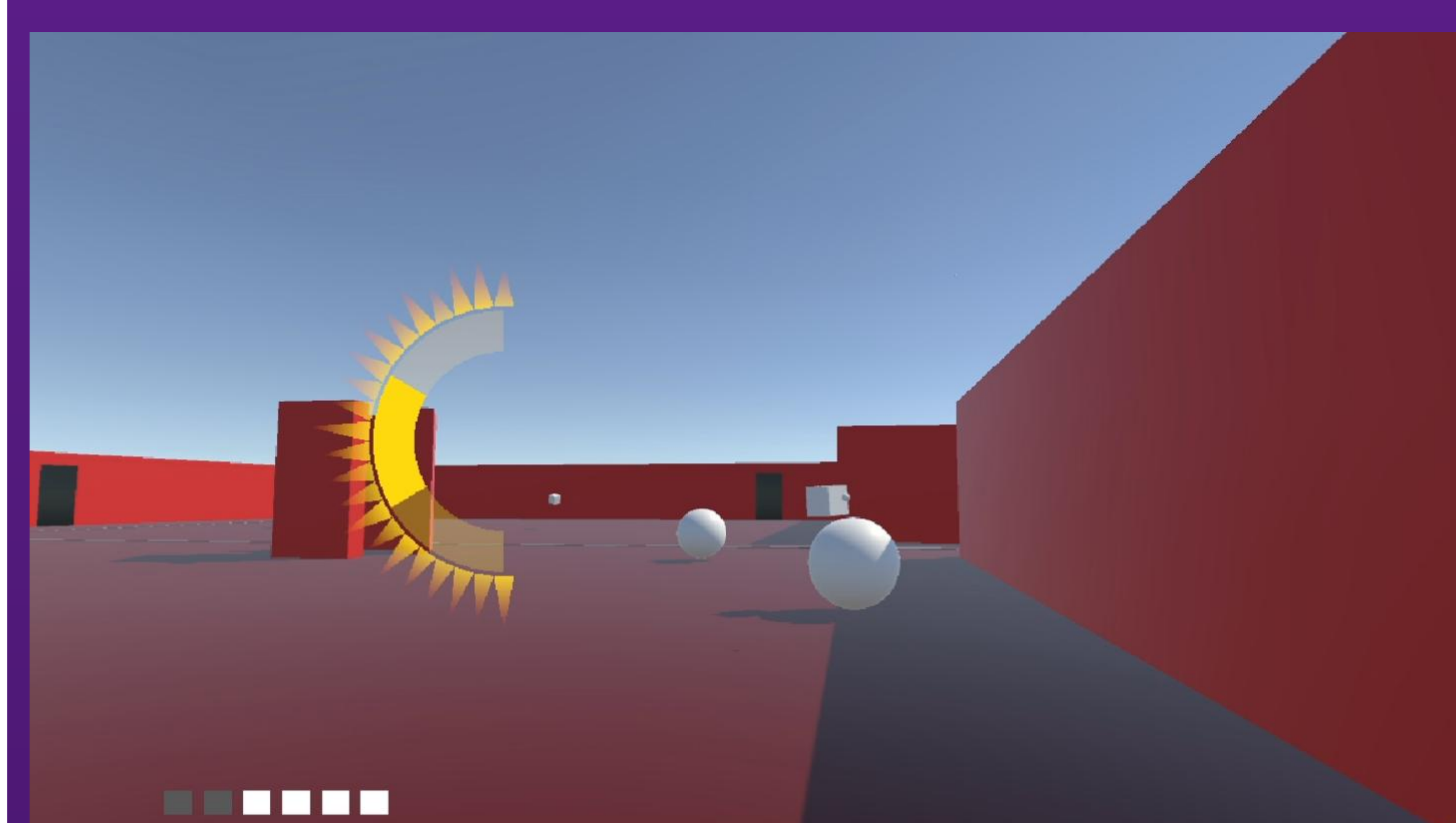
Sometimes, puzzles or games can feel too difficult. In other cases, they are far too easy. Either way, users end up feeling disengaged, bored, and frustrated.

This project explores how difficulty can dynamically adjust to tailor-fit the user, creating an engaging and immersive experience.

Methodology:

Before beginning development, I analyzed similar existing works. Given the EEG headset available to me (Emotiv Epoc X), I found that the most realistic approach would be to use decreasing beta/gamma waves and increasing alpha waves as an indicator that the user was losing focus.

Using Open Sound Control (OSC), I read this input into Unity as a single focus variable. Then, depending on smoothed and normalized focus readings over time, several parameters of the game would be changed dynamically.



The user in this example has been completing the puzzle elements of the game very easily. This has caused them to lose focus, so the game has added a stamina nerf. This makes it harder for the player to move around as quickly, meaning they must pay more attention to the enemies shooting at them.

Project Contact Information:

This was a remote project, done under the supervision of Dr. Myungin Lee:

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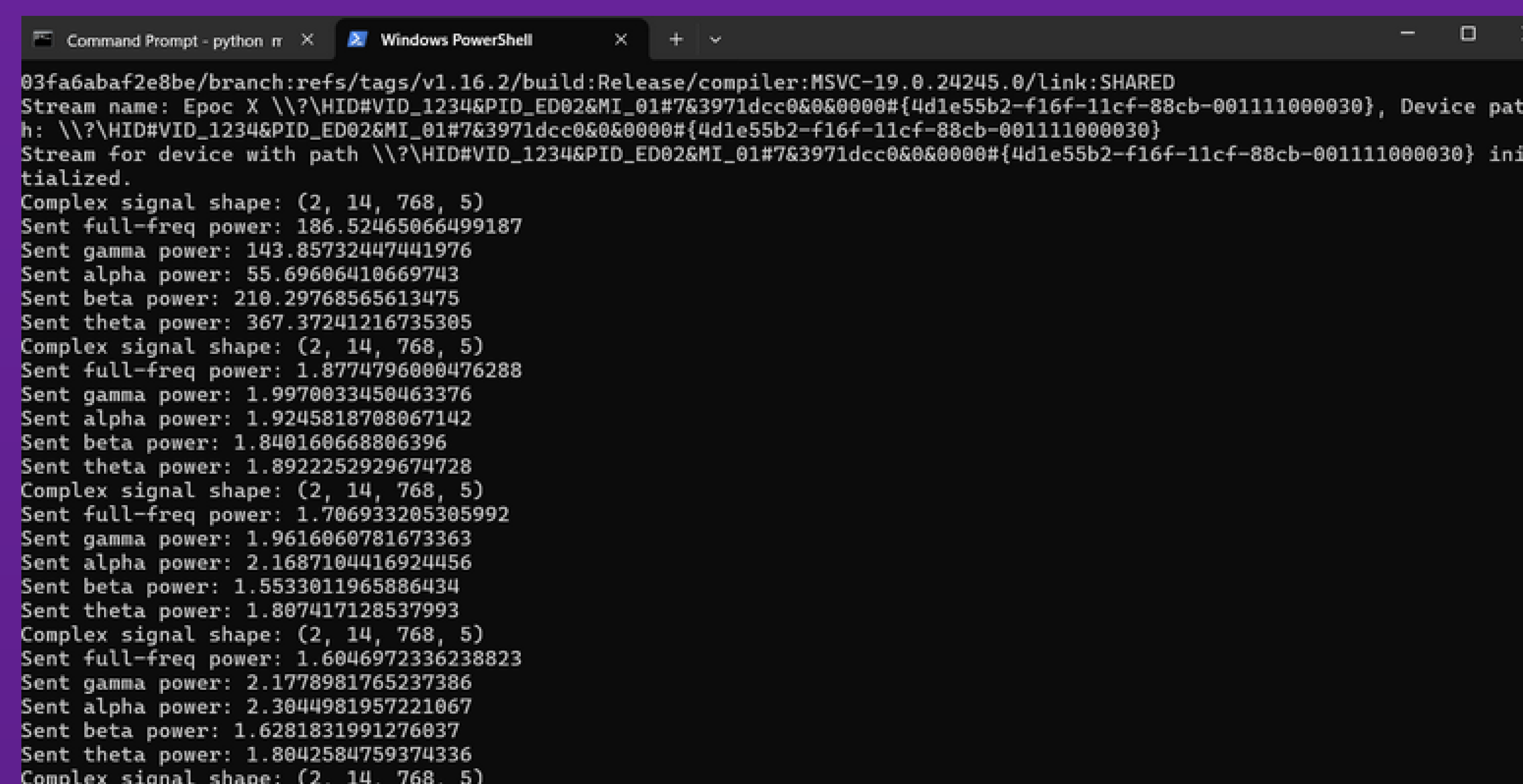

A few Python scripts oversee reading input (your brainwaves) from the EEG headset. Every channel is measured, but only three are used and sent to the game. C# was then used to normalize and smooth the sent “focus” variable.

Novelty:

Previous works that have used Dynamic Difficulty Adjustment (DDA) before have a pattern of heavily leaning into the awe factor of EEG. This project instead focuses on integrating DDA into a complete experience, where it enhances gameplay rather than defining it.

The game is a simple First-Person Shooter (FPS) combined with puzzle elements. As the player’s focus changes, gameplay responds through effects such as increased damage output or faster stamina drain. Visual effects are exaggerated to reinforce these changes and increase immersion.

Future Work:

I consider this a work in progress. The textures are still quite basic and not yet indicative of an immersive experience.

There also remains the possibility to implement a Machine Learning (ML) model using this game. By having many participants play the game, enough data can be collected to eventually create a system that predicts when the user might eventually lose focus.

Each of these elements have been explored individually, but not at the same time. There remains the possibility to create an experience that is both scientifically meaningful and genuinely engaging.

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