VR Cosmic Tennis Final Report

Motivation and Challenges:

Our primary motivation for creating VR Cosmic Tennis is that we wanted to create a fun and unique VR experience that fit the sports theme. Our motivation for giving the player a jetpack came from our brainstorming of ways for the player to locomote in a way that feels natural without having to move their whole body. Jetpack Stadium and Jetpack City Action are both pre-existing VR jetpack experiences that received poor reviews due to frustrating and slow jetpack control schemes, along with polish issues. Though we did not have enough time to fully polish our experience, we did have the goal to create a fun and immersive jetpack tennis game that has intuitive controls.

Our motivation for the space theme came from the limitless nature of VR. We wanted to give users an experience that they cannot have on earth, so we took them to space! Going along with the space theme, we thought it would be cool and interesting to have obstacles between the player and the opponent that would pull the tennis ball toward them, altering the trajectory of the ball. Our motivation for this came from the videogames Mario Galaxy and Angry Birds Space that utilize similar physics to change the trajectory of Mario's jumps and the launch path of the Angry Birds.

Some challenges that we had to overcome were figuring out how to make the jetpack controls intuitive and responsive without giving the user motion sickness, figuring out how to implement the tennis ball hitting physics and gravitational based obstacles, and figuring out what additional features we could add to make the experience more immersive.

Approach:

We built our game using the Meta/Oculus Interaction SDK. Taking advantage of some existing prefabs to come up with a complete VR experience. The player is tracked using the SDK's CameraRig prefab, which is set up to handle controller and hand tracking as input. By casting rays from the end of the user's controllers, represented in the virtual space by animated Oculus Touch Controllers, the user interacts with the UI to choose their controller hand preference.

Once the user starts the game by pressing the button labeled 'Start', the player can begin to move around their enclosed arena. The player is restricted to move along their XY plane, aka upwards, downwards, left and right. The player can control their movement by orienting their non-dominant controller upwards to the direction they intend to move in. Once they press the primary trigger, a force relative to the trigger will be applied that propels the user in that direction, mimicking the propulsion of a jetpack. To better help with precise movement, the user can press the secondary trigger to rapidly halt their momentum, before falling downwards with respect to Unity's gravity mechanics, which we have lessened to mimic the low gravity of outer space.

The dominant controller that the user selected holds a tennis racket, which is the primary interactor that the user must use to serve and send back the tennis ball. As the player swings the racket at a static or dynamic tennis ball, our engine will translate the velocity of the moving racket to the ball, sending it back in the opposite direction. It is the goal of the user to try and hit the opposing alien enemy's back wall with the ball and avoid the ball hitting the wall directly behind the player. The player must master the simultaneous control of the jetpack motion and the swinging of the tennis racket in order to direct the ball away from the enemy. The game follows the same rules as a single tennis set, where the user attempts to score more points with respect to the traditional scoring system than the enemy. The score is displayed behind the enemy on their wall so that it is always visible but doesn't block the user's view of their game area. Once the game is completed and either the player or the enemy alien opponent win, the game will return to the main menu screen for the player to try again.

As mentioned previously in order to provide a unique experience for the player, we wanted to maintain a cohesive space theming through some of our mechanics and aesthetic design. With the tennis ball physics, we had the ball's rigidbody not react to Unity's gravity system, but instead we calculate the gravitational force of the ball on a couple floating asteroid gameObjects that would circulate in a predefined kinematic pattern around the center of the arena. By applying the gravitational force equation, $F = \frac{GMm}{r^2}$, to a list of defined "Attractors" on each Fixed Update, we simulated the real gravitational pull of celestial bodies on our ball. Due to the high velocity of the tennis ball, the gravitational pull of each asteroid will affect its incoming and outgoing direction of the ball. As the ball is able to bounce on the walls of the enclosed arena, the movement of the tennis ball can be chaotic, and it adds a degree of challenge to the player hitting the ball. The alien enemy has an AI script that follows the trajectory of the ball, and does its best to return the ball, but it is entirely beatable albeit difficult as the player gets accustomed to the controls.

We aimed to achieve completeness and immersion in our game, and we succeeded with our full gameplay loop and UI elements. Through the inclusion of haptic feedback on the jetpack controller and the integration of HRTF sound to the tennis swing and tennis ball bouncing, we are able to provide the player with the immersive experience that they are in space. This is all helped through the integration of several free Unity assets, including 3D models and 2D textures for the enemy, tennis equipment, asteroids, and planets that relate to the theming of our game.

Future Work:

There are some minor tweaks we would like to make to the game in the future that should help make the experience more polished. Due to the nature of the gravitational based obstacles, sometimes the tennis ball can get stuck to the obstacle if it is not moving with high enough speed past the obstacle. As a quick fix, we implemented a timer that would reset the ball after a certain amount of time if neither the player, nor the opponent has scored a goal. Our solution to this problem was to turn off the gravitational attraction attached to the obstacles when the tennis ball passes them, but we were unable to get this solution to work in time for the final deadline.

We would also like to improve the tennis ball hitting physics. Right now, they are fairly realistic, making the ball go in a reflected direction based on the normal angle of the paddle collider. From play-testing the game, we learned that sometimes this realism can make the game more difficult to play since we noticed players would often mistakenly hit the ball sideways instead of forward. Our solution that we did not have time to implement was to make the hitting physics slightly less realistic, altering the trajectory that the ball is hit so that it always goes toward the enemy, similarly to the physics in the tennis game in the videogame, Wii Sports.

There are also some stretch goals that we did not have time to implement. Our first stretch goal, which we originally had as a main goal, but shelved due to time constraints, was to make the game multiplayer. Sports are meant to be played with other people, so we originally wanted VR Cosmic Tennis to be multiplayer. We ultimately decided to prioritize developing an immersive single player experience however since making a multiplayer experience would involve using a Unity multiplayer plugin, such as Unity Netcode, which we had no experience working with.

Another stretch goal we had was to implement a more humanoid alien opponent animated with motion capture. This opponent would have arms holding tennis rackets that would swing back at the ball. This would help the game feel more realistic as the alien would actually be hitting the ball back instead of just moving in front of the ball.

Finally, we also wanted to give the player an avatar with limbs animated using inverse kinematics. Currently, the player just has a floating controller and tennis racket. An avatar with animated limbs would make the experience much more immersive and help give the player self-perception and body-ownership.