At Bat: A Virtual Reality Batting Machine Game

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I. PROJECT OVERVIEW

This Master's Course Project will feature "At Bat" – a virtual reality game which simulates hitting balls thrown from a pitching machine with a baseball bat. In the game, the player will be able to approach home plate, wait for the pitch, and swing the "bat" using the Oculus 2 Quest controller. The user's swing will result in a strike, a foul hit, or a fair hit, with information displayed about the distance of the hit. On the screen, the user will see a baseball field with a pitching machine set up on the pitching mound and will be able to see the trajectory of each ball they hit.

II. PROBLEM DEFINITION

Existing virtual reality baseball games exist, but do not capture the action of batting intuitively enough to provide the user with an authentic and immersive baseball experience. Games like "Everyday Baseball VR" and "Totally Baseball" have reviews that indicate they have failed to provide the user with an experience that accurately simulates real-life batting [1][2].

"At Bat" will address this issue by scaling down the game of VR baseball to just batting and prioritizing the physical authenticity of the act of swinging a baseball bat in VR. This will mean providing accurate collision detection and physics while also modifying the VR controls to allow the user to execute a realistic swing.

III. SIGNIFICANCE

Sports games are a video game staple. As virtual reality games become more prominent, sports-based games may quickly rise in popularity. With a more immersive and authentic experience, "At Bat" will elevate the experience of VR baseball games. If a great amount of realism is achieved in the game, it could also be utilized by users for practice which may translate into real-life skill. Several challenges are predicted to arise during development to achieve the desired outcome of the game. This includes how to simulate authentic controls for the user; and how to program the physics of the game accurately enough to provide a realistic experience.

IV. SUCCESSFUL OUTCOME

A successful outcome will result in a virtual reality batting game which immerses the user and provides an authentic batting experience. The user will be able to swing a controller in a way that feels that they are swinging a bat. The ball will react accurately based on the physics of the pitch and the swing. The user will be able to see their ball fly through the air and will receive information from the game about their hit. The evaluation of a strike, foul ball, or fair ball will be displayed to the screen. Fair and foul balls will display the final distance of the user's hit.

V. PLATFORM

This game will be developed in Unity to run on the Oculus Quest 2.

VI. CONCEPT ART

The user will be able to see the strike zone the same way a batter would and sees their bat hit the ball from a first-person perspective:

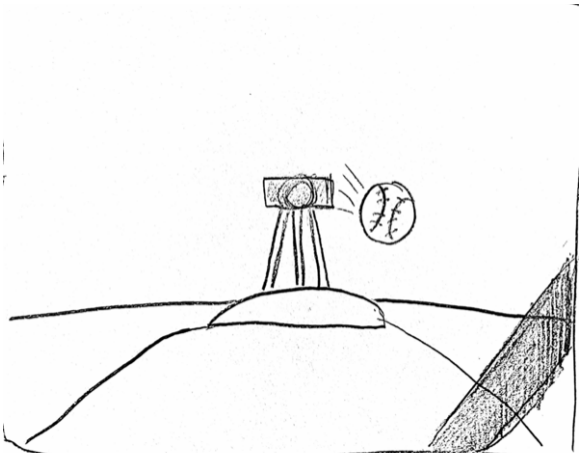

Figure 1: Poorly drawn concept art of the first person view the player may have waiting for a ball to approach from the pitching machine

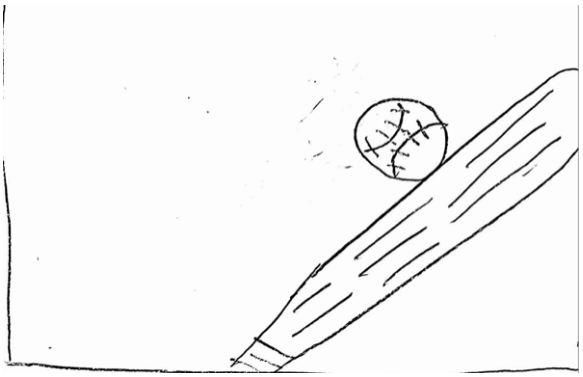

Figure 2: Poorly drawn concept art of the first person view the user would have as they see their bat hit the ball

VII. USER INTERFACE

The game will rely on a simple user interface. The user will stand at home plate and may adjust their stance slightly by physically moving forward or back. The game will not allow the user to move beyond the batter's box. The user can swing the bat with their controller as balls are shot their way. The user does not control the start of the game or the pitching of the balls. The user may only pause / quit the game using the Oculus button on the controller.

VIII. METHODOLOGY

The successful completion of this project will rely upon the completion of smaller steps which may be classified into phases. These phases include research, development, and testing.

A. Research Component

The success of this project depends upon research completed in the following areas, which are based upon the problem definition:

- What makes a baseball game feel physically authentic to the user
- How to provide accurate bat/ball collision detection in Unity
- The physics of baseball that need to be implemented in the game
- The best way to modify the controls for the user

i. Physical Authenticity

It may be apparent that a vital aspect of this project will be determining where the ball will travel based on the swing of the bat. However, the physical authenticity of the game of baseball depends upon so much more than just the visuals of the ball and the bat. For example, a good hit in baseball will give off a famous "crack" sound – signaling a successful swing to both the player and the audience [8]. A bunt or a foul ball would not give off the characteristic sound of a home run, so it will be important to reflect that within the game.

Besides visual and audio cues, the player will also rely upon physical cues for authenticity. Of course, the Oculus Quest 2 controller is not capable of producing the sting that a bat can produce on one's hands, but haptic feedback should be researched and effectively utilized to immerse user as much as possible.

ii. Collision Detection in Unity

Research will need to be completed on collision detection in Unity. Not only will the developer need to know when the ball hits the bat, they will also need to know exactly where on the bat the ball will hit. So, the collision detection will need to be highly accurate to produce correct results for the game. Researching this will involve looking at existing implementations for a similar kind of collision detection in Unity as a bat/ball collision. However, the final implementation for the collision detection will depend on how the controls are implemented, which is detailed in part iv.

iii. The Physics of Baseball

The physics of baseball are not so simple as seeing if there was a bat/ball collision and then making the ball go far. After all, we all know about the colloquial "sweet spot" on the bat. The distance the ball travels depends in part upon where it was hit on the bat [9].

The spin of the ball when it is pitched and the spin of the ball when it is hit also effects the distance the ball is hit and where it travels to. Thus, the physics of baseball and physical phenomenon such as the Magnus effect must be researched [9]. That way, the game can be programmed with physical properties that will match the actual game of baseball as much as possible.

iv. Controller Modifications

Producing an immersive baseball game on the Oculus Quest 2 without a modification to the controller would not be feasible; the existing controllers are too short for the user to grip with two hands, thus making it impossible to swing the controller like a bat. While my background is not in prototyping or physical engineering, it will be vital to provide some sort of controller modification to this game.

The Oculus Quest 2 uses two controllers. Thus, the project has the option to use one or two controllers to represent the bat in the game. One controller may provide more feasibility of implementation, while two controllers (one at the handle of the "bat" and the other at the end) may provide increased accuracy of tracking. Two controllers may also increase the weight of the controller-bat in a way that helps replicate a more realistic swing. However, a controller the full length of a bat may not be very safe for the casual user in VR.

Overall, more research needs to be completed on the accuracy of tracking with one controller versus two. Each approach may have tradeoffs with accuracy, feasibility, and safety that will have to be assessed for the final implementation. More research should also be done on existing Oculus Quest 2 controller modifications that may be utilized for this project.

B. Development

The development of the game will be broken down into subtasks for completion, including:

- Create game scene – baseball field with pitching machine on mound
- Create environmental triggers such as fair/foul areas and the strike zone
- Program pitches, randomizing speed, location, and spin within the strike zone
- Determine batting controls for user, considering possible controller modifications
- Program first-person user experience to approach home plate with bat
- Program swinging bat based on sensor data from controller
- Add collision detection to determine if and where the ball hit the bat, and with what amount of force
- Program physics to determine ball trajectory based on hit
- Display hit statistics (fair/foul, pitch speed, distance hit) to the user on the screen

C. Testing

The testing of this game will use a quantitative and qualitative evaluation as detailed in section IX.

IX. EVALUATION

To evaluate the success of the game, a quantitative and qualitative evaluation will be used. The quantitative evaluation will track whether or not the numerical calculations of the ball's trajectory is correct based upon inputs like the force and direction of the hit. The qualitative evaluation will use survey to determine how well the game performs in the eyes of the users. The qualitative evaluation will require beta testers to play the game and answer survey questions regarding their feelings of immersion and authenticity.

X. PROJECT STATUS UPDATE

A. Research Component

Research is currently being completed to fully understand the physics that will need to ne programmed in the game as well as how to accurately provide collision detection.

Research has also been done on how to best implement the controller. Several factors need to be considered when modifying the controller. These include the accuracy of collision detection and tracking; the comfort for the user; the ability for the controller to swung like a baseball bat; safety; and the feasibility of the implementation.

Not much research exists concerning the use of single versus multiple controllers for accuracy. However, there are a handful of single-controller modifications that have been posted on the internet by hobbyists and gamers. These existing, fan-made implementations may be explored for use in this project [12][13]. More research needs to be completed to determine if this is the best kind of implementation. However, the existence of designs that may work and are secure (both for accuracy and for safety) make these implementations more feasible.

Research will continue on the subject of using multiple controllers to track the position and velocity of the bat instead of just one. This could be important as the end a baseball bat will always have a faster velocity and more movement than the handle [9]. Therefore, tracking with two controllers may have a positive impact on accuracy and may be more straight-forward to program into the game. This approach suffers in the feasibility of finding a safe and secure physical controller modification.

B. Development

Initial development of a test environment that matches the dimensions of a baseball field has been completed. A VR Camera component within the environment will be added soon, as well as the visualization of the bat.

A more visually appealing baseball field environment may be imported from the work of a CU Denver PhD student, Hawkar Oagaz. That way, the focus of the project can shift to the collision detection and realistic batting physics.

In order to implement a realistic batting game, it is paramount to utilize a modification to the controller to make it easier to grip like a baseball bat. A prototype of a controller modification has been 3D printed at the Inworks Prototyping Lab [12][14]. The 3D file was created by a hobbyist who needed a controller modification for a separate game on the Oculus Quest 2. While this initial prototype is not a perfect implementation, it assists in providing a more realistic grip to the user that also keeps the controller secure. Time depending, more prototypes may be printed and tested for use within the game [13].

Figure 3: Beatsaber controller modification [12]

Figure 4: 3d print result of left controller handle from CU Denver Inworks lab [14]

XI. REFERENCES

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