Immersive Simulation of Soccer Dynamics: A Comparative Study with Traditional Training

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1 INTRODUCTION

In the realm of sports, people use technology to help athletes with training in order to help improve players' abilities. Our projects seek to transform a unexperienced athletes' skill development using virtual reality (VR) to create a training environment and provide real-world feedback to help improve the user's skills.

1.1 Motivation

Our motivation for this research was to find a virtual training method that is capable to enhancing a players performance while ensuring accessibility and affordability. There are many advanced technologies available for anyone, but the cost is too high for avenger person income. While well-known teams can afford such technologies, accessibility remains a challenge for others.

1.2 Challenges

In our project we aim to provide users with a cost-effective training program. To achieve this, we will use a budget friendly Meta Quest 2, as well as using open-source soccer training software which our team developed. With the solution created by the Quest 2 and the soccer software, we hope to help improve users hand eye coordination while also improving their ability to block shots in the real world. By improving this aspect, we hope users not only see an improvement when hitting a soccer goal, but also see improvements in their reaction time. This reaction time improvement may help in situations when avoiding an accident while driving, or catching a ball before it hits someone. We hope this project will provide improvements in the user's daily life.

2 CITING RELATED WORK

2.1 "Creating a smart virtual reality simulator for Sports Training and education" by Emil Moltu Staurset and Ekaterina Prasolova-Førland (2016)

There has been a considerable amount of work done previously in this area, to include research done by Emil Moltu Staurset and Ekaterina Prasolova-Førland. Their paper discusses the benefits of virtual reality in sports. It is detailed that training in virtual environments can improve cognitive skill and reaction time. Before the introduction of virtual reality, this type of training was done with a video, but by immersing the athlete in VR results showed improved reaction times in games, especially one where it was one player against one other player.

2.2 "The Pivotal Role of Technologu in Enhancing Athletic Performance: Insights and Future Directions" by Dovgan (2023)

He did his research using VR for sports training that similar to how an athlete prepares for a competition. He made environments that closely replicate the real-world sporting scenarios. The results come out positive, help athletes under high-pressure situations and improve their performance under stress. Also, the VR was able to manage cognitive load during training, allowing athletes to process complex game scenarios without the physical risks.

2.3 "Measuring the effectiveness of virtual training: A systematic review" by Strojny and Misiarczyk (2023)

Strojny and Misiarczyk had discussed their discovery on VR (virtual reality) for the educational effectiveness of environments. In their studies, they are examining the effectiveness of VR-based learning over time. This study highlighted that peoplesd skills for reaction time and learning level have improve over the time by using the VR.

2.4 "Attentional Skills in Soccer: Evaluating the Involvement of Attention in Executing a Goalkeeping Task in Virtual Reality" by Shimi, Tsestou, Hadjiaros, and Neokleous

In this paper, their studies are based off focusing on the cognitive aspects of the performance for sports. While using VR, the studies show the impact of a goalkeeper performance when one of the tests focuses on the attentional abilities. The finding in this researcher paper shows the sport world, that VR can help improve a players ability and show they need to focus on developing cognitive skills and attention for goalkeepers to become a better goalkeeper.

2.5 2.5 "A Prospective Study About Enhancing Effect of VR in Soccer Training" by Ferrer, KITAHARA, and Kameda

In this paper, they did their research on using VR for Soccer Training. Their goal is to make elite soccer training that would help improve players to make better strategic decisions. What they did to achieve that goal is using previous displacement data to create a new in-game for the VR environment, there for it can enhancing the visualization training and overall performance of the field. They allow players to place their ball anywhere on the field and the movement help see what strategic decisions they can make if they run into those issues in real life.

3 METHODOLOGIES

The next subsections provide the details on how we conducted the experiment and how it can be recreated. The testing portion of the experiment was divided into 3 phases. The first and last phase would measure each participants effectiveness as a soccer goalie, specifically shot blocking. In the data analysis phase, we explain how we process the data to arrive at the conclusion.

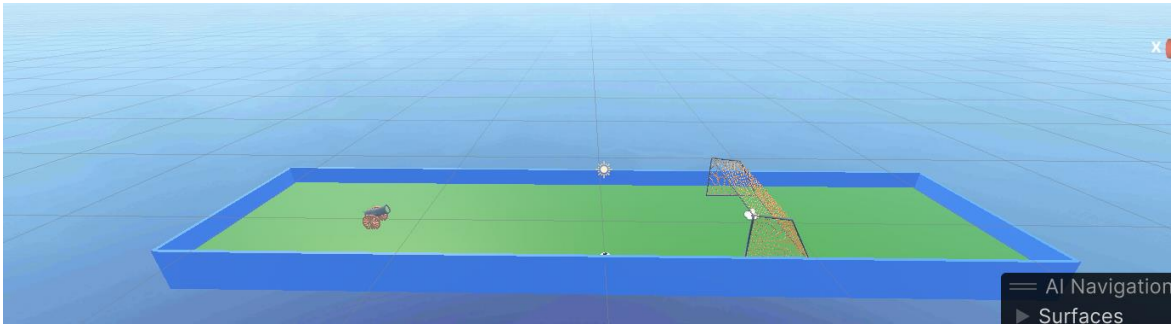
3.1 The Soccer Goalie Simulator

In this experiment, our team developed our own soccer goalie simulator that would be used by the participants. This simulator was developed using the Unity Game Engine and the scripts were written in C#. The simulator was developed specifically for use with the Meta Quest 2, shown in Figure 1 below. The simulator will use the controllers to track the user's hands. When the ball makes contact with the hands it will be reflected as it would in reality. In the simulator, the user will be positioned in the center of the goal, the goal is made to scale. You can see the skybox in figure 2.

Figure 1

Figure 2https://diviformbuilder.com/product/meta-quest-2

Figure 2



The Skybox for our simulator

3.2 Selecting Participants

In this experiment we selected 6 participants randomly from a pool of 10 people. These 10 people each had experience in various sports in high school, but none have ever played soccer goalie in a competitive environment. None of the participants had experience using a VR headset. Each participant was between the ages of 18 and 24, in good physical condition. None of the participants had any meaningful injuries that would affect their ability to act as the goalie. All of the participants would be males.

3.3 Testing Phase-1

For the experiment, we had 3 phases, in the first phase each participant would meet the research team at the Intermural Fields at CSU where they would be asked to act as goalie. In the first phase, each participant would be tasked with blocking 20 shots from an experienced soccer player standing 15 yards away. If the shot missed the net completely, it would not be counted towards the 20 shots. The participants would be given a mandatory 2-minute break after 10 shots where they could gather their breath. Participants were allowed to drink water during this time. Each of the 20 shots would be scored as either blocked or not blocked. The participants would be given time after a shot to reposition themselves.

3.4 Testing Phase-2

In phase 2 of the experiment, we would have each participant arrive at the Computer Science Lab the day following phase 1 for the next 3 days. Here they would be asked to use the Meta Quest 2 VR headset to play the Soccer Goalie Simulator game which we developed in Unity Game Engine. Each participant would be allowed to adjust the headset to their liking before the experiment began. Once the game began, the participant would be asked to block shots on goal using their hands, holding the controllers. There would be 5 seconds in between each shot and each shot would be from a perceived 15 yards away. The shot placement would be randomized to ensure complete goal coverage. They would be asked to use the simulation for 30 minutes each day, for 3 days in a row. The participants were allowed to take breaks as they pleased but would have a total of 30 minutes blocking shots each day.

3.5 Experiment Phase-3

The day following Phase-2, each participant would be asked to return to the Intramural Fields for the final day of the experiment. Once again, each participant will be asked to block 20 shots from an experienced soccer player from 15 yards away. The data will be recorded the same as it was in Phase-1.

3.6 Data Analysis

Given the data on each participant over the 3-phase testing period, we aim to determine if our findings are significant. To start the process, we developed our null hypothesis and alternate hypothesis:

$$H_0: \textit{The participants shot blocking ability did not improve after simulation training.}$$
$$H_0:\ \mu_d\ =\ 0$$

$$H_a: \textit{The participants shot blocking ability did improve after simulation training.}$$
$$H_a:\ \mu_d\ \neq\ 0$$

Looking at our data, we would condense it down to a shot blocking percentage for each participant and each phase. The shot blocking percentage will be referred to as SBP. To calculate the SBP, we used the equation shown in 2.5.1. The higher the SBP the more shots the participant blocked. If a participant blocked all the shots in phase-1, they would have a SBP1of 100. With each SBP calculated, we move onto determining whether our data is statistically significant. To do this we use a Paired T-Test. First, we will make sure that the data satisfies the assumptions of the paired t-test starting with normality. We will visually test if our data is normally distributed, which will be easy given the small sample size. Because each participant does the testing alone, the subjects are independent. Finally, each participant will experience all 3 phases of testing, proving both SBP comes from the same subject. This ensures our ability to use the Paired T-Test. To conduct the T-test we will need to calculate our test statistic. This will be done by averaging the change in SBP from Phase-1 and Phase-3. This will be referenced as:

$$\text{Average difference in SBP after simulation}\ =\ \bar{\pi}_{\mathrm{d}}$$

With the test average difference in SBP's, we will move on to calculating the Standard Error. This is calculated as follows:

$$Standard\ Error\ =\ \frac{s_d}{\sqrt{n}}$$

With the standard error calculated, we will next finally be able to calculate the test statistic as follows:

$$t\ =\ \frac{\overline{\pi_d}}{Standard\ Error}$$

For this experiment we will be setting the significance level to 0.05:

$$\alpha\ =\ 0.05$$

We will next calculate the Degrees of Freedom, by subtracting 1 from our sample size. Giving us a Degree of Freedom equal to 5. Using the Degrees of Freedom and our significance value, we retrieve the *t*-value from a t-table:

$$t - value = 2.571$$

Drawing conclusions, if the test statistic, *t*, is lower than the *t-value*, 2.571, you fail to reject the null hypothesis, meaning the participants shot blocking ability did not improve after goalie simulation. If the test statistic, *t*, is higher than the *t-value*, 2.571, you reject the null hypothesis, meaning the participants shot blocking ability did improve after the goalie simulation.

3.6.1 **Shot Blocking Formula**

$$SBP = \frac{shots\ blocked}{total\ shots} \bullet 100$$

4 References

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