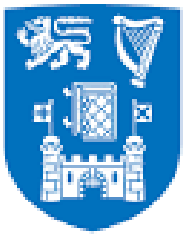

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Augmented Reality Project

Virtual Wrestling Entertainment Trump Card Game

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Declaration

I, Vanshika Sinha, declare that the report entitled “Virtual Wrestling Entertainment Trump Card Game” is completed under the guidance of “Dr. Gareth Young” in partial fulfilment of the requirements for the degree of ‘Bachelor in Engineering (BAI)’ in Computer Engineering from “Trinity College Dublin”.

I, hereby declare that:

- This project is the result of my own original work, and all sources utilized in the project have been cited.
- The project has not been previously submitted for assessment purposes, in whole or in part, to this or any other institution.
- Any content taken from the work of others that was used in the project has been properly acknowledged and cited.
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- I have read and comprehended the university's academic misconduct policy and certify that this project is free of plagiarism and other forms of academic misconduct.

I also declare that Trinity College Dublin, in whole or in part, may freely lend or copy this report for scholarly purposes.

Vanshika Sinha

10th May, 2023

Abstract

This mini scientific project aims to present a “Trump Card” game which demonstrates a type of *Virtual Wrestling Entertainment* using Augmented Reality, which uses professional wrestling characters from by companies such as WWE, AEW and ROH. The game blends aspects of trading card games and augmented reality technologies to provide an immersive and engaging gaming experience.

The game utilizes a set of 4 cards that represent wrestlers, each with their unique attributes and special moves. The various attributes of the competing wrestlers are compared one after the another, including the rating, strength and years of experience of the respective wrestler, and the player associated with the wrestler having the higher value of these attributes wins the game. Each character in the game is represented with the help of an object. As a result, there are 4 objects representing the wrestlers, there is one object to represent the ring, for the wrestler objects to interact and there is also a referee object to add authenticity to the game, which can be used as a prompt to display results or other features. Various resources and software tools are used to experiment and test various iterations of the app such as Meshroom, Sketchfab, Samsung 3D Scanner, Unity and Vuforia.

Players can bring these wrestlers to life and engage in simulated trump card battle in a virtual ring by using augmented reality. The goal of this research is to investigate the potential of augmented reality technology in improving the gameplay experience of card games and entertainment experiences. The initiative also aims to investigate the impact of virtual wrestling entertainment on player engagement and emotional attachment to the game. The project highlights the possibilities for future gaming experiences by presenting a revolutionary application of augmented reality technology in the realm of entertainment computing.

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1. Introduction

Wrestling stretches back roughly 15,000 years, according to cave drawings uncovered in France. Wrestlers are seen in Babylonian and Egyptian reliefs employing holds that are still utilized in modern-day wrestling, demonstrating the combat sport's ancient history. For decades, wrestling entertainment games have been popular, allowing users to design and manage their own wrestling characters and compete against others. Companies including as WWE, AEW, Impact Wrestling, and ROH offer touring professional wrestling events around the world, which are sometimes referred to as "American-Style" professional wrestling. Matches are extremely theatrical, with dramatic tales such as feuds between athletes devised and enacted as part of match preparation and promotion.

Since the introduction of the first video game console in the 1970s, the gaming industry has come a long way. With the rapid improvements in augmented reality (AR) technology, it is now possible to connect the real and virtual worlds in previously unthinkable ways. With these advancements, this experience may now be taken to the next level, allowing players to see favourite wrestling avatars come to life in the real world. This project will explore the possibilities of creating a wrestling entertainment game using AR technology. In this technical study, we investigate the possibility of employing augmented reality to create an immersive and thrilling wrestling entertainment game. As a result, to demonstrate such a type of virtual wrestling entertainment, this project will present an Augmented Reality based **Trump Card Game based on wrestling characters** named **Virtual Wrestling Entertainment (VWE)**. This will give Trump Card games a new platform and it will also visualize the player's imagination, which can lead to a much more immersive and entertaining experience.

2. Motivation

Wrestling is a combat sport that draws anyone to the spectacle and drama of wrestling entertainment presentations, which feature colourful personalities and outrageous tales. Wrestling curiosity develops into a greater respect for the athleticism and talent required to compete at the highest levels of the sport. Wrestling has an interesting history and culture that is worth exploring. There is a wealth of stories and characters to discover, from the sport's historical roots to modern-day wrestling entertainment performances. Wrestlers' personalities and backstories are frequently as intriguing as the matches themselves, bringing dimension and mystery to the sport.

Wrestling is more than just a physical force sport; it takes extensive mental training and strategic thought. A wrestler must be able to read their opponent's motions and predict their next move while simultaneously attempting to stay on track with their own game plan. This results in a dynamic and ever-changing match in which the edge can move back and forth between the wrestlers. Another aspect is the physicality of the sport. It is fascinating to watch two wrestlers compete for dominance, trying to outmanoeuvre and outmuscle one other. A wrestling match is always entertaining to watch, whether it is the power of a wrestler completing a suplex, the speed and agility of a high-flying move, or the technical perfection of a submission hold.

Another popular type of everyday game is Trump Card based games which can come in many shapes and forms. The rules can be different, but they are a simple, yet engaging pastime for people around the world. These types of games increase collaboration and help people compete in a fun way. They have even been found to increase cognitive abilities of the players and also help in improving social skills, concentration and even personal development.

The aim to present players with a fully immersive and engaging experience along with an approachable and fun game drove the inspiration for developing a trump card-based wrestling entertainment game employing augmented reality. We can bring the world of wrestling to life in a way that was previously

impossible by leveraging AR technology, allowing players to see their favourite wrestlers as if they were present right in front of them in the real world and interact with their environment in a whole new way. This type of game combines physical and virtual aspects in a novel way, allowing players to experience the fun of wrestling and trump card games in a more participatory and entertaining way than ever before. Furthermore, with the growing popularity of AR technology, there is a growing demand for innovative and immersive gaming experiences, making an AR wrestling game an excellent opportunity to explore the capabilities of this technology while providing a fun and exciting gaming experience to players. Developing this AR game will also allow the exploration of AR technologies and comparing and learning about various tools to perform processes such as Model Creation, Target Identification and AR app development.

3. Relevance

The Trump card game with augmented reality has various relevant and significant consequences. For starters, it can show how AR technology can be used to improve classic card games. By bringing the cards to life and creating a unique interactive experience for players, AR technology can provide a new and engaging way to experience card games. This can demonstrate the possibilities of augmented reality technology to game developers and designers, as well as the potential for augmented reality to transform the card gaming business.

Second, this can be used to investigate the viability of an AR Trump card game as a new revenue stream for game creators and publishers. With the growing need for immersive gaming experiences, an AR Trump card game might open up a new market and give a unique spin on the classic card game genre. Highlighting the game's unique characteristics and design decisions can provide useful insights to game developers aiming to construct successful AR card games.

Thirdly, these types of games can lead to other advantages for players listed above such as increased social skills and personal development, by allowing players to engage in in-person interactions rather than playing purely virtually, which has been on the rise, especially after the Coronavirus pandemic, while still adding a novel, technological element to the game.

Additionally, this can provide game designers with guidance on the best practices for creating a successful AR game. It can provide insight into the problems and opportunities of designing and producing an AR game, as well as advice on how to balance the game's physical and virtual parts to produce a seamless and engaging experience for players.

Finally, this can be a useful resource for Trump card game fans who want to learn more about the behind-the-scenes process of developing an AR Trump card game. It can provide an in-depth look at the development process, highlighting significant features and design decisions that went into making the game, as well as highlighting the unique qualities that AR provides to the genre.

To summarize, wrestling is interesting and appealing due to its physicality, strategy, and rich history and culture. It is a sport that is constantly growing, with new manoeuvres, wrestlers, and storylines to uncover. Overall, creating a virtual wrestling entertainment game with Trump cards using augmented reality can demonstrate the potential of AR technology, highlight new revenue streams and other valuable insights for game developers, provide guidance for designers, and provide valuable insights to Trump card game enthusiasts.

4. Theoretical Background

The convergence of computer technology and entertainment has given rise to the field of *"entertainment computing."* Since the 13th century, card games have been a popular form of amusement, with a number of various games and decks each with their own set of rules. The Trading Card Game is one of the most popular types of modern card games, in which players utilize a deck of cards to engage in fictitious battle. What distinguishes these games from other card games is that their cards can be purchased, acquired, and exchanged by players, allowing for a diverse range of decks to be utilized. These games are frequently expanded with new cards and rules, making them dynamic and ever-changing. Augmented Reality has been increasing in popularity over the past few decades at an exponential pace, along with other related technologies like virtual reality, extended reality etc. Although augmented reality was not formally recognized until 1990, the technology that led to its development had been tested for many years before that. Technology advancements throughout the nineteenth century and beyond established the groundwork for today's AR and VR technologies.

The use of AR technology has transformed the way card games are played. AR technology combines computer-generated virtual elements with real-world aspects. It enables players to engage with digital content in a natural and immersive manner, ultimately improving the entire gameplay experience. The ability to bring the cards to life is one of the primary benefits of adopting AR technology in card games. Traditional card games use static cards that provide limited gameplay opportunities. Using AR technology, however, the cards can be transformed into interactive elements that react to the actions of the players, providing a more engaging and immersive experience.

Another advantage of integrating AR technology in card games is the possibility to offer players with additional information and visual cues that traditional card games cannot provide. AR technology, for example, can be utilized to display real-time player statistics, game regulations, and scoring systems, boosting the overall gameplay experience. AR technology can be leveraged to develop more complicated and dynamic gameplay features. In an AR card game, for example, players can interact with virtual objects that appear on top of conventional cards, adding a layer of strategy and complexity to the gaming. Furthermore, AR technology can be used to create multiplayer experiences that traditional card games cannot provide. Players, for example, can connect with other players and compete in real-time using their smartphones or other AR-enabled devices, regardless of their physical location.

Because technological limitations currently prevent a seamless integration of the augmented world and our reality, some scholars argue that for AR games to be truly immersive, players must imagine and act as if the game's fictional world were real. This imaginative involvement necessitates cognitive effort, as players actively create and become emotionally committed in fictional scenarios. Human imagination is heightened by nostalgic experiences and a proclivity for AR content, resulting in a stronger love for in-game fictitious content. Nostalgia, emotional attachment, and social interaction all play important roles in deciding the significance of playing AR games.

In conclusion, the use of AR technology in card games has several advantages over traditional card games, including the ability to bring the cards to life, provide players with additional information and visual cues, create more complex and dynamic gameplay mechanics, and enable multiplayer experiences that traditional card games do not allow.

5. Implementation

This mini scientific project aims to present a "Trump Card" game which demonstrates a type of *Virtual Wrestling Entertainment* using Augmented Reality, which is somewhat similar to professional wrestling events offered by companies such as WWE, AEW and ROH.

Below is a brief explanation of the game rules:

- The game consists of 4 trump cards which includes 4 characteristics such as: 'Name', 'Strength', 'Rating' and 'Experience' of the respective wrestlers corresponding to a particular trump card. This is one test data for now.
- Initially, there are 2 players competing against each other (similar to 2 wrestlers in a real wrestling game), and each player has 2 cards for now.
- Corresponding to each card, one object is needed which represents the particular wrestler competing in the game. In total, for 4 trump cards, there are 4 wrestlers.
- In addition, there is another object, a ring, for the wrestler objects to interact. There is also a referee object to increase the realism in the game, which can be used as a prompt to display results, or other features.
- To start the game, the 'rating' of the first 2 cards played by the players is compared. The one with the higher rating wins the match inside the ring. If the cards have the same rating, then the 'strength' is compared and the one with the higher strength wins the match inside the ring. If the cards have the same strength, then the 'experience' is compared and the one with the higher experience wins the match inside the ring.
- After the first 2 cards are compared, then the other 2 cards of the players are compared in the same manner in which the first 2 cards were compared.
- Therefore, there are 3 rounds taking place for a set of 2 cards, in which the 1st round compares the rating, the 2nd round compares the strength, and the 3rd round compares the experience of the competing wrestlers.
- The 3rd round reveals the winner. After the successful experiment consisting of comparing all the 4 cards with each other, there is a winner with better rating wrestlers.

5.1 Resources and Software Tools Used

To complete the project, various types of resources and software tools were used to experiment and test various iterations of the app. They are listed under:

- **Meshroom:** Meshroom was used to develop model objects for characters and other in-game props for initial iterations.
- **Sketchfab:** Sketchfab was used to download models in subsequent iterations to develop the basic proof-of-concept of the game in further iterations of development.
- **Samsung 3D Scanner:** 3D Scanner is a mobile app provided by Samsung on compatible smartphones. It works on depth-based 3D scanning technique using a time-of-flight camera sensor. Basically, it works on the principle of calculating the "round trip time" taken by a signal to reflect back from a point on the object in front of the camera. Based on these distance measurements correlated with images captured by a camera, a 3D Model of the object can be generated. It was used to generate a few representative samples and explore a new technique of generating 3D Models of real-world objects.
- **Unity:** Unity was used to develop the AR application and bring all the different elements together to combine them and build and export it into a usable, packaged app.

- **Vuforia:** Vuforia is an SDK, which is a part of the plugins available along with Unity which enables the use of various Computer Vision techniques to learn about the real-world spatial features of the surrounding environment to render AR elements, such as specifying an image target associated with a model.

5.2 Methodology

The game application was developed in the following stages:

1. **Model Creation and Sourcing:** This stage consisted of developing/ sourcing various 3D Models as props in the gameplay. In this stage, various tools and techniques for developing models were tested. Firstly, Meshroom was used to generate a model using photogrammetric techniques to form a 3D model by stitching photos together. Secondly, Samsung 3D scanner was used to generate models using depth-based distance detection using time-of-flight camera sensor. This type of detection had the limitation that it could not reliably prepare a 3D scan from a distance. Due to this, full body scans of subjects could not be taken and only the bust portion could be captured. Thirdly, open-source 3D Models were sourced from Sketchfab for faster prototyping and developing and testing other app features.
2. **Real World Target Creation and Mapping:** In this stage, real world image targets were created to support further steps in the AR app development. Playing cards were made using coloured paper, patterns and payer stats were written on the same. These were then mapped to image targets by creating a Vuforia target database using the images of the cards through Vuforia developer portal.
3. **Combining Models and Targets:** The models and targets were imported in Unity and were associated to form relationship mappings in the AR world. Thus, when a player would be thrown, the associated character would appear in the AR rendering. Other elements like the wrestling ring and referee were also mapped to a separate target.
4. **Building and Testing the App:** The app was built successfully using Unity for the Android platform. For this, certain dependencies such as Gradle and JDK were configured to allow building and running the app. At first, the app was run on the built-in emulator in Unity to test the core functionality. Then, the app was exported as a .apk executable to an Android device and tested.

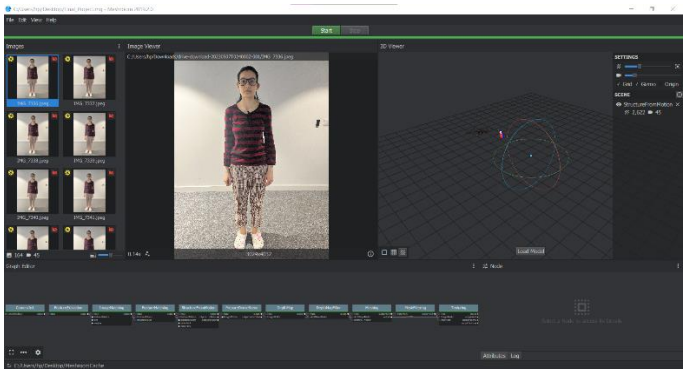

Figure 1: Creating the character model using Meshroom

Figure 2: Creating the character model using 3D Scanner

6. Results and Discussion

6.1 Results Achieved

Since the project involved several iterations at various stages of development to achieve better results and resolve errors, the results achieved also varied. The major results achieved are as follows:

1. The models generated using Meshroom had a lot of noise and extraneous details about surrounding objects. The additional artifacts and noise in the model have to be removed using blender. Hence, the Meshroom models were not used to develop the app in later stages. In addition, the Meshroom apps much more complex than other models due to the presence of a large number of feature points and lack of smooth surfaces.
2. Models generated using depth-based time-of-flight sensor-based detection were generated quickly and had better quality. The models developed had better noise suppression, so no surrounding object artifacts were present in the model.
3. The models sourced from Sketchfab were the lightest models in terms of size and complexity as they had directly been generated by meshing smooth surfaces together, preventing extraneous features from getting generated.
4. The Unity app for Android was built successfully and installed on the Android device. The app was able to perform well on the built-in Unity emulator screen with and detected all targets. But the app was not able to run on the Android device.

Figure 3: Model Generated using Meshroom

Figure 4: Model Generated using 3D Scanner

6.2 Discussion

The experiments performed and analyses of the outputs at each stage allowed a good study of various techniques and AR app development from scratch. In addition, it also helped in understanding the use of various concepts and technologies such as multi-target tracking in Unity, Marker-less rendering etc.

During the model creation and sourcing process, Meshroom models had a lot of extraneous detail and the core object had high amount of distortion. This can be due to the fact that photogrammetric algorithms rely on computer vision techniques for depth estimation and only rely on visual data. On the other hand, the models created using depth scanning were relatively better. The technology relies on estimating model dimensions using a depth perception-based point cloud to identify surfaces. Although certain features were not properly scanned and had instead been rendered using interpolation. The level of distortion in the models was lower than that observed in Meshroom but still quite high. As specified above, since Sketchfab models were directly created from 3D objects generated on a computer, they had the best quality in terms of model appearance and complexity.

The AR app creation process was observed, and important techniques and concepts related to AR were identified in practice. For the AR app to be 'aware' of its surroundings and identifying feature points and surfaces, one technique that was learned was the use of image targets as markers. The AR objects are rendered with respect to the markers identified. The markers are identified based on computer vision techniques using Vuforia. Other advanced techniques for marker less feature identification and linking various spaces to form a conjoined map of surrounding areas which are separated from each other by an obstruction were also identified and studied.

7. Challenges and Future Work

7.1 Challenges

In the execution of the project and analysis of results, the following major challenges were encountered:

1. Identification of right tools and resources for achieving specific tasks involved testing and researching about several aspects such as supported features and performance. Based on this research, scoping out the tools to use and how to use them through the project was a challenging aspect. In addition, resolving compatibility and setup issues in the software toolset was also part of the challenge.
2. Managing tasks and prioritizing various steps and features to adopt involved a lot of design decisions. For example, certain features had to be dropped to allow for rapid prototyping of the app and some new techniques and concepts had to be learned to implement certain features.
3. Resolving build issues and bugs associated with model format conversion and aligning various parts of the application together was also a major challenge.

7.1.1 Possible Causes, Justifications and Fixes Tried for Technical Issues Encountered

The major technical issues encountered and their possible causes and fixes tried are highlighted below:

1. Initial Android Build Failing: The build issues were encountered due to missing packages different versions of software packages and tools being incompatible and also due to configuration settings. These were resolved by exporting the project to a different version of Unity and aligning the software packages used according to version specifications available in the documentation guidelines. Missing packages such as Gradle, Android SDK and NDK were also installed and upgraded. Various configuration settings were also tried after which the app was rebuilt. After a few iterations, the app was built successfully.
2. AR Objects not visible on Android: AR objects not being visible on running the app on an Android device could be due to two causes: either the image targets themselves are not being identified; or after identifying image targets, the models are not being rendered in the scene. The potential root causes and fixes tried are highlighted below:
    - The quality of the mobile camera being used was not good, as the image resolution was not high causing it to be blurry. This may have distorted the target images, causing them not to match the target images supplied.
    - Due to varying scaling factors of the 3D objects used, even if the objects may have been detected, they might have been projected as too small or large and therefore may not have been visible on the viewport. To mitigate this issue, several scales of the imported models were used to build the app over iterations but still not all models were visible on the respective image targets on Android.

- Another reason why proper target detection would not have happened on android could be due to incorrect configurations, different architecture or absence of proper run-time dependencies and libraries. Various set-up configurations were tried, but they did not work. For instance, the model render pipeline was altered from Built-in pipeline to Universal Render Pipeline (URP) since it is the latest one, but the app gave the same result.
- To mitigate the possibility of Android device having the requisite software and hardware framework, the target architecture of the platform was verified to be 64 bit. Building apks for both 32 bit and 64 bit targets were tried. In addition, the list of supported devices with AR features was checked to verify that the target device was supported.

7.2 Future Work

The present project implements a simplified Trump Card Game with a simple logic to decide the winners by the players. Firstly, the app configuration and build should be stabilized and tested thoroughly to identify the root causes of the app not working as expected on an Android device. This will ensure such issues are resolved by platform developers and the AR ecosystem can be made more viable for usage. Secondly, the AR elements in the gameplay are limited to major props such as player characters, referee and ring. As an enhancement to the app in terms of functionality and interactivity, more props such as interactive audience members and animations can be implemented to increase the interactivity and immersion in the application. A better gameplay can also be developed using a more complex logic for handling multiple players, multiple attack levels and game logic. In addition, the game visuals can be made more appealing by using better graphics. Integrating custom made models using Meshroom and 3D Scanner can also be done as a next step.

In a broader sense, the techniques learned through the development of the app can be applied to other AR based games and interactive experiences. Additionally, other techniques and concepts can also be incorporated into the project like marker less surface recognition for placing the game arena. Moreover, other techniques can be used to stabilize the AR object rendering and quality of the AR projections.

8. Summary

This project was aimed at understating various aspects associated with creating an AR-based application and testing, developing the app and analysing the results observed. Keeping this in mind, an AR-based Trump card game application was developed for two players where each player can play one of their cards in a turn and the winner will be decided based on the ratings of the two cards. The AR element in the game were player models that popped up on the cards and other objects like the gaming ring and referee. Various techniques for creating models and tools for creating AR applications were compared. Based on the various options available to create 3D models, two techniques (Photogrammetry using Meshroom, Depth based detection based using 3D Scanner) were compared. Models generated using the time-of-flight approach were found to be better. Although the models used for the app were sourced from Sketchfab for faster prototyping. The app was then developed using Vuforia and Unity. The app was run and tested on Unity and an Android device.

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Link to YouTube Demo Video: https://youtu.be/IkNs_xipA4w