COMP4801 Final Year Project

Combining Physical and Virtual Gaming Experience

Interim Report

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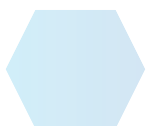3035371850

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Abstract

Since the gaming industry is becoming saturated, players tend to raise their requirements to the quality of gaming experience. Fusion of physical and virtual gaming experience may provide a fresh feeling to the players. In this project, a single-player Augmented Reality (AR) mobile game will be developed, where the players can control a spider-like robot - hexapod to adventure with the storyline in the game. Therefore, after developing a robot controlling application, it will then be transformed into a plugin for use in the AR gaming environment for further development of the game. The controlling application for the mobile phone to control hexapod was tested to be success. Meanwhile, basic operations of the game were developed, and some simple AR elements were tested, but the integration of virtual environment and real-world object in the AR scene is still working in progress. Regardless of encountering some technical difficulties, the project is on schedule. After handling the works in progress, the merging of the robot controlling application to AR game will be handled for the next major step.
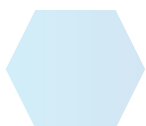
Acknowledgement

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Abbreviations

AR   Augmented Reality
RPG   Role-playing-game
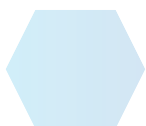
1 Introduction

Physical gaming experience stands for any physical objects for entertainment, such as teddy bears, robots, etc. Meanwhile, virtual gaming experience includes digital games, AR, etc. After clarifying the definitions of physical and virtual gaming experience, the project is then narrowed down by specifying to use the combination of robot and AR game. To introduce the project, a brief background on gaming industry, AR game and robotics is given below. The objectives of the project are then provided, followed by the deliverable and scope. There is an outline of this report at the last of this chapter.

1.1 Background

According to The State of Online Gaming 2019 research report from the Limelight Networks, people are spending more time on gaming. An average of 7.11 hours is spent on playing video games each week among every age group in 2019 which is higher than that of 5.96 hours in 2018 [1]. In the report of Betting on Billions, 50% of respondents, who use smartphone or tablet within 7 days during the survey conducted in December 2018, play games. As a result, game is in the top 3 most-used app type [2]. These statistics are showing that people are having an increasing demand of higher quality gaming experience, otherwise, they will easily get bored with massive similar gaming experience that have been launched to the market.

Pokémon Go is a famous AR game, which has the most daily revenue with USD$1,644,157 among iPhone mobile gaming apps in United States in September 2019 [3]. In Pokémon Go, players are required to capture the wild Pokémon that is augmented into the real-world environment (see Figure 1). However, the Pokémon is generated according to the location, and it is not specified to any object displayed in the real-world. As a result, switching off the AR mode can still be able to continue with the gameplay (see Figure 1). Since it is not necessary to switch the AR mode on for the gameplay and switching it on consumes the power of the mobile phone quickly, players tend to switch it off despite losing the interactive experience brought by AR. In this project, the robot used is one of the characters for the game. Therefore, the AR technology will have a correlation to a real-world object, so as to enhance the interaction between the physical world and virtual world, and to provide a better gaming experience for players.

Figure 1: Screenshots of Pokémon Go; with AR (left) [4], without AR (right) [5]

On the other hand, although entertainment robots are toys with long history, they are not out of date. Instead, the market of entertainment robots, especially those are programmable so that a series of actions can be performed, is increasing because Artificial Intelligence (AI) development is growing rapidly. The market is expected to increase at a compound annual growth rate (CAGR) of 23.06% [6]. Programmable robots are the current trend, while Boston Dynamics is told to be a world leader. Boston Dynamics develops robots which can have sophisticated and smooth movements [7] (see Figure 2). However, a robot armed with excellent movements may not be interesting and useful if it is not used for any purpose. Therefore, this project tries to merge the AR technology with the programmable robot into a mobile game.

Figure 2: Robot named Atlas developed by Boston Dynamics [8]

1.2 Objective

This project aims to provide a new gaming experience to the players as well as fulfill the increasing demand of better gaming experience by combining AR technology and robots. Most of the recent gaming experiences are monotonous, in which they are either a physical or a virtual experience. As times goes on, the development of game industry is saturated. People get bored easily since brand-new gaming experience is difficult to be discovered for either physical or virtual entertainments. Hence, this project is mixing physical and virtual world to provide an interesting and fresh idea. The idea of combination may become new blood to the industry.

Combining the two complements the weakness each other. A robot provides a realistic vision of the movements, it can also be touched in the real-world. These are the advantages of playing a robot, however, it is not very interested to look at a robot moving around. On the other hand, AR augments computer-generated characters to the real-world environment. Although the characters are generated virtually and can only be viewed through the screen of the devices, this provides a fancy feeling to the gaming experience, and increases user interaction between the physical and virtual world. Integrating the strengths of both physical and virtual gaming experience, it is believed that the result of this project is found to be providing a more attractive and interesting new gaming experience to the players.

1.3 Deliverables and Scope

In this project, a mobile game consisting AR gaming environment that can fully control the movement of the robot in physical world will be developed. It is a single-player RPG, where the robot is the character for the players. The game recognizes the physical robot with the AR technology, 3D effects like shooting and burning are augmented onto the robot. The mechanics of the game is inspired by Tower of the Sorcerer (see Figure 3).
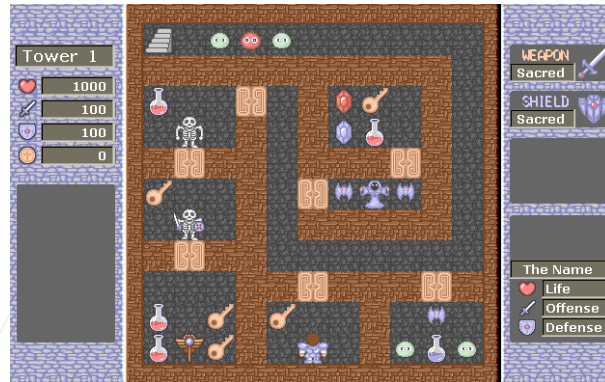

Figure 3: Screenshot of Tower of the Sorcerer [9]

It is a classic RPG developed in Japan and first issued in 1996. The feature of fixed-value RPG is reserved in the deliverable of this project, that means map, number of enemies, resources provided are not randomly generated. Since most of the value is fixed, choosing a correct order of the combats is deterministic for the players to pass through the levels, so it is also a puzzle game [9]. However, the story is changed where players are in a role of villain who breaks into the mansion to capture the princess. In the mansion, players are required to fight with some guards who try to save the princess. By utilizing ARCore, which is a development tool used for AR technology, virtual terrain and enemies are augmented into the virtual gaming environment. An exciting plot with a role that matched with the spider-like hexapod to be used is believed to make the game become more attractive.

1.4 Report Outline

The remaining of this report is organized as follows. Chapter 2 details the methodology to talk about how the project is to be implemented, while the current findings and progress of the project are stated in Chapter 3. Chapter 4 then describes the schedule of work planned to be completed in the future. A conclusion to sum up the main idea and current progress of this project are provided in Chapter 5.

2 Methodology

The project is firstly divided into two parts, mobile application to control the robot and game with AR gaming environment. After ensuring each part of them is working properly, merging of two parts will be carried out. To be exact, the mobile application will then be modified into a plugin that can be used by Unity, the game engine that used to develop for the AR gaming environment. Some specifications on hardware and software are stated below, followed by the details of each part of the project.

2.1 Equipment and Set Up

The robot used is a hexapod, which is a spider-like robot with six legs (see Figure 4). It is equipped with Bluetooth Classic, so that it can connect to other device through a wireless personal area network. Bluetooth Classic is used because it has a higher compatibility to support more devices while compares to other Bluetooth technology. In order to connect with the robot, a mobile phone which can support Bluetooth connection and location service is needed. More than that, supporting AR technology by ARCore, which is a plugin developed and maintained by Google, with Android system is also required for the phone. After equipping the required hardware, a plenty of space with ground is needed for testing with the deliverable.

Figure 4: A hexapod from Trossen Robotics [10]

2.2 Software Specifications

Since Android is used due to the simplicity of public Application Programming Interface (API) for Bluetooth Classic in Android compare to Core Bluetooth for iOS, Android Studio with Java language is used to develop the mobile application to control the robot. Meanwhile, Unity with C# language is used for building the gaming environment. Another way of implementing this project is using Android Studio for both controlling the robot and gaming environment. However, Android Studio is not specified for game development. Compared to Unity which is a famous game engine that used to develop game, Unity has more features and a better user interface to ease the game development. For example, Unity supports an easier implementation of animations, and it can control the locations of the game objects in the virtual 3D world easily. ARCore Software Development Kit (SDK) is integrated in the Unity game engine, therefore, ARCore is used to support the AR technology in the game.

2.3 Robot Controlling

Hexapod used in this project can have sixty kinds of movements (see Figure 5). There are three categories of modes, that is walking (W), dancing (D) and fighting (F).

	A	B	C	D
W (walk)	Low step	High step	Small step	Scamper
D (dance)	Freestyle	Ballet	Waves	Hands
F (fight)	Front legs	Front legs, unison	Swivel	Lean

Figure 5: Modes available for hexapod movements [11]

Four modes are in each category, while five directional buttons indicating the direction of movements. A user layout that is similar to the original Vorpal gamepad (see Figure 6) of the robot is used to implement the complicated controlling method.
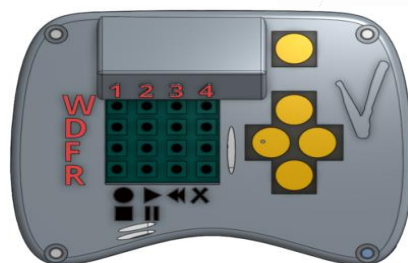

Figure 6: Gamepad for hexapod [11]

Android Studio with Java language is used to develop the following mechanism for the application. The application first requests for the Bluetooth permission and enables the Bluetooth. The application then automatically establishes a connection between hexapod and the phone. After the connection is established, the application simulates as the gamepad to send out formatted Bluetooth commands to hexapod communication packets for controlling the robot movements. Hexapod will perform corresponding actions after receiving these commands.

2.4 AR Gaming Environment

ARCore supported in Unity is used. It can augment images, animation and 3D object that is responsive to the reference images in real-world environment provided by the developer by using image recognition. As long as the players move their hands and keep the object under the camera, ARCore can track moving images on the object. With this technology, effects like smoking, burning can be augmented to the robot for better gaming experience. Apart from augmenting effects to the robot, the virtual terrain of the mansion and the enemies that the players have to fight with will also be augmented by recognizing the flat surface of the floors or walls by the flat surface recognition provided by ARCore. Using the above two recognition technology of ARCore, the game design is stated as follows. Players have to control the robot to walk through the augmented map for the mansion, picking up items such as keys to unlock the doors on the map, and gem to increase the power of attack and defense for fighting with the augmented computer-generated characters. In practical, some animations such as burning and 3D assets such as walls, characters like knights are designed and rendered into the virtual gaming environment by Unity after using ARCore to recognize the robot and the flat surface.

2.5 Combining Robot Controlling and AR Game

Since Unity supports importing Java source files as plugin for Android, only minor adjustments to the application for robot controlling is needed in order to convert it into a plugin that can be used by Unity. After building a gamepad-similar layout for controlling robot by Unity, each button and joystick in the layout will correspond to relative Bluetooth commands built in plugin. Therefore, the mechanics are as follows. After pressing the button or controlling the joystick in AR game built by Unity, Unity would receive an event to call the relative function from the plugin for Android. Bluetooth commands would be sent out by Android plugin and received by the robot to perform corresponding actions.

3 Discussion of Results

In the current stage, the robot controlling application was completed with some difficulties encountered during the process. For the AR gaming environment, basic operations of the game were built. Some simple AR elements were tested, where some limitations were discovered during the process. However, utilizing the AR technology to have a better correlation between the virtual gaming environment and the real-world environment is still working in progress.

3.1 Initial Findings

For the completed robot controlling application, the user interface of the application for robot controlling was designed (see Figure 7) to be similar to the original gamepad of hexapod, so as to simulate the gamepad for having complicated control of the robot. The functions of every button are explained in the figure. The user interface shown below is solely for demonstration purpose and will be replaced by corresponding controls of interface built in the AR game by Unity. Bluetooth connection between mobile phone and the robot and the Bluetooth commands used to control the movements of the robot were handled and tested to be succeed after that.
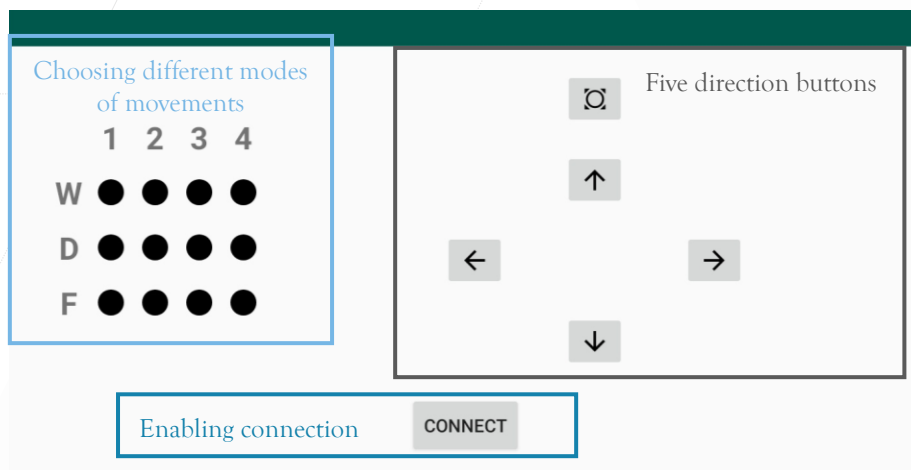

Figure 7: User interface to control hexapod

A simple map with terrain, items and enemies was built by Unity (see Figure 8). The background of the map is the real-world environment, and the virtual map that is augmented to the environment. There is a simple implementation to display the player's statistic on the left of the screen. Moreover, there is a joystick for temporary movement control of the player on the right of the screen.

Figure 8: Screenshot of AR gaming environment built

There are many different kinds of item with corresponding usage (see Table 1), players should pick up the items in order to upgrade his/her ability for fighting against the enemies. All these resources provided are fixed and not randomly generated due to the characteristic of fixed-value RPG mentioned above.

Item	Usage
Red gem	Power of attack +3
Blue gem	Power of defense +3
Red / Blue potion	Health Point (HP) +200 / +500
Gold	Money +200
Yellow / Red / Blue key	Pick up to open corresponding colored door
Key box	Yellow, red and blue key in hand +1

Table 1: List of items and usages

The enemies will not take the initiation to attack the player (see Figure 9). Once the player get close for a certain distance to the enemy, the enemy will start the attack (see Figure 10). However, the enemy will stop the attack when the players step back to keep a further distance. The system for players to fight back is left as future work to be done after the immigration of robot controlling feature to the AR game has been done.

Figure 9: Enemy on the map

Figure 10: Enemy attacks players

Although the AR camera was set up in the gaming environment, the terrain is not generated according to any object in the real-world currently. And yet, the recognition of the robot is not completed too. Therefore, the AR used in above gaming environment is not having any correlation to the real-world environment. To do so, some simple AR elements were tested, so as to ensure the basic knowledge on the usage of AR technology is equipped. Tested elements included augmenting 3D objects onto a referenced image in the real-world environment (see Figure 11), similar mechanism will be used to augment some 3D effects onto the hexapod; moreover, generating 3D objects onto a recognized flat surface (see Figure 12), this technology will be used to augment the virtual terrain onto the ground.

Figure 11: AR tested with image recognition   Figure 12: AR tested with flat surface recognition

3.2 Limitations and Difficulties Encountered

Bluetooth commands for controlling the movement of hexapod is completed, however, some technical difficulties were faced during the process. The initial approach was sending the Bluetooth commands once the button is pressed, but this may cause a continuous sending of commands. The hexapod may not have time and computation power to make response to any of the commands since it keeps receiving commands. Therefore, a regular time interval should be set to ensure only one command would be sent per time interval, even though some commands would be ignored if more than one buttons are pressed within the time interval. After trial and error, 1 second is found to be the best time interval to maximize the time given to hexapod for response and minimize the number of commands missed at the same time. Therefore, the application is set to send out formatted Bluetooth commands for controlling the robot movements in a regular time interval for 1 second.

During the testing of simple AR elements, a limitation of using ARCore was found. Since object recognition is not available in ARCore, image recognition is used. Therefore, in order to recognize the robot, the flat surface of the body of the robot is used for recognition by providing the reference images. However, the robot body is in plain color and without any characteristic features, this increases the difficulty of recognizing the robot by the AR camera, unless an image with many characteristic features is stuck on the robot body.

4 Future Work

The next step is to finish the incomplete work left for the current phase, that is to increase the level of correlation between the virtual and physical environment by utilizing AR technology. After that, the conversion of the robot controlling application into plugin will be carried out. Remaining gaming environment will be developed, some players will be invited to test the game at last. Table 2 below shows the proposed schedule for the remaining of the project.

Date	Work to be Completed
15 Feb 2020	Utilization of AR for increasing level of correlation between physical and virtual environment
29 Feb 2020	Conversion of robot controlling application into plugin for Unity
30 Mar 2020	Remaining gaming environment
5 Apr 2020	Player game testing
12 Apr 2020	Final adjustment
19 Apr 2020	Third deliverables: Final report, finalized tested implementation
20-24 Apr 2020	Final presentation
5 May 2020	Project exhibition

Table 2: Proposed schedule

5 Conclusion

The goal of this project is to provide a better gaming experience to players by blending physical and virtual gaming experience. In order to demonstrate the combination of the two, a single-player RPG adventure AR mobile game which supports the control of robots to do the adventure with the storyline will be delivered at the end of the project.

At this moment, the application for Android mobile phone to control the movement of hexapod is completed. Although the project encountered difficulties, ways to tackle down the difficulties are found. For example, the problem of frequent transmission of Bluetooth commands needed to be solved by setting a regular time interval for transmission.

Meanwhile, the development of AR gaming environment has started with a detailed game design, some basic operations of the game mechanics and tested with simple AR elements by using image recognition and flat surface recognition. However, the AR gaming environment will be developed under the limitation that only image recognition is used, which will increase the difficulty of recognizing the object comparing to object recognition.

The integration of real-world object and virtual environment to enhance the correlation between the physical and virtual environment by utilizing AR technology is working in progress. After the completion of the works in progress of current phase, the transformation of the robot controlling application into Unity plugin will be carried out.

References and Attributions

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