

**Mobile Game Development with Augmented Reality
for Ipoh Cave Attractions**

BY
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A REPORT
SUBMITTED TO
Universiti Tunku Abdul Rahman
in partial fulfillment of the requirements
for the degree of
BACHELOR OF COMPUTER SCIENCE (HONOURS)
Faculty of Information and Communication Technology
(Kampar Campus)

JUNE 2022

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It is hereby certified that Tan Jun Jie (ID No: 1806939) has completed this final year project/ dissertation/ thesis* entitled “ Mobile Game Development with Augmented Reality for Ipoh Cave Attractions ” under the supervision of Dr. Liew Soung Yue (Supervisor) from the Department of Computer and Communication Technology , Faculty/Institute* of Information and Communication Technology .

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ACKNOWLEDGEMENTS

I would like to take the opportunity to thank and express my appreciation and gratitude towards my supervisor, Dr. Liew Soun Yue who provided me the opportunity to take this project titled Mobile Game Development with Augmented Reality for Ipoh Cave Attractions. I would like to thank Dr. Liew Soun Yue for giving me a chance to engage in this Final Year Project, and also his guidance and supervision throughout this project. I would also like to give a special thanks to my friends and course mates for their support and encouragement during this project.

ABSTRACT

A lot of cave attractions located in Ipoh, Perak are yet to be discovered by foreign tourists. These cave attractions are like hidden gems awaiting tourists from other countries to discover them. In this project, a AR mobile game will be developed to tackle the problem mentioned just now. The mobile game to be develop will be able to integrate into those cave attractions in Ipoh, and thus enhance the travel experience of tourists who visit to those cave attractions. Not only that, the mobile game to be developed can also educate tourists about the information or history of cave attractions in an interesting way, so that tourists won't felt bored when they are exposed to these information. This indirectly also spread the history and information of the cave attractions to more and more tourists. The mobile game will also use Augmented Reality(AR) technology that we have now to further enhance the tourists travel experience, because AR games have the capabilities to immerse into a fictional worlds and impact events within that fictional world.

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Chapter 1: Introduction

1.1 Background Information

Augmented reality gaming, or AR gaming in short, is the combination or integration of game audio and visual content with the real time user's environment [1]. Most AR games are played using portable devices such as smartphones, tablets, and other portable gaming systems. In augmented reality, precreated environment are often superimposed on top of the user's real environment. Some simple AR game can be just Chinese chess that is played on a table surface or on the floor. Whereas AR games that are more advanced can have the ability to build an environment from the user current surroundings. For example, an in-game character that is driving a car from chairs to tables through virtual bridges. AR games improve and expands the gaming field. It takes the advantage of the various diversity of our real-world environment to make the game more interesting.

It is estimated that there will be 1.7 billion users of mobile augmented reality(AR) worldwide by year 2024 [2]. In contrast to year 2015, which there are only 200 million mobile AR users, it has already increase for 1.5 billion users, which is a huge amount of increment. It is also predicted that the market revenue for mobile AR worldwide will increased dramatically to 26 billion U.S. dollars in year 2025 [3]. As compared to year 2021, which is only 9.53 billions U.S. dollars, it is a huge increase in market revenue.

AR games are able to create meaningful experiences for players. This is because AR games allow players to immerse into a fictional worlds and impact events within that fictional world. Players' ability to relate with characters and experience positive and negative emotions through their decisions inside the game world can also be linked to a sense of meaning in games.

1.2 Problem Statement and Motivation

The first problem is that there are still many more tourist attractions in Malaysia that are yet to be discovered by foreign tourists. This includes lots of cave attractions in Ipoh, Perak. These cave attractions have their own histories and uniqueness that await to be explored. They are like hidden gems awaiting to be discovered by tourist from foreign countries.

To promote these cave attractions in Ipoh, one of the main challenges is the way to promote it and the way to spread their history and information in an interesting way. So, one way of doing it can be using an AR mobile game, which is an interesting method. However, most of the AR mobile games available currently are just for entertainment, for example, Pokémon GO and so on. We are now lacking with AR games that can combine with tourism,

where the game is integrating with those tourist attractions. With this, traveller or tourist can have more fun during their visitation to certain attractions, by playing AR games related to the attractions and enjoying their tour at the same time.

This is important because it can enhance the experience of the tour, leaving a deep impression to them. So, when they go back to their place, they might recommend their friends or relative to pay an visit to the places they've been to. This indirectly will also increase the number of tourist to certain attractions, and thus increasing the economy of Ipoh.

1.3 Project Scope

In order to tackle the problems mentioned previously, which is the lack of AR mobile games that are related to Ipoh cave attractions, the proposed solution will be an mobile augmented reality (AR) game for Ipoh cave attractions. The scope of the proposed solution will be several cave tourisms located in Ipoh, Perak such as Perak Cave temple, Kek Lok Tong Temple, Sam Poh Tong temple, Ling Sen Tong Temple, and Guanyin Cave. The aim of this project is to promote cave attractions in Ipoh, as well as enhance the experience of tourism that visit to cave attractions in Ipoh. This project also aims to increase the number of tourists travel to Ipoh cave attractions. This project contributes to the issue of the lacking of AR mobile games for Ipoh cave attractions by developing an AR mobile game specifically for cave attractions in Ipoh.

In the proposed AR mobile game, it will be a world with monster and magical creatures, as what we can think of when we first heard of cave is monster and creatures living in it. In the game, among those monsters and magical creatures, many of them are good but a portion of them likes to disturb tourists that visit the caves, some of them even like to capture tourist and eats them. So, the player's task is to find these bad monsters and magical creatures, defeat them and prevent them from disturbing and harming the tourist. After defeating them, players can choose to capture them and keep them as helper to help them out during battle, or just wipe them out. Each of the monster and magical creatures will have an element type. Element type in the game consist of water, fire, grass, rock, and wind. A monsters or magical creatures of each element will have their own special abilities. Besides that, the rarity of monsters and magical creature also varies from Common, Rare, Epic, Legendary, Unique. The higher the rarity, the lesser it will be seen by players, and the harder to defeat them as well as to capture them.

The game will have a map that is generated according to the player's surrounding, with a marker indicating their position on the map. Monsters and magical creature will be spawned on the map. To fight a monster or magical creature, players need to approach them and tap on them. This will bring them into the battle mode, where players are facing against the monster or magical creature and they need to defeat it. Other than monsters and magical creatures on the map, there is also a shop in this app. This shop allow players to buy items to capture those magical creatures. Some items are only available during certain events, so players need to be quick to purchase them.

Not only that, this games allow players to share the monsters or creatures they've captured using AR. Players can choose to turn on the AR option where the background of monsters and magical creatures displayed are the surroundings of the players.

Moreover, there are also minigames in this mobile game. One of the minigame is the quiz about the information of the cave they visit, and most of the answer of those questions are based on the information displayed during loading. So players need to be more alert on the information displayed. The more questions they answered correctly in the minigame, the higher the reward they will get.

Other than that, on the user profile, information such as player's name, their level, the total distanced they walked and so on will be displayed. The monsters or magical creatures they captured can also be seen on the collection page too.

1.4 Project Objective

There are 3 main objectives of this project, which includes :

- To promote tourism in Ipoh cave attractions so that more tourists will travel to Ipoh
- To develop a mobile game that uses augmented reality (AR) technology for Ipoh cave attractions
- To enhance the experience of tourists during their trip to Ipoh cave attractions

1.5 Impact, Significance, and contribution

This project will contribute to the travel experience of tourist that travels to Ipoh cave attractions through enhancing it using AR mobile gaming. Not only that, tourists will also being educated throughout their trip about the history and information of those cave attractions. After the tourist's travel experience to Ipoh cave attractions are being enhanced, they will be satisfied with their trip. When they go back, they will tell their friends or relatives that Ipoh cave

attractions is a fun place to visit, and they will more likely to visit Ipoh again. This will indirectly boost up the economy of Ipoh since there will be more tourist travelling to Ipoh. Besides that, cave attractions in Ipoh can also be discovered by more tourist.

1.6 Report Organization

There are a total of 7 chapters in this report. In Chapter 1, some background information, problem statement and motivation, the project solution, project objectives and the significance of this project are discussed. In Chapter 2, a literature review of gamification elements, gamification in tourism and augmented reality is presented. This chapter also includes review on some other similar applications. Whereas in Chapter 3, the system design diagram, such as the system architecture diagram and the methodology used will be discussed. For chapter 4, the system flowchart will be discussed. As for Chapter 5, the hardware and software used to develop this project, the implementation challenges and the system operation along with screenshots will be presented. Next, for Chapter 6, the system testing along with the results will be presented. Lastly, for Chapter 7, the conclusion of this project will be discussed.

Chapter 2: Literature Review

2.1 Gamification Elements

There are several elements in the aspect of gamification. Ranking, point scores, level, badges are gamification elements that are very commonly used in application of gamifications [7]. The point scores is used to measure the success that user has achieved. Level is used to let users have a feeling of their progress in the game. Whereas badges are used as a sign of appreciation to the user upon their successful completion of certain task or certain process. Badges can also be designed using psychological factors to make it more attractive.

Besides that, some another gamification elements are leaderboard, progress bars, avatars, and teammates. Leaderboard is used to maintain the motivation of users by entering their names to the leaderboard and they will be ranked based on certain criteria such as their total scores, the level they completed and so on. Progress bars are similar to levels, where it is used as the marker for user's progress in the game. Whereas for avatars, it is for representing the users in the game. We can also allow users to modify their avatar based on their preference, for example changing the outfit of their avatar. As for teammates, it can be other users or some non-player characters (NPCs).

Apart from that, storyline and meaningful story is also elements of gamification. Storyline is used in providing a narrative or storyline in the game. Whereas for meaningful stories, it is similar to storyline, but it mainly focus on the background of users, in order to make the effects of stories being more pronounced.

2.2 Gamification in Tourism

Technology is reshaping modern life, and its impact can be felt across each and every industry. The tourism industry is also heavily influenced by modern technology, and it is constantly striving to boost people's excitement. Gamification in tourism is one such attribute that provides both joy and excitement. Gamification in tourism means using gaming methods in tourism to digitally engage customers and motivate them to accomplish specific goals or objectives [4]. This improves the whole experience by making the entire visit to a specific tourist attraction more enjoyable, interesting, and interactive [4].

As we all know, nowadays almost each and everyone has a smartphone or tablet, so this makes engaging with visitors much easier via: Challenges, where people are asked to complete a puzzle or visit specific areas of the site and submit a photo to complete certain aspect of an assignment; Scores, where people are needed to complete certain task that they are assigned to,

and along the way this stimulates them to collect points as well as knowing how well they are progressing towards the goal; Leaderboards, since people are motivated to score higher and love to compete with their friends, this will put more fun into their experience; Rewards, where people will be awarded to titles and badges or able to unlock new levels when they accumulates certain number of points; and so on.

2.2.1 Benefits of Applying Gamification in Tourism

Gamification in tourism offer several benefits. One of the benefits is more engaged visitors [4]. The immersion level that games can offer are significant. People will be able to fully enjoy the experience of being at a specific place or sight, and as a result, that trip will be an unforgettable experience for them. Because people are so hesitant to start exploring new places, we need to give them a reason to do so, and providing them with an unforgettable experience will go a long way toward motivating them to visit some new places.

Besides that, gamification in tourism can also increase visitor loyalty [5]. When a customer is really satisfied with their experience, they are far more likely to come back. This could be done in a variety of ways. As an example, parents may wish to take their children to the museum, but they are concerned that their children will be bored and want to return home as soon as possible. If the museum has an interactive game that keep the kids engaged and make the trip more enjoyable, while also relieving some of the tension from the parents, they are far more likely to return and promote the museum to their friends.

Other than that, marketing for hospitality and tourism will also be improved [4]. As we all know, hospitality and tourism are the sectors that are impacted by all those lockdown restrictions. These sectors are using all kinds of marketing techniques to encourage people to start travelling. Thanks to gamification, brands can boost consumer loyalty by improving engagement and making their overall experience more enjoyable. While this isn't a new idea in the hospitality industry, using modern technologies and social media requires a fresh perspective.

2.2.2 Usage of Gamification in Touristic Apps

There are numerous ways in which the game has become an element of digital tourism communication. For instance, Intermediation tourism apps based on augmented reality, local thematic apps, or treasure hunt apps, are based on actual itineraries that unravel through the destination's POI (Points of Interest).

One interesting case is Nexto, which is a mobile app that turns traditional audio guides into augmented reality challenges, encouraging users to seek out new landmarks in order to earn badges, climb the ranking list, and unlock new, enjoyable levels [5]. Users can also listen to the guides through online or offline while virtually recreating ancient buildings, searching for famous objects that once belonged to people from earlier eras, and seeing known historical figures pop out of the screen.

Besides that, an app named Stray Boots, which is from Stray Boots Inc [5]. also offers touristic tours in New York. In this app, users are need to follow directions provided which will bring them to get in contact with POI, but most importantly, with real people.

Another app named TripCollective [5], which is the advanced program of TripAdvisor, also uses gamification. Users will be rewarded each time they add content into the main app. Users receive points for each action they make inside the portal, such as writing reviews, publishing photos, and sharing their scores. The more points users earn, the higher their level and acknowledgment for their contributions to the travel community. This level will be clearly visible on the user's traveler profile.

2.3 Augmented Reality Is the Future of Tourism

Using the most up-to-date technology, augmented reality development companies have revolutionised the gamification industry [6]. They primarily employ a variety of applications to explore and give comprehensive information about a variety of tourist destinations, which will always have a significant impact on tourist's knowledge.

Different devices are also being developed to make this possible and to make something that have huge impact on tourism sector. These devices have been added with a camera that always simulates the first person view and projects the tourist's real-time. These devices are known for implementing tracking and method for calculating the position of the proper virtual content, which always spikes interest of viewers to explore and come to a conclusion to make all of these things possible.

Gamification has the potential to provide unique and outstanding experience to tourists who travels to certain tourist places [6]. Game development companies are constantly attempting to meet the current gaming alternatives in order to meet the environment. It will be a tremendous step forward in creating something more significant, and it will certainly come with a great test that can't be obtained from any other source. Augmented reality development companies are a step forward in providing anticipated benefits that make the tourism sector more enjoyable.

Despite the advancement in information technology, we are still a long way behind from having pinpointed knowledge of any tourist places and its history. It is feasible to have all of these things in one go with the help of augmented reality.

2.4 Review on Similar Application

2.4.1 Pokémon Go

This is a location-based augmented reality (AR) mobile game released on 6 of July 2016. It is developed by Niantic Labs. This game is available on both iOS and Android devices. Pokémon is always about 2 things, catching creatures known as Pokémon, and use them to fight against opponents. So, the Pokémon Go bring those challenges to our real world by using augmented reality.

In this game, the player's role is a young Pokémon trainer. Players can search and collect different Pokémon in real-world locations, it can be either through walking, jogging, biking and so on. The real-world locations will be stimulated by a GPS tracking system that will follow players around the map [9]. This game also allows players to customize their avatar, such as changing the skin color, hair color, eye color, shirts, pants, shoes and so on. In the game, players can capture wild Pokémon, collect resources, and also visit training gyms. When Pokémon appear on the map, players can approach to them, and tap it to try to capture it. After players tap on it, their mobile device's camera will be launched. Then the Pokémon that we attempt to catch will be shown in AR, with our surroundings as the background. Players need to throw something called Pokeballs to the Pokémon to capture it. Players can also choose to capture the Pokémon using the AR technology and their mobile device's camera. If this option is turned on, when players are attempting to catch Pokémon, they background will be the player's surroundings and the Pokémon will be displayed on it, which gives a feel that the Pokémon exist in front of the players. An interesting fact is that Pokémon with certain element such as fire, water, ice, rock, grass and so on, will be spawned in certain biomes respect to it's element. For example, we can get more water Pokémon near the lake or rivers.

As for the training gym mentioned just now, they are a place where we can battle with other trainers(which are NPCs, not real players) or other boss Pokémon. These training gyms can be found throughout the map. These training gyms can be found more on downtowns areas of city [8]. Beside training gyms, there are also Pokestops in this game. Pokestops can be landmarks, buildings, or other objects that will give players bonuses such as Pokeballs and so

on when players pass by them. Pokestops are marked using blue boxes in the map. Figure 2.4.1 shows the main page with a map and player's avatar on it.

Next, some of strengths, limitations as well as recommendations of this AR mobile games, Pokémon Go will be discussed.

Strengths:

Customization of avatar – This game allow players to customize their avatar based on their preference. Huge variety of choices is available for user to customize their avatar.

Adding friends – Players can add their friend either by entering the account's code or by scanning their friend's account QR code. Then they can receive or send gifts to friends in the game.

Allow players to explore more – Due to the presence of Pokestops, players will go to places such as Museums to collect the rewards. Then players especially those younger ones will have the opportunity to explore these locations and understand more about the past.

Limitations:

Massive phone battery drains – This game eats up phone battery very much. This is because the game uses many sensors and resources at a time.

Limited game play – Some players complaint that same Pokémons is spawned repeatedly, and this makes the game a little boring.

Engaged in unlawful activity – Due to the game, players may be trespassing certain private properties, or may hospitalized others if they play the game when driving.

Imbalanced spawn points of training gyms and Pokestops – Players that are in some rural areas complaint about the lack of training gyms and Pokestops in their area. Spawn points of these training gyms and Pokestops are more weighted on urban centers and downtown areas.

Recommendations:

Control user when unlawful activity detected – Taking players playing the game while driving as an example. The game can detect the user's moving speed, if it exceeds a certain limit, then the game should display a warning to user and disable them to play until their speed if lowered down to normal speed.

Spawn more different Pokémon– The game can increase the spawn of different Pokémon at various location instead of always spawn the same Pokémon. This can increase the excitement

of players when they are playing the game, as they won't know what Pokémon they will approach to next.

2.4.2 Ingress Prime

This is a location-based augmented reality (AR) mobile game developed by Niantic Labs, and it is released on 5 of November 2018. This game is available for both iOS and Android devices. This game uses the player's device GPS to locate them in the game world, which also corresponds to our real world. Basically, this game is about 2 rival forces, namely *The Enlightened* and *The Resistance*, battling and fighting for the control of a mysterious energy source, "Exotic Matter", or "XM" in short. *The Enlightened* is the side that want to embrace this energy source, while *The Resistance* sees it as a potential threat that will cause harm to mankind.

The XM is the heart of this game [11]. Based on the storyline of this game, XM leaks to the world through the Portals. Both the forces, *The Enlightened* and *The Resistance* fight to control those Portals in order to control the XM. At the beginning of the game, players are required to choose a side, either *The Enlightened* or *The Resistance*. It is then followed by some tutorials on basic instructions, and players will begin to play. Players need to travel to real-world locations for gathering the XM and taking control of portals located around the local landmarks in order to gain a victory. They can do this by walking, driving, or biking.

Portals are set at several public points around the player's town. These portals normally located in somewhere near the monuments, statues, and historical buildings that exist in our real world. After player successfully captured the portal, they can link it with other portals that are captured. To capture a portal, players need to "hack" the portals and also waypoints, through pressing some button on-screen [10]. Large city will have more portals compared to small towns.

Besides that, there are also some specific missions that require players to visit certain places in the game, which is correspond to our real world. This game also comes with a global chat feature, where it allows players to chat with members of the same force. Moreover, in certain period of time, there will be some events offered by this game, which is called anomalies. These events are community events, and it gathers players together at a certain real world locations to fight for controls. Figure 2.4.2 shows the main page of the game with a map and an arrow indicating the player's current location.

Next, some of strengths, limitations as well as recommendations of this AR mobile games, Ingress Prime will be discussed.

Strengths :

Different playing styles – There several different ways to play this game. Players can do anomalies, do missions, or do glyph hacking.

Encourage social interaction – The game takes teams of players from one forces to take control of the portal run by another.

Global chat – The game allows players to chat with other players that are on the same force. This provide the opportunity for players to know more people on both locally(town) and regionally(state, country), and players can interact, collaborate with them

Limitations :

Lack of in-depth tutorial – The tutorial provided during the beginning of the game is very brief and short. This may cause confusion for new players where they don't understand how this game works and how to play it.

Flashy interface – The game has a flashy user interface. This can bring confusion to players.

Recommendations:

Provide more information during tutorial – In order to let players fully understand the basic gameplay of the game, sufficient tutorial should be given to the players before they start the game. The tutorial should also be in simple language that players are easy to understand.

2.4.3 Harry Potter: Wizards Unite

This is a location-based augmented reality (AR) mobile game is released on 21 of June 2018, and it is developed by Niantic Labs. This game is available for both iOS and Android devices. The storyline of this game is a series of events, known as the Calamity, has caused people, creatures, artifacts and memories from the Wizard world to diminish. The Calamity is also destroying the barrier between both the magical world and normal world, known as muggle world. It also scattered many magical beings and objects into the muggle world, and these many magical beings and objects are called 'foundables' in the game.

The role of players in the game is a new recruit witch or wizard of the Statue of Secrecy Task Force. Where the task of players is to explore the muggle world and make sure these foundables are returned back to the magical world before they are discovered. Besides that, there will also be an evil force, named 'confoundables', which players will battle with. Players can also team up with other players to complete their task.

In the game, there are 3 classes available for players to choose, which are Magizoologist, Auror and Professor. Each of these classes are represented by a known character from the Harry Potter movie. Besides that, each class will have different skill set with abilities to choose by the players. But players can switch between the class if they want to. Fortresses also exist in the game, where it has several floors that is full of enemies, which are non-playable characters (NPCs). The difficulties increase as players reach higher floors. So players can form a team with other players that consist of different classes to clear the enemies together [12]. Furthermore, players can also craft potions in the game by following certain recipes. 'Portkeys' are also available that is used to open up a portal, and it will teleport players to other locations, but these Portkeys need to buy using Gold in the game. Figure 2.4.3 shows the main page of the game with a map and player's avatar on it.

Next, some of strengths, limitations as well as recommendations of this AR mobile games, Harry Potter: Wizards Unite will be discussed.

Strengths :

Niantic parents account – For young players under 16, parents can create a Niantic parents account for their kids to play. This account allows parents to monitor and adjust the features that will be use by their child and parents can also change the safety settings.

Add friend – This game has a friends system which allow players to add their friend, and they can receive gifts from friends or raid the fortress with them.

Limitations :

No global chat – There is no global chat or some other communication that allows players to chat with other players across the globe, except players that are added to their friend list. This may limit the opportunities of players that wanted to know more people playing the game.

Recommendations:

Add in global chat feature – The game should have the global chat feature made available. This is because players can communicate with other players across the globe, they can made new friends and form a group to play the game. Or maybe if some player facing difficulties to pass a particular level, others can help out too through the global chat.

2.4.4 Jurassic World Alive

This is a location-based augmented reality(AR) mobile game developed by Ludia Inc., and it is released on 14 of March 2018. This game is available on both iOS and Android devices. This game's gameplay is similar to Pokémon GO, where player can approach to dinosaurs and extract their DNA to breed the dinosaurs, which is similar to catching Pokémons by throwing Pokeballs to them.

The extraction of dinosaur's DNA is through a helicopter dart-shooting mini-game [13]. Players need to extract certain amount of DNA then only the dinosaur can be breed. After player breed the dinosaurs, they can use them to fight with their opponents, wither in PvP battles, where players will fight with other players, or in the Campaign mode, where players are playing against non-playable characters(NPCs). Players can also evolve their dinosaurs, to increase it's health points, damage, speed and so on. Beside breeding the dinosaurs through extracting the DNA, players can also merge the DNA extracted to get new different dinosaurs. This can eliminate the player's boring experience where they always see the same dinosaurs repeatedly.

Dinosaurs are randomly spawned on the map, where generated through the players real location via their device's GPS. There are different classes of dinosaurs, which are Common, Rare, Epic, Legendary, Unique, and their rarity increase respectively. Besides that, supplies also exist in the map. But it is located at fixed location, where players can approach them to get their collection and loot. This game also consists of AR within the "Share your Collection" feature. It allows player to display dinosaurs they breed in their surrounding and take a snapshot of them. Figure 2.4.4 shows the main page of the game with a map and dot with radar around it indicating the player's current location.

Moving on, some of the strengths, limitations as well as recommendations of this AR mobile games, Jurassic World Alive will be discussed.

Strengths:

High quality graphic design – This game's models and animations are minimalistic. The dinosaurs also look very realistic, and they are represented by impeccable animations in some mode in the game.

Sufficient tutorial provided – Tutorial provided to players before the game starts are clear and concise, it give adequate knowledge about how to play the game and so on to the players before they start the game.

Has player-versus-player(PvP) mode – Instead of just battling with non-playable characters(NPCs), many players want to play against other real player. This feature makes the game more appealing and more competitive.

Limitations:

Low variety of actions in battle mode – In the battle mode, players can only choose either one action from 2 attacks or switch another dinosaur. There are relatively less choices of action for players, and might cause them to feel bored during the battle.

Recommendations:

Include more actions in battle mode – The game can have more actions included in the battle mode. For example, heal the dinosaurs that has low health points, use potions to increase the dinosaurs damage, and many more. This can increase the gameplay during the battle so that player won't feel bored.

2.4.5 Orna

This is a location-based augmented reality(AR) mobile game developed by OdieRpg, and it is released on 17 of June 2019. This game is available on both iOS and Android devices. This game combines both role-playing adventure and geocache-style real world treasure hunt. At the start of the game, players are required to choose 1 of the 3 classes, Warrior, Mage or Thief. There will be an upgrade of the class to roles such as 'Knight' or 'Archmage' available as player progress through the game [14].Different class will use different attacks and certain items are not available for purchase according to the classes that player choose.

Players can move around in the game by moving around in the real world just like other location-based AR mobile game. The map is also generated using the players real location. Monsters will be spawned randomly on the map. They vary in both level and type. Players can fight those monsters by approaching them and tap on them. During the fight, players and their opponents will take turns to attack each other until one of their health points turn 0. Besides attack, there are also some other actions that players can do during the fight. They can defend, flee, or use a skill or item. Defend will decrease the opponent's attack and flee will allow the player to run away from the fight.

Moreover, shops will sometimes pop-up on the map. It allows players to buy items such as potions weapons or other things that player may need to complete their quest. Some specific

shops like ‘Blacksmiths’ also exist in the map, where players can upgrade their gear there, and ‘Bestiary’ that let players to buy pets to assist them during their fight. Besides shops, dungeons also exist in the game. Players can enter them and battle against challenging random enemies. Players will get loots and experience points after they defeat those enemies. Figure 2.4.5 shows the main page of the game with a map and player’s avatar on it.

Next, some of the strengths, limitations as well as recommendations of this AR mobile games, Orna will be discussed.

Strengths:

Sufficient tutorial provided – Before the game starts, adequate tutorial on the basic knowledge of the game such as the how to fight a monster, how to navigate to certain page and so on are given to players.

Lots of monsters around – There are always monsters around to fight with. Players won’t have any hard time to find monsters. This is a good thing as players won’t feel bored and wander around finding no monsters to fight with.

Limitations:

Need to be ‘more social’ – This game need to include features that let players to engage some activities such as global chat, where it allows players across the globe to chat together. There is player-versus-player (PvP) mode in the game, but players are actually fighting with AI in this mode instead of fighting real people.

Recommendations:

Include global chat feature – Global chat can be included in the game to let players chat with each other. This can make them feel the game is more social and can feel there’s a community of the game.

2.4.6 Strength & Limitation of AR Mobile Games Summary

AR Mobile Game	Strengths	Limitations
Pokémon GO	<ul style="list-style-type: none"> • Customization of avatar • Adding friends • Allow players to explore more 	<ul style="list-style-type: none"> • Massive phone battery drains • Limited game play

		<ul style="list-style-type: none"> • Engaged in unlawful activities • Imbalanced spawn points of training gyms and Pokestops
Ingress Prime	<ul style="list-style-type: none"> • Different playing styles • Encourage social interaction • Global chat 	<ul style="list-style-type: none"> • Lack of in-depth tutorial • Flashy interface
Harry Potter: Wizards Unite	<ul style="list-style-type: none"> • Niantic parents account • Adding friends 	<ul style="list-style-type: none"> • No global chat
Jurassic World Alive	<ul style="list-style-type: none"> • High quality graphic design • Sufficient tutorial provided • Has player-versus-player(PvP) mode 	<ul style="list-style-type: none"> • Low variety of actions in battle mode
Orna	<ul style="list-style-type: none"> • Sufficient tutorial provided • Lots of monsters around 	<ul style="list-style-type: none"> • Need to be 'more social'

Table 2.4.6 Strength and Limitations Summary

Chapter 3: System Methodology / Approach

3.1 System Design Diagram

3.1.1 System Architecture Diagram

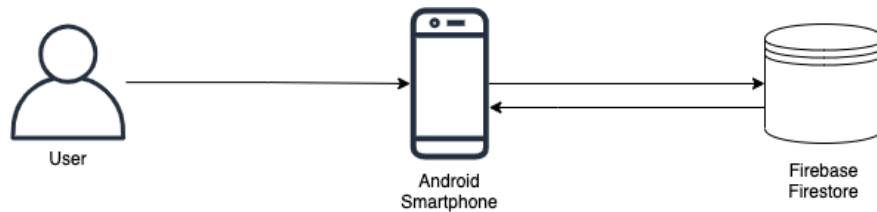


Figure 3.1.1-1 Client Server Architecture

The system architecture design used in this project is Client Server Architecture. Firebase Firestore will be used as the backend database of this project. Data needed in this project will be stored in Firebase Firestore. For example, when user create a new account, the data of this user will be stored into a 'Users' collection in Firebase Firestore. Not only that, there will also be a few more collections stored in Firebase Firestore, where one of it is 'Monsters' collection, which stores the information and data of all monsters. In the mobile application, data needed will be retrieved from Firebase Firestore.

3.1.2 Methodology and General Work Procedure

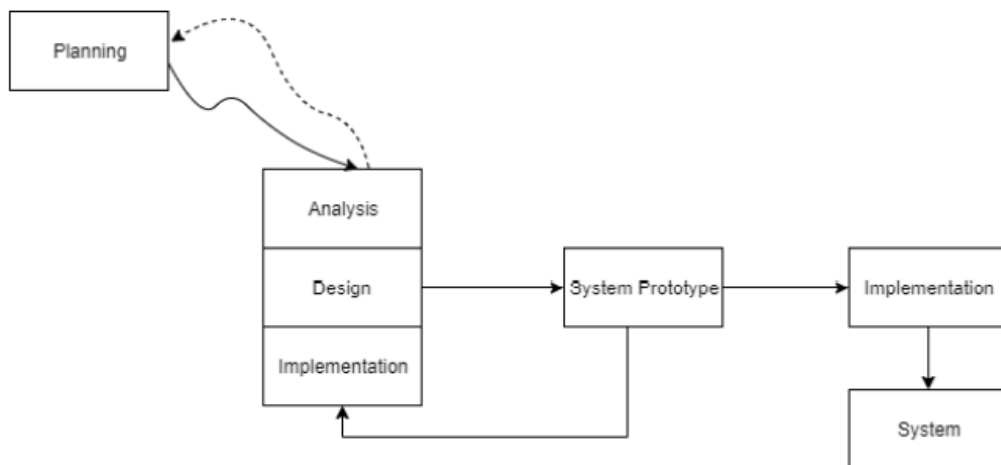


Figure 3.1.1-2 Rapid Application Development

The methodology to be used in this project is Rapid Application Development. It is a prototyping-based methodology. The reason of choosing this methodology is because it is suitable for projects with short development time, where it suits this project as the development time for this project is less than a year. First, planning phase and analysis phase will be carried

out. During these 2 phases, the project background, previous work by others, as well as some problems that we currently have will be studied and analyzed. Then, a clear understanding on the project to be developed should be done. After that, the design phase of the first prototype of this project will be done and it will be implemented. After the first prototype is done, it is followed by the design and implementation of the second prototype. Then the third prototype will be designed and implemented, and the cycle goes on until the final version of the project is developed. It is then followed by the validation and verification of the final version of the project.

Chapter 4 : System Design

4.1 System Flowchart

Figure 4.1-1, Figure 4.1-2, Figure 4.1-3, and Figure 4.1-4 shows the system flowchart of this mobile application. The first screen shown to user is the Sign In Screen. If the user doesn't have an account, they can proceed to create one, where they will be directed to the Sign Up Screen. They will be needed to input the username, email, and password to create a new account. Then the app will check if there is any exception or errors occur, such as wrong email format. If there is, user will be needed to insert those information again. If there isn't any error, their new account will be created using Firebase Authentication service. Then they will be directed back to the sign in screen.

For user that has an account, if they forgot their password, they can choose to reset password, which they will be directed to Forgot Password Screen. They will be required to input their email to get the email for resetting their password. Then the app will check if there is any exceptions or errors such as wrong email format. If there is error, they are needed to enter their correct email. If there are no errors, an email to reset password will be sent to the email they entered just now. Then they can proceed to reset their password, and sign in using their new password.

For the sign in process, user are needed to input the email and password. If the email and password inputted are correct without any error, Firebase authentication will be used to sign user in. Then they will be directed to a Splash Screen, where all necessary data are being initialize and ready here. After these data are ready, user will be directed to the Home Screen. Home Screen has a bottom navigation bar that can navigate to 5 different screens, which are store screen, collection screen, main screen, inventory screen and profile screen.

If the user wish to go to Main Screen, they will be navigated to the Main Screen. Then, there are 2 buttons in this screen, Map button and Minigame button. If user pressed Map button, they will be directed to the Main Screen, but a Loading Screen will show first while loading those necessary data. When user reach Map Screen, the app will get the user's current location, and display it on a map with a marker. If the user's location has changed, the app will get the new location again and update it on the map. Around the cave attraction's location, there will be several randomly spawned markers, if user pressed on these markers, they will be directed to the Choose Item Screen, where those item that user has will be retrieved from Firestore and display out for user to choose which to use. After user has chosen one item, they will be directed to the Capture Monster Screen. Then if user press on the capture monster button, the animation of capturing monster will be started. Then the app will generate a random probability number. If the number is larger than 0.3, it means the monster is captured successfully, data will be updated to Firestore and user will be directed back to the Main Screen, otherwise it means capture failed, and user will be directed back to the Main Screen.

If user pressed on the Minigame button, a dialog box will pop up asking user to choose the minigame they want to play. There are 2 choices, Hangman and quiz. If user chose Hangman, they will be directed to Hangman Screen, and a random word will be retrieved randomly from a word collection stored in Firestore. Then if the user guess the word within the maximum number of tries, they win the game, coins will be rewarded and data will be updated in Firestore, user will then be directed back to the Main Screen, otherwise they lose the game and will be directed back to Main Screen. If user chose Quizz, 5 questions will be randomly retrieved from a collection of questions stored in Firestore. After that, user will answer those questions, and will be rewarded coins based on the score they get, data will be updated to Firestore and user will then be directed back to the Main Screen.

If user wish to go to Store Screen, they will be navigated to the Store Screen. Items available to be sold will be displayed on screen. If user press the button to buy that item, a dialog box will pop up to let user select the quantity they want to buy. Then the app will check whether user have enough coins to buy the items. If enough coins, purchase successful and data will be updated to Firestore. Otherwise a message of not enough coins will be prompted to user.

If user wish to go to Collection Screen, they will be navigated to the Collection Screen. The monsters caught by user will be retrieved from Firestore, and being displayed on screen. If user pressed on one of the monster, they will be directed to Monster Detail Screen, where the data of respective monster will be retrieved from Firestore, and display on screen to the user.

If user press on the button to show monster using AR, they will be directed to AR Screen, where a 3D model will be displayed on the user's surrounding using AR. If user pressed the back button twice, they will be directed back to the Collection Screen and can choose to navigate to other screens.

If user wish to go to Inventory Screen, they will be navigated to the Inventory Screen. The data of user's item that they currently have will be retrieved from Firestore and being displayed on screen to the user.

If the user wish to go to the Profile Screen, they will be navigated to the profile screen. The app will first retrieve data of the user from Firestore, and display it on screen. If the user wants to edit settings, they will be navigated to the Settings Screen. In the settings screen, user can choose to edit their profile, change email, change password or sign out. If the user wish to edit their profile, they will be directed to the Edit Profile Screen. User can then edit their username or change their avatar. If the changes they made doesn't have any error, it will be updated to Firestore. If the user wants to change email, a change email dialog box will pop up. User can then input their password and the new email they want. If none error occurred, the new email they entered will be updated to Firebase using Firebase Authentication. If user wants to change password, a change password dialog box will pop up. User can then input their current password and the new password they want. If none error occurred, the new password they entered will be updated to Firebase using Firebase Authentication. If user wants to sign out, they will be signed out using Firebase Authentication, and when this process finished, they will be directed back to the Sign In Screen.

Chapter 5: System Implementation

5.1 Hardware Specifications

The hardware to be used is a 16-inch MacBook Pro 2019. It is running Macintosh Operating System and having a 2.6 GHz 6-Core Intel Core i7 processor. Besides that, it has a RAM of 16 GB 2667 MHz DDR4. Besides that, the graphics of this device is Intel UHD Graphics 630 1536 MB.

Operating System	Macintosh OS
Processor	2.6 GHz 6-Core Intel Core i7
RAM	16 GB 2667 MHz DDR4
Graphics	Intel UHD Graphics 630 1536 MB

Table 5.1 Hardware Specification

5.2 Software Specifications

In this project, Visual Studio Code, famously known as VS code, is used to develop the AR mobile game. Besides VS code, Flutter and Firebase are also used in this project, where Flutter is the framework used in developing the AR mobile game, and Firebase is used as the backend of the mobile game to store data such as user account and manage user accounts.

Visual Studio Code (VS Code)

This is a free open-source text editor created by Microsoft. It is a relatively lightweight text editor. Although it is lightweight, still it has some powerful features embedded in it. VS Code is made available for all Linux, Windows, and MacOS

Flutter

This is a free and open-source mobile user interface(UI) framework. It is released in May 2017 and developed by Google. It allows us to develop native mobile applications with only 1 codebase. In other words, we only need to use 1 programming language and 1 code base to create 2 different applications for both iOS and Android platforms. Flutter has 2 important parts, a software development kit (SDK) and a framework (UI library based on widgets). The SDK consists of tools that allow us to compile our code into native machine code (for both iOS and Android). Whereas the framework is a set of reusable UI elements, such as text inputs, buttons, sliders and many more that we can customize in to match our own needs.

The reason of choosing Flutter is because it has its own rendering engine. Flutter let developers to do lots of stuff with our application what are not available on other platforms. It uses Skia to render itself onto a platform-provided canvas. UI built in Flutter are capable to be launched virtually on any platform due to the engine. In other words, when we are transferring to another platform, we don't have to adjust the UI. This significantly simplifies the development process.

Firestore

Firestore is a Backend-as-a-Service(BaaS) developed by Google. It provides developers a set of different tools and services that normally developers have to build themselves. The tools and services provided by Firestore are analytics, authentication, configuration, database, file storage, push messaging, machine learning, and many more. These services are hosted in the cloud. Developers just need to use the client SDKs provide by Firestore to interact with those backed services without needing to establish any middleware between the service and out applications.

To be more specific, the services and tools to be used in this project are Firestore Authentication and Cloud Firestore. Firestore Authentication is basically a Google authentication feature tailored for applications that uses Firestore. It allows us to make use of the pre-built UI or create custom UI for user authentication. It also provides user login through custom credentials, social media or emails. So Firestore Authentication will be used for user authentication or user login in this project.

Whereas Cloud Firestore is a cloud-hosted real-time database that supports NoSQL. Cloud Firestore is actually designed for use in enterprise, where it entails scalability, advanced querying options, and complex data models. We can use the Firestore console to view data stored in the database, as well as modifying or deleting data. So in this project, the database used to data will be Cloud Firestore.

5.3 System Operation

5.3.1 Sign In Screen

Figure 5.3.1-1 shows the sign in screen of this mobile app. This sign in screen is to allow users to sign in their account. Users need to input their email and password, and then press the sign in button to sign themselves in. Firestore Authentication is used in this sign in process. If there are any exceptions or error occur during the sign in process, it will be prompted to the user

using Flutter's `SnackBar`, and user will need to try to sign in again. After user has successfully signed in, they will be directed to the Home Screen, which will be discussed below.

5.3.2 Sign Up Screen

For user who is new to the app and doesn't have an account, they can create a new account. Figure 5.3.2-1 shows the sign up screen of this mobile app. The sign up new account process is also done using Firebase Authentication service. User will need to enter the nickname they want, their email, and a password for the new account. Similarly, any exceptions or errors occurred during signing up will have error message prompted to user using Flutter's `SnackBar`, and they need to try again. After they signed up successfully, they will be directly directed to the Home Screen

5.3.3 Forgot Password Screen

There might be situations when a user has forgotten his or her password, so this mobile app includes a reset password function. Figure 5.3.3-1 shows the forgot password screen. This allows user to reset their forgotten password by entering their email. Then, an email which contain a link to reset their password will be sent to the email they entered just now. Any error occurred will also be displayed to user. After they reset their password successfully, they can use that new password to sign in to their account.

5.3.4 Home Screen

This is a screen that contains a bottom navigation bar. And user can use this navigation bar to navigate through and forth 5 different screens, which are Main Screen, Collection Screen, Store Screen, Inventory Screen and Profile Screen. All these screens will be discussed below.

5.3.5 Main Screen

Figure 5.3.5-1 shows the main screen of this mobile app. It basically has 2 buttons, Map button and Minigames button. If user press the Map button, they will be directed to the Map screen. Whereas if user press Minigames button, a dialog box will be prompted to user, which is shown in Figure 5.3.5-2, where user can choose the minigame they want to play. There are 2 choices, Hangman and Quizz, and each of them will direct user to the Hangman Screen and Quizz Screen respectively.

5.3.6 Collection Screen

Figure 5.3.6-1 shows the collection screen of this mobile app. This screen will display all the monsters that users catch previously. These data are read from Firebase Firestore, and being displayed on this screen. Each monster's name, their element type, and their picture will be displayed. And if user tap on one of these monsters, they will be directed to the Monster Detail Screen, which will be discussed next. There is also a Reward button located on the bottom right of this screen. User will be directed to the Reward Screen is they pressed this button.

5.3.7 Monster Detail Screen

Figure 5.3.7-1 shows the monster detail screen of this mobile app. This screen will display the details of the selected monster, such as name, element type, height, weight, spawn time, weaknesses, and also it's image. All these data are being retrieved from Firebase Firestore. There is also a back button on the top left corner to navigate back to the collection screen. Whereas on the top right corner, there is a button that will direct user to the AR Screen when user pressed on it.

5.3.8 Reward Screen

Figure 5.3.8-1 shows the Reward Screen of this mobile app. This screen will display all the different combination of the monster that user need to collect in order to claim reward from the counter of the cave attraction. There is also a info button on the top right corner of the screen that will show user the steps and procedures to claim their reward.

5.3.9 AR Screen

Figure 5.3.9-1 shows the AR Screen of this mobile app. This screen is being integrated with ARCore, which allow user to display 3D models on their surrounding. Initially, the 3D models being displayed using AR should be the respective monsters, but due to the time constraints, there aren't enough time to draw out the 3D models, so a 3D models that is loaded from the internet will be displayed to demonstrate the concept.

5.3.10 Store Screen

Figure 5.3.10-1 shows the Store Screen of this mobile app. This screen is to allow user to buy items to be used when catching monsters. There are total of 6 items with different prices that user can buy. When user press the button to buy the item, a dialog box will be prompted to user,

which can be seen in Figure 5.3.10-2. User can then choose the quantity they want to buy, and press the purchase button. Then the app will check whether the user have enough coins to buy, if enough, the purchase will be successful and data will be updated to Firebase Firestore. Otherwise it will notify user about the insufficient of coins.

5.3.11 Inventory Screen

Figure 5.3.11-1 shows the Inventory Screen of this mobile app. This screen will show users the item they bought and the respective quantity they have currently. All these data are being retrieved from Firebase Firestore.

5.3.12 Map Screen

Figure 5.3.12-1 shows the Map Screen of this mobile app. This screen will get the user's current location, and display it on the map of this screen with an avatar marker on it indicating the user's current position. A location changed listener is also attached, so that when the user moves, the listener will update this new location data and display the user's new position on the map. This is achieved by integrating the Google Map Service into this mobile app. Besides that, several warning markers will also be randomly spawned around the cave attractions. This indicates that there are monsters detected in that location. So user can press on that marker, and a dialog box will be prompted to user, telling user to defeat and capture the monster, which can be seen in Figure 5.3.12-2. Then if user press the Go button, they will be directed to the Choose Item Screen to choose the item to capture the monster.

5.3.13 Choose Item Screen

Figure 5.3.13-1 shows the Choose Item Screen of this mobile app. This screen will display out the items that the user has, and ask them to choose one to be used to capture the monster. It will also display the monster detected, as this is random, user won't know which monster they will be capturing when in the Map Screen. After choosing one item, user will be directed to the Capture Monster Screen.

5.3.14 Capture Monster Screen

Figure 5.3.14-1 shows the Capture Monster Screen of this mobile app. This screen will let user to capture the monster using the item they spawned. And it is not guaranteed the monster will

be captured successfully, there is possibility that the monster will run away. Depending on the item that user choose, which can increase the chances of capturing the monster.

5.3.15 Loading Screen

Figure 5.3.15-1 shows the Loading Screen of this mobile app. In this screen, information about the cave attractions will be shown to user while they are waiting for the load. User need to pay attention to these information as one of the minigame, Quizz, will ask question based on these information displayed.

5.3.16 Quizz Screen

Figure 5.3.16-1 shows the Quizz Screen of this mobile app. This is one of the minigame of this mobile app. It has several pages, where each page will display one question to user and user need to answer the question. All these questions are being retrieved from Firebase Firestore. The last page will be the result, where the user's result will be displayed and the higher score the user get, the more coins they will be rewarded.

5.3.17 Hangman Screen

Figure 5.3.17-1 shows the Hangman Screen of this mobile app. This is another minigame of this mobile app. First, a word will be retrieved randomly from Firebase Firestore, where a collection of words are being stored there. Then user will need to guess out the word by guessing it alphabet by alphabet. There are limited tries allowed, if user guess the word within the tries limit, they win the game and coins will be rewarded, otherwise they will lose the game and get nothing.

5.3.18 Profile Screen

Figure 5.3.18-1 shows the Profile Screen of this mobile app. This screen will display the user's information, such as their nickname, level, number of monster caught, total experience points, date they start to play this game, and also their avatar. All these data are retrieved from Firebase Firestore. A realtime listener is also attached, so that if any of these data are being changed or modified, the data displayed on screen will be updated on the spot. On the top right corner of this screen, there is a setting button, which will bring user to the Settings Screen when they press it.

5.3.19 Settings Screen

Figure 5.3.19-1 shows the Settings Screen of this mobile app. In this screen, there are 3 subsections, which are main settings, account, and information. Main settings has the settings for SFX. User can toggle the switch to turn on or off the SFX. In the account subsection, user can edit their profile, change email and change password, these will be discussed below. Whereas for the information subsection, user can press to view the About page and Credits page of this mobile app.

5.3.20 Edit Profile Screen

In Figure 5.3.19-1, we can see that there is a button for user to edit their profile. When user pressed this, they will be directed to edit profile screen, which can be seen in Figure 5.3.20-1. User can change their avatar, by pressing on the edit button located at the bottom right corner of the avatar, which can be seen in Figure 5.3.20-2. By changing this avatar, not only it will be updated on their profile, the avatar marker on the Map Screen will also be updated to the avatar that user chose. Next, user can also edit their nickname, by entering the nickname they want in the text field and click save. Then this data will be updated to Firestore. If user press the cancel button, no data will be updated on Firestore.

5.3.21 Change Email Button

Figure 5.3.19-1 shows that there is a button for user to change email. When user pressed on this, a dialog box will pop up, which can be seen in Figure 5.3.21-1. This is to let user change their account's email. To change their email, user need to first enter their password, and then insert the new email they want. After that, Firebase Authentication service will be used to update the user's email. If any error occurs, error message will be prompted, and user may need to try changing it again.

5.3.22 Change Password Button

Figure 5.3.19-1 shows that there is a button for user to change password. When user pressed on this, a dialog box will pop up, which can be seen in Figure 5.3.22-1. This is to let user change their account's password. To change their password, user need to first enter their current password, and then insert the new password they want. After that, Firebase Authentication service will be used to update the user's password. If any error occurs, error message will be prompted, and user may need to try it again.

5.3.23 About Screen

Figure 5.3.23-1 shows the About Screen of this mobile app. This screen display some information about the mobile app.

5.3.24 Credits Screen

Figure 5.3.24-1 shows the Credits Screen of this mobile app. This screen display credits to some other site.

5.3.25 Sign Out Button

Figure 5.3.19-1 shows that there is a button for user to sign out their account, which is located on the bottom of the screen. When user pressed on this, they will be signed out, and being navigated to the sign in screen again. This sign out process is done using Firebase Authentication service.

5.4 Implementation Issues and Challenges

Not much issues are encountered during the implementation of this AR mobile game, but there are 2 main issues and challenges faced. First, during the early phase, one of the biggest issues faced was learning how to use flutter. This is because a lot of materials and tutorial video found on YouTube are outdated and contain certain errors. Since newer version of Flutter introduces null safety, so those material and tutorial videos produce these null safety errors. This caused additional time is spend on understanding and learning these kinds of errors and the way to fix and avoid it. Next, when implementing the AR part of this mobile game, one problem arises is that the ARCore plugin itself has errors. So I need to find another plugin that allows using AR with ARCore to replace this plugin with error.

Chapter 6: System Evaluation and Discussion

6.1 System Testing

6.1.1 Sign In

Test Case	Expected Result	Actual Result	Status
Leave email field empty	Display error message	Display error message	Pass
Leave password field empty	Display error message	Display error message	Pass
Insert invalid email format	Display error message	Display error message	Pass
Insert wrong password	Display error message	Display error message	Pass
Insert email and password for account that doesn't exist	Display error message	Display error message	Pass
Insert correct email and password	Display "Signed In Successfully" and direct to Home Screen	Display "Signed In Successfully" and direct to Home Screen	Pass
Press "Forgot Password?"	Direct to Forgot Password Screen	Direct to Forgot Password Screen	Pass
Press "Sign Up"	Direct to Sign Up Screen	Direct to Sign Up Screen	Pass

Table 6.1.1 System testing for Sign In

6.1.2 Sign Up

Test Case	Expected Result	Actual Result	Status
Leave email field empty	Display error message	Display error message	Pass
Leave password field empty	Display error message	Display error message	Pass
Leave username field empty	Display error message	Display error message	Pass
Insert invalid email format	Display error message	Display error message	Pass
Insert email that already exist	Display error message	Display error message	Pass
Insert username, email, password in correct format	Display "Account created Successfully" and direct to Home Screen	Display "Account created Successfully" and direct to Home Screen	Pass
Press back button	Direct back to Sign In Screen	Direct back to Sign In Screen	Pass

Press “Sign Up”	Direct to Sign Up Screen	Direct to Sign Up Screen	Pass
-----------------	-----------------------------	-----------------------------	------

Table 6.1.2 System testing for Sign Up

6.1.3 Forgot Password

Test Case	Expected Result	Actual Result	Status
Leave email field empty	Display error message	Display error message	Pass
Insert correct email format	An email with reset password link sent to the email inserted	An email with reset password link sent to the email inserted	Pass
Reset password using the link sent to email	Able to sign in using new password	Able to sign in using new password	Pass
Press back button	Direct back to Sign In Screen	Direct back to Sign In Screen	Pass

Table 6.1.3 System testing for Forgot Password

6.1.4 Home Screen

Test Case	Expected Result	Actual Result	Status
Press on Store in bottom navigation bar	Navigate to Store Screen	Navigate to Store Screen	Pass
Press on Collection in bottom navigation bar	Navigate to Collection Screen	Navigate to Collection Screen	Pass
Press on Home in bottom navigation bar	Navigate to Main Screen	Navigate to Main Screen	Pass
Press on Inventory in bottom navigation bar	Navigate to Inventory Screen	Navigate to Inventory Screen	Pass
Press on Profile in bottom navigation bar	Navigate to Profile Screen	Navigate to Profile Screen	Pass

Table 6.1.4 System testing for Home Screen

6.1.5 Main Screen

Test Case	Expected Result	Actual Result	Status
Press on Map button	Navigate to Map Screen	Navigate to Map Screen	Pass
Press on Minigames button	Pop up dialog box to choose minigame	Pop up dialog box to choose minigame	Pass

Table 6.1.5 System testing for Main Screen

6.1.6 Store Screen

Test Case	Expected Result	Actual Result	Status
Press on button to buy item	Pop up dialog box to choose quantity	Navigate to Map Screen	Pass
Press on cancel button in dialog box	Dismiss dialog box	Pop up dialog box to choose minigame	Pass
Press on purchase button in dialog box	Check enough coins or not. Enough coins, update data to Firestore. Not enough coins, prompt message to user.	Check enough coins or not. Enough coins, update data to Firestore. Not enough coins, prompt message to user	Pass

Table 6.1.6 System testing for Store Screen

6.1.7 Inventory Screen

Test Case	Expected Result	Actual Result	Status
Display items with respective quantity that user has	Quantity are tele with data stored in Firestore	Quantity are tele with data stored in Firestore	Pass

Table 6.1.7 System testing for Inventory Screen

6.1.8 Collection Screen

Test Case	Expected Result	Actual Result	Status
Display monster that user had caught	Monster are tele with data stored in Firestore	Monster are tele with data stored in Firestore	Pass
Press on monster	Navigate to Monster Detail Screen	Navigate to Monster Detail Screen	Pass
Press on reward button	Navigate to Reward Screen	Navigate to Reward Screen	Pass

Table 6.1.8 System testing for Collection Screen

6.1.9 Monster Detail Screen

Test Case	Expected Result	Actual Result	Status
Display monster details that user pressed on	Monster details are tele with data stored in Firestore	Monster details are tele with data stored in Firestore	Pass
Press on AR button	Navigate to AR Screen	Navigate to AR Screen	Pass
Press on back button	Redirect back to Collection Screen	Redirect back to Collection Screen	Pass

Table 6.1.9 System testing for Monster Detail Screen

6.1.10 AR Screen

Test Case	Expected Result	Actual Result	Status
Press on add monster button	A 3D model being displayed on the user's surrounding	A 3D model being displayed on the user's surrounding	Pass
Press on back button	Redirect back to Monster Detail Screen	Redirect back to Monster Detail Screen	Pass

Table 6.1.10 System testing for AR Screen

6.1.11 Reward Screen

Test Case	Expected Result	Actual Result	Status
Press on info button	Pop up a dialog box with procedure to claim reward	Pop up a dialog box with procedure to claim reward	Pass
Press on back button	Redirect back to Collection Screen	Redirect back to Collection Screen	Pass

Table 6.1.11 System testing for Reward Screen

6.1.12 Map Screen

Test Case	Expected Result	Actual Result	Status
User walks (location changes)	Marker indicating move along as user walks	Marker indicating move along as user walks	Pass
User press warning marker on screen	Pop up dialog box telling user to capture monster	Pop up dialog box telling user to capture monster	Pass
User press go button on dialog box	Navigate to Choose Item Screen	Navigate to Choose Item Screen	Pass
User press cancel button on dialog box	Dismiss dialog box	Dismiss dialog box	Pass
User press rotate left button	Rotate map view clockwise	Rotate map view clockwise	Pass
User press rotate right button	Rotate map view anti-clockwise	Rotate map view anti-clockwise	Pass

Table 6.1.12 System testing for Map Screen

6.1.13 Choose Item Screen

Test Case	Expected Result	Actual Result	Status
Display items with respective quantity that user has	Quantity are tele with data stored in Firestore	Quantity are tele with data stored in Firestore	Pass
User press on item that they want	Navigate to Capture Monster Screen	Navigate to Capture Monster Screen	Pass

Table 6.1.13 System testing for Choose Item Screen

6.1.14 Capture Monster Screen

Test Case	Expected Result	Actual Result	Status
User press on capture monster button	Generate random probability number	Generate random probability number	Pass
Random probability number generated less than 0.3	Capture fail, redirect user back to Main Screen	Capture fail, redirect user back to Main Screen	Pass
Random probability number generated more than or equals to 0.3	Capture success, update data to Firestore, redirect user back to Main Screen	Capture success, update data to Firestore, redirect user back to Main Screen	Pass

Table 6.1.14 System testing for Capture Monster Screen

6.1.15 Hangman Screen

Test Case	Expected Result	Actual Result	Status
User guess word correctly within number of tires	Reward coins, update data to Firestore, redirect user back to Main Screen	Reward coins, redirect user back to Main Screen	Pass
User unable to guess word correctly within number of tires	Game over, redirect user back to Main Screen	Game over, redirect user back to Main Screen	Pass
User press on back button	Redirect user back to Main Screen	Redirect user back to Main Screen	Pass

Table 6.1.15 System testing for Hangman Screen

6.1.16 Quizz Screen

Test Case	Expected Result	Actual Result	Status
User answer question correctly	Score awarded	Score awarded	Pass
User answer question wrongly	No score awarded	No score awarded	Pass
User press next question button	Go to next question page	Go to next question page	Pass
User finish answer all question	Reward coins based on score	Reward coins based on score	Pass
User press back button	Redirect user back to Main Screen	Redirect user back to Main Screen	Pass

Table 6.1.16 System testing for Quizz Screen

6.1.17 Profile Screen

Test Case	Expected Result	Actual Result	Status
Display user information on screen	Information displayed are tele with data stored in Firestore	Information displayed are tele with data stored in Firestore	Pass
User press settings button	Navigate to Settings Screen	Navigate to Settings Screen	Pass

Table 6.1.17 System testing for Profile Screen

6.1.18 Settings Screen

Test Case	Expected Result	Actual Result	Status
User press edit profile button	Navigate to Edit Profile Screen	Navigate to Edit Profile Screen	Pass
User press change email button	Pop up dialog box to change email	Pop up dialog box to change email	Pass
User press change password button	Pop up dialog box to change password email	Pop up dialog box to change password email	Pass
User press about button	Navigate to About Screen	Navigate to About Screen	Pass

User press credits button	Navigate to Credits Screen	Navigate to Credits Screen	Pass
User press sign out button	Sign user out using Firebase Authentication	Sign user out using Firebase Authentication	Pass
User press back button	Redirect user back to Profile Screen	Redirect user back to Profile Screen	Pass

Table 6.1.18 System testing for Settings Screen

6.1.19 Edit Profile Screen

Test Case	Expected Result	Actual Result	Status
User change nickname and press save button	Update data to Firestore, redirect user back to Settings Screen	User change nickname and press save button	Pass
User press change avatar button	Pop up dialog box to change avatar	User press change avatar button	Pass
User change avatar	Update data to Firestore, dismiss change avatar dialog box	User change avatar	Pass
User press cancel button	Discard changes and redirect user back to settings screen	Discard changes and redirect user back to settings screen	Pass
User press back button	Redirect user back to Settings Screen	Redirect user back to Settings Screen	Pass

Table 6.1.19 System testing for Edit Profile Screen

6.1.20 Change Email Button

Test Case	Expected Result	Actual Result	Status
User enter wrong current password	Display error message	Display error message	Pass
User enter new email with invalid format	Display error message	Display error message	Pass
Password field left empty	Display error message	Display error message	Pass
New email field left empty	Display error message	Display error message	Pass
User enter correct password and valid email format	Reset email with Firebase Authentication and require user to re-login	Reset email with Firebase Authentication and require user to re-login	Pass

Table 6.1.20 System testing for Change Email button

6.1.21 Change Password Button

Test Case	Expected Result	Actual Result	Status
User enter wrong current password	Display error message	Display error message	Pass
User enter new password with invalid format	Display error message	Display error message	Pass
User enter confirm password that is not same as new password	Display error message	Display error message	Pass
One of the field or all field being left empty	Display error message	Display error message	Pass
User enter correct current password and valid new password format	Reset password with Firebase Authentication and require user to re-login	Reset password with Firebase Authentication and require user to re-login	Pass

Table 6.1.21 System testing for Change Password button

Chapter 7: Conclusion

In conclusion, the first problem found is that there are still a lot of Malaysia tourist attractions that are still undiscovered by foreign tourists. And a lot of fun and interesting cave attractions in Ipoh, Perak is included in this undiscovered area. Besides that, to promote these cave attractions, spreading their history and information in a way that is interesting is needed, or else it will be boring and tourists won't even bother about it. So one of the way to achieve this is through AR mobile games. However, most of the AR mobile games we have currently doesn't primarily used to promote the cave attractions and they can't fully integrate with those attractions.

Thus, the main objective of this project is to develop an AR mobile game that can be used to disseminate those cave attractions in an fun and interesting way, and it can also integrate well with those attractions. Moreover, this AR mobile app can also enhance the experience of the tour, leaving a deep impression to the tourist. So that more and more tourists will come to Ipoh and visit these cave attractions. The mobile app will also include some information or history of the cave attractions, such as the history of a statue, how the cave is formed, and so on. This can educate tourists about the cave attraction, and at the same time the history and information of the cave attractions will be spread to more and more tourists.

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APPENDICES

Review on Similar apps



Figure 2.4.1 Main Page of Pokémon

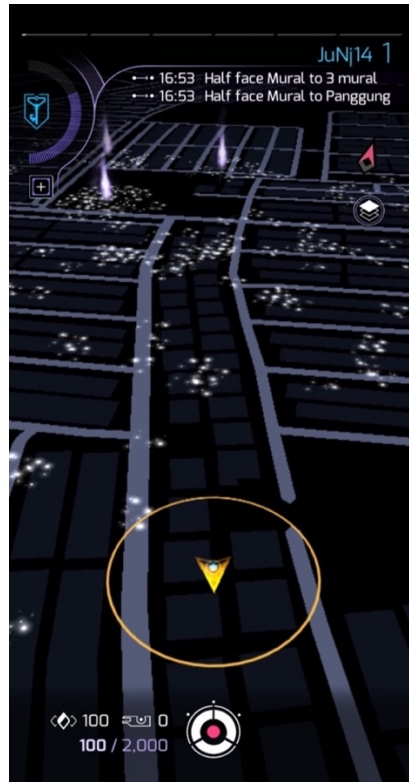


Figure 2.4.2 Main Page of Ingress



Figure 2.4.3 Main Page of Harry Potter: Wizards Unite



Figure 2.4.4 Main Page of Jurassic World



Figure 2.4.5 Main Page of Orna

System Flowchart

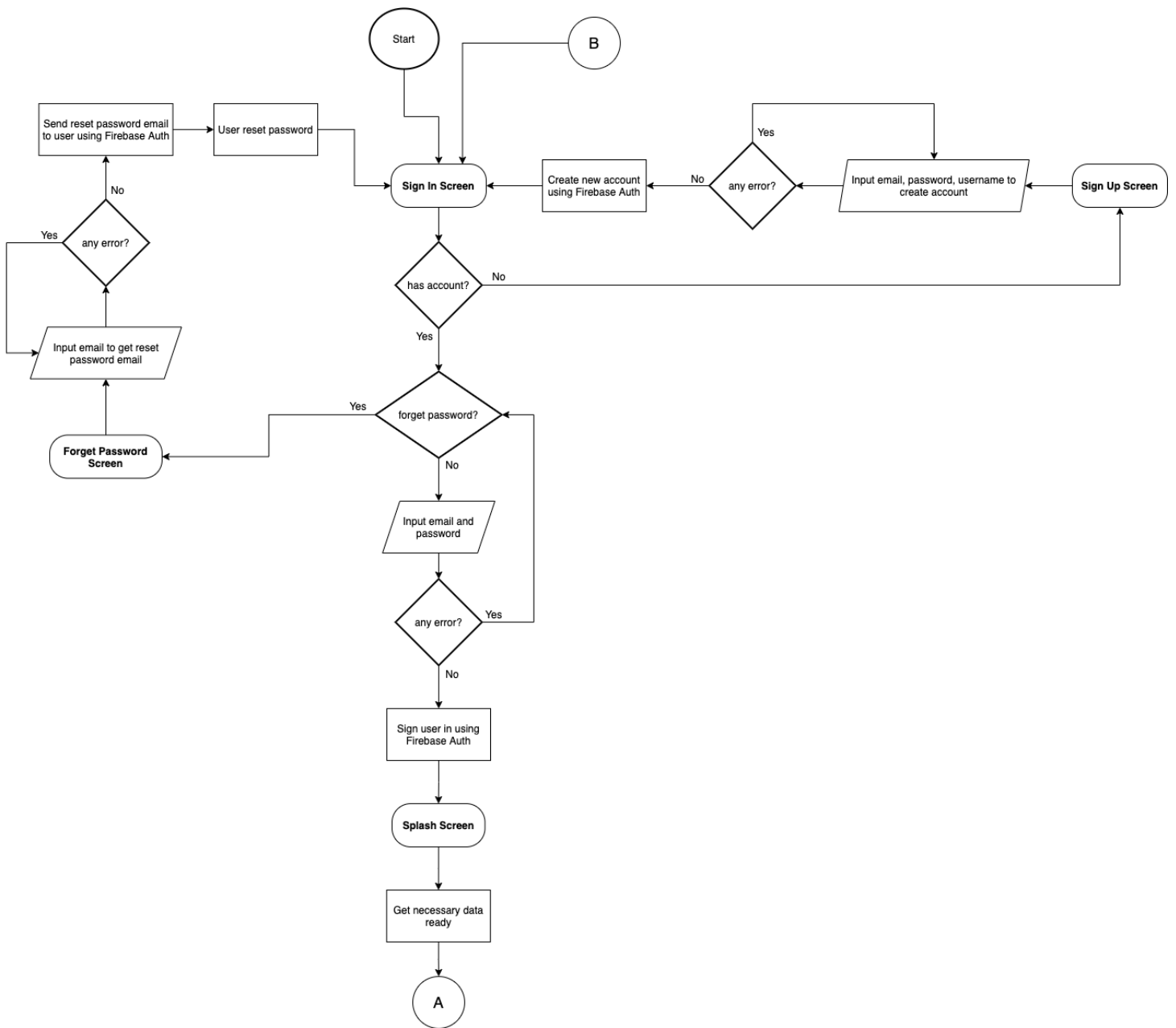


Figure 4.1-1 System Flowchart

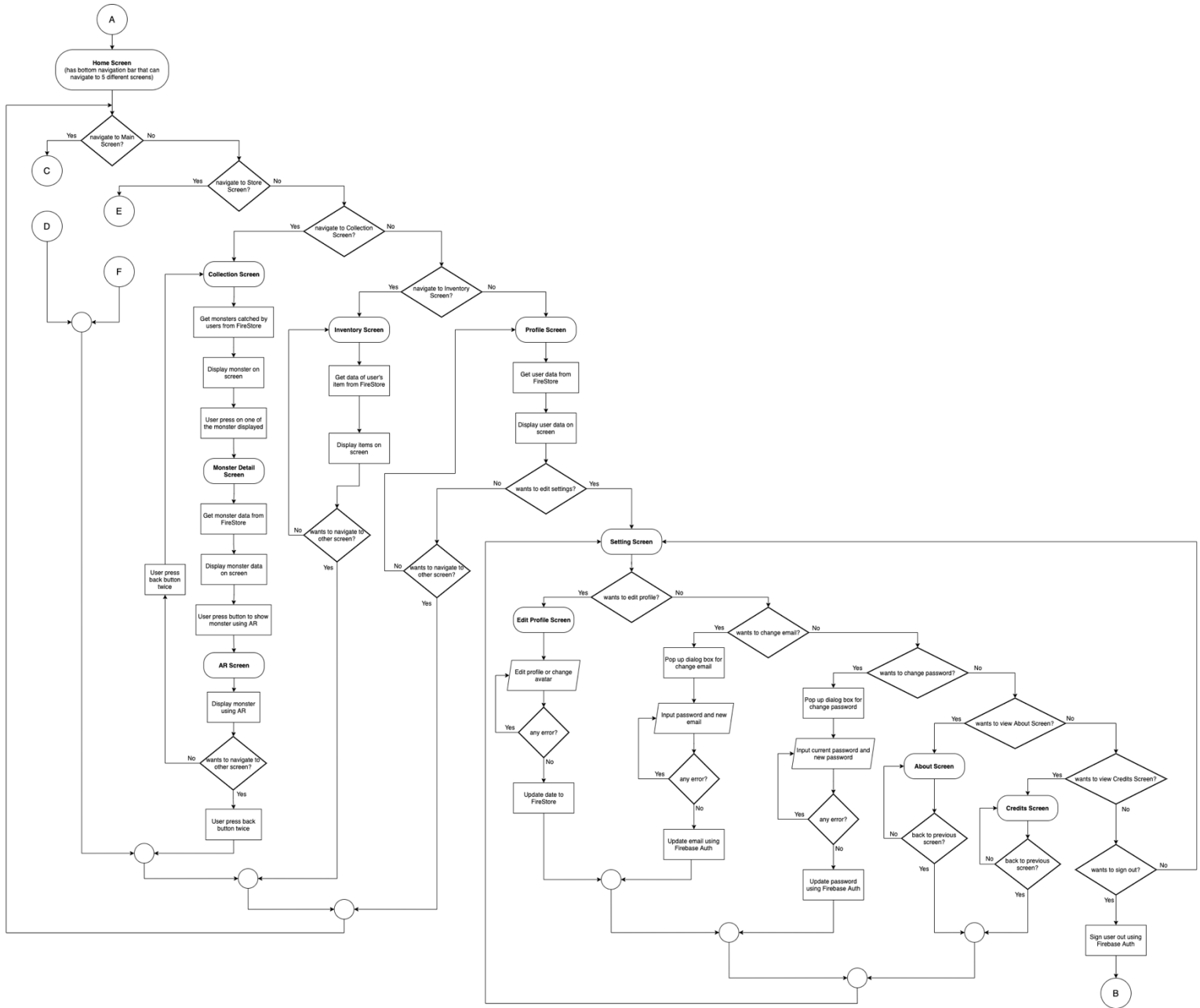


Figure 4.1-2 System Flowchart

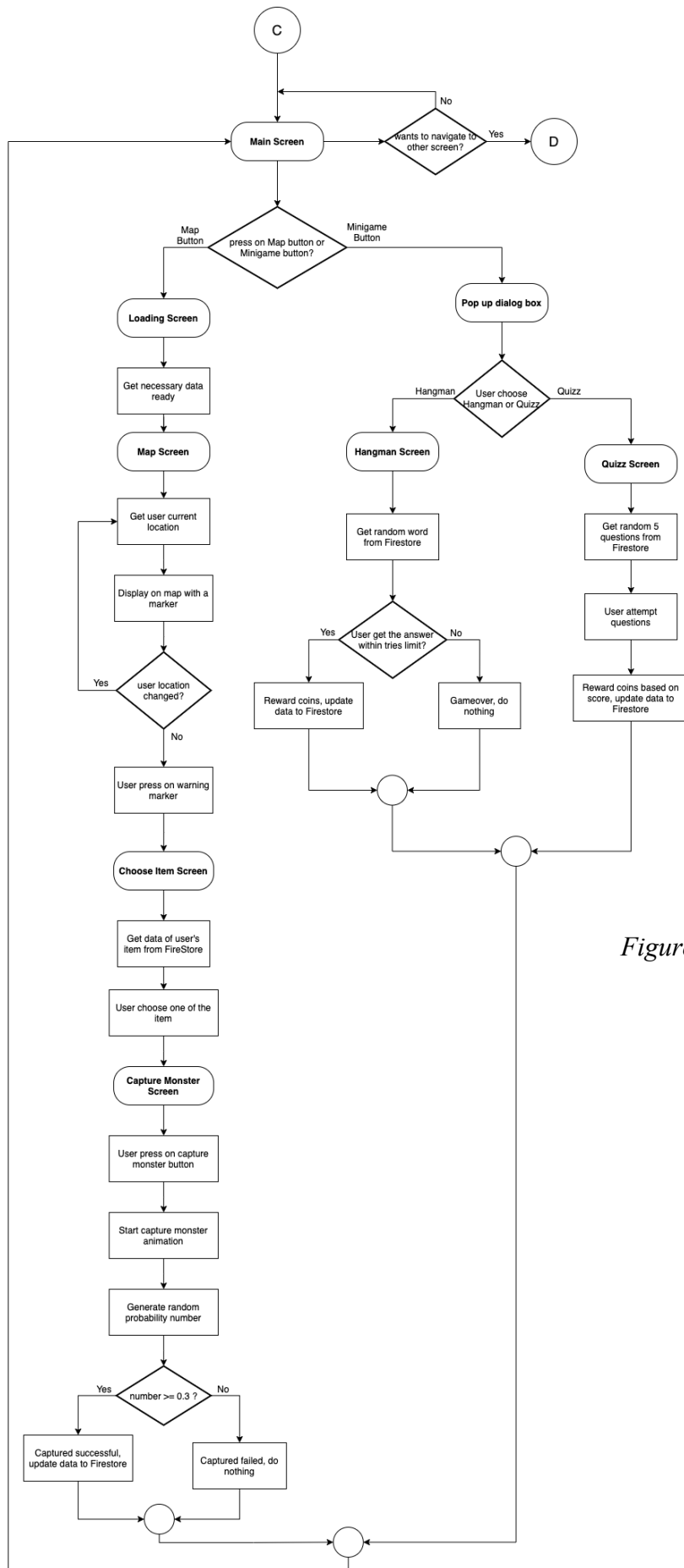


Figure 4.1-3 System Flowchart

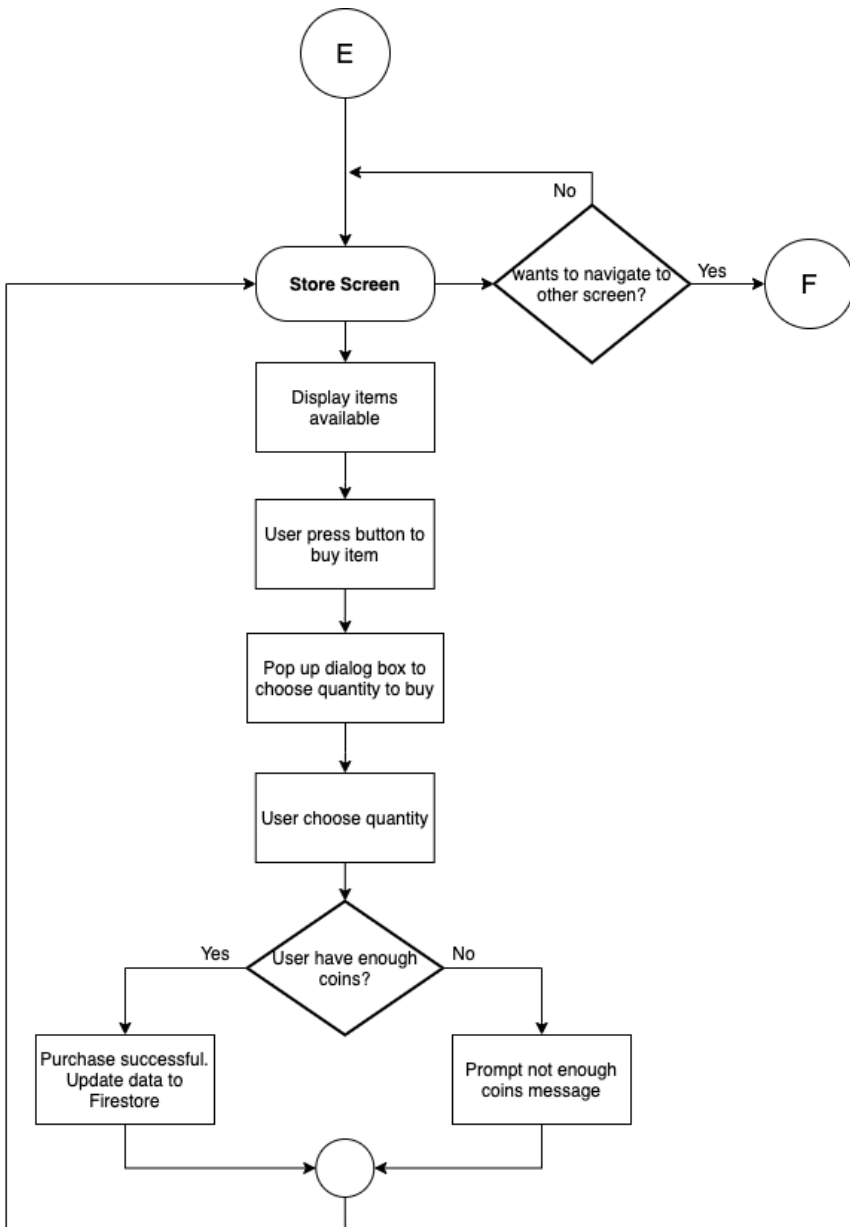


Figure 4.1-4 System Flowchart

System Operation

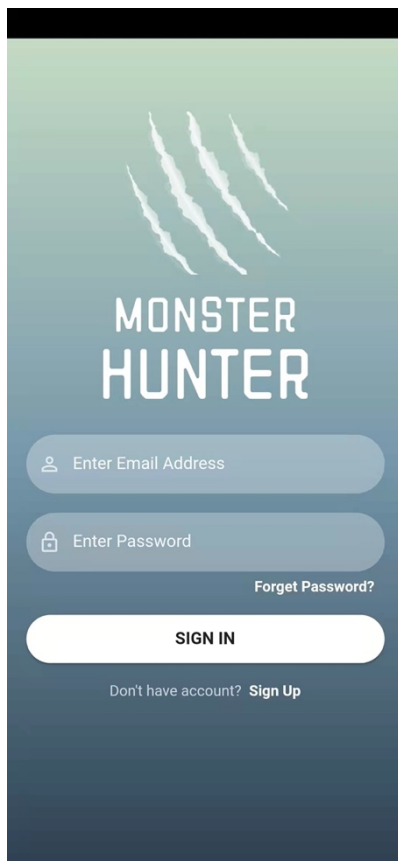


Figure 5.3.1-1 Sign In Screen

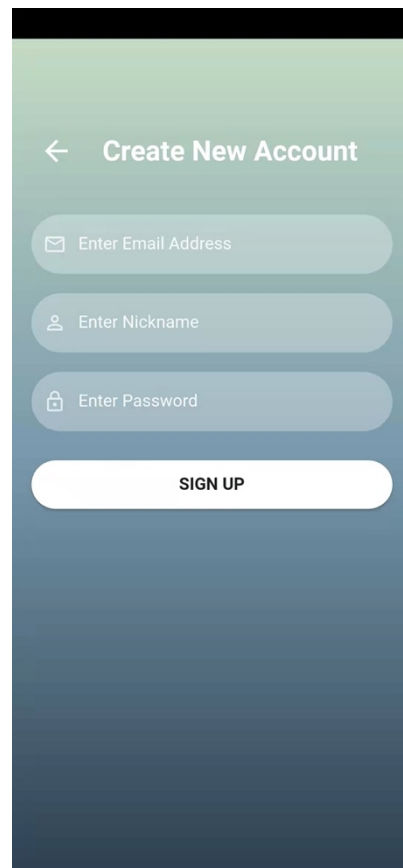


Figure 5.3.2-1 Sign Up Screen

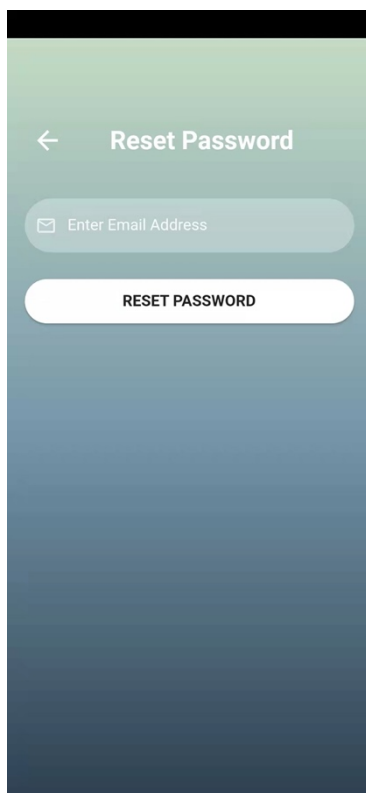


Figure 5.3.3-1 Forgot Password Screen

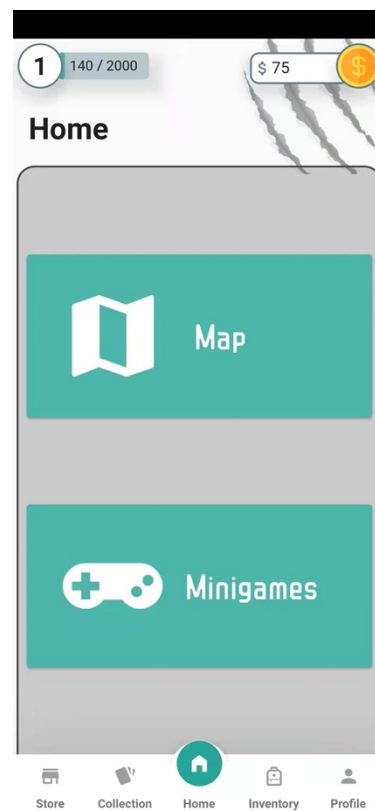


Figure 5.3.5-1 Main Screen

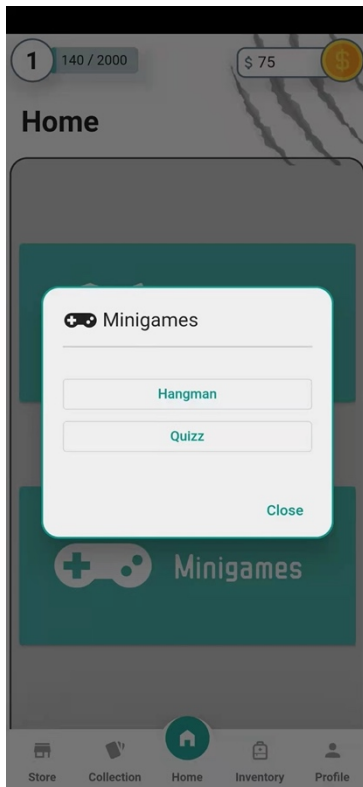


Figure 5.3.5-2 Main Screen 2

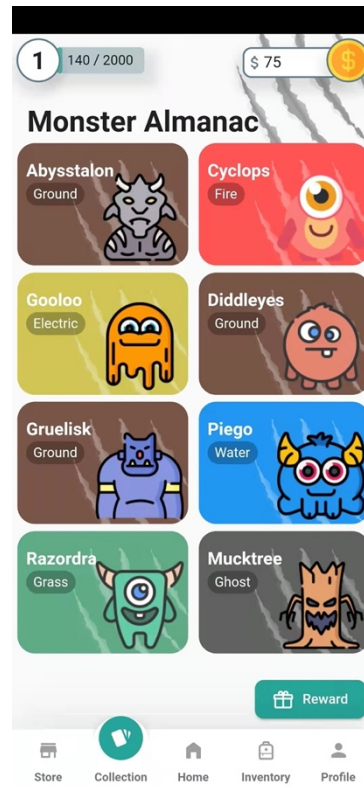


Figure 5.3.6-1 Collection Screen



Figure 5.3.7-1 Monster Details Screen



Figure 5.3.8-1 Rewards Screen

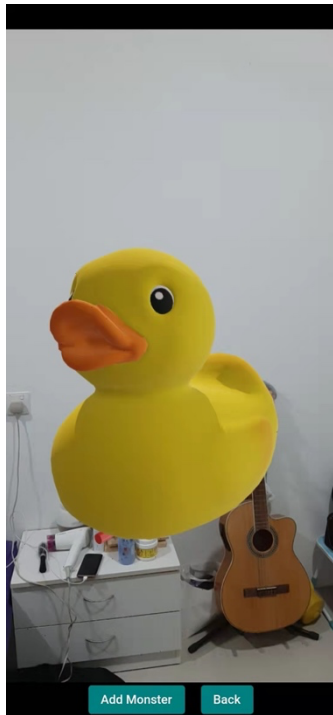


Figure 5.3.9-1 AR Screen

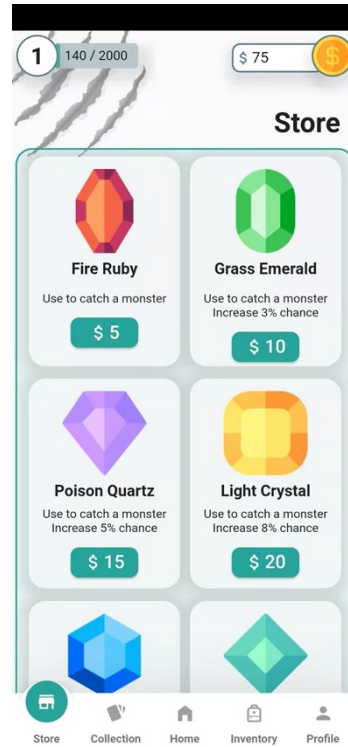


Figure 5.3.10-1 Store Screen

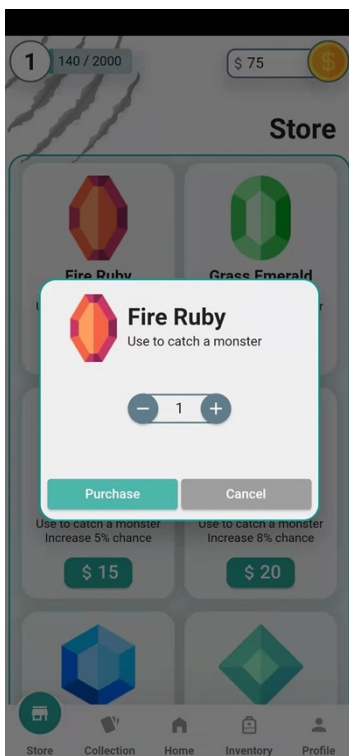


Figure 5.3.10-2 Store Screen 2

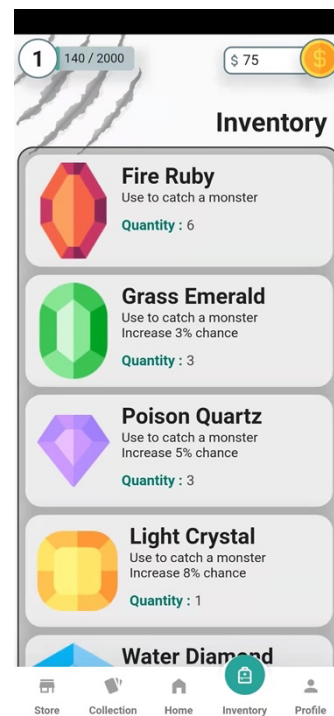


Figure 5.3.11-1 Inventory Screen

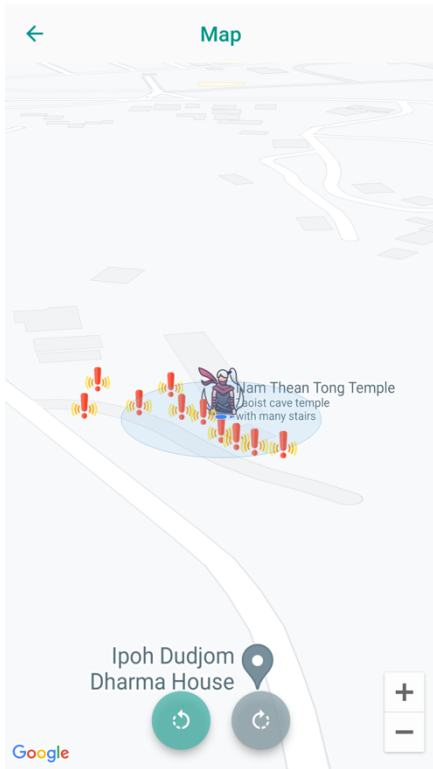


Figure 5.3.12-1 Map Screen

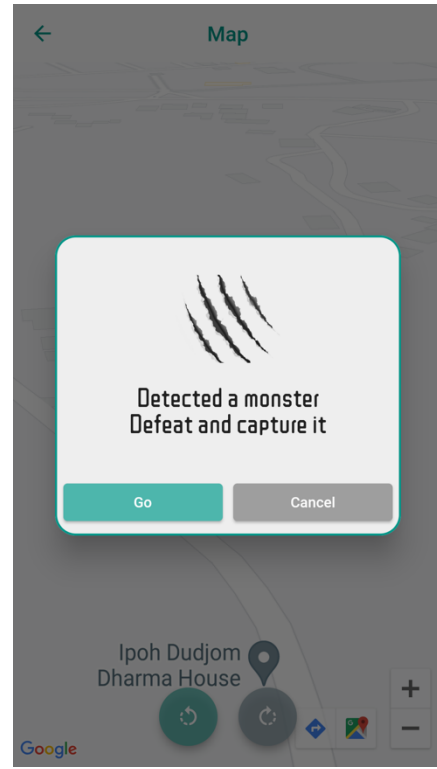


Figure 5.3.12-2 Map Screen 2

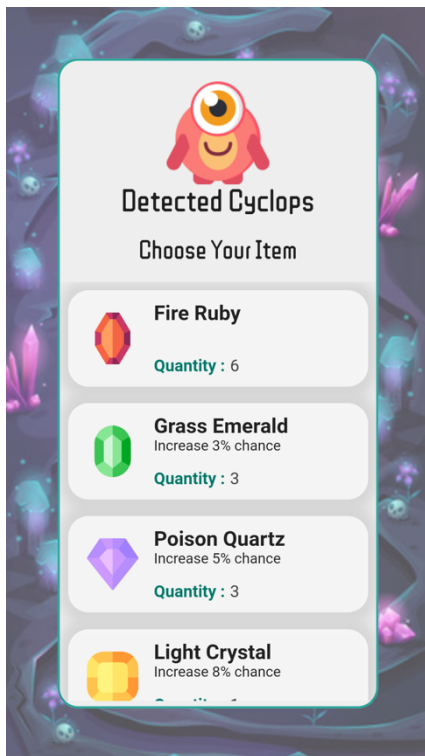


Figure 5.3.13-1 Choose Item Screen

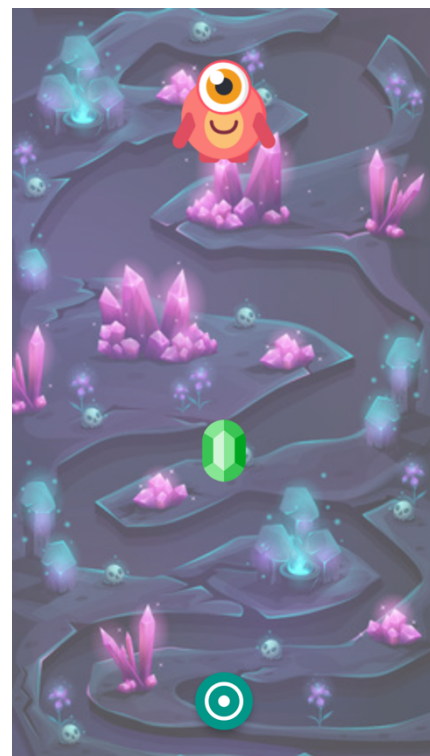


Figure 5.3.14-1 Capture Monster Screen

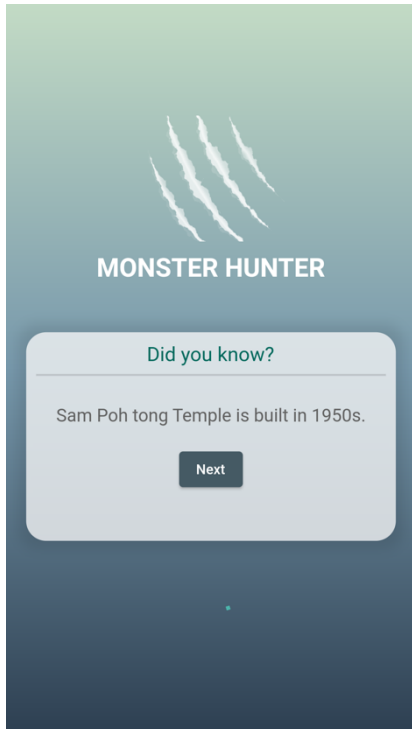


Figure 5.3.15-1 Loading Screen

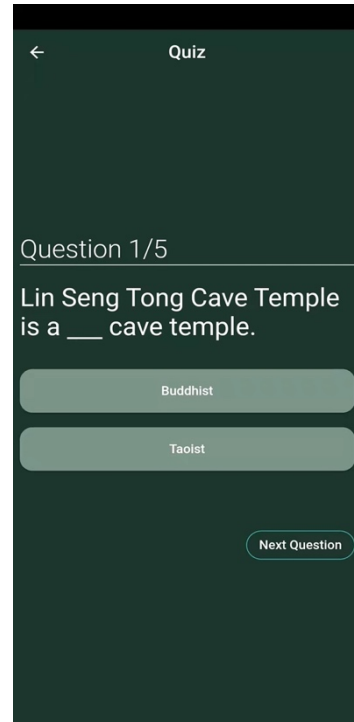


Figure 5.3.16-1 Quizz Screen

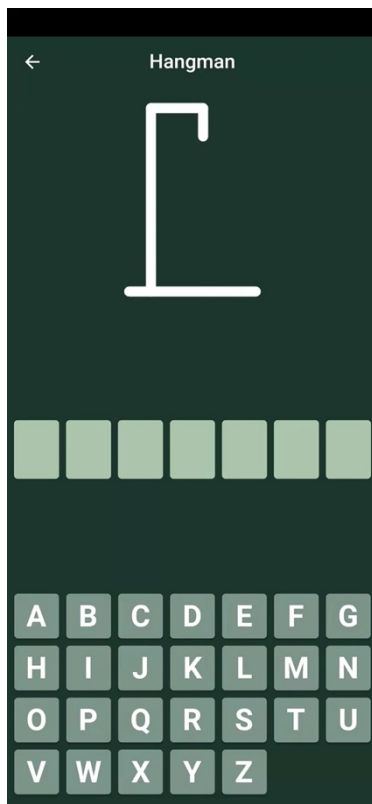


Figure 5.3.17-1 Hangman Screen

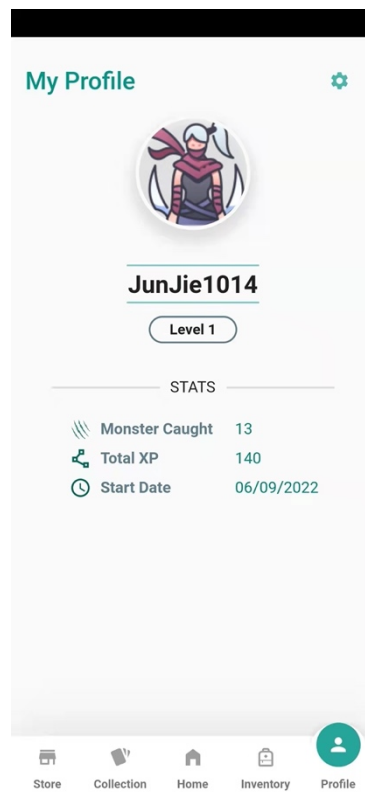


Figure 5.3.18-1 Profile Screen

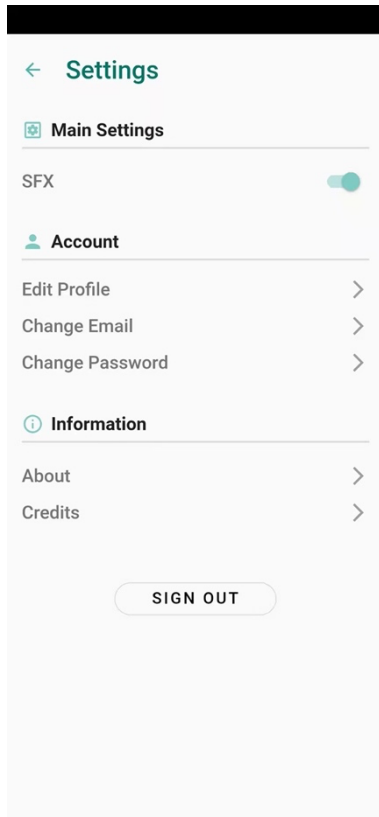


Figure 5.3.19-1 Settings Screen

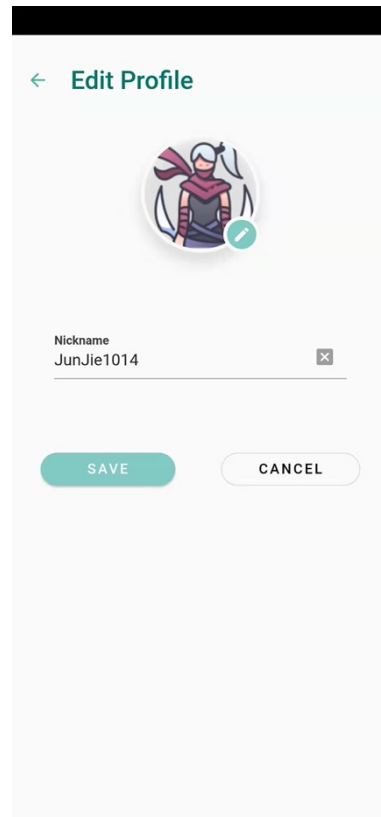


Figure 5.3.20-1 Edit Profile Screen

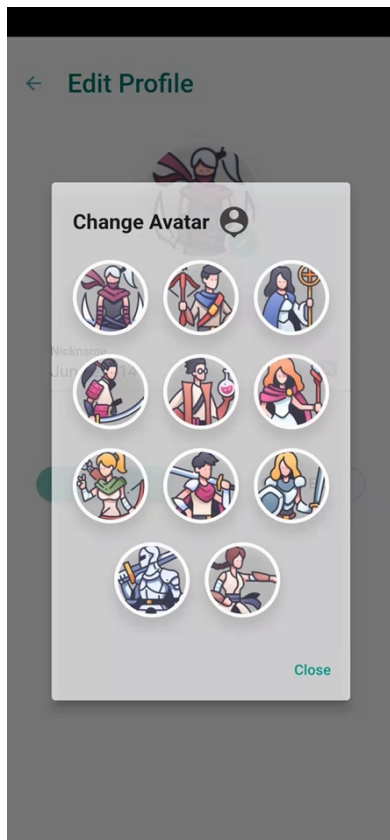


Figure 5.3.20-2 Edit Profile Screen 2

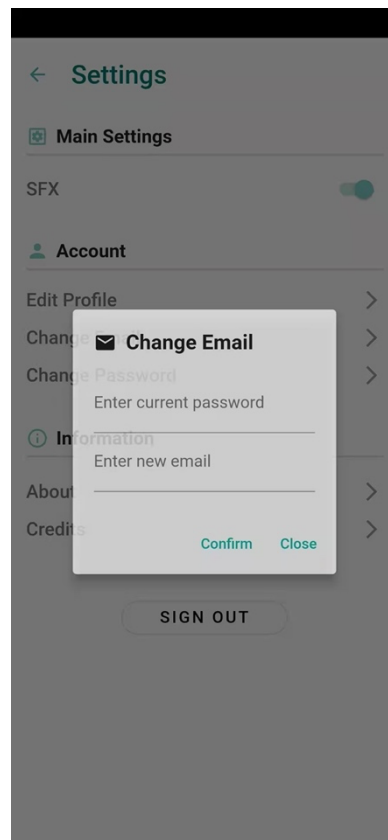


Figure 5.3.21-1 Change Email

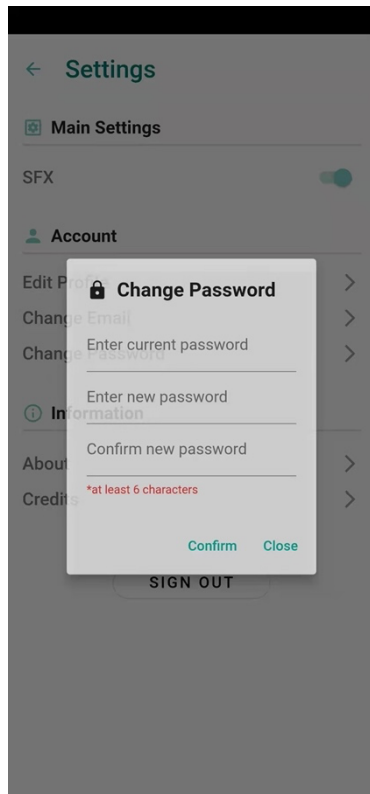


Figure 5.3.22-1 Change Password

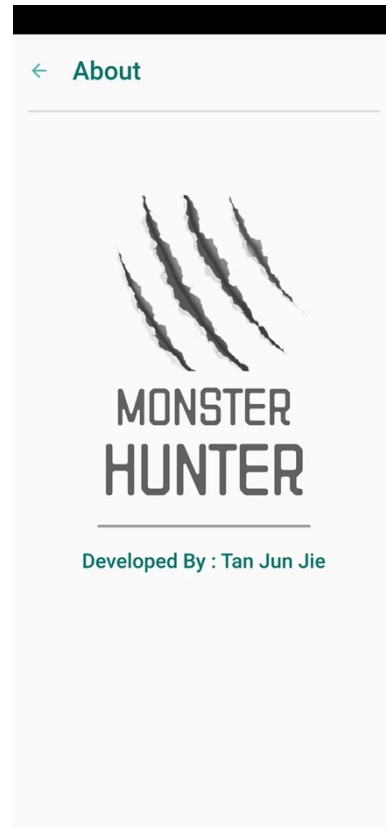


Figure 5.3.23-1 About Screen

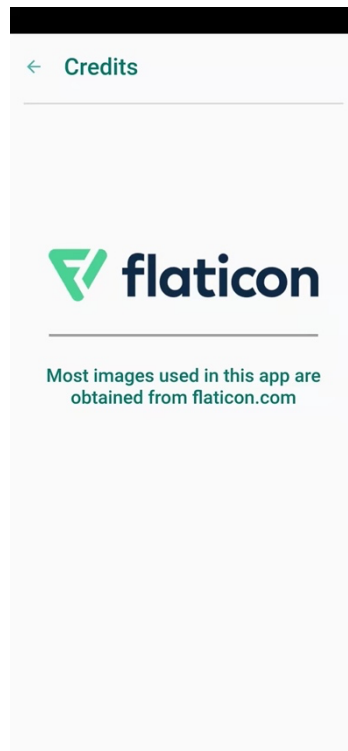


Figure 5.3.24-1 Credits Screen

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 4
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Revise report 1, plan work and features to be included and implement in FYP2. Research and analyse other similar apps to get some inspirations on those features to be implemented.

2. WORK TO BE DONE

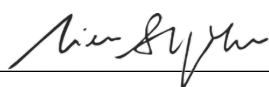
Report Writing

3. PROBLEMS ENCOUNTERED

No problem encountered.

4. SELF EVALUATION OF THE PROGRESS

Starting point is good.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 5
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Done Chapter 1, Chapter 2, Chapter 3 of Report 2. Modify UI for Main Screen.

2. WORK TO BE DONE

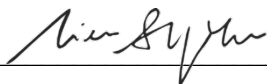
Continue implement features.

3. PROBLEMS ENCOUNTERED

Ran out of idea during the design process

4. SELF EVALUATION OF THE PROGRESS

Some of the UI took quite long time to design.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 6
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Implemented Rewards Screen.

2. WORK TO BE DONE

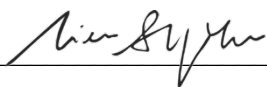
Implement AR Screen using ARCore.

3. PROBLEMS ENCOUNTERED

No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

Quite satisfied with the UI designed.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 7
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Done implementing AR Screen.

2. WORK TO BE DONE

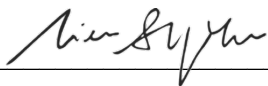
Modify Store Screen and implement it's function.

3. PROBLEMS ENCOUNTERED

ARCore plugin contains bugs.

4. SELF EVALUATION OF THE PROGRESS

Quite satisfied.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 8
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Done modify and implement function of Store Screen.

2. WORK TO BE DONE

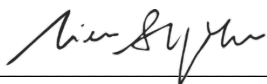
Implement random spawning of markers on Map Screen.

3. PROBLEMS ENCOUNTERED

Null safety error.

4. SELF EVALUATION OF THE PROGRESS

Spent some time in developing Shop screen.



Supervisor's signature

Bachelor of Computer Science (Honours)

Faculty of Information and Communication Technology (Kampar Campus), UTAR



Student's signature

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FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 9
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Random spawning of marker on Map Screen done implementing. Added onPressed listener on each marker.

2. WORK TO BE DONE

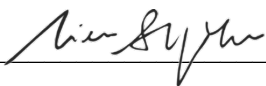
Implement the capturing of monster.

3. PROBLEMS ENCOUNTERED

No problem encountered.

4. SELF EVALUATION OF THE PROGRESS

Need to speed up.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project I!

Trimester, Year: Y3S3	Study week no.: 10
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Done implementing Choose Item Screen and Capture Monster Screen.

2. WORK TO BE DONE

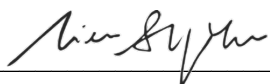
Implement minigames.

3. PROBLEMS ENCOUNTERED

No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

Screens is developed in a smooth process.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 11
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Implemented the Hangman minigame.

2. WORK TO BE DONE

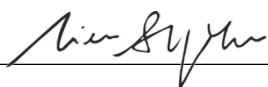
Implement one more minigame.

3. PROBLEMS ENCOUNTERED

Null safety error..

4. SELF EVALUATION OF THE PROGRESS

Need to improve knowledge on Flutter's null safety.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 12
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Implement quiz minigame

2. WORK TO BE DONE

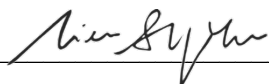
Report Writing

3. PROBLEMS ENCOUNTERED

No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

Satisfied.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

Project II

Trimester, Year: Y3S3	Study week no.: 13
Student Name & ID: Tan Jun Jie (1806939)	
Supervisor: Dr Liew Soung Yue	
Project Title: Mobile Game Development with Augmented Reality for Ipoh Cave Attractions	

1. WORK DONE

Finish report writing

2. WORK TO BE DONE

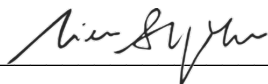
-

3. PROBLEMS ENCOUNTERED

No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

Satisfied.



Supervisor's signature

Bachelor of Computer Science (Honours)

Faculty of Information and Communication Technology (Kampar Campus), UTAR



Student's signature

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POSTER

Mobile Game Development with Augmented Reality for Ipoh Cave Attractions



By : Tan Jun Jie Supervised By: Dr. Liew Soung Yue

1

Introduction

This is a AR mobile game that can be integrated into cave attractions in Ipoh. Tourists can play this game during their visit to the cave attractions. This not only can enhance their travel experience, they will also be educated on the history and information of the cave attractions.

2

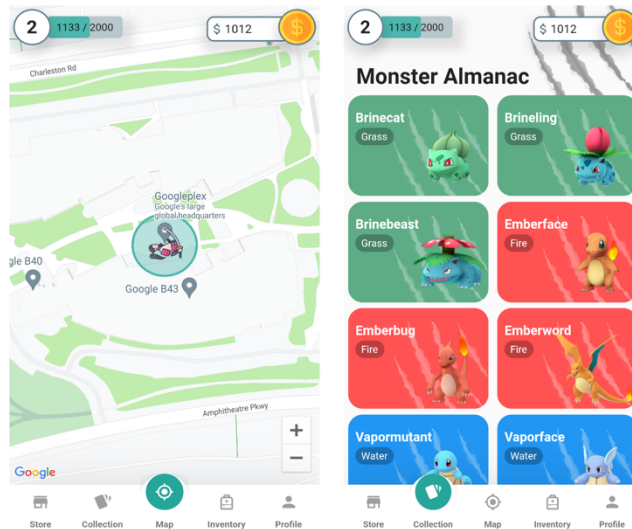
Objectives

- Promote tourism in Ipoh cave attractions
- Develop a mobile game that uses AR technology for Ipoh cave attractions
- Enhance tourist's experience during their trip to Ipoh cave attractions

3

Main Features

- A map that display user's live location
- Catch monsters displayed on the map
- Display monster caught using AR



Technologies



“The best way to predict your future is to create it.”

– Abraham Lincoln

PLAGARISM CHECK RESULT

The screenshot shows the Turnitin Feedback Studio interface. The document title is 'FYP2' by 'Tan Jun Jie'. The match overview on the right indicates a total similarity of 7%. The matches are listed as follows:

Match Number	Source	Similarity
1	arvrjourney.com Internet Source	1%
2	www.getplayoff.com Internet Source	1%
3	whatis.techtarget.com Internet Source	<1%
4	www.worldreligionnews.com Internet Source	<1%
5	Submitted to Queen M... Student Paper	<1%
6	Samuli Laato, Sampsa... Publication	<1%
7	Submitted to Universiti... Student Paper	<1%
8	Submitted to The Unive... Student Paper	<1%
9	en.wikipedia.org Internet Source	<1%
10	teddit.sdf.org Internet Source	<1%

The document content on the left includes the following text with highlighted matches:

1.1 Background Information
 Augmented reality gaming, or AR gaming in short, is the combination or integration of game audio and visual content with the real time user's environment [1]. Most AR games are played using portable devices such as smartphones, tablets, and other portable gaming systems. In augmented reality, precreated environment are often superimposed on top of the user's real environment. Some simple AR game can be just Chinese chess that is played on a table surface or on the floor. Whereas AR games that are more advanced can have the ability to build an environment from the user current surroundings. For example, an in-game character that is driving a car from chairs to tables through virtual bridges. AR games improve and expands the gaming field. It takes the advantage of the various diversity of our real-world environment to make the game more interesting.

It is estimated that there will be 1.7 billion users of mobile augmented reality(AR) worldwide by year 2024 [2]. In contrast to year 2015, which there are only 200 million mobile AR users, it has already increase for 1.5 billion users, which is a huge amount of increment. It is also predicted that the market revenue for mobile AR worldwide will increased dramatically to 26 billion U.S. dollars in year 2025 [3]. As compared to year 2021, which is only 9.53 billions U.S. dollars, it is a huge increase in market revenue.

AR games are able to create meaningful experiences for players. This is because AR

The screenshot shows the Turnitin preferences and document viewer interface. The document title is 'FYP2' by 'Tan Jun Jie'. The match overview on the right indicates a total similarity of 7%. The matches are listed as follows:

Match Number	Source	Similarity
1	1% match (Internet from 05-Nov-2020) https://arvrjourney.com/gamification-in-tourism-benefits-use-cases-30a8752c9a09?gi=c32ffe775986	1%
2	1% match (Internet from 20-Jun-2021) https://www.getplayoff.com/blog/gamification-tourism-territorial-marketing/	1%
3	< 1% match (Internet from 02-Mar-2017) http://whatis.techtarget.com	<1%
4	< 1% match (Internet from 09-Jan-2018) http://www.worldreligionnews.com	<1%
5	< 1% match (student papers from 21-Mar-2021) Submitted to Queen Mary and Westfield College	<1%
6	< 1% match (publications) Samuli Laato, Sampsa Rauti, A.K.M. Najmul Islam, Erkki Sutinen. "Why playing augmented reality games feels meaningful to players? The roles of imagination and social experience". Computers in Human Behavior, 2021	<1%
7	< 1% match (student papers from 31-Aug-2021) Submitted to Universiti Tuniku Abdul Rahman	<1%
8	< 1% match (student papers from 29-Apr-2016) Submitted to The University of Manchester	<1%

The document content on the left includes the following text with highlighted matches:

1.1 Background Information
 Augmented reality gaming, or AR gaming in short, is the combination or integration of game audio and visual content with the real time user's environment [1]. Most AR games are played using portable devices such as smartphones, tablets, and other portable gaming systems. In augmented reality, precreated environment are often superimposed on top of the user's real environment. Some simple AR game can be just Chinese chess that is played on a table surface or on the floor. Whereas AR games that are more advanced can have the ability to build an environment from the user current surroundings. For example, an in-game character that is driving a car from chairs to tables through virtual bridges. AR games improve and expands the gaming field. It takes the advantage of the various diversity of our real-world environment to make the game more interesting.

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Form Title : Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1 of 1



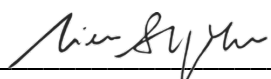
FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Tan Jun Jie
ID Number(s)	18ACB06939
Programme / Course	Bachelor of Computer Science (Honours)
Title of Final Year Project	Mobile Game Development with Augmented Reality for Ipoh Cave Attractions

Similarity	Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)
Overall similarity index: <u>7</u> % Similarity by source Internet Sources: <u>5</u> % Publications: <u>0</u> % Student Papers: <u>3</u> % %	
Number of individual sources listed of more than 3% similarity: <u>0</u>	
Parameters of originality required and limits approved by UTAR are as Follows: (i) Overall similarity index is 20% and below, and (ii) Matching of individual sources listed must be less than 3% each, and (iii) Matching texts in continuous block must not exceed 8 words <i>Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.</i>	

Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.



 Signature of Supervisor

Name: Liew Song Yue

Date: 8/9/2022

 Signature of Co-Supervisor

Name: _____

Date: _____



UNIVERSITI TUNKU ABDUL RAHMAN

**FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY
(KAMPAR CAMPUS)**

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Student Id	1806939
Student Name	Tan Jun Jie
Supervisor Name	Dr. Liew Soung Yue

TICK (√)	DOCUMENT ITEMS
	Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
-	Front Plastic Cover (for hardcopy)
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
-	List of Symbols (if applicable)
-	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

***Include this form (checklist) in the thesis (Bind together as the last page)**

I, the author, have checked and confirmed all the items listed in the table are included in my report.

(Signature of Student)

Date: 8 / 9 / 2022