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Design and Development of Augmented Reality-based Virtual Pet Simulator Game to Simulate Pets Behaviors

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Abstract: Augmented reality is an enhanced version of the real physical world integrated with 3D representation that helps users to understand an abstract concept. This paper discussed the design and development of 'smARt CAT', an AR virtual pet game. smARt CAT is a virtual application that uses Augmented Reality (AR) technology to display a virtual pet, to enhance the users' experience. Through the smARt CAT application, users can also understand the daily behaviors of pets while self-curing loneliness or depression. The application development methods are carried out starting from idea creation, design, development, testing and release phases based on Mobile Software Development Lifecycle (Mobile SDLC). This application is developed by using the Unity3d game engine and combine with the AR technique which is ARCore. Furthermore, the artificial intelligent part which is voice recognition is added to the application. Testing results from 20 respondents which are children between 6 to 12 years old shows that the application was received more positive feedback. About 80% of the respondents enjoy playing smARt CAT, therefore showing the acceptance rate of the application.

Keywords: Augmented Reality, Virtual Pet, Android

1. Introduction

The first virtual pet, Tamagotchi, is very popular worldwide since the 90s. Tamagotchi has a small black and white LCD screen of a key-ring shape, three rubber buttons, and a speaker [1]. Users can feed and play with their virtual pets. They also can bring their virtual pet anywhere and anytime. In the case of a live pet, many places are not allowed to bring the pet in. It is due to some building or particular place's rules and regulations. Bringing a pet might cause an uncomfortable situation or unwanted smell to those who have sensory issues with it. In 2018, Malaysia has a cat population of about 795,000 cats and the numbers steadily growing each year [2]. Having a pet can bring positive impacts such as teaching responsibility and discipline, reducing stress levels, and many more. Many families or individuals are considering adding a pet to be their new family member. Some first-time pet owners reported having problematic behavior such as fear, excessive excitement, and owner-directed

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aggression [3]. Unintentionally, they tend to harm their pets due to a lack of awareness in handling their pet's needs.

Nowadays, almost every person in the population has phones for communication purposes in first place. Moreover, there are many applications and mobile games had been developed about virtual pets. The latest AR technology can enhance the user's perception of reality by combining computer-generated data and real-world view [4]. By using the technology of Augmented Reality, virtual pet game applications may improve the play experience of the user [5].

This paper proposed the design and development of an AR virtual pet AR called smARt CAT. The game is a means of practicing pet care before live pet adoption. Not everyone can keep a pet due to expenses, allergies, and lifestyle. Therefore, the existence of a smARt CAT can act as a substitute for real pets. The organization of this paper is as follows (1) to design the content of a virtual pet game by using augmented reality (AR) with simulation genre, (2) to develop a mobile application named "smARt CAT" on the Android mobile platform and (3) to evaluate the functionalities and acceptance of the developed mobile game to target user which is children between 6 to 12 years old.

This paper will be five chapters. The first chapter discuss the project overview, problem statement, objectives, project scope and project significance. Next, chapter 2 will be the related work, including the technology used and comparing the existing applications in the market. Chapter 3 will be the methodology that using for the development of the proposed application. Moreover, chapter 4 includes testing result and discussion of the application. Lastly, chapter 5 conclude the paper and giving some improvements in future.

2. Related Work

2.1 Augmented Reality

In these recent years, Augmented Reality (AR) has been an emerging technology and it also is a big technology trend now. The definition of Augmented Reality (AR) is the combination of virtual scenes and real scenes in the device. It is meaning that the real scene is viewed by the user but the virtual scene is generated by a computer that augments the scene of additional information [6]. In other words, Augmented Reality (AR) is defined as immersion of virtual environment to the real environment which enriches the vision, audition or even taste, touch and smell [7].

Apparently, smartphone-based and other device AR applications are becoming more widely available throughout the world. We can see the real-life environment in front of us by using technology AR.

2.2 Comparison of Existing Applications

The existing applications in the market such as AR Dragon, Dinosaur 3D AR, Planet AR - Virtual Pet and my proposed application which is the smARt CAT are reviewed and compared for their advantages and disadvantages. Table 1 displays the comparison of various applications developed for a virtual pet.

Table 1: Comparison of related application

	AR Dragon	Dinosaur 3D AR	Planet AR - Virtual Pet	smARt CAT
Type of pet	Dragon	Dinosaur	Dog	Cat
Augmented Reality	Marker-less	Marker-less	Marker-based	Marker-less
Animation	More (Provide several animations on eating,	Less	Less	More (Provide several animations

Table 1: (continued)

	AR Dragon	Dinosaur 3D AR	Planet AR - Virtual Pet	smARt CAT
	playing with users and so on.)			on pets' daily behaviour and several animations on different commands)
Pet's Shadow	Yes	No	No	Yes
Game Session	Yes	Yes	No	Yes
Pet Appearance Changeable	No	Yes	No	Yes
Strengths	•Not easy to get bored because the dragon will grow up one day by one day. •Provide rescan the searching the surface to prevent unbalance surface.	•Provide zoom in, zoom out and rotate function	•The interaction between the pet is more interesting.	•Provide voice recognition to let the application more interesting.
Weaknesses	•Only sits at a certain place and would not move around.	•Low graphic design.	•User needs to print the image to spawn the pet.	•Not stable on augmented reality plane.

3. Methodology

smARt CAT virtual pet application is developed in an Android-based operating system using Mobile Software Development Lifecycle (Mobile SDLC) methodology [8]. There are five (5) major phases of the process which are the Inception Phase, Design Phase, Development Phase, Stabilization Phase and Deployment Phase. Details of each phase will be discussed in the following topic.

3.1 Inception Phase

In the inception phase, a rough concept of defining and refining the idea of an application. Table 2 shows a sample of the application inception plan document produced for the smARt CAT.

Table 2: smARt CAT Application Idea Creation

Item	Description
Pet type	Cat
Application Concept	Simulation genre
Target device	Android mobile
Target users	Pet lover especially for children among age 6 -12
GUI (Graphical user interface)	Main interface and Augmented reality interface
Animation	Cat
Application synopsis	smARt CAT is a virtual pet application that is purposely designed for children between 6 to 12 years old to give them happiness and some pet knowledge.

3.2 Design Phase

The second phase is the design phase. After the feature and functionality of the application have been determined, the creation of application design based on the application concept, user interface (UI) design and object design can start to build. UI is usually done via wireframes or mockups by using some design toolkits. For this project, the application was visualized by creating a use case diagram, navigation structure and flowcharts. The UI design of the mobile application was creating and put on the storyboard. A good UI design of the mobile application is important so that gives people a good first impression. Next, the design software will be used such as Adobe Illustrator and Adobe Photoshop for the logo and button designs and the blender for the 3D model. The object design of the smARt CAT application includes the creation of buttons, logo and 3d model as shown in table 3.

Table 3: Object Design

Object	Design
Button	
Logo	
3D model	

3.3 Development Phase

This stage is where the main function of smARt CAT is developed, which include spawning cat to AR interface, animation of cat function and speech recognition. Integration between objects and scripts is a process of attaching the script files to the game assets through Unity. In this project, Unity was used to integrate the game elements. Unity is the main platform to develop the whole proposed application includes GUI, AR engine and AI technologies. In order to combine the AR technique with a virtual pet, ARCore which is an augmented reality software development kit (SDK) for mobile devices is used to plug into the Unity platform so that the virtual pet can be brought to the real world and become more real. The ARCore only supports AR application development for Android devices. Scripting in Unity is implemented using C# script language to execute series of actions or commands. In the application, different scripts were created to execute commands such as to control characters and generate props. After the scripts were created, they were then attached to the corresponding object in Unity. Figure 1 shows the partial code in cat to spawn into the augmented reality interface. Figure 2 show the attachment of animation to the cat. Figure 3 shows the attachment of the script to the cat to have the feature of speech recognition.

```
else if (curentNumberOfObjects == 0)
{
    curentNumberOfObjects++;
    GameObject prefab = Cat_model;
    // Instantiate prefab at the hit pose.
    houseObject = Instantiate(prefab, hit.Pose.position, hit.Pose.rotation);
    // Compensate for the hitPose rotation facing away from the raycast (i.e.
    // camera).
    houseObject.transform.Rotate(0, k_PrefabRotation, 0, Space.Self);
    // Create an anchor to allow ARCore to track the hitpoint as understanding of
    // the physical world evolves.
    var anchor = hit.Trackable.CreateAnchor(hit.Pose);
    // Make game object a child of the anchor.
    houseObject.transform.parent = anchor.transform;


}
```

Figure 1: Script of Spawn the Cat to Augmented Reality

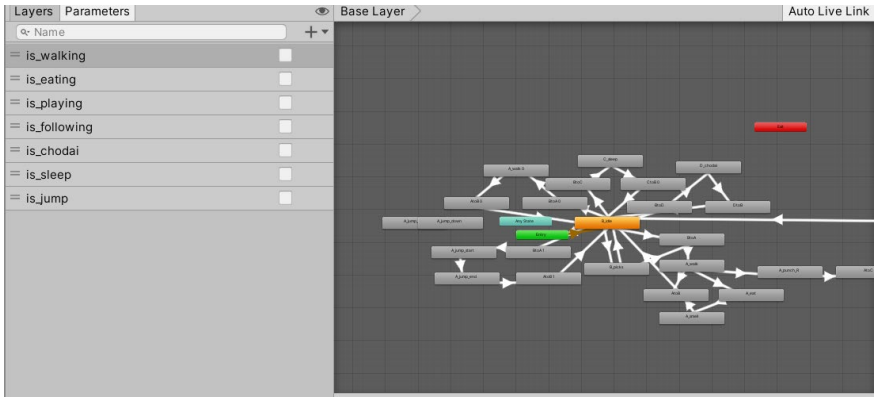


Figure 2: Attachment of Animation to the Cat in Unity

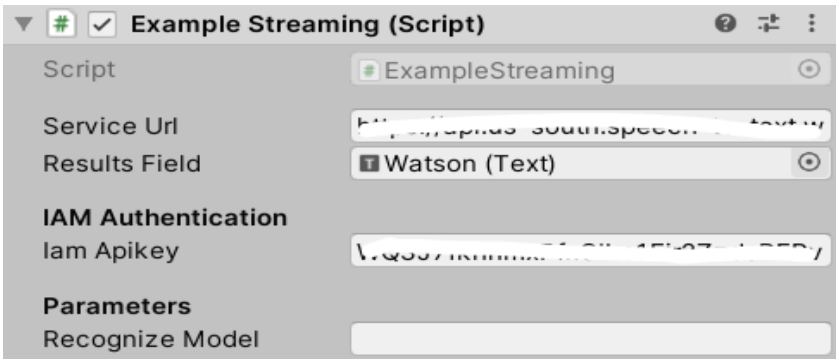
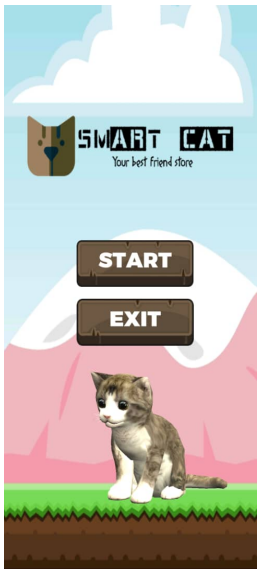


Figure 3: Speech Recognition Implemented

3.4 Stabilization Phase

The fourth phase is stabilization which is also known as the testing phase. Testing is significant in the development process that helps the developer to know whether an application can be correctly and accepted by target users. The testing phase is the phase where alpha testing was conducted to test the game's usability and playability of the prototype and beta tests are find any bugs that remained in the game and collect satisfaction feedback from the testers. In this project, the alpha test was conducted by the developer and the beta test was conducted among 20 selected target users. Any bugs, loopholes, or dead ends discovered during playtesting are documented in the testing plan and fixed. Figure 4 show the main menu of smARt CAT. Figure 5 show the cat selection of smARt CAT. Figure 6 show the augmented reality interface of smARt CAT.



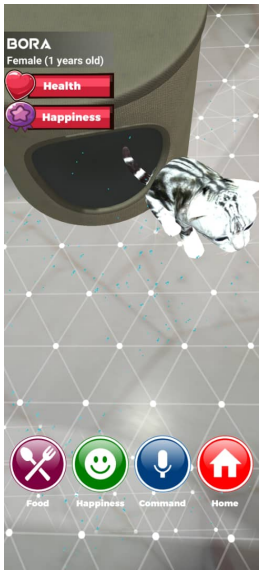


Figure 4: Main Menu Interface **Figure 5: Cat Selection Interface** **Figure 6: Augmented Reality Interface**

3.5 Deployment Phase

The last phase of Mobile SDLC is the deployment phase, which includes product launching and project documentation. The deployment phase is the time when the application build has reached the final stage and ready to be released to the public. However, due to the publishing application in google play will cost some money thus the output which is the APK will place it at social media for people to download.

4. Results and Discussion

The subjects of testing are 20 respondents of the age of 6-12 who were involved in the testing. A set of questionnaires that covers 3 components (understanding analysis, user acceptance and functionality) was distributed to the target users.

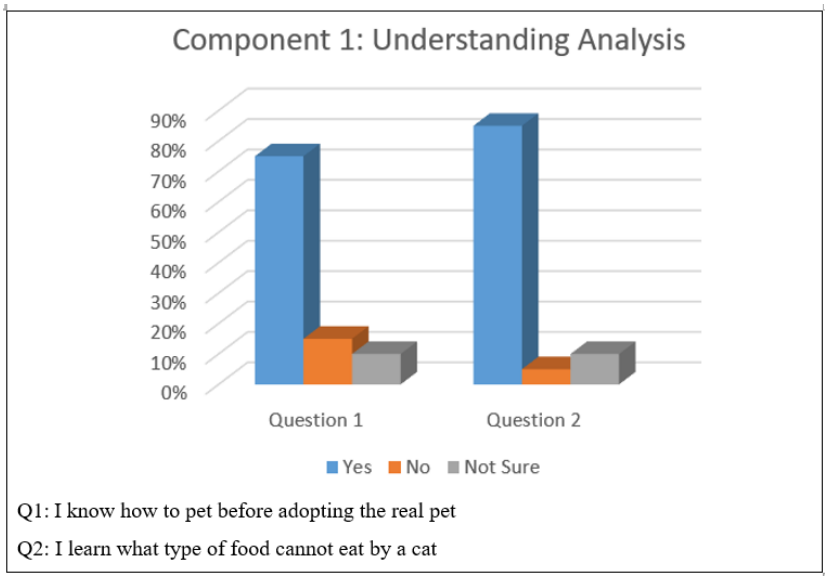


Figure 7: Understanding Analysis

In Component 1, there are two questions of the understanding analysis as shown in Figure 7. These two questions are related to the learning outcome of 'smARt CAT' application. In question 1, 75% of

respondents responded yes, 10% responded not sure and another 15% answered no. In question 2, 85% of respondents responded yes, 10% responded not sure and 5% answered no. In conclusion, most of the respondents provided positive answers. It means that the respondent has learned something.

Based on Figure 8, component 2 has three questions. In question 3, 80% of respondents think that 'smARt CAT' is beautiful and interesting, 10% responded not sure and another 10% answer no. In question 4, 80% of respondents supporting the game application are fun to play with, 5% responded not sure and another 15% gave the negative result. In question 5, 80% of respondents support that the application is easy to understand, 15% responded not sure, and another 15% answered no. In conclusion, the user acceptance level results are acceptable from the respondent.

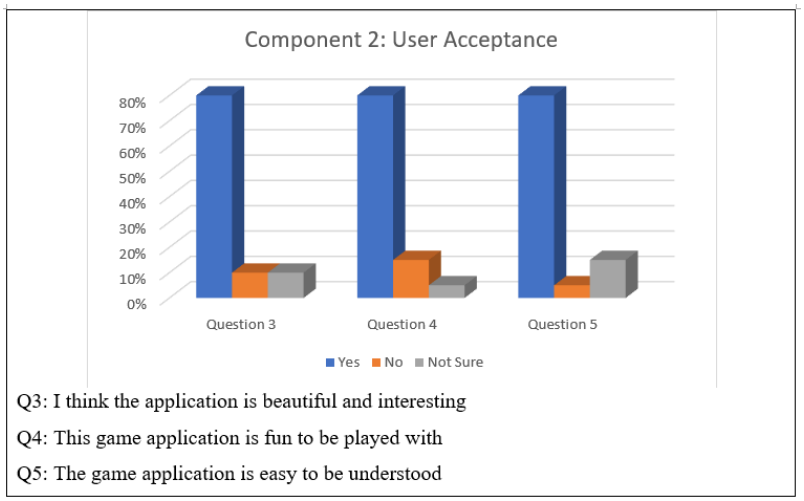


Figure 8: User Acceptance

In component 3, there are four questions as shown in Figure 9. In question 6, 85% of respondents responded application could run smoothly on an Android device, 5% responded not sure and another 10% responded negatively. In question 7, 80% responded they understand the use of buttons and functionality, 15% responded not sure and another 15% responded negatively. In question 8, 85% of the respondents supported that the virtual cat animation is smooth, 5% answered not sure, and another 10% responded negatively. In 1uestion 9, 80% of the respondents support that navigation of application is smooth, 10% responded not sure and another 10% answered negatively. In conclusion, the functionality of 'smARt CAT' is excellent and smooth.

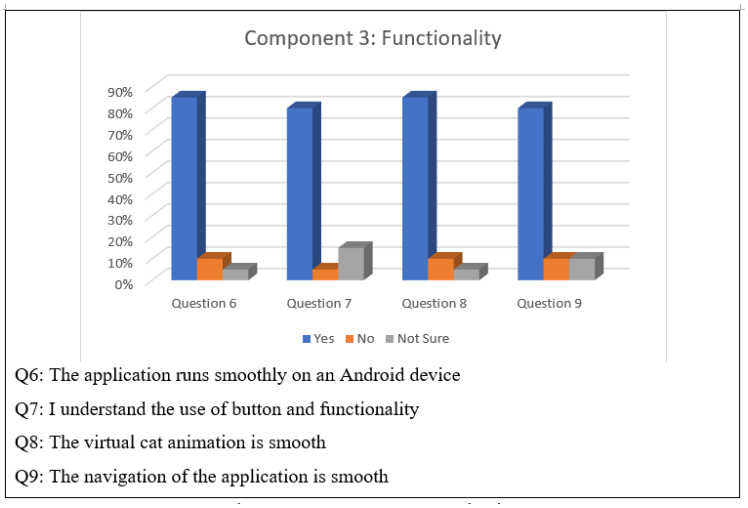


Figure 9: Functionality

Overall, the results gained for three components, Understand Analysis, User Acceptance and Functionality received more positive and acceptable results from the respondents. These 20 respondents fill in the form after install and run the 'smARt CAT'.

5. Conclusion

In conclusion, smARt CAT is suitable for the target users. The smARt CAT was developed to let lonely people get a companion to stay beside them and improve the welfare of pet animals. smARt CAT has several advantages, such as provides positive results in learning outcomes which is the user learn pet behavior before adopting the pet. The user has the experience and learns several pieces of knowledge of taking care of a pet such as what kind of food is suitable for pets. Targeted users agreed that the user interface appears attractive and they enjoy using the application. Next, the functionality is very well supported and all the multimedia elements were appropriately meet the design requirements. Lastly, this game can be play by all pet lovers. All three objectives of this project have been achieved. However, some improvements might be needed by adding more attractive features and functionalities for future implementation.

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