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Augmented Reality to Induce Enjoyment in Edutainment Mobile Game

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***Abstract*— Augmented reality (AR) is a technology that overlay the computer generated image on real world object. AR has been implemented in various fields and one of the fields is edutainment-based game. Edutainment-based game is a game designed to make the learning process become more fun. Among the edutainment gameplay genre such as tile-matching, action puzzles, traditional puzzle games, and hidden object. However, there are still a lack of edutainment gameplay that utilizes AR technology for hidden object game genre. The hidden object game in the market today does not use 3D scene as their background. Therefore, the objective of this project is to develop an AR edutainment game in 3D scene view by using hidden object puzzle genre. This edutainment game can be used as an alternative edutainment teaching aids in kindergarten and primary school. Player's enjoyment is measured based on the evaluation of user acceptance level towards the gameplay, functionality and performance level. Results of user testing shows that 67% of the total respondents strongly agreed that this game is enjoying to be played. In addition, there are 53% of the respondents agreed that the game is stable when being played in a mobile device. Next, there are 67% of the respondents agreed that the presentation of the information and instruction are clear.**

***Keywords*— Augmented reality, edutainment, mobile game.**

I. INTRODUCTION

Augmented reality (AR) technology refers to the inclusion of virtual elements in views of actual physical environments, in order to create a mixed reality in real time [1]. The virtual scene generated by the computer is designed to enhance the user's sensory perception of the virtual world they are seeing or interacting with. At first, AR started was used by the military, industrial and medical applications, later on, various areas such as architecture, commercial, construction, gaming, education, sports, entertainment and edutainment also implement AR technology into their fields. Edutainment, referred to by educational entertainment, is another approach that uses games to deliver content as well as to educate children. 'The Treasure Hunt AR Viewer' and 'AR Bone Puzzle' are examples of edutainment games that implemented AR technology -. There are various types of genre in edutainment game in mobile such as adventure, platform, arcade, puzzle, strategy, shooter, role-playing and so on. From all of them, puzzle games usually involve player's logic and problem-solving skill like pattern matching, reaction time toward certain puzzle, memorizing and etc. [2]. Puzzle games also can be sub-divided into few genres such as tile-matching, action puzzles, traditional puzzle games and hidden object games [3]. For hidden object games, player is required to find hidden objects at several scenes. 'Gardenscapes 2' [14] and 'Little Shop of Treasures 2' [15] by GameHouse are the few popular puzzle games. Nevertheless, those games did not implement augmented reality. Therefore, inspired by those games an AR edutainment game namely Help Me Out! were developed based on hidden object puzzle genre.

Nowadays, AR has been implemented tremendously into various fields such as gaming, entertainment, education and so on. Based on few examples in the mobile market nowadays, there is a lack of AR integration in edutainment game. The existing hidden object game in the market such as 'Gardenscapes 2' and 'Little Shop of Treasures 2' did not use 3D scene. Therefore, this AR technology is found to be an alternative approach to induce player's excitement and deliver the content in an interesting way. This project is developed to fulfil three objectives: (i) designing a gameplay of AR edutainment game by implementing puzzle genre; (ii) developing Help Me Out! game on Android platform with marker-based approach; (iii) performing evaluation to the target user based on Technology Acceptance Method (TAM).

The target users for this game were primary school pupils aged 7 - 12 years old. This game uses three markers to

represent three different scenes: city, garden and room in a house. The player is required to find five objects in each scene to complete the scene. This edutainment game is developed using English language.

The rest of the paper is organized as follows: Section II describes the literature review and existing applications. Section III presents the methodology used to develop the application. Section IV discusses about the evaluation analysis from target users' perception and acceptance. Finally, section VI concludes the work and highlights the limitation of the project and possible future improvement.

II. Literature Review

This section discusses about a review of augmented reality, edutainment approach in education and further exploration in similar type of augmented reality game application which related to the project.

A. Augmented Reality

Augmented reality was introduced by Ivan Sutherland in 1968, the creator of first Virtual Reality system, also creates the first augmented reality system [4]. Then the first marker systems with 2D matrix markers (square-shaped barcodes) that allow camera tracking with six degrees of freedom was created [5]. Generally, there are four types of AR approaches, which are marker-based AR, markerless-based AR, image-based AR and location-based AR [6]. Figure 1 shows the framework for marker-based AR.

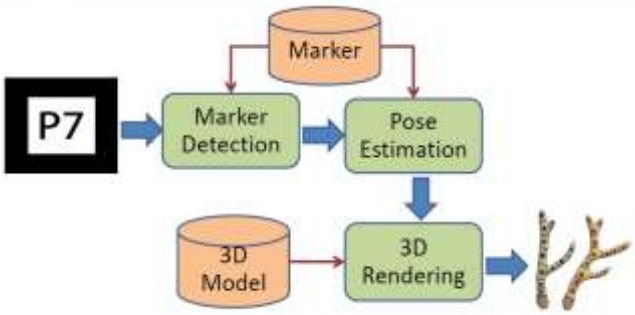


Fig. 1 Framework for marker-based AR [6]

Previous research on AR identified that an AR system must have three characteristics: combination of real and virtual, interactive in real-time, and registered in 3D [1][7]. Besides, six classes of potential AR applications are discussed such as medical visualization, maintenance and repair, annotation, robot path planning, entertainment, and military aircraft.

B. Edutainment Approach in Education

Edutainment refers to computer games, television programs, books, or other materials that is designed to educate and entertain people at the same time. Edutainment are delivered as the same way as education does. Several ways of deliver educational information to user are conventional learning, computer-based learning, and mobile-based learning. Mobile learning is defined as the intersection between mobile computing (the application of small portable and wireless computing devices) and e-learning (learning facilitated and supported through the use of ICT) [8]. Based on the given definition, mobile-based learning (M-Learning), is another approach of delivering knowledge to people who are using handheld devices such as notebook computers, Personal Digital Assistants (PDAs), smartphones, tablet personal computers (Tablet PCs) and others [9]. Based on the above various type of mobile device, mobile technology improvements in built-in camera, sensors, computational resources and power of cloud-sourced information have made AR possible on mobile device [9]. Nowadays, AR is implemented in edutainment field. By integrating real world and digital learning resource, user's perception and interaction was enhanced using virtual experiments in the real-world environment [10]. Until now, edutainment games that uses AR technology such as ARMuseum [11] and AR Bone Puzzle [12] can be found in the market. ARMuseum is a guiding application for tourist when visiting the Museum of Industrial Olive Oil Production in Lesvos. The weakness of ARMuseum application is it requires an active internet connection to send and receive the data such as personal information, location information and multimedia data to the server. Besides that, the security and privacy issues regarding the personal information stored in the server are of concern. Meanwhile, AR Bone Puzzle is an AR edutainment system for bone anatomy learning. The weakness of AR Bone Puzzle is the system requires a space for the device to be setup and installed. As for the content itself, the level of detail for the skeleton decomposition is not enough for senior student (with respect to their knowledge). Thus, the proposed AR-based edutainment mobile game is developed with minimal specification.

III. Methodology

'Help Me Out!' AR-based mobile game is developed using Multimedia Mobile Content Development (MMCD) [13]. It is a methodology used to develop mobile learning (m-learning) applications. MMCD methodology is developed based on the characteristic of agile model and Flash Lite (FL) technology. There are five stages in this methodology, which are application idea creation, structure analysis, process design, main function development and testing. In each stage, there are several activities that will be performed in order to complete this application. Figure 2 shows the MMCD model used in the development of this application.

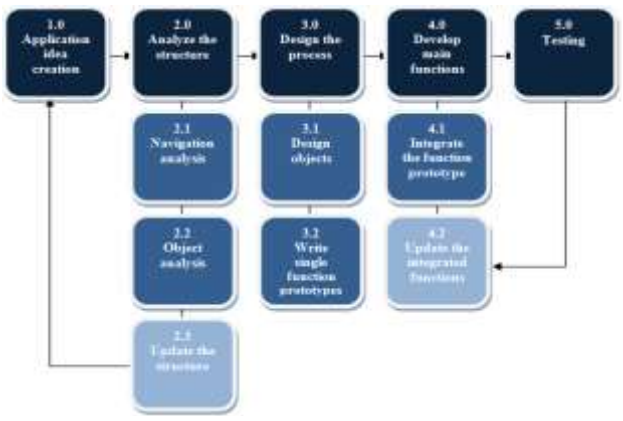


Fig. 2 MMCD Methodology [13]

A. Application Idea Creation

In application idea creation stage, a list of information needed is checked. By reviewing the similar application, problem statements, objectives and project scope were determined to fulfill the user and application requirements. Table 1 shows the checklist of overall ideas for the application that will be developed.

TABLE 1
APPLICATION IDEA CREATION CHECKLIST

Item	Note
Type of application	Edutainment
Target device	Android Smartphone
Target users	Pre-school and primary school (Ages 4 – 12)
Application settings	Programming language: C# Resolution: 1920 x 1080
Graphical user interface (GUI)	Background (Introduction, main menu and credits)
Images	Background image
Video	None
Audio	Background sound, voice-over audio
Application synopsis	This application is an AR hidden object edutainment game that requires the player to find all of the hidden objects throughout the scene in order to complete the game mission.

TABLE 2
APPLICATION STRUCTURE CHECKLIST

Item	Note
Scene design	Scene 1: Main menu Scene 2: Story introduction & instruction Scene 4: City scene Scene 5: Garden scene Scene 6: Room scene Scene 7: Ending scene
Menu and navigation	Main menu o Play o Credits o Exit
Images	Main background images
Placing audio	Intro audio and clicking sound effect
Storyboard	Example as shown in Figure 3
Objects	Props: 3D scene models : 2D hidden objects Character: Siew Ling
Button	Functional button, eg: Zoom Navigation button, eg: Next

B. Analyze the Structure

The structure of the application was analyzed before the development process starts. It involves analyzing the suitable navigation structure and objects. Table 2 shows the application structure checklist based on the application idea creation phase. In this game, hierarchical navigational structure is applied since the user is familiar with the natural logic of the content. There are three main scene (ie: city, garden and room). In each scene, there are five objects hidden all over the scene. Each object was designed to suit the metaphor in the scene. There are book, cake, pencil, ruler and a cup of coffee hidden in the city scene. In the garden scene, the hidden objects are water bottle, fork, kite, plate and spoon. While in the room scene, the hidden objects that needs to be found are alarm clock, lamp, laptop, school bag and toothbrush.

C. Designing the Process

In this stage, the application is designed based on the application structure as shown in Table 2. The flowchart and storyboard are drawn in this phase. After the objects were designed, function prototypes and scripting are developed to allow the interaction and functionality of the application.

1) Designing the game style: The game styles for Help Me Out! is single player offline mode. The button available are functional button, such as rotate and zoom while the navigation button, such as next and home. The game requires user to tilt around the marker so that the hidden objects can be seen clearly.

2) Designing the objects: All the objects used in the development process were designed in this phase. The objects included buttons, stages, backgrounds, character, and hidden objects. These objects were designed and modeled using Adobe Photoshop CS6 and Autodesk 3Ds Max respectively. The buttons were created using Adobe Photoshop CS6 and saved in Portable Network Graphics (.png) file format.

3) Marker creation: First, the pattern of the marker is created and edited using Photoshop CS6. Then, sign in to Vuforia website to upload the image to Target Manager and Vuforia will convert the image target into an asset package that will be imported into Unity 3D. Figure 3 shows the framework of image marker creation. Three markers were created as shown in Figure 4.

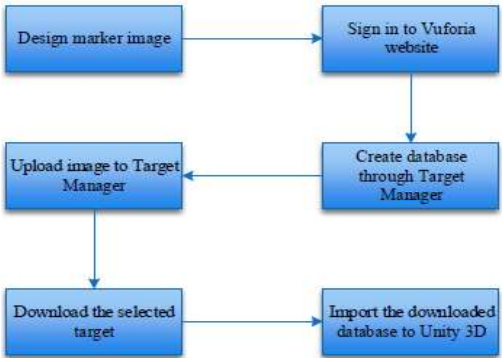


Fig. 3 An image marker creation framework

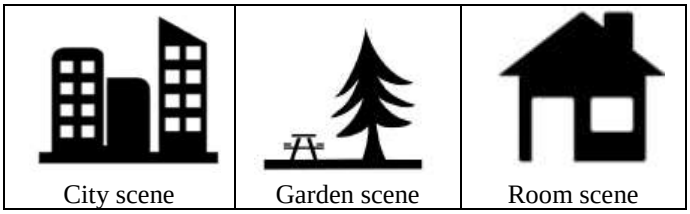


Fig. 4 Help Me Out! markers

4) Write single function prototypes: The function prototypes and scripting of the objects were developed using C# programming language. The scripting is extremely important to the functionality, interaction and navigation of the application. Some of the functions that enable user to interact with the game are rotation and scaling. For scaling, player can scale up and down the city up to three times of its original size. Figure 5 shows the code snippet for interaction with the hidden object.

```
public void ZoomIn (){
        if (mCityTransform == null)
                return;

        if (mCityTransform.localScale.x < 1.7)
        {
                float oldScale = mCityTransform.localScale.x;
                float newScale = oldScale * 1.2f;
                mCityTransform.localScale = new Vector3 (newScale, newScale, newScale);
        }
}

public void ZoomOut (){
        if (mCityTransform == null)
                return;

        if (mCityTransform.localScale.x > 0.58) {
                float oldScale = mCityTransform.localScale.x;
                float newScale = oldScale / 1.2f;
                mCityTransform.localScale = new Vector3 (newScale, newScale, newScale);
        }
}
```

Fig. 5 Code snippet for zooming function

D. Developing the main function

In developing the main function, the navigation scripting is written to enable the navigation between the scenes. The script of buttons are attached to each navigation button respectively. The objects are attached with the collider and script to enable it for interaction purpose. All objects are arranged according to the storyboard as shown in Figure 6.

Fig. 6 The arrangement of city props in Unity 3D

(a) (b)

Fig. 7 (a) Home menu of the application, (b) Scene selection of the game based on the given markers

(a) (b)

Fig. 8 (a) Hidden objects in the city scene, (b) High score board of the game

Figure 7(a), 7(b) and Figure 8(a), 8(b) show several screenshots of the game application interface.

E. Application release

Lastly, the application is published in *.apk* file format. Users need to install the Android Application Package (APK) file into their Android phone to carry out the evaluation phase.

The steps of building the application are listed as follows:

Step 1:	Go to 'File' menu and choose the option 'Build Settings'
Step 2:	Select all the scenes involved in 'Scenes In Build' by ticking them.
Step 3:	Choose the 'Android' platform in 'Platform' column and click on the 'Player Settings' under the 'Platform' column.
Step 4:	Enter the application name at the 'Product Name' text field.
Step 5:	Choose the application icon by uploading the designed icon into Unity 3D.
Step 6:	Click on the 'Build' button and wait for the exporting process to finish.
Step 7:	The window of .apk file will appear after the exporting process is completed.

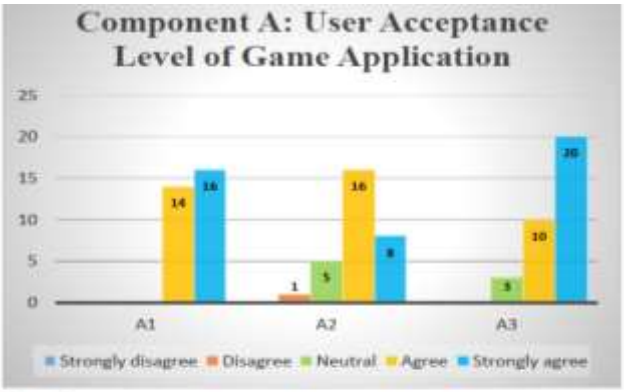
IV. RESULTS AND DISCUSSION

The game application was successfully built with the size of 1920 x 1080 pixels resolution. User testing was carried out to evaluate three variables: users' acceptance level towards the gameplay approach, functionality level and performance level of the game. This testing involved 2 teachers and 28 primary school pupils. The respondents were aged from 7 – 12 years old, involving both genders and all races. The testing was conducted at UTHM in Parit Raja, Batu Pahat.

Figure 9 shows that 53% (16) respondents strongly agreed and the remaining respondents agreed that the game is interesting to be played. Also, 53% (16) respondents agreed that they had learnt something new from playing this game. Conversely, one respondents disagreed due to unfamiliarity with AR game concept. Interestingly, 67% (20) respondents strongly agreed that the game is fun to be played.

Meanwhile, Figure 10 displays user's acceptance of the game. Most of the respondents (97%) agreed that the game is stable when being played in a mobile device. Besides that, majority strongly agreed (97%) that the control buttons work

perfectly in the game. Moreover, most of the respondents agreed (87%) that the multimedia elements in the game are integrated and arranged nicely.



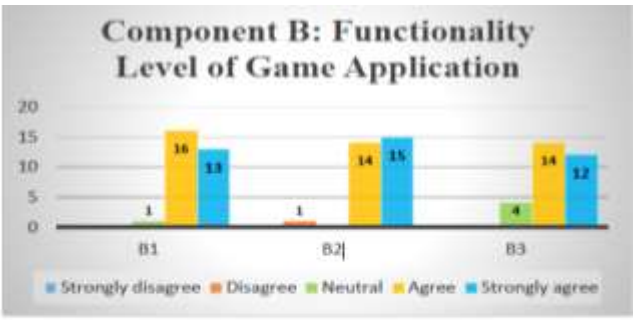
Questions

A1 - The game is interesting to be played.

A2 - I learnt something new from playing this game.

A3 - The game is fun to be played.

Fig. 9 User acceptance level of game application



Questions

B1: The game is stable when being played in a mobile device.

B2: The control buttons work perfectly in the game.

B3: The multimedia elements in the game is integrated and arranged nicely including the quality.

Fig. 10 User acceptance towards game functionality

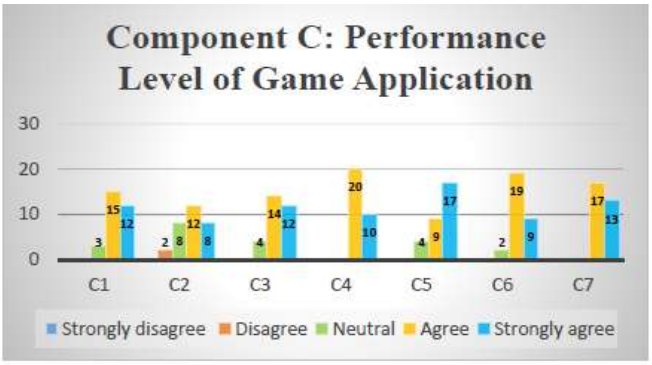
User acceptance level of the game is shown in Figure 11. For the navigation of the game, 90% of the respondents agreed it is easy to be understood and controlled. 67% of the respondents agreed that the screen design is suitable with the theme featured, while all respondents find the information presented in the game is clear. The words, illustrations and icons used are suitable in each screen as agreed by 93% of respondents and integrated properly in good quality (87%). Most of the respondents strongly agreed (57%) that the aesthetic/art in the game is fun. Thus, the overall game application functions perfectly.

V. Conclusions

As conclusion, Help Me Out! has been developed successfully and achieved all the objectives of this project. The advantages of the game are it allows the interaction with virtual objects and player is freely to explore the scene by themselves.

The application can be used as a new alternative learning aid for primary school as the content can be dynamic and flexible. Nevertheless, the limitation of the application is the limited number of hidden objects, story and scene due to the application size as it involves many multimedia elements.

For future works, improvement will include additional character to provide more variety of storyline in the application. In additional, more hidden objects will be added to increase the difficulty of the game.



Questions

C1: The navigation of the game is easy to be understand and controlled.

C2: The screen design is suitable with the theme featured in the game.

C3: The multimedia elements in this game is integrated properly and in good quality.

C4: The presentation of the information and instruction are clear.

C5: The aesthetic/art in the game is fun.

C6: The words, illustrations and icons used are suitable in each screen display.

C7: The overall game application functions perfectly.

Fig. 11 User acceptance towards game performance level

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