ARkanoid: Development of 3D Game and Handheld Augmented Reality

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Abstract

In this paper, researcher presents ARkanoid, a 3D Handheld Augmented Reality game. Through this project, researcher tried to remake the old 2D game and brought it into something new. This time, researcher chooses an Arkanoid game which was first introduced in 1986 and became very famous together with the raise of video game era on that moment. Not only makes it in the 3D version, but also researcher combines it with an Augmented Reality (AR) technology. And finally, this AR project is finalized through handheld devices so that it can be commercialized to the real world in the future. This paper discusses the technical aspect of the game, the design and development process and the result of user study. The goal of this research is to explore the affordances and constraints of handheld AR interfaces for 3D games. This project showed some promising results of handheld AR application in game. User feels that the game presentation with 3D and AR technology is more interesting than general 2D game, the immersion of virtual object in real world also brings unique game ambient and touch-screen gameplay makes the player becomes more engaged to the game. Researcher hopes this research can be the milestone and will inspire the further research of respected field. Researcher also hopes this Arkanoid AR game can educate the user of handheld device who mostly grew up in previous era of Arkanoid game, that they can easily get familiar with AR technology applications.

Keywords – Arkanoid game, 3D Game, Handheld AR

I.   Introduction

These last decades, the 3D technology has been well developed and this knowledge has become more mature than before. We can see that 3D technology has been used in several fields in our daily life. However, to reach the end user or audience, this 3D technology needs to be displayed. In general, there are 4 types of 3D display, namely stereoscopic, augmented and virtual reality, integral image and holographic display. Figure 1 will display a simple graph of 3D technology display.
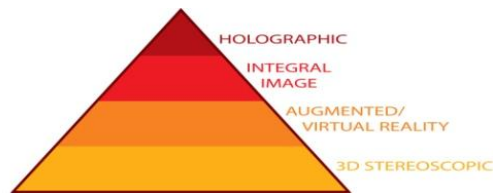

Figure 1. 3D Technology Display

Historically, 3D technology was developed based on 2D graphic. In the early of 90's 2D graphic technology got its popularity. Then, 3D technology became mature and started to be commercialized. Several fields had been reached by previous 3D technology. 3D technology then derived again become 3D stereoscopic that been massively used these days. After that, researchers tried to find another way to display 3D technology, and then augmented/virtual reality appeared. Recently, an augmented and virtual reality has reached certain level to bring them from research lab into real world. The core technology has been mature enough to be applied in several fields of human life, such as entertainment, education and others.

The integral image is starting to develop as well these days. It rose to overcome several disadvantages appeared from 3D stereoscopic technology, such as parallax problem. This technology is still in process to find their maturity in research lab. And finally, the most ideal 3D technology display is holographic display. The previous 3D display however is still covered by the screen. It is just the illusion of 3D display behind the screen. Holographic display will display the 3D object in the free-space and can interact directly with the user. Figure 2 will display the 3D display technology transition.
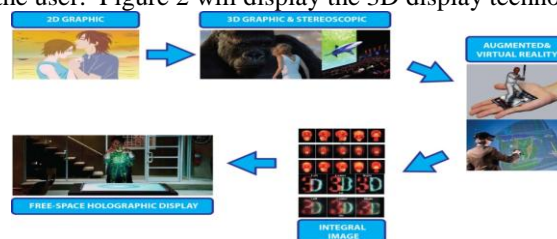

Figure 2. Display Technology Transition

In this paper, researcher decided to develop a project related to handheld augmented reality. Some expertise believed that an AR/VR is a proper bridge to reach an ideal 3D display, holographic. While the integral image is still in the research and development phase, an AR/VR technology has reached their maturity. Reaching more than 10 years since its first official conference, this research field has grown significantly. Based on this fact, lately several parties started to move this technology to real world so it can give benefit a lot of people. Previously this technology had several barriers related with the commercialization effort. But the invention of handheld devices happened recently and helped AR technology to reach end user easier than before. Based on these facts, researcher chose an augmented reality that is finalized in handheld device to display the 3D object in this game.

From this project, researcher would like to support the commercialization effort of AR technology. Several AR projects have been developed before in the various fields and now researcher wanted to represent one of the famous games in previous era, Arkanoid, and combined it with recent technology. This research is expected to be a proper milestone for further research and development of AR technology in various fields. It is the right time for AR technology to show its contribution to real human life.

II.   Previous Work

The commercialization effort of AR technology has been appeared since several years ago. Various fields have been reached by AR technology but in general there are six types of applications, namely personal information system, industrial and military applications, medical applications, entertainment, office applications, education and training [1]. But, still it found some difficulties to reach end user in real world. The invention of handheld device, such as smart phone and computer tablet, which had been massively used by people recently really helped AR technology to reach real world application. It also had domino effect to the number of research in handheld AR. Survey found that the published papers about handheld AR has become more popular these days [2].

In education field, Markus et al had developed an AR edutainment content for Sungsan elementary school (SES) in Busan - South Korea[9]. The project name is EDUtangram and it combined conventional Tangram edutainment tool with AR technology. This project was also finalized using handheld devices, iPad2. An AR Tangram edutainment was then installed on 30 iPads belonged to SES and they used it regularly during their class session.
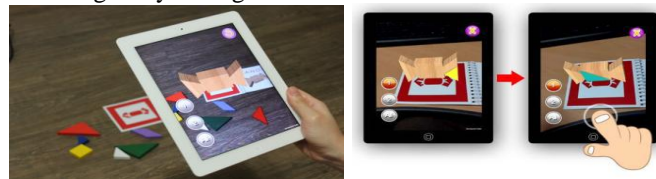

Figure 3. EDUtangram project.

In entertainment field, these days there are several great AR projects released. At least there are three big names in entertainment industry exploring AR technology for their activity. Transformer creates an AR application for iPad device to support their movie in the theater. This year Marvel Corp. also releases an AR application for one of their most famous hero characters, Iron Man. And lastly, to support the commercial release of newest Spiderman movie in theater, they also create AR application for handheld device. Together with conventional promotion media such as poster and website, this handheld AR application become an integrated and creative marketing tools.
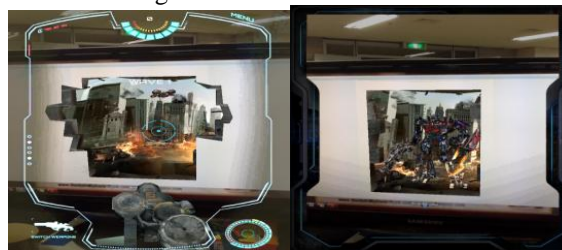

Figure 4. Transfomer Handheld AR Applications

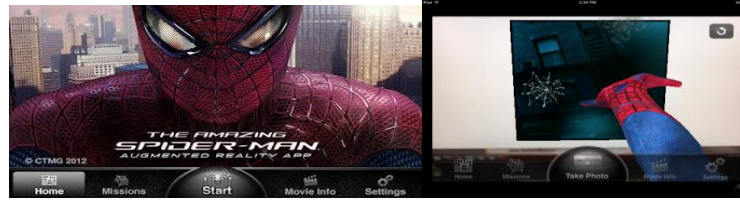**Figure 5.** Marvel Handheld AR Applications

Figure6. Spiderman 4 Handheld AR Applications.

Not only in entertainment field, increasing number of AR project also happened in game field. Several published plug-in or software for AR purpose had contribute to blooming number of AR applications in this field both for PC- based, handheld device-based and other possible device. One of the developers who develop 3D AR game for handheld device is Fuzzy Logic. They developed an Augmentron for iPad2 device.
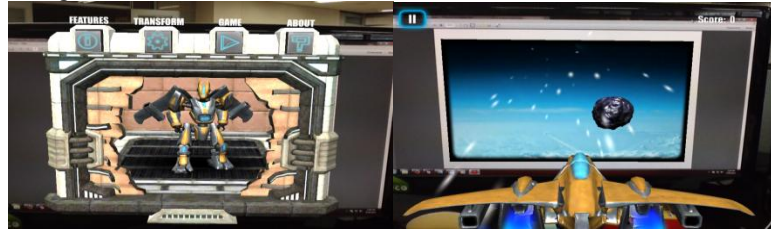

Figure7. Augmentron handheld AR applications

III.   Game Description

ARkanoid was chosen as the main theme of this project. Arkanoid is an arcade game developed by Taito in 1986 and it first released for Atari consol. This game is well-known on that moment so that it reproduced again for several game consoles that released after Atari console era. In simple way, the player of Arkanoid will control the paddle and prevent a ball falling down from playing field. When the ball hit the paddle, it will bounce against the brick that are provided in the field. The objective is to finish all of the bricks, end the game and move to next stage. The objective is simple but the challenge is not that easy. It makes the player become addicted to this game. In 1989, Arkanoid was reviewed by Patricia Hartley and Kirk Lesser. In their "The Role of Computers" column, the reviewers gave this game 5 out of 5 stars.

Figure8. Arkanoid Game in Early Era.

Children who play an Arkanoid game in early released era had been grown up now, finished their higher education and some of them already maybe working. The most important thing is they are the user of the handheld devices recently. By combining the game that famous in their childhood era with AR technology, researcher tries to educate this generation to be familiar with this recent technology. So that, they will be able to get used with further AR application easily.

IV.   Augmented Reality

Augmented reality topic was first introduced by Sutherland in 1960. Then it became an emerging research topic when Milgram and Kishino published their paper and introduce about the concept of "Virtuality Continuum"[7]. In this concept, they clarify the position of the augmented reality in the simple graph as seen in figure 9. This concept then became the milestone of the Augmented Reality development until these days.

Figure9. Virtual Continuum Concept

Augmented reality is technology which allows computer generated virtual imagery to exactly overlay physical objects in real time. AR allows user to interact with the virtual images using real objects in a seamless way [4]. Furthermore, Azuma provide commonly accepted definition of AR as a technology which combines real and virtual imagery, interactive in real time and registers the virtual imagery with the real world [8]. In order to provide an effective AR experience there are number of factors that must be developed, namely graphics rendering hardware and software, tracking techniques, tracker calibration and registration tools, display hardware, computer processing hardware and interaction techniques [2]. During the evolution of AR, there are various research topics appeared and developed extensively.

In general, there are 2 groups of AR research topic [2]. First group contains the main research areas of Tracking techniques, Interaction techniques, Calibration and Registration, AR Applications and Display techniques. This group represents the core AR technology areas which are needed to deliver an AR application. Second group of topic reflects more emerging research interest, including Evaluating/testing, Mobile/Handheld AR, AR Authoring, Visualization, Multimodal AR, Rendering [2]. Since the invention of handheld devices in our daily life, the number of research in mobile AR has been raised as well.

One of the main components for AR is display. There are three major types of AR displays, namely Head-Mounted Display (HMD), Spatial Display and Handheld Display [3]. HMD is a display device worn on the head or as part of helmet and that places both images of the real and virtual environment over the user's view of the world. Spatial Display makes use of video projector, optical elements, holograms, radio frequency tags and other tracking technologies to display graphical information directly onto physical object without requiring the user to wear it or carry the display. Handheld display employs small computing devices with a display that the user can hold in their hands. There are three distinct classes of commercially available handheld display that are being used for AR system, namely Smart-phones, PDA and Tablet PC [3].

The presence of handheld devices in AR field is expected to contribute more in commercialization effort of AR technology. The reason is because handheld AR is predicted to fulfill some requirements to be successful systems in the market. Carmigniani and Furht stated there are three requirements for systems to reach its success in market. First is socially acceptable, it means that is subtle, discrete and unobtrusive. Second is natural interaction which is needed to be able to interact with the system in a natural way. And last factor is fashionably acceptable so that user does not need to look strange while operating the system [3].

V.   Design And Development Process

ARkanoid is a project that combines conventional Arkanoid game with Augmented Reality technology and installed on handheld device. The gameplay of Arkanoid itself will remain unchanged, still related to paddle, ball and brick. But this time, researcher represented Arkanoid game in 3D version.

To build this game, researcher used Unity3D game engine. Unity3D game engine right now has been widely used by game developer. There are tons of advantages offer by Unity3D, such as multi-platform device possibility (iOS, android, Xbox, Nintendo wii, PC), graphical advantages, simple user interface and others. Unity3D is supported by 3 common programming languages such as java, c# and boo. Unity3D also has a strong community to support each member in this area and it becomes another advantage for the various skill range of user (www.unity3d.com).

To build the AR session, researcher used Vuforia. Vuforia is the AR extension created by Qualcomm and it perfectly bundled with Unity3D software.Vuforia is a marker-based AR system and it enables vision detection and tracking functionality into Unity3D IDE, it also allows developers to easily create AR application and games. A Vuforia based AR application is composed of the following core components: camera, image converter, tracker, video background renderer, application code and target resources. Figure 10 is the data flow diagram of Vuforia Ar extension (http://ar.qualcomm.at).
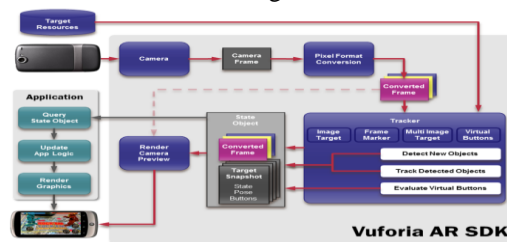

Figure10. Data Flow Diagram of the Vuforia AR Extension

Basically, Vuforia is Marker-based AR extension. Because of that, we need the marker so that the system can detect it, track it and then visualize the 3D object above the marker. Unlike the previous AR tool, Vuforia allow us to create colorful marker because they just extract the edge and contrast as a feature point. Figure 11 show the design of marker for ARkanoid project.

Figure11. ARkanoid Marker Design.

To play ARkanoid AR game, user needs to prepare and put the marker in the horizontal position. After that, they need to point device's camera into the marker. When the camera already capture the marker, 3D object will automatically appeared in the screen and audience can start to play the game. Figure 12 show the gameplay procedure of ARkanoid AR game.

Figure12. ARkanoid Gameplay Procedure

Previously, player needs to use joystick, keyboard or any other 3rd parties to move the paddle. But, since this new ARkanoid is built on the handheld devices that had no additional button, researcher added slide function to move the paddle. Using this function, player can slide their finger on the device's screen to move the paddle to the respected direction. Figure 13 show the slide function of ARkanoid 3D game.
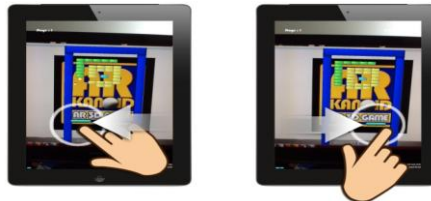

Figure13. Slide Function of ARkanoid 3D Game

In conclusion, researcher try to bring the same gameplay experience from the conventional while in the same time researcher should adjust some parts to fit the AR technology and handheld devices. The general gameplay is still remaining the same, but the 2D graphic display was changed into 3D graphic display. This game also created on marker-based AR technology. Finally, since it built on handheld devices, rather than using 3rd parties to interact with 3D object, player can directly touch and interact with the paddle on this game.

VI. User Study
4.1 Goals and Participant Recruitment
After complete ARkanoid game prototype, researcher conducted small user study with 10 participants. Specifically, researcher hoped to explore their opinion about the comparison of 3D AR game with the conventional 2D game, the augmented reality technology embedded with game and the gameplay of new Arkanoid. We were interested to find out their interest about an AR game and their feedback about the gameplay itself would be valuable information for the further research in AR game.

To recruit participants, we have several situations to be considered. First, the participant should have an experience playing an early Arkanoid game, no matter what game console they used at that time. Since we want to compare between conventional Arkanoid games with our new Arkanoid, so the previous experience of an early Arkanoid game should be fulfilled by participant. Second, we try to find participant from various background of knowledge as long as they can satisfy first requirement. They can be a student from various major, workers, housewife and other else. And last, we try to observe multi-nation participant. Rather than focusing in one nation or races, we open this research for participant from various nationalities.

Finally, we found 10 participants with the age range from late of 20's to mid of 30's. Since they spent their childhood in 1980's until early of 1990's, all of them definitely had an experience playing early Arkanoid game. 2 of them are the undergraduate students from non computer science major, 4 of them are graduate students from computer science major, 2 of them are workers, and 2 of them are housewife. The participants were from 5 countries, namely Korea, China, Malaysia, Indonesia and Russia. Except the graduate students, all of them do not have prior knowledge and experience in augmented reality games before. For the research in Indonesia, researcher sent the application installer to the participant and the survey was completed by skype chatting.

4.2 Procedure and Setting

The user study was divided into three parts. First, researcher gave a brief explanation about the gameplay procedure; in this case researcher already prepared the marker and handheld device. After that, researcher let the participant played the game directly and there was no game time limitation. Participant could decide by themselves when they wanted to stop playing the game. Except for the participant in Indonesia, all the research was done in the research lab with one condition should be considered, it should be indoor. Indoor place was chosen to prevent unexpected distraction to the tracking robustness ability. And last, researcher interviewed the participant to gather needed information, data and opinion.

The user study also conducts individually. It means that it separately from one participant to each other. Since mostly of user study were done by interviewing, it would be easier to explore their opinion when discussions were held individually. By using individual interview, not only we can observe more about participant opinion but also it can keep privacy from each recruited participant.

VII. Discussion

Through the user study, participants gave us valuable feedback about ARkanoid AR game. We interviewed the participants whether they like or dislike the new appearance of Arkanoid game. 8 of the participants were pros to the new ARkanoid AR game. Most of them explained that the using of 3D graphic and AR technology bring this game to the next level and it is more interesting than conventional 2D game. The rest participants choose to cons the new ARkanoid AR game since they felt there is no significant difference to early Arkanoid game and there is no urgency to use 3D and AR technology since they already like early Arkanoid format.

Next, we try to observe their opinion about the AR technology that embedded in this game. 6 of the participants said that they are excited and interested about the AR technology. Rather than playing a fully virtual game, the immersion of virtual object in the real world gave them a unique sensation during game session. The rest participants stand for cons position since they felt that AR technology made the gameplay become more difficult because they needed to point the camera to the marker during game session, the other else said that it was quite heavy to hold the device during game session.

Last, we observe their opinions about the gameplay of new ARkanoid game. 7 of the participants said that they like the new way of the ARkanoid gameplay. Previously, they need to move the paddle using 3rd parties' device such as joystick, keyboard and other else. But using handheld device and sliding function, participants could interact with the paddle directly from the screen. It made them comfortable and more engaged with the game itself. 2 of the participants said that using handheld device to play a game was fine and they give suggestion to put the virtual button in the screen to move the paddle rather than using slide function. And 1 of the participant said that playing with the joystick was better especially in controlling the paddle.

VIII. Conclusion

In this paper, we conducted research about the potential of combination 3D game and handheld AR technology then analyzed the user study from it. In contrast with the early design of Arkanoid game, researcher tried to represent it into 3D platform game and furthermore combine it with an AR technology. And finally, the new ARkanoid game was finalized in the recent handheld devices that already massively used these days.

Our research about the combination of 3D game and handheld AR technology found promising result and it can be the basic of the further research to bring this technology from research lab to the real world. We can conclude that users feel the game presentation with 3D graphic and AR technology is more interesting than general 2D game, the immersion of virtual object in real world also brings unique game ambient and touch-screen gameplay makes the gap between player and the game became closer and it makes them more engaged to the game.

As we move forward, researcher hope this research can be milestone and will inspire further research of respected field. Researcher also hopes can educate the user of handheld device who mostly grew up in the previous era of Arkanoid game, so that they can easily get familiar with AR technology applications. Since AR is pretty new technology in our daily life, we need to educate the people as end user so that they can get used and familiar with this technology. In the long run, we hope to explore an AR technology deeper and observe the application of AR technology in various fields, any other purposes and brings more benefit to people in the real world.

References

1. D.W.F. Van Krevelen, R. Poelman. A Survey of Augmented Reality Technologies, Applications and Limitations. In *The International Journal of Virtual Reality,* 2010, 9(2), pp1-20.
2. F. Zhou, H.B.L. Duh, M. Billinghurst. Trends in Augmented reality Tracking, Interaction and Display: A Review of Ten Years of ISMAR. In *International Symposium on Mixed and Augmented Reality (ISMAR'08).*
3. J. Carmigniani, B. Furht. Augmented Reality: An Overview. In *Handbook of Augmented Reality.* ISBN: 978-1-4614-0063-9. Springer Science, London.
4. M. Billinghurst. Augmented Reality in Education. *New Horizons for Learning.* Retrieved from: http://www.it.civil.aau.dk/it/education /reports/ar_edu.pdf.2002.
5. M. Billinghurst, A. Henrysson. Research Direction in Handheld AR. In *The International Journal of Virtual Reality,* 2006, 5(2), pp51-58.
6. M. Haller, M. Billinghurst, B. Thomas. Augmented Reality: Interfaces and Design. ISBN: 1-59904-066-2. Idea Group Publishing.
7. P. Milgram, F.Kishino. A Taxonomy of Mixed Reality Visual Displays. In *IEICE Transactions on Information Systems,* VolE77D, No. 12, December 1994.
8. R.T. Azuma. A Survey of Augmented Reality. In *Presence:Teleoperators and Virtual Environment,* 6:4, 355-385, August 1997.
9. S. Markus, F.Y. Wang, B.G. Lee. Development of Edutainment Content for Elementary School Using Mobile Augmented Reality. *Proceeding of ICCRD'12* (Chengdu, China, May 5-6, 2012).