

Effect of Augmented Reality on User Enjoyment and Mastery of Controls on mobile Castle Defense game

Seymur Mammadli

Department of Multimedia Informatics

Informatics Institute

Middle East Technical University

Üniversiteler Mh, Dumlupınar Blv. No:1, 06800 Çankaya/Ankara

e184833@metu.edu.tr

Abstract

We have developed an Augmented Reality Castle defense game, which is designed as a Project of course of Game Development Pipeline in 2017. As a Project of this course we have conducted a Game User Research to measure the difference on users' enjoyment on playing an Augmented Reality versus Standard version of the Game. We have collected data of eleven participants on both versions of the game. The result we have found that the Augmented Reality version of the game was rated by the participants as slightly more enjoyable. The AR version of the game is also rated more intuitive to use by means of the game controls and there are no any drawbacks of on mastery of controls while using AR.

Author Keywords: Augmented Reality, Game user research, enjoyment, mastery of controls,

1. Introduction

However, The Augmented Reality(AR) systems are not very new concept the usage of these systems are not highly accomplished. The AR features are applicable different subjects such as medical(surgery), military, architecture and design, entertainment and many more other subjects. The usage of AR on Digital Games is one of the main application area.

The current assumption is that the novelty and experience of AR more suitable for particular applications. Because of the limitations on the technology the AR not improved very fast and there have been few user studies to demonstrate the appeal and enjoyment of the AR experience.

By using an AR feature we believe that the features of the AR features have enables providing easy to use controls and engaging user interface on many subjects.

The purpose of the study is to determine the improvement of player enjoyment while playing an

AR featured counter-part of the same game and to measure the effect of AR on the mastery of the controls for the players who are novice on AR game experience. We have designed a user study by inviting appropriate number of people to the experiment. The participants played the pre implemented Castle Defense Game both on AR mode and Standard mode which are built on Android platform. Furthermore, we have used statistical techniques to collect and analyze the collected data to derive appropriate and meaningful result. Moreover, despite this not the first Game User study to compare enjoyment level of the player on AR and traditional version, it is one of very few study to determine the stated phenomenon.

We have not used and specific AR hardware during experiments. Both of the version of the game were implemented on the mobile device.

We have firstly mentioned on some previous studies. The brief introduction of the AR technology and detailed description of the Game have also included. The content of the article followed by explaining the experiments and statistical methods that we have used. The results and the conclusion based on derived results also have been included.

2. Background

The section provides a detailed introduction to Augmented Reality and usage of AR on games. The brief overview of the methods that have been used to evaluate the different versions of the Castle Defense game has also presented.

2.1 AR Gaming

As stated above, the AR is not a very new concept and it is already applied on many subject. The digital games are one of main areas that the AR is applicable. There are simple digital games have AR features. It is doubtless that the most popular example of the AR based digital games is [Pokemon Go](#). It is location based AR game which is not only popular AR game it is also Popular game in general categories.

On the paper with the title of “*Evaluation of User Satisfaction and Learnability for Outdoor*” Benjamin et al divides AR games into two main groups. Indoor AR games and outdoor AR games. As far as we consider it is not easy to characterize every AR games by means of these two categories. We have used AR game on this study which is playable in both indoor and outdoor environments.

Formally, AR technologies have been categorized into some specific categories. According to an article titled “[Types of AR and Future of Augmented Reality](#)”, there are four major types of the AR. These are:

1. Marker-Based Augmented Reality
2. Marker-less Augmented Reality
3. Projection Augmented Reality
4. Superimposition Based Augmented Reality

We have used Marker-Based Augmented Reality to design AR version of the game.

2.2 Previous Work

The GUR (Game User Research) is an important step of the Game Development pipeline because of the companies and the individuals invest significant amount of resources and time to develop new digital games. It is important to get ensure that the developed game is enough enjoyable which will lead to the success after publish. GUR have many methods to test the different aspects of the digital games before and after production to get useful analysis. There are some methods that we have learned during the semester. The Rapid Interactive and Evaluation(RITE) method has been developed by Microsoft. The method helps to evaluate the games by means of collected data from many players. After fixing the defined problems the new version of the game testing to further improve the game before production.

There is few research on the effect of using Augmented Reality on Game enjoyment and Mastery of controls. Benjamin et al. (Benjamin, 2004) conducted research to compare the enjoyment improvement while using AR. However, this research used A/B testing of the same game on different environments (indoor, outdoor). They have also used special device for AR which may have a significant effect on the result. The study has used game specific questionnaire that we have generalized a bit.

3. The Game

As stated above the game was developed for the course of Game Development Pipeline on the last year. The main purpose of the project was to follow guidance of the course to design appropriate game which have some features to gain immersion of the player. We have decided to design Augmented Reality based Castle Defense game for the sake of using the futuristic characteristic of AR. The game is Mobile based castle defense game. The current version has built on Android and Developed on Unity 3D. There are three types of scenes which are menu scene, trailer scene and Level scenes. It is basic Castle Defense game and included some items listed below.

- ◆ Enemies
 - Zombie
 - Troll
 - Orc
 - Wolf
- ◆ Armory
 - Machine gun
 - Barrel bomb
 - Dark hole
 - Tower gun
- ◆ Knights
 - Knight
- ◆ Game Objects
 - Houses
 - Trees
 - Castle
 - Visual Effects

The players need to defense the castle against infinite waves of the enemies. The game is designed so that the player should loose defense state and the iconic item, “Source of Life” should be taken by enemy army. On the next level the knights should return the “Source of Life” within the duration that the player was able to defend the castle on defense level. Player able to buy armory by killing enemy army and every enemy have different values. Every armory has also different prices. All armory is adding by choosing appropriate item button and dropping item on wherever part of the scene. Only machine guns are put-able on specific places (At the top of Castle Towers).

3.1 AR Version of the Game

The only scenes which base on AR are Level Scenes. The AR implemented by using Qualcomm Vuforia SDK and it is target based AR. The scene generating by scanning the map (printed image) of the terrain of game terrain by means of device camera. The player need to be interactively add and improve defense items to defend the castle. The zooming is performing by manually rotating and moving the device backward

and forward by hand. The player sees real environment and generated game environment at the same time.

3.2 Standard version of the Game

The first Idea was to compare the PC version of the same game on which the AR feature should be removed. The PC version of the game was designed and tested on initial test phase. After testing the PC version, we have decided to design same game on Mobile on which the AR feature should be removed. We have changed this to get more robust and appropriate result for the sake of appropriate results related to our Hypothesis.

4. Game User Study

In this user study, every participant has played both version of the game one after other. Both version was played around 3 minutes. The general information about both versions have provided to all participants. Furthermore, all participants have explained the story of the game.

The research hypotheses are

1. The usage of the AR increases the enjoyment of playing digital game (The major research hypothesis).

2. Despite AR is novel technology, playing AR game has not significant unfavorable effect on mastery of controls.

The alternative hypotheses are

1. The usage of AR has not any positive improvement on enjoyment of playing digital games.

2. Playing AR games has a negative effect on learning curve of the games.

We have used the standard questionnaire for the survey which is based on Likert-type scales evaluation. The questionnaire was derived from Benjamin et al.'s study on same research. We have removed 8th and 16th questions from an original questionnaire because of these are specific to the Game described on the original article. We have change 9th question of the original questionnaire. The original statement was 'I knew when I was out of ammo' which we after changed to 'I knew when I was out of coins' for an appropriateness. The sample of the questionnaire have added at the end of this paper on Appendix part.

4.1 Research Hypothesis 1

We have used a t-test method to compare questionnaire responses by considering specific results of the specific questions which are appropriate to compare enjoyment level of two versions.

4.2 Research Hypothesis 2

This hypothesis examines the change on mastery of the controls while playing on AR version of the same game. We have used specific questions for this hypothesis from the questionnaire (Questions 2,4,6,8,9,13,14,15,17,18).

We used a t-test to compare the results of the questionnaires of different versions by means of change on mastery of controls.

4.3 Participants

11 participants have attended the experiment. The participants were from different subject areas and the age of participants were from 23 to 33. There were no any constraints and the participants mainly were non gamers. Most of the participants are from my work place. The majority of the participants were male. Furthermore, most of the participants were tried the AR for the first time during this experiment.

4.4 Procedure

4.4.1 Sessions

Every participant takes a procedure without seeing the previous sections with other participants. At the beginning of the test every participant acknowledged about the games and the differences. The game mechanics also explained for not to get confused on the first test. Every participant has played both versions of the game. The mode of the first game-play randomly assigned (AR or Standard). Every game-play last around 3 minutes and every participant take two game sessions. Before AR session every participant got some general information about AR because of first experience.

As we have stated above the questionnaire have been used from the paper titled "Evaluation of User Satisfaction and Learnability for Outdoor Augmented Reality Gaming". The template of the questionnaire has been added at the end of this paper. The questionnaire has been included the questions by means of which we were capable of derive useful information related to our hypothesis. Every participant answer two questionnaires after the game-play sessions. The comments of the participants also have been recorded.

5. Results

Table 1 describe the result of the survey by means of the median, variance and standard deviation of the responses for both of the games.

Benjamin et al. (Benjamin 2006) have describe the survey procedure that they have conducted. They recorded the favorite games of the participants and it has been stated that 39% of the participants were like the first person shooter games. Since the most of the invited participants on our survey were non gamers we have not collect such data.

	AR			Standard		
	M	V	SD	M	Var	SD
1. The pace of the game is appropriate	4.22	0.17	0.41	4.11	0.39	0.31
2. The controls for the game confused me	2.00	0.22	0.47	1.77	0.39	0.62
3. There were parts of the game that didn't make sense	1.66	0.22	0.47	1.77	0.39	0.62
4. If I were interrupted while playing the game, I would have been annoyed	4.22	0.39	0.62	3.44	0.91	0.95
5. I enjoyed playing the game	4.66	0.22	0.47	3.66	0.88	0.94
6. I could easily aim/place the gun	4.33	0.22	0.47	4.11	0.32	0.56
7. I found the instructions helpful	4.11	0.76	0.87	4.33	0.88	0.94
8. I knew when I was out of coins	4.11	1.43	1.19	4.11	1.43	1.19
9. I would recommend this game to a friend	4.55	0.24	0.49	3.44	1.58	1.26
10. This game is not for me	1.44	0.47	0.68	2.44	1.35	1.16
11. I would be bored with the game after 15 minutes	1.88	0.54	0.73	3.00	1.55	1.24
12. it was hard to see the enemy	2.00	1.11	1.05	1.88	0.99	0.99
13. I enjoyed the sound effects	3.66	0.44	0.66	3.77	0.61	0.78
14. I would like to turn the music off	2.33	0.22	0.47	2.22	0.17	0.41
15. I did not know when the game ended	2.33	0.66	0.81	2.55	0.91	0.95
16. I understood if I won	3.66	0.22	0.47	3.77	0.39	0.62
17. I would like to play this game again	4.77	0.17	0.41	3.55	1.58	1.25

Table 1. Questionnaire Results (M = mean, V = variance, SD = standard deviation)

As stated paper we have also average the response scores of the questions 4, 5, 10, 11, 12, and 19 to get measure of the Game Enjoyment score. As understand from the table 1 the game enjoyment level was higher for the AR based version of the game which have mean of **3.58** and the standard deviation of the **1.37**. These values were **3.25** for the value of the mean and **0.41** for the value of standard deviation on Standard version of the Game.

The response scores of the questions 2, 4, 6, 8, 9, 13, 14, 15, 17, 18 averaged and used to determine the negative effect of using AR feature on Mastery of Controls. Despite AR has added extra enjoyment to game-play the controls have not effected considerably by the usage of the AR as understand from the table.

6. Discussion

Our research demonstrate improvement on player enjoyment while playing an AR version of the Game. We demonstrate that the usage of AR has not any negative effect on mastery of controls. We will discuss specific contents that have affected our results. Furthermore, we are going to state the recorded notes and feedbacks from the participants.

6.1 Participant's Engagement

We have asked some general questions to the participants of the survey. We have found out that most of the participants are like to play castle defense games. As we noticed that the most of the participants have enjoyed playing the castle defense interactively by moving around the image target.

6.1.1 Survey Question Results

The questionnaires were filled by every participant after finishing two gameplays which were last around 3 minutes. The questionnaires were consisting of 17 same questions which were arranged on the form of Likert-type scales evaluation. The first question measures the pace of the game and to the participants the pace of the game was appropriate. The results of the participants' answers imply that on the AR the enjoyment improving during gameplay. Furthermore, the results demonstrate that the participants would get more annoyed while interrupted during playing of AR version of the game. This is because of the interactivity that the AR version offers while gameplay. The results also demonstrate that the participants would recommend AR version of the game more than the standard version. They also would not be get bored after 15 minutes of gameplay on each version of the

game. Furthermore, there was not any negative effect of using AR feature on the mastery of the controls for novice users. The overall controls were found easy by the participants on both version of the game. The effect of the sound was also almost same on both version and independent of usage of AR.

6.1.2 Feedback of the Participants.

Some participants have feedback during the sessions which we have recorded to further improve our game. Probably the first and most stated issue was the size of the game items. The participants stated that it would be nice to see every item and enemies without approaching to the image target too much. The second stated issue was the blinking of the armory buttons which are not understandable on first look. Furthermore, the lack of the life bar of game items and information about the price of each items were mentioned by the participants.

7. Limitations

Despite the result of the research is that the AR version of the game is more enjoyable, it is hard to imply the same result in general. There are some important points need to be considered as limitations of this study. First of all, the number of the participants on the study was the main limitation to derive robust and reliable result. Secondly, the questionnaire may not be designed well enough to measure the specific differences on enjoyment level and the differences on mastery of controls. Furthermore, all participants are non-gamer which may also be considered as a limitation of this study. As stated above paragraphs there are a lot of different types of AR games. Some games are appropriate to design on AR mode but others are not. Some games such as MMOs may not be proper to design on AR because of challenge and the comfort needed during the game-play.

Furthermore, the novelty of the AR games may be another reason on high enjoyment level for novice users. The study may be hold by inviting the people who have already gained enough experience on AR games.

The study should be extended to make more experiments by holding different experiments and using different games and different AR environments. The duration of each session also another major limitation of this study which may be extended on days or weeks by applying data collection during game-play using more advanced techniques such as biometric tools. The novelty maybe considered as an enjoyment

for some participants which also may be lead to misleading results.

8. Conclusion

Based on game user study that we have conducted, we can imply that the AR characteristic of the Castle Defense game improves the enjoyment. The study also demonstrate that AR featured game is not hard to learn by novice player. Furthermore, the results are implying that the learning rate (Mastery of controls) of AR version of the game has not had considerable noticed difference with the learning rate of the standard version of the game. Our results are having been derived by means of the questionnaire and the recorded comments and actions of the participants during game-play.

The participants of the user study expressed their feelings and the results of the user study have also demonstrated that the AR version of the game has provide more enjoyment during gameplay. There should be some improvements on UX design and game mechanics as most of the participants have stated. The further improvements will be investigated in the future. The proper size of the target image will be also investigated for appropriate usage and sake of easy control.

9. References

- [1] Singh, H. (February 23, 2018). *What is Augmented Reality? - Types of AR and Future of Augmented Reality*. Retrieved January 17, 2019 from <https://dev.to/theninehertz/what-is-augmented-reality--types-of-ar-and-future-of-augmented-reality--1en0>
- [2] Avery, B. Piekarski, W. Warren, J. Bruce H. Thomas. 2014. *Evaluation of User Satisfaction and Learnability for Outdoor Augmented Reality Gaming*. Retrieved January 17, 2019 from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.79.6796&rep=rep1&type=pdf>
- [3] Calle-Bustos, A. M.-Carmen Juan, Garcí'a-Garcí, I., Abad, F. (August 28, 2017). *An augmented reality game to support therapeutic education for children with diabetes*. Retrieved January 17, 2019 from <https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0184645&type=printable>
- [4] Cheok, A. D., Goh, K. H., Liu, W., Farbiz, F., Fong, S. W., Teo, S. L., Li, Y., and Yang, X. (2004): *Human Pacman: a mobile, wide-area entertainment system based on physical, social, and ubiquitous computing*. Personal and Ubiquitous Computing, Vol. 8, No. 2, pp 71-81, 2004.

PC Standard Castle Defense

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1. The pace of the game is appropriate	1	2	3	4	5
2. The controls for the game confused me	1	2	3	4	5
3. There were parts of the game that didn't make sense	1	2	3	4	5
4. If I were interrupted while playing the game, I would have been annoyed	1	2	3	4	5
5. I enjoyed playing the game	1	2	3	4	5
6. I could easily aim/place the gun	1	2	3	4	5
7. I found the instructions helpful	1	2	3	4	5
8. I knew when I was out of coins	1	2	3	4	5
9. I would recommend this game to a friend	1	2	3	4	5
10. This game is not for me	1	2	3	4	5
11. I would be bored with the game after 15 minutes	1	2	3	4	5
12. it was hard to see the enemy	1	2	3	4	5
13. I enjoyed the sound effects	1	2	3	4	5
14. I would like to turn the music off	1	2	3	4	5
15. I did not know when the game ended	1	2	3	4	5
16. I understood if I won	1	2	3	4	5
17. I would like to play this game again	1	2	3	4	5

Mobile AR Castle Defense

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1. The pace of the game is appropriate	1	2	3	4	5
2. The controls for the game confused me	1	2	3	4	5
3. There were parts of the game that didn't make sense	1	2	3	4	5
4. If I were interrupted while playing the game, I would have been annoyed	1	2	3	4	5
5. I enjoyed playing the game	1	2	3	4	5
6. I could easily aim/place the gun	1	2	3	4	5
7. I found the instructions helpful	1	2	3	4	5
8. I knew when I was out of coins	1	2	3	4	5
9. I would recommend this game to a friend	1	2	3	4	5
10. This game is not for me	1	2	3	4	5
11. I would be bored with the game after 15 minutes	1	2	3	4	5
12. it was hard to see the enemy	1	2	3	4	5
13. I enjoyed the sound effects	1	2	3	4	5
14. I would like to turn the music off	1	2	3	4	5
15. I did not know when the game ended	1	2	3	4	5
16. I understood if I won	1	2	3	4	5
17. I would like to play this game again	1	2	3	4	5