Project Report

Multimodal Interaction and Interfaces

DT2140

PongAR

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By:

Project Group 2

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Abstract

Smartphones today are an ideal platform for augmented reality with the combination of a display and a camera. In this report we explore the compatibility of augmented reality with a phone. In order to do so we recreated a classic pong game where we investigated weather touch or motion is the the most appropriate type of control while playing such a game. We conducted a study were the participants tried out our game with the two different controls where their goal was to keep the game ongoing for as long as possible without the ball reaching the goal they defended. The results showed that it was easier to be in control of the paddle and play the game while controlling the paddle with touch rather than motion. A big reason for this seem to be the inherent problem that with motion control, you have to move the screen through which you are looking. This makes it hard to navigate the game field and be fast and precise at the same time.

Introduction

One of the most important factors which may influence gaming experience is good interaction [8]. This would ideally mean, in a game, that the user feels in control over their actions with precise motions and that they receive corresponding feedback at appropriate moments. Good interactions could also imply that the game's interaction metaphors can be dimensional charted to intuitive control mechanisms relative to the real world so that it is easy for casual users to access and understand the game play.

Traditional controllers such as keyboard, mouse, joystick and touchscreens are common within gaming, they are explicit and comfortable for users to access and control the game mechanics. The touchscreen inputs, press and swipe, which could be compared to a mouse click and a mouse drag and the interaction with touch sensitive screens are the most direct form of HCI where the information display and control are one and the same surface [1].

There is however another form of interaction where the information display and control can be the same surface whilst using a device. Accelerometer devices allows interaction through gesture recognition, which nowadays most smartphones are equipped with. This allows usage of gestures and motions as user input but mobile operating systems only uses motion for screen orientation and games only uses the "tilt" of the device and not gesture input [2].

This kind of interaction allows users to be more engaged in their usage when the experience are not only affected by button pressing and timing but also by movement.

Background

Augmented Reality (AR) games are gaming environments that embed virtual, location-specific and contextual information into a physical site. Instead of putting people in an artificial world, these games augment the physical world by embedding them with digital data, networking and communication abilities and enhanced properties [3].

Using AR we can enhance our perception with augmentations such as audio, video, textual information and even tactile information to understand what is going on around us. With these added data, rather than seeming out of place, we can perceive it as a one coherent environment. As a new type of entertainment experience, combining the above, these systems have potential to create a great gaming experience [5].

Before 2008 one could find the implementation for AR games, such as NetAttack [7] and Epidemic Menace [6], rather annoying due to the head-mounted apparatus used, like an backpack for the equipment. Most existing location-based AR games such as ARQuake[1] and Epidemic Menace were restricted to specific local environments and their adaptation to other locations required a higher amount of effort [5].

In our work we wanted to investigate the combination of multiple modalities on a phone. Could an AR mobile game with motion controls be suitable for a fast-paced game like the classic pong game?

In order to explore this subject we chose to recreate the game CurveBall[2], where the most related previous work would be Hakkarainen's game SymBall. A table tennis game between either two people or one could play alone, where camera phones equipped with Bluetooth were used. On the screen users could see a table tennis court and a virtual paddle. As they moved the phone their paddle moved in the x and y direction on the screen. So, in this case it's a two dimensional motion of the phone that is being tracked, rather than the six degree position and orientation tracking which would normally be the case in a AR application [10]. When they developed the game, the tracking performance were slow with their generations of phones which meant that the best games were those who didn't rely on quick reflexes or fast competition. They considered the phone as an input device and the phones motion as the interaction method. A different method from the traditional AR interfaces where the display and input devices were separated [9].

The authors result showed that users feel that multi-sensory output is important in AR games. They collectively rated the conditions which provided the most sensory output as audio, visual and haptic. These were both the easiest and most enjoyable

[1] https://wearables.unisa.edu.au/projects/arquake/
[2] http://www.curveball-game.com

to play with. They also found that their participants prefered audio as output over haptic [9].

One popular AR game released in 2016, Pokemon Go, used “hot spots” of digital information to appear in specific physical locations that could only be retrieved by using a smartphone. The users were encouraged to detect and access these hot spots and use the embedded data, in conjunction with real world objects, to play the game. While using the camera on the phone the user perceive the real world with data such as figures which the user could interact with.

Another example is a study of AR in a cooking game, where a mobile phone was used to simulate a frying pan and the players goal was to cook various types of food. The authors goal with the study was to see how the interaction with the game would work and if they could make the interaction feel natural for the player. It was found that with the help of AR and motion controls they managed to create a game with very intuitive controls by making sure that the motion of the phone were very close to that of the motions used in real life cooking, such as flicking the phone to flip the food in a virtual frying pan just as you would in real life [4].

PongAR[3]

To compare different types of control modalities we decided to create a game, PongAR, which allows both gesture and touch control in an augmented reality playing field. PongAR is a game inspired by the old classic game Pong[4] and a flash game called CurveBall[5]. With these games as inspiration and with Unity[6] as the game engine of choice a simple game where the goal was to bounce a ball against a wall as many times as possible was created.

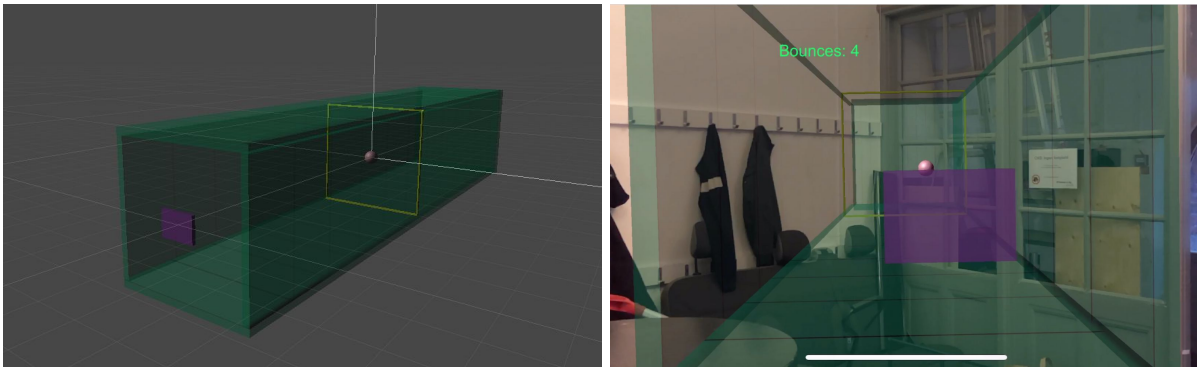

Figure 1, 2: PongAR in development (1) and in game (2)

[3] Demo video: https://vimeo.com/311074610
[4] https://sv.wikipedia.org/wiki/Pong
[5] https://www.curveball-game.com/
[6] https://unity3d.com/

Figure 1 and 2 are images of PongAR. Figure 1 shows the game in the Unity development view and figure 2 shows what the actual game looks like when you are playing. The game has five major components: the ball, the paddle, the boundaries, the sound and a highlighted square.

The player controls the purple paddle which can move on an horizontal and vertical axis (X and Y axis). Since the game has three dimensions there is also a Z-axis, the paddle is however locked on this axis and can not be moved in or out through the tunnel. When the game is started the pink ball starts going inwards towards the back wall of the tunnel at a random angle. If the ball touches the walls which sets the boundaries of the game the ball bounces against them. The goal is for the player to use the paddle to make sure that the ball doesn't leave the tunnel. The player gets one point each time the player manages to bounce the ball back and if the ball bounces out, past the paddle, the game is over and the points are reset. At every bounce, either off the paddle or the walls, sounds are played to help the player know when the ball touches bounces. If the player hits the ball with the paddle the paddle will flash with a white color to give a clear visual indication that the ball has been hit.

The highlighted yellow square follows the ball on the Z-axis through the tunnel. That way it's easier for the player to understand where the ball is and when it's close to the opening of the tunnel. This square is really helpful for the player since it can be really hard to judge the depth of the tunnel while looking through such a small screen and having the tunnel right in front of you.

Our game PongAR gave us a really good testing ground to test different types of controls. The game is easy to understand, easy to play and the test subjects can focus entirely on just hitting the ball. There are also versions of PongAR with computer opponents and planned implementation of ball curving and multiplayer. However, these additions were scrapped for testing since it was decided that in order to get better test results elements such as these should be left out as they could lead to random elements which would affect the players ability to hit the ball.

Method

Creating PongAR

With this project having a short turnaround time of just a few weeks we went with building the application for our study in Unity[7], a game engine with excellent support for mobile 3D applications and a available interface[8] to Apple's native AR interface ARKit[9].

[7] https://unity3d.com/
[8] https://bitbucket.org/Unity-Technologies/unity-arkit-plugin
[9] https://developer.apple.com/arkit/

To get a markerfree AR experience we went with ARKit as even though only half of the project members can run it on their phones but that being advantageous to non of the members being able to run it on their own devices if we'd used ARCore[10] and would have to relied on loaned devices.

Other middleware technologies such as Vuforia[11] heavily relies on marker based tracking which was something we aimed to avoid to provide a more dynamic experience that was not bound to external to the program conditions that needed to be satisfied for it to run properly.

Our development cycle followed a series of sprints which implemented iterations of the core concept after internal testing from the previous cycle. This let us be agile in the early parts and adjust our priorities and design decisions along the way.

During this period there was some but informal external user testing to test some of the gameplay and to make sure we were not tuning the experience and difficulty levels to our own standards (as we would have an higher level of experience with the application and it's controls then the normal user).

As the main purpose was to develop for our study some of the earlier implemented features such as an rudimentary AI which could possibly skew the test results were disabled.

Evaluation

The suitability of motion based controls in augmented reality was investigated by comparing it to touch based controls in our user studies. During the course of the project, application testers for user tests were contacted continuously and requested to be available at a time when a more or less finalized product were scheduled to be complete. Smaller and less structured tests were carried out with voluntary application testers at an earlier stage, with the first working prototype, in order to asses intuitivity and aid in game design decision-making.

The main user study aspired to collect both quantitative and qualitative data. Qualitative data through measurements and comparisons of achieved in-game scores and qualitative data through observation of user interaction and an interview with questions further encouraging users to reflect on their interaction with the mixed reality world.

The main user tests followed this template:

- Introduction and explanation of how the test would be carried out as well as the basics of the game.
- A few practise runs until they had figured out the controls and how the game worked.

[10] https://developers.google.com/ar/discover/
[11] https://www.vuforia.com/

- The user then got three attempts to try and achieve the highest score possible, these scores were all documented.
- The same test was repeated with the other input method for steering the paddle. Half of the users started with motion control and half started with touch control.
- A series of open ended predetermined questions were asked in a structured interview about their experience of the game and their answers were transcribed.

This method of evaluation allowed us to compare the different types of input for controlling the paddle utilizing both subjective thoughts and reflections as well as objective data. The majority of the tests and interviews were carried out in close temporal proximity and around the university campus of the Royal Institute of Technology in Stockholm. Ten voluntary participants completed the main user tests, six males and four females, spanning 21 to 27 years of age. The foregoing tests of the early prototype included four testers and were all unstructured interviews spread over two days.

Study Results

The test group consisted of six males and four females who all completed all parts of the test. All users played the same version of the game and got the same instructions. Two of the test users played the game on an iPhone 7 and eight users played the game on an iPhone X. All tests were supervised by a member of the project team to make sure everything worked as intended.

In-Game Score Comparison

To compare the difference between scores using motion and touch control the test users played three rounds with each type of input. The two different scores using touch and motion control were summed up separately and compared to each other.

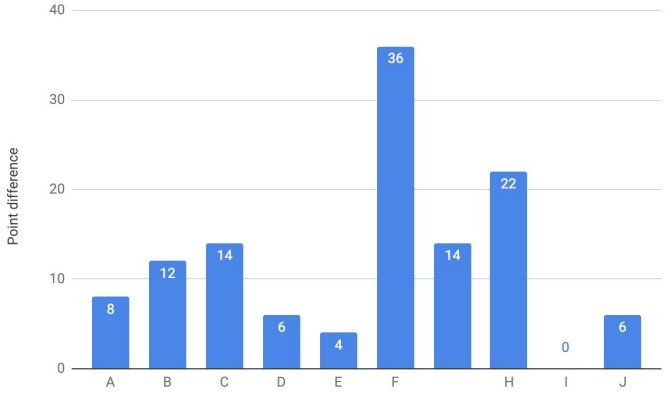

Figure 3: Point difference between total accumulated scores using motion control and touch control. Positive numbers means a higher score was accumulated while using touch control.

In figure 3 we can see the difference between each players total accumulated score using touch control and motion control. Positive numbers mean that the player accumulated more points using touch control than motion control. From the graph in figure 3 we can see that all users except user "*I*" managed to accumulate a higher score using touch control than motion control.

Player	Decrease in score measured in %
A	67%
B	63%
C	67%
D	37.5%
E	10%
F	88%
G	54%
H	73%
I	0%
J	55%
Average	51%

Table 1: Decrease in score when using motion controls compared to touch controls

Table 1 shows the decrease in score measured in percent and on average the use of motion controls yielded 51% lower score than when the game was played with touch controls. Notable test results are the results by user "*I*" who managed to get the same score with both motion and touch control and player "*F*" who had a bigger difference between scores than the others.
It is important to note that the individual scores between test users differed. In total there were 30 rounds of touch control and 30 rounds of motion control measured. The average score per round of using touch control was 11 and the average score per round using motion controls was 7.

Interviews

During the interviews each test user was asked the same questions. The questions were open ended and based around their experience with the game and the different input types. When asked what type of input the users found to be easier all of them answered that touch control was easier, in addition three users also answered that touch was more intuitive than motion control.

"Surprisingly, it's not easy to say! Both input types had their strength and weaknesses. But I think touch control may have been a bit easier." - Test User E

The users were then asked to describe their experience using touch control to which they all answered that it was very easy and intuitive. When asked the same question about motion control the overall consensus seemed to be that the controls were still intuitive and easy, but it was hard to see the game boundaries and the ball while moving the phone around which led to some annoyance. Three also answered that they weren't able to move the paddle fast enough to keep up with the ball while using motion controls.

At the end of the interviews the test users were encouraged to give any additional comments of their own choice. Eight users gave additional comments and out of these users four thought the game was fun and liked the idea. Two thought that the speed of the ball should be changing to make the game more interesting and one of the participants explained how the addition of AR glasses might give an even better experience. Three users also mentioned that even though touch was easier, motion control was a bit more fun.

Discussion

In the scope of the project and the limited time, more elaborate user tests were difficult to conduct which thus makes for more careful conclusions. Ideally more tests should be carried out and the interviews should be more extensive and in-depth. The results are however quite unanimous and enough so to allow for some careful assumptions, attempted conclusions and interesting discussions. Many of the test users had the same background (studying at KTH) which can also limit the validity of the results when applied to a more general audience.

The maturity of AR and trackerless world tracking is not quite there yet for a final product that requires quick and rapid movement of the device as this is something likely to cause drifting, meaning that the game field floats away since it's not properly anchored to real world objects. In this case it breaks the experience rather quickly before the engine have time to readjust and anchor itself to the world again. Even though several of the user pointed out the game to be more "fun" and engaging with motion control we feel that these flaws in combination with a lack of a strong use case when it comes to these technologies it's still a better user experience to control the game with touch. It is also less limiting in its requirements of physical space and lighting conditions.

Test users also expressed problems with keeping up with the speed of the ball when playing with motion based controls. They often experienced that the paddle was moving too slow. However, the slower movement may be required to maintain accuracy, precision and a more natural feel of the paddle. Speeding up the movement can possibly make it harder to hit the ball. Finding the correct balance between speed and precision may be hard. The paddle is designed to follow the center of the screen and if the players themselves moves fast the paddle should be

able to keep up. There is however a bit of inertia in the paddles movement which may be interpreted as the paddle being slow. However, without this inertness the movement would feel jerky, shaky and unnatural and the gaming experience may suffer. These are all variables which could be tested in future research.

As to why a big score difference between playing PongAR with motion controls and touch controls can be observed there may be a several reasons. A big reason may be that users in general are more used to using touch controls than motion controls. This was mentioned by several of the test users and it's safe to assume that smartphone users in general use touch control more often than motion control since touch input is more common in both mobile games and general applications.

One of the biggest problems with a game like PongAR and using movement based controls is that you need to move the screen which you are looking through. This immediately creates a problem in keeping up with what's going on on the screen. Trying to make out details, such as where the ball is headed, is of course much harder on a screen that moves than on a screen that stays still. This may also be a big contributing factor to why there was a clear score difference between motion and touch control. During the project the idea was raised that it may be better if you were able to disconnect the view in to the AR scene and the controller from each other, for example by the help of AR glasses. We believe that users may get an even better experience if they could hold a phone in their hand as a paddle controller and at the same time see the game scene through a pair of glasses. This way you could alleviate the problem for the players expressing that they were not able to see the boundaries or keep up with the moving ball while moving the phone around.

As a testing platform PongAR had a few weaknesses and strengths. It's biggest strengths is that the game is easy to play and easy to understand for everyone. None of the test users had any problems understanding what was going on. A big strength is also that PonagAR a great platform for comparing the two modalities tested in this project since it tests the users skill with very few random elements involved. However, it's biggest weakness was that it was not completely bug free. There was a risk of drifting which could disrupt the use experience, we did however make sure that this was as little of a problem as possible by making sure the test users got a stable game field every time they played.

With PongAR it was possible to compare touch and motion controls in an effective way and the results all point in the same direction; AR and motion controls in dynamic, fast-paced gameplay may not be as suitable as standard touch controls. PongAR showed that it's possible to make intuitive motion controls for a simple fast paced AR pong game, but it comes with quite a few inherent problems. These problems does not only make the game more difficult, which may not be a bad thing, but can also be of some annoyance. Not being able to see what is going on in the game because of fast movement during the use of motion control is not only making it more difficult, but also impairs the user experience.

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