Bachelor´s Thesis in Digital Game Development
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Using Gyroscope Technology to Implement a Leaning Technique for Game Interaction

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Abstract

Context. Smartphones contain advanced sensors called microelectromechanical systems(MEMS). By connecting a smartphone to a computer these sensors can be used to test new interaction techniques for games.
Objectives. This study aims to investigate an interaction technique implemented with a gyroscope that utilises the leaning of a user's torso and compare it in terms of precision and enjoyment to using a joystick.
Methods. The custom interaction technique was implemented by using the gyroscope of a Samsung Galaxy s6 Edge and attaching it to to the torso of the user. The joystick technique was implementation by using the left joystick of an Xbox One controller. A user study was conducted and 19 people participated by playing a custom made obstacle course game that tested the precision of the interaction techniques. After testing each technique participants took part in a survey consisting of questions regarding their enjoyment using the technique.
Results. The results showed that the leaning technique was not as precise as the joystick implementation. The participants found the leaning technique to be more fun to use and also more immersive compared to the joystick implementation. The leaning technique was however also more uncomfortable and difficult to use, and players felt less competent in their ability to control the player character with it.
Conclusions. The performance difference might have been due to the lack of familiarity with the leaning technique compared to the joystick implementation. The leaning technique was more difficult to use and more uncomfortable than the joystick method. However, the leaning technique was also more fun to use and more immersive. This offers up the opportunity to keep exploring possibilities with this technique.

Keywords: User study, Player experience, MEMS, Leaning, Gaming interaction.

Contents

Chapter 1

Introduction

In the last decade, different attempts have been made to implement motion controls in gaming. The Wii, Xbox Kinect, PlayStation Move, among other motion control devices are examples of this. Motion controls offer new possibilities for gaming. Allowing new interaction methods take the place of joysticks, mice and buttons.

Motion controls require sensors in order to be implemented. One method to implement sensors for motion controls is by using microelectromechanical systems(MEMS), which are microscopical devices with sensors and actuators[1]. An example of this is Nintendo's Wii Remote controller that uses a MEMS technology for its accelerometer[2], and with the introduction of Wii MotionPlus, also its gyroscope [3].

Smartphone also contain MEMS. Amongst other things, the MEMS in the smartphone is used to detect the orientation of the phone, measure heat, forces and magnetic fields. Since smartphones contains so many MEMS sensors they have considerable potential as motion control devices. Studies have therefore been done on the application of smartphones as game controllers for computers [4] [5].

One research field that is bringing motion controllers into computer games is virtual reality(VR). Studies have proven that locomotion derived from physical activity, such as motion controls, increase the spatial orientation and reduce simulation sickness in users[6][7]. Simulation sickness is a type of nausea that is common in VR games.
It can be argued that using motion controls in VR offers up the opportunity to introduce more immersive control methods than using traditional input methods such as directional pads, buttons and joysticks.

A commonly tested motion controlled locomotion method is walking in place or walking around within a certain boundary. Several studies have evaluated this method [8] [7]. However recently a study has also tested using body leaning as a locomotion method[9]. And a device is being developed called the VRGO that similarly uses body leaning as a locomotion method [1].

Very little research has been done on using the leaning of a users body as a locomotion method in games. Especially outside of VR environments. This study aims to fill this gap by implementing a leaning method with MEMS. The method will use the leaning of a users torso to induce locomotion. The proficiency of the method and how enjoyable it is will be compared to a more traditional, non-motion controlled alternative. In this case a joystick. In order to gather data on the methods, a user study is conducted.

1.1 Aim and objectives

This study aims to implement and test a locomotion method utilizing the body leaning of a user. This leaning method as it will be called will have the user rotating his or her torso from side to side as well as forward and back in order to move in a three-dimensional computer game.
The leaning method will be compared to a more traditional movement method utilizing a joystick. What is to be compared is the performance and enjoyment of using the two methods.

To perform the study a list of objectives had to be completed:

- Create a game that can test and compare the interaction methods.
- Implement a version of the leaning method.
- Implement a joystick method.
- Compare the methods.
- Analyse the results.

The steps are discussed further in the methodology chapter.

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[1] VRGO , `http://www.vrgochair.com/`, accessed 2017-08-08

1.2 Research question and hypothesis

The research question for the study is:

- How does a locomotion method translating the movement of a user's torso compare, in terms of performance and enjoyment, to a traditional joystick controller in a three-dimensional game?

The hypothesis for this study is that the leaning method will be more enjoyable and accurate than the joystick method. This is based on the results of the study by Harris, et al., 2014 [9], where a leaning method was tested that performed better and was enjoyed more than using a joystick controller.

Chapter 2

Background

This chapter will go through some of the technology and methods used in the study.

2.1 Microelectromechanical systems

Microelectromechanical systems(MEMS) are microscopical devices that contain structures, sensors, actuators, and microelectronics. The dimensions of MEMS devices can vary from below one micron, all the way to a few millimeters. The MEMS research field is also known by other names such as "Micro System Technology" or "nanotechnology".

MEMS are typically sensors that convert a measured mechanical signal into an electrical signal that can be interpreted. MEMS have been developed for a lot of sensing modality including temperature, pressure, acceleration, strain, fluid flow, orientation, and more [1].

MEMS can be integrated into devices to support them with sensory information. This can include having a gyroscope and accelerometers to track the orientation of the device. Or a compass to aid navigation. In this study, the data from a MEMS gyroscope inside a Samsung Galaxy S6 Edge phone is read to track the orientation of the phone.

2.2 Gyroscope

The word gyroscope originates from Greek and is a combination of the words seeing and rotation. As the name implies gyroscopes are used to measure the rotation of objects. The oldest gyroscope is the rotating gyroscope, which is similar to a spinning top in that it uses angular momentum in order to keep its orientation. The effect that makes this possible is called precession. In modern time other types of gyroscopes have been discovered that does not need to spin and therefore suffer less friction and last longer. One of the most common modern gyroscopes is the vibrating structure gyroscope. This is because it is cheap to manufacture and can be created as a MEMS. This type of vibrating

gyroscope measures sinusoidal Coriolis force in order to measure the orientation of the device[10].
Since gyroscopes can measure the rotation of objects they are commonly used for navigation. They have also been used in vehicles, such as in the conference paper by Attal, et al., 2014 [11] where a gyroscope is used to determine if the rider is about to fall. Gyroscope data can also be used for games. An example of this is Pokemon Go that uses gyroscope sensors alongside other sensors to track the player's position in the world [12].

2.3 Motion controllers

A motion controller is a type of game controller that tracks the user's movements and transform them into inputs for games. Two examples of motion controllers are Nintendo's Wii Remote and Microsoft's Kinect.

The Wii Remote contains a three axis accelerometer which is a sensor that detects external forces that act upon it. This accelerometer is used to detect the motions of the user and the orientation of the remote [13]. While the sensor is not always used the same, an example of its capabilities can be seen in the game Wii Sports. In Wii Sports a player can simulate the motions of swinging a golf club or a tennis racket with the Wii Remote and the accelerometer will translate the motions into the game. In the year 2009, an extension to the Wii Remote called the Wii MotionPlus was released containing a gyroscope. This enabled Wii games to more accurately determine the orientation of the controller[3] and was used in the game "The Legend of Zelda Skyward Sword" to enhance swordplay.

The Kinect, developed by Microsoft contains a depth sensor, a color camera, and an array of microphones. These sensors enable the Kinect to track skeletal and facial movements in real time, and also receive voice commands [14]. The tracking of skeletal movement can be utilized to enable motion controls. In the game Kinect Sports, players use body motions to compete in different sports using skeletal motion tracking. The sports include but are not limited to: running in place to compete to in virtual track and field, kicking to participate in virtual football, and punching to participate in virtual boxing.

2.4 Evolution of the joystick controller in games

The game industry has had a close relationship with joystick controllers for a long time. The first digital joystick for a gaming platform came with the Atari 2600, released in 1977. This joystick consisted of four switches that correlated to the directions: up, down, left and right. However, since joysticks were frail and hard to use, Nintendo took a step backwards and implemented the directional pad(D-pad) that was implemented on the Nintendo entertainment system's controller. The D-pad allowed for digital movement in 8 different direction using buttons [15].

In the late nineties, games had begun to explore three-dimensional environments and needed a higher directional accuracy than before. Nintendo's solution to this problem was an analog joystick(analog stick) that was built into the Nintendo 64 controller. The analog stick allowed for 360 degrees of motion instead of the eight directions that the D-pad had allowed for. Four directional buttons were also built into the Nintendo 64 controller called the C buttons. These were intended to be used to pan the camera in games.
In 1997 Sony released the DualShock controller for the PlayStation. Instead of using buttons to pan the camera like the Nintendo 64, the DualShock controller came equipped with two analog sticks. One for character movement and one to pan the camera. To this day most modern controllers utilize the same principle as the DualShock controller[16].

2.5 Fixed camera games

Some games do not allow for camera movement. This is called having a fixed camera and means that the attributes of the camera, such as positioning, is set during the creation of the game and can not be controlled by the player. Games such as Crash Bandicoot and the original Resident Evil game is famous for this.

2.6 Easy WiFi Controller

Easy WiFi Controller is an asset pack on the Unity asset store that contains scripts(and some materials and scenes) that allow smartphones to be used as game controllers for Unity games. To set up Easy WiFi Controller, a server and a client version must be created. The client version runs on the phone and decides what data to send to the game, the server version is the main game and receives the data. For the Easy WiFi Controller to work, both the server and client version of the game must be on the same WiFi network [1].

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[1] Easy WiFi Controller, `https://www.assetstore.unity3d.com/en/#!/content/31991` , accessed 2017-08-08

Chapter 3

Related work

This chapter will go through some of the studies that have been done on the same subject as this thesis.

3.1 Comparing motion controls to traditional control schemes

Mattias Landerholm compared users efficiency when playing a first person shooter(fps) game with three different control schemes. The schemes were: the PlayStation Move (a motion controller similar to the Wii Remote), mouse and keyboard and lastly a PlayStation DualShock 3 controller. The goal of the fps was to complete the level as fast as possible. The mouse and keyboard proved to be the most efficient method, the DualShock controller was the second most efficient method and the PlayStation Move came in last. The author notes that participants had more experience with the keyboard and mouse control scheme and the DualShock 3 control scheme. He states that it can be assumed that at least a few participants would likely have finished the game quicker with the PlayStation Move than the DualShock 3 controller, if they were more experience using it[17].

3.2 Using body leaning as a movement method

In a study by Harris, et al., 2014 [9] motion controls for locomotion in VR was tested using a Wii-balance board and a Microsoft Kinect. Ten participants were exposed to a VR environment and told to remember the location of six objects. The participants were then instructed to move to one of the specified objects. This was done using three methods: using a joystick, leaning on the Wii balance board and walking in place using the Kinect. The results showed that the leaning method resulted in less turning errors than the joystick method and was preferred by the participants. The most accurate locomotion method was the walking in place method. The leaning method was the most preferred of the methods.

In another study by Phillip Adam 2014, three different movement methods for a virtual environment utilizing only an Oculus Rift head mounted display(HMD) were tested. One of them, called the "Motorcycle Control Scheme", utilized the leaning of a player's head in order to turn in the game. Replicating the leaning used to turn with a motorcycle. The other methods, named by the author the "Aviation Control Scheme" and the "Stillness Control Scheme", utilized rotating of the head in order to turn. All the movement methods received moderately positive responses from participants. However, a big issue with the methods was that participants experienced simulation sickness using them[18].

3.3 Using a smartphone as a computer controller

An experiment was conducted at Blekinge Institute of Technology by Löwgren and Johansson, 2013[5] measuring how suited a smartphone can be as a controller for different types of computer games. To measure this three different game was made: a spaceship simulator, a labyrinth game and a sniper game. For each game, a control scheme was implemented utilizing the touchscreen and sensors of the phone. The smartphone's control scheme was then compared to a traditional alternative. The smartphone controller was preferred in the labyrinth and space game. However, in the sniper game where the smartphone utilized its touchscreen as a joystick, the traditional alternative consisting of mouse and keyboard was preferred.

Chapter 4

Methodology

To answer the research question a user study was conducted and participants were invited to play and obstacle course game. The game was played with an implementation of the leaning method and an implementation of the joystick method. Performance data was collected as participants played the game. The data consisted of the amount of time it took to complete the obstacle course and the number of collisions the participant had during the process. After having tried a method participants rated a series of statements in a questionnaire regarding their enjoyment of the method. The rating went from one to five.

The mean and median collision count was used to see which method was the most accurate. The same was also true for the amount of time it took to complete the course but a paired t-test was made to check if the difference in time to complete the obstacle course with the different methods was significant. Each question from the questionnaire regarding enjoyment was handled separately and answers regarding the methods were compared.

4.1 Implementations

This section explains how the implementations of the experiment were made and motivates them.

4.1.1 The Game

In order to measure the accuracy of the controllers, it was decided to make an obstacle course game where the player navigates a cube through a maze. Unity 5.6 was used to make the game. This was mainly because Unity would speed up the process of making the game.

It was decided to keep the camera fixed in the game and no implementation for rotating the player was made. This was mainly to avoid problems with the implementation of the leaning method. Since the computer screen was stationary, turning with leaning method would have had the user move away from the computer screen. If the user would have had a head mounted display this would not have been an issue.

The obstacle course game consisted of a corridor, a green cube that the player controlled, a start line, and a finish line. The goal of the game was to navigate the green player cube from the start line to the finish line and avoid as many of the obstacles as possible. The obstacle consisted of red blocks that stood still as well as orange blocks that moved in the x-axis and yellow blocks that moved in the z-axis. To see the overview of the map, see Figure 4.1. The player started 20 units from the start line. In order to go from the start line to the finish line, the player had to move 135 units forward in the z-axis.

The game measured time and the number of collisions with obstacles. A time variable started incrementing when the player passed the start line and stopped incrementing when players passed the finish line. Every time a player hit an obstacle a collision variable incremented. Collisions with the same obstacle several times was not measured as to avoid the collision counter rapidly incrementing upon the player staying in contact with an obstacle. The time and collision variable could be seen on the screen.

The game was designed with a test mode, where time and collisions were not recorded. If the test mode was disabled then the time and collision variables were saved in a file on the player passing the finish line.

The player's movement was implemented by updating the player cubes position. A player used either the leaning method or the joystick method to input a horizontal and vertical input values. These inputs values ranged from -1 unit to 1 unit, and were made into a movement vector. See equation 4.1. The movement vector was multiplied by the delta time since the last game update, to make sure the cube had the same speed even if the computer's frame rate varied. And also a speed variable set to five to make the cube faster. See Equation 4.2. Lastly, the player cubes position was then incremented by the movement vector, making the cube move. See Equation 4.3.

$$Movement_Vector = [HorizontalInput, 0, VerticalInput] \tag{4.1}$$

$$Movement_Vector = MovementVector * 5 * dt \tag{4.2}$$

$$PlayerPositionVector = PlayerPositionVector + MovementVector \tag{4.3}$$

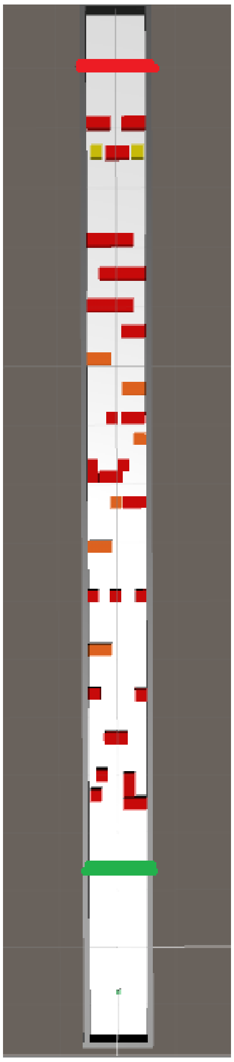

Figure 4.1: Overview of the obstacle course. The green line represents the starting line and the red line represents the finish line. To get to the finish line the player must increment its position in the z-axis.

4.1.2 Joystick movement implementation

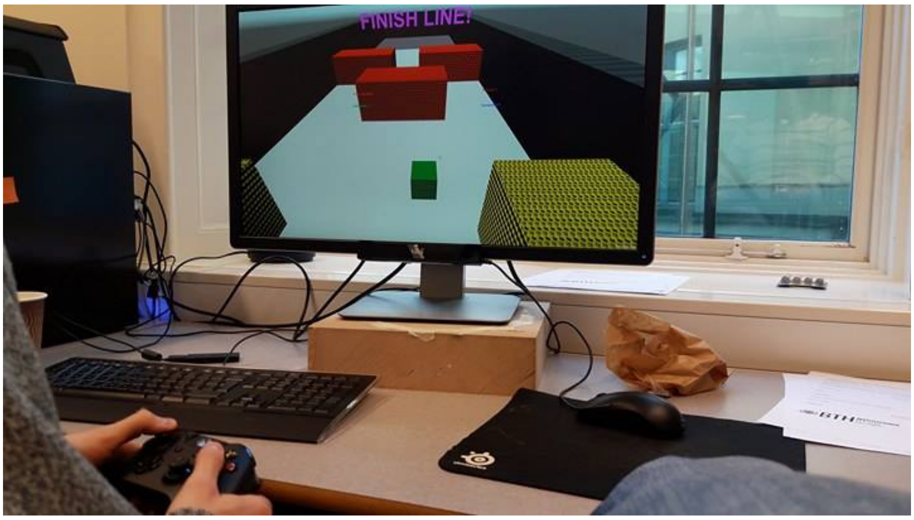

Figure 4.2: Player using the Xbox One controller.

To implement a joystick controller, an Xbox One controller was used. According to the sales tracking website VGChartz[1], it is estimated that around 140 million Xbox units have been sold. So the controller should be familiar to a lot of gamers. The Xbox One controller has two joysticks. One on its left side and one on its right side. For this experiment, only the left joystick was used. The output from the joystick translated into the horizontal and vertical input value ranging from negative one unit to one unit. The controller was connected to a PC using a Microsoft Xbox Wireless Adapter for Windows [2]. To see the controller being used, see Figure 4.2.

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[1] VGCartz,`http://www.vgchartz.com/` , accessed 2017-08-08

[2] Microsoft Xbox Wireless Adapter,
`http://www.xbox.com/en-US/xbox-one/accessories/controllers/windows-wireless-adapter` , accessed 2017-08-08

4.1.3 Leaning method implementation

Figure 4.3: Player wearing the gyroscope solution

For the leaning method, a device had to be implemented that could transfer its orientation data into Unity. Several devices can do this, for example, a Wiimote with Wii-MotionPlus could have been used[19], or an Arduino device with a gyroscope attached. These are only two examples, any wearable device with a gyroscope and the ability to transfer the gyroscopic data into Unity would have worked.

In this study, a Samsung Galaxy S6 Edge smartphone was used, see Figure 4.3. The main reason for the choice was because it had a gyroscope and scripts to support transferring the data into Unity. Which decreased the implementation time. The support for transferring the data into Unity came from the Easy WiFi Controller asset pack from the Unity Asset store.

By using the Easy WiFi Controller assets, the smartphones rotation could be acquired in the form of a rotation quaternion. The quaternion was then translated into a euliar rotation vector which was used for deciding movement. If the phones pitch rotation was between 0 degrees and 180 degrees the movement direction was considered to be forward. if the phones pitch rotation was between 360 degrees and 181 degrees the movement direction was considered backwards. The same logic was used when determining horizontal movement, only the roll axis was used instead of pitch.

As with the Xbox One controller, the movement input from the leaning method varied from -1 to 1 in vertical and horizontal directions. Leaning 9.35 degrees forward or backwards resulted in a maximum speed in that direction. Leaning 10.5 degrees to any side resulted in a maximum speed in that direction.

4.1.4 Gameplay Tweaks

During pilot testing, it was noticed that It was difficult to stand still when using the leaning method. A movement threshold was implemented to solve the issue. Any movement variable less than zero point three units would be ignored. This change made it possible to stand still when using the leaning method and was also applied to the Xbox One controller in order to make sure the methods had the same potential performance. During pilot testing, it was also noticed that braking with the leaning method often resulted in the player cube moving backwards. This was a cause for many collisions. The speed of going backwards was reduced by 50% in order to make the game a bit more lenient. This was also done for both methods, in order to make sure that the method had the same potential performance.

4.1.5 The Questionnaire

A questionnaire was designed to clearly understand how the user experienced the methods and also measure their enjoyment. The questionnaire had two parts, one for each movement method, with identical questions. The questions were several statements that were to be judged on how true they were for the experience the player had with the controller method. The questions and responses were in Swedish since the study was taking place in Sweden, and it is usually easier for people to express themselves in their native language. The available responses for each statement translated to English were:

- Very untrue
- Mostly untrue
- Somewhat true
- True
- Very true

The statement translated to English were:

- I had fun using the method
- I felt immersed in the gaming experience while using the method
- I had good control over the player when using the method.

- I found the method uncomfortable to use
- I found the method difficult to use

In order to gather additional data, a comment box for each method was also added. This box was not made mandatory but if a participant wanted to add a comment they could.

4.2 Experiment design

4.2.1 Participants

Two participant criteria were enforced:

- Participants must have played at least ten hours of games with a fixed camera.
- Participants must be in the age range of 18-28.

The first criteria were enforced to make sure the participants had experience with the experiment's environment and therefore would initiate fewer errors unrelated to the movement methods.

The second criteria were enforced to establish a homogeneous group. The scope of the thesis was insufficient for comparing the result of different age groups as doing so would have required a greater timespan and more participants. The age range of 18-28 was chosen because of an abundance of people in that specified age range at the college Blekinge Institue of Technology(BTH) where the study was taking place.

In total, 19 subjects participated in the experiment. 17 of the participants were men and two were women.

4.2.2 Experiment set-up

The experiment was held in a controlled environment at BTH. A computer able to run the game at 60 frames per second was provided and used to play the game.

A strap was used in order to attach the phone containing the gyroscope to the body of participants.

4.2.3 Order of method used

The order for which control scheme was used first changed between every other participant.

4.3 Experimental procedure

Students at BTH were asked to participate in the experiment. After showing interest they were lead to the experiment room where they read a paper containing information about the experiment. After having read the information they were asked by the test examiner if they fulfilled the criteria to participate. If they fulfilled the criteria and were willing to participate they signed a consent form. The consent form verified that the participant had read the information on the study and understood that he or she could abort the experiment at any time.

After the form had been signed, the participant was informed which controller they would test first. Then the examiner showcased how the game was played with the controller and finished the obstacle course so that the participant could see the level. Then the participant was told to test the control method and complete the obstacle course themselves, without worrying about collision or time.

After the participant had tested the game with the first control method, they were asked to do it again but as quickly as possible while avoiding the obstacles. This time the result of the participants run was saved. When the first method had been tested, and the time and amount of collisions had been saved, the participant was led to answer the questionnaire's questions regarding the method that had been used.
After having answered the question regarding the first control method, the second method was tested and the same procedure was followed. After that, the experiment concluded.

Chapter 5

Results

This chapter will present the result of the study. The result will be divided into two parts. First, the performance data will be presented, then the survey results will be presented.

5.1 Performance data

5.1.1 Time

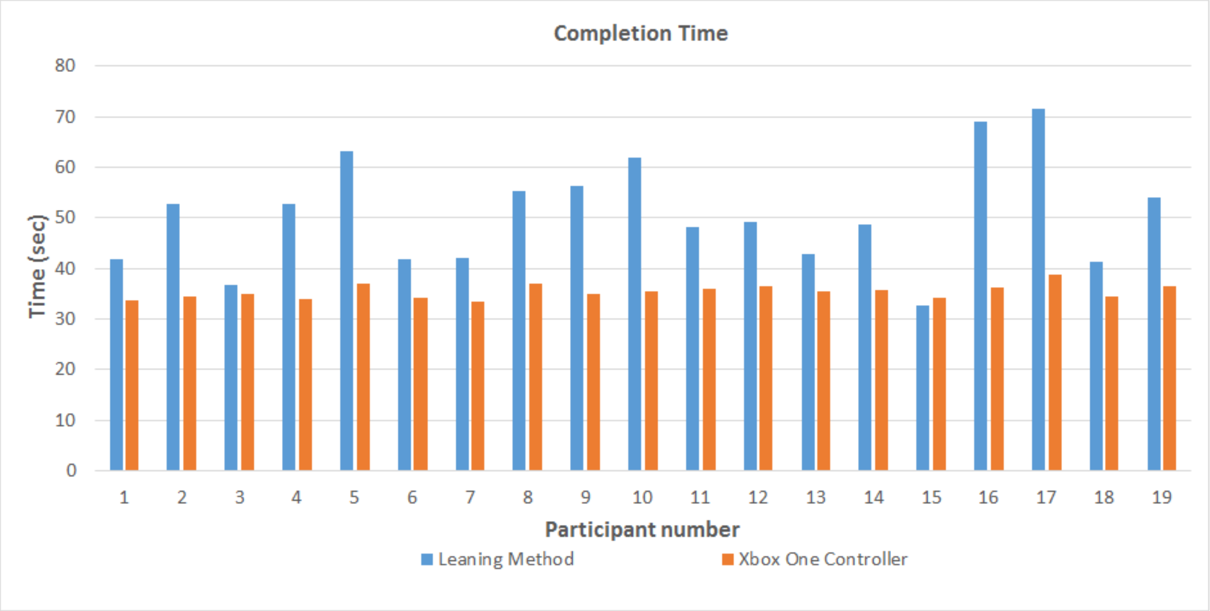

Figure 5.1: Each participant's completion time playing with the leaning method and joystick method.

Table 5.1: Table showcasing the mean and median time for completing the course with the methods

	Joystick Method	Leaning Method
Mean time for completions	35.4 seconds	50.6 seconds
Median time for completions	35,5 seconds	49,1 seconds

It can be seen by looking at the data, See Figure 5.1 and Table 5,1, that participant took longer time to complete the course with the leaning method. However, a paired t-test was performed in order to find out if this result was reliable and could be assumed to be true for other groups of people with similar background. Paired t-tests are used when data is collected from an individual twice with two different methods[20]. In this case, the methods are the joystick method versus and the leaning method. For each of the participants, the results of using the joystick method are subtracted by the results of using the leaning method. Revealing how different the methods performed for each participant. The mean difference of all participants is then used to find out if it there is a reliable difference between the methods. The calculations for this relies on the number of participants, along with how much the methods differentiated for the participants. In the end, a paired t-test returns a probability value(p-value), indicating how likely the result is to be a fluke. if a p-value returns that the likelihood of the difference being a fluke is less than 5 percent. Then the difference is considered significant and the result reliable.

In this case, the paired t-test was used to check if the amount of time to complete the obstacle course differed when using the leaning method compared to the joystick method. The p-value returned was 1.97033 * 10ˆ6 indicating that there was indeed was a reliable difference between the methods.

5.1.2 Collisions

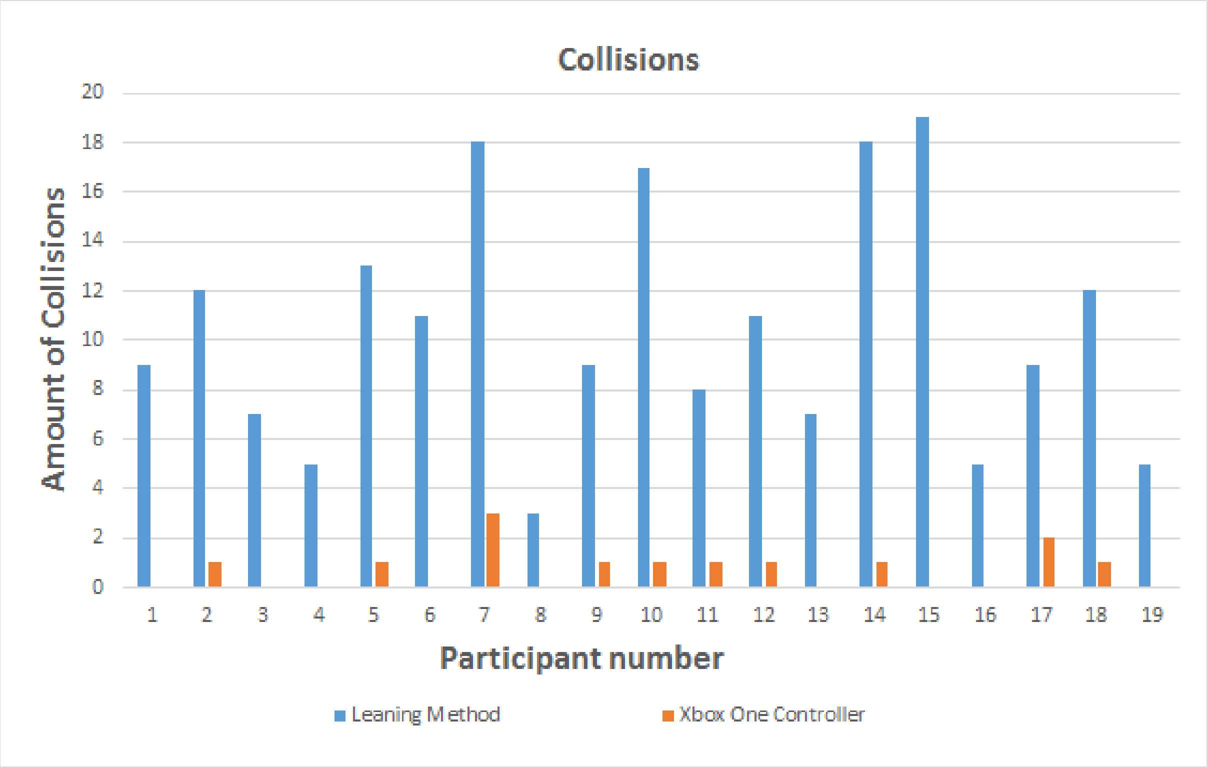

Figure 5.2: Each participant's collision count playing with the leaning method and joystick method.

Table 5.2: Table showcasing the mean and median collision count when completing the course with the methods

	Joystick Method	Leaning Method
Mean collision count	0.7	10.4
Median Collision count	1	9

In terms of precision, the joystick method outperformed the leaning method, resulting in fewer collisions than the Leaning method. As can be seen in Figure 5.2 and Table 5.2.

5.2 Survey data

As mentioned in section 4.1.5, the survey consisted of statements regarding the movement method. Participant answered how true each statement was to their experience playing with the method. five possible answers were available ranging from "very untrue" to "very true". In order to compare the results of the survey, each answer will be given a value ranging from one to five. A higher value is going to indicate that participants found the statement to be overall true, a lesser value will indicate that participants found the statement to be overall untrue. The answer "very untrue" in the survey will, therefore, be worth one value unit and the answer "very true" will be worth five value units. This method is used to calculate the mean answers for each of the survey questions.

5.2.1 Fun

Table 5.3: Mean answer for the statement "I had fun using the method"

	Joystick Method	Leaning Method
Mean answer(rounded up)	3.5	4.2

The survey results showed that participants found the leaning method more fun to use than the joystick method, as can be seen in table 5.3 . Figure A.1 in Appendix A displays more data on how the participants answered the question.

5.2.2 Immersion

Table 5.4: Mean answer for the statement "I felt immersed in the gaming experience while using the method"

	Joystick Method	Leaning Method
Mean answer(rounded up)	3.3	3.7

The survey results showed that participants felt more immersed in the experience using the leaning method, as can be seen in table 5.4 . Figure A.2 in Appendix A displays more data on how the participants answered the question.

5.2.3 Control over character

Table 5.5: Mean answer for the statement "I had good control over the player when using the method"

	Joystick Method	Leaning Method
Mean answer(rounded up)	4.6	2.4

The survey results showed that participants felt more confident in their ability to play the game using the joystick method. As seen in table 5.5 . Figure A.3 in Appendix A displays more data on how the participants answered the question.

5.2.4 Comfort

Table 5.6: Mean answer for the statement "I found the method uncomfortable to use "

	Joystick Method	Leaning Method
Mean answer(rounded up)	1.3	2.6

The survey results showed that participants found the leaning method more uncomfortable to use than the joystick method. As can be seen in table 5.6 . Figure A.4 in Appendix A displays more data on how the participants answered the question.

5.2.5 Difficulty to use

Table 5.7: Mean answer for the statement "I found the method difficult to use"

	Joystick Method	Leaning Method
Mean answer(rounded up)	1.3	3.5

The survey results showed that participants found the leaning method more difficult to use than the joystick method. As can be seen in table 5.7 . Figure A.5 in Appendix A displays more data on how the participants answered the question.

Chapter 6

Analysis and discussion

This chapter will analyse and discuss the results of the experiment in two sections. One section regarding the user's performance and another for the user's enjoyment of the methods. The chapter will also have a third section that reflects on the validity of the results.

6.1 Performance

The joystick method implemented with the Xbox One controller was better than the leaning method in terms of performance. Allowing users to finish the game more quickly and avoiding collisions better.
The reason for this may be one of the following:

1. joystick movement is common in games and it is likely that participants have a more experience with them than the implemented leaning technique.
2. Motor skills are developed by practice[21]. It is possible that the amount advanced hand movement the participants perform on a daily basis, writing, typing, and so on, have made their hands motor skills greater than that of torso and back.
3. The quality of the joystick implementation could have been higher than that of the leaning method. Joystick movement has existed for a long time and it is possibly more refined than that of the implemented leaning method.

6.2 Enjoyment

The leaning method was deemed more fun to use than the Xbox One method. It is possible that the increased difficulty that came with the loss of precision when using the method provided the participants with a more challenging and rewarding task. It's also possible that the method was considered more fun since it was novel.

When using the leaning method participants felt more immersed in the game. This might be because the leaning movement more accurately represented walking in real life than the joystick method did. It might also be because the unfamiliar method required the participants to concentrate more on the game.

Participants felt less confident in their ability to control the player when using the leaning method. The performance results show that users were less competent when using the leaning method, so it is understandable that the participants also felt less confident in their ability to control the player.

Participants also felt that it the leaning method was more difficult to use than the joystick. This is also an accurate representation of the performance results, as the results show that it was more difficult to play the game with the leaning method
Most participants answered that the leaning method was somewhat uncomfortable. See Figure 5.6. This may be because it required the user to wear a strap with the phone on it. It may be that the torso and back movement needed to use the leaning method could be straining.The comfortability of the leaning method can likely be improved with a better implementation of the method and with a smaller gyroscopic device.

6.3 Possible validity issues

The female to male ratio of the participants for this study was 2: 17. This ratio does not represent the ratio of female to male gamers in Sweden at the time of the study. In 2012 the ratio of male to female gamers in Sweden was 53: 47[22] and it is unlikely to have changed much since then. It is also unlikely however that this affected the result since all participants had prior gaming experience.

While this study did compare a joystick movement method to a leaning method utilizing the player's torso, the implementation and setup of the leaning method may not have been optimal. A phone was strapped to the torso of users, in order to get the orientation of the user, but in some cases, the phone changed its orientation during gameplay. This may have caused reduced ability to control the player character for some users and affected the final results. The strap might also have been a source of reduced comfort for users as it could have been either too tight or too loose depending on body type. Having a Samsung galaxy s6 edge attached to the torso might also have been a source of reduced comfort.

Chapter 7

Conclusion

The research question for this study was "How does a locomotion method translating the movement of a user's torso compare, in terms of performance and enjoyment, to a traditional joystick controller in a three-dimensional game?". In order to test this a user study involving 19 people was conducted. The user study involved having participant play an obstacle course game with a leaning method utilising a smartphone gyroscope, and with the left joysticks on an Xbox One controller. The participants precision and speed was measured when playing the game. After each game session, the participant answered questions on a survey regarding their enjoyment of the used method.

The performance data showed that the leaning method did not reach the same performance as the joystick method. Participants finished the game slower with the leaning method and hit a lot more obstacles. The performance difference is probably due to the lack of familiarity with the leaning method compared to the joystick controller, but could also be because the joystick implementation was more refined then the implemented leaning technique.

The results of the enjoyment survey showed that people thought the leaning method was more fun to use and more immersive than a joystick controller. However, they also found it more uncomfortable and difficult to use. Similar to what the performance results showed, participants also felt less confident in their ability to control the game with the leaning method.

Chapter 8

Future work

The fact that the leaning method was deemed fun and immersive offers up the opportunity to keep exploring possibilities with this technique. A good idea could be to test this method in VR as a head mounted display would allow the leaning method to turn in the yaw axis. A smaller easier to wear gyroscope could also be tested to make the leaning method easier to use and less uncomfortable.

Appendices

Appendix A

Survey results

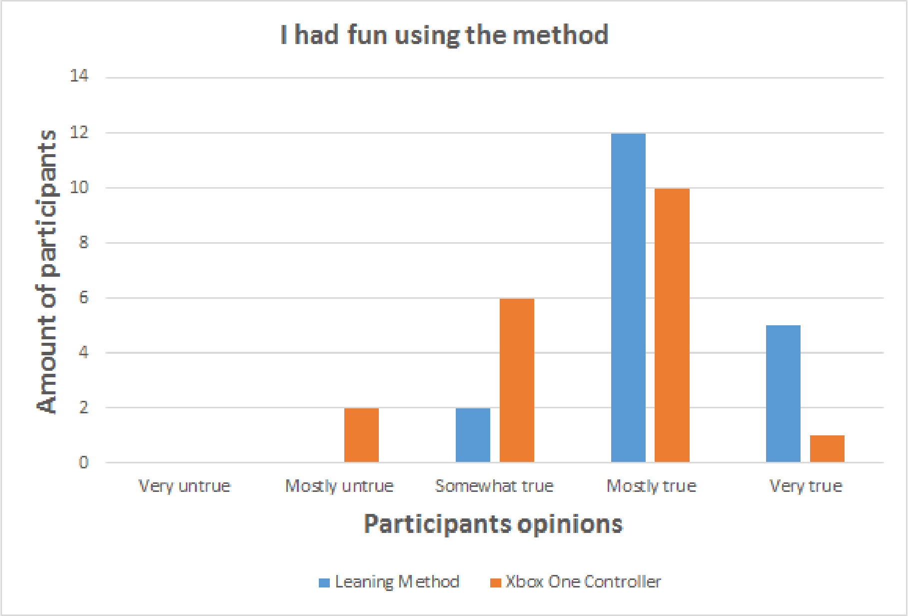

Figure A.1: Bar chart showcasing the participants answers to the statement "I had fun using the method" .

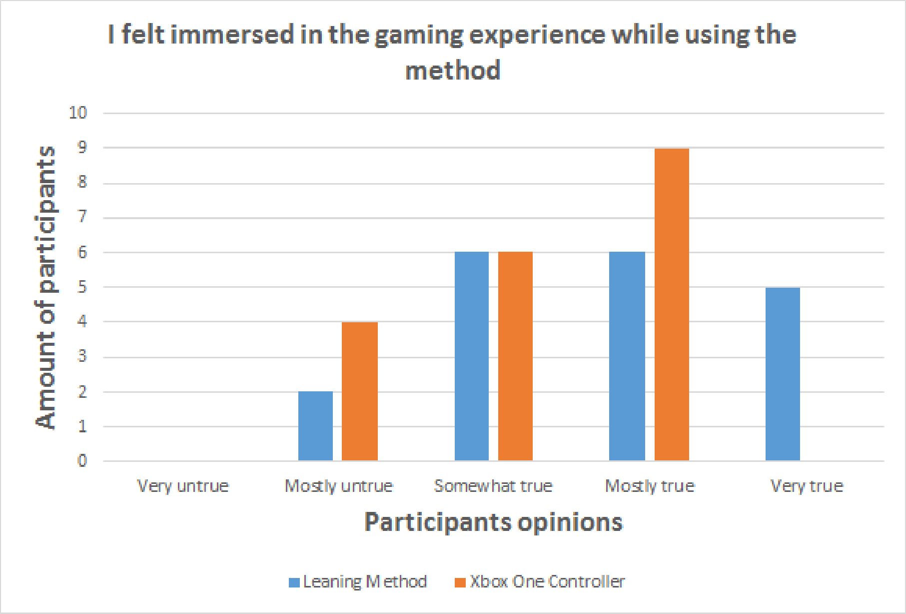

Figure A.2: Bar chart showcasing the participants answers to the statement "I felt immersed in the gaming experience while using the method" .

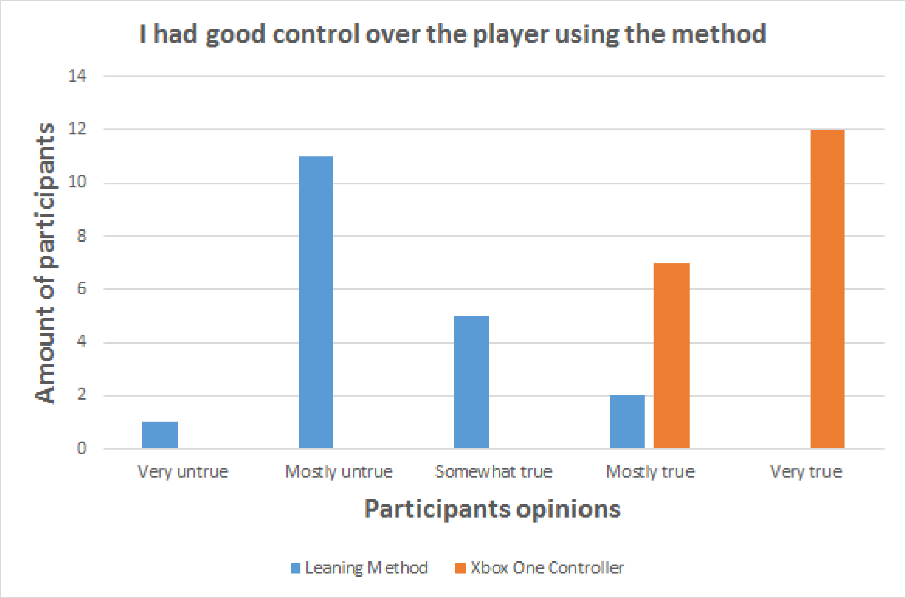

Figure A.3: Bar chart showcasing the participants answers to the statement "I had good control over the player using the method".

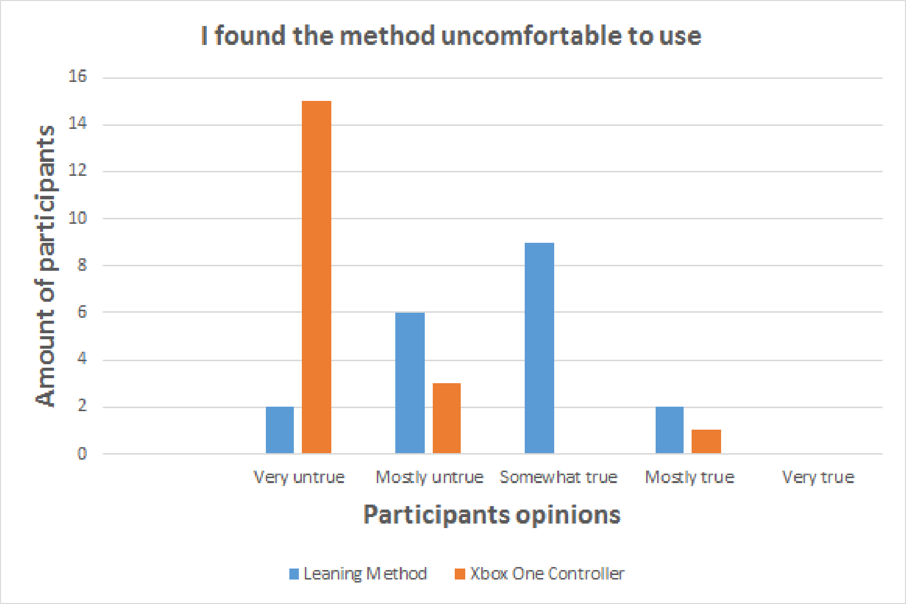

Figure A.4: Bar chart showcasing the participants answers to the statement "I found the method uncomfortable to use.

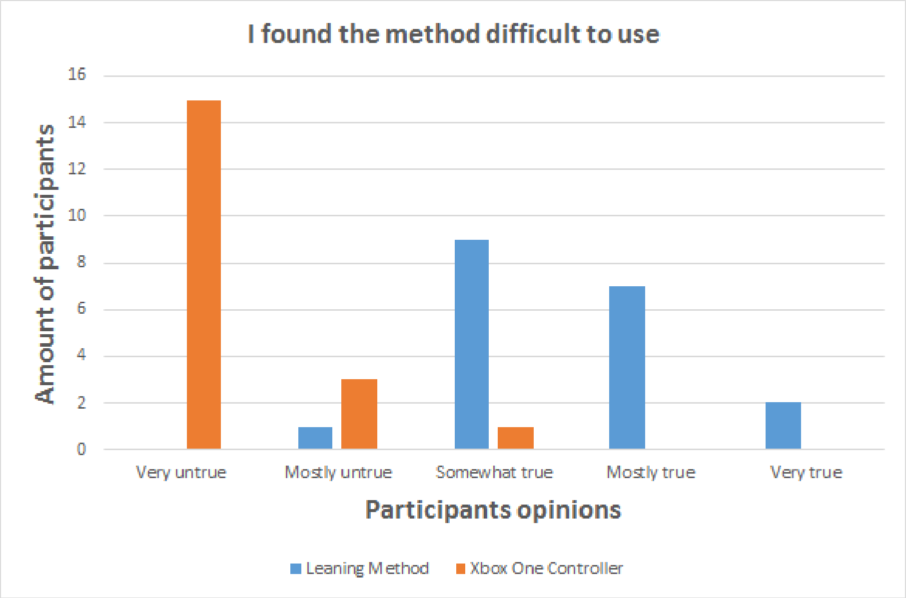

Figure A.5: Bar chart showcasing the participants answers to the statement "I found the method difficult to use".

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