NTNU
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# Design, creation, and evaluation of CyberSteamPunkHoverWar 2088.

A multiplayer racing exercise bicycle game.

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# abstract

This project is a study into exergames (exercise games) and how to design and implement an exergame that is both enjoyable and capable of replacing traditional exercise methods. Topics examined during the project included, genres of video games, existing exergames, health benefits of regular exercise, game design, and enjoyment of video games.
In order to conduct user-tests, a prototype exergame called CyberSteamPunkHoverWar 2088 was designed and implemented using the Unity game engine. The prototype was a networked multiplayer competitive racing game that utilized an existing controller developed by Playpulse. The controller is essentially an exercise bicycle with button controllers fitted to the handlebars. The game was designed by examining video game genres in order to find one or more genres that would be well suited for an exergame. In addition, research into general video game design and the flow model as a measure of the enjoyment was used during the design and implementation phase. The study also examined what types of constriction the controller, exercise activity and input method placed on the game genre and the design of the game. The prototype was then put through a user-test were the subjects would be observed during play. After the session, the subjects responded to questionnaires and was put through a simple group interview in order to evaluate the game and their enjoyment of it. In addition, pulse-watches were used on some of the subjects in order to evaluate the exergames ability to function as an exercise method and its ability to replace existing exercise methods.
Data from the questionnaires were also used to determine if the subjects previous interest in video games and regular exercise had any major impact on how they responded to the exergame.
The results of the user-test indicate that the selected game genre, racing, was well suited as an exergame. However, for other game genres that also seems well suited, there was not any evidence to support that fact. The exercise equipment, activity, and input method did provide constrictions to the design of the game. This includes limiting the number of unique actions the controller can support, requiring continuous activity in order to function as an exercise method, and limiting the duration of single play sessions in order to function as an exercise method. Testing revealed that the implemented game would be able to cover the recommended amount of physical activity. The data also indicated that a majority of subjects preferred the exergame to traditional exercise methods, this means that the exergame can replace traditional exercise methods. Finally, the data showed that the level of interest in video games, as well as, a previous interest in regular exercise had no significant impact on how the subjects responded to the exergame.

# Sammendrag

Dette prosjektet undersøker exergames (exercise game) og hvordan man kan designe og implementere et exergame som er både gøy og i stand til å erstatte tradisjonelle treningsmetoder. Emner undersøkt i løpet av prosjektet inkluderer videospill sjangre, eksisterende exergame, helse fordeler knyttet til regelmessig trening, spilldesign og fornøyelse av spill. I prosjektet ble det designet og implementert en prototype av et exergame, CyberSteamPunkHoverWar 2088, med Unity som spillmotor som det deretter ble utført brukertester på. Prototypen var et nettverksbasert flerspiller racing spill som brukte en eksisterende spillkontroller utviklet av Playpulse. Kontrolleren består av en treningssykkel med knapper festet til styret og en sensor som registrerer rotasjon av sykkelhjulet. Spillet ble designet etter å ha undersøkt eksisterende spill sjangre for å finne en eller flere sjangre som passer som et exergame. I tillegg ble det brukt resultater fra undersøkelser innenfor spilldesign, og flow modellen for å måle fornøyelse i video spill. Prosjektet undersøkte også begrensninger knyttet til kontrolleren, trenings aktiviteten og input metoden i forhold til spillets design. Prototypen ble kjørt gjennom brukertester der kandidatene ble observert mens de spillet. Etter spillsesjonen så svarte kandidatene på spørreundersøkelser og deltok i gruppeintervju for å evaluere hvordan opplevelsen deres var. Kandidater ble også utstyrt med pulsklokker mens de spilte for å evaluere hvordan spillet fungerte som en treningsmetode. Data fra undersøkelsene ble også brukt for å avgjøre om kandidatenes interesse i videospill og regelmessig trening påvirket hvordan de reagerte på spillet. Resultater fra brukertesten indikerte at sjangeren som ble valgt for spillet, racing passet bra som et exergame. For andre sjangre som ble undersøkt var det ikke tilstrekkelig data for å bevise at disse var egnet som exergame. Treningsutstyret, treningsaktiviteten og input metoden hadde begrensninger på spillets design. Dette inkluderer et begrenset antall unike handlinger som kunne utføres i spillet, det faktum at utstyret og treningsmetoden krever kontinuerlig aktivitet fra spilleren for å fungere som treningsmetode og, begrenset varighet for en spillsesjon for å kunne fungere som en treningsmetode. Eksperimentet viste at prototypen som ble implementert kunne brukes for å dekke anbefalt mengde fysisk aktivitet. Resultatene indikerte også at flesteparten av kandidatene fortrakk spillet sammenlignet med tradisjonelle treningsmetoder. Dette betyr at spillet er i stand til å erstatte tradisjonelle treningsmetoder. Til slutt viste resultatene at interessen i videospill og regelmessig trening blant kandidatene ikke påvirket hvordan de reagerte på spillet.

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# Part I

# Introduction

Part I presents the introduction to this thesis, the research methodology, project goals and the research questions.

Chapter 1

# Motivation

Video games have become increasingly popular over the last few years. It is also no longer an activity associated with just young people, In fact, it has become very common for adults to use video games as a regular recreational activity. This may be one contributor to why people are less physically active as well. In addition to computer games, the internet has made many activities such as social interaction and buying goods or services available from the comfort of your own house.
The health benefits from regular exercise are well documented and the recommendation for minimum exercises is as low as an average of 22 minutes per day. Without regular exercise, people are at risk of such negative effects as obesity, increased risk of heart disease, diabetes and a general reduction in life quality. This is not only an issue for individuals but also one for the community in general since resources needed to treat these conditions could have been utilized elsewhere if exercise was used as a preventative measure. However, many people still choose not to exercise because they either lack the motivation or because they would rather spend the time engaging in activities they find more enjoyable. For people who play video games on a regular basis, this is often the case, and they would rather spend another half hour playing a game than exercise. This is the issue exergames try to address, how to combine the fun and enjoyment of video games with the health benefits associated with regular exercise. The motivation for this study is to find the requirements for an exergame that can and will be used by people as a motivator for regular exercise. Once the requirements are set they will be implemented as an exergame and tested to assess the potential of exergames as a motivator for regular exercise. As a gamer and programmer, I also have a personal interest in this study, Not only am I interested in discovering how such a game could be designed, but I am also interested in utilizing exergames as a motivator for my self.

Chapter 2

# Project goals and research questions

This chapter describes the goals of this project and defines the research questions for the thesis. This projects main goal is to design and implement an exergame and test the game in order to examine how users respond to the game. The experiment will test how fun the game is, how well it motivates the users to exercise and, what the physical impact of the game is. Before designing and developing the game I will conduct research into video game genres and game mechanics in order to determine if some video game genres are better suited to be implemented as an exergame. The results from this will be used during the design and implementation of the game. The goal here is to verify how well the selected genre and mechanics performed as an exergame. In addition, I will be investigating what constraints some unique elements of an exergame place on the design of the game. These elements are, the exercise equipment used, the exercise activity itself and, the method of input to the game. I will also investigate how people with different interest levels in video games and regular exercise responds to the implemented exergame. In order to meet these goals, I have derived 7 research questions:

**Research questions**

- RQ1: Are there genres of games more or less suitable for an exergame?
- RQ2: What constraints do the equipment, activity, and input provide to the game's design?
- RQ3: How does the implemented game affect the player's motivation to exercise?
- RQ4 : How well does the implemented game cover the recommended amount of physical activity?
- RQ5: How well can the implemented exergame replace traditional methods of exercise?

- RQ6: How does an interest in video games affect the response to an exergame?
- RQ7: How does an interest in regular exercise affect the response to an exergame?

RQ1 will investigate different genres of games in order to determine if some games will be easier to implement as a successful exergame. This would be helpful information for further research into exergames and for people who want to achieve commercial success with exergames.
RQ2 will determine the limiting factors that would impact an exergame compared to traditional video games. This is also helpful information when designing future exergames.
RQ3 will be used in order to evaluate the success of the exergame as a motivational factor for exercising. This can, in turn, be used to demonstrate exergames general ability to motivate people to exercise.
RQ4 will be used to evaluate the success of the game as an exercise method. In order to have a beneficial impact on peoples physical fitness and health the game would need to be comparable to traditional methods of exercise.
RQ5 will be used in order to evaluate the exergames ability to replace traditional exercise. In addition to covering the recommended amount of exercise the game also needs to be suitable for long-term use and also provide additional enjoyment to the user in order to justify the cost and time invested into the development of the game.
RQ6 will investigate if people respond better or worse to an exergame based on the number of video games they already play. It could be useful information when designing future exergames to know how different target groups will respond to the concept of the exergame.
RQ7 will investigate if people respond better or worse to an exergame based on the amount of regular exercise they are already engaging in. It could be useful information when designing future exergames to know how different target groups will respond to the concept of the exergame.

Chapter 3

# Research method and process

For this thesis, I used an Empirical Research method based on Briony J. Oates framework from the book Researching Information Systems and Computing.(Oates, 2006, P. 32) Empirical research is the method of gaining knowledge through observation and experiments. The framework and the parts I used can be seen in Figure 3.1. The starting point for me was a combination of *experience and motivation* and *literature study* conducted in my pre-study. Based on this I derived my Research Questions and primary goals. The strategy I chose was design and creation where I designed and implemented an exergame based on findings from my pre-study. For data generation methods I used a combination of Interviews, Observation, and Questionnaires. Interviews allow the researcher to gather data by asking a subject or multiple subjects at once questions and registering their response. There are multiple types of interviews, they can be structured, there are a set of predefined questions the subject must answer,semi-structured, you still have a list of themes and questions you want to be answered, and unstructured where you introduce a topic and let the subject or subjects discuss the topic freely. In this thesis I will be using an unstructured interview in order to allow test subjects to provide feedback by discussing among themselves.(Oates, 2006, P. 186)
Observation is used as a research method in order to find out what people actually do rather than what they report they do when questioned. Using observation during a user test is quite common and provides another data-set to compare against what the user reports himself. In this case, I will be observing the users as they test the exergame, this can provide additional insight into how they react to the game. However, since I will be instructing the users and perform the test there could be limitations to how well I can observe all participants during the test. One of the disadvantages of observation is that the observer can be distracted and miss important details. If the observer is also the one conducting the research there can be some bias created by this. A questionnaire is a pre-defined set of questions assembled in a pre-determined order. Respondents answer the questionnaire and the responses are then analyzed and interpreted. Questionnaires can be self-administered, this means the respondent completes the questionnaire without the researcher present or involved. Or the researcher can present the questionnaire as a set of questions verbally

while the respondent answers.(Oates, 2006, P. 202) Questionnaires can have open questions, the respondent is then free to answer as they chose, or closed questions where the respondent chooses from a pre-determined set of answers. Questionnaires are frequently used with surveys and can provide a large dataset from multiple respondents. They can also provide standardized data when using closed questions. The quality of the data depends on the quality of the questionnaire and possible issues can be, ambiguous questions, poor wording, and little or no relevance to the research subject(Oates, 2006, P. 219).
Finally, I decided to take a Qualitative approach to the data analysis. While I could conduct a Quantitative data analysis on the questionnaires it seemed unlikely that I would be able to obtain a large enough sample size for the user tests for the data to prove anything conclusive. Instead, the questionnaires are used to confirm observations and feedback directly from the test candidates gathered through observation and interviews.


**Figure 3.1:** Research method framework from Briony J OatesOates (2006)

The overall process of this paper becomes similar to the process of the empirical research method and is divided into 4 parts. The pre-study or literature review, Design and implementation phase where the game is created using Unity, Testing phase with user testing conducted with the Playpulse controller/bicycle and finally the analysis and conclusion.

Chapter 4

# Report outline

The report is divided into 5 parts. Part I is the introduction and contains a presentation of the research methodology, project goals and, research questions. Part II presents the prestudy conducted for this report and contains sections where I investigate video games, exergames, exercise and its health benefits, the game engine that will be used, the exercise equipment and controller that will be used, and, some fundamentals of game design. Part III presents the prototype game design and the implementation of the game. Part IV presents the user test conducted and the results of the user test. Part V contains the conclusion and suggestions for further work based on this report.

# Part II

# Pre-study

Part II presents the findings from the pre-study I conducted prior to the design and implementation of the exergame. In the pre-study, I examine video games, exergames, exercise and its health benefits, the game engine I will be using, the exercise equipment and controller I will be using and some fundamentals of game design in order to acquire the knowledge needed to create the new exergame. I also looked broadly into what type of games that would be most suitable for an exergame concept.

Chapter 5

# Exercise and Health Benefits

This chapter describes the health benefits of regular exercise and what requirements are needed to achieve those benefits. The increase in people who lead a more sedentary lifestyle has resulted in more people being at risk for certain diseases related to the lack of physical activities. Research indicates that activities that do not require physical exertion such as watching TV are one of the contributing factors to this. And that this again leads to common diseases such as obesity, cardiovascular diseases, and diabetes.(Hu, 2003) Obesity and diseases linked to this has been described as an epidemic with many different factors and no single available solution the main goal of any preventive measure should be to motivate a change in lifestyle of the people in the risk group.(Chan and Woo, 2010)
In this chapter, I will examine some of the health benefits of regular exercise and find recommendations for the amount and type of exercise that is required.

## 5.1 Health benefits

This sections describe the healt benefits of regular exercise. The health benefits from regular exercise are well documented and can reduce the risk factor for a number of diseases such as heart disease and cardiovascular-related deaths, cancer, diabetes mellitus, obesity, hypertension, osteoporosis, and osteoarthritis. Recent discoveries could indicate that regular exercise reduces the risk of death by cardiovascular disease by more than 50%. An increase in physical fitness of 1 MET (metabolic equivalent) per week is associated with a mortality benefit of 20% In physically inactive middle-aged women engaging in less than 1 hour of exercise per week the increase in all-cause mortality was 52% consisting in a doubling in the mortality risk for cardiovascular diseases, a 29% increase in cancer-related deaths and with similar results for hypertension hypercholesterolemia and obesity, These risk factors approach those associated with moderate cigarette smoking. (Warburton et al., 2006)

In addition to the physical health benefits, there are also documented psychological benefits related to regular exercise. Regular exercises have been known to help in cases of

depression, anxiety and panic disorders. Both aerobic training and strength training are effective in this regard, and physical activity appears to be as effective as psychotherapy for mild-to-moderate depressive symptoms. While there is no evidence that regular exercise has a preventive effect on depressive symptoms but it can be used to manage mild symptoms so they do not excavate. It is also important to note that excessive physical activities can cause overtraining and generate symptoms that mimic depression.(Paluska and Schwenk, 2000)

## 5.2 Recommended amount of exercise

This section describes the recommended amount of exercise to achieve health benefits described in Section 5.1. Most recommendations regarding the amount of exercise are given as a length of time combined with an intensity level of the activity. The intensity is commonly expressed by the unit MET(Metabolic Equivalents) which is the ratio of a persons working metabolic rate relative to their resting metabolic rate. One MET is defined as the amount of energy required to sit still or 1Kcal /Kg/Hour. A persons caloric consumption is three to six times greater during moderate-intensity activities and more than 6 times during Vigorous-intensity activities.(WHO, 2017a) In Figure 5.1 you can see a summary of recommended exercise methods and their estimated intensity.

| **Moderate-intensity Physical Activity (Approximately 3-6 METs)**<br><br>Requires a moderate amount of effort and noticeably accelerates the heart rate. | **Vigorous-intensity Physical Activity (Approximately >6 METs)**<br><br>Requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate. |
|---|---|
| Examples of moderate-intensity exercise include: | Examples of vigorous-intensity exercise include: |
| • Brisk walking | • Running |
| • Dancing | • Walking / climbing briskly up a hill |
| • Gardening | • Fast cycling |
| • Housework and domestic chores | • Aerobics |
| • Traditional hunting and gathering | • Fast swimming |
| • Active involvement in games and sports with children / walking domestic animals | • Competitive sports and games (e.g. Traditional Games, Football, Volleyball, Hockey, Basketball) |
| • General building tasks (e.g. roofing, thatching, painting) | • Heavy shovelling or digging ditches |
| • Carrying / moving moderate loads (<20kg) | • Carrying / moving heavy loads (>20kg) |

**Figure 5.1:** A table from WHO‘s site describing the intensity levels of excersise and activities that are related to them.

While there is an agreement on the benefits of increased physical activities, the amount

will often vary depending on the study and source. However, the WHO(World Health Organization) recommends the following for adults aged 18-64. At least 150 min of moderate-intensity training or at least 75 min of vigorous-intensity training or an equivalent combination per week. Duration of sessions should be at least 10 minutes. They also recommend muscle-strengthening activities at least twice per week. For adults aged 65 and upwards the same amount is recommended unless they have a health condition that prevents them from doing this. Then they should be as physically active as their condition allows. Added health benefits can be achieved by doubling this amount For children aged 5-27 the recommendation is 60 minutes of daily moderate-to-vigorous training with activities beyond this adding additional health benefits.(WHO, 2017b)

## 5.3 Measuring the intensity

This section describes how to measure the intensity of an exercise session. The most common way to measure the intensity of an exercise session is to measure the heart rate of the person performing the activity. Target Heart rate for different types of activities will always vary based on an individual's maximum heart rate, However, the common practice is to use a heart rate zone as a percentage of one's maximum heart rate. Common zones are 50%-70% for medium intensity exercise and 70% - 90% for vigorous intensity exercise.(CDC, 2011) But in order to utilize this method, the maximum heart rate is required and the common method for estimating this is the following formula, 220-Age. This formula, however, is not considered to be accurate or has any documented scientific research to confirm its viability.(Robergs and Landwehr, 2002) The main reason for its use is probably because it does not require any measurements to be made over time in order to determine an individual's maximum heart rate.

## 5.4 Summary

The health benefits from regular exercise are well established and documented. We also have reliable measurements as to how much exercise is required to get the minimum of benefits. Despite this obesity and diseases related to low amounts of physical activity remains one of the largest health-epidemic in the western world. It becomes apparent that people either remain ignorant of this or that this information simply is not enough of a motivator for everyone affected. New methods of motivation could mitigate this effect, exergames combine exercise with a well established and popular entertainment medium. This could possibly provide additional motivation to people who do not have the motivation or interest in physical activities such as sports and outdoor activities.

Chapter 6

# Game Engine

This chapter presents the Unity game engine and describes some of the features it offers to the users. The goal of this chapter is to get further acquainted with the software that will be used during the development phase.

## 6.1 Game Engine

A game engine is a software framework used to create and develop video games. The core functionality of a game engine usually provides the framework for rendering engine, physics engine, sound, scripting, animation, AI, and networking. Current game engines are often cross-platform allowing the games being created to be built for multiple platforms such as windows, Playstation, Xbox, iOS, Android without major alterations to the game itself. In addition to the framework, game engines can also supply an editor, a UI that the developer can use to create the game. Game engines can be created for a specific game or series of games, often reused to save cost for the developers. Some game engines are also open-source or commercially available to other developers allowing an offset of cost on the development of the engine itself. Unity engine and Unreal engine are two examples of game engines being available for free to non-commercial developers and available to commercial developers against payment.

### 6.1.1 Unity Game Engine

The Unity game engine is a cross-platform game engine that allows the user to create games for multiple platforms. Written in C, C++ unity provides a full framework for game development and scripting trough C#, formerly BOO and UnityScript but both of them are deprecated. The scripting language, as well as the engine, is object-oriented. Graphics are programmed using HLSL(High level shading language). Unity currently supports 27 different platforms including Windows, PlayStation, Android, Xbox, iOS, macOS and a number of VR platforms such as Google cardboard, and HTC vive.

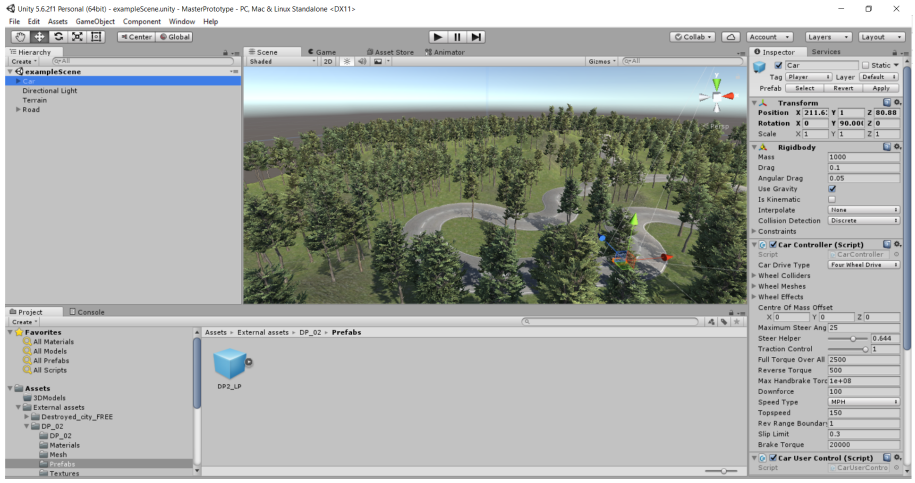

**Figure 6.1:** The Unity engine editor

The unity editor provides a full user interface where the developer can create their games. You can see an image of the editor window in Figure 6.1 Unity‘s object hierarchy stores all game objects and scripts within scenes. A scene can be viewed as a level of the game but is also used for other purposes, for instance, the main menu is also created as an independent scene with game objects. Unity‘s folder hierarchy is centered around the Asset folder where the user can define their own internal structure of all assets. You can see the folder hierarchy in Figure 6.2. An asset can be any piece of code the developer uses, common asset types are scripts, materials, models, and prefabs. Scripts contain functional code, models are 2D or 3D models, Materials modify the visual aspect of the models with textures, colors, transparency etc. Prefabs or prefabrication’s are composite objects made of often multiple scripts, models, and materials. This allows the developer to re-use such composite multiple times in a scene or across different scenes. It is common in a multi-level game to have for instance a player prefab to save development time and continuity across the game.

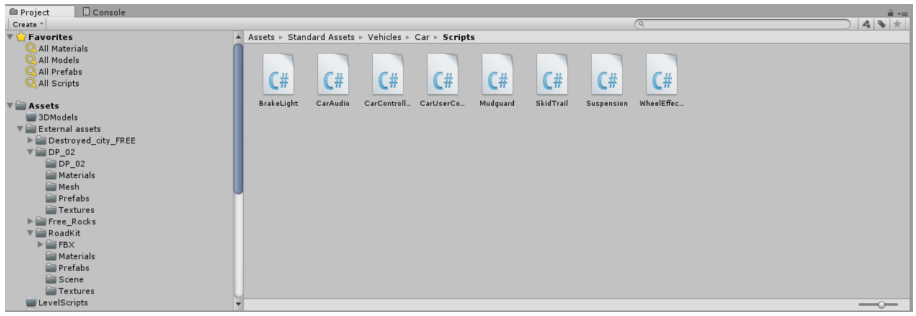

**Figure 6.2:** Example of Unity folder structure

Attaching scripts to game objects allow the user to add functionality to the object, such as interacting with physics or changing their appearance or behavior. Certain standard unity classes can also be added to the object such as Rigidbody in Figure 6.3. In the inspector you can also modify public and serialized variables on your own scripts, this allows you to reuse scripts on multiple objects without the need to hardcode values. An example of a C# script can be found in Figure 6.4

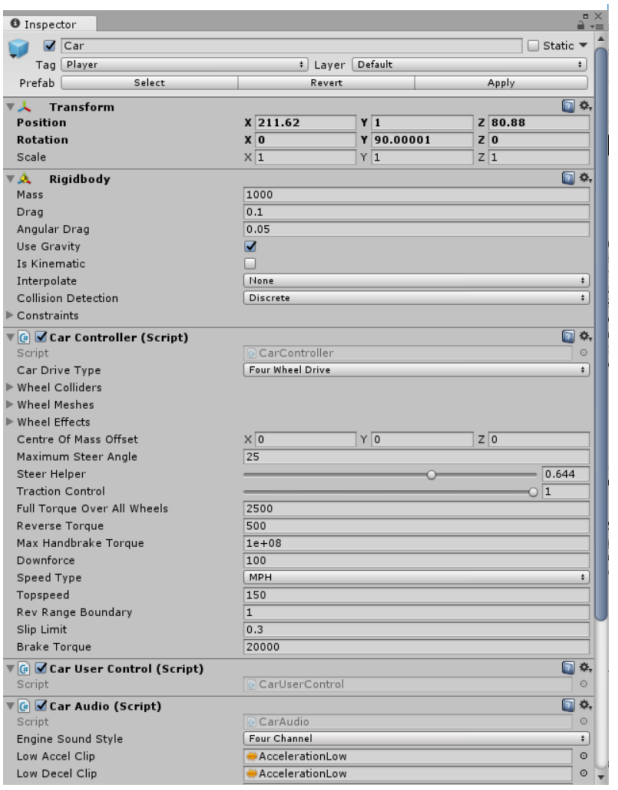


**Figure 6.3:** A unity Game object being inspected

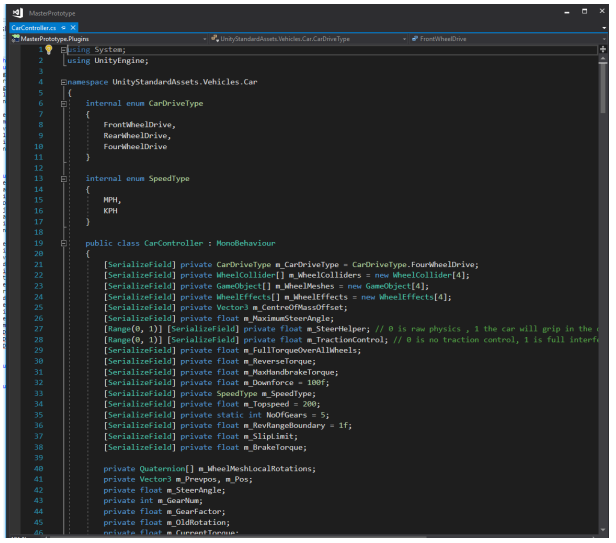


**Figure 6.4:** A Unity C# script

Because of its flexibility and availability, Unity is widely used by both amateurs, researchers, indie developers and larger professional developers.

## 6.2 UNET

This section presents the UNET framework. Creating a networked multiplayer game is a bit more complex than creating a single player game or a local multiplayer game. Unity has a high-level API called UNET that allows for easier integration of networked games. The most common type of patterns used in multiplayer games is peer-to-peer P2P and Client-server patterns. Furthermore, the client-server pattern can also be set up either with a dedicated server or with one of the clients having the role of the server as well. This client is commonly referred to as the host. In a P2P game, all clients have equal authority and this is mostly used in simple non-synchronous games. UNET supports by default the Client-Server pattern with a client operating as the host server. This setup is significantly cheaper than using a dedicated server but will often need a matchmaking server in order to connect clients to each other. Unity also provides a free matchmaking service that can be used during testing or for simple games. However, the limit for the free service is 20 concurrent players using the Unity personal subscription and up to 200 while using Unity Pro. If you need to support a larger client base then either a dedicated matchmaking server is needed or you need to pay additional fees for the service. An overview of UNET‘s API structure can be found in Figure 6.5.

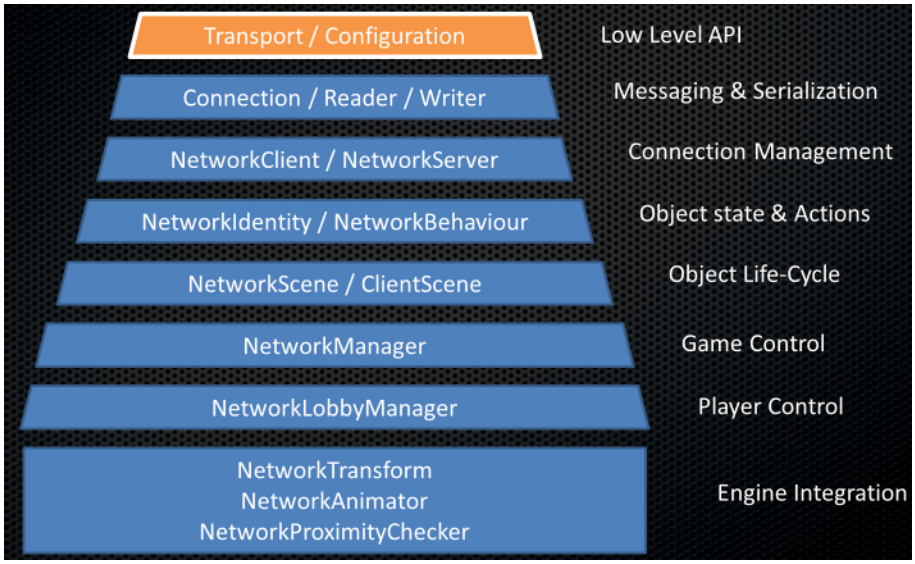


**Figure 6.5:** UNET high level API structure

### Using UNET

Using the basic functionality of UNET is not that difficult, you simply need to add an instance of the NetworkManager class to your game and the supply every object that needs to be synchronized across the network with a NetworkIdentity. The network identity will give the object a unique ID that will allow UNET to keep track and apply changes to this object as is required. Other classes such as the NetworkTransform and NetworkAnimator are dedicated to synchronizing specific component such as the transform of the object to all the clients. This allows for easy synchronization of the movement of objects that are networked. In order to synchronize function calls, you have to include the Networking namespace to your scripts and attach this script to an object with a NetworkIdentity. Once the script is network capable, the functions can be called in several different ways. Functions can be called only on the local client just like any other function call. Functions can be run on the server using the [Command] attribute. Functions can be run on all connected clients using a remote procedural call with the [clientRPC] command. For both of these commands, the network latency will have a significant impact on the behavior of these functions. For instance when using the [Command] attribute the code is executed only on the server, if the code alters the game state for all clients by for instance creating new game objects, or moving an existing one then changes will occur at different times for each client depending on the network latency. Most noticeably the client that is currently hosting will most likely get the updated state before any of the remote clients. When high network latency is an issue, running code on the server can introduce significant lag on all connected clients. Using remote procedural calls can suffer from the same issue: RPC‘s are called on each client by the server meaning that a client with low latency will receive the command before a player with high latency. There are methods of reducing the effect

of network latency such as client-side predictions where each client tries to predict the game state until a correct update is received from the server as well as simply reducing the amount of network traffic.

## 6.3 Summary

Unity engine is a power-full tool for game development, Whether you want to make a simple game or a more sophisticated one unity can provide all the basic tools needed to implement a video game. In addition, the UNET framework provides what you need to implement a multiplayer video game. It would seem like Unity provides everything I need in order to implement a prototype Exergame.

Chapter 7

# Playpulse Controller

This chapter presents the Playpulse controller that will be utilized in combination with an exercise bike in the development and testing of this exergame. The goal here is to look at some of the possibilities and limitations for such a controller.

## 7.1 Playpulse controller

The Playpulse controller was developed as a custom controller for use with an exercise bicycle. The controller is comprised of three different components, two button controllers as seen in fig 7.1 that are fitted to the handlebars on the exercise bicycle, And a sensor that registers the rotations of the front wheel of the exercise bicycle as seen in Figure 7.2 The API allows you to use these values the same way you would use any other 3rd party controller or joystick with the buttons registering as joystick button 1-6 and the movement of the wheel as a value on the Y-axis of a joystick.

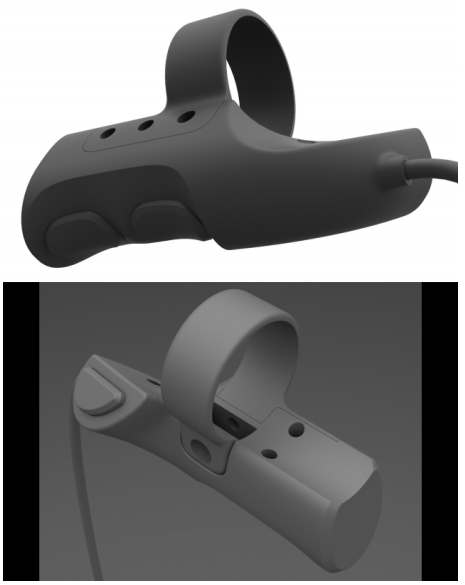

**Figure 7.1:** Playpulse controller

**Figure 7.2:** Bicycle wheel with sensor.

This provides some limitations for the type of games the controller can be used with. With 6 input buttons and the sensor providing input for speed/movement, the controller is limited to a certain number of unique actions. (See Figure 7.3) There are also limitations on the sensor, it only registers the number of revolutions of the wheel in a given time frame and not the direction the user is pedaling. Meaning the sensor cannot be used as forward/backward unless it also uses one of the buttons to change direction. As far as precision in movement speed there are also some limitations, not just with the controller registering the movement but also with its effectiveness as an exercise method. In order to provide adequate exertion in the game, the player should peddle continuously rather than stop and start in order to navigate with precision.

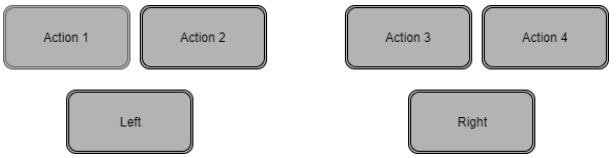


**Figure 7.3:** A template for a Playpulse controller scheme

As far as the number of unique functions, the controller can support this can be increased by using one of the buttons as a dedicated ALT (alternate) function. (See Figure 7.4) Holding down the ALT button would assign a new set of actions to the remaining buttons giving you a total of 10 unique actions you could map to the buttons. This, however, adds complexity to the control scheme and increases the learning curve slightly. This should not be critical as most people who play video games are already familiar with the Alt function on QWERTY keyboards. It should also be noted that existing exergames designed for this controller utilizes two of the buttons as dedicated left and right buttons. While left and right are unique actions they are also vital movement actions and using alt functions for these could become confusing for the player and make movement difficult to while performing other actions. As such the controller would support 4 unique actions excluding left and right without the alt function and 6 unique actions with an alt function.


**Figure 7.4:** A template for a Playpulse controller scheme with Alt function

So does this mean the controller has a limit of a maximum of 10 unique actions and input value on Y-axis? No, it does not. You can easily expand on the alt function in order to increase this. Instead of using an alternate set of actions and holding down the alt button, it could toggle between any number of alternate sets. Using 3 sets of actions and toggling between them would give the player 15 available unique actions. See Figure 7.5 This concept could be expanded to as many sets as you want to. Also using another alt button could provide up to 16 unique actions by mapping actions to four buttons on no-alt,

alt1,alt2, and alt1+alt2.

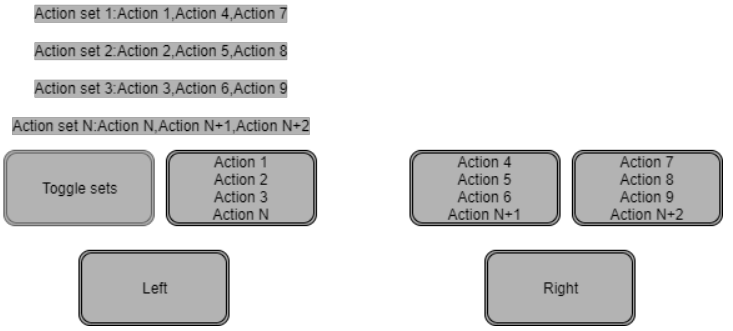


**Figure 7.5:** A template for a Playpulse controller scheme with Action set function

However, both of these methods will increase the complexity of the controller scheme and the gameplay as each action becomes more complex to perform. Depending on the gameplay and the tempo of the game, this could end up detracting to the experience rather than adding to it. If the tempo of the game is slow and players have ample time to perform actions then a slightly more complex controller scheme could work. But if the tempo is high and the player has little time to navigate the different actions available then this adds a unnecessary difficulty to playing the game. The controller scheme will naturally depend on the game, and often the type of game and number of actions required to support the gameplay.

## 7.2 Summary

The Playpulse controller while having a limited amount of buttons will still be sufficient to support a reasonable amount of unique actions to function in a lot of different types of video games. While it comes nowhere close to the complexity and flexibility of a keyboard and mouse it can still be used effectively for a game designed for the controller. The controller also utilizes the movement of an exercise bicycle which makes it well suited for use with an exergame. This is no surprise as it was this use-case it was designed for.

Chapter 8

# Videogames

This chapter presents video games, what a video game is, different categories and genres of video games. I will also provide examples of video games within these genres. The goal of this chapter is to get a better understanding of the concept and scope of video games.

## 8.1 What is a game?

*Games are an exercise of voluntary control systems, in which there is a contest between powers, confined by rules in order to produce a disequilibrial outcome.*(Avedon and Sutton-Smith, 1971)

*[A game is] an interactive structure of endogenous meaning that requires players to struggle toward a goal.*(Costikyan, 2005)

There is no clear-cut definition of what a game is, this is partly due to the fact that game is such a broad term and a single definition that describes all games is difficult to create. The two definitions given here are perfectly valid and well-crafted definitions, however, they do require some analysis in order to be used in the design process. Jesse Schell discusses them in The art of game design and trough this a few qualities emerge that apply to most games.(Schell, 2014)

- Games are entered willfully.
- Games have goals.
- Games have conflict.
- Games have rules.
- Games can be won and lost.
- Games are interactive.

- Games have a challenge.
- Games can create their own internal value.
- Games engage players.
- Games are closed formal systems.

Now, this is more like it, now we have some clearly defined and more relate-able quality attributes that a game should have. Now that we have a better understanding of what a game is, we can use these qualities that a game should have either in the design process or to evaluate the design of a game.

## 8.2 A brief history of Video games

*A video game is an electronic game that involves interaction with a user interface to generate visual feedback on a video device such as a TV screen or computer monitor.*

This section presents a brief history of video games and how they have developed over time. While video games started emerging as computer science projects in the 1950‘s the commercialization of video games started in the 1970‘s with arcade games and gaming consoles where made. These where fairly simple consoles with limited capabilities and often hard coded for a specific game. Pong and various clones of it was the first big success as a home console system.(Wikipedia, 2018)

#### 1970‘s-1982

The period 1978 to 1982 is sometimes referred to as the golden age of arcade video games, it was also during this period that the 2 gen consoles such as the Atari made it possible to play games at home rather than visit an Arcade in order to play video games.(Wikipedia, 2018)

#### 1983-1990

The video game crash of 1983 saw several video game producers and hardware manufacturers bankrupt. The crash was caused by several different factors such as a market flood of low-quality games, the commercial failure of many Atari 2600 titles and the increase in affordable home computers that quickly mad consoles obsolete. During the 1980‘s the 3rd generation of home consoles where introduced, these where 8bit consoles such as the Nintendo Entertainment System. Gaming computers such as the Commodore 64 and the Atari 8-bit family also became successful and made home computing more common among people who did not require a computer for work-related tasks. The first 16-bit console, the TurboGrafx-16 came in 1987 and was followed by the more successful Super Nintendo Entertainment System SNES in 1990.(Wikipedia, 2018)

#### 1990-2000

The 1990‘ had major advancements in video game technology such as the introduction fo CD-ROM for computers and 3D technology for video games. The 5th generation of consoles (32 and 64 bit) such as the Sony PlayStation and Nintendo 64 were released and 3D based games became the new standard of video games. PlayStation also introduced CD-ROM‘s as a replacement for the cartridge system on consoles and this later became the standard for consoles as well as PC games. This period also introduced online play on computers, a feature that would spawn whole new types of video games such as MMO‘s and multiplayer FPS.(Wikipedia, 2018)

#### 2000-2010

The 6th generation consoles, 1998-2013 saw the entrance of Windows on the console market with the XBOX. The XBOX along with the Playstation and Nintendo cornered the market on consoles and to this day they are the 3 major producers of console hardware. This generation also saw a increased use of more powerful gaming computers. The video game industry also changed during this period and saw a reduction in console exclusives in favor of games being released on multiple platforms. Now it is not uncommon to find the same game released on PC, XBOX, and Playstation with Nintendo being the only console manufacturer still holding on to exclusive game titles for their console. Online gaming became more common also on consoles in this period further blurring the lines between a console and a PC.(Wikipedia, 2018)

#### 2010-present

The 7th generation of consoles 2005-present has evolved towards becoming more and more PC-like. Both the hardware and software is more similar to a home computer system than the classic console, this includes more storage with the option to increase and more powerful processors and Graphical processors.(Wikipedia, 2018)

## 8.3 Categories of video games

Video games have many different categories and these can be further divided into sub-categories. In this section, I will not be discussing all of them but rather divide into a few selected categories based on how games are designed, played and some core functionality associated with them.
There are two main categories I will be discussing in this section and for the purpose of this paper. Single-player games and Multi-player games. A genre of a game may fall into one or both of these categories depending on the features the game will provide.
The definitions of these terms are as follows, a single-player game is a game you play alone without interacting with other humans. A multi-player game is a game where multiple players are interacting to play the game.
Multi-player games may also be further subdivided into COOP, (cooperative), PVE, (Player versus environment) or PVP, (Player versus player). In addition to this, I will also use 2-D

**Table 8.1:** Selected categories of Video Games

| |
|---|
| Single-player |
| Multi-player COOP |
| Multi-player PVP |
| Multi-player PVE |
| 2D - Games |
| 3D - Games |

and 3-D as categories as they are often used as a descriptive category for video games. All of these categories can be seen in Table 8.1.

## 8.4 Genres of video games

This section presents different genres of video games. A genre of video games is a categorization that is defined by its gameplay characteristics. The genre of a game can provide a lot of information to the player about what to expect from both gameplay and the theme of the game.
The categories I described in Section 8.3 can be explicitly or implicitly described within the genre of a game but this might not give enough information. This is why I wanted to describe separate categories in order to use in combination with a genre to accurately describe the game or type of game I am discussing. In Table 8.2, Table 8.3, and Table 8.4 i have provided a selection of different genres that are common in video games. I will not discuss all these genres but will rather select a few of them with well-known examples, I will then discuss how well the specific genre can be used towards an exergame.

**Table 8.2:** Selected genres of video games 1/3

| **Action** | **Action-adventure** | **Adventure** | **Role-playing game(RPG)** |
|---|---|---|---|
| Platform games | Survival horror | Text Adventure | Action RPG |
| Shooter games | Metroidvania | Graphic adventure | MMORPG |
| Fighting games | | Visual novels | Rougelikes |
| Stealth game | | Interactive movie | Tactical RPG |
| Survival games | | Real-time 3d adventures | Sandbox RPG |
| | | | Dungeon RPG |
| | | | Japanese RPG(JRPG) |
| | | | Western RPG |

**Table 8.3:** Selected genres of video games 2/3

| **Simulation** | **Strategy** |
|---|---|
| Vehicle simulation | Real time stragey(RTS) |
| Construction and management simulation | Real time tactics(RTT) |
| Life simulation | Multiplayer online battle arena (MOBA) |
| | 4X |
| | Artillery |
| | Tower defense |
| | Turn-based strategy (TBS) |
| | Turn-based tactics (TBT) |
| | Wargame |

**Table 8.4:** Selected genres of video games 3/3

| **Sports** | **Other selected genres** |
|---|---|
| Racing | Educational games |
| Sports game | Exergames |
| Competitive | Serious games |
| Sports base fighting | MMO |
| | Casual game |
| | Party Game |

### 8.4.1 2-D Platformer

2-D platformer is one of the most common genres for older platforms such as the NES and SNES. The main mechanics for a 2-D platformer is that the player or players progress trough the level by navigating hazards by jumping on platforms. Other mechanics can be introduced as pickups that alter the mechanics or as triggers in certain areas. The 2D platformer can have a simple controller scheme and a basic game only requires left, right and jump as actions. Super Mario Bros (See Figure 8.1) is one of the most successful 2-D platformers and many would say that they defined the genre.


**Figure 8.1:** Super Mario Bros released to the NES

However 2-D platformers are still very much alive in the gaming industry. The genre is now popular both in mobile games and indie games. The demands on both hardware capabilities as well as development time for a 2-D platformer is lower because of the simple format of both graphics and game mechanics. And modern game development tools often support 2-D games for this purpose. Super Meat Boy (See Figure 8.2) is an example of an indie game that has made success reusing the formula for the 2-D platformer and it is based on many of the same gameplay mechanics as Super Mario.

**Figure 8.2:** Super Meat Boy released to Xbox 360 and windows PC in 2010

Low hardware demand and simple mechanics also make this genre usable on mobile phones. A lot of casual mobile games are 2-D based and the 2-D platformer is ideal for casual games that you can play in short intervals or pause and resume later. Fun Run (See

Figure 8.3) made a lot of success as a Multiplayer 2-D platformer where you compete against other people on your mobile device in short games.


**Figure 8.3:** Fun Run released to IOS and Android in 2012

### 8.4.2 Action-adventure

Action-adventure is a hybrid genre combining Action games that rely on action mechanics such as sword fighting, shooting, and unarmed combat with adventure games that use puzzles and a rich storyline in order to engage the players. The line between Action-adventure and Action or adventure is often blurred and a game can fall into a genre based on reception of the audience rather than the intention of the developers. A classic and current example of an Action-adventure game is the Zelda games. The Legend of Zelda series has followed more or less the same gameplay and story recipe since the first game released in 1986.(See Figure 8.4 ) They have however altered the gameplay mechanics when transitioning from 2-D to 3-D and added and removed mechanics between games. The similarities between games are part of what makes them so successful, people enjoy to some extent playing a familiar game and how the game works. The Action mechanics

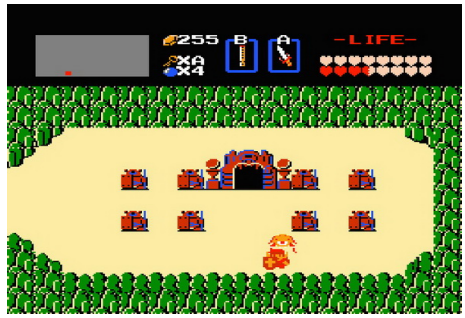


**Figure 8.4:** The Legend of Zelda released on NES in 1986

revolves around sword fighting and use of a various range of weapons and tools such as the bow and arrow, slingshot and boomerang. These mechanics are reused between games and often tie into the puzzles the players need to solve. The story of the games are always centered around the protagonist, Link the princess, Zelda, and the Antagonist Ganondorf.

The puzzles are often tied to gameplay, for instance, you need to unlock the slingshot in order to solve the puzzle that takes you to the next stage of the game. This is how adventure

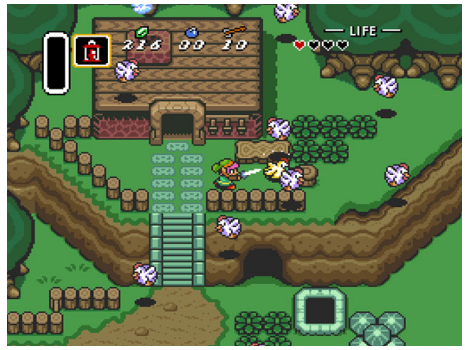


**Figure 8.5:** A link to the past released in 1991 on the SNES platform

games often combine the action gameplay mechanics with the adventure mechanics. The Action mechanic needs to be unlocked through completing puzzles. The mechanic is the required on a later puzzle giving the player reason to use the mechanic later. The mechanic should also be useful to the player in the action gameplay. This increases the value of both the puzzle mechanics and the action mechanics for the player.


**Figure 8.6:** Ocarina of Time released on the Nintendo 64 in 1998

This allows Zelda to reuse old mechanics without them becoming too repetitive from game to game. Simply adjust the adventure mechanics to utilize them in a different way giving the players a new challenge to solve with a well-known mechanic. The transition from 2D to 3D was also made without sacrificing the core gameplay, and visual style, In Figure 8.5 we have a screen-shot from, A link to the past that was released in 1991, while in Figure 8.6 we have a screen-shot from Ocarina of time released in 1998. Despite 7 years between the release of these games and a transition from 2D to 3D they still have more common traits than differences. This has worked successfully for this game series for more than 20 years now and its news release, seen in Figure 8.7, still shares a lot of common traits with every previous game in the series.

**Figure 8.7:** Breath of The wild released on Nintendo Switch in 2017

Adventure games can have simple mechanics and add complexity and difficulty to the puzzles. This allows developers to balance the game after all the base mechanics have been implemented without going back and changing the base mechanics. The experience can also be enhanced using a complex story told either through sound, text and cutscenes. Because of the focus on puzzle solving and story these type of games are usually single player games. While it is possible to introduce multiplayer or multiplayer aspects to an action-adventure game the multiplayer would usually focus mainly on the core action mechanics. Also while perfectly doable on split-screen or in a LAN setting solving complex puzzles in an online environment with strangers can in my experience be a difficult task.

### 8.4.3 Shooter games

Shooter is a sub-genre of action game where the core gameplay mechanics is the use of firearms or a similar long-range weapon. shooters are usually subdivided based on the player perspective into first-person shooter (FPS) and 3rd person shooter with some games giving the option to choose between these. Shooters can be either single-player or multi-player or a combination of both where the game offers a single-player campaign or story mode and a multi-layer online mode. In multi-player, they can include PVP, PVE both coop, and competitive.
Shooters specifically team based PVP is one of the most common online games. Examples include Counterstrike, Call of Duty series, Battlefield Series. The main mechanics of these games are centered around guns and the setting is often as a soldier or similar in a war. The goal of the game is to defeat the opponent either NPC‘s in a story or COOP setting or other players in a PVP setting. The main mechanics are not very varied and the games usually vary in terms of level design and visual changes. Games that are based on actual wars or a fictional war set on earth often simulate real weapons, equipment, and settings based on the setting of the game.
Counter-strike (See Figure 8.8) is one of the most played FPS games in the world on PC and utilize a basic FPS gameplay. Variations can be found in the different game modes that are often used by many of these games such as, Team Deathmatch, Capture the flag and Free for all deathmatch. The fact that a lot of games use the same game modes reduces the learning curve for new games because the player may already be familiar with how the game is played.

**Figure 8.8:** Counter strike is a classic FPS game where players compete in teams

The Call of Duty (See Figure 8.9) series began as a PC game and expanded to console. The game series gained popularity as an online FPS game featuring the standard FPS gameplay and game modes. The series has become notorious among the player base due to the frequent release of games roughly 1 per year since 2005 with the first game releasing in 2003. And for reusing the same gameplay with little change to the actual game except for the setting and cosmetics. In this regard, the shooter genre can both benefit and suffer from the lack of innovation in the genre. Some people will always enjoy the low learning curve that they experience when playing a new FPS game while others will find the repetitive nature of these games boring.

**Figure 8.9:** Schreenshot from Call of Duty Modern Warfare 2

### 8.4.4 RPG

Role-playing video games use much of the same mechanics, settings, and terminology as classic table-top role-playing games. The setting of an RPG can often be quite detailed, the story and world setting can heavily impact the user experience specifically with regards to immersion. The story is divided into parts often referred too as ”quests” where the player performs tasks needed to complete the quest in order to progress through the game. Information on the world and story can sometimes be provided through optional

tasks, item description and special items that only supply the player with text-based information, (scrolls, books, notes). This information is not essential to the main plot but supplies background to the environment and increases the immersion. This is sometimes referred to as the games ”Lore”. Well written Lore gives depth to the game world and is aimed at giving the player the impression that the game world is as big and as detailed as the real world. An example of this is how Oblivion provides additional lore that does not heavily impact the game through in-game books as seen in Figure 8.10.

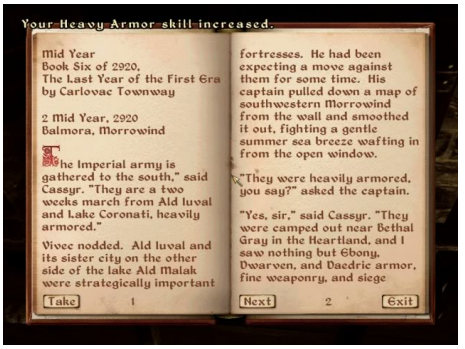


**Figure 8.10:** In The elder scrolls IV Oblivion books provided additional lore as well as an improvement in skills. These were optional to find and optional to read as well.

In an RPG the player controls a character or sometimes a set of characters. A character in an RPG often has an in-depth back-story a name and several attributes that the player can modify either at the start or by progressing through the game. The ”Main” character can be left as a blank slate allowing the player to choose its own background, stats, and name. This lets the player experience the world setting playing either as them self or as a character they themselves defined. As RPG games often have a ”World setting” a big part of the game is in exploring this world, using multiple locations with either a world map (See Figure 8.11) as the ”selection hub” or an open world setting. This again adds both to the experience of the story and to the Lore of the game. The world setting can be whatever the designer chooses, realistic, fantasy, sci-fi etc.


**Figure 8.11:** World map from Final Fantasy VII provides the player with access to all areas of the game while giving the impression of moving through the world rather than a series of levels

A key feature of the genre is the leveling system, progressing through the leveling system allows the player to grow in power and take on more challenging tasks giving them a sense of achievement beyond the completion of the story.(See figure 8.12) Leveling is usually done by completing tasks that award Experience Points(XP) or some similar point based system. This system also lets the game balance the challenge as you progress through the game without increasing the difficulty of the game. For instance, a level 5 challenge undertaken by a level 5 character should provide the same difficulty as a level 10 challenge undertaken by a level 10 character. However, the player can also choose to accept challenges above its current level. This increases the difficulty but usually also the reward as the amount of XP gained from a task often increases with the challenge level.


**Figure 8.12:** Leveling system from Final Fantasy VII

Player interaction can be varied depending on the game as well, Text based RPG games only provide a menu option as an interaction tool. Classic pc RPG's have movement and actions as keypresses that activate a pre-animated ability's being presented to the player and often relies on the strategy used when selecting stats, equipment, and abilities to provide the challenge. Turn-based combat is common in this type of RPG where players and

the AI take turns selecting an action. In Action-RPG which is a subgenre of Action games and RPG games, the combat and movement mechanics are taken from the Action genre while the World setting and character leveling are taken from the RPG genre.
JRPG or Japanese RPG is a subgenre of RPG that was defined by the unique style of RPG games being produced in Japan. Most of these JRPG games where set in a fantasy setting and relied on Turn-based combat and with an RPG style leveling system.
Western RPG‘s is another subgenre that was defined by the style being produced by developers in Europe and America. Most of these are action-RPG games using an action combat system with an RPG leveling system.

### 8.4.5 MMORPG

A massively multiplayer online role-playing game or MMORPG is another sub genre of RPG games and is quite similar to a classic RPG as it utilizes a similar setting, gameplay and leveling system. MMORPG‘s are played exclusively online and incorporates multi-player both PVP and PVE as part of the gameplay. In these games, players interact with each other in multiple ways among other cooperate in order to complete quests, trade items, and resources with each other, compete in a PVP setting and even socialize within the game. Playing with other people rather than playing a single-player game can in some cases increase the immersion of the game itself, this, of course, depends on the commitment of other players. This is where the RPG element creates an opportunity for players to interact with each other not as themselves but as the character they have created. Character creation often involves more than just selecting abilities and leveling, it can also involve visual aspects in terms of clothing and equipped items.(See Figure 8.13)


**Figure 8.13:** A character sheet from World of Warcraft. This is simial to how they are used in tabletop RPG‘s

One of the reasons why MMORPG is mentioned as a genre here is due to the success of games such as World of Warcraft, Diablo, and other MMORPGs. Not only are the games purchased and played by a great number of people but the amount of time a player will

invest into an MMORPG is usually higher than many other games. In order to maintain activity over time content must be added continuously to an MMORPG in order to keep the playerbase interested in the game. Part of what separates MMORPG's from a single player RPG is how the players themselves interact with each-other, (See figure 8.14), this allows the game to offer complex challenges by allowing the players to chose between COOP player modes, PVE player modes, and PVP player modes while keeping all of these game modes within the same game world. MMORPG usually contains a great number of activities for the player to engage in but even so without additional content, the players would eventually lose the incentive to continue playing the game.

**Figure 8.14:** Multiple players interact in World of Warcraft for a number of reasons. Completing quests is only one part of the game.

### 8.4.6 MOBA

Multiplayer online battle arena or MOBA is a subgenre of Real-time strategy(RTS) games where the player controls a single character in one of two teams. The main gameplay is centered around controlling your character and several computer-controlled characters that move along a straight path set by the players. The goal of the game is to destroy or control structures owned by the opposing team. MOBAs use a class-based system where part of the strategy involves interacting with your team in order to balance the different classes. The strategy also involves selecting abilities to use and navigating the map in order to defeat the opposing team.In Figure 8.15 we see a screen-shot from Dota 2, one of the most popular MOBA games currently active.

**Figure 8.15:** Schreenshot from Dota 2 where a player is engaged in combat with the opposing team

These types of games became popular as eSports titles where players engage in tour-

naments in order to win prizes. The RTS based gameplay is well suited for these types of competitions. eSports tournaments have grown in popularity and these events can often draw a large crowd of other players as spectators.(See Figure 8.16)

**Figure 8.16:** Image from a Dota 2 tournament where the players are situated in the middle and a large audience follows the event live

### 8.4.7 Vehicle simulation

Vehicle simulators are a genre of video games where the player controls a realistically portrayed vehicle such as a car, airplane etc. The gameplay is centered around controlling this vehicle and depending on the game the simulation can be quite realistic. The goal of the game can be varied based on the vehicle being used but it can often also be realistic in nature, the player could be charged with completing a task associated with that vehicle, for instance, an airplane simulator could give the task of completing a commercial air flight where passengers are simply traveled from one place to another. Or a truck simulator could give the task of transporting cargo from one city to the next. The challenge in these games or often not the tasks themselves but how well they are performed given the setting of the game.

### 8.4.8 Racing

Racing video games are a subgenre of Vehicle simulation where the goal of the game is to complete or win a race. The player controls a vehicle of any type and competes against either computer AI or other players. Racing games can be either serious simulation or have a fantasy setting and the gameplay is centered around the vehicle being controlled. Similarities in gameplay will occur between racing games such as similarites between two different car games but can be varied in terms of additional content such as damage to the vehicle, unlocking new vehicles or power ups in the game.
In Mario Kart (See Figure 8.17) which falls into the Racing genre, the player controls a go-kart piloted by a character from Nintendo‘s Super Mario games. This is a racing game set in a fantasy setting without realistic vehicle controls, in addition to the racing mechanics the players can acquire pickups that give them some advantage over their opponents. The game supports PVP and split screen where players can compete against each other. This game gained popularity due to having simple racing mechanics combined with pickups

that not only gives the players an advantage but also allows them to disrupt other players in order to win the game. The relative short rounds, low learning curve and lack of leveling system allow this to be a casual game that players can pick up quickly and play in short sessions in a social setting.


**Figure 8.17:** A screenshot from Mario Kart. The game supplies simple driving mechanics and supports the classic Mario theme in graphics design

The Grand Turismo series (See Figure 8.18) is an example of a racing game that is closer to a simulator in terms of both the design and gameplay mechanics. In addition to actually racing the player is awarded in-game money for winning, this is used to unlock new vehicles that enable them to progress through the game. The actual driving mechanics are made to be more realistic but this still simplified in order to allow the player to drive at higher speeds than is realistically possible.


**Figure 8.18:** A screenshot from Grand Turismo 2 simulation mode where the player must win prizes and complete challenges in order to unlock new vehicles

## 8.5 Summary

Video games are today a significant part of our culture, in the 40 plus years since the first games where created video games have grown into one of the largest entertainment industries in the world. Video games are now an accepted form of recreational activity among people of all ages and interests and no longer limited to children or adults with

a special interest for computers. The variation of video games in terms of platform and genre have also grown as the technology and interest grew over the years. At this point, there is also little indication that this development will halter in the near future.

Chapter 9

# Exergames

This chapter presents exergames and will examine existing implementations of exergames. The goal here is to examine the state of the art and some of the successful implementations of exergames and exergame concepts that have been developed into games.

## 9.1 What is an exergame

Exergame, from a combination of the words, exercise and game, (sometimes referred to as exertion game) is a video game that requires physical activity.(Boulos and Yang, 2013) Most exergames are designed to be used as an exercise method and utilize methods like custom controllers, custom exercise equipment, GPS, or other input methods such as cameras and motion controllers. The main goal of most modern exergames is to provide a fun alternative to traditional exercise methods and also aid in combating the increase in various diseases related to lack of physical activities.

## 9.2 Examples of exergames

This section presents various examples of exergames that have been successfully implemented in the past.

### 9.2.1 DanceDanceRevolution

DanceDanceRevolution, (DDR) is a series of games that are based on performing dance moves that are registered on a pad the player steps on. The gameplay is centered around stepping on the pad in the correct order given on screen. Based on dancing the game also provides music and the sequence the player follows is given based on the song and difficulty required. DDR has been released as both arcade games as well as console games. In the console versions, a pad was often included and this made it possible to play the game at home. Because of its popularity and the physical activity involved in playing

these game, DDR has been used in physical education, (PE) as an alternative to traditional PE activities. Research done on the use of dance-based games on students in Oregon have provided positive results in regards to average fitness and an increase in motivation. The study conducted over a period of five months on 120 third and fourth-graders saw a reduction in absenteeism of more than 50% and improve students mile run times by 14%. (Lieberman, 2006) Studies also indicate that playing DDR did, in fact, increase heart rates and energy expenditure to the point where it is considered aerobic exercise, however, to be effective one would have to play for extended periods of time.(Tan et al., 2002)

### 9.2.2 Wii Sports

Wii sports was a game released with the Nintendo Wii that utilized the motion controllers included to simulate simple sports activities. The activities simulated where golf, tennis, bowling, boxing, and tennis. In Figure 9.1 we can see a screenshot of a Wii sports tennis match. Simple in their design the activities where made to show the potential of the Wii motion controller system and not as a substitute for regular exercise.


**Figure 9.1:** Wii Sports tennis

However, some research has been done in order to assess the value of the game as a method of exercise. A study found that out of the five activities Wii boxing had enough energy expenditure to be considered a viable way for young adults to exercise. This study showed that the boxing was comparable to a brisk walk on a treadmill.(Willems and Bond, 2009)

### 9.2.3 Wii Fit

Wii fit is an exergame released to the Wii console where the player utilizes a custom balancing board as a controller for the game. The game had activities such as yoga, (See Figure 9.2), strength training, aerobics and balance training. Wii fit became quite popular and sold over a quarter of a million copies in its first week.

**Figure 9.2:** Wii fit yoga

Some research has been done into how Wii fit can be utilized as a training tool, a study conducted with ten women aged 3058 years found an effect on strength and balance.(Nitz et al., 2010) Another study found that the activities provided light-medium intensity training for all age groups, but also that the game provided higher enjoyment to exercising on a treadmill. It also indicated that enjoyment could be comparable to regular gaming.(Graves et al., 2010)

### 9.2.4 Nike+Kinect

Nike + Kinect training was an exergame released to Xbox 360 in 2012 that relied on input through the Kinect camera. The game was based on actual training exercises that the player would perform and be evaluated on based on motion tracking feedback from the Kinect camera. The game provided a virtual trainer that would instruct the player in each exercise. The player was also awarded points and evaluated on their fitness in order to keep track of their improvement and set future goals. Nike+kinect was basically a sports simulator game that had incorporated a gamification approach to the scoring system, as such the experience it was supposed to deliver was meant to be similar to a real workout session in a training studio. While it did deliver and was considered to be one of the best exercise games on the market it seemed like it was marketed towards people who wanted to exercises regularly but did not want to use traditional training facilities either due to time constraints or personal preferences.(Marshall, 2012) Most reviews deemed it as a really good exercises simulator but not a particularly fun game to play.(Beck, 2012)

### 9.2.5 Pokemon Go

Pokemon Go is a free to play location-based mobile game developed by Niantic and release on iOS and Android. The game was developed as a collaboration between Niantic and Nintendo/The Pokemon company. The game is mainly location based and supplies the player with a map of the real world where the player can interact with in-game characters and objects at predefined locations. The gameplay revolves around capturing pokemon on these locations and requires the player to go to real-world locations in order to capture

pokemon or visit poke stops that supply the player with items.(Niantic, 2017) You can see an example of the in-game map in Figure 9.3 this also shows a number of pokestops. The intention of the game was to make an experience similar to the scenario played out in other pokemon games where the player character moves around a fictive open world in order to catch pokemon. In pokemon go this meant the player moved in the real world as well.


**Figure 9.3:** The map with location tracking Pokemon GO

The game also incorporated simple AR features where the camera of the phone was used with an overlay that would make it look like the pokemon was present in the real world (See Figure 9.4). The game had a separate leveling system for players and their pokemon but in both cases the main mechanic, catching pokemon was how the player progressed. The game also had a micro-transaction system and a premium currency for certain items. This was the game's source of revenue and it was a quite success full payment plan.

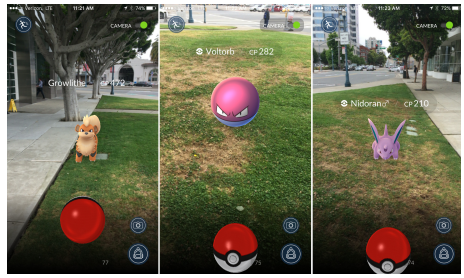


**Figure 9.4:** The AR functionality of Pokemon GO

Because the core gameplay is situated around walking and due to the success of the game at launch Pokemon GO is possibly one of the most successful exergames in recent time. However, the impact this game has had and will have in the long term on physical health is not fully documented. A study conducted in America with participants aged 18-35 saw a significant increase in the number of steps per day during the first few weeks of playing the game. However, within 6 weeks the players had returned to the same amount of steps per day as before installing the game.(Howe et al., 2016) This could indicate that exergames may suffer the same diminishing returns as regular video games. Several gaming-related articles indicate that most players do not complete the games they are playing.(Snow, 2011) (Moriarty, 2014)
The reason for this can be varied and is dependent on the players, could be lack of time, boredom or just the novelty of the game wearing off. This is a challenge that is more important for games on a continued payment plan such as monthly subscriptions or micro-transactions, but it is also a challenge for an exergame since the long-term impact of the game is dependent on the players continuing to play the game. In the case of Pokemon GO, the developers can and have added content to the game after release. Expansions of the game will allow players who still play it to get a continued experience however it will not necessarily motivate players that have stopped playing to start again.

### 9.2.6 Icaros

The Icaros virtual reality fitness experience is a new system based on the Icaros platform that can be seen in Figure 9.5 that enables the user to exercise while playing a human flight simulator. The platform is made to track the user's movement as well as allowing the user to move as if they were actually flying (See figure 9.6). The tracked movement is then used in a VR app either running on the Samsung gear, on an Oculus Rift or HTC Vive headset.(Icaros, 2017)

**Figure 9.5:** The Icaros platform

While the price and size of the platform indicate this is not meant for the average home consumer, pricing starting at roughly 9200 USD, it is still an innovative way to use video games in order to achieve physical training. The platform might med suited as an optional exercise machine for Training studios, especially since it can be used with the Samsung gear. This would allow users of the training studio to use the platform without a need for a dedicated machine. While Icaros has won several design awards, there is still not enough research available to determine the long-term effect of using it as a training method.(Pertsch, 2017)

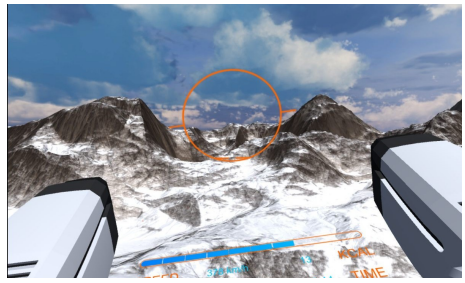

**Figure 9.6:** Schreenshot of a game played on the Icaros Platform

The unique exercise method of the Icaros could be advantageous to the success of the games itself, while the novelty factor is high and people might not end up using it for extended periods the fact that it is dissimilar to conventional training exercises could improve the immersion of the game itself. The platform also opens up for future integration of both video games and virtual reality into training equipment supplied to gyms.

### 9.2.7 Prop Cycle

Prop cycle was an arcade game released by Namco in 1996 and was designed around a bicycle that was used as the controller (See Figure 9.7). Gameplay was centered around flying mechanics where the user could steer left and right by leaning on the bike, increase altitude by pulling on the steering wheel and increase speed and lift by peddling on the bike. The game had a story mode and an arcade mode where the player would fly through

a level and avoid obstacles and try to hit balloons.(Gameroomblog, 2011) Not released as an exergame where one of the goals of playing was to exercise but rather as a for the time innovative new way to control a character in a game. The game was used in entertainment arcades and not as workout equipment in a gym or at home. However, it is a genuine example of a pedal based video game that gained some success in arcades before innovations in console and pc gaming eliminated the need for dedicated video arcades.


**Figure 9.7:** A flyer for the Namco prop cycle

### 9.2.8 Exermon

Exermon is an exergame designed to incorporate strength training and was developed for a mobile phone platform. The gameplay revolves around training a monster by performing exercises such as push-ups, sit-ups, squats, and others. The activity is registered by the game using the phones proximity sensor and accelerometer sensor. As the player exercises the players monster will level up. The player can then use this monster in order to fight against other monster controlled either by AI or in multiplayer against friends. The game also allows players to capture new monsters and train these. The game could be expanded to allow for even more monsters to be added, this again adds motivation for the player to

continue using the app. Utilizing mobile phones instead of a computer and specialized exercise equipment would also lower the threshold for trying the game. Anyone with a mobile phone would be able to play it anywhere.
An experiment conducted showed that the game had an effect on the subject's physical fitness, and did succeed in motivating the players to exercise more frequently. Around 40% of subjects increased their physical exercise while playing the game and, 90% of subjects stated that they were motivated to play the game.
The experiment also revealed that the players enjoyed playing the game and that they were engaged in the gameplay, however, only 25% of subjects became so engaged that they became less aware of their surroundings. (Wang et al., 2017)

### 9.2.9 Pedal Tanks

Pedal tanks is a multiplayer PVP game developed by Playpulse where the gameplay is centered around team-based competitive combat. Each player controls a tank with a cannon and a special ability and the object of the game is to capture the opponent's flag and return this to your base. The controller, see Figure 9.8, used for this game is a exercise bicycle where pedaling on the bike is translated into movement in the game. The bike is also fitted with 2 controllers with 3 buttons each fitted to the handlebars.

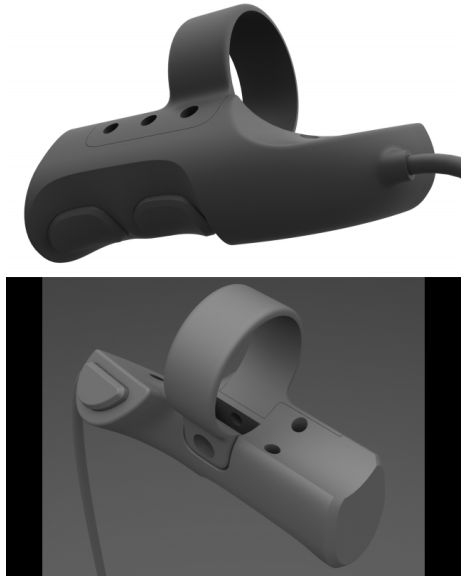

**Figure 9.8:** Playpuls controller

The Game is designed as an exergame relying on competitive playing to be one of the motivators both for the intensity of the workout and for continuous use. Like a lot of online PVP games the challenge is determined by the players you play with and so can the enjoyment level (See figure 9.9). The gameplay itself can be varied based on the vehicle selected with different vehicles having different special abilities allowing the players to us

a level of strategy when playing the game. The game mode is not dissimilar to a well-known game mode in a lot of FPS games known as capture the flag.

**Figure 9.9:** Playing Pedal Tanks

An experiment was conducted in order to determine how well the exergame worked. In the experiment subjects were asked to both played the exergame and engage in a control activity where they would walk for the same amount of time. The results showed that the subjects had a significantly higher energy expenditure while playing the game than walking. In addition, the results of the experiment indicated that the enjoyment factor of the subjects was much higher when playing the game than when walking. The subjects also indicated that the game was a much better motivator for exercise. (Hagen et al., 2016) (Moholdt et al., 2017)(Chorianopoulos et al., 2015)

## 9.3 Summary

In this chapter, I have examined the definition of an exergame and how developers have implemented exercise into video games previously. Some of these examples such as DanceDanceRevolution and Pokemon GO have had success by using physical activity to augment the core gameplay or even create whole new ways of playing video games. Games like Nike+kinekt and Wii sports have made use of motion control technologies in order to track movement and become commercially successful because of the new ways the player gets to interact with the game. Other such as Wii fit Pedal Tanks and Icaros have been designed around exercise equipment in order to promote physical activity, this can increase the effect of the exercise but players will have to suffer the cost of additional equipment. The equipment just as the game itself needs to be affordable for the user. The common challenges all of these games have had is to make the game enjoyable, incorporate new or existing technology and motivate the players to keep playing over time. Based on this chapter, I have made some observations that can be used during the design of an exergame.

- The game should be enjoyable on its own and the player should be motivated to play

it without exercise being the prime motivator.

- The exercise component should augment the experience rather than detract from it.
- Widespread success can be impacted by the cost of the game and required equipment.
- A game with higher replay-ability or prolonged gameplay can have a greater effect.
- Exergames, like regular video games, will have a limited life-cycle based on either the experience of the game or the technology it utilizes.

Exergames face the same challenges as regular games but with the added challenge of motivating the player to exercise regularly. Technology and availability if this is also a bigger issue for exergames. Most exergames aim at replacing a traditional controller with one that promotes physical activities and these are often proprietary, expensive and can discourage new players from trying the game.

Chapter 10

# Game Design

This chapter presents some fundamental aspects of game design that can and should be used when designing a video game. While there is a lot of research on game design due to the massive increase in video games in the last 30 years there are still differences of opinion in what makes a game good, and how to design accordingly to this. One thing that is agreed upon is that a good game always gives the player some kind of challenge to complete. Without a challenge, the player gets bored easily and the game is not fun. At the same time, too great a challenge becomes frustrating and causes the player to lose interest. This is one of the reasons why you cant follow a design recipe for creating a game, if the challenge is too similar to a game the player has already completed then this detracts from the player experience. I will discuss this further in Section 10.2.

## 10.1 What is game design?

*Game design is the act of deciding what a game should be.*

A simple yet descriptive statement from The art of game design a book of lenses.(Schell, 2014) Games are designed through a series of choices that define the parameters of the game, such as the game world, game logic, game rules, game mechanics etc. Game design does not require computer programming skills, as it is not about programming the game, rather creating the concept of the game. As such anyone can become a game designer simply by making up a game, games are not limited to computer or board games either so there really are no absolute prerequisites for becoming a game designer. This, however, does not mean game design is simple or easy to do. There is no unified theory of game design yet and no standard recipe for game design that works in every case. There are many fields that will increase your ability to design good games such as psychology, anthropology, architecture, engineering, history, mathematics, music, creative writing, communication, and business. Because of this, games are often designed in teams and the design will also be influenced by the developers throughout the developer cycle an often after the game has been released in the form of updates.

### 10.1.1 Designing the experience

A game designer creates an experience for the player. This experience will inevitably be influenced by the player and vary depending on the player. The four main elements of a game that also greatly influences the experience are mechanics, story, aesthetics, and technology. You can design a game with the same mechanics, story, and aesthetics for both a tabletop game and a computer game. However, the experience for the player will be different depending on the level of technology used. The same can be said for the other elements and while some games will focus more on the mechanics than the story and vice versa. Aesthetics need to fit the game. This does not mean we need realistic artwork in order to give the player a good experience. There are plenty of minimalist aesthetics that compliment both the story, mechanics, and technology. The retro pixel art aesthetic style seeks to recreate how games looked in the 80‘s and early 90‘s and is used in order to give players a experience similar to the ones they had when playing games when they were younger. The experience a player has can also be impacted by external factors, such as the hardware used to play or social interactions while playing. The game itself is not the experience, the game enables the player to have the experience and because of this it is important to consider what kind of experience you want the player to have.(Schell, 2014)

## 10.2 Flow

Flow is a state of complete immersion in an activity. The concept of flow is that given a challenge that corresponds with your skill level in that field and a setting where you are immersed in the task at hand will let you enter a state where you are working at your optimal capacity without being distracted from the task. Also known as in the zone, most people who experience flow will describe it as a positive experience, a situation where perceived time seems to speed up and one is enjoying the task being performed. Flow can be experienced in any situation where one is given a challenge and manages to complete this challenge without suffering from boredom or anxiety. The flow model can be viewed in Figure 10.1. The model marked as a, is the original simplified model which has a simple linear zone marked where challenge and skill are correctly balanced. In the model marked as b, we see a more updated version that is a bit more complex. The core principle is still there when challenge and skill are correctly balanced the flow state is achieved. This model, however, takes into consideration other psychological states that can be achieved. For instance, if the challenge and skill are balanced but both are at a significantly low level it is more likely that one would experience apathy rather than the flow state. This could be because despite having the correct skill level the challenge could still be perceived as mundane and pointless. We also the low end of the skill level with higher challenge divided into a state of worry and a state of anxiety. The high end of the skill level with the low challenge has zones for control and relaxation. Because the updated model provides more descriptive states it will make it easier to judge how the balance of skill and challenge should be adjusted in order to achieve a flow state. The flow state can be achieved in several different settings. This could be work, creative activities such as painting or sculpting or sports and games including video games.(Nakamura and Csikszentmihalyi, 2014)

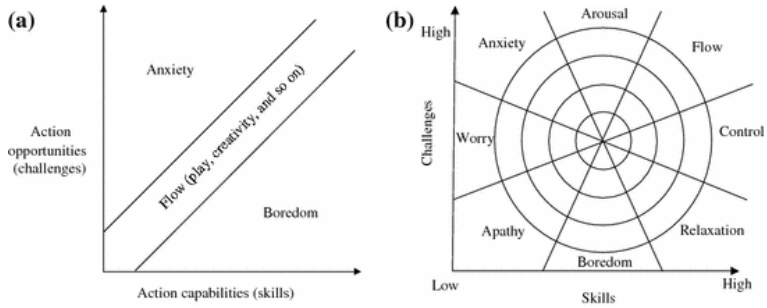


**Figure 10.1:** a. The original flow model. b. The current version of the flow model

### 10.2.1 Gameflow

The concept of flow was used as a basis for developing a model to gauge enjoyment in games by Sweetser and Wyeth, this model was called Gameflow.(Sweetser and Wyeth, 2005) The Gameflow model describes eight elements affecting players' enjoyment when playing games: Concentration, challenge, skill, control, clear goals, feedback, immersion and social interaction.

#### Concentration

A game needs to require concentration from the player in order to be enjoyable. The more concentration a task requires in terms of attention and workload the more absorbing it will be. The game should grab the players attention and maintain this throughout the game, this can be done by either intense task, detailed game worlds, or a sense of impact on the game world. It is important not to give the player tasks that do not feel important in the setting of the game. In addition, UI elements that can distract the player's attention from the game itself should be kept to a minimum or removed completely. This can be difficult to do if the player requires updated information at all times, such as health or status on the current task.

#### Challenge

One of the most important aspects of game design, the challenge of the game needs to match a players skill level and increase in response to the players increase in skill. You also need to have different difficulty levels in order to match the skill level of each player. If the challenge is greater than the skill level then the player experiences anxiety if it is lower then the player experiences apathy and becomes bored. Pacing is important for the player, the rate at which challenges are presented can be varied so the player does not get frustrated while playing. It is also important to remember that a player, and not just his character acquires skills as he plays. So initial challenges should take into consideration a possible learning curve for controls and game mechanics.

### Player skills

Balancing skills with challenge is also important, the player should be introduced to the gameplay through a appropriate tutorial or given the information through UI elements or cutscenes. A lengthy tutorial is not necessarily good as the player can become bored with this quickly. If possible gameplay mechanics should be introduced gradually to give the player appropriate time to develop the skills needed to utilize them. Advanced mechanics can be explained through menus or introduced as part of later tasks, but the introduction to the game should give the player the basic skills needed to play the game. As the player masters, the controls and physical skills required to play the challenge can be increased by increasing the characters skills and stats, while the gameplay is still just as challenging, the perceived increase in challenge by adding more power-full enemies for the player to defeat can still maintain the game-flow.

### Control

The player needs to feel like he is in control when playing the game. This means both literally as the player needs to feel like he is controlling the actions of his character when playing. Both physical interactions and when the character interacts with NPC‘s trough speech options.

Errors and crashes that result in losing progress can also feel like the player lacks control when playing, the option to save and load can mitigate this as the player did have the option to save. While it will still annoy the player if he loses progress there is a option to take back control by saving more often.

The player needs to get the sense that his actions impacted the game world, this does not mean the player should be able to rewrite the story completely to suit his own will. But when the player completes tasks this should be reflected in the game world and the NPC‘s so the player feels like his actions are making an impact on the game. Often giving multiple solutions to a problem and multiple strategies to complete the game can be an effective way to give a player a sense of control. Also adding multiple endings that vary based on the players choice can add to the game experience and motivate the player to try again with a different strategy.

### Clear goals

A game should have a clear overarching goal for the player to complete. Save the world, save the princess etc. But providing smaller goals to complete as you progress through the game is just as important to keep the player interested during the game. Providing rewards for individual goals is a great motivator for the player, optional goals are good when the task is not directly related to the main goal. These can be ignored by players who just want to play through the game and explored by players who want more out of their experience.

### Immersion

Players should feel involved in the game they play, immersion engagement and absorption are keywords when it comes to both flow and the game flow model. When a player

is immersed in a game he focuses fully on the game‘s actions, tasks, story, and world, completely losing focus on the real world, work, school and everyday life.

Games are often seen as an escape from the real world, its social structure, and limitations. By playing a game people can perform tasks they cant in real life because of limitations to skills, resources, social permissions and even the laws of physics. People often say they play games to relax or unwind after school or work and the more immersive the game is the better the experience.

Keeping the players immersed throughout the game is an important challenge for designers, it requires effort in all aspects of the game like artwork, music, story, UI, voice acting, and gameplay. It takes a combination of all of these to immerse the player and a mistake in only one of them to break the illusion.

#### Social interactions

Social interaction is an important part of all video games. Today we think of social interactions in gaming related only to games with online features or online gameplay but it was an important part of single player games, arcade games before online game was available. Playing arcade games was often done in groups and playing single player games often results in discussing this game with friends or online forums. Today online games usually supplies text chat, voice chat or both allowing players to interact with friends and strangers while playing. However just adding social features should be handled with care, a link to the real world can detract from a players immersion and depending on the game become just plain annoying. A key question one should ask is if this feature adds to the gameplay experience in any way, if not then it should at the least be a optional feature the player can turn off or ignore.

## 10.3 Challenges and rewards

This section presents challenges and rewards in games. Every game needs challenges, this is described both in Sections 10.1 and 10.2 But in order to motivate the player, some kind of reward should be offered. The reward can be a higher level, a new item, gold a trophy or achievement, a high-score etc. The reward given should match the challenge with a more difficult task giving a higher reward. The value of the reward will often be judged by the player and because of this, it is difficult to find a balance between challenges and rewards. Another quality described in Section 8.1 is that games can create their own internal value. This is the most common way to balance rewards in video games. It is important to remember that one type of rewards can lose its value while the player plays the games. Here are some common rewards used an how they can lose value to the player.

- XP, Experience, levels. Useful until the player hits max level or the player skill exceeds the challenges
- In-game currency. When the player has purchased all available useful items or has more currency than needed.
- Rare items. Same issue as currency.

- Unique rare items. Once acquired not eligible as a reward again. Too many unique items will reduce the value of them.

- Collectable, unique items that do not affect gameplay: Can only be awarded once and their value will depend on the player.

- Trophies, achievements: Awards that can be viewed by other players. Only applies to players who compare progress with friends or other players.

- Winning in multi-player games. The value of this reward will vary greatly depending on the players.

Most rewards in games will lose value when being repeatedly awarded, even if the reward is useful if it is frequently awarded the player will at one point expect the award and no longer be motivated by it. Rare and unique rewards are motivator until they are acquired and will lose their effect once obtained. Collectables need to provide a manageable challenge in obtaining the set if collectible are easy to find but there are too many objects in a set the player gets bored and loses interest. If there are few and they are too difficult to obtain the player becomes frustrated. The only reward mentioned here that can sustain value over time is victory in multi-player games. This is because the challenge and value will depend on who you play against. Often the victory has more value if you play against friends and people you know.

## 10.4 The Game world and the story

This section presents the concept of the game world and how the story affects a game. The Game world is a term used to describe the setting of a game. The story is what happens in the game and takes place within the game world. A game world does not need to be big or detailed, but it does need to give the player a impression of the setting where the game takes place. The game world can be presented in a number of ways, cutscenes, level design, story, character design and text information. While it could be tempting to present this before the player actually plays the game through either text or a lengthy cutscene the better option is to allow the player to experience the game world as they play.

## 10.5 The three C‘s

This section presents the concept of the three C‘s, Character, camera, and controller. Getting the design of these 3 components well defined and working well together before development of the game can be crucial to a successful design. This is because they are the components the player uses to interact with the game and changing one of them during development can have implications on the other two, and even the gameplay designed around these components.(Rogers, 2014)

### 10.5.1 Character

The character is what the player controls and has certain aspects that greatly affect the gaming experience. Personality, appearance, metrics, equipment are all aspects that the player will observe during the entire playtime and should to some extent give the player information about the game. The character will provide a connection between the player and the game and needs to be designed to be compatible with both the world you are creating and the player.
If possible and this adds to the gameplay the player should be able to choose some or all of these aspects for them self. This is what is sometimes referred to as a blank slate or the silent protagonist depending on the genre of the game. By giving the player a blank slate where they choose the name, appearance and sometimes the actions of the character you allow them to influence the story of the game in a way that can increase the enjoyment and immersion of the experience. This is one of the core features of the RPG genre. However, creating an immersive game world with a rich storyline and interesting NPC‘s to interact with a character that has no personality of its own can be difficult. Unless the player takes the time to project these aspects onto the protagonist this could detract from the immersion of the game. Common default personalities that are often used are the Heroic character and the Badass character (sometimes called the anti-hero). The character appearance should also be designed to fit the personality of the character and in the case of the character being a blank slate, the player should be able to chose the appearance that fits his character best.

Metrics and equipment are the two aspects that can greatly affect gameplay, the metrics or size and shape of the character needs to be consistent and designed for interactions with the game world. This is important because the player will use the metrics, either consciously or subconsciously to gauge movement such as running speeds and jumping distances. If the gameplay is combat focused metrics will also be used to gauge melee range and projectile range. Changing the metrics midways or just in some parts of the game could negate the skill the player has developed during the game and might seem like an unfair challenge to present to the player. Equipment, and by this, I mean usable items that enable certain gameplay actions can also change the gameplay for the player. If the player is given a choice between a sword and a gun then the gameplay will be defined by the player’s choice. Challenges will then need to have solutions for both gameplay styles and offer a similar challenge. This adds complexity to the world design and challenges for the developer, but the choice the player is given can increase immersion for the player.

Most of these character features are expanded if the player can control multiple characters either at once or one at a time. When using multiple characters the differences in these characters is usually the incentive for doing so. If a game incorporates a class system, Warrior, Mage, Spy etc then these classes can have different gameplay mechanics related to the class. Some multiplayer games also use characters to represent a class so that players can differentiate between the class used by other players more easily during a session.(Rogers, 2014)

### 10.5.2 Camera

The camera is the viewpoint that the player experiences the game world through. There are multiple different ways to implement a camera in a video game, static camera, scrollable camera, parallax scrolling, first-person camera and third person camera are some common options.
A static camera does not move and is common if your game does not require movement during gameplay. Such as point and click games where the player is only presented with one image at a time. A scrollable camera is similar to a static camera but with a larger image that the camera can be scrolled to view, variants of this is common in RTS games. Parallax scrolling is quite common with 2D side-scrollers where the camera scrolls sidewards as the player moves and the background changes to depict the game world. A variant of this is forced scrolling where the camera moves and the player is forced to keep up with the camera. This is a good example of how a simple change in the camera style can affect the gameplay. First person and third person cameras became more common with 3D games and are the most common in games today. In first person, the camera displays the world from the viewpoint of the character being played. In third person, the camera display the entire character and it often follows slightly behind and above the character being controlled.
While most games will utilize several different camera styles, it is still highly recommended to use one style as your main camera. Some games offer a choice between first and third person and usually uses a static camera on the menus. Designing a game for one specific camera style as the main camera and then changing the style while developing can lead to a lot of extra work and unintended complications. For instance, a game developed for a first-person view and single player has no need for a complete character representation. Arms are usually all the player needs to see in order to get the full experience so why take time to develop more than you need. But if you then decide to add the option of a third person camera or a multiplayer feature you would need the complete body and also adapt the gameplay to support the third person angle. This is why it is important to determine the main camera and all of the supporting camera styles during design time rather than development time.(Rogers, 2014)

### 10.5.3 Controller

The controller scheme will often depend on the platform or platforms the game is being developed for. PC games have mouse and keyboard as a controller but will often support a gamepad layout as well. Consoles such as Playstation and XBox have controllers and sometimes cameras with motion detection. VR and Nintendo have motion controller detection.
However, for the design of the game, mapping different controller layouts to different platforms is less important than supporting continuity of a selected scheme throughout the game. Players will understand that playing a game on a console with a controller is different than on a PC with a mouse and keyboard. However, if you drastically change the way the controller is used during gameplay then the player can become confused and find the challenge too difficult because they have not developed the skills needed yet.
Examples of this can be minigames, special levels or boss fights where a unique action or

combination of actions are needed to complete the task. Minigames with quicktime events that require specific buttons to be pressed in a specific order should follow the layout of the controller you are using and the scheme that you are using. Keeping in mind the ergonomic limitations of that control when the player needs to perform fast-paced actions.
Changing the controller scheme in special levels or boss fights can be required but it should still follow the logic of the main scheme. For instance, if you have a fire button mapped to R2 of the controller used on all of the game's weapons right up until the final boss fight where a special weapon needs to be fired during a quick time event. Do not map this event to the X button. The player has just spent the entire game learning that you fire weapons using R2 and you present him with a situation that requires him to fire the weapon then the skills the player has acquired tells him to press R2. While this can be viewed as a added challenge, it will in my experience detract from the enjoyment of the game when these types of tactics are used to trick the player into failing. If a new action is added to the game either permanently or for special instances, this action should be mapped to the button that has the closest relation to the action. Special jump, use jump button, special fire use fire button etc. If the action has no relation to any previous gameplay actions and you already have a general interaction button on your scheme use this.
The controls need to be planned out in advance to support all of the actions the player will use during the game. It should also be planned accordingly to the ergonomics of the controller and the sequence the player needs to use these actions in gameplay. If you are designing a game within a genre that already has a common controller scheme associated with it such as a first-person shooter, you should use this since you can make use of the skills the player has from other games.(Rogers, 2014)

## 10.6 Considerations for designing exergames

This section presents some considerations needed for the design of an exergame. Designing a video game will have similar challenges regardless of the platform the game is intended for. However, with an exergame, some additional considerations need to be made based on the method of exercise and the platform the game will be running on. In this section, I will be looking at some considerations specific to the design of an exergame.

### 10.6.1 Dual Flow

Duel flow is a model based on the flow model designed to create and evaluate exergames. This model can be viewed in Figure 10.2. Keeping the concept of game flow in mind for the design of the game itself it also takes into consideration the relationship between the players current fitness and the intensity of the exercise. In the case of exercise activities the fitness of the player would be considered the skill and the intensity the challenge, it is not uncommon for people to enter such a state of flow when engaging in exercise activities.

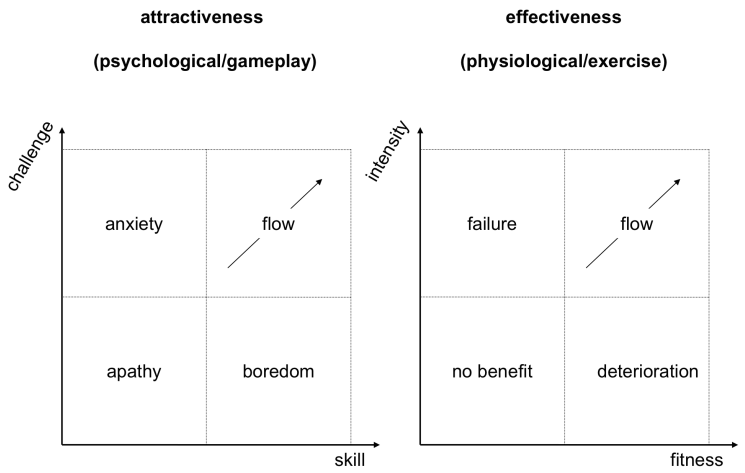


**Figure 10.2:** The dual flow model

The consequences of a mismatch between the intensity and fitness of the player are similar to that of the flow model, if the intensity is to low compared to the players fitness he will not gain any benefit from playing the game and the players fitness could deteriorate. If the intensity is too high then the player will reach a state of failure and will not be able to continue.
It becomes apparent that both of these flow's need to be considered when designing a exergame. Even if the game is entertaining and fun if the exercise component is mismatched or has low flexibility the game will not appeal to the broader audience. If the exercise component is to hard the players will not want to play the game regularly or possibly even at all. If it is to easy then the player will not receive any benefits to fitness or health from playing the game.(Sinclair et al., 2007)

### 10.6.2 Pacing and game time

Based on the information given in Chapter 5 there are some considerations regarding the session length of a exergame. While there could be a risk of overtraining the amount of playtime required is most likely out of the scope of any conventional exergame so the main consideration is the minimum recommended amount of moderate-high intensity training. This leads us to the following requirements for pacing and play time of a session.

1. session should be at least 10 minutes, regardless of player fitness.
2. The game should motivate the player to play at least 30 minutes per day 5 times per week if the game supports only medium intensity and at least 15 minutes per day 5 times per week if the game only supports high intensity. For a combination of the two intensity levels, the minimum amount would need to be between 15-30 minutes per day 5 times per week.
3. The game should motivate the player to play multiple sessions.

4. Scaling of the amount is recommended, either with longer sessions or by promoting multiple sessions. This will depend on the game itself and how it is designed.

5. Sessions should not be so long that it adds a fitness based challenge to the gameplay or decreases motivation for the player.

6. In order to gain health benefits you need to exercise regularly and continuously. A exergame needs to be designed so it has a high replay value.

### 10.6.3 Increasing the fitness challenge

This will depend on how the game is designed. If the game requires dedicated exercise equipment it would be prudent to allow the equipment to have a modifier that increases the intensity. A combination of game difficulty and adjustment of the equipment should make it possible to scale the game challenge and skills as well as fitness and intensity for all potential players in order to achieve dual flow. If there is no dedicated equipment or this cannot be adjusted the game should implement different difficulty levels that take into account both the game challenge and the intensity of the exercise and balance this with the player's fitness and skill. The ladder can add a lot of complexity to the game an make it difficult to make a exergame that can be utilized by different players.

### 10.6.4 Rewards in exergames

The reward system in a exergame does not need to be any different than in a ordinary video game. (See Section 10.3) The goal is still to motivate the player to continue playing the game. However, there are added rewards to a exergame, the increased fitness of the player and the health benefits that come with this. (See Chapter 5) The question here is should the designer take this reward into consideration when designing the game itself. There are a few things to consider here. What is the player‘s motivation for playing the game? Is it to play a video game or to exercise? How does the player want to experience the activity? As a video game session or as a exercise session?
If the intent is to create a game that provides the player with a vigorous exercise session without the player thinking about the activity as a exercises session, then having the game remind them of this could have a negative impact on the player experience. On the other hand, providing exercise based trophies and information about the health benefits could be a powerful additional motivator for the players.
Connecting progress within the game directly to progress in the player's fitness could both motivate the player to progress or discourage them from playing further.

### 10.6.5 Limitations of the Machine-Man-Interactions

A video game requires input from the player. In an exergame, this can provide limitations to the amount of interaction the player can have when also conducting a exercise. In every example of exergames in Chapter 9, the method of input is usually tied directly to the gameplay and or provides limitations to how the game is designed. In the example of the Playpulse controller, I will be using that is described in Chapter 7, the number of buttons

available limits the number of unique actions the player can use. While it could be possible to design a game for a exercise bike utilizing a full keyboard or a controller with more buttons you could end up increasing the learning curve and complexity of the gameplay. If complex gameplay combined with the exercise itself becomes too challenging for the player this would disrupt the flow state resulting in a poor game experience.
This means that the combined challenge of both the exercise and the game will need to be considered, while both the gameplay and the intensity of the exercise could seem to be perfectly balanced combining these to activities provides can quickly become more challenging than expected. It is important to remember that the player is, in fact, doing two things at the same time, both playing a game and exercising. The combined challenge of these two activities performed as one must also be take into consideration.

## 10.7 Summary

Game design is a complex subject that encompasses all aspects of creating a game both digital and otherwise. While the core principles do not change from a tabletop game to a video game or even a exergame there are considerations to be made to the medium or platform the game is created for. Since game design is comprised of design principles there are no absolute answers to whether a design is a ”good” design, it can only be more or less suited for the specific task. However, there are some common denominators to games that allow for certain design principles to remain the ”correct” choice for a majority of video games. Some of these principles have been outlined in this chapter not because they are universal and always true, but because they seem to be more or less suited for the game that I will create. In addition, some considerations had to be made to the specific platform I am developing for and for the type of game I am creating. This being the Playpulse controller for a PC and an exergame respectively.

Chapter 11

# Prestudy Findings

This chapter presents the findings from the prestudy. This includes which genre of games that are more or less suitable for an exergame as well as which genres and design choices that have been made for the prototype exergame and why these choices were made.

## 11.1 Which game genres are suitable as exergames

This section presents an analysis of different game genres regarding their suitability for exergames. Based on the prestudy I have a few major factors that will have an impact on the suitability of a game genre.

- The method of providing input to the game.
- The complexity of the game and the complexity of the gameplay.
- The duration of a single session of the game.
- The duration of the entire game.
- The challenge of the game.
- The motivation for the player in the game.
- Replayability of the game
- The method of exercise and its intensity.

The input method will heavily impact the controller method and as such the gameplay mechanics of the game. A keyboard has more options than a controller, and a controller can have more options than motion input like a Kinect camera. The input method can also be affected by the exercise method and vice versa. The complexity of the game and gameplay can have a negative effect on both the experience and the exercise. If the player needs to stop the exercise in order to effectively play the game this would be detrimental

to the exercise and possibly the game experience as well. How effective the exercise is will depend on both the intensity and duration of the game and a single round. However in Section 5.2 the recommended minimum time of a session is roughly 10 minutes in order to get the benefits. This means the game should encourage at least 10 minutes of exercise every time someone plays it. This does not mean one round has to take 10 min but, if a round is less than this the game should encourage playing multiple rounds. If the games entire duration is to short this could impact the longterm effect of the game, and if it's too long it could present a demotivating challenge to the player.
The game needs to provide some motivation for the player beyond the benefits of the exercise itself. If the game and gameplay itself do not motivate the player beyond exercising it would be more difficult to obtain the dual flow state described in Subsection 10.6.1. The goal of the game itself should be to provide additional motivation and not just to distract the player from the exercise. The replayability of the game will greatly affect the long-term impact of the game if the player can enjoy multiple replays of the game it is more likely they will continue playing the game over long periods of time. Finally, the method of exercise and its intensity, just as the complexity of the game and its gameplay mechanics can become a distraction for the exercise, the intensity of the exercise can provide a distraction for the gameplay itself. There needs to be a balance between the exercise and game that allows most players to master both at the same time.

Based on these factors I can make a prediction on how well the genres described in Chapter 8 are suited as an exergame.

### 11.1.1 2-D Platformer

2-D Platformers have a simple controller scheme that is well suited for combining with a method of exercise, it can also have simple gameplay that is easy to master and can provide varied challenges to the player. Duration can also be well suited where levels can be balanced in terms of duration based on the exercise method and the challenge of completing the different levels could provide enough motivation for the player to continue playing the game. 2-D platformers can also be designed as a multiplayer game in order to provide additional challenge and motivation. In addition to simple gameplay, 2-D Platformers also often have a simple gameworld and a simple story. This lets the player quickly pick up where they left off if there is an extended time period between sessions. This allows the player to complete a long game over time as long as the levels are balanced as a single training session. 2-D platformer also has a high replayability as people often enjoy the gameplay more or as much as the setting and story of the game. The method of exercise would have the most impact on the gameplay itself if it relied on continuous movement such as if the controller was based on a thread-mill or a bicycle. However, infinite runner platformers are quite common and popular as mobile games that are intended to be played for limited time periods but still provide an increased challenge as the player progresses. All this would indicate that the 2-D Platformer Genre could be well suited for an exergame.

### 11.1.2 Action-Adventure

Action-Adventure games can have a simple controller scheme and will be heavily impacted by the exercise method. These types of games can often have high complexity with somewhat low complexity gameplay. Usually, they include a story that heavily impacts the game and items and equipment the player uses to achieve their goals. This would also mean some kind of inventory and inventory management and quest log. They do not really have sessions or levels but rather split up the game into quests, areas, and chapters in the story. As such they are designed to be played from start to finish in order to get the entire experience. Because of this, it could be difficult to compartmentalize the game into individual training sessions and also to balance the gameplay and exercise within these sessions. These types of games often have low replayability because the story will often heavily influence the experience during the first play-through and after this, the player lacks additional motivation for repeating the game right away. While they can have multiplayer functionality such as cooperative play, Action-Adventure is mostly a single-player genre. Once again the method of exercise will affect the game itself and Action-Adventure is not well suited for continuous movement as they involve exploration and puzzle solving. This makes it difficult to integrate into common exercise equipment. While it would be possible to implement an Action-Adventure exergame, it is not the best option. Low replayability, balancing issues, often complex UI and the fact that it is not suited for constant physical activity makes it a difficult genre to use as the basis for an exergame.

### 11.1.3 Shooter games

Shooter games can be implemented with a fairly simple controller scheme. Gameplay is simple and often similar across different games and the game world and story does not impact the game a lot. Shooter games are usually divided into matches that can be easily balanced for gameplay and exercise. While they can provide a single player mode they are usually more engaging when playing against other people. Competing against other players also provides most of the challenge and motivation in the game. Shooter games have a high replayability because of this and are well suited for playing small sessions regularly over long periods of time. While continuous movement does not fit the shooter genre at all it could be incorporated into a new game mechanic. Or you could find another use for the input that actually movement such as restocking ammo or enabling special ability's. Shooter games could be well suited as an exergame in terms of providing entertainment and motivation to the player. The main challenge would be connecting the exercise method to the gameplay.

### 11.1.4 RPG

RPGs, in general, requires an advanced controller scheme and as such can quickly become complicated where trying to integrate this with exercise. Gameplay is often somewhat slow paced and relies on tactics in order to provide a challenge to the player. In addition to this, the inventory management and character leveling which is the main roleplaying components of RPGs are complex and requires time and effort. RPG games are also story driven and do not compartmentalize easily into simple game sessions. Games are tradi-

tionally divided into quests and story chapters with multiple optional side quests making the total play time of the game quite long. Players are motivated by the story as well as the leveling system that would require some kind of UI in order to offer the flexibility of the player character. RPGs can offer replayability but will players will likely have extended time periods between each play-through. Few exercise methods would be suitable for integration with an RPG, simple walking on a treadmill would be the most appropriate but it is unlikely the gameplay would become fluent and actions such as inventory management and leveling would break up the exercise since there would be little motivation to continue exercising while doing it, Western RPGs or action RPGs could be integrated with exercise to the same extent an Action-Adventure game could but the exercise would still be disrupted by the roleplaying components. This means they would integrate poorly with high-intensity exercise. It would seem that RPG games might not be the best genre to create an exergame that motivates players to exercise, it would also be difficult to combine any method of exercise other than walking with this genre.

### 11.1.5 MMORPG

MMORPG suffers from the same issues as traditional RPGs with the added problem that the range of gameplay and abilities are often much higher requiring much more complex controller schemes. MMORPGs are almost exclusively designed with a mouse and keyboard in mind and players have the option of customizing key bindings themselves. Often players can have several dozens or more unique actions bound to unique keys or combinations of keys. Because of the complexity of the gameplay, combining this with an exercise method could make it problematic for the player to focus on both tasks. Like RPGs the use of a thread-mill could have potential as much of the time in MMORPGs is used traversing the game world, but people who play these games can spend multiple hours each session and it is likely the exercise after a while would impact the experience of the game. In addition, MMORPGs require a lot of players interacting with each other at the same time in order to reach the full experience, and if the player base is reduced then this will eventually detract from the experience for the remaining players. It would seem like MMORPGs like single player RPGs are not well suited as an exergame.

### 11.1.6 MOBA

MOBA being a subset of real-time strategy is also difficult to play using anything other than a mouse and keyboard with numerous key bindings. As it is strategy based and uses a number of abilities this could be difficult to implement as an Exergame. MOBAs are match based and could be balanced into exercise sessions and has high replayability due to the multiplayer aspects. However, the fast pace of the strategy gameplay would be difficult to combine with an exercise activity without the two activities disrupting each other. Also, the gameplay mechanics would be difficult to combine with any method of exercise that is traditionally used in exergames. It seems unlikely that MOBA would be a suitable genre for an exergame without a new an innovative piece of exercise equipment or a complete redesign of the genre.

### 11.1.7 Vehicle simulation

Vehicle simulation is a much broader genre than the previous entries. It can have simple game mechanics and require a simple controller scheme. The complexity of the gameplay will vary based on the vehicle and how realistic it is meant to be portrayed. It can be divided into simple sessions such as levels or races and balanced against an exercise session. They often have high replayability and can provide various levels of challenge. The main selling point for a vehicle simulation is the fact that vehicles usually are in motion when playing. Because of this using input from a piece of exercise equipment such as a bicycle, thread-mill or rowing apparatus, and connecting it to the gameplay is fairly straightforward. If the game simulates a bike, someone running or rowing a boat the then activity feels natural and connected to the game. Vehicle simulation can also be multiplayer and provide additional challenge and motivation by playing against other people. Vehicle simulation seems to be well suited for exergames both because of the simple controller scheme required and the simple way they can be integrated with existing exercise equipment.

### 11.1.8 Racing

Racing is a sub-genre of vehicle simulation and as such has all of the same benefits in terms of use as an exergame. In addition, racing games are usually divided into single smaller sessions and are quite often implemented with multi-player functionality. Racing games also often encourage the player to keep moving all the time which can easily be combined with an exercise method that requires you to exercise continuously such as running and biking. Just like its parent genre racing seems like it is well suited for an exergame.

## 11.2 Choices for prototype

This section presents the choices made for the prototype. After looking into multiple possible game genres and examining the possibilities of the controller and game engine I made several choices that would impact my prototype development. In this section, I will present which choices I made and why I made these choices for the prototype exergame.

**Game engine:**
The Unity engine was actually selected before the pre-study was conducted, while I had options in terms of the game engine I decided to use unity because previous prototypes and games for the Playpulse controller also had been developed with this engine. In addition, the UNET framework for multiplayer has the potential to simplify the networking of the game
**Multiplayer:**
While it is possible to create a single player game for this prototype, the added benefits a multiplayer game gives in terms of gameplay challenge and motivation is enough to justify the added work of implementing the game as a multiplayer game.
**Genre:**
I decided on a racing game because it seems like it is well-suited as an exergame in general and even more so when the method of exercise is biking and the controller itself registers

input from the pedaling of the exercise bicycle.

**Vehicle choice and theme:**

The choice fell quickly on a hoverbike concept. This gives a connection between the exercise method: biking and the vehicle the player controls. I addition, a sci-fi theme to the vehicle opens up new possibilities to the game concept in terms of additional gameplay such as weapons and power-ups. It would be more difficult to add such gameplay features to a game that simulated a normal bicycle.

**Core gameplay:**

The core gameplay will be racing with added weapons and powerups that can be used to disrupt the other players. This is similar to games such as Mario Kart and is meant to promote a casual competitive gameplay. Rather than the players simply utilizing their physical skill in order to win a traditional race this added gameplay may help to balance the game between players of different physical skill. It could also provide an advantage to players that master the skill of the game in addition to increasing their physical skill. It also utilizes the dual flow method by challenging players in both skill areas in order to achieve a dual flow state.

## 11.3 Summary

Some game genres are more suited as exergames with the main consideration needed is the limitations of the platform, controller, exercise method and player capabilities. Platform and controller will limit the number of unique inputs the game can have and thus the complexity of the games controller scheme. The exercise method and player capabilities can limit the amount of focus the player can have on the combination of these two activities and potentially reduce the player's chances to reach the desired flow state. As such games that have a low complexity to both controls and gameplay seems to be more suited for this combined activity. Based on this I have settled on both genre and type of gameplay for the prototype exergame. While it would be tempting based on the information to try and conclusively settle on certain game genres as the best fit for exergames and other genres to be inherently impossible to implement as an exergame this would only be conjecture on my part. Without implementing each genre as an exergame and testing them individually I cannot conclude with certainty how accurate this prediction would be. This, however, would be somewhat outside the scope of this thesis. What I can say is that based on the considerations required to implement a genre as an exergame certain genres such as Action-Adventure RPG, MMORPG and MOBA would be more difficult to adapt to include an exercise method. 2D-platformer, Vehicle Simulation, and Racing, on the other hand, would be easier to adapt to include an exercise method.

# Part III

# Game Design And Implementation

Part III documents the design and implementation phase of the development. This will include a detailed overview of the game design as well as architecture and code documentation.

Chapter 12

# Designing the game

This chapter describes the design of the prototype,CyberSteamPunkHoverWar 2088, using the Ten pager Game Design Document(GDD) described in Chapter 4 in Level Up! The guide to great video game design. (Rogers, 2014) This document is intended to be used while prototyping and creating games in order to describe the overall design of the game. It is written before the actual development of the prototype is created and then updated during the development phase in order to accurately reflect the game. This document does not provide the full documentation of a game but is rather an overview of the game in its entirety. It should be supplemented with documents describing the technical components of a game and also a document describing the game world and its rules in greater detail. However, for a prototype game, it is sufficient to describe the design of the game. While I do use this template as a basis I do not follow it completely and only use it as a general guideline.

## 12.1 Inspiration

This section describes the main sources of inspiration for the game, both gameplay and aesthetics.

The game, specifically the gameplay takes a lot of inspiration from the Mario Kart games. I wanted the game to have the same level of ”relaxed competitiveness” as well as simple and intuitive mechanics. The game should, of course, be competitive but not to the extent that players become aggressive against each other. Mario Kart provides this type of competition where players care about winning when they are playing but not about who won after the game is over. Mario Kart is also a casual game without long-term progression or leveling where players are equal, with the exception of the players own skill. In Figure 12.1 you can see a snapshot from a round in Mario Kart 64 with powerups, these powerups will be similar in the exergame prototype. This allows new players to quickly learn and master the game when playing against more experienced players.


**Figure 12.1:** Gameplay from Mario Kart 64 with powerups.

Star Wars: Shadows of the Empire Visual design was limited by the artwork available to me during the implementation, but a lot of inspiration towards the look and feel of the game was taken from one game level in Star Wars: Shadows of the Empire. A snapshot from this level can be seen in Figure 12.2. Here we see an example of the type of hovervehicle I wanted for the prototype. This swoop bike level was partly the inspiration for the use of hovercrafts rather than ground vehicles as well as inspiration for the design of the test level. In addition to power-ups that are taken from Mario Kart the player also has laser weapons that took inspiration from Star Wars.

**Figure 12.2:** Image from Swoop racing in Shadows of the empire

## 12.2 Game description

This section presents a brief description of the game, this is similar to the information that would traditionally be available on the back of a game case or on an information page for digital download. Like the rest of the GDD, this section would be reiterated during the development process in order to accurately describe the game at release.

**Title :**
CyberSteamPunkHoverWar 2088
**Game Systems :**
Primary system: Windows 10
Secondary system: ios/mac
**Game Engine :**
Unity, Unet multiplayer
**Genre :**
ExerGame, Racing, Competitive, Multiplayer.
**Target users :** The game is primarily targeted at teenagers and young adults with some or extensive knowledge and experience of video games. The game also targets people who are looking for a new way to exercise that combines this with a video game experience.

**Key features :** The game is controlled using an exercise bike with the Playpulse controller. This controller registers input from the motion of the wheel of the bicycle and also provides 6 button inputs. The game's racing mechanics are centered around a hover vehicle rather than a traditional vehicle. The games multiplayer component is intended to challenge and motivate players to exercise without overexertion in order to provide a balanced workout.
**Game description :**
As a member of one of two factions in the post-apocalyptic hover war take command of a hover vehicle and compete for glory in the arenas of battle. Chose your side: Steampunk or Cyberpunk, the decision you make could impact the future of mankind. Race against your friends or use the online matchmaking service to compete against other players in the racing mode. Use advanced weapons to disrupt your enemy and score the finishing blow in death ball, warning balls can and will explode if you are careless.

## 12.3 Game Story

This section presents a brief synopsis of the story of the game world. The year is 2188 and the CyberSteamPunkHover war has been raging for a hundred years... With the invention of hover-based technology as was proficiesed by Back to the future 1-3, World war 3 was all but inevitable. The war ended in 2061 when all parties involved resorted to the use of nuclear weapons which completely devastated every civilized country as well as every non-civilized country in the world. The few pockets of humanity that survived promptly declared it a draw.
The tattered remnants of humanity scavenged the remains of the old technology and tried to use it for the benefit of all mankind, however, a principle design choice ended up dividing mankind again resulting in the CyberSteamPunkHover war of 2088. The war is fought between those who prefer CyberPunk technology based on the 1980‘s movie props and those who prefer SteamPunk based technology based on the SteamPunk movement of the early 2000‘s which again was based on the 1890‘s steam-based technology.
With both sides unwilling to concede to the others design choices the two sides waged war for a full century. In the present, the present being 2188 war is no longer just about design choices and resources, it is also the principle form of entertainment. Because of this, both sides agreed to only wage war in arena‘s with predefined rules so that the audience at home could follow without getting all confused and stuff.

## 12.4 Tutorial

This section describes how the tutorial will be handled. There is no tutorial level or tutorial game mode in this game. The player will be given information through the controller scheme option in the menu and will need to play the game in order to learn the mechanics. Information about actions available will also be provided by the hud when in play mode. If the player wishes to practice the game allows you to play the racing mode without other players present, however, there will not be any AI competitors present. The most efficient way to learn the game is to actually play with other players.

## 12.5 Game flow

This section describes the game flow of the prototype.

*A description of what the player will be presented with when playing the game and actions available. Not to be confused with the flow model*

The player will be able to control a hover vehicle as a member of one of the factions in the hover war. As a soldier in the hover war, you will be pitted in competition with other soldiers controlled by other players. The hover vehicles are fitted with weapons that can be used to disrupt the progress of competing players, the field of battle also has hazards place such as rocks and fences aimed to make impede all combatants as well as pickups containing more powerful weapons and areas that can boost the player's speed. The rules of the battle arena will dictate the winning conditions, in the racing arena you must finish first in the race in order to emerge victoriously.

The player first has the option of selecting to either join a match or host it. Then once all players that join the match has marked themselves as ready, the match begins. The players then race against each other while using the weapons and powerups to disrupt the other players. Once all players have completed the players are returned to the main menu. A full overview of the game flow can be seen in Figure 12.3.

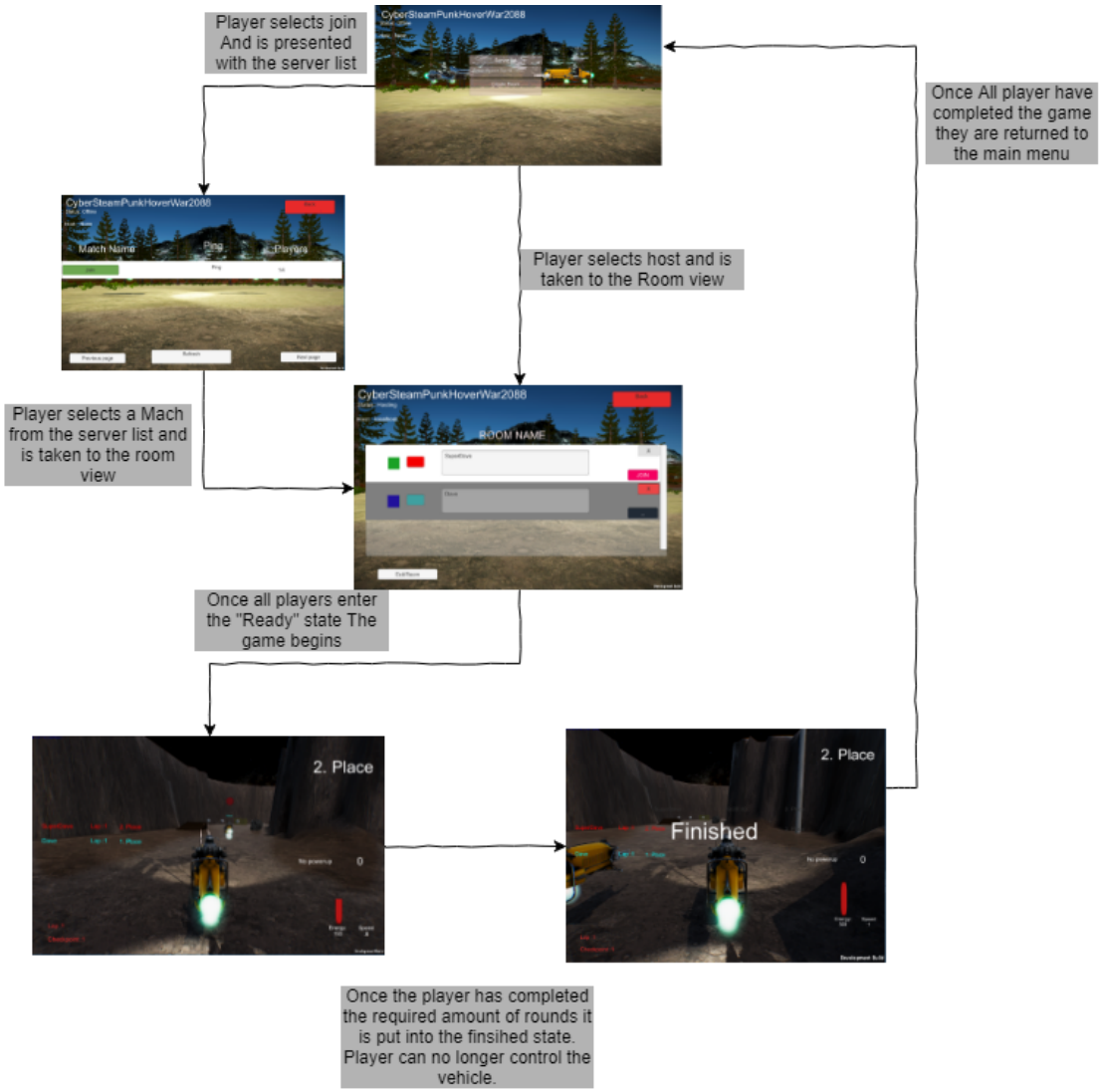


**Figure 12.3:** A flow chart describing the flow of the game for the player

## 12.6 Character

This section describes the visual aspect and the motivation of the character or characters the player will control during the game.
The player controls a hover vehicle from either faction, there is no difference between the vehicles in terms of gameplay it is only a cosmetic choice. The two choices available to the player are Cyberpunk and Steampunk.
The characters main motivation in the game is to destroy the opposing faction by any means necessary. The character design for the Cyberpunk character can be found in Figure 12.4 while the character design for the Steampunk character can be found in Figure 12.5.

**Figure 12.4:** The Cyber X-01 alpha is the default cyberpunk vehicle and has had a long service time within the cyberpunk movement. With 4 forward facing alternating laser cannons and an additional launcher for missiles it truly is a devastating display of Cyberpower.

**Figure 12.5:** The Steampunk S.T-1888 Codenamed ”Traktor” is a brand new vehicle designed to look like it has had a long service time within the Steampunk movement. It also has 4 forward facing alternating laser cannons and a additional launcher for missiles and is a devastating display of Steampower.

## 12.7 Controller

This section describes the controller used by the player and controller scheme implemented in the game.
The player controls the character using the Playpulse controller seen in Figure 12.6. The throttle is based on the rotation of the wheel on the exercise bike while steering and additional controls are handled by the buttons on the handlebars.
The buttons control the following functions,left,right,Jump,Revers,toggle powerup,fire laser/powerup. This can be seen in Figure 12.7. The goal is to give the player an immersing experience while exercising on the bike and allow the player to feel like he is actually controlling a hoverbike.

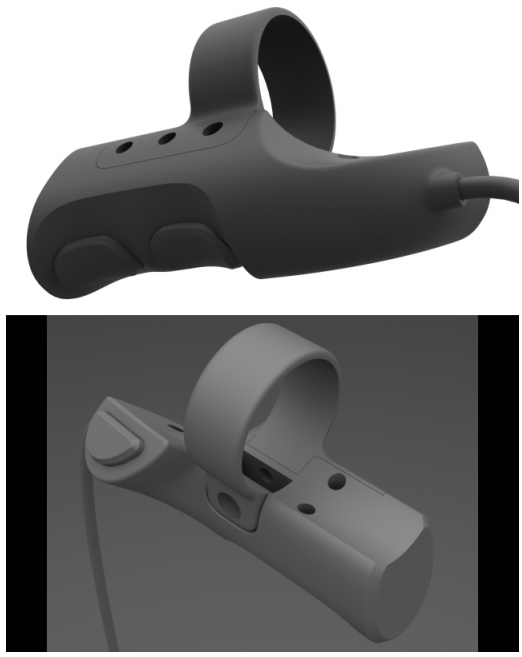

**Figure 12.6:** Playpulse controller


**Figure 12.7:** Controller scheme

## 12.8 GamePlay

This section describes the Gameplay the player will engage in while playing.
The main gameplay is centered around the hover vehicle the player controls. This is similar to most racing mechanics where the player can operate it almost like any other vehicle. The goal of each level is to compete for first place in the race, in Figure 12.8 we can see multiple players engaged in a match. A supporting mechanic is the weapons the player can use to disrupt other players. The default weapon is a laser cannon that will temporarily stun other players when they are hit with it, this can be seen in Figure 12.9. Since there is no health mechanics the purpose of the laser cannon and the other weapon available is to disrupt opposing players and gain the upper hand. How this is achieved depends on the game mode and the weapon used. Additional weapons will be described later as power-ups. The racing mode has traditional racing mechanics and the goal of this mode is to complete the race in first place.


**Figure 12.8:** Players competing in a race


**Figure 12.9:** Players use the lasercannon to disrupt each other

Weapons and powerups are used here to get an advantage or to give a disadvantage to the other players in order to complete in first place. An example of a power-up being used can be seen in Figure 12.10, this is the missile type weapon that will track a player and impact them unless the player can use the environment to block it. The basic racing mechanics will also have an impact as you need to navigate some hazards within the level as well as avoid other players targeting you during the race. A lot of the hazards are breakable and will be destroyed when fired upon or impacted, this can be seen in Figure 12.11. The main genre of this game is Exergame but it also falls into the genre of a competitive racing game due to the combination of racing mechanics and shooting mechanics.


**Figure 12.10:** Players use the powerups to gain an advantage over competing players


**Figure 12.11:** Players need to navigate hazards, some of these can be destroyed.

## 12.9 Game World

This section describes the game world the game is set in. This section will provide both programmers and graphical designers the setting they need in order to create the game world. During development, this is updated to reflect the world depicted in the final game. The game world has a dystopian post-apocalyptic design to it. This is both to fit the story and to account for the limited access to graphical work. Since most of the meshes and textures of the game are from online free sources such as the Unity asset store there are limitations to what can be done with the resources available.
For the title screen we display a somewhat green and open landscape, this has more color and variation than play levels but should set the tone as to the quality level of the rest of the game and is comparable to the aesthetic look of the play levels. This can be seen in Figure 12.12.


**Figure 12.12:** The title screen of the game.

The racing level has little in terms of decorations and the ground has a single texture added for simplicity and continuity. The time of day is night and the entire scene has a darker look and feel to it. A snapshot from this level can be seen in Figure 12.13. The level contains gameplay related components such as the breakable rocks, and wooden fences as well as powerups and jump ramps with speed boosters. The track itself is set in a canyon. This provides a natural boundary to the players and reduces the need for unnatural boundaries such as invisible walls or misplaced fences. Progression to the level is linear, or rather circular since it is a racing mode where the number of laps can be changed for the final release. While there is still some work that can be done to increase the visual of this level it is not required for the gameplay to function properly. In fact, adding unnecessary items to the level can impede the racing mechanics and possibly affect the performance of the game.


**Figure 12.13:** Image from racing level

## 12.10 Gameplay Mechanics

This section describes what type of gameplay mechanics the player can utilize and how they affect the player or players in-game.

**Vehicle mechanics:**
The player can accelerate the vehicle by pedaling on the bike.
The player can turn left or right by using button 3 and 4 on the Playpulse controller
The player can jump by using button 2 on the Playpulse controller
The player can reverse by holding down button 1 on the Playpulse controller and pedaling on the bike.
The player can fire the laser cannon by pressing button 6 on the Playpulse controller.
the player can activate the current powerup by pressing button 5 on the Playpulse controller. If no powerup is active the hud will provide feedback on this. If the powerup has multiple uses then the hud will provide feedback on remaining uses.

**Targeting:** The player has a targeting system for use with the launcher powerups. Targeting requires other players to be in the field of view and will mark the currently targeted player with a red dot.

**SpeedBoost ramp:**
The speed boost ramp will increase the maximum speed of the player for a short duration. The player will be required to increase the pedaling action in order to utilize this boost.

**Hazards:** Wooden fences are placed around the level as hazards, this can be fired upon

and destroyed and will also be destroyed on impact with a player. A player impacting a fence will be given a small reduction in velocity as a penalty for impacting the fence. In some settings, the fence can be circumvented by jumping.
Rocks are placed around the level as hazards, rocks can be fired upon and destroyed and will also be destroyed on impact with a player. A player impacting a rock will be given a small reduction in velocity as a penalty for impacting the rock. In some settings, the rock can be circumvented by jumping.

**Powerups:** There are specialized weapons and powerups available to the players. These can be obtained by colliding with the powerup box. IMG powerup This will trigger a random number generator that will supply the player with one of the 5 available power-ups. If the player already possesses a powerup activating a new powerup will replace the one currently active.

**Missile:**
This is a scaled up version of the laser projectile and will temporarily stagger the player hit. The missile requires targeting and will not fire if no other players are currently targeted. If targeting changes after launch the missile will keep the lock on from the original target. This powerup has 3 uses.

**EMP:**
This will reverse the steering input on players hit. This will potentially confuse the player and impede them so the attacking player gains an advantage. The EMP requires targeting and will not fire if no other players are currently targeted. If targeting changes after launch the EMP will keep the lock on from the original target This powerup has 3 uses.

**El reverso:**
This will change the point of view of the player hit temporarily, instead of an behind the shoulders point of view the impacted player's point of view will be reversed so the player looks back on its own character. The El Reverso requires targeting and will not fire if no other players are currently targeted. If targeting changes after launch the El Reverso will keep the lock on from the original target This powerup has 3 uses.

**Slowmo:**
Triggering this powerup will reduce max speed for all other players temporarily This powerup has 1 uses.

**Speedboost:**
Triggering this powerup will give the player a speed boost temporarily The player will be required to increase the pedaling action in order to utilize this boost. This powerup has 1 uses.

## 12.11 Progression

This section will consider how a leveling system or an Achievement system can be used by the player to track their progression through the game. While this will not be implemented in the prototype it has been considered during the design phase.

This game does not have a leveling system implemented yet, however, there are options available for later expansion and implementation. These leveling systems will have both advantages and disadvantages and I will list two options that have been considered for this game.
The first option is a simple linear leveling system the player can progress through by gaining experience points (XP) that for each level will provide some kind of reward for each level gained. The rewards could either be purely cosmetic items that don't affect gameplay or upgrades that will affect gameplay. This would be similar to the leveling system found in online games such as Call of duty and Battlefield.

**Advantages:**
Players become more engaged and have additional motivation to keep playing the game. Players enjoy the game more as they see in-game rewards and benefits to the time and effort they spend on the game. Can add depth to the gameplay if different upgrades have a cost/benefit to usage resulting in tactics regarding equipment becoming part of the gameplay. If the rewards are purely cosmetic then this will have no impact on gameplay and all players regardless of experience will have the same starting point when playing a new round.

**Disadvantages:**
If the player-base consists of mostly high level experienced players the learning curve for new players is increased. New players can experience a greater challenge when facing high-level opponents adversely affecting their flow state. Experienced players can experience a lack of challenge when facing new players adversely affecting their flow state. Adverse effects on the challenge of the game between new and experienced players will also be impacted by the difference in skill between players. Adding gameplay benefits could, therefore, widen the gap between them. Once players reach a maximum level they will lose the motivational benefit, this can be amended by having a reset to the leveling system where the player gains titles for each progression through the levels. (i.e. prestige in Call of Duty)

The second option is not actually a leveling system but rather an Achievement/trophy system. The players would have milestones within their own statistical records like the number of games won/lost. Distance traveled in the game which could be represented as actual distance covered while exercising. The number of power-ups used both in general and related to specific types. The purpose of such a system is to provide the player with rewards, that in this case would not affect gameplay and allow them to compare this to other players. Rewards could also be given as cosmetic items.

**Advantages:**

Players become more engaged and have additional motivation to keep playing the game. Players enjoy the game more as they see in-game rewards and benefits to the time and effort they spend on the game. Will not affect gameplay so players are on equal standing regardless of experience. Easy to implement. Can be easily scaled by adding new milestones.

**Disadvantages:**
Achievements are not as predictable as an XP based system and between unlocks, the player may not be able to see the same steady progression. Achievements can have a motivational effect but for some people not to the same extent as level progression. When all achievements are unlocked players will lose the motivational benefit. This can be amended by adding new milestones/achievements.

**Summary:** If the goal is to motivate players to play the game regularly and over extended periods of time an achievement and leveling system that provides long time goals for the player can be quite beneficial. However, it could provide challenges when players reach the longtime goal in terms of keeping them motivated to play. Connecting long-term goals to the benefits of regular exercise can also be considered and could motivate people to continue playing after all the in-game rewards are attained. You can also add a combination of these systems but I would first implement an achievement system and then reconsider a leveling system once large-scale testing has been done. For this game, any reward that provides benefits to gameplay could have a severe adverse effect on all players and should be considered carefully and balanced accordingly.

## 12.12 User Interface (UI)

This section presents how the User interface is implemented in the prototype. The User interface the player is presented with during play is designed to give relevant information to the player. The UI during play is presented as a standard Heads up display and can be seen with an explanation in Figure 12.14. The information given to the player consists of a leaderboard displaying all players, the player position, the player's current lap and checkpoint, the player's current powerup, the player speed and the player's laser cannon energy. This UI is basic and intended as a first draft, as such in later development this should be improved using more symbols and images to replace information given in the text. It should also be improved so the symbols are more visible than the current text and color scheme of the UI.


**Figure 12.14:** Another image from racing level

## 12.13 BEAT chart

This section presents the BEAT chart for the testing level in the prototype. The BEAT chart is a tool used to describe each level of a game for development and documentation of the level. It allows developers to plan each level before developing and provide a guideline to programmers and level designers. Once the level has been implemented the chart can be updated to provide detailed information about the implemented level. This allows developers to not only keep track of how each level is implemented but also how they connect to the overall structure of the game.(Rogers, 2014)
In Table 12.1, you can see the BEAT chart for the Canyon level from the prototype.

| | |
|---|---|
| Level | Racing lvl 1 |
| Name | Canyon Level |
| Time of day | Nighttime |
| Progression | Player is introduced to the game and learns basic controls. |
| Est. Play time | 7-8 Minutes |
| Color Map | Brown,sand,desert. |
| Enemies | Other competing players |
| Mechanics | Competetive racing with weapons and powerups. Breakable hazards |
| Hazards | Breakable Fences and rocks |
| Powerups | Missile,EMP,El Reverso,SlowMo,speedboost,speedbostramps |
| Abilities | Lasercannon and powerups |
| Economy | NA |
| Bonus materials | NA |
| Music Track | NA |

**Table 12.1:** The BEAT chart for the games first implemented racing level.

## 12.14 Summary

In this chapter, I have outlined the design of the prototype exergame based on a Game Design Document template. This document will provide both as documentation for the design of the game and as a guideline for further development should that become necessary. Comparing the design of this game with the feedback from the user tests conducted could also provide information on how well the design worked for the intended purpose.

Chapter 13

# Implementing the Game

This chapter presents the implementation of the game. This will include the software architecture used, description of major classes in the game, and the structure of the game presented as a folder view.

## 13.1 Software architecture

This section presents the software architectural design and patterns used in the prototype.

### 13.1.1 Entity-component-system

Unity uses the Entity-component-system pattern which is widely used in game development. It follows the composition over inheritance principle, which states that a class should achieve polymorphic behavior and code reuse by containing instances of other classes rather than inherit functionality from a base or parent class. Every object in the game scene is an entity. An entity consists of one or more components. In addition, you can add components to an entity at runtime enabling you to change the functionality of the entity. This eliminates the ambiguity of a deep and wide inheritance hierarchy that can be difficult to understand, maintain or extend. In Figure 13.1 we see a simple example of the composition over inheritance and how using multiple classes that are included as instances in the composite class removes the need to inherit unnecessary code from a parent or grandparent class. Composition allows us to reuse code but at the same time separate different functionality so that classes that either does not need it or should not have access to this functionality are not forced to inherit it.

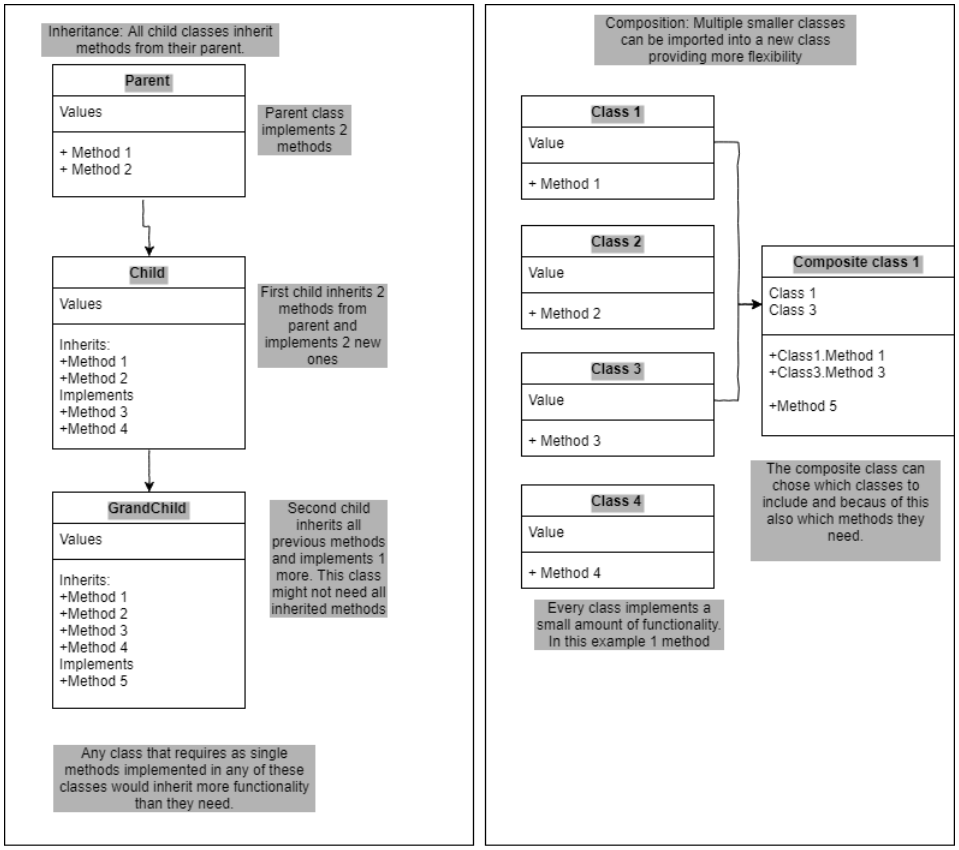


**Figure 13.1:** A simple model of the composition over inheritance principle

In the Unity, the scene hierarchy contains all entities as Game Objects and components can be added either from unity's standard selection or by adding custom scripts with your own behavior. These components can be removed and added either in the editor or by code at any time including runtime.
In Figure 13.2 we can see snapshots from the Unity editor where the two highlighted game objects are in this case entities. The inspectors showed are displaying all of the components attached to these two entities. Both of them have the Transform component, Mesh Filter component, and mesh renderer component which is all basic unity components. They both also contain as Script component called DestroyAfterTime wich, in this case, will destroy both game objects after a set amount of time. In the case of the first Gameobject, it also has a Box Collider component that allows it to detect collisions and or block other colliders. The second game object does not have this component and will not detect collisions at all or block other game objects. This is an example of how adding different components to an entity can change its behavior in the game. A Script component can not only add custom behavior but also be used to add other components to the entity even at runtime. In this case, we could add a script to the second object that adds a box collider 5 seconds after the

game starts. This would mean this entity would not block other game objects for the first 5 seconds of playtime, however, once the Box collider was added after 5 seconds it would behave similarly to the first game object.

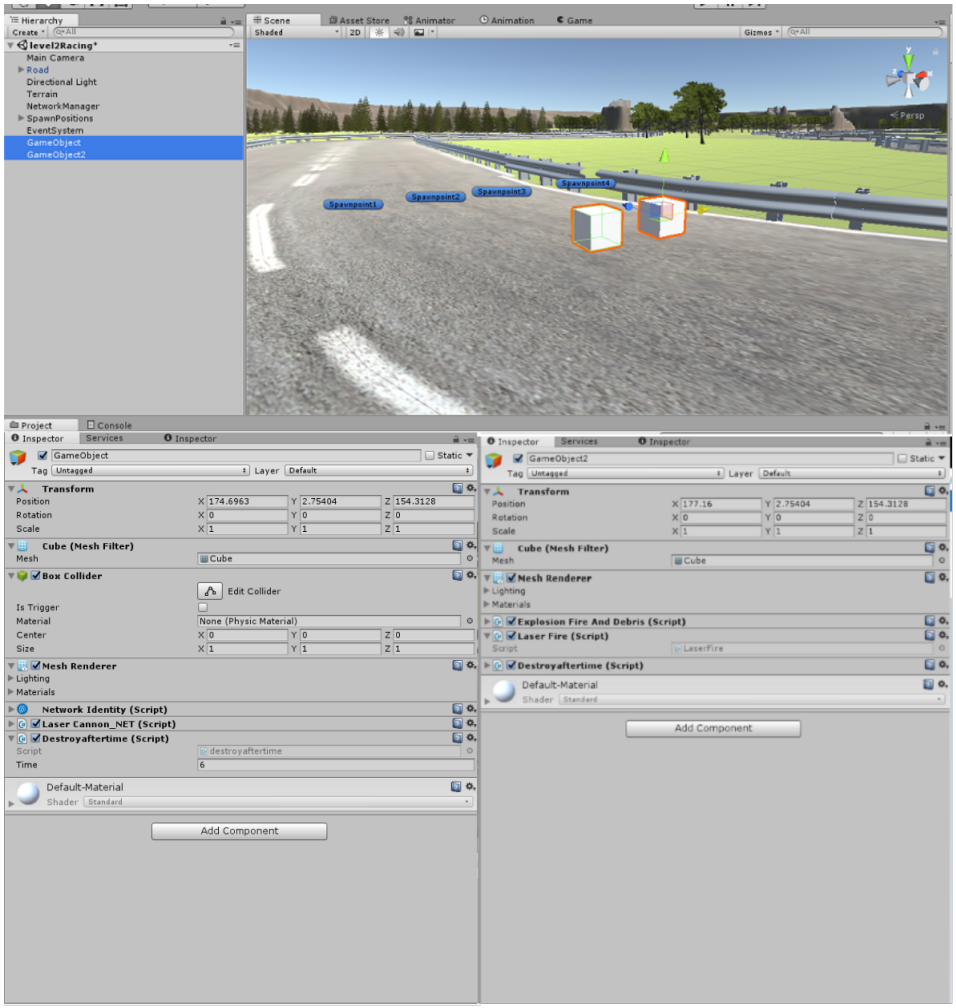


**Figure 13.2:** A illustration of the entity component system in Unity

### 13.1.2 Client-Server pattern

The Client-Server pattern is a distributed application that divides tasks between the providers of a resource or service called servers and the service requesters called clients. This pattern is one of the most common for multiplayer games that connect through the internet. UNET utilizes a pretty standard implementation of the client-server pattern for video games. Rather than using a dedicated server one client, the host will act as both server and

client. While UNET does support dedicated servers, I did not have the need or resources to implement that in this project.

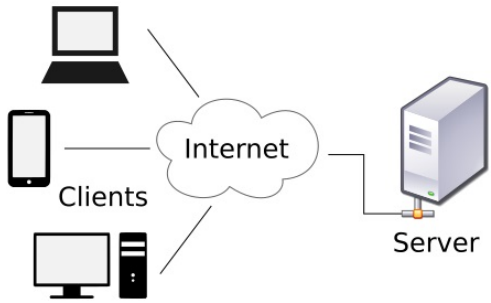


**Figure 13.3:** Client server model

### 13.1.3 MVC

The Model-View-Control Pattern or MVC is commonly used for user interfaces and aims to separate the information is presented and accepted by the users. The model contains data and updates the view, the view presents the data to the user and the controller updates the model based on input from the user. This is widely used in Unity and not just in the UI elements of the game. Any game object that is visible becomes the View, and scripts utilized to manipulate the object can act as either the controller or the model. Quite often in unity each game object will be delegated a small responsibility and does not require persistent data storage across sessions. Because of this, a script will often contain both the Model and the controller functionality.

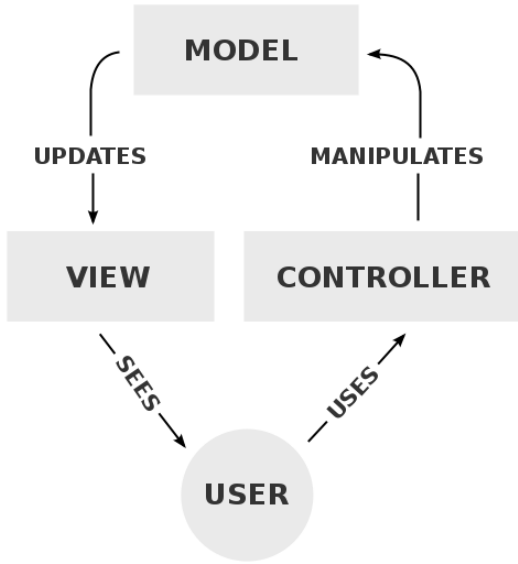


**Figure 13.4:** MVC model

### 13.1.4 Singleton

The singleton pattern restricts the instantiating of a class to just one object. This is usefull when the system requires one and only one instance for coordination of data between systems where multiple instances could introduce either complexity or errors when sending data. In this project, the singleton pattern is used in the Lobbymanager class which is an extension of the Networkmanager class in UNET. This class runs on all the clients and handles data between clients and server. Here we need just one instance per client in order to ensure data is processed correctly between all the clients, it also ensures that each instance of the game is only connected to one multiplayer game at a time.

## 13.2 Class descriptions

This section presents descriptions of major classes and their responsibility

### 13.2.1 Hovercraft

*Some of the hovercrafts functionality is based on the Unity package Realistic Hovercraft Controller by Bonecracker games*(BoneCrackerGames, 2017)

#### RHCHovercraftAnimator

This class handles passing information from the HovercraftController to the animator that controls the animation of the pilot. From the Unity asset package Realistic hovercraft controller. Has not been altered by me.

**RHCThruster**

The thruster class is placed on objects attached to the hover vehicle, this class handles the upward thrust required to keep the vehicle hovering. Is controlled from the main hovercraftcontroller. From the Unity asset package Realistic hovercraft controller. Has not been altered by me.

**RHCHovercraftController**
Requires:LaserCannon_NET,MissileFire_NET,Player,RHCThruster

This is the player controller, it handles movement as well as secondary functionality related to the powerups and weapons. All input is handled in this class and it will call functions to fire both the LaserCannon_NET script as well as MissileFire_NET. input is received from the InputManagerscript. Both positive and negative effects to the player are handled in this class after the player has been impacted by a hazard or weapons fire. Since negative and positive effects are related mostly to movement speed this became a reasonable solution for the prototype. It also contains the logic for randomly generating a power up and sending messages to the other components of the player object. From the Unity asset package, Realistic hovercraft controller but has been altered significantly by me in order to adapt to the gameplay of my game.

### 13.2.2 Weapons and poweups

**LaserCannonNET**

This class handles the firing of the laser weapon. As well as manages the energy for the weapon. The shoot function will instantiate a projectile from a prefab that has the projectile script on it. Energy is decremented when shot and incremented based on the pedal input.

**ProjectileNET**

The class holding Data and updating the projectiles fired by the laser cannon. Handles actions when the projectile impacts other objects. The projectile will destroy itself on impact or after a certain amount of time has passed.

**MissileFireNET**
Requires: Targeting

The script responsible for launching a homing projectile. This is any projectile that uses the HomingMissileNET class. The shoot function will instantiate a projectile from a pre-

fab that has the HomingMissileNET script on it. The projectile target will be passed from the targeting script to the projectile.

**HomingMissileNET**

The class attached to all homing weapons requires a transform as a target and will handle movement of the game object as well as actions when the object collides with other game objects.

**Targeting**

The targeting class for the Launcher based weapons, this will provide target data to the launcher that in turn supplies this to the missile. Data is a game object to be targeted. Game objects that can be targeted must have the ”Player” tag.

**BreakableObjectNET**

The class handling all breakable objects, when an object takes enough damage it will spawn a new game object from a prefab containing the Voronoi fractured game object. The original object containing the BreakableObjectNET script will then be destroyed.

### 13.2.3 Managers

**InputManager**
This class handles all the input from the bicycle controller as well as input from a keyboard.

**PlayerSetup**
Requires: Behaviour[] componentsToDisable, Player

This class sets up players on all clients based on whether or not they are the local client. All components added to the Behaviour componentsToDisable will be disabled unless they are on the local player.

**Player**

Holds data on the Player passed from the lobby as well as current position and a boolean that keeps track of if the player has finished the game. All data is synced across the server so that each client can access data for updating the position and scoreboards.

**RacingManager**
Requires: Player[],List<LapCounter>

Handles the logic for the racing game itself. Starting the race and ending it as well as updating the list of players based on their positions. Also holds a variable with the number of laps that can be altered during development time in order to balance the duration of a match.

**GameManager**

Holds a static Dictionary of all players and their NetID and allows other classes to get this info.

**LapCounter**

The lapcounter is attached to the player object and interacts with all checkpoints Has an array of all checkpoints in the level sorted based on the name. Has a CompareTo method that sorts the lapcounters based on laps, checkpoints, and distance to next checkpoint. This is used to calculate the positions of the players.

**CheckPoint**

This class is attached to the checkpoints, it will increment the current checkpoint or lap on the lapcounter assuming the lapcounter has correct progression.

**SpawnAllNetIdObjects**

This class will spawn all breakable objects that require syncing over the network. These will be spawned in at the start of the level and respawn at intervals during the game.

### 13.2.4 UI

**HudUpdater**
Required classes: LaserCannon_NET,Player,RHC_HovercraftController,LapCounter

This class updates the HUD on the player. It will update the current speed,current energy on lasercannon,The current lap and checkpoint and the current position of the player.

**PowerUpHudUpdater**
Required classes:RHC_HovercraftController,MissileFire_NET

This class updates the powerupDisplay on the HUD. This includes the type of powerup and the number of uses.

**ScoreBoard** Required classes: []LapCounter
Required prefabs: playerScoreBoardIem

A class for updating the scoreboard during playtime.

**RacingEndScoreBoard**
Required classes: []LapCounter
Required prefabs: playerScoreBoardIem

A class for updating Data for use in the final scoreboard displayed after the end of a round

**PlayerScoreBoardItem**
A class containing Data Model for displaying the names and positions on the hud during playtime.

**RacingScoreBoardItem**
A class containing Data Model for displaying the names and positions on the Screen After the round has ended.

### 13.2.5 Lobby

*The networking functionality is based on the Unity package Network Lobby Example*(Unity, 2017a)

**LobbyCountDownPanel**
Handles updating the UI for the countown to start.

**LobbyInfoPanel**
Updates the infopanel. Will display information when connecting to matchmaking services.

**LobbyMainMenu**
UI update and onclick functionality for the main menu.

**LobbyManager**
A implementation of the standard UNET NetworkManager. Allows users to connect to a lobby before starting the playscene. Holds functionality for creating, hosting, joining and disconnecting from multiplayer matchmaking games.

**LobbyPlayer**
Holds and updates data for players in the lobby. Name, selected color etc.

**LobbyPlayerList**
Updates the list of connected players

**LobbyServerEntry**
Onclick functionality for joining a match/server.

**LobbyServerList**
Updates the list of currently available matches on the
matchmaking service.
**LobbyTopPanel**
Updates the top panel of the UI in the main menu.

**NetworkLobbyHook**
The hook that passes data to the play scene such as player name and selected color.

**RoomListItem**
A script containing data for a created room. Updates the RoomListItem object.

## 13.3 Development view

This section presents the development view for the prototype. The programs folder structure follows a pretty standard unity project setup. By separating 3D models, textures, materials, scripts etc into separate folders this simplifies development by making the components easier to locate. The diagram of the structure provides an overview of the most important folders in the project. (See Figure13.5.)

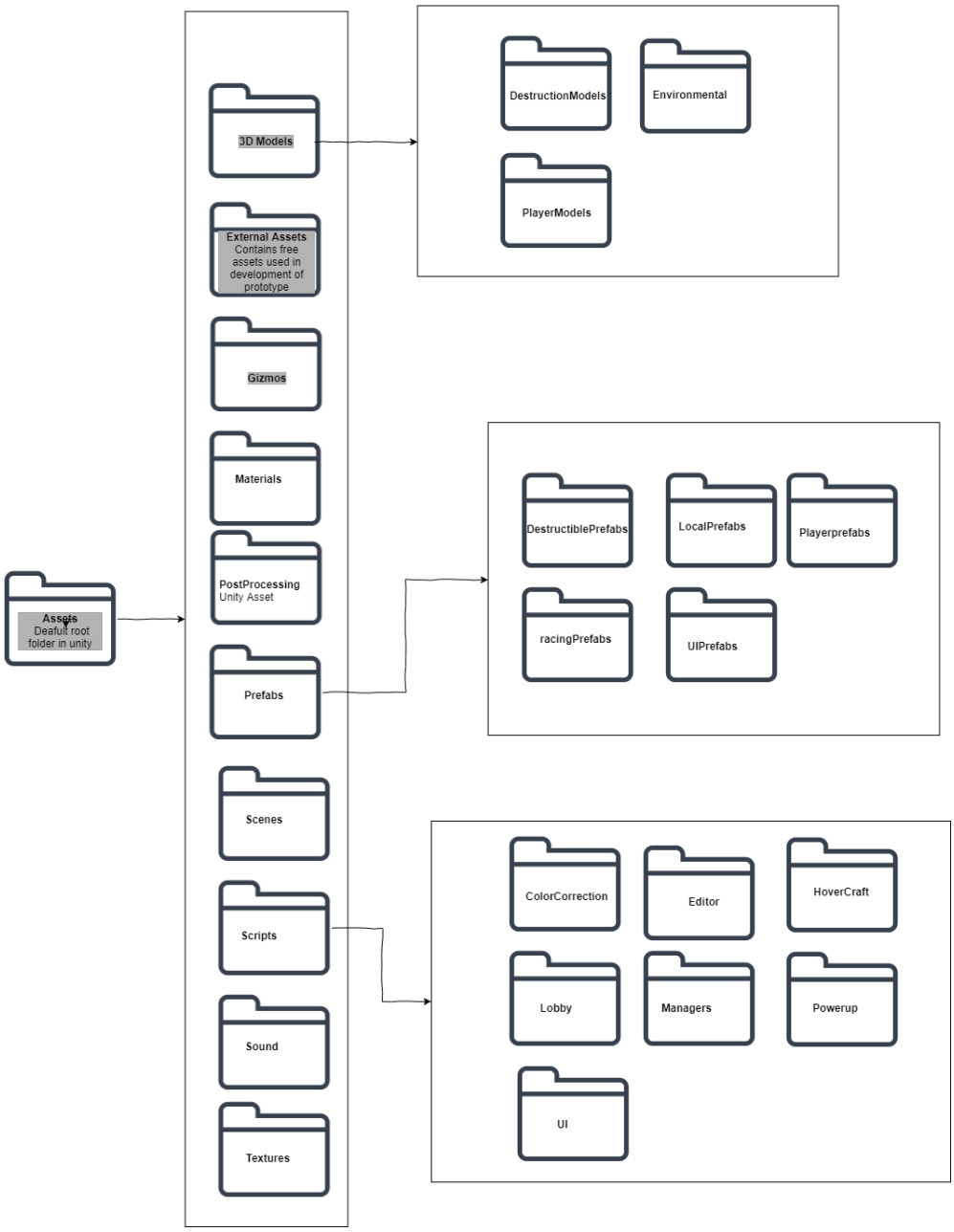


**Figure 13.5:** Folderstructure of the game. Non-essential folders such as content in external assets are not displayed here

## 13.4 Summary

This chapter provides insight into the structure and coding of the implemented game. It also documents the architectural patterns used and an overview of the major Scripts and classes of the game. To utilize this information some pre-existing knowledge of the Unity Game Engine and access to its documentation is required.(Unity, 2017b) It is also implied that you have access to the source code of the game and the comments included in the code.

# Part IV

# Testing and results

Part IV presents the user test conducted on the prototype exergame and all the results from the user test.

Chapter 14

# User test

This chapter presents the user test and the results from testing of the prototype. In order to evaluate how well the exergame prototype is both as a game and as an exercise method, a user test was conducted. Questionnaires were used in order to evaluate how the users experienced the exergame. The focus of the test was to measure the effect of the exercise, the enjoyment of the game, how well the game motivates players to exercise and, to measure if the subjects achieved a flow state during the test.

## 14.1 User test

This section presents how the user test was conducted.

## 14.2 Test environment

The user tests were conducted at 3T Pirbadet where Playpulse has 12 bicycles available for members of the studio. In Figure 14.1 we can see the bikes and the test environment where the user test was conducted. The bikes are placed in groups of 2 or 4 bikes, this allows players to engage in multiplayer gameplay while still allowing them to communicate with each other while playing. While the games are connected to the internet this setup better enables social interactions between players. The bikes themselves have been fitted with the Playpulse controller and a PC monitor attached to the front of the bike. The platform is then connected to a PC with a single USB connector and an HDMI cable to the monitor (See Figure 14.2).

**Figure 14.1:** The test environment located at 3T pirbadet in Trondheim


**Figure 14.2:** A close up of the Playpulse platform.

## 14.3 Test process

Table 14.1 contains the 6 steps used during the user tests. The time frame for each test was estimated to take roughly one hour, but no specific time limit was given to the subjects on each step.

- Step 1, participants arrive at 3T and are given time to change into appropriate clothing.
- Step 2, the participants sign the participation agreement(See Appendix F). And answer the personals survey(See Appendix C).
- Step 3, The players play the first round with 2 players in each match.
- Step 4, The players play the second round with 4 players in each match.
- Step 5, The players answer the game test survey (See Appendix A) and, the flow state questionnaire (See Appendix B).
- Step 6, the players engage in a group interview where they can provide open feedback on the game. In this step, the subjects are encouraged to discuss the game between each other.

Step 3 and 4 were conducted with a brief 2-minute break where the next match was prepared. For two of the user tests, the subjects were equipped with pulse watches that measured their heart rate during playtime. Only 8 of the 14 subjects were equipped with these because the watches were not available to me during the entire test period.

| | |
|---|---|
| 1. | Participants arrive |
| 2. | Participants sign agreement and fills in personal info |
| 3. | First round commences. 2 player matches |
| 4. | Second round commences. 4 Player matches |
| 5. | Participants fill in questionnaries |
| 6. | Participants give verbal feedback and discuss their experience. |

**Table 14.1:** The test process used during the user-test

## 14.4 Tester personals

The user answered a survey before conduction the user test that gathered personal data. The results of this survey are not included in raw form in order to protect the anonymity of the subjects. The survey can be seen in Appendix C. The age of the testers ranged from 20 years to 30 years and with an average of 25.6 years (see Figure 14.3). The height of the testers ranged from 163 cm to 190 cm with an average of 179 cm. The weight of the subjects ranged from 59 kg to 110 kg with an average of 82.1 kg. The majority of test subjects were male with 13 male subjects and 1 female subject. The test subjects were asked how much time they spent playing video games on average per week. From this data two categories were created, those who play less than 10 hours per week referred to as gamers, and those who play more than 10 hours per week referred to as hardcore gamers (see Figure 14.4). The test subjects were asked how often they exercise on average per week. From these data, two categories were created. Those who do not exercise regularly, less than once per week. And those who exercise regularly, 1 or more times per week (see Figure 14.5). The test subjects preference regarding multi-player and single player were evenly divided, 5 stated they prefer single player, 4 stating that they prefer multi-player, and 5 had no preference (see Figure 14.6). Only one of the test subjects had previous experience with the Playpulse platform.

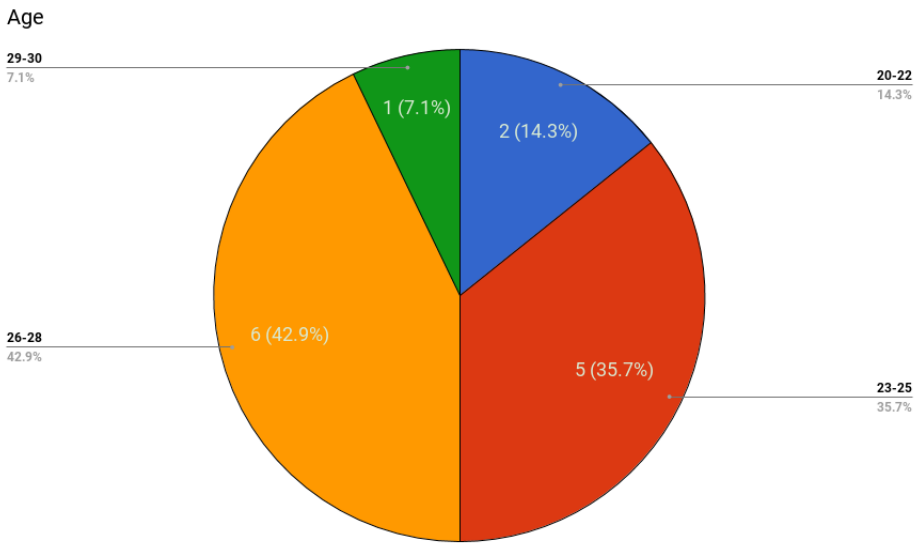


**Figure 14.3:** Age distribution

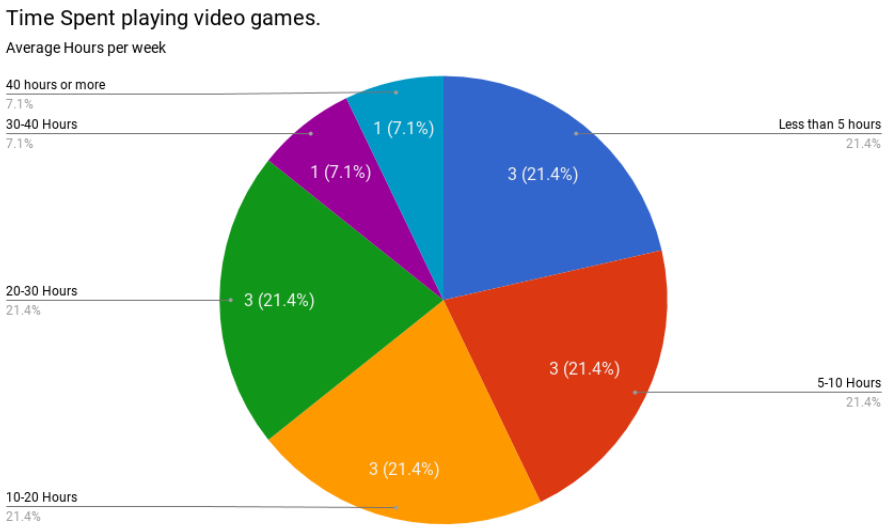


**Figure 14.4:** Subjects average playtime

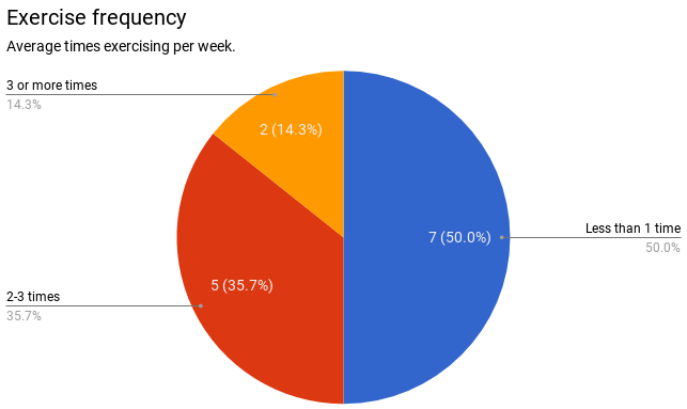


**Figure 14.5:** Subjects average exercise

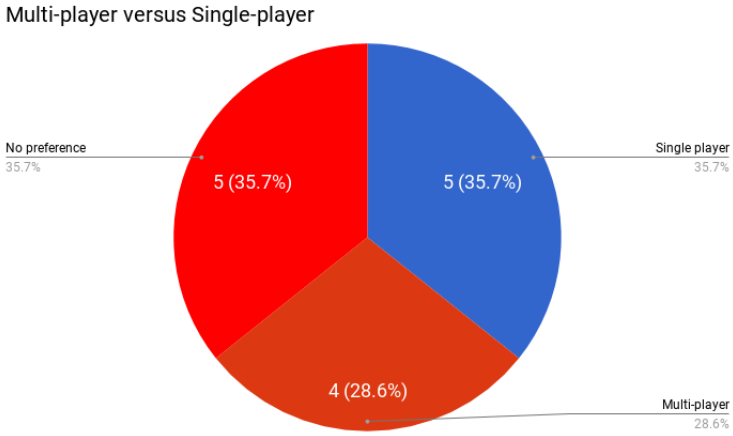


**Figure 14.6:** Subjects preference between single and multi-player games

Chapter 15

# Game survey

This chapter presents the results from the Game Test Survey (See Appendix A). The survey was comprised of 11 multiple choice questions where the user selects a value from 1-5. 1 being the lowest score and 5 being the highest score. This is based on the Likert scale.(Likert, 1932) These 11 questions were designed to provide data on how the user experienced the game, gameplay, and the exercise session. All these questions can be found in Table 15.1 In addition, the survey had 2 open answer questions that were intended to provide general feedback and suggestions for improvement to the game.
After the data was gathered, the participant's responses to each question were categorized into, low, medium, and high. Values between 1 and 2 are considered low, the value 3 is considered medium and values between 4 and 5 high. In Table 15.2 this data is presented for each question as the percentage of participants that provided a high, medium or low response.

I also examined how the level of interest in video games and exercise respectively affected the response to each question. This information was sourced from the demographic survey the users filled out before the test (See Appendix C). I divided all 14 subjects into the following subcategories. People who play video games less than 10 hours per week, people who play video games more than 10 hours per week, People who exercise on average less than once per week, and people who exercise more than once per week. This data is presented in Table 15.3 and Table 15.4
The significance of these results will be examined and discussed in their respective subsubsections.

**Table 15.1:** Questions from the Game test survey

| Game test Survey Questions. | | |
|---|---|---|
| Question | Fulltext | Shorthand |
| 1 | Rate the intensity of the exercise from low to high. | Intensity of exercise. |
| 2 | How tired are you after the session? | How tired are you? |
| 3 | Compare the exercise experience to traditional exercise I.E. Cycling,running etc. | Compared to regular exercise |
| 4 | What do you think of the Game itself? | Rate the game. |
| 5 | Rate the core game-play (Hovercraft+Weapons). | Rate the core gameplay. |
| 6 | Rate the racing game-play. | Rate the racing gameplay. |
| 7 | Rate the aesthetics of the Game. I.E. Graphics and visual design. | Rate the aesthetics. |
| 8 | How did the game motivate you to exercise? | Motivation to exercise. |
| 9 | Would you consider using this method of exercise in the future? | Would use again. |
| 10 | How likely is it that you would recommend this game and the method of exercise to a friend? | Recommend to a friend. |
| 11 | How fun was the game? | How fun was the game? |

## 15.1 Game test Results all subjects

Table 15.2 presents the results from the game test survey for all participants. I will relate the results from this survey to the primary goals and my research questions in the following way, I will look at the results from questions 1,2,3 in order to evaluate of how well it works as an exercise method. Results from questions 4,5,6,7, and 11 will be used to evaluate the success of the implemented game design and how well the genre and mechanics worked as an exergame. The results from questions 8,9, and 10 will be used to evaluate how well the game motivates the player.

#### As an exercise method

I will begin with the exergame prototype as an exercise method. The majority of subjects (79%) rated the intensity as high. When rating how tired they were, half the subjects rated it as high or very tired while 36% gave it a medium. As for how well it compares to regular exercise 71% rated it as high and 21% rated it as medium or the same as regular exercise, in other words, 93% rated it as either the same or better than regular exercise methods. This indicates that the game as an exercise method is both well received and for the subjects appeared to be an efficient method of exercise.

#### As a game

When rating the game itself, core gameplay, and the racing mechanics the majority of players provided positive feedback. Roughly 60% of testers rated these elements as high. When it comes to the Graphics and visual design the majority, 60% rated it neutral. As for how fun it was 78% gave it a high rating while 22% gave it a medium rating. This

can indicate that the game itself and gameplay is suitable as an exergame while the visuals would most likely require some improvement.

### Motivation

Motivation has a significant high rating on all 3 questions. 86% rated it high, meaning they were very motivated by the game. We also see that 93% of the subjects would both like to use an exergame as a method of exercise in the future as well as recommend this game to a friend. This indicates that the game was successful in motivating players both to exercise and to utilize this as an exercise method in the future.

### Summary

All in all, we see a positive response to most of the questions with a few candidates providing negative feedback on some of the questions. Despite this, on question 11 how fun was the game on a range from 1-not very fun to 5 very fun, we also saw the highest score. With 21% giving a medium score or fun and 79% giving it a high score or very fun. This indicates that all the subjects enjoyed the game despite having some criticism regarding both visuals and gameplay.

**Table 15.2:** Results from Game test survey

| Game Test survey 14 subjects. | | | | |
|---|---|---|---|---|
| Questions | Low | Medium | High | Stdv |
| 1:Intensity of exercise. | 7% | 14% | 79% | 0.77 |
| 2:How tired are you? | 14% | 36% | 50% | 0.94 |
| 3:Compared to regular exercise. | 7% | 21% | 71% | 0.92 |
| 4:Rate the game. | 7% | 29% | 64% | 0.74 |
| 5:Rate the core gameplay. | 7% | 29% | 64% | 0.95 |
| 6:Rate the racing gameplay. | 21% | 21% | 57% | 1.02 |
| 7:Rate the aesthetics. | 14% | 64% | 21% | 0.77 |
| 8:Motivation to exercise. | 7% | 7% | 86% | 0.78 |
| 9:Would use again. | 0% | 7% | 93% | 0.65 |
| 10:Recommend to a friend. | 0% | 7% | 93% | 0.65 |
| 11:How fun was the game? | 0% | 21% | 79% | 0.73 |

## 15.2 Comparing results from Game test survey based on play time

In this section I will be comparing the difference in feedback between users based on how much video games they play, the full data set can be found in Table 15.3. I will relate this data, in the same way I did in Section 15.1 and evaluate how well the game is as an exercise method, a game/exergame and how well it motivates the players. The subjects were divided into two groups, people who play less than 10 hours per week referred to as gamers and, people who play more than 10 hours per week referred to hardcore gamers.

#### As an exercise method

As an exercise method, there are similar results regarding the intensity of the exercise, gamers gave it an 83% high rating while hardcore gamers gave it a 75% high rating. When asked how tired they were 50% of gamers gave it a medium rating while 63% of hardcore gamers gave it a high rating. When comparing it to traditional exercise the results are also similar to gamers giving a 67% high rating and hardcore gamers giving it a 75% high rating. This indicates that the perceived intensity level was not affected by the subjects interest of video games, however, people who play more video games are more likely to be fatigued by the exercise.

#### As a game

The game itself is rated higher by subjects that play fewer video games with an 83% high rating on the game itself compared to a 50% high rating among subjects that play more than 10 hours per week. Hardcore gamers also rate the core gameplay slightly higher with a 75% high rating and a 13% medium rating while gamers gave it 50% high and 50% medium rating. As for aesthetics, the rating is somewhat even between the two groups. As for how fun the game is the gamers gave it a significantly higher score with a 100% high

**Table 15.3:** Game test results divided based on time spent playing video games

| Game Test Results. Subjects rate from 1-5 low is 1-2 medium is 3 and high is 4-5. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Subjects who play games less than 10 hours per week. 6 subjects | | | | Subjects who play games more than 10 hours peer week. 8 subjects | | | |
| Question | Low | Medium | High | Stdv | Low | Medium | High | Stdv |
| 1:Intensity of exercise. | 17% | 0% | 83% | 0.98 | 0% | 25% | 75% | 0.64 |
| **2:How tired are you?** | **17%** | **50%** | **33%** | **1.03** | **13%** | **25%** | **63%** | **0.92** |
| 3:Compared to regular exercise. | 17% | 17% | 67% | 1.03 | 0% | 25% | 75% | 0.83 |
| **4:Rate the game.** | **0%** | **17%** | **83%** | **0.63** | **13%** | **38%** | **50%** | **0.74** |
| **5:Rate the core gameplay.** | **0%** | **50%** | **50%** | **0.98** | **13%** | **13%** | **75%** | **0.99** |
| 6:Rate the racing gameplay. | 0% | 17% | 83% | 0.41 | 38% | 25% | 38% | 1.28 |
| 7:Rate the aesthetics. | 0% | 67% | 33% | 0.84 | 25% | 63% | 13% | 0.64 |
| **8:Motivation to exercise.** | **17%** | **17%** | **67%** | **0.84** | **0%** | **0%** | **100%** | **0.52** |
| 9:Would use again. | 0% | 0% | 100% | 0.52 | 0% | 13% | 88% | 0.74 |
| 10:Reccomend to a friend. | 0% | 0% | 100% | 0.52 | 0% | 13% | 88% | 0.76 |
| **11:How fun was the game?** | **0%** | **0%** | **100%** | **0.52** | **0%** | **38%** | **63%** | **0.83** |

rating compared to hardcore gamers 63% high and 38% medium rating. The data indicates that the game scored better with gamers, Core gameplay, racing gameplay and the game in its entirety scored better. The rating on question 11, how fun was the game, indicates that gamers enjoyed the game more overall than more experienced gamers. The overall results still show a positive response among both groups.

#### Motivation

As for motivation, it would seem like hardcore gamers are slightly better motivated by the game with a 100% high rating, in the gamer category we see a 67% high rating,17% medium and 17% low rating. As for the questions regarding if they would play want to use this exercise method in the future and if they would recommend it to a friend the results are reversed. Gamers gave a 100% high rating while hardcore had an 88% high and 13% medium on both questions.

This could indicate that the game motivates the users regardless of how much they play video games.

## 15.3 Comparing Results from Game test survey based on the amount of exercise

In this section, I will be comparing the difference in feedback from users divided based on the average amount of exercise per week. I will relate this data, in the same way I did in Section 15.1 and evaluate how well the game is as an exercise method, a game/exergame and how well it motivates the players. The users have been divided into two groups, those who exercise on average less than 1 time per week, and those who exercise on average 1 or more times per week.

### As an exercise method

In terms of intensity, there is little difference between the results from both groups. We do see a significant difference in how fatigued they were after the test. Only 29% of those who exercise more than 1 per week rated this as high, compared to 71% of those who exercise less than once per week. We also see a better result when they were asked to compare this to traditional exercise method among those that exercise regularly. This indicates that while subjects who exercise regularly did experience less fatigue the perceived intensity of the exercise was not diminished by this. In addition, the people who exercise regularly preferred this method of exercise compared to traditional exercise to a greater degree than those who do not.

### As a game

In regards to gameplay, the results were similar in both groups. The group that exercises more than once per week rated the racing gameplay slightly higher with a 43% medium response and a 57% high response compared to 43% low response and 57% high response. The group that exercises less than once per week also rated slightly higher on how fun the game was with a 14% medium and 86% high rating compared to 29% medium and 71% high. However, the response in both groups is still considered to be positive. This indicates that a difference in exercise routines and physical fitness might not affect the enjoyment of the game itself and the gameplay to a significant degree.

### Motivation

The motivation is also similar in both categories, both have 86% high rating on question 8 How did the game motivate you to exercise. And both rate quite high when asked if they would want to play the game again and if they would recommend it to a friend. This could indicate that a difference in exercise routines and physical fitness might not affect the motivations of the player.

**Table 15.4:** Game test results divided based on amount of weekly exercise

| Game Test survey results divided based on regular exercise. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Subjects that exercise on average less than 1 time peer week 7 subjects | | | | Subjects that exercise on average more than 1 time peer week. | | | |
| Questions | Low | Medium | High | Stdv | Low | Medium | High | Stdv |
| 1:Intensity of exercise. | 14% | 14% | 71% | 0.95 | 0% | 14% | 86% | 0.58 |
| **2:How tired are you?** | **0%** | **29%** | **71%** | **0.82** | **29%** | **43%** | **29%** | **0.82** |
| **3:Compared to regular exercise.** | **14%** | **29%** | **57%** | **0.98** | **0%** | **14%** | **86%** | **0.76** |
| 4:Rate the game. | 14% | 14% | 71% | 0.95 | 0% | 43% | 57% | 0.53 |
| 5:Rate the core gameplay. | 14% | 14% | 71% | 1.07 | 0% | 43% | 57% | 0.90 |
| **6:Rate the racing gameplay.** | **43%** | **0%** | **57%** | **1.25** | **0%** | **43%** | **57%** | **0.76** |
| 7:Rate the aesthetics. | 14% | 57% | 29% | 0.95 | 14% | 71% | 14% | 0.58 |
| 8:Motivation to exercise. | 0% | 14% | 86% | 0.69 | 14% | 0% | 86% | 0.90 |
| 9:Would use again. | 0% | 14% | 86% | 0.79 | 0% | 0% | 100% | 0.53 |
| 10:Recommend to a friend. | 0% | 14% | 86% | 0.76 | 0% | 0% | 100% | 0.53 |
| 11:How fun was the game? | 0% | 14% | 86% | 0.69 | 0% | 29% | 71% | 0.82 |

## 15.4 Summary

The results from Section 15.1 indicates that the response to the prototype exergame was positive among the test subjects. The only aspect that received a mostly neutral or negative response was the games aesthetics. The results from Section 15.3 indicate that gamers enjoyed the game more than hardcore gamers. They also rated the game itself higher. Hardcore gamers responded better to the core gameplay while gamers responded better to the racing gameplay. The two groups rated the exercise somewhat similar with hardcore gamers responding that they were more tired from the exercise. The results from 15.3 indicates that subjects that exercise less experienced more fatigue from the test. Subjects that exercise regularly responded better to the exergame as an exercise method. Subjects that exercise regularly also rated the racing gameplay better. When it comes to motivation and how fun the game was the results were similar for both groups.

Chapter 16

# Flow state survey

In this section, I will be presenting the results of the flow state survey. The flow state questionnaire was intended to measure to which degree the participants experienced a flow state during the user test. This questionnaire was sourced from a previous experiment conducted on Pedal Tanks (Hagen et al., 2016) which in turn was based on the flow state scale (Jackson and Marsh, 1996). It also utilizes the Likerts scale for measurements (Likert, 1932). It is comprised of 27 questions were the user is asked to rate a statement form 1-5 where 1 is strongly disagree 3 is neither disagree or agree and 5 is strongly agree. A full overview of the questions can be found in Table 16.1 The average of all these ratings will be referred to as the flow state score. A score below 3, in this case, would indicate that the participants did not achieve a flow state during play, a score of exactly 3 could be interpreted either way while a score above 3 would indicate the participant's div achieve a flow state. There is significant room for error in this evaluation however because of the number of questions and number of participants, however, there was no single individual that deviated too much towards either a completely positive or negative score. It should also be noted that if one of the flow elements that are considered to be required to achieve a flow state is rated extremely negative this could disrupt the flow state for that particular subject. For instance, if the subject replied 1 to half of the questions and 5 to the other half, if you examined this subject as an individual it would be difficult to claim that he reached a flow state based on the results. Table 16.3 contains the average flow score for all 14 participants with the 27 questions divided into 9 different flow elements, this can be viewed in Table 16.2. In addition to this, I will also be looking at the average flow score for each of the subgroups I examined in chapter 15. People who play more than 10 hours of video game per week, people who play less than 10 hours of video game per week, people who exercise more than once per week, and people who exercise less than once per week.

**Table 16.1:** Flow state survey questions

| Flow state survey questions | |
|---|---|
| Question:1 | I was challenged, but I felt my skills allowed me to meet the challenge. |
| Question:2 | I made the correct movements without thinking about trying to do so. |
| Question:3 | I knew clearly what I wanted to do. |
| Question:4 | It was clear to me that I was doing well. |
| Question:5 | My attention was focused entirely on what I was doing. |
| Question:6 | I felt in control of my actions. |
| Question:7 | I was not concerned with what others may have been thinking of me. |
| Question:8 | Time seemed to alter during play (either slowed down or speeded up). |
| Question:9 | I really enjoyed the experience. |
| Question:10 | I was aware of how well I was performing |
| Question:11 | It was no effort to keep my mind on the game. |
| Question:12 | It felt like I could control what I was doing. |
| Question:13 | I was not worried about my performance during the game. |
| Question:14 | I felt I was competent enough to meet the demands of the situation. |
| Question:15 | I played automatically. |
| Question:16 | I knew what I wanted to achieve. |
| Question:17 | I had a good idea while I was playing about how well I was doing. |
| Question:18 | I had total concentration |
| Question:19 | I was not concerned with how I was presenting myself. |
| Question:20 | At times, it almost seemed like things were happening in slow motion. |
| Question:21 | The experience left me feeling great |
| Question:22 | The challenge and my skills were at an equal level. |
| Question:23 | I did things spontaneously and automatically without having to think. |
| Question:24 | My goals were clearly defined. |
| Question:25 | I felt in control of my body. |
| Question:26 | Time passed quickly during play |
| Question:27 | I found the experience rewarding. |

**Table 16.2:** Flow state questions divided into flow elements

| Flow element | Questions |
|---|---|
| Challenge-skill balance | 1, 14, 22 |
| Action-awareness merging | 2, 15, 23 |
| Clear goals | 3, 16, 24 |
| Unambigous feedback | 4, 10, 17 |
| Concentration on task at hand | 5, 11, 18 |
| Paradox of control | 6, 12, 25 |
| Loss of self-consciousness | 7, 13, 19 |
| Transformation of time | 8, 20, 26 |
| Autoletic experience | 9, 21, 27 |

## 16.1 Flow state Results all subjects

Table 16.3 shows the average score in each of the different flow elements. All elements had an average rating of 3 for each element, however, some elements seem to have been more successful than others. The lowest score is Action-Awareness merging with a 3.4 while the highest score is awarded to Clear goals with 4.3. The remaining categories have evenly distributed scores between these two values. By looking at the Radar chart in Figure 16.1 for these values we see that the flow score is somewhat symmetrical with the exception of these two values. As mentioned earlier we can make an assumption on whether or not the game is capable of creating a flow state by evaluating the value of each of these categories. The fact that all values are above 3 and we don't have an uneven distribution across categories could indicate that the users did experience a flow state during the user-test. The average for all categories is 3.9 and this becomes the total flow score for the user-tests which also indicates that the users did experience a flow state during the test. Still, there seems to be some room for improvement on how the game stimulates the user.

**Table 16.3:** Average flow score for all subjects

| Flow element | Flow score |
|---|---|
| Challenge-skill balance | 3.8 |
| Action-awareness merging | 3.4 |
| Clear goals | 4.3 |
| Unambigous feedback | 3.9 |
| Concentration on task at hand | 4.1 |
| Paradox of control | 3.9 |
| Loss of self-consciousness | 3.6 |
| Transformation of time | 3.8 |
| Autoletic experience | 4.1 |

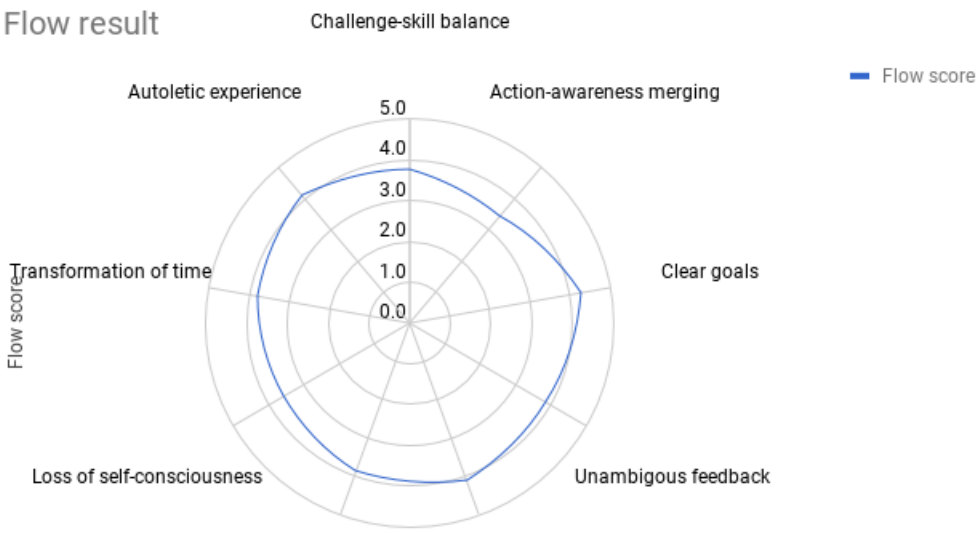


**Figure 16.1:** Average flow experienced for all subjects

## 16.2 Comparing Results from Flow Survey based on the amount of play time

We have similar results when comparing gamers and hardcore gamers. In this comparison, the largest difference in value is in the flow element, Loss of self-consciousness, with gamers having their lowest score here with 3.1 and hardcore gamers having their highest score with 4. In the rest of the flow elements, the two sets of results as can be seen in the radar chart in Figure 16.2 are quite similar. This could indicate that subjects who play more video games were more immersed in the game. Despite this, the data indicate that subjects in both categories did achieve a flow state. We also see that the total flow score for both groups was similar with a score of 3.8. This indicates that time spent playing video games does not affect the subjects ability to reach a flow state while playing this exergame.

**Table 16.4:** Average flow score based on play time

| Flow element | Flow score Gamer | Flow score Hardcore Gamer |
|---|---|---|
| Challenge-skill balance | 3.8 | 3.8 |
| Action-awareness merging | 3.3 | 3.5 |
| Clear goals | 3.8 | 3.8 |
| Unambigous feedback | 4.0 | 3.8 |
| Concentration on task at hand | 4.3 | 3.9 |
| Paradox of control | 3.8 | 3.9 |
| **Loss of self-consciousness** | **3.1** | **4.0** |
| Transformation of time | 3.9 | 3.8 |
| Autoletic experience | 3.8 | 3.8 |
| Total score | 3.8 | 3.8 |

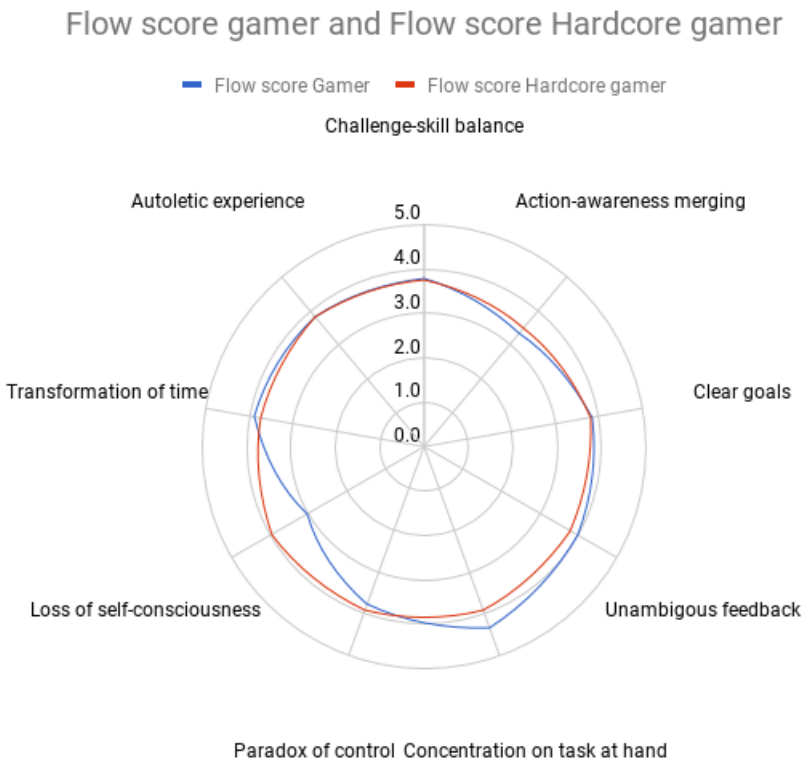


**Figure 16.2:** Average flow experienced divided based on play time

## 16.3 Comparing Results from Flow Survey based on amount of exercise

When examining the difference between people who exercise regularly compared to people who don't we have a larger deviation from the results when viewing all the subjects. There are noticeable lower scores among people who do not exercise regularly to the flow elements, Challenge-skill balance, Action-awareness merging and clear goals. See Table 16.5 The other flow elements have similar scores for both groups and we can clearly see the points where the two groups deviate in the radar chart in Figure 16.3. This could indicate that the challenge of the game and exercise was closer suited towards people who already exercise regularly. It could also be the difference in physical fitness that resulted in the group who don't exercise regularly to feel like the combined challenge was greater than their current skill level,

**Table 16.5:** Flow score divided based on amount of exercise

| Flow element | Flow score Low exercise | Flow score regular exercise |
|---|---|---|
| **Challenge-skill balance** | **3.5** | **4.0** |
| **Action-awareness merging** | **3.0** | **3.9** |
| **Clear goals** | **3.5** | **4.1** |
| Unambigous feedback | 3.9 | 3.9 |
| Concentration on task at hand | 4.0 | 4.1 |
| Paradox of control | 3.7 | 4.0 |
| Loss of self-consciousness | 3.5 | 3.6 |
| Transformation of time | 3.8 | 3.8 |
| Autoletic experience | 3.9 | 3.7 |
| Total | 3.6 | 3.9 |

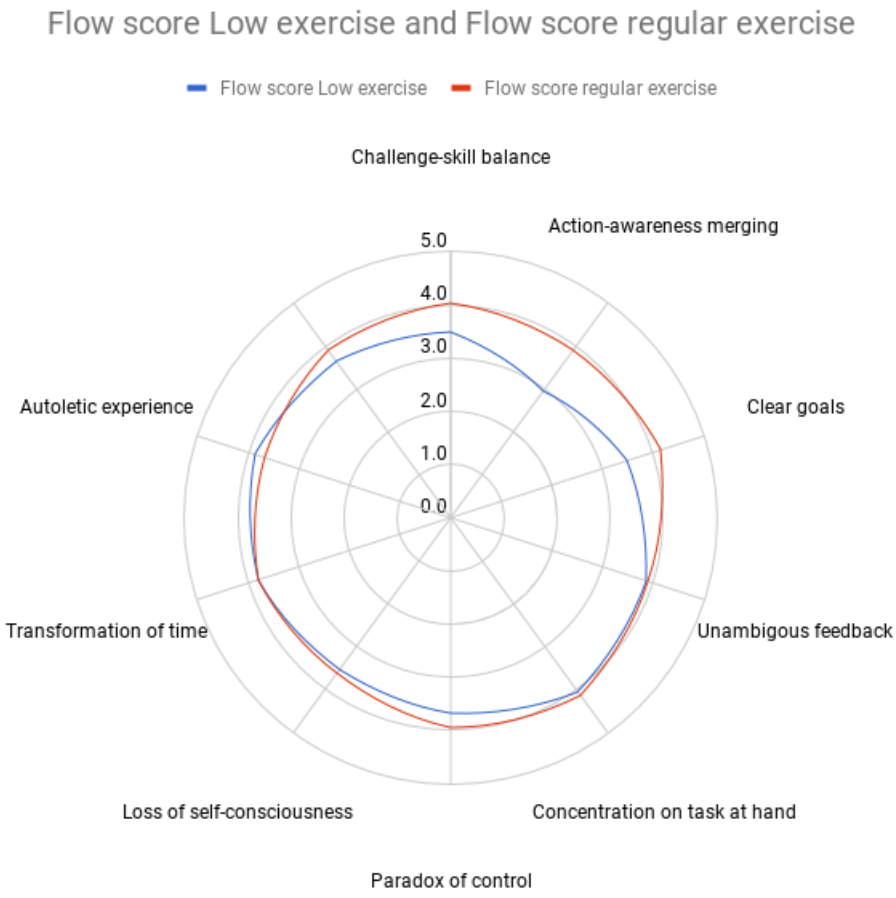


**Figure 16.3:** Average flow experienced divided based on amount of exercise

## 16.4 Summary

The prototype exergame implemented received a decent flow score that indicates that the test subjects achieved a flow state during play. The results from Section16.2 indicates that the level of the subjects interest in video games did not have a significant impact on their ability to achieve a flow state. The results from Section 16.3 indicates that the level of the subjects interest in regular exercise did not have a significant impact on their ability to achieve a flow state.

Chapter 17

# Heart rate charts

This Chapter presents the Heart rate charts with measurements taken from the user testing. For the measurements, the subjects were equipped with Fitbit charge 2 pulse watches that was used to record their heart rate during the test. The devices are not intended to provide accurate scientific measurements however they will provide a reasonable indication of the activity level and the heart rate of the subjects during the test. Only 8 of the 14 subjects where provided these, this was because the pulse watches were not available for use during all of the different testing sessions.

## 17.1 Results

In order to determine the effect the exercise had on the subjects, I examined if they had reached the recommended heart rate zone based on the recorded BPM (Beats per minute) during the test. The recommended heart rate zone varies from person to person and is difficult to determine exactly without first measuring the specific persons resting heart rate and knowing the specific age. For the testers who all where within the 20-30 age group this should be between 95-133 BPM for medium intensity and 133-171 for vigorous intensity. This is based on the target heart rate zones and maximum heart rate formula described in Section 5.3. While the formula is not accurate it is still a decent estimate and determining the actual maximum heart rate for all subjects would not be possible in this experiment. During the user tests, the players all played 2 rounds of the game with a brief pause between sessions. The charts contain data from the entire session and may contain low points where the user was not playing the game. In addition, the watch can provide false readings if the user is not wearing it or wearing it correctly.

All of the 8 subjects had a steady recording above 100 BPM for a period of the test. Chart 1 (see Figure 17.1) indicates a resting heart rate between 50 and 70 BPM for the first round, this could be either a measuring error or the player played a slow first round.

During the second round, the heart rate increases to 130-140 BPM well within the target zone. Chart 2 (see Figure 17.2) shows a peak of around 125 BPM for the first round and during the second round the user held around 100 BPM. Cart 3 (see Figure 17.3) has a peak of between 130-140 BPM during the first round and an average of around 110-120 for the remaining session. Chart 4 (see Figure 17.4) shows a peak just under 125 BPM and then only a normal resting pulse for the remainder of the test around 60 BPM. Chart 5 (see Figure 17.5) shows a heart rate between 120-140 BPM for both rounds. Chart 6 (see Figure 17.6) shows a peak of about 160 bpm for the first round, a noticeable dip most likely in the pause between rounds and another peak around 180 BPM during the second round. Chart 7 (see Figure 17.7) shows a heart rate between 100-110 BPM for most of the session and a peak of 130 BPM. Chart 8 (see Figure 17.8) shows a heart rate around 100 BPM for the first round and then an increase to around 150 BPM for the second round.

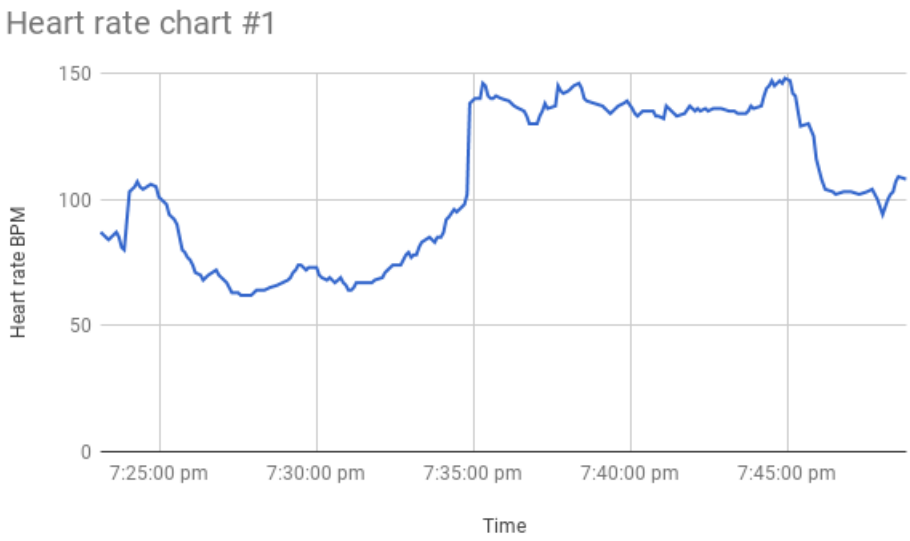


**Figure 17.1:** Chart based on measurement from Fitbit charge 2

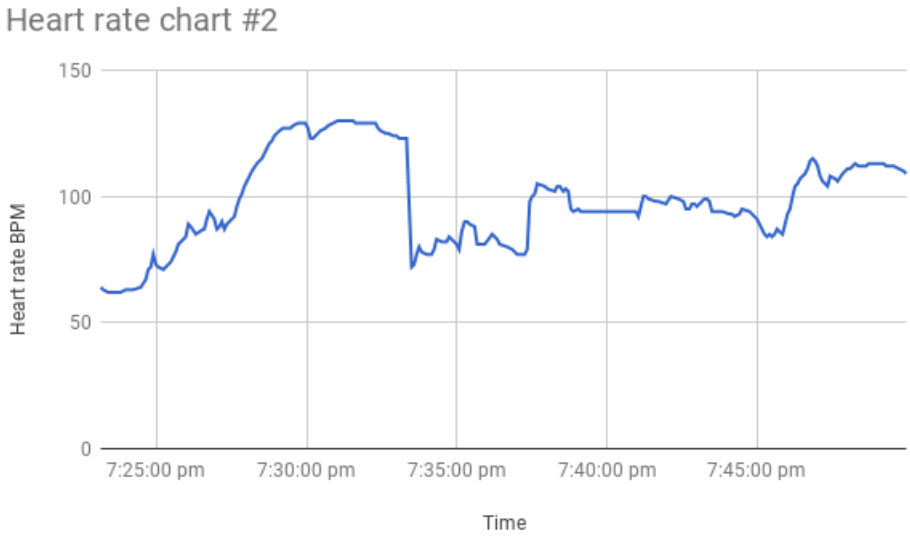


**Figure 17.2:** Chart based on measurement from Fitbit charge 2

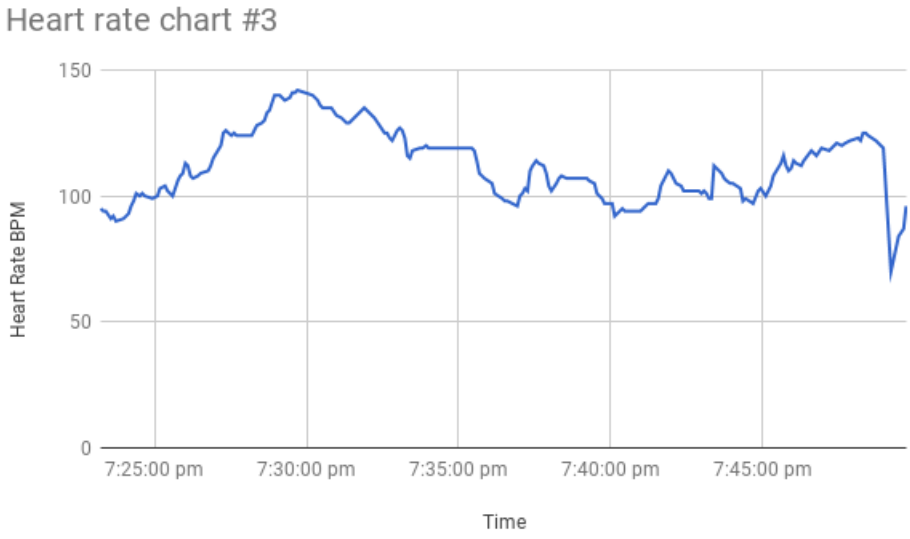


**Figure 17.3:** Chart based on measurement from Fitbit charge 2

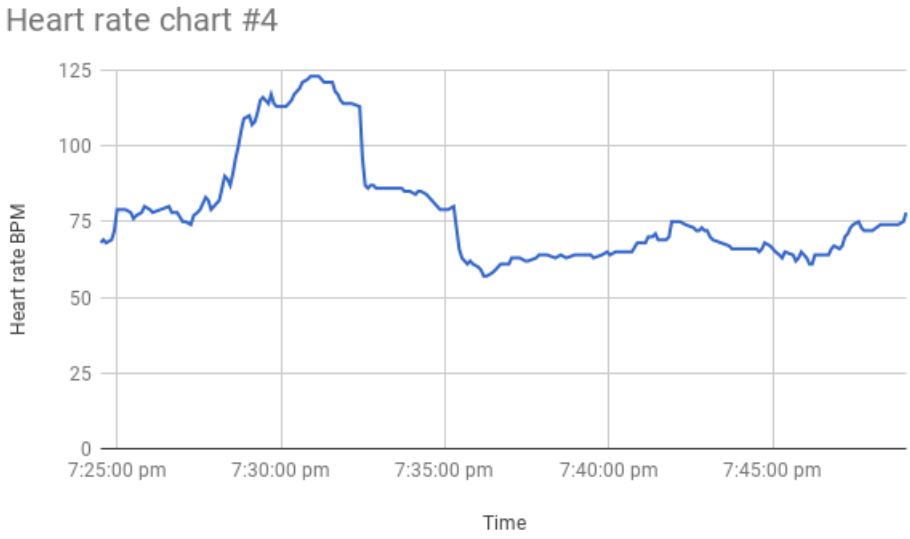


**Figure 17.4:** Chart based on measurement from Fitbit charge 2

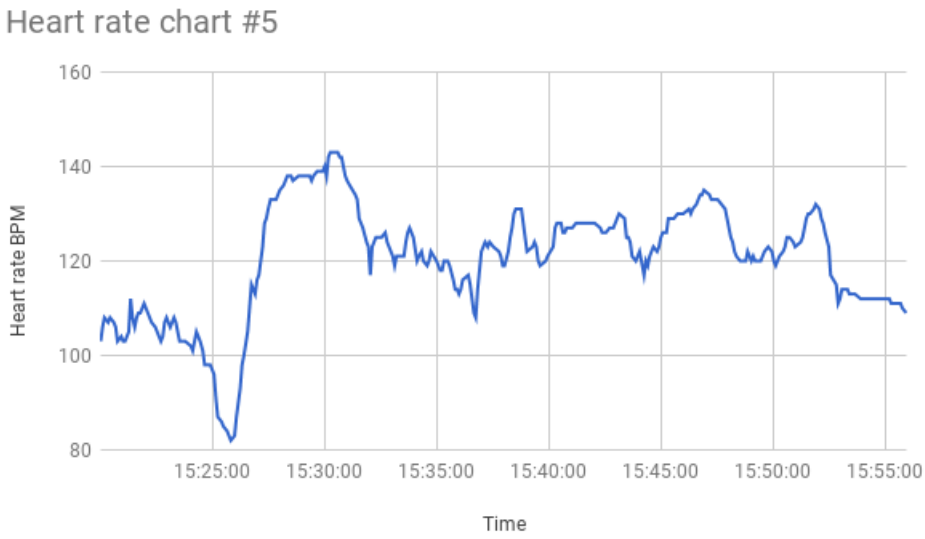


**Figure 17.5:** Chart based on measurement from Fitbit charge 2

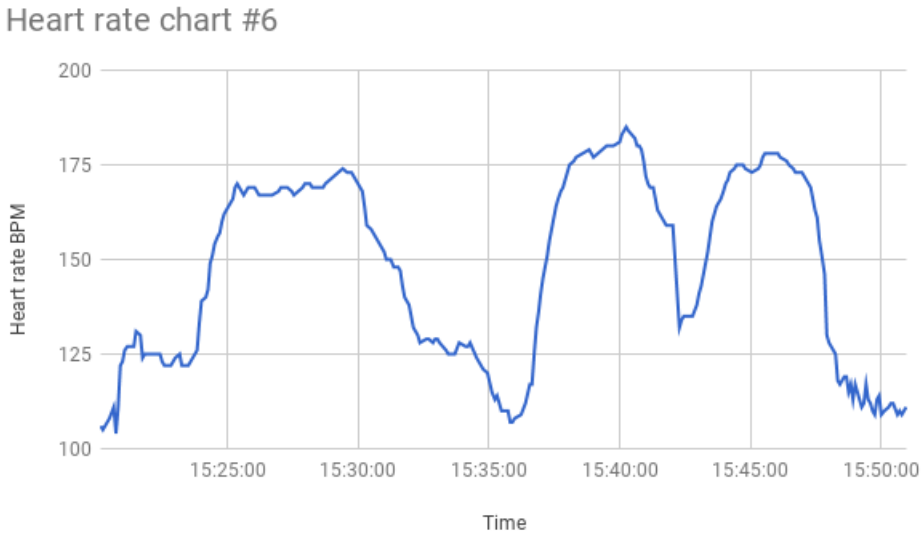


**Figure 17.6:** Chart based on measurement from Fitbit charge 2

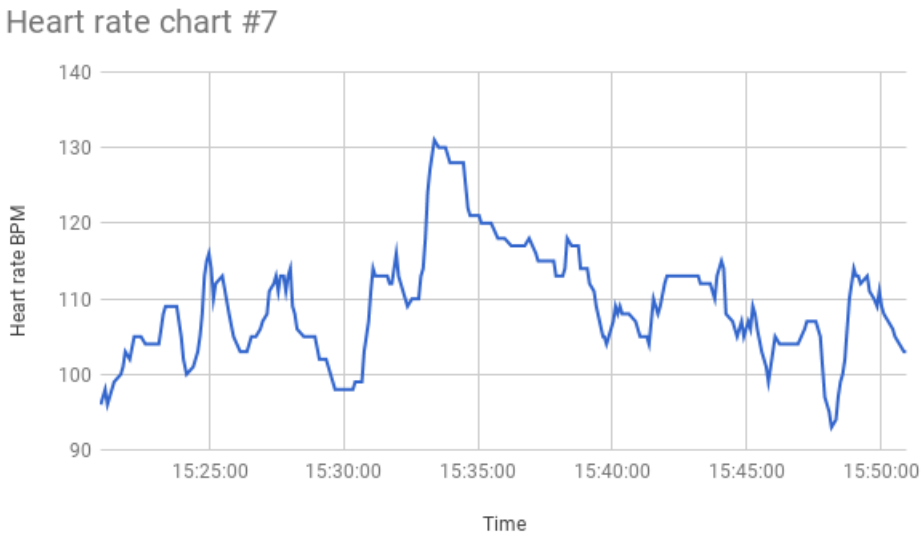


**Figure 17.7:** Chart based on measurement from Fitbit charge 2

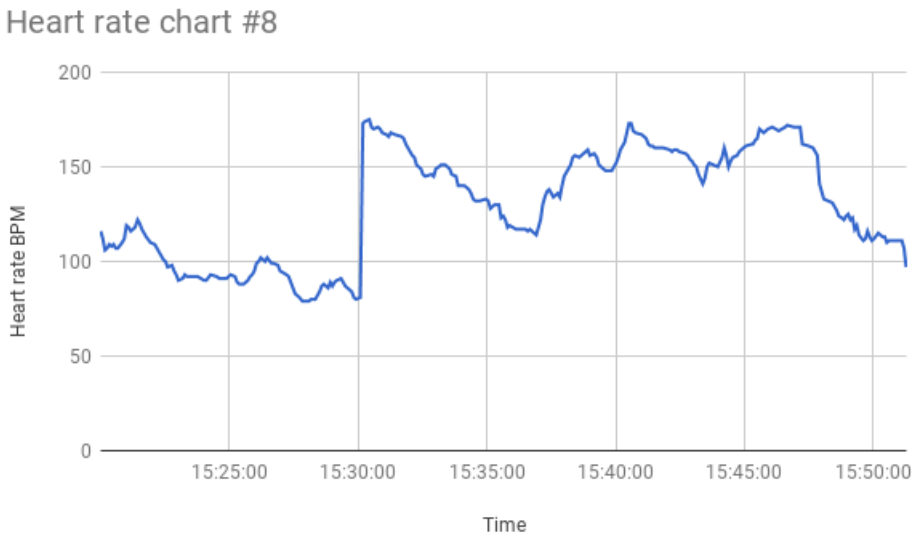


**Figure 17.8:** Chart based on measurement from Fitbit charge 2

## 17.2 Summary

All the heart rate data indicates that all subjects reached the target heart rate for medium intensity exercise and with the exception of chart 4 (Figure 17.4) all users reached vigorous intensity exercise during the test. This indicates that the game can be used for both medium and vigorous intensity exercise for the recommended amount of time. It also indicates that some level of adjustment needs to be available for the physical aspect of the game. While the testers were not explicitly informed that the exercise bicycles could be adjusted to lower or heighten the resistance of the pedals and therefore the intensity of the exercise, some of the subjects did use this feature during the test. This could have impacted the results for those subjects that lowered the resistance to a point where the challenge of the exercise was far lower than their skill level in terms of physical fitness.

Chapter 18

# Feedback from testers

This chapter presents feedback from the subjects who conducted the user test.

In addition to the two open questions provided in the Game test survey, I also conducted an unstructured interview with the test subjects after they had completed the user test. The interview was conducted as a group interview where all subjects could discuss the game with each other. I also had a few questions that I would ask if the discussion halted and if they had not already been covered by the discussion. The questions where as follows:

- What did you think of the game?
- What did you like most about the game?
- What was more fun, 2 or 4 player matches?
- Anything you would like to change, add or remove?
- Anything else you would like to comment on?

The responses from the interviews and game tests were then compared and any duplicate responses, not relevant responses and responses that were not serious was removed. I also observed all the candidates during the test and made notes about how subjects behaved during the test.

## 18.1 Feedback from Game test and interviews

The feedback from the game test responses has been altered in order to correct spelling errors and translated if responses were given in Norwegian. Here are some of the feedback from the subjects:

**From Game test: General feedback section**

*Fun game. Very intense when you do not know how long the game lasts before you play. 2nd time around was less intense because I turned down the resistance to match how long it would last. Selecting length of the game could be an idea. In general: Cool mechanics. Probably needs some balancing and fine-tuning, but it was fun to play.*

*More fun with 4 players compared to 2.*

*Made me forget that I was exercising, which was great. Good, and surprisingly intense.*

**From Game Test: Comments on the game-play and suggestions for improvements.**

*Less edges to get stuck on along the sides of the track. Because you already have enough stuff to slow you down.*

*Maybe remove the hard cap on speed and instead scale the speed so that really fast pedaling yields some small amount of additional speed. Gui feedback for racing the wrong way, gui in general*

**Feedback from group interview**

*The pacing of the exercise was good.*

*More players were more fun, 4 players had a lot more chaos than with 2 players. The chaos made the game more interesting and took the focus away from the exercise.*

*Would use if I had the setup. (At home, not leaving home to play games).*

*Playing with 4 people became a bit confusing, felt more in control during the round with 2 players.*

*It was OK*

*Core gameplay was awesome.*

Most of the feedback from the game test and the interviews was positive, in addition to the responses listed there were also a lot of feedback both positive and negative regarding graphics. The user interface was by far the aspect that received mostly negative feedback due to how simple it was. The responses from the general feedback section of the game test and the interview indicate that the subjects enjoyed the game. And that it was more enjoyable when playing with 4 players.

## 18.2 Observations

During all 4 test sessions, I observed the subjects while they were playing. This section presents a synopsis of the notes I made. During the observation, there were a few things I

paid particular attention to:

- How quickly did the subjects learn the gameplay?
- How did their behavior differ when the number of players increased from 2 to 4 players?
- How tired did the players become during play?

All of the subjects were able to handle the racing mechanics right from the start and, most of them understood how to use the lasercannon after trying it once. Som subjects did take some time to understand the powerups, this was partly due to the low visibility of the UI element that informed them of the type of powerup and number of uses. By the time the subjects had completed the first session with 2 players in each match, they had a firm grasp of the gameplay. For most of them, however, it took a long time to understand how the breakable hazards and the speed boost ramps worked. Some would accidentally fire on the breakable objects and realize they could break them before crashing into them, but few used this as a tactic. Very few subjects discovered that the ramps would provide a temporary speed boost when using them. When transitioning from 2 players to 4 players all subjects were familiar with the gameplay. Most subjects also appeared to enjoy the 4 player match more than the 2 players. Frequently they would comment on echoed when they either passed other players or was passed by another player. During the 2 player match, some players would get a significant lead over another, however, when playing in 4 player matches the players were much closer to each other. This was partly due to the increase in speed given to players who were behind and the fact that lead players would disrupt each other giving others the chance to catch up. How tired the players were varied from player to player, but most subjects appeared to be getting a decent workout from the game.

## 18.3 Summary

Feedback from the subjects was mostly positive. They seemed to enjoy the game and the majority of negative feedback was related to graphics, UI, and suggestions for small changes to the gameplay. Subjects responded better to the 4 player matches, and this was also the impression I got from observations. This indicates that the game was successful in both motivating the players and also increasing the enjoyment of the exercise. It also indicates that the game would need improvements to both the gameplay, graphics, and UI before further testing. And that these improvements could further increase the enjoyment of the game.

# Part V

# Conclusion and Further Work

Part V presents the conclusion and suggestions for further work based on this thesis.

# Chapter 19

# Conclusion

This chapter presents the conclusion to the thesis.
In this project, the main goal was to design and implement a prototype exergame for the Playpulse platform. Before the design and implementation, I conducted research into video games, different genres of video games and, existing exergames. This research was then used in order to determine one or more genres of video games that would be well suited as an exergame. The results of this research then made the basis for the design choices of the prototype. When the implementation of the prototype, CyberSteamPunkHoverWar 2088, was completed it was put through user testing in order to determine how successful it was as an exergame. The experiment tested how fun the game was for the subjects, how well it motivated the subjects and, what the physical impact of the exergame was in the subjects. The results of the research and experiment were then used to answer the research questions described in Chapter 2
The first research question focused on game genres and what types of genre are suited to be implemented as an exergame (RQ1). In order to answer this, I used the findings from the pre-study that can be viewed in Chapter 11. Because of the limited amount of exergames available there is not enough data available to provide statistical evidence for each game genres viability as an exergame. However it can be argued, as I did in Chapter 11 that some genres due to the restrictive nature of combining a video game with an exercise method and a custom input method are not viable as exergames. These include Action-adventure, RPG, MMORPG, and MOBA. Other genres can have less complicated gameplay and could more easily be combined with an exercise method and a specialized controller. These include Vehicle simulation, racing, shooter games and 2D-platformer. The implementation of a racing game with a positive response from testers indicates that racing games are well suited as an exergame. However, I can not confirm the predictions made about the other genres review in Chapter 11 without implementing a game in each genre and then comparing the results. The conclusion to RQ1 is that certain genres appear to be better suited as exergames, but further research is required to confirm this.
The second research question focused on what types of constrictions the equipment, exercise activity, and input method will put on the design of the game (RQ2). Specific input

methods for video games will always provide a constriction to the game's design. The specific constriction the controller for the implemented prototype is described in Chapter 7. In short, the controller with 6 buttons only allows for 6 unique actions. Two of these were used for left and right steering, and because the controller attached to the bike could not differentiate between someone pedaling forward or backward, one button had to be used for brake/reverse. This left 3 buttons for additional gameplay mechanics such as weapons and jumping. The implemented game also uncovered limitations connected to the exercise activity, in this case, the fact that in order for the exergame to be effective it relies on the user being in continuous movement. The fact that the game relies on continuous movement also placed limitations on how long each match could be, in the prototype a match lasted roughly 10 minutes depending on how fast the subjects pedaled. Most subjects stated that the duration of each match was fine, but any longer would result in them becoming too exhausted. The conclusion to RQ2 is that the exercise equipment and method of input will put constrictions on the complexity of the exergames gameplay. The activity of itself will put constrictions on how the game is designed in terms of intensity and duration of the game session.

The third research question asked how the implemented exergame would affect a players motivation to exercise (RQ3). Based on feedback displayed in Chapter 15 the implemented game provided a lot of motivation for the players to exercise.86% of testers rated the games ability to motivate them as high. In addition, 93% of testers stated that they would want to use the game as an exercise method in the future. The conclusion to RQ3 is that implemented prototype provided additional motivation to exercise, this was achieved by the game aspect of the combined video game and exercise method.

The fourth research question focused on how well the exergame could cover the recommended amount of physical activity (RQ4). The game is played in single rounds that are roughly 10 minutes long, with testers playing 2 rounds with a short pause this amounts to 20 minutes in one session. The Heart rate charts in Chapter 17 indicate that most subjects reached a high-intensity workout meaning a session per day 5 days per week a total of 100 minutes would more than cover the recommended 75 minutes of vigorous intensity exercise described in Section 5.2. The conclusion to RQ4 is that the implemented exergame is very capable of covering the recommended amount of physical exercise.

The fifth research question focused on how well the exergame was able to replace traditional methods of exercise (RQ5). Results from Chapter 15 indicate that the game as a method of exercise is well received. 71% of subjects gave it a high rating when comparing it to traditional exercise, only 7% or one subject indicated that the game was worse as an exercise method that traditional exercise The game provides additional motivation to exercise and is capable of covering the recommended amount of exercise. People also seem to enjoy it more than traditional exercise methods. The conclusion to RQ5 is that the game is well suited to replace traditional exercise methods.

The sixth research question asked how the level of interest in video games would impact the player's response to an exergame (RQ6) When looking at the results from Section 15.2 we see some differences in how the tired they were after the session. It would also seem like gamers enjoyed the game slightly more than hardcore gamers. Despite these differences, both groups did respond positively to the game. In regards to the motivational factor, there was no difference between the two groups. Looking at Section 16.2 the re-

sponses were more even and both groups had the same average flow score of 3.8. Based on the findings the conclusion to RQ6 is that the subjects interest in video games did not have a significant impact on how they reacted to the game.
The seventh research question asked how the level of interest in regular exercise would impact the player's response to an exergame (RQ7) When looking at Section 15.3 we see little difference in the perceived intensity of the exercise from the two groups. There is also no major difference in how the two groups experienced the game itself or how well it motivated them. In Section 16.3 there is a slight difference in the average flow score with the subjects who exercise regularly giving it an average score of 3.9 while subjects who do not exercise regularly giving it a score of 3.6. This is not a large enough difference to conclusively determine a difference in the response to the exergame. Based on the findings the conclusion to RQ7 is that the subjects interest in regular exercise did not have a significant impact on how they reacted to the game.

Chapter 20

# Further work

The feedback and observations from the user test show that the prototype exergame requires further work. Visuals, user interface, and some components of the gameplay mechanics need refinement before it could be put into wide-scale testing or commercial use. In addition, the game‘s networking requires improvement. Further, the game should be fitted with some kind of progression system as discussed in Section 12.11 in order to further motivate the players. The game‘s genre and core gameplay received positive feedback and would be suitable as an exergame.
Further research into which genres could be well suited as a video game would also be recommended. Exergames are becoming a genre of itself, however, it still relies on traditional video game genres to set the theme and mechanics. I would recommend running experiments on the genres discussed in the pre-study to confirm how well suited they are as exergames. For the prototype and other exergames developed for the playpulse platform, I would recommend testing in larger scales in addition to running a long-term experiment in order to determine how well the exergame(s) motivate players in the long run. While results of this test were positive, almost all test subjects were using the platform for the first time during the tests. There could be a novelty factor with a new system that impacts the user experience and long-term testing would determine if players maintain motivation over time. Such a test could also further investigate an exergames ability to replace traditional exercise both in terms of enjoyment and health impact. It should also to run an experiment that measures the long-term health benefits and motivation with a control group that engages in the same exercise activity but without an exergame. This would more accurately measure the impact of the exergame. Since the results indicate that the level of interest in video games and exercise did not impact the subject’s response to the exergame it would seem like these types of exergames are well suited for a variety of users. Further research to confirm these results is also recommended.

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# Appendix

## Appendix A

### Game Test survey

# Playpulse Game Test

1. **Tester Id**

2. **Rate the intensity of the exercise from low to high**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Low | ◯ | ◯ | ◯ | ◯ | ◯ | High |

3. **How tired are you after the session**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not tired | ◯ | ◯ | ◯ | ◯ | ◯ | Very tired |

4. **Compare the exercise experience to traditional exercise I.E. Cycling,running etc.**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Worse | ◯ | ◯ | ◯ | ◯ | ◯ | Better |

5. **What do you think of the Game itself.**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Bad | ◯ | ◯ | ◯ | ◯ | ◯ | Good |

6. **Rate the core game-play (Hovercraft+Weapons)**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Bad | ◯ | ◯ | ◯ | ◯ | ◯ | Good |

7. **Rate the racing game-play.**
   *Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Bad | ◯ | ◯ | ◯ | ◯ | ◯ | Good |

8. **Comments on the game-play and suggestions for improvements.**

9. **Rate the aesthetics of the Game. I.E. Graphics and visual design.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Bad | ◯ | ◯ | ◯ | ◯ | ◯ | Good |

10. **How did the game motivate you to exercise.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not at all | ◯ | ◯ | ◯ | ◯ | ◯ | Very Much |

11. **Would you consider using this method of exercise in the future.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| No | ◯ | ◯ | ◯ | ◯ | ◯ | Yes |

12. **How likely is it that you would recommend this game and the method of exercise to a friend.**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not likely | ◯ | ◯ | ◯ | ◯ | ◯ | Very Likely |

13. **How fun was the game?**
*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Not fun at all | ◯ | ◯ | ◯ | ◯ | ◯ | Very fun |

14. **General feedback.**

# Appendix B

## Flow State Questionnaire

# Flow state Questionnaire

1. **ID**

2. **Untitled Question**

*Mark only one oval per row.*

| | 1 (Strongly disagree) | 2 | 3(Neither agree or disagree) | 4 | 5(Strongly agree) |
|---|---|---|---|---|---|
| 1. I was challenged, but I felt my skills allowed me to meet the challenge. | | | | | |
| 2. I made the correct movements without thinking about trying to do so. | | | | | |
| 3. I knew clearly what I wanted to do. | | | | | |
| 4. It was clear to me that I was doing well. | | | | | |
| 5. My attention was focused entirely on what I was doing. | | | | | |
| 6. I felt in control of my actions. | | | | | |
| 7. I was not concerned with what others may have been thinking of me. | | | | | |
| 8. Time seemed to alter during play (either slowed down or speeded up). | | | | | |
| 9. I really enjoyed the experience. | | | | | |
| 10. I was aware of how well I was performing | | | | | |
| 11. It was no effort to keep my mind on the game. | | | | | |
| 12. It felt like I could control what I was doing. | | | | | |
| 13. I was not worried about my performance during the game. | | | | | |
| 14. I felt I was competent enough to meet the demands of the situation. | | | | | |
| 15. I played automatically. | | | | | |
| 16. I knew what I wanted to achieve. | | | | | |
| 17. I had a good idea while I was playing about how well I was doing. | | | | | |
| 18. I had total concentration | | | | | |
| 19. I was not concerned with how I was presenting myself. | | | | | |
| 20. At times, it almost seemed like things were happening in slow motion. | | | | | |
| 21. The experience left me feeling great | | | | | |
| 22. The challenge and my skills were at an equal level. | | | | | |
| 23. I did things spontaneously and automatically without having to think. | | | | | |
| 24. My goals were clearly defined. | | | | | |

| | 1 (Strongly disagree) | 2 | 3(Neither agree or disagree) | 4 | 5(Strongly agree) |
|---|---|---|---|---|---|
| 25. I felt in control of my body. | | | | | |
| 26. Time passed quickly during play | | | | | |
| 27. I found the experience rewarding. | | | | | |

# Appendix C

## Personals survey

# Anonymized personals

1. **ID**

2. **Age**

3. **Height**

4. **Weight**

5. **Gender**
   *Mark only one oval.*

   - Female
   - Male
   - Other: _____

6. **How often do you exercise**
   Average sessions per week,Choose only one
   *Mark only one oval.*

   - Less than 1
   - 1
   - 1.5
   - 2
   - 2.5
   - 3 or more

7. **How much time do you spend playing computer games?**
   Average hours per week, Choose only one option
   *Mark only one oval.*

   - Less than 5 hours
   - 5-10
   - 10-20
   - 20-30
   - 30-40
   - 40 or more

8. **Chose the option that describes you best**
   Mark one option.
   *Mark only one oval.*

   - ◯ I prefer single-player games
   - ◯ I prefer multi-player games
   - ◯ No preference

9. **Have you used the Playpulse system before?**
   *Mark only one oval.*

   - ◯ Yes
   - ◯ No

# Appendix D

## Results from Game Test survey

| Timestamp | Rate the intensity of the exercise from low to high | How tired are you after the session | Compare the exercise experience to traditional exercise I.E. Cycling,running etc. | What do you think of the Game itself. | Rate the core game-play (Hovercraft+Weapons) |
|---|---|---|---|---|---|
| 3.20.2018 19:28:47 | 4 | 2 | 5 | 4 | 5 |
| 3.20.2018 19:28:49 | 4 | 4 | 5 | 4 | 4 |
| 3.20.2018 19:29:56 | 3 | 3 | 3 | 2 | 2 |
| 3.20.2018 19:30:24 | 4 | 4 | 5 | 3 | 3 |
| 3.21.2018 15:49:26 | 5 | 4 | 4 | 4 | 5 |
| 3.21.2018 16:40:06 | 4 | 3 | 5 | 4 | 5 |
| 3.22.2018 16:54:34 | 4 | 3 | 4 | 4 | 4 |
| 3.22.2018 16:55:26 | 4 | 4 | 3 | 4 | 4 |
| 4.11.2018 19:51:02 | 4 | 2 | 4 | 3 | 3 |
| 4.11.2018 19:51:10 | 4 | 5 | 4 | 5 | 5 |
| 4.11.2018 19:51:13 | 2 | 3 | 2 | 4 | 3 |
| 4.20.2018 15:51:10 | 5 | 4 | 3 | 4 | 3 |
| 4.20.2018 15:51:16 | 3 | 3 | 4 | 3 | 4 |
| 4.20.2018 15:57:35 | 4 | 5 | 4 | 3 | 4 |

| Rate the racing game-play. | Comments on the game-play and suggestions for improvements. |
|---|---|
| 5 | More maps, making usage of power ups, and the effect clearer. |
| 2 | Ask me xoxo |
| 2 | |
| 3 | Map, easier to understand the reactions of weaponry on walls |
| 4 | Controls should be delinated to left and right bumpers per movement and per weapon, traditional gaming has this and it is automatic for regular gamers |
| 4 | Clearer visualization of the different powerups in the GUI would be good |
| 3 | |
| 5 | Maybe remove the hard cap on speed and instead scale the speed so that really fast pedaling yields some small amount of additional speed. Gui feedback for racing the wrong way, gui in general |
| 4 | |
| 4 | Suggest level of difficulty. Offer a space for beginners. |
| 4 | |
| 4 | |
| 3 | Better visualization of the power ups affecting you would be nice |
| 2 | Less edges to get stuck on along thensides of the track. Because you already have enough stuff to slow you down. |

| Rate the aesthetics of the Game. I.E. Graphics and visual design. | How did the game motivate you to exercise. | Would you consider using this method of exercise in the future. | How likely is it that you would recommend this game and the method of exercise to a friend. | How fun was the game? |
|---|---|---|---|---|
| 3 | 4 | 5 | 5 | 5 |
| 3 | 4 | 4 | 4 | 4 |
| 2 | 4 | 3 | 3 | 3 |
| 2 | 5 | 5 | 5 | 3 |
| 4 | 5 | 5 | 5 | 4 |
| 3 | 2 | 4 | 4 | 4 |
| 3 | 4 | 5 | 5 | 4 |
| 3 | 4 | 5 | 4 | 5 |
| 4 | 4 | 4 | 4 | 4 |
| 5 | 4 | 5 | 5 | 5 |
| 3 | 3 | 4 | 4 | 4 |
| 3 | 4 | 4 | 4 | 5 |
| 3 | 4 | 5 | 5 | 3 |
| 3 | 5 | 5 | 5 | 4 |

General feedback.
Love the concept, and I see this as the future.
Kool

Funnier with 4 players compared to 2.

Made me forget that I was excersising, which was great. Good, and surprisingly intense.

Fun game. Very intens when you do not now how long the game lasts before you play. 2nd time around was less intense because I turned down the reistance to match how long it would last. Selecting length of the game could be an idea. In general: Cool mechanics. Probably needs some balancing and fine tuning, but it was fun to play.

# Appendix E

## Results from Flow State Questionnaire

| Timestamp | [1. I was challenged, but I felt my skills allowed me to meet the challenge.] | [2. I made the correct movements without thinking about trying to do so.] | [3. I knew clearly what I wanted to do.] | [4. It was clear to me that I was doing well.] | [5. My attention was focused entirely on what I was doing.] | [6. I felt in control of my actions.] | [7. I was not concerned with what others may have been thinking of me.] |
|---|---|---|---|---|---|---|---|
| 3.20.2018 19:24:09 | 5 | 4 | 5 | 5 | 5 | 4 | 5 |
| 3.20.2018 19:24:32 | 2 | 4 | 5 | 2 | 3 | 3 | 5 |
| 3.20.2018 19:26:02 | 2 | 1 | 1 | 3 | 5 | 3 | 1 |
| 3.20.2018 19:26:11 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| 3.21.2018 15:47:33 | 4 | 2 | 5 | 5 | 4 | 4 | 5 |
| 3.21.2018 16:37:54 | 4 | 5 | 5 | 4 | 5 | 4 | 2 |
| 3.22.2018 16:51:39 | 3 | 4 | 5 | 3 | 4 | 3 | 2 |
| 3.22.2018 16:52:33 | 4 | 2 | 4 | 3 | 5 | 3 | 5 |
| 4.11.2018 19:55:52 | 5 | 3 | 4 | 4 | **4** | 3 | 1 |
| 4.11.2018 19:56:50 | 3 | 2 | 4 | 5 | 3 | 2 | 1 |
| 4.11.2018 19:57:41 | 5 | 1 | 5 | 5 | 5 | 4 | 5 |
| 4.20.2018 15:54:22 | 4 | 4 | 4 | 3 | 5 | 4 | 5 |
| 4.20.2018 15:55:43 | 4 | 4 | 4 | 4 | 3 | 4 | 4 |
| 4.20.2018 16:02:06 | 4 | 3 | 3 | 4 | 5 | 4 | 5 |

| [8. Time seemed to alter during play (either slowed down or speeded up).] | [9. I really enjoyed the experience.] | [10. I was aware of how well I was performing] | [11. It was no effort to keep my mind on the game.] | [12. It felt like I could control what I was doing.] | [13. I was not worried about my performance during the game.] | [14. I felt I was competent enough to meet the demands of the situation.] | [15. I played automatically.] |
|---|---|---|---|---|---|---|---|
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | 4 | 3 | 4 | 3 | 2 | 3 | 3 |
| 3 | 4 | 3 | 5 | 3 | 5 | 3 | 4 |
| 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 |
| 3 | 4 | 4 | 3 | 4 | 5 | 5 | 2 |
| 4 | 4 | 4 | 1 | 4 | 1 | 4 | 5 |
| 5 | 4 | 4 | 4 | 3 | 4 | 4 | 2 |
| 5 | 4 | 4 | 5 | 3 | 2 | 3 | 4 |
| 4 | 4 | 4 | 4 | 3 | 5 | 5 | 4 |
| 5 | 3 | 4 | 4 | 4 | 2 | 2 | 2 |
| 5 | 5 | 5 | 5 | 4 | 3 | 4 | 2 |
| 3 | 4 | 4 | 5 | 4 | 3 | 4 | 3 |
| 5 | 5 | 3 | 3 | 4 | 4 | 4 | 4 |
| 5 | 4 | 4 | 5 | 4 | 2 | 4 | 5 |

| [16. I knew what I wanted to achieve.] | [17. I had a good idea while I was playing about how well I was doing.] | [18. I had total concentration] | [19. I was not concerned with how I was presenting myself.] | [20. At times, it almost seemed like things were happening in slow motion.] | [21. The experience left me feeling great] | [22. The challenge and my skills were at an equal level.] | [23. I did things spontaneously and automatically without having to think.] | [24. My goals were clearly defined.] | [25. I felt in control of my body.] |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 5 | 5 | 5 | 3 | 5 | 5 | 4 | 5 | 5 |
| 5 | 4 | 3 | 5 | 2 | 3 | 3 | 4 | 5 | 5 |
| 3 | 4 | 4 | 2 | 1 | 3 | 3 | 3 | 4 | 3 |
| 4 | 3 | 3 | 4 | 2 | 2 | 4 | 4 | 5 | 4 |
| 5 | 4 | 3 | 5 | 3 | 4 | 4 | 2 | 5 | 4 |
| 5 | 5 | 5 | 2 | 4 | 4 | 2 | 4 | 5 | 4 |
| 5 | 3 | 3 | 3 | 2 | 5 | 5 | 4 | 5 | 5 |
| 4 | 4 | 5 | 1 | 2 | 4 | 4 | 3 | 3 | 3 |
| 4 | 3 | 4 | 5 | 3 | 3 | 4 | 4 | 4 | 5 |
| 4 | 4 | 3 | 2 | 5 | 3 | 2 | 3 | 4 | 4 |
| 3 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | 4 | 5 | 5 | 1 | 3 | 4 | 4 | 2 | 5 |
| 4 | 3 | 3 | 5 | 4 | 5 | 3 | 5 | 4 | 4 |
| 5 | 5 | 5 | 5 | 5 | 5 | 3 | 4 | 4 | 5 |

| [26. Time passed quickly during play] | [27. I found the experience rewarding.] |
|---|---|
| 5 | 5 |
| 3 | 3 |
| 4 | 5 |
| 4 | 4 |
| 3 | 4 |
| 5 | 4 |
| 5 | 5 |
| 5 | 4 |
| 4 | 3 |
| 2 | 5 |
| 5 | 5 |
| 3 | 4 |
| 5 | 5 |
| 5 | 5 |

# Appendix F

## User Consent Form

# Forespørsel om deltakelse i forskningsprosjekt

## Bakgrunn og formål

Formålet med studien er å undersøke om et utviklet exergame kan dekke anbefalt daglig fysisk aktivitet, i forbindelse med en masterstudie ved IDI, NTNU. Testkandidatene er fortrinnsvis personer på mellom 18 og 30år, som er godt kjent med dataspill.

## Hva innebærer deltakelse i studien?

Data som vil bli samlet inn i forkant av eksperimentet (spilling av exergamet): Kjønn, alder, høyde, vekt, treningsvaner og dataspillvaner. Under eksperimentet vil puls og energiforbruk bli registrert. Etter eksperimentet vil testkandidatene bli spurt om å fylle ut et spørreskjema, med spørsmål rundt exergamets underholdningsverdi, brukervennlighet, og fysisk anstrengelse.

## Hva skjer med informasjonen om deg?

Alle personopplysninger vil bli behandlet konfidensielt. Alle testkandidater vil bli tildelt et tilfeldig nummer som de signerer all data med. Kobling mellom navn og nummer vil aldri bli registrert. Anonymisert statistikk fra eksperimentet vil bli offentliggjort i masteroppgaven. Deltakere vil aldri kunne bli gjenkjent i publikasjonen.

## Frivillig deltakelse

Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli anonymisert.

## Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er villig til å delta

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(Signert av prosjektdeltaker, dato)