Master thesis on Cognitive Systems and Interactive Media

Universitat Pompeu Fabra

Human challenges: Difficulty in video games

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Contents

Abstract

In this master thesis, we discuss the factors that constitute difficulty into the video games field, a field really concurrent of studies in the last few years. Fields like teaching, or therapeutic purposes or even to validate the response to perform different tasks, however, the field that we want to study as the difficulty has not been explored much and in the investments in which the terminology has explored the difficulty in video games, they explored in a very general way. [1]

We first show the importance of difficulty, explaining the link between the challenges in video games with the player's performance, learning, attention, and skills. We then report about what difficulty factors we wish to include in our research and why showing some examples of how to evaluate these factors and analyze their results. We argue that the analysis is limited if it does not consider difficulty from the human player's point of view. We provide a player and Game Design-oriented definition of the challenge and difficulty notions in games. Finally, we talk about the next steps in this field such as the study of other factors unrelated to those we will study in this research and the use of AI and how this affects the difficulty in video games, including what difficulty factors can be helpful for learning purposes.

Keywords: Video games; Challenge; Difficulty; Factors; Skills; Humans

Chapter 1

Introduction

1.1 Problem Statement

Difficulty factors in games are rarely discussed as important, in this field of research the most normal topics of research are how to use the video games to learn or how to use video games with therapeutic purposes as we mentioned before in the abstract. In the video games field some games, they are well-thought-out additions, built for the hardcore players. Taking into account that the difficulty of a game is centered on the player and reflects his or her skills, these skills, therefore, change depending on the type of game or the condition of the player. For example: the skills used by a player who is used to playing shooting games may not be suitable for platforming games. Consequently, their score in a platforming game would also be lower considering that different reflexes and motor skills are needed. These are, of course, quite large suppositions, on which we will formulate our research question: What are the factors that affect the difficulty of video games for humans?, question we expect to resolve at the end of this research.

In this work, we will analyze the importance of different types of difficulty in video games to better understand what are the components that make video games hard or easy for humans. We chose video games as the task because many researchers are focused on solving video games but only a few of them are focused on humans.

[2]

1.2 State of the Art

Why humans have a quick maturation when they play "hard" video games? Is the practice the only factor that makes this maturation faster? Which factors determine whether a video game is hard or easy for humans? We will try to address these questions and others as part of this research project. The idea is to go deeper into the difficulty of video games and their main components. [2]

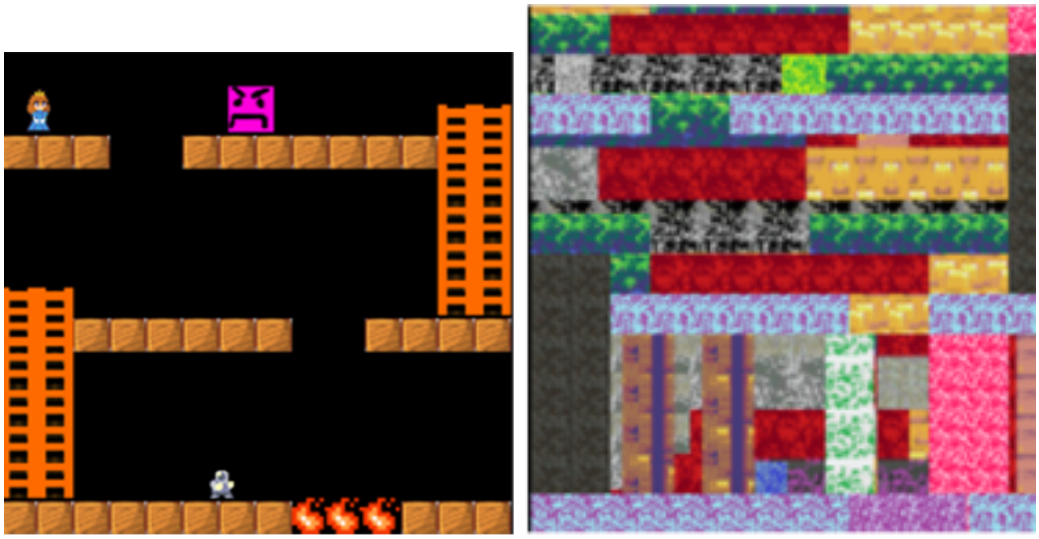
We will start with a short definition of the difficulty in video games and why it is important in the world of video games. Difficulty in video games is one of the most classic variables in this industry. From the difficulty levels to be selected by the game a priori, to the difficulty selectors in domestic video games.

Juul's supports the importance of the difficulty in video games saying that: a game is a set of rules with a variable and quantifiable result when having to make an effort the player persists a challenge and foresees a direct influence of the difficulty in the result to be obtained. [3] On the other hand, Robin Hunicke describes a game as the use of Mechanics, Dynamics, and Aesthetics. The mechanics are the limits or rules created in a game, Dynamics are the possible interactions that the player generates based on the mechanics, and Aesthetics are the emotions generated in response by the player and it is perhaps the combination of these three components that it makes the difficulty continuously be perceived as a challenge to be overcome by the player. [3]

After that, we must talk about video game difficulty. We need to separate difficulty into factors that make it hard or easy, such as reaction time, participant skills, attention limits (How many things on the game can I pay attention?), and physics in the virtual environment. As explained by Dubey (2018) some components in this area come from the context of the participant. [2]

Imagine that you are playing a video game you have never played before, as shown in Figure 1(a). The game is well-known and the interactions are familiar to some

humans (move in two directions, jump, use ladders to reach higher platforms, kill monsters and save the princess). The final goal is to rescue the princess by avoiding all the traps and enemies. This is a classic platforming game. The problem occurs when we change the visual stimulus for something less ordinary in the eyes of the human player (b), and a game that could take 2 minutes suddenly becomes a 10-minutes game or longer, which gives us the opportunity to analyze the factors that make it harder. In this research we are not focus on the human priors but for future research could be good to analyze this field too. [2]



(a) Original State. (b) Modified Game.

Figure 1: (a) A simple platformer game. (b) The same game modified by re-rendering the textures. Despite the two games being structurally the same, human players took twice as long to finish the second game as the first one. [2]

This paper will present a series of studies on a specially-designed game environment, The full game (unlike the first example) is going to be designed to be sufficiently complex for humans, taking into account the above mentioned factors, to easily measure the difficulty factors.

We are going to take the human as a logical being and test it on several settings where we vary such difficulty factors. It should be noted here that our aim is not to understand how humans learn a particular task (game) or how are they going to handle that task, but rather understand the entire process and to assess which types of task attributes affect human performance and how.

In addition to prior knowledge in this field (video games), humans also bring in rich prior knowledge about intuitive physics and strong motor control priors when they approach a new task. Here, one of our objectives is to take some initial steps to explore the importance of such priors in the context of humans into the difficulty in the video games field.

For us, that games that seem very different at first glance may be very similar at a more abstract level and beyond their immediate facade, games can be defined in terms of a number of factors, and furthermore it is these factors that define the complexity of a game and the best strategy to play it well.

-The factors mentioned above arise from the following questions:

-The number of players. Is the game played by a single player or multiple players, or does a single-player play with/against computer-controlled enemy units?

-Stochasticity. Is the outcome of the game determined only by the player?

-Time granularity. Is the game turn-based or real-time?

-Observability. Is the game partially observable or does the player have perfect information?

-Action space size. The number of actions the player can take.

In our case, we will analyze humans as the game-learners and consider games that can be played similarly to the ATARI 2600 games (Pac-Man, private eye, asteroids, etc...), where we can define and test the effect of such factors. Using average game scores, we will analyze the success of the task and how to perfect it. For instance, if the task is jumping on a vertically moving enemy, like in platforming game scores will depend on timing. If the jump is made at the right time, the score will be higher than if the jump is made out of time. In that way, we can assess the accuracy of the action in comparison with the skill being observed.

Within Damien Anderson's investigations, it can be seen how some artificial intelligence agents, when they are tested in some tasks, are vulnerable to several

deceptions, so they can verify the weaknesses of several of these agents. If we use this logic with humans, ideally we might be able to discern other difficult factors for humans in video games and that can help us create new paradigms of difficulty. [4]

At this point, we have used the term of difficulty in games without providing any definition of this word. We will not attempt to provide a general definition of difficulty covering a wide range of psychological aspects from emotional problems to intellectual and physical challenges. Instead, we consider the notion of difficulty in the sense used in game design, that is video games are built as combinations or sequences of predefined challenges. Thus, the study of the overall difficulty for a given video game involves studying the difficulty factors players experiment when overcoming a task. [5]

In some cases games adapt the presented difficulty using the Dynamic Difficulty Adjustment (DDA). This is a general term used to express the change of difficulty during a game, it is a method to adapt the experience as the player's level increases. In the games that this method has been implemented, it is carried out starting from the adjustment of parameters, the modification of the level design, the automatic learning, the use of classification systems or the players modeling. [6]

In the current investigation, we will not focus on AI, but further research could to compare these factors with AIs and humans, and analyzing if these difficulty factors affect both subjects. We estimate the AIs will present a better performance, yet also problems with some logical tasks like in Montezuma revenge or private eye or many others (ATARI 2600 games), According to some research, a very popular setting for a general-purpose evaluation today is the collection of games or tasks under an interactive scenario, where agents can perceive and act and are rewarded when they succeed. Many different platforms have recently appeared for that. Some benchmarks that have become particularly popular in the past years are the Arcade Learning Environment (ALE) and General Video Game Artificial Intelligence (GVGAI). [7, 4, 8]

Chapter 2

Methods

The impact of video games in recent years has increased considerably, which has allowed the emergence of new fields of research. Currently, many studies have established design practices that allow improving the user experience or even using video games as a method to improve educational processes [9], however, the elements that directly influence the difficulty of the challenges proposed into the virtual universes it is still uncertain. For this reason, we have defined as the main objective of this research, to evaluate and validate some factors within a specific situation, presenting a digital environment that progressively increases its complexity by modifying specific variables.

In this way, a design process has been carried out to establish the main aspects to be integrated into the virtual environment; to later develop the application and obtain relevant information from the user behavior. We have fragmented the latter into two groups: experienced and inexperienced users, thus confirming that the player's experience directly influences their performance [10].

At the same time reaching the conclusion of adopting as secondary objectives the design of a video game where you can evaluate some of the factors that have a potential relationship with the difficulty. Focusing mainly on the video games platformers type, thinking this one could be the most common type of video game to be previously played by people and tanking into account this type of game has already

in the patterns and speed of enemies a potential factors that affect the difficulty of these. The patterns, we will use for this investigation are those that have the x-axis as the main axis, which means horizontal patterns, the in-depth explanation of these patterns will be found later in the design and development section.

For the data collection, we have a secondary objective that is the storage and analysis of the possible dependent variables generated from the interaction of the participants with the proposed virtual environment. The main dependent variable is the minimum distance between the participant's virtual character and the enemies when performing any action, we can understand this in more detail in the design and development section.

2.1 Design & Development

As previously mentioned, the proposed method is the creation of a platform video game to evaluate the difficulty in two factors, see Figure 2, the first factor is the patterns of the enemies and the second factor is the speed of their movement, within this investigation we will focus specifically on horizontal patterns and these horizontal patterns we will divide it into Patterns with subdivisions at a distance in x (defined by a scalar α) and patterns with points of random choice in x (defined by a scalar β).

Figure 2: A full view of the level.

what α will show is a series of jumps equivalent to the number of subdivisions in the y-axis, to expand this idea look at figure 3.

On the other hand, the scalar β will define the number of possible places to which the enemy can move, e.g. if the number of points or possible places is 4, it means that the enemy, in a random way, will move between those four points; for more information see figure 4.

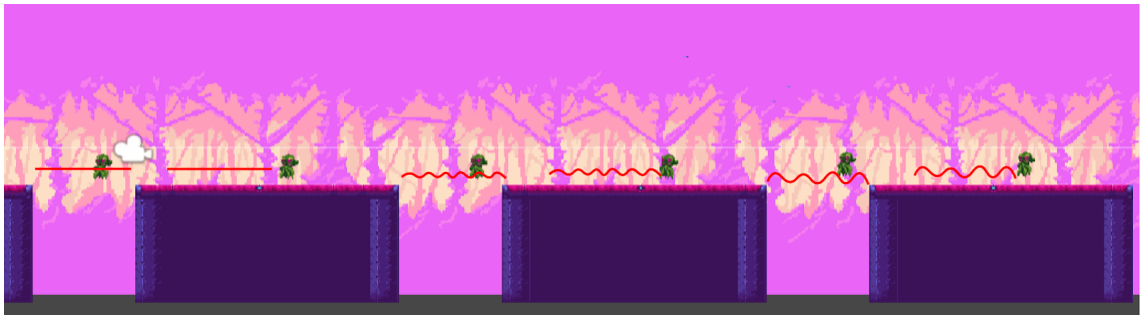


Figure 3: The red lines and curves in the image represent some of the possible α, as we can see as more subdivisions it will generate smaller arcs, while with fewer subdivisions it tends to have larger arcs.

Figure 4: The orange and yellow dots in the image represent some of the possible random decision points they have when moving enemies. In the case of oranges $\beta = 4$ and the case of yellows $\beta = 8$

A hole (h) parameter has also been included, which evaluates for each α and β if there is an added difficulty when integrating a hole; see Figure 5.

As previously mentioned, this virtual environment is developed in Unity 2019.3.06f which is a multiplatform video game engine created by Unity Technologies. In this specific case using the C # programming language for object-oriented programming. The assets (Tilesets, sprites, and background) come from the asset store of Unity, around this topic a question also arises that will not be answered within this research and is: Does the graphic aspect influence the performance of someone who plays video games?

Talking punctually about the characters in the virtual environment we have these constants: The maximum movement distance in x that each enemy reaches is 3.2 meters (this measure is understood within the virtual environment). And the maximum movement distance in and having an α of 4 is 0.87 meters. The minimum

Figure 5: We can see how these two enemies have a state where there are a hole and another in which it is on a platform, in this case, both enemies have the same pattern $\alpha = 0$ and $\beta = 2$ where it will move from one side to the other linearly at x.

distance the user can have with an enemy is when colliding with it and is close to 0.6. The virtual character has a jump force of 500, thus generating a jump height of 0.5 meters. When you reach the door at the end of this level, reset the level and add one to the speed of the enemies, starting at 1 and achieving a maximum value of 6.

Every time the user's character collides with an enemy, it reappears at a checkpoint that is always in a position after the enemy the user collided with. When reappearing in this position, the character's actions will be disabled for 3 seconds. In case of colliding with the last enemy in the level, this will be the same as the restart of the level and increasing the speed value by 1.

The research question who begins this research is, What are the factors that affect the difficulty of video games for humans? taking into account this question we

formalize this hypothesis:

-The combination of the different paths (different α and β) and the speed is harder than the evaluation of each of these things for separate. -The holes make easier to avoid the enemies with these two parameters(α and β) -A higher α means a lower distance when you execute an action. -A higher β means a lower distance when you execute an action. -The expected function in this experiment is a decreasing function for each of the possible cases, validating the other hypothesis above. -It is more difficult a higher α than a higher β.

Expecting a decreasing function on some of these graphs as the main result, To know a decreasing function f is a function such that increasing the independent variable (α, β, h, speed) x decreases the dependent variable (Distance) y. A function f is decreasing if for every point x in the domain the derivative is negative, that is f '(x) $\succeq$ 0. We will touch on this topic in greater depth in the section Procedures used to obtain data and results.

2.2 Experiment Design - Set-Up

To develop a good experiment several measures are proposed, the experiment will take place in a closed space where distractions can be avoided during experimentation time.

The interface to play is the computer keyboard, using the right and left arrows for movement into the virtual environment, and the space bar to jump. The in-game camera moves with the character as can be seen in Figure 6. In order to reach the conclusion of this interface, it was discussed in this regard and the result of the said discussion was the use of a simple interface, of daily use and that is known by the majority of participants. Also thought in case of carrying out the tests on several computers and in this way not having the need to build multiple interfaces since the testing time is limited.

In this space we mention before we gonna have: a computer, a screen, headphones for the reproduction of the game's audio since the effect of music in video games has

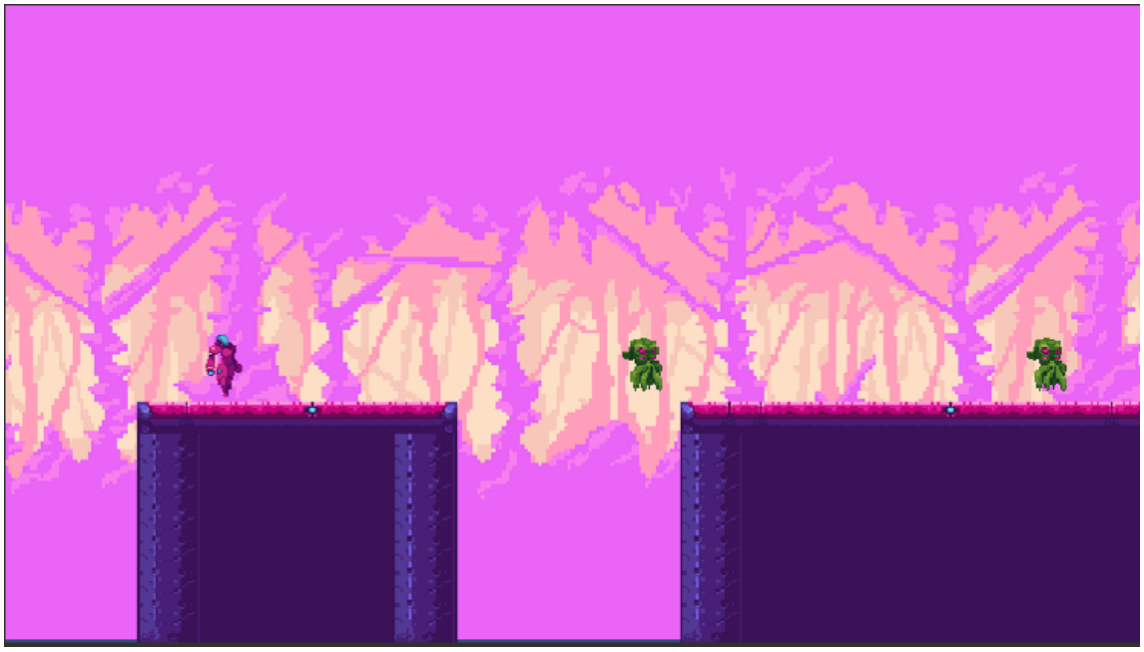


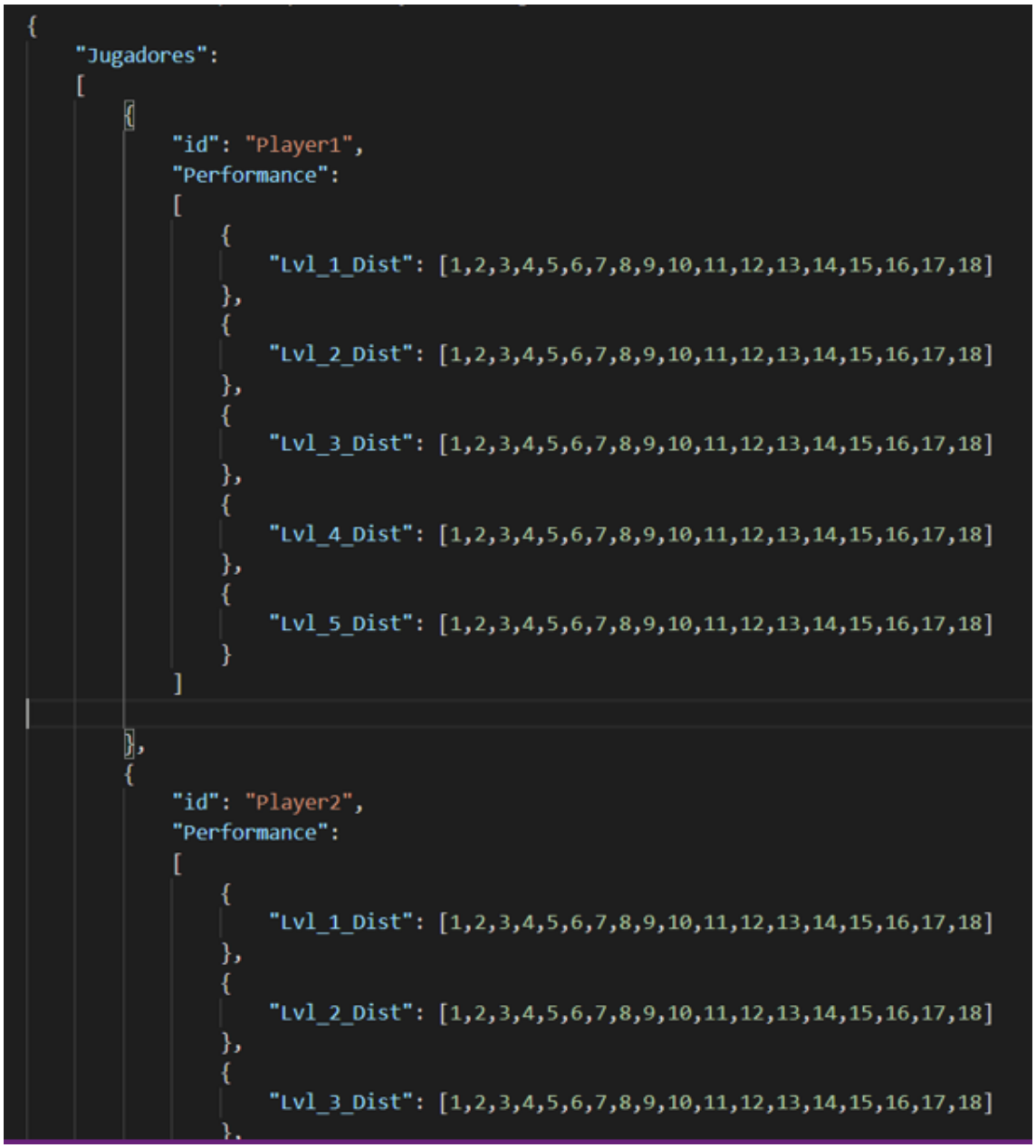
Figure 6: The visualization of the camera, this is how the participant will be able to appreciate the virtual environment.

been studied and has an effect (for more information cite paper), a table, a chair and a person doing a follow-up in case of any doubt. The participant must read the instructions at the beginning of the game and play trying to achieve their best performance (ensure that the minimum distance between the virtual character and the enemies is the maximum possible). At the end of the game, the participant can be able to read and sign the terms of use of their data and a short survey in which they will respond to ensure greater reliability in the data obtained, in addition to having information that may be useful for other possible research.

2.3 Procedures used to obtain data and results

To obtain data as previously mentioned, The plan is saving the minimum distances of each performance (the actions between the virtual character and the enemies into the virtual environment), saving this information in a Json, a simple text format for the exchange of data. Saving in this format for each participant an ID and the 18 possible minimum distances for each level, building the Json structure seen in Figure 7.

The expected results, as previously mentioned the graphs could have the behavior of the decreasing functions, the expected results would be for every pattern with a lower α (fewer subdivisions more height) and/or a greater β (more points decision or movement) and a higher speed the minimum distance is getting smaller, thus showing that the difficulty to achieve high results is greater.



```
{
    "Jugadores":
    [
        {
            "id": "Player1",
            "Performance":
            [
                {
                    "Lvl_1_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_2_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_3_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_4_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_5_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                }
            ]

        },
        {
            "id": "Player2",
            "Performance":
            [
                {
                    "Lvl_1_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_2_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
                {
                    "Lvl_3_Dist": [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]
                },
```


Figure 7: Data saving structure, JSON.

To illustrate a little of our procedure to obtain the data and the graphitization, we develop a short concept test, where the game was tested with three young people

between 20 and 25 years old. By graphing the data we obtained some expected results, other results would be good to make with a larger number of participants. The implemented graphs are the relationship between Alpha, Beta and the speed with the minimum distance of the performance, for this process we made the average of the minimum distances of each of these variables. The terminology used was Alpha = α, Beta = β, h=1 (Means there is a hole), h=0 (Means there is not a hole)

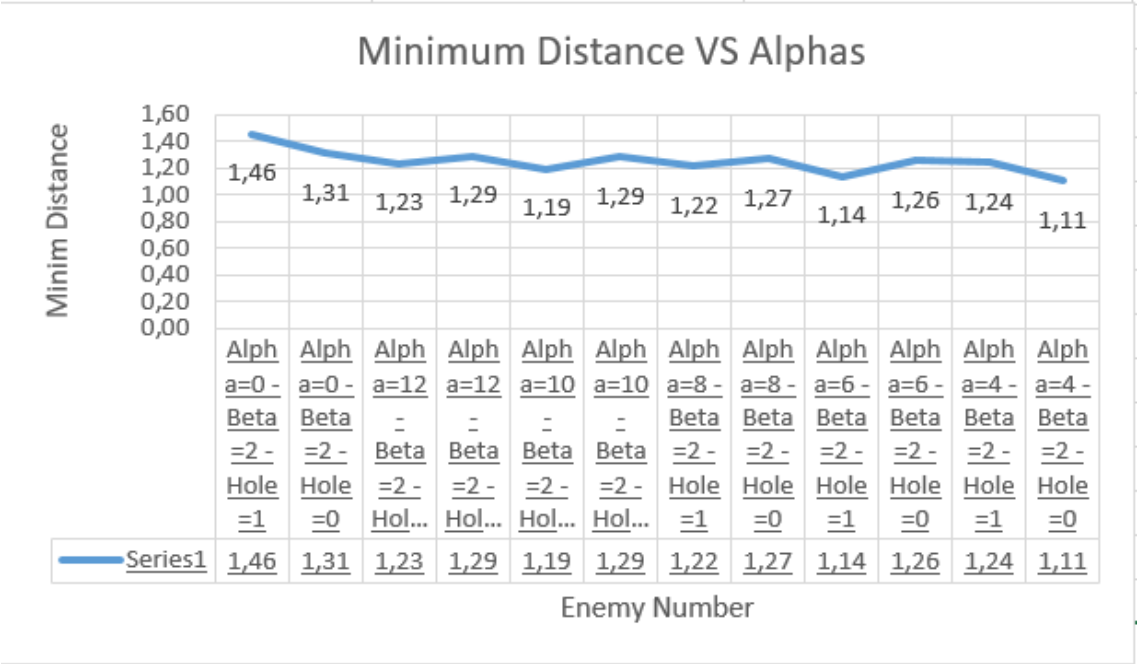


Figure 8: Relation between the distance and the diferent α.

In the graph of the different α and velocities (see figure 8 and figure 10), we can see they follow the behavior of a decreasing function, therefore we can determine that we are obtaining approximately the expected results, in the case of the different β (see figure 9) we do not have this function behavior but we believe if we obtain a larger sample size may begin to demonstrate the expected behavior.

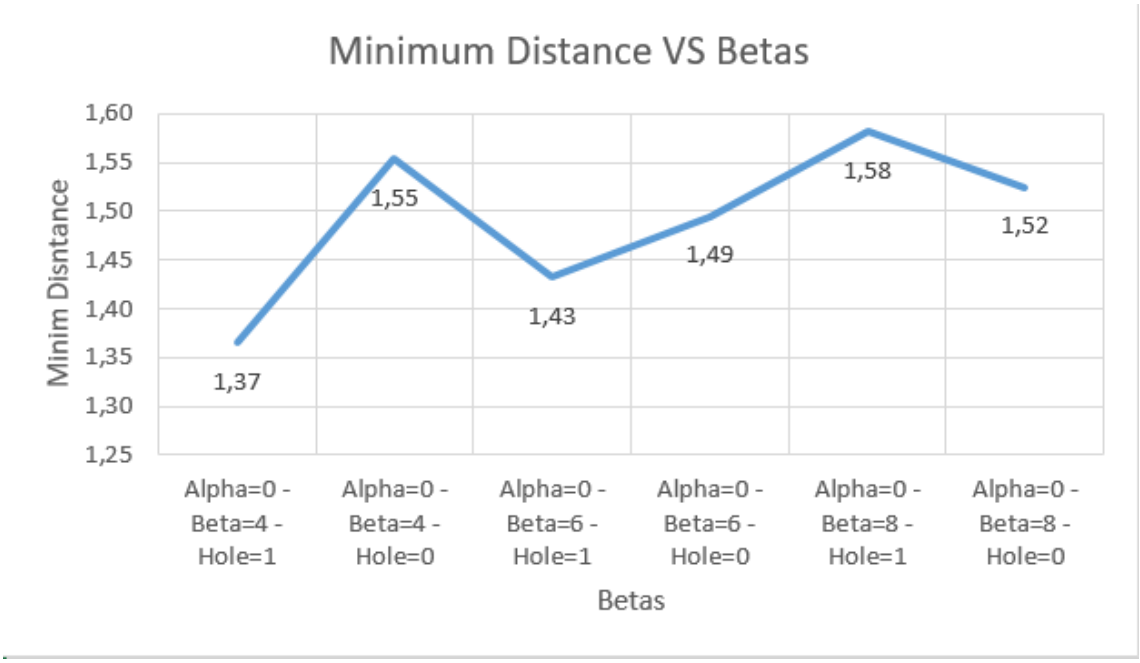


Figure 9: Relation between the distance and the diferent β.

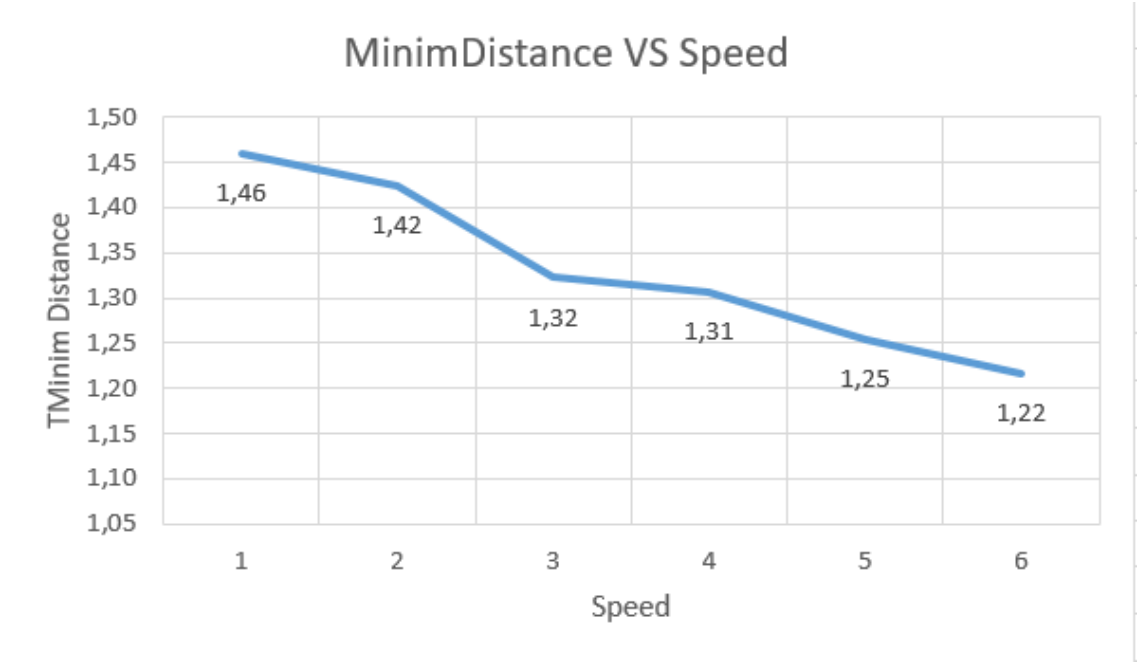


Figure 10: Relation between the distance and the diferent speeds or levels.

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