

Master thesis on Cognitive Systems and Interactive Media
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Human challenges: Difficulty in video games

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Abstract

In this master thesis, we discuss the factors that constitute difficulty. 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.

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 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 rest the main question belying our hypothesis: What are the factors that affect the difficulty of video games for humans?

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.

[1]

1.2 State of the Art

Why are humans so good at solving complex video games? 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. [1]

We start from Juul's definition to explain why difficulty scaling is so important in game design: 'A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable.' [2] Robin Hunicke describes a game using Mechanics, Dynamics, and Aesthetics. Mechanics are the tools we use to build a game (e.g. the rules and limits.), Dynamics describes the way the Mechanic's components behave in response to the player, and Aesthetics is the desirable emotional responses evoked to the player. Of course, the design goals are the Aesthetics, that is to say, the player's emotions. We argue that the difficulty of the challenge greatly influences the video game's aesthetics and therefore plays a central role in game design. [2]

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. [1]

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. [1]

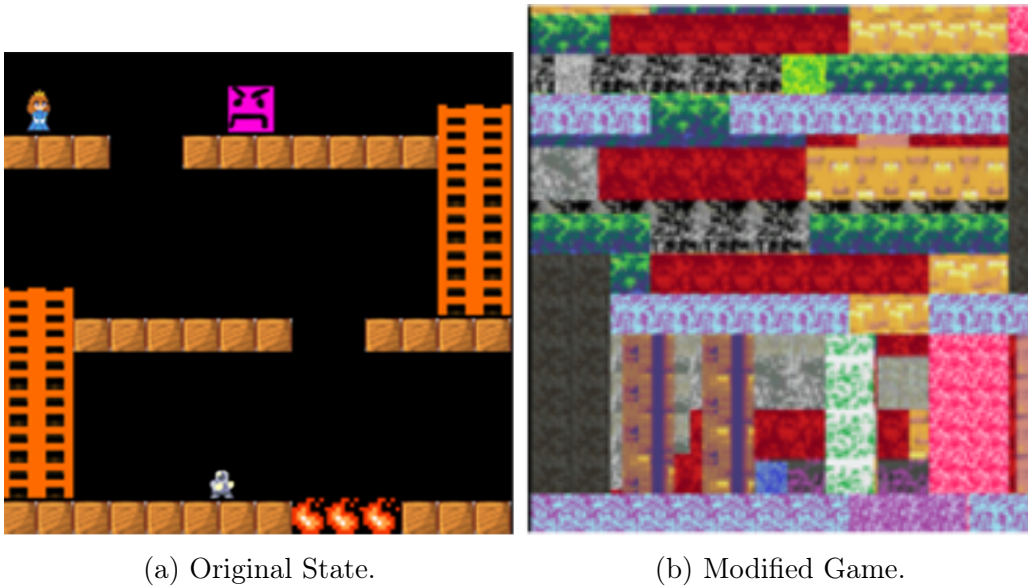


Figure 1: (a) A simple platformer game. (b) The same game modified by re-rendering the textures. Despite the two games being structurally the same, human players took twice as long to finish the second game as the first one. [1]

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 abovementioned 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 about objects, humans also bring in rich prior knowledge about intuitive physics and strong motor control priors when they approach a new task. Here, we have taken some initial steps to explore the importance of such priors in the context of human gameplay.

It is our contention in this paper 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.

The results of Damien Anderson show that all tested AI agents are vulnerable to several kinds of deception, but those different agents have different weaknesses. This suggests that we can use deception to understand the capabilities of a game-playing algorithm, and game-playing algorithms to characterize the deception displayed by a game. If we use this logic with humans, we could ideally be able to discern other difficult factors for humans in games that may help us to create new difficulty paradigms. [3]

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. [4]

Dynamic Difficulty Adjustment: Rather than presenting every player with the same difficulty, some games tailor the difficulty presented to each player using Dynamic Difficulty Adjustment (DDA). DDA is a general term for techniques used to dynamically modify in-game difficulty during the course of gameplay as a means to tailor the experience more toward the player's current level of play. This has been achieved in games through various techniques such as parameter tuning, modifying the level design, machine learning, the use of rating systems and player modeling. [5]

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 (GV-GAI). [6, 3, 7]

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 (citation), 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 (citation).

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 platforms type, thinking this one could be the most common type of video game to be previously played by people and taking 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).

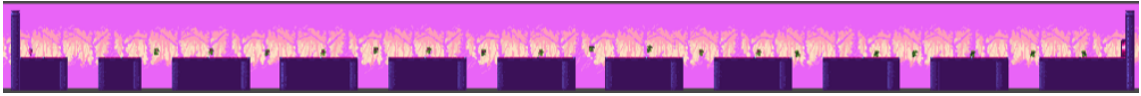


Figure 2: A full view of the level.

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.

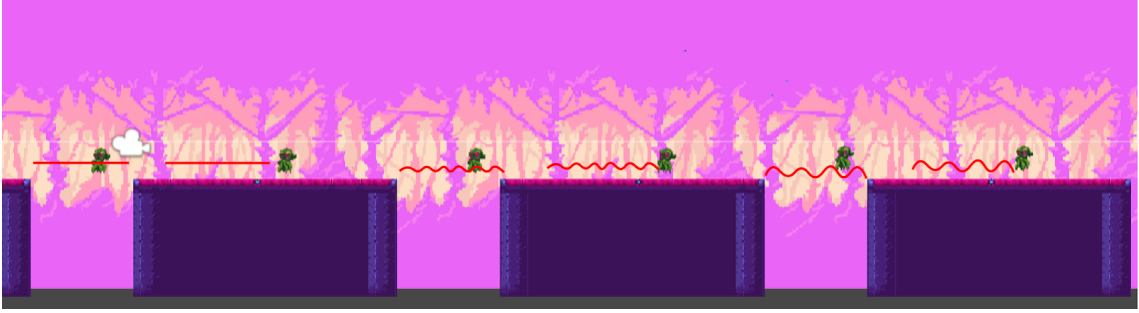


Figure 3: The red lines and curves in the image represent some of the possible α , as we can see as more subdivisions it will generate smaller arcs, while with fewer subdivisions it tends to have larger arcs.



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 $f'(x) \leq 0$. 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

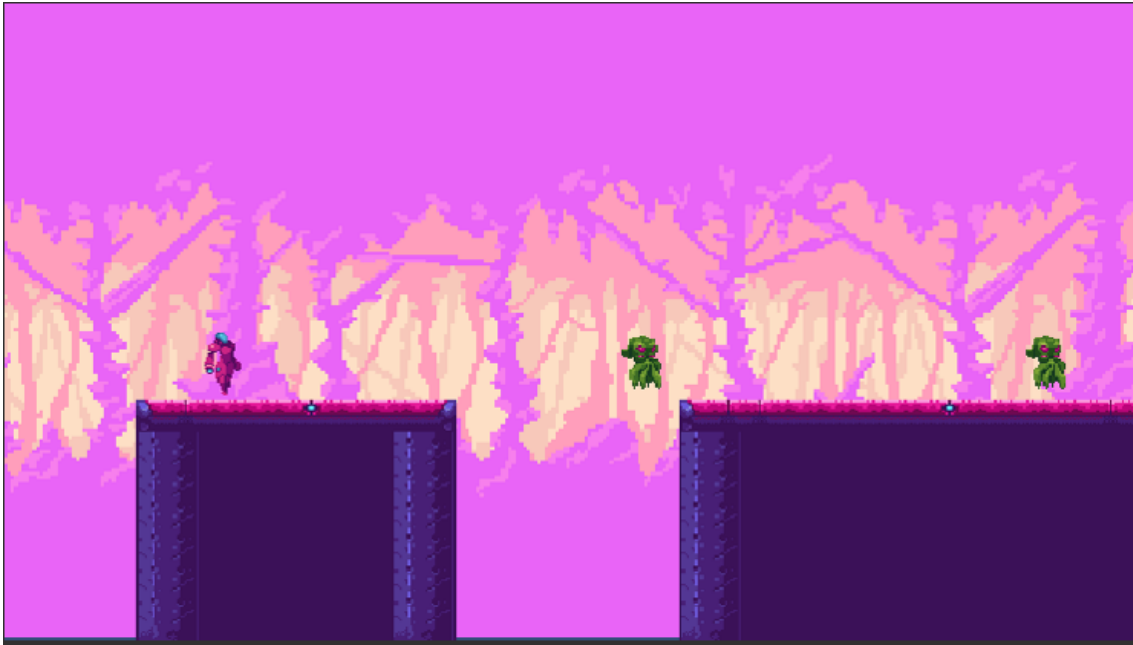


Figure 6: The visualization of the camera, this is how the participant will be able to appreciate the virtual environment.

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.

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