Choosing to See:
Designing Accessible Video Games for Visually Impaired Players

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Introduction

Abstract

As players when thinking of playing video games some memories come to mind, and those images and memories involve people playing around a screen, something very normal when performing such action. But what happens to those that can't see properly? Or those that can see at all? How can they play?

The word video game already includes "video" on it, something that involves the use of the sight. And in their origin video games were something that was created having in mind that the players would be able to use the visual feedback as a way to interact with the game itself. But technology and science have evolved in the last 50 years and nowadays it is possible for a completely blind player to play and finish a 30 h long video game.
Of course this is not the case for the great majority of video games. Most video games developed in the last 20 years have little to no accessibility options, and even the ones that are currently released by big companies and studios rarely meet the expectations.

Living in the 21st century in an advanced and technologic world where even VR games can be played at home, not having proper Accessibility options for the players seems wrong. As developers Accessibility is something that should be taken into account in each game and project worked on from now on. The objective of this paper is not to expose or criticize video game studios in the industry but quite the opposite. The goal of this paper is to inform and educate others and myself on a topic that must concern every developer and that should be something to take into account from the beginning of the development, how to make a video game more accessible for all players, especially for players with visual disabilities.

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Motivation

I started the Video Game Design and Development Bachelor's Degree because I love videogames and they have been a part of my life since I was a little kid. I played them for years without any further problems such as not being able to buy the newest game or console, or having difficulties with certain bosses or levels that were frustrating… but when I saw a visually impaired youtuber, Steve Saylor beat a game like TLOU 2 it fascinated me. The fact that he could play and beat games… How could he? That's when I first learned about Accessibility in video games and the incredible mission that it fulfilled for a lot of disable gamers around the world.

As I studied in this degree and learned about how videogames were made I also realized that not only we didn't have any subject/optative about Accessibility but that we didn't even have notions on it at all. Luckily I'm a healthy person and I've never had a serious health issue, nor think of something permanent. So I grew up without considering how other players with physical or cognitive impairments played the same games I was playing at the time.

This is one of the main reasons why I decided to do my thesis about this topic. To learn and educate myself on the subject of being able to develop video games that take into account Accessibility. Making the decision of focusing only on the vision impaired players was a tough decision to make at the beginning since I'm not targeting the whole Accessibility scene, but I chose to focus on the players that most suffered with the interaction player-screen, a huge pillar in any video game. I thought that targeting visually impaired players would allow me to learn better from a starting point how to design games with Accessibility options in mind, since even though I have no vision problems it is something that I can relate better than having a motor malfunction/problem, in order to adjust game mechanics, add inclusive options etc. Also if I inquired about all the different parts of

Accessibility in video games I would need much more time and I couldn't fit it all in the thesis with the same profoundness with which I would like to. So only targeting how to design accessible games for vision impaired players will allow me to investigate deeply and learn about it in the professional and effective way that I want to do for this thesis.

The Problem to Solve

Accessibility in video games is a much bigger problem than we think. According to the United Nations Disability Statistics Programme in most countries 10-20% of the population considers themselves to be disabled to some degree, and a part of this percentage is interested in or plays video games. From all these disabled gamers this paper will only focus on the hardships and problems that vision impaired players suffer in the gaming world, which are not few.

As video games became more realistic with the change of 2D or simpler video games to more realistic 3D worlds at the same time players with visual disabilities were "punished" so to speak, because visual complexity multiplied with the advance of the technology. And instead of developers making up for it working on Accessibility options that could paliate the new barriers this players experienced, nowadays in the video games industry Accessibility appears to be something unknown or nonexistent in a lot of cases, and it seems that instead of educating about it and helping to make it better, it's preferable to ignore it. With this paper my main focus will be to make the people who read it open their eyes for the players that can't.

This thesis will target the problems and barriers that vision impaired players have to experience when it comes to playing video games and will try to determine if there is a solution for most of them from the design/development perspective, or if by the other hand

some of the problems are so complex and cost so much effort and money to solve that is not viable to do in a normal video game development cycle. AAA productions should always work with Accessibility, hiring professionals of the sector to work in these areas. This paper should guide and inform small video game studios, indie studios, young developers/designers etc.

Is important to raise the awareness of all the readers of this thesis that vision impaired players should enjoy their games in the same way that others do. That designing and applying Accessibility options for them should not feel like a burden on their game development and that it doesn't drag the final result but instead it improves it, because it adds players to enjoy the experience. Not all players will like the same game genres and games, but at least they should be able to try them and judge by themselves.

General and Specific Objectives

The main or general objective for this thesis is to learn more about the impaired vision gamers and their community and identify their problems and struggles when playing video games and how some Accessibility features and techniques help them. Then I'll study success stories in the video games industry related to the Accessibility for vision impaired players, analyze why they have triumphed and what they've done well. With this analysis I'll try to determine from my experience as a game developer, how we can design and add these helping tools to a normal game development cycle(personal projects, indie games etc.)

Educate on the subject of Accessibility and its applications in video games, more specifically for vision impaired players. Once learned everything possible about it,

this thesis will be able to synthesize and correlate their adversities when playing video games with the technicalities of video game design and development.

Analyze and investigate successful cases in the video games industry. The aim is to discover the reasons for their success in terms of Accessibility for vision impaired players and delve into the design techniques and tools they have used to achieve it.

Write and elaborate a set of guidelines. Once educated on the visual Accessibility and researched the techniques and tools that successful industry games have used, the objective is to elaborate a list of rules, techniques and tricks that readers will be able to use in their future projects. These guidelines will also take into account the limitations of resources and time that solo/indie developers have during the development of a project. They will also be different from others that already exist that are general in terms of disabilities, focusing on the field of vision problems and expanding further on it.

To prove that making games with Accessibility in mind is something good. Not only for the industry and for inclusive reasons, but also to put an end to the belief that adding accessibility tools or designing video games with them in mind is not a waste of time but something that should be standardized. Sooner or later we'll all need more options in digital media, either because of a temporary injury or because we age and our body parts no longer work as before. Designing with Accessibility now will help us in the future.

My end goal for this project is to have been able to determine a set of guidelines and tips that will help other developers and people who read this paper on the mission of how to design games having vision impaired players in mind.

Scope of the Project

This project will deal with Accessibility issues in video games and how to solve them from a developer point of view, but it will be focused on visually impaired players. Further investigation into other player profiles with Accessibility issues such hearing issues, cognitive, motor… won't happen in this thesis since more time and even an individual thesis would be needed for each one of those player profiles. It's also important to clarify that there will be segments of this player group that won't have guidelines that will work for their problems, either because it would require advanced knowledge in order to tackle their disability barriers or because the lack of enough time to do so. Even so the vast majority of players with vision problems will be included but it is likely that the guidelines won't work for specific player profiles.

This project will be mainly theoretical, no tools or plug-in that could be used in a game engine will be developed. Instead some guidelines will be created that will be helpful for other developers or academic researchers who want to make games for people with vision impairments. Since the approach of this paper will be mainly divulgative and it has lots of concepts not only from a technological point but also medical-health based, working on a prototype or tool it's out of scope.

The target for this paper will preferably be young game developers who want to learn more about what Accessibility does and what it has to offer, but is also targeting small indie developers that have already created games and would like to add Accessibility options for vision impaired players to their future projects. Overall the main idea for this paper and the guidelines are that they could be read by anyone and that after doing so readers could understand why Accessibility options and design are so important for visually impaired players and how they can have a better experience thanks to it.

Glossary

Abbreviations

Etc., et cetera, and so forth, and others

I.e., id est, that is, in other words, that is to say

Acronyms

3D Three Dimensional

AAA Triple-A video game studios. Their games distributed by major publishers

AMD Age-Related Macular Degeneration

APA American Psychological Association

APX Accessible Player Experiences

CEAPAT Centro de Referencia Estatal de Autonomía Personal y Ayudas Técnicas

CRPD Convention on the Rights of Persons with Disabilities

CVI Cortical/Cerebral Visual Impairment

ESA Entertainment Software Association

FOV Field Of View

GPS Global Positioning System

HCM High Contrast Mode

HP Hit Points

HUD Heads-Up Display

IAPB International Agency for the Prevention of Blindness

IGDA International Game Developers Association

IOVS Investigative Ophthalmology and Visual Science

LP Light Perception

NES Nintendo Entertainment System

NLP No Light Perception

NPC Non-Player Character

PS4/PS5 Playstation 4/Playstation 5

SWOT Strengths Weaknesses Opportunities Threats

TLOU 2 The Last Of Us Part 2

TTS Text To Speech

USA United States of America

VI Visually Impaired

VR Virtual Reality

XAG Xbox Accessibility Guidelines

Vocabulary

508 Section Law that requires Federal agencies to make their electronic and information technology accessible to people with disabilities. Section 508 was enacted to eliminate barriers in information technology, to make available new opportunities for people with disabilities, and to encourage development of technologies that will help achieve these goals.

Accessibility Is the design of products, devices, services, vehicles, or environments so as to be usable by people with disabilities.The concept of accessible design and practice of accessible development ensures both "direct access" (i.e. unassisted) and "indirect access" meaning compatibility with a person's assistive technology.

Alpha Channel Alpha indicates how opaque each pixel is and allows an image to be combined over others using alpha compositing

Attack Combos Typical movements of a fighting video game where the players have to press a succession of buttons to execute combinations of powerful attacks

Autosave Video game feature that allows the players not to have to worry about manually saving their process in the game

Camera Shake Camera Shaking is a technique used to add some real feel to a game. It’s great for signifying the action and making the camera feel more real and part of game

Core Gameplay Principal and most repeated activities that a player can do in a video game

Disability An illness, injury, or condition that makes it difficult for someone to do the things that other people do

Dexterity The ability to perform a difficult action quickly and skillfully with the hands

GAconf Game Accessibility Conference

Game Engine Software framework primarily designed for the development of video games, generally includes relevant libraries and support programs

Game Mechanic Rule or procedure that guide the player and the game response to the player’s moves or actions

Gamepad Type of game controller held in two hands where the fingers are used to provide input for the game.

Game Prototype First iteration of a game that is done before advancing into more elaborated game production phases. It has the principal game ideas and feeling and normally used to pitch the game and evaluate if it's worth fully developing it..

Game Tutorial Tool that teaches players the rules and controls of the game. Some are integrated inside the game while others are totally optional and skippable.

Golden Path In level design, terminology used to define the most correct or shortest path that the player has to follow to complete a level

Guidelines Information intended to advise people on how something should be done or what something should be

Haptic Feedback Technology that can create an experience of touch by applying forces and vibrations or motions to the user

Hardware The physical and electronic parts of a device such as a computer or console, rather than the instructions it follows

Hobby An activity that someone does for pleasure when they are not working

Indie An indie studio is small and not owned by a larger company. Indie video games are made by companies like this

Motion Blur Effect used primarily in games where the surroundings appear blurry on the screen as the player moves quickly through a particular area.

Navigation Mesh Also known as navmesh, is a layer that exists in a game level but that is invisible for the player. It is used to determine which parts of the level are navigable or are obstacles that cannot be passed by the character and the other NPCs

Non-Diegetic Source external to the context of the story, and not heard by the characters

Plug-in A small computer program that makes a larger one work faster or have more features

Remapping Option to assign an input or function to a different key.

Spatial Audio Audio technique that manipulates the sound produced by stereo speakers or headphones. This frequently involves the virtual placement of sound sources anywhere in three-dimensional space, including behind, above or below the listener.

Taboo A social or religious custom prohibiting or restricting a particular practice or forbidding association with a particular person, place or thing.

Target Locking Feature that allows players to target an enemy causing all movement and attacks revolve around it.

Third Person Type of camera where the player character is visible on-screen during play

Tier A level or grade within the hierarchy of an organization or system.

Video Game Studio Company or business specialized in the development of video games

Visual Feedback Visual output from a system such as a video game that allows the user to interact better with the system.

Youtuber Individual who produces videos on the video-sharing platform YouTube.

Methodology

Documentation Structure

The documentation of this thesis will follow a custom structure made from the combination of the recommendations from the tutor of this project, the reference examples given by the college institution and general guidelines found on academic papers. The format of this thesis will partially follow the 7th edition of the APA style which have been used as reference for its sections, titles, headings, text, grammar, citations, bibliography, and most of its general layout, although personal formats to enhance clarity and consistency have also been created and used.

However, function over form will be prioritized, therefore if a certain ruling or format makes it difficult to understand a section of the paper, such will be adapted in that particular part of the thesis with the goal of maintaining the text clear and well-structured, i.e., rules will be ignored if their application in context does more harm than good to the clarity of the contents.

Phases of the Thesis

To elaborate this thesis it will be divided into 5 different phases that will help achieve the desired outcome in a more strategic and clear way.

1. ***Preparation Phase:*** In this initial phase of the thesis first and foremost is key to search for all the initial information and documentation available and group it into a **Milanote** board for later purposes. During this phase it is also very important to start deciding and creating the project management tools that would be used during the

thesis like the **Gantt table and Trello board,** and redact the Introduction and Methodology sections.

2. ***Research Phase:*** The Theoretical Framework will be redacted during this phase, bringing the information and knowledge of concepts needed for later. During this phase it is important to study the State of the Art of the topic in question and to extract all the key information done by professionals and researchers of the matter. Also, to explore the chosen Case Study **The Last Of Us Part 2** a critically acclaimed masterpiece in the area of visual Accessibility that will help during the Development Phase.

3. ***Development Phase:*** Probably the most important phase of the thesis. During this crucial phase it is important to create a summary so that the readers of this document can understand what visual disabilities are and the barriers that they imply in video games. Also to analyze the proposed Case Study and extract useful techniques and design strategies from it from a developer standpoint.

4. ***Conclusion Phase:*** In this phase it will be necessary to elaborate the guidelines after researching the Case Study during the previous phase. To review the guidelines and their usefulness, a visual Accessibility rework will be done to one of the most famous video game levels in history: **Super Mario Bros Level 1-1(NES).** After reviewing the results, it will be clear if the rules have been useful or if any leftovers or tweaks are needed for the final version of the guidelines. If it is possible to contact a professional from the industry so that they can review the final version of the guidelines, the interview will also be included in this phase as an evaluation method and feedback on the project's results.

5. ***Examination Phase:*** Final phase of the thesis, review it from top to bottom making sure it meets the expected quality standards.

Modifications of the Initial Approach

The phases of the thesis **have been modified** for this delivery. This has been decided because the study of The Last of Us Part 2 has ended up being quite rigorous and has taken more time than expected. In addition to the analysis of the visual Accessibility techniques in the game, an explanation has also been included from the point of view of a video game developer who tries to extrapolate them for his projects. This has required more time than expected and the results of such action have created a kind of **draft of these Accessibility guidelines for players with visual disabilities,** that was one of the objectives during the Development Phase.

Therefore, it has been decided that the elaboration of the final version of the guidelines and the subsequent analysis and modification of the level of Super Mario Bros will be carried out during the **Conclusion Phase** as an evaluation method for the thesis to prove if the developed guidelines are useful. Also because the study of TLOU 2 has been so extensive and precise, there has been a lack of time to add an extra case study that was planned in the beginning with **Spiderman: Miles Morales**. It was also planned to ask some questions to different industry professionals who could contribute knowledge for the thesis, but these interviews could not be carried out due to not being able to contact them. In any case the interview will also become part of the Conclusion Phase if at the end it is possible to do, as an evaluation method.

Project Management

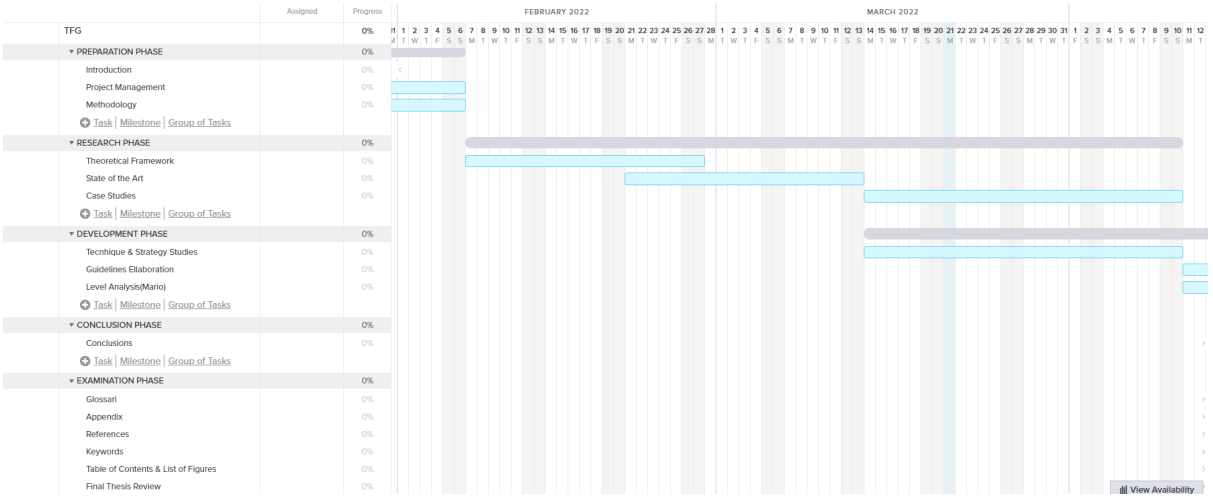
Tools for Project Monitoring

Gantt Chart

A Gantt Chart will be created with the help of the webpage ***TeamGantt.com*** that has all the phases of the thesis explained above. This tool will be used to keep up to date with the predicted work timing, making sure that the times are fulfilled and all the proposed tasks are carried out successfully.

Figure 1

Gantt Chart

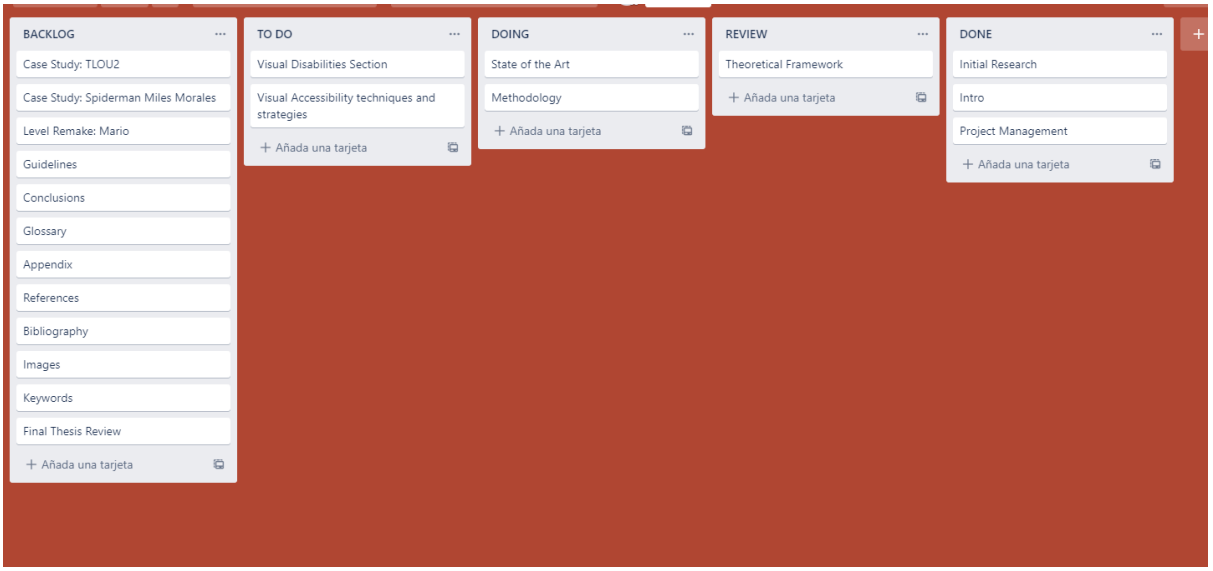


Kanban Board

Another key tool that will be used during this project is a Kanban Board with the help of ***Trello***. Lots of small tasks will be created to dissect the blocks of the thesis in order to carry it out more efficiently, in addition to being able to have an overview of what has been done and what still needs to be done. The Kanban board and the Gantt chart will complement each other very well, helping to know at all times the current position in the global set of the thesis.

Figure 2

Kanban Board

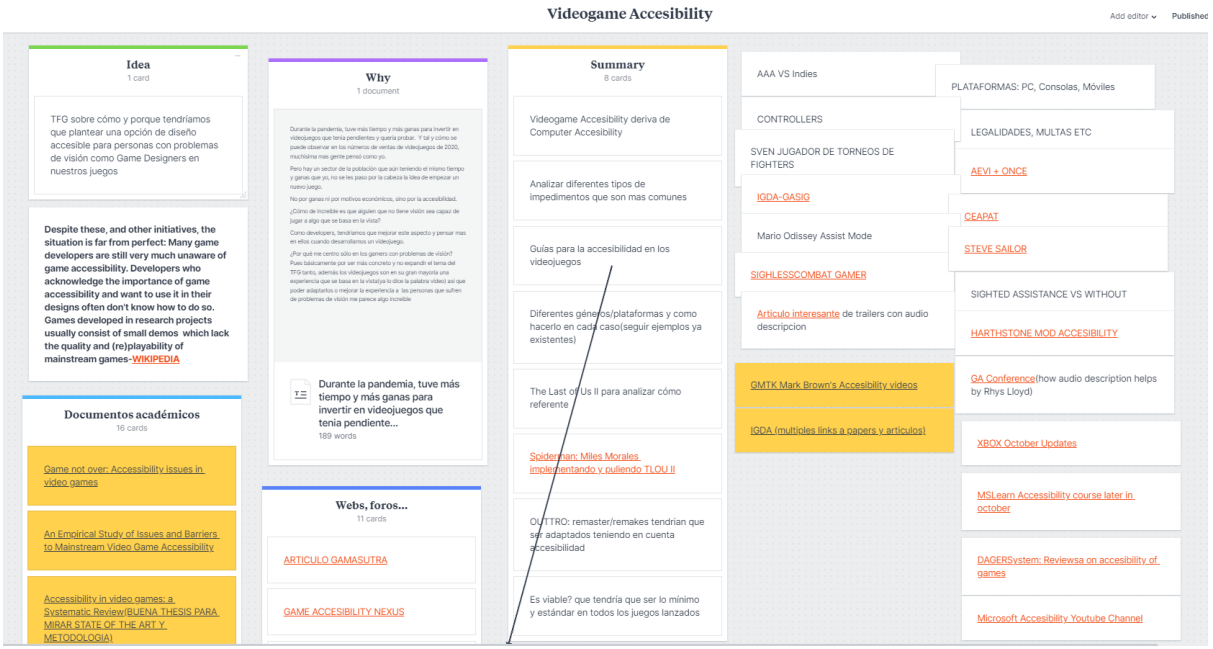


Milanote Board

One of the first things that has been done is to create a board that could store all the important and useful information to be found before starting to write the thesis. ***Milanote*** was the best option because it is clean and simple enough to act as a personal library for academic papers, websites or videos that would contain important concepts for the project.

Figure 3

Milanote Board



Evaluation Tools

The main evaluation tool that will be used to check if the final guidelines are valid, will be to use them in an existing video game level to find out if they can achieve a similar visual Accessibility result like the ones used in video games that have done a good job in terms of visual Accessibility. If they approach something feasible by game developers and are something that can be done in almost any game development cycle, there will be prove that they are useful guidelines that can be extrapolated outside of this thesis

It would be nice to also do some questions or even interviews with some professionals that work or have worked in Accessibility in the video games industry or in an organization that works towards making games more inclusive for players with disabilities. This way the thesis conclusions could be upgraded with their professional feedback.

SWOT Analysis

A **SWOT** analysis will be used to compare the position of this project with other academic research or guidelines that already exist.

Table 1

SWOT Analysis

	Positive	**Negative**
Internal	**Strengths** - Video game development experience - Big interest in the Accessibility area of video games - Proficient with English writing and reading - The thesis requires no big financial investment	**Weaknesses** - Not a real prototype to validate the results - Not very used to academic work - Not experienced with Accessibility
External	**Opportunities** - Guidelines and conclusion could be used by other people - Accessibility is a “hot” topic nowadays - This thesis could bring me to explore other Accessibility areas in the future	**Threats** - Working a full time job, not a lot of time to work on the thesis - Finding candidates for interviews might result difficult - Final result could not be as deep for other experienced developers

Risks and Contingency Plans

One of the biggest risks of this thesis is the available time to develop it. Since I'm working a full time job some problems can appear in terms of grasping too much terrain during the thesis. Another risk is that this thesis won't have any prototype to test the guidelines and conclusions and evaluate them properly. It will be needed to rely on the information extracted from the selected Case Study and in the practical approach redesigning the Super Mario level.

Table 2

Risks and Contingency Plans

Risk	Solution
There's not enough time: I can't do as much work for the thesis as I would like due to time limitations	1. Be more concise and reduce the workload of the thesis to be able to finish it 2. Simplify some parts of the thesis like doing 1 case study instead of 2 3. Remove planned interviews and the redesign of the Super Mario level
Not having enough validation methods: I cannot be sure that my guidelines and conclusions are good enough	1. Focus on developing less guidelines, only the ones that I can be sure that work 2. Reach out to Accessibility professionals to have them validate my conclusions 3. Find other ways of validation

For reasons of time, one of the 2 case studies that were planned for the thesis, Spiderman: Miles Morales, had to be discarded. So the **Risks and Contingencies Plan has been used**. TLOU 2 has been chosen to study because lots of diabled gamers consider it the most accessible video game in history. Cutting the number of video games will make the study much deeper and more rigorous.

Initial Cost Analysis

This is not a project focused on making profit. It will be developed in 4 months and will be treated as if it was a fulltime job in the area of initial costs with the actual economic situation. The thesis won't need a large sum of money to be carried out. The categories of the costs have been reduced to these: hardware, software, books and salary/living costs.

Table 3

Initial Cost Analysis

Concept	Price(€)
Personal Computer(Hardware)	850€
Peripherals(Hardware)	150€
PS5(Hardware)	600€
TLOU Part 2(Software)	20€
Accessibility in Games: Including people with Disabilities(Book)	35€
The Accessible Games Book(Book)	22€
Salary	1000€/m
Water	10€/m
Electricity	40€/m
Total	**5877€**

Theoretical Framework

Accessibility and technology are something that are bound to be together. Ourselves as human beings we are imperfect and we decay over time, our body functionalities stop being the same at some point due to age or other factors. But technology advances to make our life and daily activities better, to help us and to make it more accessible in a lot of cases. Video games are not different. Since some years ago they have become a part of our culture more than a hobby. Nowadays they are one of the big content sources and amusement activities that we consume as a society.

As video games grow popular and become part of our lives, more people become active players and video game consumers. In 2021 at least 67% of the USA's adult population has played some sort of video game according to ESA(Essential Facts About the Video Game Industry, 2021), that's 227 million American citizens. And in 2020 in the USA there were an estimated 16 million people with vision loss, 640.000 were blind(IAPB, 2021). That's a lot of potential players that want to enjoy video games but they can't have a good experience with most of them. As mentioned before, disabilities and life expectancy are closely related and since we live in a world where technology and science make our lives longer, so does the number of health problems associated with aging and disabilities increase. So it is very important that before further advancing in this paper we learn and understand about the most common disabilities amongst video game players and the barriers they suppose to them.

The vast majority of disabilities types that affect people that play video games can be broken into 4 down big groups: Mobility, Auditive, Cognitive and Visual disabilities.

- ***Mobility Disabilities***

Mobility disabilities can be caused through illness, injury, genetics or old age. Players with this type of disabilities are restricted in a very important part of video games, interactivity with the controller or the mouse. Merely moving the mouse fast enough or pressing a sequence of keys or buttons can be a huge problem for these gamers. We can subclassify the different types of mobility-related disabilities in:

Players with Limited Fine Motor Skills and Manual Dexterity: These are players that have difficulties performing small and precise hand, fingers and wrist movements like pressing keyboard keys or grasping a standard controller. This type of mobility disability implies barriers for the players like not being able to play games where the use of 4-5 buttons on an input or action are required to perform essential tasks or the presence of quick-timed events in the game. Solutions for these players include adaptive controllers and specialized hardware, but there's general design solutions that can also make their gaming experience better. Like making sure that all interface components of the game can be operated with digital input or the option for players to automate inputs that must be held in the game for extended periods of time.

Players with Limited Coordination: This subclassification includes players that have hard times doing quick and precise movements, like aiming at small targets in a shooting game. Coordination is a key factor in a lot of our daily life actions, like grabbing a bottle of water and bringing it to our lips to drink from it. For a lot of people it doesn't seem a problem and is an automatic action, but it requires a high coordination and precision to not spill or miss the lips. So imagine how difficult it is for some players to aim precisely in a shooting game using a standard gamepad. Some design solutions to the barriers that this player experience are allowing players to disable or extend time limits inside game events and action, or providing the players with options to have assists to lessen the demand of precise motor movements like for example target locking.

Players with Limited Endurance: Players that experience this type of motor disability will get tired really fast by just the mere action of holding a controller or pressing repetitive buttons, like is typical in a fighting game where players must input combinations of buttons for an extended period of time to create attack combos. One of the best design choices that can be made in this case is to include an Autosave feature inside the game and to allow the customization of it. This way players that may get exhausted in the middle of a crucial point will have the least punishment for stopping the game session. Another good design choice is to have a good remapping feature for players that want to customize their controls, allowing them to place the most important inputs in their prefered way so it's easier for them to play.

Players with Situational and Temporary Factors Impacting Mobility: Like there are gamers that experience disabilities since they were born, there are others that will also experience motor disabilities during a period of time at some point of their lives. This can refer to for example having to wear a cast because of a broken arm, or to having to hold a newborn baby having to change the way they experience gaming. Even in these times Accessibility can make the gaming sessions of these players better and more satisfactory. A good way of doing so is allowing an extense remapping of the controls of the game so players can adapt to it in most of the situations. Or having multiple customization features like auto target locking and being able to extend the time limit in some actions of the game.

- ***Auditive Disabilities***

Players that experience auditive disabilities will have difficult times having a good gaming experience. Lots of games will use the audio element as a pillar for some of their

core gameplay, like for example hearing footsteps in a stealth game, or the gunfire location in a competitive shooting game. Not only that, but some players will experience difficulties and will get lost in the multiple sound pieces that can happen at the same time, like music or NPC conversations. Auditive disabilities can be subclassified in this categories:

Players with No Hearing: Players who cannot hear anything at all will most likely lose some key auditory information inside the gameplay that is not represented with other non hearing related features like text labels, subtitles, visual cues etc. When this key game information is only presented via the auditory channel, gamers who experience this type of disability will have a bad experience and in some cases won't be able to play the game. In an online game that needs communication between players via voice to have a better experience is not such a big factor, but in some shooter games listening from where the bullets are coming is a key factor to enjoy the game. Some good design strategies are to represent audio cues and key info via visual or haptic channels and support subtitles for ingame sounds and dialogues.

Players with Limited Hearing: Some players will have varying degrees of ability to hear the game audio. They will most likely have even harder times to hear when different audio channels are happening at the same time: sound effects, character dialogues, music…
The best solution is to provide players with the option to customize the volume of each individual audio channel.

Players with Asymmetrical Hearing: As there are varying degrees of hearing ability there's also players that have better hearing from one ear. They will experience barriers when a technique as used and popular as 3D/spatial audio happens in a game.
A good solution is to facilitate players with an option to toggle mono audio on and off during their game session.

Players with Situational and Temporary Factors Impacting Hearing: There's many circumstances that make a player's hearing ability be limited while they play. Some players will experience barriers when they play in loud environments or when they need to lower their game volume to avoid disrupting quiet environments like when a baby is sleeping closely. A common case is the lack of access to headphones in public places. In those situations they will need an alternative to hearing the game. Good strategies and techniques are to represent audio cues through additional channels, support subtitles and captions for character dialogues or to provide full transcripts of game narration and dialogue online for player reference.

- ***Cognitive Disabilities***

Cognitive disabilities include a wide variety of difficulties that go from dyslexia to memory loss. Playing video games requires a constant process of information from the game to the player so he can make decisions and react. But players that have cognitive disabilities have problems that affect cognitive processing speeds, attention, memory etc. so there's a lot of games that can create barriers for these players. As said before cognitive disabilities are wide and diverse, but we can subclassify them in this groups:

Players with Learning and Cognitive Processing Disabilities: Game genres are very wide as is their range of difficulty and complexity, but there's general facts such as that players make decisions and decide strategies to solve the problems that games pose to them. These player behaviors come from having previously understood the rules of the game either through a game tutorial or other techniques, but if these techniques to help understand how the game works are poorly expressed or difficult to understand, players with cognitive disabilities will have a pretty bad gaming experience. To help them there are solutions like presenting the game information in a clear and concise way that can be easily

understood, adequately labeling the menu and in-game elements or allowing players to access game glossaries, key terms and items and redo tutorials at any point of the game.

Players with Disabilities that Impact Attention: This classification involves players that easily distract or have difficulties attending to a task for a period of time. Fully focusing on what's happening on the screen is crucial in some games, as in some cases missing out 2 seconds can mean game over for the player. And that’s why developers should allow options for the players to have the minimal possible distractions ingame that interfere with the core gameplay. Good examples of those features are allowing players to adjust the notifications frequencies and timings or to provide high contrast modes that visually mute non-essential background elements.

Players with Disabilities that Impact Memory: Some players may experience barriers when in game references like control schemes, mechanics or objectives of the game are not provided and not accessible from one session to another. Games with complex storylines and narrative or puzzle solving mechanics that require memorization can become a nightmare for players with memory disabilities. Good measures to avoid these barriers are the inclusion of summaries of the narrative storyline of the game that the players can revisit every time or allowing players to create markers and hints that help them remember information in their next gaming session.

Players with Situational and Temporary Factors Impacting Cognition: It is very common to have cognition, memory or attention be easily affected by temporary or environmental factors, like feeling anxious or coming home feeling tired from a difficult day. Young players that are still developing their cognition, problem solving skills or reading abilities can be included in this group too. A good approach to these problems is to portray game information

through multiple methods to supplement text, like audio description, symbols, images… or to allow players to review progress made at any point in time.

Visual Disabilities won't be talked about here because this is a pillar topic in the thesis and will have its own section that we will see later in the document. Personally, being visually impaired or not being able to see anything at all is a type of disability that really strikes at first when we think about having a good gaming experience, just by the nature of video games. That's why it was chosen among other types of disabilities that are just as important and deserve their own thesis.

Historically, Accessibility in technology media started to become a popular topic with the 508 Section in the year 1998 making many organizations having to start getting familiar with how to make websites more accessible for all publics. But it's not really until a few years ago when it's really starting to become a mainstream theme to talk and discuss accessibility openly in the video game industry. The truth is that the great majority of video games that are released nowadays don't have enough Accessibility options and have not been designed to work for disabled players. But there's hope in this situation and there exist some organizations and resources for game developers that work so that their experiences playing video games as well as the standards of the industry improve.

State of the Art

Organizations and Portals

It’s important to talk a little bit about the organizations of professionals that fight towards making this industry more inclusive and that are good advocates and communicators of today’s gaming Accessibility status.

IGDA. The International Game Developers Association is one of the pillars in the gaming industry that cares about working and promoting towards a better gaming Accessibility standard in the industry. Is a huge non profit organization that was created in 1994 and that not only works for the sake of players with Accessibility issues but also takes care of many other issues such as advising young developers towards their future work on the industry, game industry standards etc

They organize a yearly conference, the GAconf where attendees and viewers can listen to a large variety of topics, presentations and research on Accessibility and video games.

AbleGamers Foundation. This charity organization has done and still does an incredible job for Accessibility in video games. The professionals who are part of its ranks have been in charge of training and teaching hundreds of developers in the field of Accessibility. In addition they’ve also connected many players with Accessibility issues to industry studios so that they can echo their problems when playing with their products. They’ve even helped thousands of disabled players with counseling and thanks to their Engineering Team they have created 49 custom equipment solutions for players with disabilities.

And above all something very interesting for this document and that we will see a little further down, is that AbleGamers has created multiple documents and guidelines that

have marked a before an after in terms of spreading and raising awareness about Accessibility in the video games industry

CanIPlayThat?. This web portal does a precious informative work in terms of the video game titles that disabled players can enjoy. The website is responsible for providing players with information about the new titles that come onto the market and how accessible they are. They also have a Codex section where gamers can search and view reviews for the games they want to play, from an Accessibility standpoint. So it’s a perfect tool to analyze how accessible are the games that are currently being released.

And of course the others that haven't been named on this list but work year after year to make the video game industry a more welcoming place for players with Accessibility issues, either through their direct work on projects and video games or through research and dissemination.

Guidelines and Academic Documents

Here's a list of some of the most well known and important guidelines about Accessibility and video games that exist to the date, at least in the public domain. Of course there's more than the ones shown on this list but this list contains the key ones:

AbleGamers Includification(Barlet & Spohn, 2012). As the name of it reveals, this paper wants to act as a first introduction to game developers and studios that want to make video games more inclusive for the players with disabilities. It is a really good starting point to find out more about Accessibility and video games since it is quite easy to read and very interactive. It has great features like a "tier" of 3 levels that does Good/Better/Best for each Accessibility section. This allows devs that want to expand more in certain areas of the document to find more resources about it if they wish. It also has a group of sections called Developer Exercises that help developers and readers apply what's just been read to their prototypes and designs. It was written by Mark C. Barlet and Steve D.Spohn in 2012 in the name of the AbleGamers Foundation. It's a little bit old and may be a bit outdated. That's one of the main reasons why the AbleGamers Foundation worked on a newer and more complete project that we will see next.

AbleGamers Accessible Player Experiences(AbleGamers Charity, n.d). As the industry of video games has evolved since 2012, so had to do the **AbleGamers Includification** paper. So the AbleGamers Foundation partnered with the University of York in a project to upgrade and build from the base of their previous award winning job into something that was more with the actual state of the industry. APX is a web portal that as his predecessor did aims to …

The APX contents are divided in a pyramid shape like system. The base of the pyramid is the Access section and in this part it asks developers to focus on fulfilling the Access Patterns, a set of guides that help players access the worlds and the games created

by the developers. Then in the middle we have the Challenge one, this part of the pyramid is basically the one that helps players adapt the problems and the defiances that happen in that game or in their playing session by following a set of guidelines called the Challenge Patterns. When both parts of the pyramid are successful is when we have created the apex of the pyramid and the Accessible Player Experience has been accomplished.

XBOX Accessibility Guidelines v2.5(Microsoft, 2021) . Microsoft is one of the top companies in the industry that has been most involved with the community and acts as an advocate for players with Accessibility problems. During last year 2021, Microsoft has worked on a lot of projects to help the industry take more care of this group of players with things like: letting developers submit their games to them for evaluation and feedback in Accessibility matters, releasing a 4 hours free Accessibility online course available for everybody, adding Accessibility options to their console and tags inside the microsoft store… And last but not least important updating their Accessibility Guidelines. These guidelines are directed to developers that want to generate ideas and designs that are able to pass a series of checklists to ensure that their projects are “accessible friendly”.

As said before in addition to these guidelines Microsoft has more resources that can help developers with Accessibility matters such as the free Accessibility online course or a complementary document to the XAGs, the **Gaming and Disability Player Experience Guide(Jones & Mortaloni & Zahand, n.d.).** This supplemental resource aims to help developers understand the barriers and problems that players with disabilities have to fight to enjoy a gaming experience, complementing the XAGs document that focuses more on technical video game development related material.

Game Accessibility Guidelines. These Accessibility guidelines are probably one of the most famous inside the videogame industry. They are very complete and are divided in 3 categories: Basic, Intermediate and Advanced. These categories are determined by the

balance between the number of people they will reach, the impact or difference they will make for those people and the cost of implementing them. They are also subdivided by the type of impairment that the gamer is suffering: motor, cognitive, vision, hearing, speech and general.

This document is written by a group of top notch developers and experts on Accessibility and each section is very easy and clear to understand even for a new developer since at the end of each guideline section there's an area of the best games that have applied that Accessibility feature correctly. They also have created an excel document that works as a checklist for developers when they are working on their future games, with links to all the guidelines which is very helpful.

Good practices of accessibility in video games(L Pérez-Castilla Alvarez, 2012). This document has been included in the section because it was made by professionals from Spain, my country and personally it made me happy to see that Accessibility and videogames was a concern that was being addressed in our national industry. It is supported by the State Reference Center for Personal Autonomy and Technical Assistance(**CEAPAT**) and intends to help developers and designers make their games more inclusive for disabled players from the beginning of their design process.

Towards Generalized Accessibility of Video Games for the Visually Impaired(Yuan, 2009). Even if this document is a bit old and can suffer from being outdated, it is very interesting not only because it explains the Accessibility of video games State of the Art for those years but also because it studies and extracts conclusions from 3 different case studies of video game prototypes created by themselves.

Having seen some of the existing guidelines and documents that tackle video game Accessibility, the main reason why this will be different and how it will contribute to the

readers of the thesis will be explained next. This document has a clear objective that others seen above don't have, it targets specifically players with a visual impairment. This means that all efforts will be put into delving into this subject, making case studies of industry video games that have achieved good results in those terms and allowing me to develop much more precise guidelines and advice for readers who are interested in Accessibility for visually impaired players. The techniques and design strategies that will be studied will also be pretty actual since some case studies will be recent industry games, so my conclusions will also be more reliable to the current state of the technology and the video game industry.

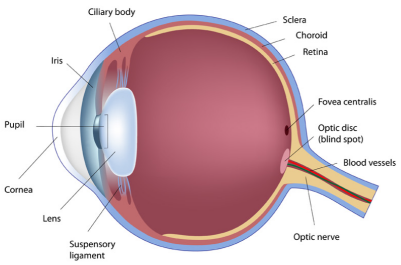
Visual Disabilities

Vision is probably one of the most important corporal senses that we use when playing video games. So it's safe to say that players with vision impairments suffer many problems and struggles to enjoy the experience of playing video games. VI gamers must rely on other senses like touch and hearing, and use them far better and more extensively than anybody if they want to play a game and have a good session without the vision sense. Vision is incredibly complex. We have sight thanks to our eyes and they are able to work all day non stop even though they are a small part of our body. To understand vision in a general spectrum and figure out what are we talking about, vision works in this way:

1. The light passes through the ***cornea***, that bends light to help the eye focus
2. Some of this light enters the eye through an opening called the ***pupil***. The ***iris*** controls how much light the pupil lets in
3. Then the light passes through the ***lens***. It works together with the cornea to focus light correctly on the ***retina***
4. When the light hits the retina, special cells called ***photoreceptors*** turn the light into electrical signals
5. These electrical signals travel from the retina to the brain through the ***optic nerve***. Then the brain turns the signals into the images we see.

Figure 4

Eye anatomy



What is a Visual Disability

Disabilities can be defined using the medical and social models(CRPD, n.d). Using the medical model it could be said that a visual disability occurs when a person’s interaction between its vision sense and his health condition are not working properly, either for example because they see blurry instead of clear or because they cannot see at all . The social model on the other hand would explain that a visual disability happens when a mismatch between a person's vision sense and its environment/daily life occurs. Let's put a simple example to better explain the social model definition.

A blind person is walking in the street, crossing traffic lights and street crossings thanks to a machine that interacts with the traffic lights and produces a sound when they are green. This sound warns the blind person that they can pass. The disability appears when the machine that interacts with the traffic light stops working, because that VI person was able to do his day to day normally until that moment in which a barrier was created for him.

Perceiving disabilities from the social model prisma is more correct and should be standardized, because it implies that being disabled is not something limited to a disease or a lifelong condition. It implies that being disabled is something that can happen to anyone at certain times in their life. That makes more sense since it is possible for example that in 20 years from now someone you know could have problems with my sight, making that person VI and having to face daily barriers.

Types of Visual Disabilities

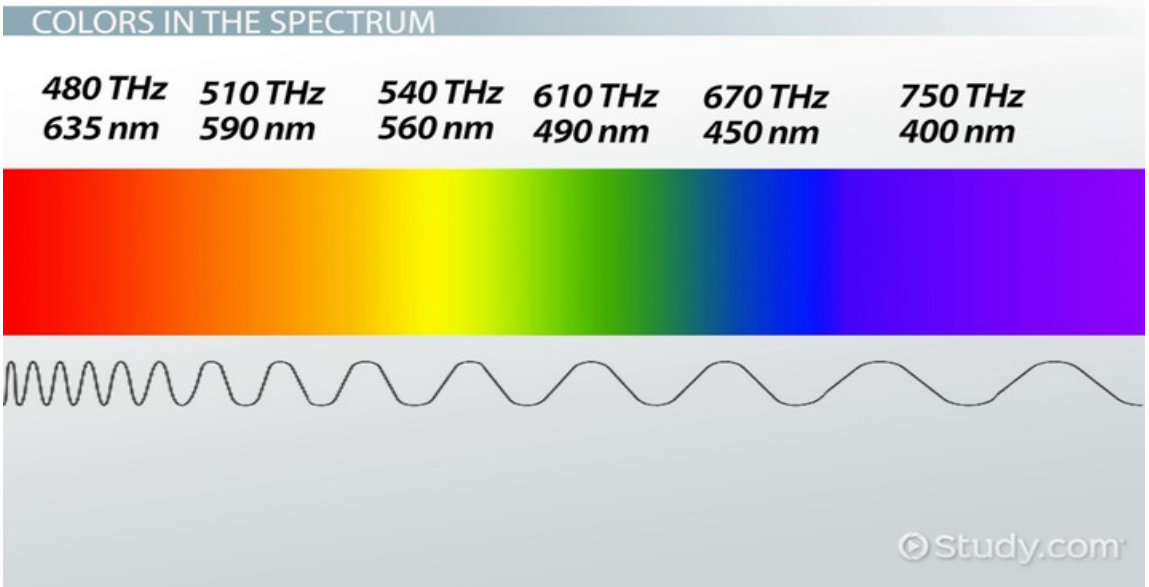
Visual disabilities are very extensive and each one causes players different barriers in their gaming experiences. The most common visual disabilities that affect gamers will be explained next: how they happen (since now we have a better understanding of how vision works) and the barriers that are created when a video game is not accessible enough for their condition.

- ***Color Vision Deficiencies(Color Blindness)***

Color blindness or more accurately, color vision deficiency is a condition that affects how humans perceive color. In the backside of the internal part of our eyes we have the **retina,** formed by special nerve cells that contain pigments that react to the light(**cones**). Our eyes act as a camera that captures the wavelength of the light, and each color has a frequency.

Figure 5

Colors in the spectrum



The most common cause for color blindness comes from the genes inherited from the parents. But there are other causes for color deficiency like physical or chemical damage to the eye, damage to parts of the brain that process color information, cataracts or age. Color deficiency happens when there's a problem with how the cone cells react to the light wavelength. This can cause color deficiency varieties depending on which colors are affected, or even by not seeing colors at all. These are the different types of color blindness:

Red-Green Color Blindness: Happens when the cone cells don't work properly with red or green color frequencies. Is the most common form of color blindness. Some varieties like the **Deuteranomaly** can make yellow and green colors look redder and make it hard to tell blue from violet. The **Protanomaly** variety can cause orange, red and yellow to look greener and make colors less bright. Other varieties like the **Protanopia** and **Deuteranopia** can cause to not have working red cone cells or green cone cells respectively, not being able to perceive those colors.

Blue-Yellow Color Blindness: This type of color vision deficiency happens when the cone cells don't work properly or at all with blue frequencies. The **Tritanomaly** variety makes blue colors look greener and it can be hard to distinguish pink from yellow and red. **Tritanopia** makes blue look totally green and yellow look light gray.

Complete color blindness: People with this color blindness don't see any color at all and their vision may not be as clear. The **Rod Monochromacy** variant makes the world black and white, like in an old time movie. The **Cone Monochromacy** makes the person not be able to distinguish hues. This type of color blindness creates barriers that cause everyday tasks to become really difficult to do because of it.

Tetrachromacy: This variant happens mostly to women and provoques them to have a “super color vision” allowing them to see 100 times more colors than the rest of the population. This variant of color deficiency can also cause barriers when playing video games.

Having problems perceiving the green and red colors, for example, can create big barriers in video games. Because those 2 colors are used very much in lots of situations and core mechanics like distinguishing an ally from an enemy or location useful/dangerous game items… Green and red colors are pillars in game design and because of the **color affordance** and the message they provide to the player(good/bad), designing the gameplay without having in mind Red-Green color deficiencies can create big accessibility barriers. Now we will see the most important techniques and design strategies that can help avoid the accessibility barriers that players with color blindness experience

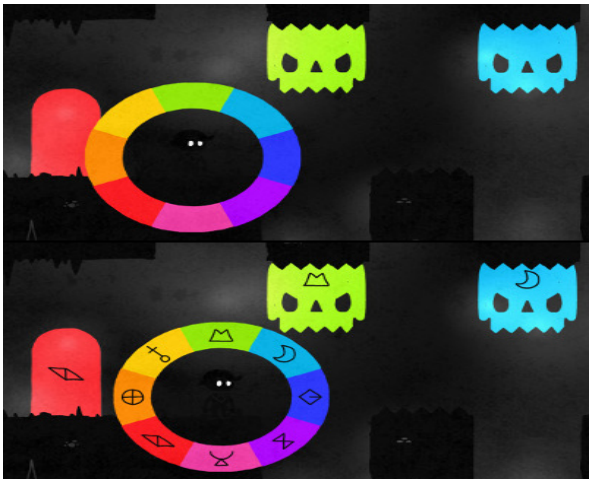
Color blindness is mostly present from birth, and people with it usually experience normal and complete lives. It is true though that in some cases like for example applying for a specific job position or playing video games, color blindness can create multiple barriers. In this section we will talk about the most common barriers in video games for players that experience color blindness and the best techniques and strategies that are used in video game development and design to facilitate them for the players.

A lot of times in video games we use the language of colors to give information for the players in a visual fashion. It is very common to see important/interactable NPCs with a color that symbolizes good/friend like the green color and also the other way around, dangerous or enemy characters with the red color. This is very effective in most of the cases but is also very misleading for a colorblind player.

It is better to **use color as a backup** to something more general such as a **symbol or a shape** that causes less impact on a colorblind player. A good approach would be to allow UI and Gameplay elements that are color dependent to be customizable in color and contrast. The player must have the freedom to choose the color he wants to see his enemies with, which color should the crosshair be etc.

Figure 6

Hue's colorblind mode



And even better than that, would be to have different **pre-made profiles** for the most common types of colorblindness, so the players can select them and jump right into the game instead of wasting time customizing the colors of each element.

Important HUD elements like the health bars or the text dialogue captions should have a **high contrast** design between them and the background. When this is not possible add to them **outlines and shadows** to separate them from the background colors.

Figure 7

Bertram Fiddle subtitles

Recolouring the whole game using a palette filter is something that has been done multiple times and that is very tempting due to the "cheapness" of it. But a big part of the color blindness players are not 100% ok with it since they are forced to see the whole game in a weird and unnatural manner, which makes them feel strange and frustrates them. Therefore before applying a recolor to the entire game palette, it is much more preferable to give other types of Accessibility options such as those mentioned above.

Figure 8

Overwatch color blind mode

Some tools are available for developers to help verify that their games are viable and meet the condition for not creating barriers related to color perception, such as **Color Oracle** or plug-in filters for popular game engines such as UE and Unity. These tools will help developers test before prototyping to see if game elements need changes and continue designing from there.

And at last a good rule of thumb to make game elements or team based games more accessible for colorblind players without requiring any major changes is to use **orange and blue color palette** to define the color affordance. Orange and blue are colors that most color blind players can easily differentiate so it's a good design approach instead of using red-blue or red-green colors.

Figure 9

Rocket League color palette

- ***Low Vision:***

Players with low vision disabilities experience different degrees of ability to see visual digital content. This can't be cured or fixed with contact lenses/glasses or even surgery, and they face multiple barriers while playing video games or consuming digital media. Low vision can be caused by many different eye conditions which include: cataracts, AMD, glaucomas, diabetic retinopathies or retinitis pigmentosa. Aging doesn't cause low vision on its own but it's more common in older adults due to many diseases that can cause it being more common in that age.

Figure 10

Low vision view examples

Cataracts are a clouding of a part of the **lense** inside the eye. The clouding interferes with the light that reaches the **retina** causing the loss of vision. This condition can be caused by long-term exposure to the sun's ultraviolet radiation, injuries, diseases and inherited disorders. **Age-related macular degeneration** is a condition that affects the retina, most specifically the **macula** (area on the retina responsible for sharp central vision) that deteriorates causing blurred vision or even a central blind spot on the area of vision. AMD is mainly age related but also has other primary factors like nutrition and cigarette smoking. A

glaucoma is a group of eye disorders that lead to progressive damage to the **optic nerve**. It is known by loss of nerve tissue that results in vision loss. A **diabetic retinopathy** is a condition that may occur in people who have diabetes, causing progressive damage to the **retina** resulting in vision loss. **Retinitis pigmentosa** is a group of inherited diseases that damage the light-sensitive specialized cells, the **cones** and the **rodes** in the retina. This gradually destroys night vision and reduces side vision.

As seen above there's multiple conditions that can lead to low vision disabilities, causing lots of Accessibility barriers for the players. Some of the most common low vision disabilities that affect gaming are:

Central Vision Loss: The loss of the central vision creates a blur or blind spot which makes it difficult to read, recognize faces and distinguish detail at distance. Mainly produced by conditions such as AMD or Diabetic Retinopathies.

Figure 11

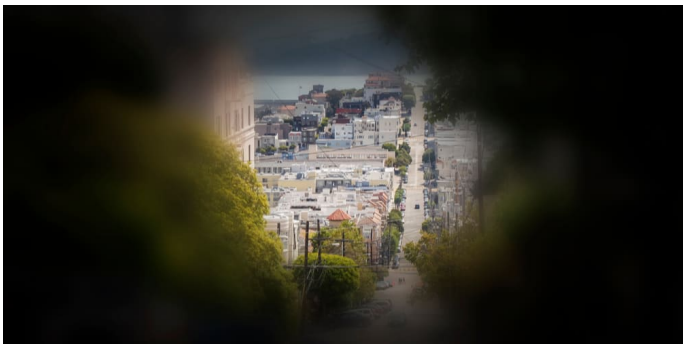
Central vision loss example

Peripheral Vision Loss: People without peripheral vision cannot distinguish anything to one side or both sides, or anything directly above and/or below the eye level. The loss of peripheral vision can create the “tunnel vision” effect that may create big difficulties to read

since the person can only see a few words at a time. It's mainly produced by conditions such as Glaucomas or Retinitis Pigmentosa.

Figure 12

Peripheral vision loss example



Blurry/Hazy Vision: With blurred vision both near and far vision is out of focus even with the best possible correction with eyeglasses.

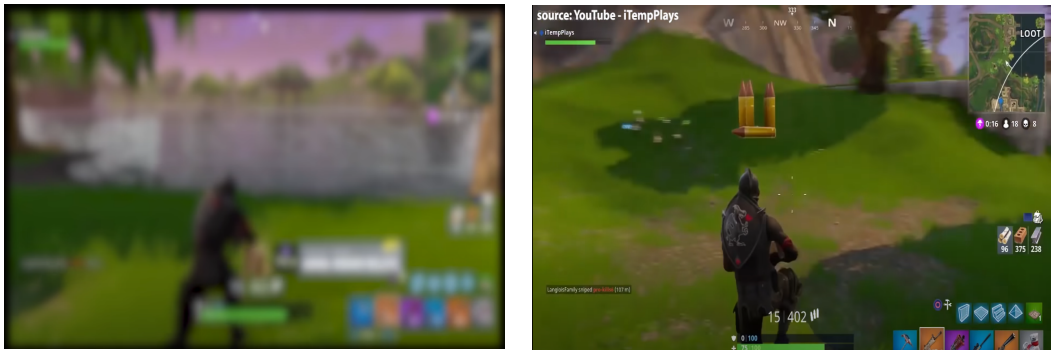
Players with low vision disabilities experience lots of difficulties while using a screen since they might miss some vital visual information being presented. One of the best solutions that can be added to the video game options for that problem is to provide the ability to **manipulate the position of important HUD elements** so they can change it in convenience for their personal condition.

Supporting **text and UI scaling** is another key Accessibility option for low vision players. Text and UI are very important elements of video games, in areas such as in menu screens, text in gameplay environments and even in error messages. These elements should be modifiable in aspects like size, color, thickness, type of font… there's a huge variety of possible modifications. The best way to do so is providing players with total control over these aspects to adjust their values at will.

Allowing players with low vision to use **Magnification Tools** in game is of huge help when they want to focus on some part of the screen they are struggling to see, or in that part of the level they need to check better. Low vision players may need to play nearly glued to the screen at a super close distance to play in normal conditions and distinguish all the elements of the game. With magnification these problems can be solved allowing players to zoom in when they need.

Figure 13

Low vision player(Steve Saylor) view at a normal distance VS how other players see it



Total **remapping of the controls** is important for a lot of players with low vision. If a video game has lots of features they can use that helps the players with the gaming experience like the previously seen the Magnification Tool, the players should be able to decide which keys or controls they want to use for that specific feature. Also in PC games it is very likely that low vision/blind players won't use the mouse because it is not useful for them, so if the controls are not fully remappable to the keyboard the game won't be accessible for them.

If a video game has **opaque backgrounds behind text** or has the option to do so, it's helpful for players with low vision since it allows them to focus the sight effort on the text without having the background images disturbing them.

In 2016 when Uncharted 4 was released by the video game company Naughty Dog developers of the game were creating an Accessibility feature without knowing it, the Thief Mode. The game already had some Accessibility options, but this one was unintended. This **high contrast** feature was unlocked after players finished the game, and it allowed them to activate this visual high contrast filter that helped players with low vision problems a lot. Thanks to the higher contrast between the enemies the player and the level, things suddenly were easier to distinguish and the gaming experience was way better for people with low vision. This would be the precedent or first stone of the High Contrast Display, an Accessibility option that the company would integrate into one of its next games TLOU 2 and which we will talk about later.

Figure 14

Uncharted 4 Thief Vision Mode

Of course this type of work clearly needs more resources and time to be something that an indie developer can manage, but there are some alternatives that can be accomplished with not much effort playing with the contrast.

- **No Vision:**

When we refer to players with no vision we talk about players who cannot perceive on-screen content and that experience barriers for that. We can consider most of these players to be what is called “legally blind”, that is based on measurements of central visual acuity (what’s directly in front of you) and field of vision (what’s above, below and to the sides). Someone is legally blind if their better eye — while wearing any glasses or contacts — has a visual acuity of 20/200 or less or a field of vision of less than 20 degrees(based on the United States of America laws). In 2020 it was estimated that nearly 50 million humans(IOVS, 2020) were legally blind. This doesn’t mean that they can’t see at all, most legally blind people have some form of usable vision, blindness can be divided by people who have LP or people with NLP the later being the one known as totally blindness.

The majority of the causes for being legally blind are the same explained in the low vision section: Cataracts, Glaucoma, Retinitis Pigmentosa, AMD and Diabetic retinopathies; since these conditions when aggravated can end up causing blindness. Of course there’s more possible causes for it like the **CVI**, the leading cause of blindness in children. This type of visual impairment is brain related unlike most of the previously seen before that were eye related. People with CVI can see, but what they see is not the reality so they are blind to it. A child with CVI, for example, may see the world as a swirling mass of colors, motion and light.

Figure 15

CVI view example

Blind players need to rely on other senses besides the vision, the most importants being the hearing and the touch. Since most of the visual information that is depicted on the screen will be useless for them, they will face lots of barriers when playing video games. Having this in mind it can be determined that **adding more sounds and having a good sound design** is a key factor to make a video game playable for blind players. This means having a sound dictionary for the gameplay, from elements like the footsteps of the character to help players know if they are actually moving or bumping sound when colliding with walls or structures to make sure they don't get stuck. Any sound cue possible will be needed and each individual sound should be different and recognizable so blind players can memorize them.

Having sounds for everything possible is good, but the quality of the audio must also be prioritized. The video game should have what is called a **spatial audio** sound system, meaning that every sound the player hears is localized and has a sense inside the game world. For example if an enemy is coming from the north-east direction the sound must come from that direction too, and the intensity of that sound should also depend on the distance of the enemy. Having the ability to **fully customize** different audio sources individually is another helpful tool since players might feel overwhelmed listening to all the

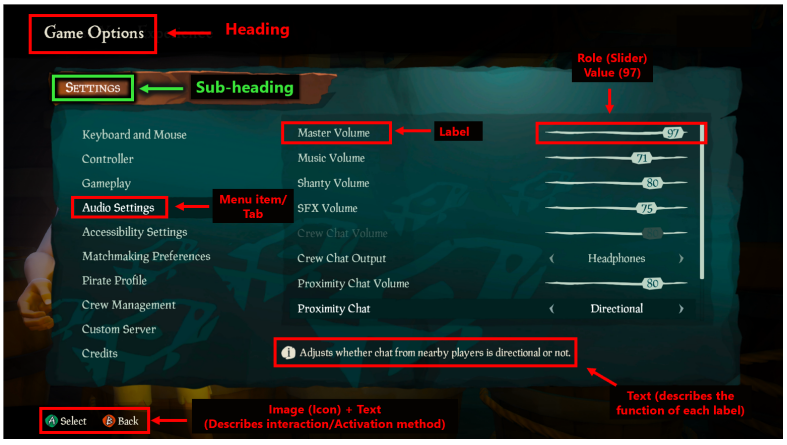
sounds at the same time, so being able to lower/amplify determined sounds is a good facilitator for blind players.

The touch is the other main sense that blind gamers must rely on when playing. There's multiple good devices that can allow developers to add extra feedback to their games, like for example the current PlayStation 5 DualSense Controller that has an incredible **haptic feedback** used to help players. So when possible adding this system to the video games will allow for a better gaming experience for blind players.

One of the main barriers that blind players have while playing is that they cannot navigate the menus. This should be a main feature when working on accessibility options for people with visual impairments. If an audio queue prompts up when the player is focusing a menu text or a menu label it's possible to understand what he's doing without external help. **Menu narration** should describe exactly what a sighted player will see, even the "B button for going back" or "A button to accept" images/icons should be narrated when the action is required.

Figure 16

Sea of Thieves menu narration scheme



Besides menu narration another must have accessibility feature is the **narration of all game text**. This includes every text inside the gameplay, from options to items available to buy from a merchant NPC. All the text narration of the game can be achieved via self voicing(more expensive and time consuming) or via the use of an external piece of software, a **screen reader**. Of course not every game has the same elements or the same game mechanics, but almost every game has elements like the UI that are very suitable for the use of this type of software, speaking out the UI elements that the players are focusing on. Nowadays this feature is quite easy to apply in video game development thanks to famous game engines like Unreal or Unity supporting third party software screen readers or plug-ins.

And last but not least, adding **audio description for cinematics and cutscenes** is another accessibility feature for players with no vision. This does not only include big cinematics, but any kind of cutscene or text based dialogue that can happen in the game should also have audio description. If the game has any kind of story based element, making players feel immersed in the story is crucial for them to feel engaged with the game.

Case study: The Last of Us Part 2

As had been stated in the Methodology section, for this thesis the best case study is the TLOU 2. This video game was developed by the American company Naughty Dog, that has developed games such the Crash Bandicoot series, Jak and Daxter or the Uncharted games. The game was released in the summer of 2020 for the PS4 and later a performance update was released for the PS5 in 2021. TLOU 2 is the sequel of the successful The Last of Us previously released on PS3 in 2013, and it was directed by Neil Druckmann.

Figure 17

Naughty Dog's video game franchises

Besides being a big commercial success, it was qualified by many visually impaired players as one of the most accessible video games ever made. For this paper it is very interesting to analyze the work carried out and managed by two lead designers in specific: **Emilia Schatz**(Lead Game Designer) and **Matthew R. Gallant**(Lead Systems Designer). Both were in charge of the Accessibility features and options that TLOU 2 ended up offering.

One of the main reasons why the game was a huge Accessibility success is due to the developers creating a **special QA Accessibility** team that would check each feature to

make sure it was working well and fulfilling its purpose. Another big reason why it went so fine is because the studio contacted and hired external **Accessibility consultants** like Steve Saylor or Brandon Cole, both suffering from visual disabilities not only to help with the design of the features but also giving them feedback in playtest sessions to iterate on the feedback they would give. And lastly but not less important, the Accessibility of TLOU 2 was conceived from the pre-production phase of the game development, designing the levels, the game mechanics, the UI teh gameplay etc with **Accessibility in mind from the beginning**.

These elements added to the efforts that the Naughty Dog team did are the keys that made the video game so accessible and the reason for choosing it as an example of study for this thesis.

Vision Accessibility Features

Using the the Dualsense controller plus the Pulse 3D headset of the PS5 it will be easier to test the features of visual Accessibility features in TLOU 2 thanks to the haptic feedback and 3D spatial audio that they offer, and that will be very helpful in the process of analyzing the visual Accessibility features of the game.

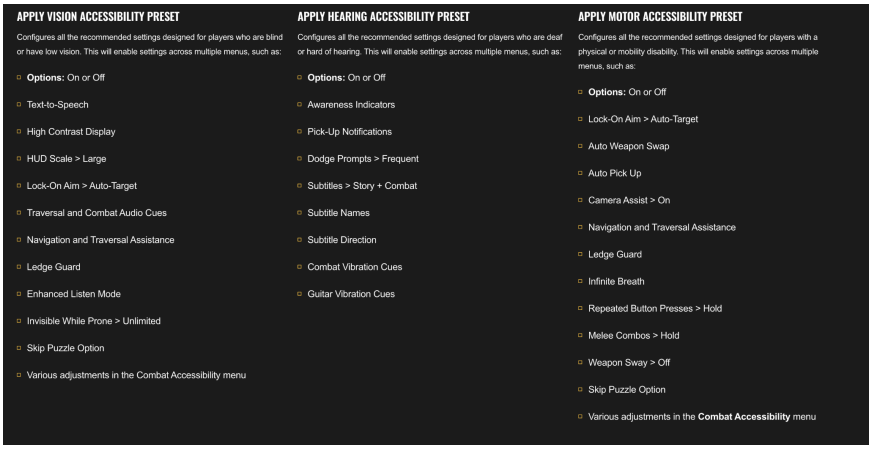
In this section of the thesis the most powerful visual Accessibility techniques that the game has to offer will be reviewed. After that there'll also be an analysis of how they've been done from a development standpoint and if they are able to be reproduced in a normal video game development, normal in the sense of not being a AAA video game production counting on limited time and small resources. If the feature is not too personal with respect to the project, since there are some features that only make sense in TLOU 2 and not in other games, alternatives will be given that can replicate what the studio was focusing on when developing such features. Also it will be specified which profile of player with visual disabilities it's been targeted with each Accessibility feature.

Vision Accessibility Preset

From the moment that the video game starts, Accessibility is something that is shown to the players. Naughty Dog does it with these 3 Accessibility Presets: vision, hearing and motor. For this thesis the interesting one is the vision preset, but is it clear that the studio took their time and effort to work on multiple accessibility profiles and include their players in the game.

Figure 18

List of Accessibility features included in the presets



The vision Accessibility preset acts as a template or quick profile allowing players with visual disabilities to jump right into playing. This way players don’t have to bother or waste precious time fighting with the options before playing the game. The vision preset depicts the accessibility features it includes in a side text so players know what they are selecting.

Targets: All players with disabilities

Development Cost and Logic: All developers that added Accessibility features in their games **could have this preset**, since it's a simple UI menu with text that when selected changes the logic or boolean expressions that activate/deactivate some of the Accessibility features that the game already has. In the case of TLOU 2 is very necessary because it has lots of different features for multiple disabilities and player profiles, but in a more basic game this menu could depict different color blindness profiles for example. It's all about making the players more comfortable.

High Contrast Mode

This feature started its development from a previous game feature, the **Uncharted 4 Thief Vision** feature. The studio received feedback from players with visual disabilities explaining that it improved their gameplay experience because it allowed them to focus on what mattered on the screen. In TLOU 2 this feature has been improved and very polished since then offering more possibilities and overall a better experience.

Figure 19

High Contrast Mode predecessor, Uncharted 4 Thief Vision

The idea of developing the high contrast mode feature came as a bit of a surprise as it was prompted by an Uncharted 4 Thief Vision feature that was not intended for visual Accessibility. In early stages of development the developers tried to desaturate the 3D world and render with a strong blue color the player and helpful NPCs, a strong color red for the enemies and a yellow tone for important interactable objects or collectibles.

Figure 20

Early version of the High Contrast Mode

To tune it correctly the developers used some **low vision goggles** that helped simulate visual conditions, to make sure that what was being seen in the game was visible for players with those disabilities(like tunnel vision).

One problem that was being seen in early prototypes of this feature was that in small places of the game with lots of 3D assets it was hard to see for the players, because they were outlining each asset. This also happened with things like foliage or bushes because the image was having too much noise for players to be comfortable with it.

Figure 21

Foliage noise when rendering the High Contrast Mode in prototypes

This was solved by making the outlines less bright and apparent the closer they were to the player, so the farther away an object is the more prominent its outlines will be, although at the same time it will be darker, revealing what it is but without overwhelming the player. In the final version of this feature players can even select between **3 color profiles of the High Contrast Mode** so it can be adapted to their preferences.

Targets: Low Vision players and players with Color Vision Deficiencies.

Development Cost and Logic: The High Contrast Mode is a very impressive feature, is one of the most important features for visually impaired players and at the same time it entails a high level of work by the studio. It shows that development and design for Accessibility was hand in hand during development of TLOU 2.

Players can activate/deactivate it easily with a simple left swipe in the tactile part of the gamepad, which makes it really easy to use it in determined parts of the game where players with low vision feel they need it without even pausing the game and going through

the options, like in **dark spaces where is hard to see**. It can also be customized to adapt for different colorblind profiles or preferences(blue-red-yellow, blue-yellowish-yellow, green-greenish-orange)

Figure 22

Comparison between normal dark space VS HCM dark space

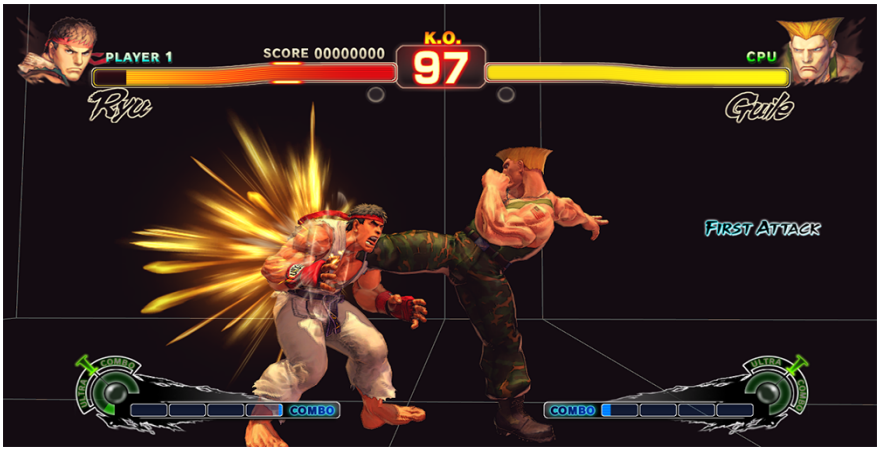
The difficulties to develop it reside in that the scripting system for the game needs to be able to detect not only the character and friendly NPCs to render them in high contrast tonalities, but also needs to detect interactable objects and all the enemies. Not only that but also some objects can be enemies or threats like traps or landmines, so it's very important that the visual language of the contrast mode is depicted through the whole game without exceptions. Also dead enemies and already interactable items should stop omitting a high contrast color when the player has finished the interaction with them, for example by killing an enemy.

This feature would need a technical artist profile in the development team that could work with the design team in order to make this feature possible for the specific game. It would also be very much needed the help of external visual Accessibility consultancy to do actions like calibrating and testing the feature. It is easy to see how a normal small studio development could struggle to achieve the extraordinary feature that Naughty Dog has done.

Although there are other alternatives that more austere developments and simpler games can implement to work on contrast features. Some good examples are the Street Fighter IV low back detail option, that allows players to ignore the ambient and focus on the characters.

Figure 23

Street Fighter IV low background detail option



Another good example of more simpler approaches is the contrast adjustment setting that Epic Eric offers. It's the correct approach to use in 2D games that offer different layers of graphics, and with a simple slider to adjust the contrast of the background more players can have a better experience.

Figure 24

Epic Elric background contrast adjustments

Navigation Assistance and Traversal

These two features are together because they target the same purpose, to help the players move through TLOU 2 3D world. The Navigation Assistance feature is really important for players with no vision. The base of this feature is to provide a “GPS” like feature for blind players to know to which place they should go. Moving through a complex 3D world like the one in TLOU 2 is very difficult and complex for players with no vision, and having an easy and instant way of having the knowledge of where to go is a must.

The feature is very simple to explain, the player presses the left joystick when he feels that he's lost and a 3D sound will instantly popup in the direction that he should go. Besides that, the playable character will auto rotate to face that direction so the player can just go straight in that direction when the correct button has been pressed. The feature also allows players with low vision to see a big visible pointer in the screen and face that direction, so if they feel distressed or overwhelmed by visual noise on screen they can still see the right path.

Figure 25

Navigation Assistance display on screen

The Traversal feature is a set of options that the players can activate to facilitate the use of complex movement and actions. This includes automating things like climbing over ledges or getting through tight spots, which might take different inputs from the players to do. It also includes the option of being able to warn the player with additional sounds and strong vibration of the controller if they are going to fall off a ledge in the level or any danger that a player with visual problems could not detect.

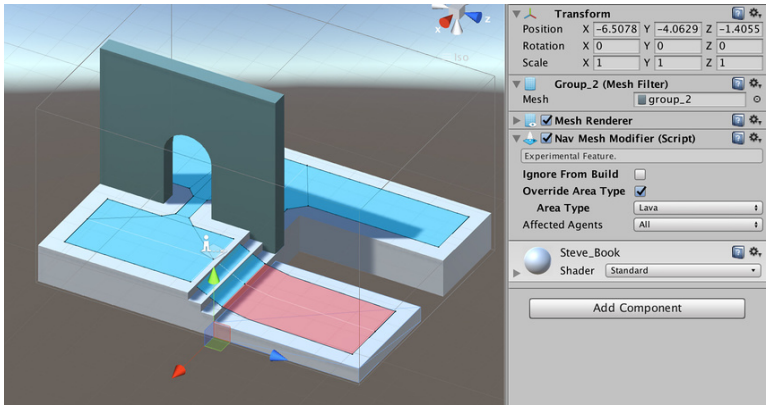
Targets: No vision and low vision players.

Development Cost and Logic: The Traversal options are cheap to implement because by adding an extra condition to the code of the features to detect if the feature is activated. The difficult task about implementing them is finding the adequate game mechanics in each game that need to have these extra aids for players with visual impairments. For example if the character in the game can swim and can die by drowning, blind players need an option to have infinite oxygen because it's hard for them to determine if the player is swimming and how to not drown.

The Navigation Assistance feature is a bit more complex to achieve. Since it acts like a GPS it needs a good 3D audio system integrated in the game to work. The sounds that pop up marking the correct positions that the players should follow must make sense geographically and be easy to understand, increasing or decreasing the strength of the sound depending on whether the player is far away or not. All these marks need to be correctly placed in the **navigation mesh** of the level and should follow the **golden path**. They also need to work when the player is exploring the level through other paths.

Figure 26

Unity navigation mesh level example



For those reasons it is very important that the Design team works from the pre-production phase of the development in these aspects, because they are the ones that know more about the design of each level and the mechanics that can create barriers for players with vision problems. Furthermore it is key that lots of testing is done for the Navigation Assistance points in each level, and balancing for the Traversal features to not feel too easy or hollow for the players and keep the game difficulty experience.

Enhanced Listening Mode

The game has a mechanic called **Listening Mode**. It consists in that when players press a certain key of the controller they launch a kind of sonar from their position that for a few seconds allows them to see nearby enemies and dangers, even through walls. This mechanic is a core part of the gameplay as there are times when players will need to avoid enemies or unwanted encounters if their character is in a critical state.

Figure 27

Listening Mode display on screen

Since TLOU 2 has this game mechanic that allows players to use a visual sonar to detect the surrounding enemies and see them through walls, the developers have added an Accessibility option that improves this feature and allows players without vision to benefit from it. Once activated from the options menu, the enhanced version of this feature will also provide audio feedback. So players with visual disabilities will be able to detect enemies by pressing an extra button while in Listening Mode. Pressing another extra button will also detect items surrounding the player.

Figure 28

Improved audio feedback of the Enhanced Listening Mode

Targets: Players with no vision and with low vision disabilities.

Development Cost and Logic: Since this is an enhancement of an already existing feature of TLOU 2 it's easy to implement. The main difficulty in developing it is that the 3D audio system has to be already working perfectly in the 3D world, since a very close enemy and a distant one have to be distinguished even through walls and obstacles. Also the sound dictionary would have to be perfectly distinguishable since the sounds of different enemies and different objects would have to be recognizable.

But this feature is totally optional and it is **totally linked to a specific TLOU 2 mechanic**. Other games of the stealth genre could apply it, although it is not a generalizable feature that can be applied to all video game genres.

Magnification Tools

TLOU 2 has a magnification tool called **Screen Magnifier**. This feature is very useful for low vision players since it allows them to see much better any detail of the game, from enemies moving through the level to the subtitles during the cutscenes. If the option is enabled, the players can use the touchpad to point to the area of the screen they want to zoom in on and use their fingers to zoom in by tapping the touchpad twice. Once zoomed in, the player's view will stay zoomed in by that amount until they decide to zoom out. To zoom out and return to the default view, it only takes another double tap on the touchpad.

Figure 29

Player using the Screen Magnifier to zoom on an enemy

The control is super intuitive and once the players have used the feature a couple of times they quickly take control over the feature. In addition, there are several magnification values: **small, medium and large**, for different profiles or preferences.

Targets: Low vision players

Development Cost and Logic: The Screen Magnifier tool that TLOU 2 has is really impressive and very useful for visually impaired gamers. Although not all games need this type of tool, as is the case with 2D platformer games a priori, it is something that should be taken into account when designing a 3D game or one that has high levels of detail.

Developing it is not complex, it basically acts like the zoom of a sniper scope in any shooter game. There is a lot of information on how to do that kind of camera movement online, especially for major game engines like Unity or Unreal Engine. The difficulty lies in designing how to apply it so the process of activation and deactivation is simple and intuitive for the players, as in the case of TLOU 2, with a simple combination of keys or buttons of the game controller.

Figure 30

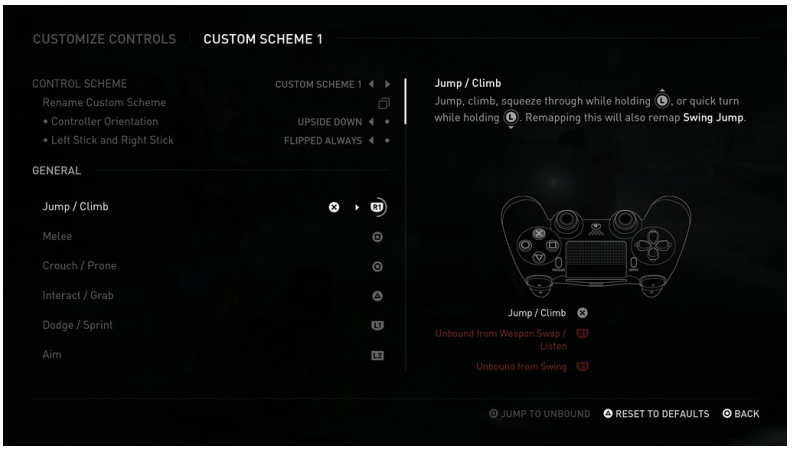
Sniper zoom mechanic in a shooting video game

Control Customization & Alternative Control Inputs

TLOU 2 was the first time that Naughty Dog allowed the total remapping of the game controls. This is very useful for a lot of players but in the case of players with vision impairments like low vision is very important since the use of the joysticks or some keys of the gamepad is hard for players that can’t identify properly which are which

Figure 31

Controls customization screen in TLOU 2



If a studio is developing a game where manipulating the mouse is a key element, having in mind that low vision players and blind players will have a hard time identifying where the cursor is or in which direction they are facing with the rotation of the mouse, is necessary. In the case of TLOU 2 their answer was to offer another possible type of input with the Alternative Control Accessibility option.

Alternative controls in TLOU 2 vary from multiple game mechanics and situations in which players with visual impairments can have trouble during their game experience. For example there are options for auto targeting enemies when aiming with a gun , so it's easier to hit them. Players can activate the option to automatically change the weapon when they

are out of ammo, so that blind players or players with low vision that may have problems paying attention to the audio indications or HUD images when in the middle of a confrontation can forget about it.

Targets: All players with disabilities

Development Cost and Logic: Developing Control Customization is very simple, the inputs of a video game can be completely remapped whether they are keyboard, mouse or gamepad controls. Popular game engines like Unity or Unreal have plug-ins in their respective stores that will help developers carry out this feature easily so players can assume the control of their remapping preferences.

The most difficult part of developing Alternative Control Inputs comes from the design standpoint, and it involves identifying which game mechanics of the game can cause barriers or difficulties to players with vision impairments when gaming. There are features like allowing options to auto loot and auto target enemies that can be added always if the game allows it, but other features like letting players choose between holding a determined button to perform an action instead of constantly pressing will most likely need external consultancy and testing sessions from players with visual disabilities.

Text to Speech, Audio Cues and Haptic Feedback

Any information of the game that is exclusively visually given is unavailable for the blind players. The Naughty Dog studio knew how to digest this by creating some accessibility options that would help visually impaired players: **TTS, audio cues(with an extended audio glossary) and haptic feedback.**

TLOU 2 allows players with visual disabilities to **handle text on screen** with the TTS feature. TTS takes care of reading for players who cannot see, giving audio feedback. This includes giving feedback to a wide variety of elements of the game, from the character's current state to the menu text that the player is selecting. To achieve such a feature TLOU 2 developers relied on an external software called **ReadySpeaker.**

With this external software the developers were able to feed the program big documents of text strings to generate offline audio files that they would include into the game. Keep in mind that TLOU 2 is playable in **24 different languages.** Luckily each synthesized language occupied approximately 140MB of space, not much because the audio quality provided by ReadySpeaker was quite inferior to the one used by the characters in the game for example.

A clever design choice that the studio developed was to allow the players to know their status at any given time by just swiping up on the controller's touch screen. This way blind players could just listen to their current percentage of health and the position that the character was(standing, crouched…) whenever they felt like it. TTS is also super useful for the menu parts of the game, so the players can know at any time what they are focusing/selecting and don't feel lost or need external help to modify some options and accessibility features.

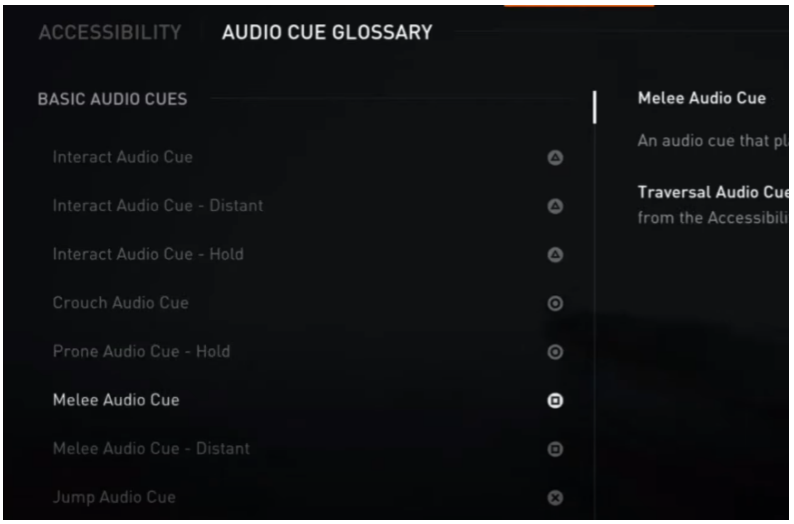
Although the feature was very polished in the final version of the game, the study had lots of problems during the development phase of the TTS. One of them was how to prioritize some audios over others, for example if the player wanted to know the current status of the character and at the same time some text for a tutorial was being shown on the screen. Another problem was that some words are written the same but pronounced different, and TTS was having trouble differentiating them. Like the word bow(weapon) and bow(gest/action).

For **all the other important non-text information** displayed on the screen, TLOU 2 offers a great audio cue system. Adding characteristic non-diegetic audio cues when for example the player is close to an interactable object, or when the player is having a melee combat with an enemy really helps players with visual disabilities because the information of the inputs that is given visually to all the players with sight can reach them in the same way via the audio cues.

In order to make the audio cues system work on TLOU 2 the sounds needed to be designed in 3D to give additional spatial information to the players. Also each sound had to be characteristic for each action since multiple actions could be performed with the same button in the game. So creating a complete **audio glossary** that players could easily access from the menu would help players to learn and memorize the sounds that they would listen during the gameplay.

Figure 32

Audio cue glossary in the options menu



Audio cues inside TLOU 2 can be modified to affect elements such as the **traversal and the exploration**, playing audio cues when the character is close to jumpable spaces, scalable zones. Or when the player is close to interactable objects or collectible items for example. And of course the audio cues are of vital importance also for the **combat moments**, and the game allows to also activate audio cues when an enemy is trying to grab the character, or when the player has impacted a bullet into an enemy etc

Once a game has that many audio channels with lots of audio cues and sounds, it is very important for players that mostly rely on hearing when playing to be able to customize what type of sounds they wanna hear more or less. Thanks to the Volume menu TLOU 2 players can adjust the sound to their preferences at any moment of the game.

Figure 33

Audio channels volume customization

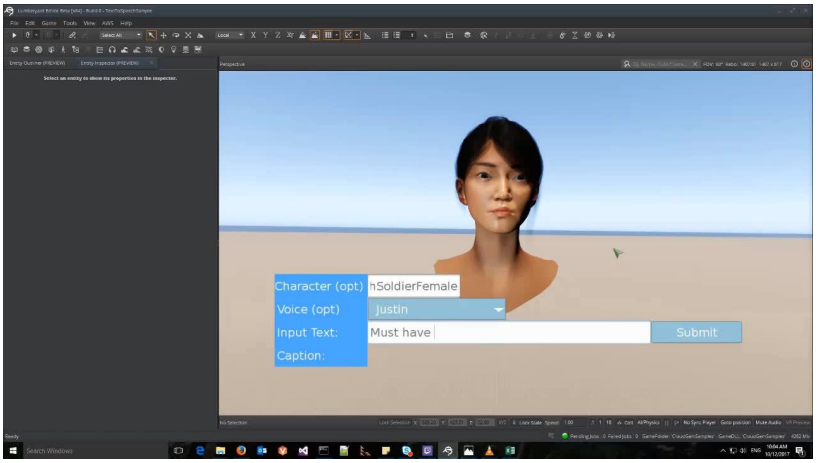
And last but not least, with the **haptic feedback** visually impaired players can receive useful extra information that will not saturate the auditive channel. TLOU 2 adds controller vibrations to help players notice when they have landed shots to an enemy for example, to not waste ammunition shooting to empty spaces.

Targets: No vision and low vision players

Development Cost and Logic: Developing TTS features can at first seem quite expensive for a simple video game with a team that has few resources. But there are multiple free to use tools and services that can help developers achieve this Accessibility feature. **Amazon Polly**, for example, allows developers to create TTS in 24 different languages and even sintaxis modifications of words that may be problematic.

Figure 34

Amazon Polly TTS generation software



Another good approach if the game is relatively simple and doesn't have too much text would be to provide **pre-recorded voice overs** for all the text in the game. That also includes menus and installers, which are something that is not usually taken into account and is key to have a good experience playing as a player with visual problems.

As it has been said before, developing a TTS can have unexpected challenges. For that reason it is very important to test the feature thoroughly, most of all if the game has lots of ingame dialogues.

Having an audio cue glossary like the one in TLOU 2 is not necessary because not all the games display that many actions/mechanics with the same buttons. But what is basic necessary is to design and create **sounds/audio queues that can be differentiated** for important things inside the game. Such as if the player has little HP and is in a critical state, auditory feedback when the player hits an enemy, and audio cues for enemies close to the player, different sounds for different enemies etc each game will have its own elements and the developers will have to be able to select those ones that will need that extra auditory feedback, so players with no vision can memorize them.

Any ingame audio cue should be designed with **spatial audio** in mind, so players can have that extra information to where the sound is coming from. Creating a 3D sound system in modern game engines shouldn't be a problem. Good results can be achieved thanks to multiple libraries that already provide the code and tools to achieve it or just simply because there are free plug-ins and assets with such features already integrated.

Adding **haptic feedback** to the controllers that players use is quite simple to do in current game engines and shouldn't be a problem for any developer also. One possible setback could be that the elements that the gameplay elements that should give the haptic feedback were not well identified or that this feedback system was abused making it annoying for the players. In any case, testing and adjustments would be needed to find a correct version of this feature.

HUD Customization

TLOU 2 has an option that allows players to make the ingame HUD bigger and more remarkable. It also allows you to change the background of the HUD, so it can be more opaque for players with vision problems to see it easily and not get distracted by other elements appearing on the screen. Furthermore the color of the HUD can be changed between: white, yellow, blue, red and green colors in order to adapt to the tastes and preferences of the player

Targets: Players with low vision

Development Cost and Logic: Customizing the HUD it's a cheap and easy way to allow players with vision problems to have a better gaming experience. The ingame HUD is a crucial part of almost any video game, players will have it on the screen nearly all the time

that they are playing and it should be a tool that helps them when playing by giving important information. Not allowing players to use it because they are not able to see it or differentiate it well on the screen is a big mistake that a developer should never make.

A simple route plan to alleviate this problem is, once the HUD is created at the default size(the size that all players will have when entering the game for the first time) is to create 2 more sets of the same HUD: icons, bars etc one that is smaller and one larger. It would be better to give the players the option to modify the size to their liking, but covering the default, small and large sizes many players will already have a better experience.

The color of the HUD could be totally modifiable by simply adding a color roulette or palette on the menu screen. If not the Naughty Dog approach of loading a handful of different color profiles could suffice in order to help with a more limited customization. Either way the cost to reproduce such features is very small, and is very easy to achieve in modern game engines.

And for the background image to help players with low vision focus better on the HUD and not get distracted by other elements showing on the screen, adding a simple option with a slider to adjust the alpha channel of the background image could work perfectly.

Colorblind HUD Options

Certain profiles of colorblind players can have the option to change the colors of their HUD so they can correctly identify the language that Naughty Dog wanted to express with the colors. More precisely TLOU 2 allows 3 presets of HUD color palettes for players with: **Protanopia, Deuteranopia and Tritanopia.**

Targets: Players with color deficiencies.

Development Cost and Logic: A feature like this is necessary if the video game contains color-based language. In the case of TLOU 2, some colors are used in the HUD to communicate danger to the player, such as when the player has little oxygen left while swimming or when the player is hurt in a critical state.

Any video game that depicts information to the player with colors should have the options to depict it to colorblind players also. In TLOU 2 it is done by adding 3 colorblind presets that change automatically those affected colors to the variants that would work the different colorblind profiles.

This approach can be reproduced if the elements that use color to give information are clear(game designers). Once these elements are clear, software tools such as Color Oracle can be used to help simulate how different frames of the game or the HUD, are viewed from the types of color blindness. In this way, it is possible to locate conflicting colors or elements that are not clear to find a better color and create preset profiles that help players with color vision deficiencies.

Motion Sickness

Visually induced motion sickness happens to some people when playing video games. A dissonance between the eyes and the inner ear causes the brain to believe that something wrong is happening, such as that the player is being intoxicated. This produces a feeling of dizziness that can cause the player to stop the gaming session because of how bad the feeling is. This condition becomes more noticeable in VR games, but it also happens to a lot of games like in the case of TLOU 2. Games that have **closed third person cameras**, or that use **camera shake** and **motion blur** can trigger these episodes on players that suffer from motion sickness.

Figure 35

Motion Blur example

Naughty Dog created some Accessibility options that would help reduce this feeling of discomfort, such as: allowing adjustments in the intensity of the camera shake, motion blur and FOV. Another technique the studio implemented to help the feeling of motion sickness was being able to activate a **dot in the middle of the screen** at all times. So players could persistently focus on that part of the screen.

Targets: All the players that experience this condition

Development Cost and Logic: Motion sickness is very particular and each player can experiment it in one way or another, with more or less intensity. Therefore trying to mitigate it for all profiles when developing a game is quite complicated. The point is to let players tweak the camera to their liking within the limits that the game has, but letting them modify and adjust the FOV, the intensity of the camera shake etc are Accessibility options that are cheap to develop if the feature already exists in the game and they help deal with motion sickness significantly.

Subtitle Customization

Some time after the game came out, TLOU 2 developers retrieved post launch metrics about the most used Accessibility features. Subtitles and subtitle customization were on top of the list. The game offers subtitles for the history dialogues and also for the combat dialogues, very useful for ghen the players are in stealth mode.

It also offers some subtitle customization like choosing between small, medium and big size, 5 different colors and adding some background to the text strings so they are easy to see.

Figure 36

Subtitle Accessibility customization in TLOU 2

Targets: Players with low vision

Development Cost and Logic: Players may use different screens, sizes of screen and even distances to the screen when playing a video game. Adding subtitles should come hand in hand with being able to customize them, to make sure players find them useful.

There's lots of documentation and tutorials online on how to do subtitles with a modern day game engine like Unity/Unreal. Although the reality is that in order to add desired customization options, the best thing to do is to self develop a subtitle system that adjusts to the needs of the game. For that, developers should have decided in advance all the dialogues and when they will happen, the voice lines that will be triggered with specific events, such as when the player receives damage, etc. All this has to be designed and defined before starting to develop the subtitle system in order to save time and resources.

Skipping Puzzles

This feature is really interesting and it makes a lot of sense in TLOU 2. During the game the players will come across puzzles that they will have to solve, sometimes optionally to get rewards and other times the puzzles will be mandatory to advance in the story. Since TLOU 2 has a linear progression, if players get stuck in an obligatory puzzle that they can't solve because they have visual impairments it's bad design.

Figure 37

Guitar skippable puzzle in TLOU 2

That's why the studio created a feature accessible from the options menu to let players skip the puzzles, because some of them were not accessible for blind players for example. In later patches of the game the studio released additional assistance to solve these puzzles without having the need to skip them.

Targets: No vision and low vision players

Development Cost and Logic: A video game should never have any mechanic that stops the progress of the players, as it's the case with TLOU 2 puzzles for players with vision problems. If these mechanics are going to be mandatory since they are linked to the narrative of the game for example, developers must give the option for the player to advance so that they don't get frustrated if they can't realize such mechanics.

The real work behind this Accessibility option is to know the game and their mechanics, and to identify those situations where players could face mandatory mechanics that can prevent them from moving forward.

Combat Accessibility Options

Combat is a huge pillar of TLOU 2, which is why the developers wanted to make it fully accessible for players with vision problems. This was achieved by allowing a variety of options to be activated from the Accessibility menu, such as being able to enter slow motion mode when the player is aiming his weapon or being able to make the character invisible if he is prone on the ground in order to experience the game in stealth mode like the other players do.

Targets: Players with no vision and low vision players

Development Cost and Logic: Having a combat accessibility section in the options menu is something that does not apply to all games. Knowing that the game in development has a pillar such as combat gameplay and that players with visual problems are going to run into barriers and difficulties is something that the game developers knew and consequently decided to implement these options.

Therefore, determining the cost and how to develop something that totally depends on the game in question is very complex. The developers must be able to design and develop Accessibility options that are useful for players with visual disabilities, adjusting to the pillars and core mechanics of the game.

Additions and Improvements to the Accessibility Features

After playing TLOU 2 using the accessibility options for players with visual disabilities, some of the conclusions drawn after a few hours of play have been amazement and understanding that behind the development of each feature there has been a lot of work and intention to help vision impaired players, especially in features such as the High Contrast Mode. But this doesn't mean that there may be improvements to the visual Accessibility options.

Adding more control over the HUD customization is one of the first observations made when testing the Accessibility options. Although it is true that there are already customization features such as having 3 size presets, the player must be able to **fully control the size** (within certain limits) and this could be done with the addition of a slider. Same for the HUD colors, 5 presets are too short and it would be better to provide a **color palette**. One of the important points of the HUD customization that is missing is being able to **control the position of the HUD**. It is super important not only for personal comfort but

because there are players with visual conditions that cause them to lose peripheral vision or that makes them only see specific parts of the screen well, and being able to reposition the HUD is something easy to do that could solve these problems.

Another improvement to TLOU 2 Accessibility features would be to allow more control over the **text and subtitles customization**. Having a good default size is beneficial, but there's not an universal text size that all players can read, due to differences in levels of visual impairments and differences in screen size or viewing distance. It is also important to have different **types of fonts** since some are much less visible than others and sometimes because they "comply" with the artistic direction, the texts become less accessible.

Figure 38

Warlock of Firetop Mountain text customization

As the last visual accessibility improvement that TLOU 2 could have, it would be to add **audio description** for the cinematic scenes. If the players can't see these scenes in a game that has so much weight in narration, they end up losing interest. For example when you go on to play as another character in the game(Abby) that character is never physically

described, something that is really annoying if the player is going to be handling it for several hours of gameplay.

Vision Accessibility Guidelines

After studying and analyzing the visual Accessibility techniques used in TLOU 2 to understand their purpose and their development cost, some guidelines will be developed that may be useful when making video games more accessible to players with vision disabilities. As has been seen in the previous TLOU 2 case study some of the techniques and features analyzed are very complex and require a lot of effort from the studio to be developed, something that is not possible in many situations. Furthermore some features only worked and made sense for TLOU 2 or specific types of video games. Due to this, the following guidelines have been classified into two sections: **basic guidelines and advanced guidelines**.

The **basic guidelines** will be general proposals that could be used in the vast majority of video games. They are not complex to implement and really are useful when making a video game more accessible for players with visual disabilities, in addition they are cheap to implement especially if they are being taken into account from the beginning of the development. Basic guidelines will also include a mini section that will add challenges for developers that want to go a little further and get a better result. On the other hand the **advanced guidelines** will be more demanding and will require more dedication/resources in order to be implemented. Perhaps in some cases they will not have a place in the video game, but mostly they will be guidelines that could be implemented most of the time if the developers add more resources to their development to achieve better visual Accessibility results.

Basic Guidelines

1. **Allow HUD customization**

The HUD should be able to be modified for the different needs of the players since it is an important part of a video game that displays vital information for the players. The HUD is made up of several elements and can vary from game to game, but in almost all video games there are usually common elements that should be customizable like the HP/mana/energy bars, the skill icons, the minimap, the score, the text etc. This includes letting players control features such:

- **Size**
- **Positioning on the screen**
- **Color**
- **Font text**

The **text from the menus** should follow the same treatment even if it doesn't belong to the ingame HUD, since it’s a major part of the game. If the game has **subtitles** included the text should also be customizable by the players.

Going the extra mile: *Adding a background image behind the important parts of the ingame HUD that can have its alpha color channel adjusted, can help players differentiate the HUD elements from the rest of the screen more easily even in dynamic and fast situations.*

2. **Add extra feedback**

Since players with visual disabilities cannot rely on their sight, it will be key to add as much feedback as possible that uses the senses of hearing and touch. If the gaming platform for which you are developing allows the use of a video game controller consider adding **haptic feedback** with vibrations, for example to warn players in critical moments in the game like when their character has little HP left.

Creating **audio cues** for the game can substantially improve the quality of life of a player with visual disabilities. Completely blind players appreciate the existence of audio cues for every possible action in the game, even some basic features like adding sound when the character is walking or a distinct sound for when the character is bumping against a wall. These audio cues must be distinguishable from each other so that the players can memorize them correctly and get used to them.

Another option that should be added to your game is to provide **pre-recorded voice overs** for all the text in the game, especially for the menus. This way the players will know what they should do and what they are selecting to not feel lost.

Going the extra mile: *Adding a* ***TTS*** *feature for all text on the screen will be better than using a limited pre-recorded voice over. It would be nice to add an easy to access* ***audio glossary*** *for the players to listen to the audio cues in your game. And to allow players to modify the sounds that the game offers(including the feedback audio cues) adding an* ***audio channel volume customization*** *menu would be good.*

3. Think in players with color vision deficiencies

To make your game inclusive for colorblind players the main rule to follow is to make sure that **no essential information or visual feedback is given through colors alone.** Although the language of color is very important and widely used in video game development it must be taken into account that there are players who will not be able to distinguish between the “good” green and “bad” red visual feedback, for example. The best approach is to complement this color language with **symbols or marks** that coloblind players can distinguish and process.

To make video games more accessible for colorblind players, it is also highly recommended to allow **HUD color customizations** and elements of the user interface that are fundamental for the game or grant feedback of some sort, like for example the crosshair in shooter games or the red flashes/animations that are used in lots of video games to give feedback that the character is in a critical state.

Going the extra mile: *If you can go further and work on something extra that can help players with color vision deficiencies the best idea would be to work on* ***preset profiles****. This would save players a lot of time and could target the most popular color blindness types by creating profiles for players with Protanopia Deuteranopia or Tritanopia where the HUD and important colors of your game change with them.*

4. Allow input customization

Letting players customize the way they communicate with the game via inputs is very helpful for visually impaired players, who may have trouble distinguishing things as simple as finding the position of the mouse cursor on the screen. The best way to ensure that the needs and preferences of the players are met is by allowing a **complete remapping** of the controls in your game.

Also in some video games that include more complex commands, such as keeping a button pressed for X seconds to perform a certain action or pressing multiple buttons at the same time to perform a combo attack, allowing **alternative inputs** like auto holds for these actions and mechanics can be of great help for the player.

Going the extra mile: *In the case that you want to work further on facilitating the controls for your players with visual disabilities, the most important features that can be developed are those that serve to help the player during the gameplay. By this I mean options like being able to auto loot enemies when you walk past them instead of having to use an input, or allowing auto aimlock when aiming enemies that move fast across the screen.*

A great help for players with vision problems is to add a ***"slow mode" time window*** *when a critical action is going to happen, like in a hand to hand combat situation and the player must react fast to input the dodge or block buttons.*

5. Provide contrast options

The vast majority of the time not even half of what's being shown on the screen is important for the players. This has even more impact when we talk about games that take place in a 3D world, where players have more room to move and explore. With so many elements on the screen it is easy for players with visual difficulties to get lost and not have a satisfactory experience while playing. Knowing this is important to keep in mind that the **stronger the contrast ratio** the easier a game element will be seen.

Designing with contrast in mind from the beginning can be a good approach to create a clearer gameplay for the players: the playable character should be highlighted, the enemies/traps, the key and interactable items etc developers will need to be able to discern the elements that will be highlighted in their game. Highlighting elements using outlines or particles/lights can be a good idea although colorblind players should be taken into account when designing the color palette.

Another approach would be to create contrast options to adjust the contrast of such elements ingame. When the video game is being developed in 2D it is easier to independently control the amount of contrast of the different **graphical layers** where the game elements are being rendered. For example the layer where the character and enemies are should be separated from the rest of the elements so the contrast can be easily modified with a simple slide bar on the options menu. In a 3D game it is harder to adjust contrast but a good approach would be to work on **high contrast shaders** for the playable character, allies, enemies etc so players can activate them at ease from the options menu, something that **Marvel's Spider-Man: Miles Morales** does pretty well.

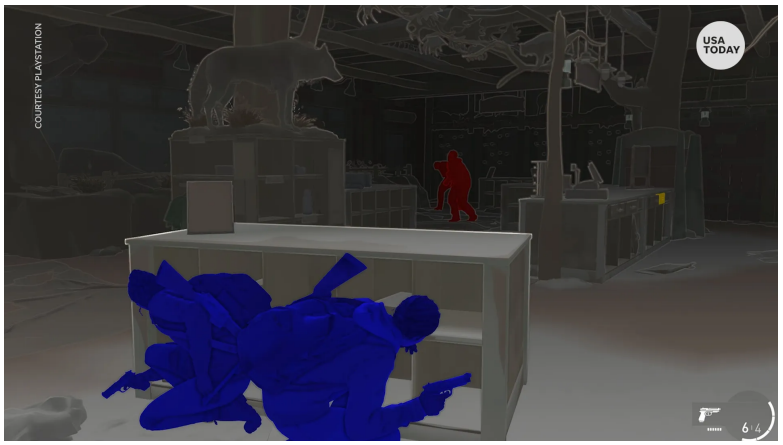
Figure 39

High contrast character shaders in Spiderman: Miles Morales

Going the extra mile: *If you really want to work on adding contrast options for your players, the best thing to do is step up from the other methods and make a world that fully reacts to contrast change. Creating a similar feature to the* ***High Contrast Mode*** *like the one in TLOU 2, where both the important elements of the game and the rest of the elements and the background are affected by this contrast adjustment to make the game more visible.*

Figure 40

High Contrast Mode in TLOU 2



Advanced Guidelines

1. **Work on magnification tools**

Allowing visually impaired players to turn on a camera zoom option at any point in the game is a great Accessibility feature that can solve many problems and barriers that players will encounter in your game. This feature should be easy to access while playing to be able to activate it quickly, using a gamepad/keyboard button that is intuitive for players. Think of a visual magnification tool like a **sniper zoom** in a shooter video game, easy to enter and exit at any given time.

The magnification tool should also have the possibility to **modify the amount of zoom** used, so that players with different types of vision impairments can customize this value to their liking.

2. **Prevent motion sickness**

Motion sickness can be induced by visual elements of your game. If your game has a **closed third person camera** or includes visual techniques like **camera shakes** and **motion blur** during the gameplay, it is better to add customization options in order to deactivate them for players that can have motion sickness triggered by it.

Creating options for the players to tweak camera values such as the FOV, the intensity of the camera shake and the motion blur is crucial for players that suffer from visual motion sickness.

3. Implement a 3D audio system

Having spatial audio in your game is a feature that can be very beneficial for visually impaired gamers that use headphones. Thanks to a 3D audio system players will be able to detect the direction and to calculate the distance they are from the source of the sound. In addition to that if we use **surround sound** type of audio for our game rather than stereo, being able to identify the sound in this spatial audio system will be even more reliable.

Once the 3D audio system is implemented inside the game, you can get a lot of juice out of it by creating features and options that could be very helpful for players with vision problems. In a video game that uses exploration and has complex levels to navigate implementing an input that launches a **sonar** ingame in a surrounding area to the players to help locate the enemies, important objects etc can be very helpful for low vision and blind players. Or in a shooting game players could listen from which directions they are being fired, to help them locate their enemies.

A **navigation assistance feature** can be also achieved thanks to having a 3D audio system working. This feature is very useful for blind players that could feel lost while playing, since it helps them via spatial audio to find the next position they should move to. As you can imagine to have an optimal experience using the navigation assistance feature, the game must have a precise spatial audio system that correctly marks the next position of the golden path that the player must follow in the current level/area of the game.

4. Include audio description

If your video game has cinematic scenes or cutscenes it is important that you add audio description so that players who cannot see them have the context of what is happening on the screen. In video games that are narrative focused and have multiple cutscenes, creating a way for players to be more involved with how the main characters react to dialogues or situations is something that will add richness for all those players that cannot visually grasp the message you are sending.

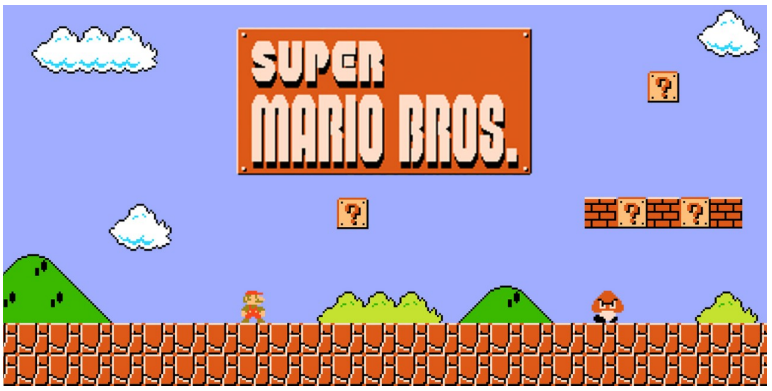
Also adding a menu that contains audio description for: characters, locations, historical/important events named during the video game etc. can help players with vision impairments to remember or learn more about them. Visual memory helps a lot to remember these elements and lots of players cannot take advantage of this.

Making Super Mario Bros. World 1-1 Visually Accessible

This section will consist of making a level of a video game more visually accessible, in this case the first level of **Super Mario Bros. World 1-1**. This will be done by examining the level from start to finish to add improvements that will come from the Vision Accessibility Guidelines that have been defined in the previous section. In this way it will be possible to determine if they really make sense and are useful and intuitive to apply in most video games. During this exercise it will be assumed that the game is playable using a **modern gamepad like the XBOX one** and that the technological advances are those of today and not those of 1985 when the game came out, which will allow the implementation of more advanced techniques.

Figure 41

Image of Super Mario Bros. World 1-1



The reason for choosing this specific level is because it is one of the **most iconic levels** in the history of video games, if not the most. It should be noted that being a level of a "retro" video game in 2D and also belonging to the Japanese company Nintendo, which since its origins has been known for making games for a "younger" audience, it is a game that is already **more visually pleasing and accessible than the majority** due to the simplicity of the elements on screen and the basic color contrast between elements. This

visual Accessibility is not due to the designers making these games with Accessibility in mind but rather a natural design factor that Nintendo games have. So the level it is a perfect fit to to show the veracity and usefulness of the guidelines.

Super Mario Bros came out for the NES in 1985 and the World 1-1 level acts as a tutorial and introduction to the rest of the game and also lays the groundwork for future Mario games. It is considered by many connoisseurs of level design as a master class from its designer, **Shigeru Miyamoto**, on how to design a good tutorial level.

That it is such a good tutorial level is not because all of Mario's mechanics are explained in detail and to perfection during the level, just the opposite. At the time this game was developed, it was very unusual to create an in-game tutorial to teach players the mechanics, and Super Mario Bros. was no exception. But this first level was designed in such a way that the players learned the rules by themselves and without any kind of explicit instruction while they were playing the level. According to its creator, the Word 1-1 level of Super Mario Bros. contains everything that players need to **"understand what they are doing gradually and naturally".**

Introduction to the Level

Before explaining which visual Accessibility guidelines can be applied to this level and how they can be applied, it is important that the **mechanics, objectives and elements** of this level are clear beforehand. Especially for readers who have never played this level and do not know what the video game is about.

As has been stated before Super Mario Bros. is a video game that came out in the 1980s for the NES and it belongs to what is called the genre of platform video games. On it

the player controls Mario, the hero and protagonist, in an adventure where he must rescue the Princess from the clutches of a villain. The video game is divided into 8 worlds, each one containing 4 levels. At the end of each level, a castle stands with a flagpole nearby. When Mario reaches the flagpole, he takes down the enemy flag and enters the castle, **completing the level** and advancing to the next one.

The **principal rule of the game** is simple: Mario must finish each level until it rescues the princess in the final one. But for that, the player has to take these other rules into account:

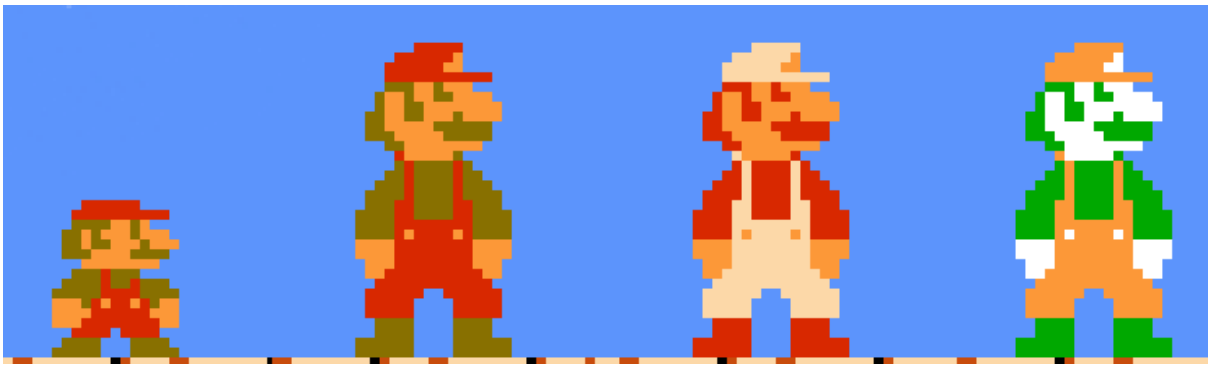
- The player starts with 3 **lives**, and each time he gets hit from an enemy or falls through a pit/platform it loses 1 life. If the lives run out a Game Over screen will appear and the player will need to start the game from the beginning.
- Each level has a **timer.** When the count gets to 0 the player will lose 1 life and will restart the level from the beginning.
- Players can earn **points** while playing each level by collecting coins, killing enemies, destroying terrain etc. These points will increase the player's score for each level.

Mario

Mario has a unique sprite that no other character in the game has, so it's easy to recognize it visually on screen. He has different sprites that belong to the transformations he can achieve by finding items during the game: Base Form, Super Form, Fiery Form and Invencible Form.

Figure 42

Mario forms



In addition to that, it also has a good variety of personal **audio cues associated with some of the actions** that it can perform during the gameplay: for jumping, for when it destroys terrain, for when it picks up an item, etc. The movements and states that players can experience with Mario are these:

Walking: Mario can move right and left in this 2D world. The character movement has an **acceleration** value that increases/decreases depending on whether the players hold down the direction button.

Running: Besides just walking, Mario can run if the players maintain an extra button of the controller when they are walking in a direction. While running Mario will move faster and also if he jumps while running it will clear more distance than when walking.

Jumping: This action is performed when players press the jumping button and can be performed whether Mario is walking, running, crouching or in idle state. The jump has a **scale of power** that the players can modulate according to whether they press the button quickly or hold it for a bit. Jumping also acts as the **primary weapon** for Mario against enemies since jumping above enemies will normally kill them.

Crouching: This movement is only accessible when Mario is not in his base form. Players can crouch by pressing the down direction to avoid some projectiles. This action also allows Mario to go through **warp pipes** that are in the levels and grant access to extra zones.

Attacking: This action is unique to one of the forms that Mario can become during the gameplay, the Fiery form. When Mario transforms eating the fire flower, players can press the same button they use for running to launch a fireball that bounces and hits enemies.

Getting hit: Normally if Mario gets hit it means that he dies losing a life in the process. But this is not always true since when Mario is transformed in forms such as the Super or the Fiery ones, the players will be able to get hit extra times before dying. When Mario has been hit he will regress to an inferior form and will enter a momentary period of time where he will be invincible. This invincibility state will display a sound effect to help understand players what's going on.

Dying: If the player loses all his lives, Mario will die making the game restart from the beginning.

HUD

Since the main objective of this introduction to the game is to help understand what's being shown on World 1-1, only ingame HUD will be explained. The ingame game screen counts with a basic HUD that uses quite small size letters and numbers. The ingame HUD displays information for:

1. **Score:** This part of the HUD shows the current score of the players, which can be increased by earning coins, defeating enemies and other actions.

2. **Coins:** There’s a count of how many coins the players have collected during the level. They are scattered throughout the level and in some cases they will be found in secret areas of the level. If the players collect 100 coins they will earn an extra life.

3. **World-Level:** This information helps the players by reminding them on which World and on which Level they are currently playing.

4. **Time:** Each level has a timer that starts decreasing from the moment the level begins. If the timer gets to 0 the players lose a life and the level restarts.

Besides this HUD information there's some menus and screens that players will be able to interact with. Players can **pause the game** by pressing the associated button at any given time. This pause state freezes the game and the timer. Players can detect that the level is paused because a peculiar audio cue will pop up each time the players enter/leave this pause state, besides the game music will also stop while paused.

Each time that players die, losing a life in the process, a "**you have died**" black screen will pop up with a distinctive sound. In this screen it will be shown some important information like how many lives the players have left.

If the players lose all their lives, a **Game Over** screen will be shown and will mean that players must restart the game from the beginning.

And last but not least, there's another screen that will pop up when players **successfully complete a level.** This screen will show the same as the "you have died" screen but with the level information updated.

Items

While playing the level, players will be able to find a variety of items that will interact with Mario in different ways:

1. **Mushrooms:** This red mushroom object acts as a power up and will allow Mario to turn into his Super Form if he collides with it, making him bigger and adding 1 extra survival point against the enemy's hits. Also in this form Mario will be able to destroy Brick Blocks. The mushroom will move in a direction when spawned, so it's not a static object.

2. **Fire Flower:** This powerup will make Mario transform into his Fiery Form, although only if he is already in Super Form, if he is in Base Form and finds this object he will transform into Super Form instead. In this form Mario will gain the same effects as in his Super form as well as the ability to shoot fireballs. The fire flower object is static and will stay in the same place where it has spawned.

3. **Star:** This power up item will allow Mario to turn into his Invincible form for a few seconds. In this form Mario will be invulnerable to damage in addition to being able to eliminate any enemy just by touching him. Though hazards like a pit or lava floor will still hurt Mario. It is a very rare item and when the player has interacted with it the music will change to a distinctive one while the effect persists. This item is not static and will move and bounce in a direction.

4. **1 UP Mushroom:** This valuable item allows the player to gain 1 extra life. Physically it is the same as the normal Mushroom but in green color. They are normally hidden in invisible blocks making them very rare and valuable for the players. It is not a static object and it moves in one direction just like the normal mushroom.

5. **Coins:** They can be collected to increase a player's score and grant extra lives, every 100 coins the player collects 1 extra life will be added. When Mario interacts with them it triggers a very distinctive sound.

6. **Green Koopa Troopa Shell:** This static and interactable object will appear after Mario jumps on top of a Green Koopa Troopa. The enemy will die but its shell will remain on screen. If Mario steps on it or jumps on it, the shell will be shot in the direction that Mario is pointing, eliminating any enemy it touches. But if the shell hits a wall it will change direction and can hurt Mario if it collides with it. They can only be removed if Mario launches a fireball in his fiery form.

Enemies

In this level of Super Mario Bros. 2 basic enemies are introduced that players will see throughout the whole game:

1. **Little Goomba:** These enemies are the first ones to appear in the level. They are mushroom-shaped and brown, and appear in the most number during the level, there are about 16 of them scattered all around. Little Goomba's have a very basic behavior and only move forward. If they touch Mario, he loses a life. To eliminate them players can either jump on them, throw fireballs/shells at them or touch them while Mario is in the Invincible Form.

2. **Green Koopa Troopa:** During the first level there is only 1 enemy of this type. Is the second type of enemy that players will encounter in the level. It represents a turtle that moves forward walking and has a green shell. When they die they drop their shell. If the player leaves the shell untouched after a while the turtle is reborn from the shell.

Blocks and Layout

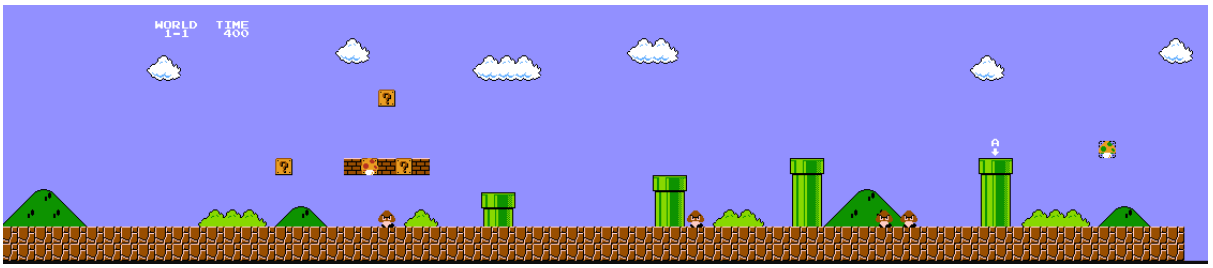
To analyze any level of Mario, it is very important to not skip analyzing the type of blocks and the areas that make it up. In addition, this information will be very useful for the implementation exercise of the visual accessibility guidelines.

1. **Initial area:** In this area the players will find the first blocks. The ground will be conformed by a special and indestructible block type. There'll also be **? blocks** and **brick blocks.** The ?blocks are those that when Mario collides with them from the bottom they release some item or reward (mushrooms, coins etc). When freeing the

object normally the ? block will become an **empty block**, an indestructible block that will stay there. Brick blocks on the other hand are blocks that Mario can destroy if he is in a form that is not the Base Form. Destroying them will make the brick block disappear. These blocks can also contain hidden objects inside.

Figure 43

Initial area of the level

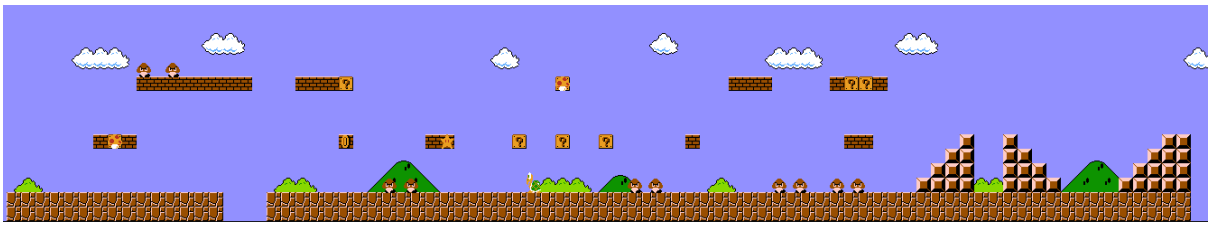


In this initial area of the level the player will also see the **green pipes**. These elements are indestructible and comform part of the level. Some of the green pipes will allow Mario to move from one point in the level to another through a Bonus Area. These pipes are called **warp pipes**, and there is one present in this initial part of the level. If Mario enters it, he will skip the middle area and advance to the end area through the bonus area. The initial area ends when the first pit appears.

2. **Middle area:** In the middle area of the level is where more enemies will be presented to the players, creating a sense of bigger challenge. It is also where the Green Koopa Troopa will appear as a secondary enemy of the level. Towards the end of this area the players will find an ascending structure that will force him to climb it to jump to the next area. This action will be a hint of what the player will have to do when they reach the end of the level.

Figure 44

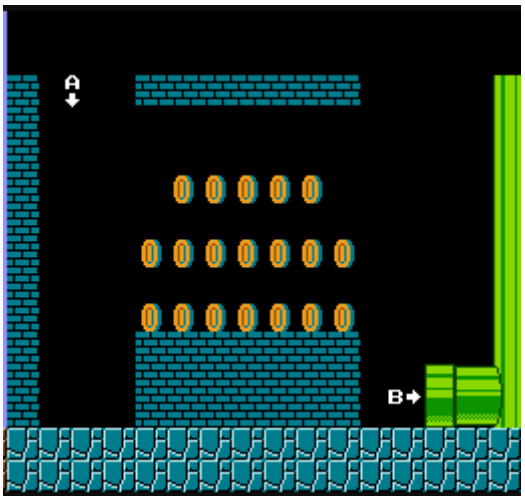
Middle area of the level



3. **Bonus area:** This special area is only accessible if the players make Mario enter the warp pipe located in the initial area. Once inside, Mario can earn extra coins and will be able to leave the area through the exit warp pipe, which this time will take him directly to the final zone. Basically through this zone the players will be able to skip the middle area and advance directly to the final area.

Figure 45

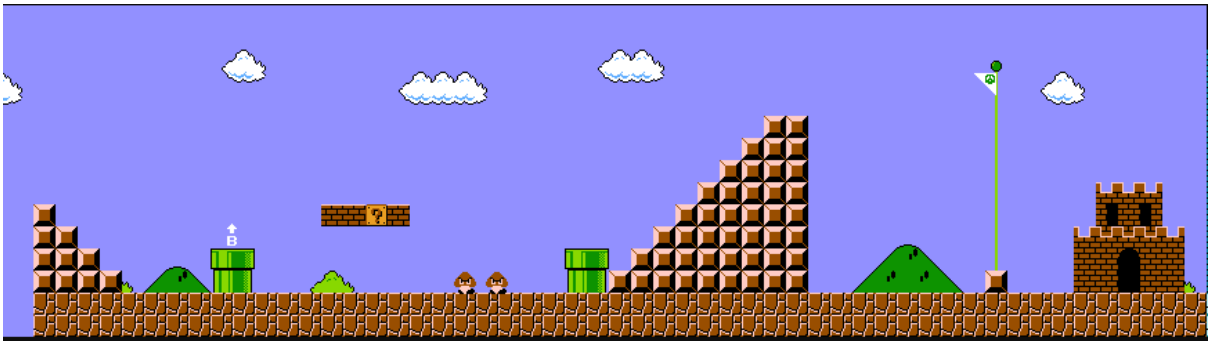
Bonus area of the level



4. **End area:** As already explained there are two ways to get to the end of the level: through the warp pipe from the bonus area or from the middle area. In this area the players will find a structure of ascending blocks that will block their way (already seen before in the middle area) When the players ascend it they will be able to jump to the **flagpole** from the top to complete the level

Figure 46

End area of the level



As explained at the beginning of this section, since this level World 1-1 acts as a tutorial and shows almost everything that the players will face during their adventure. If the visual accessibility options are successfully applied to this first level, they can easily be applied directly **to the rest of the game** since the basic design is the same.

Application of the Visual Accessibility Guidelines

To make it easier and to be able to propose improvements to the level based on the Visual Accessibility Guidelines, some **short codes called VAGs** will be used behind the explanation of each improvement. These codes will refer to the different guidelines(Basic and Advanced) that have been elaborated in this thesis:

- **BVAG-1:** Allow HUD customization
- **BVAG-2:** Add extra feedback
- **BVAG-3:** Think in players with color vision deficiencies
- **BVAG-4:** Allow input customization
- **BVAG-5:** Provide contrast options
- **AVAG-1:** Work on magnification tools
- **AVAG-2:** Prevent motion sickness
- **AVAG-3:** Implement a 3D audio system
- **AVAG-4:** Include audio description

The first improvement that could be applied and be useful as soon as the game starts is to have **TTS in the menu text** so that players who are totally blind or have low vision know what they are navigating and selecting at all times. Another equally valid option would be to **add a pre-recorded voice overs** for each menu text if TTS is not an option since Super Mario Bros. is a simple game that doesn't have many situations where in-game TTS needs to be applied. In this way more time and resources could be devoted to polish the voice over lines(**BVAG-2**).

Adding an **options menu** in the main menu screen would be a must since the original game does not have it. From there, the different visual Accessibility options that will be added to the game could be controlled. Like the next improvement, **sliders to control**

the pixel size of the HUD text and make it more readable for low vision players(**BVAG-1**), and a **color palette** to help colorblind players select their color preferences(**BVAG-3**).

Adding improvements to the sound apartment would be key to making this level fully visually accessible. Mario would need to have designed a **specific audio cue** for every possible move and interaction with the level, to give that extra feedback to players who can't see the screen(**BVAG-2**). This includes the different forms of Mario. Some of these audio cues already exist in the original game(although they were made without Accessibility in mind), for example when Mario jumps in Base Form and when he jumps in Super Form the audio cue is different. But not all Mario interactions with the level had audio cues designed when the game came out. The clearest and most basic example to understand the importance of this feature is the fact that there is **no audio cue for when Mario is walking**, so a blind player cannot distinguish if he’s moving or on the contrary he’s stuck against a wall or an obstacle. Apart from Mario's interactions with the level, it would be necessary to add other audio cues that the game lacks: for the different enemies, for when there are a few seconds left until the level timer runs out, different interactable items etc.

Another great improvement that would give quality of life and make the level more visually accessible, would be to link a **status audio** to a simple and easy to access input of the controller. This audio-status would play the HUD and critical information such as the player's remaining lives or the level he is at.

To make the level really accessible for visually impaired players, it is super important that the game has a **3D audio system**(**AVAG-3**). Having this audio system could open the door to many other Visual Accessibility improvements and options that benefit from the existence of spatial audio. For example audio cues that could have these proximity and

direction attributes to help players, like when an enemy approaches Mario from a platform that is suspended in the air.

With so many different types of sounds and audio sources, **adding channel volume customization** inside the options menu would help players to organize and prioritize which sounds are most important to them. In addition, creating an **audio glossary** that acted like a dictionary for players and that could be added to the menu so that players could consult and relate sounds to elements and actions in the game(**BVAG-2**).

Another improvement in this case for players with color vision deficiencies would be to **not express essential information through color alone(BVAG-3)**. In the level this happens in some cases, such as the existence of green and red mushroom items, each one with a different effect for the players. To remedy this, it would be necessary to make the sprite of each mushrom different in shape or add an icon to distinguish them from the other. This problem occurs in other levels of the game where enemies are presented with the same sprite where only the color of the sprite changes, making it almost impossible to distinguish them for colorblind players.

One much-needed feature that the original game lacks is a full **pause menu**. In the original game pausing the game would not pop any menu options, which is going to be necessary with all the Accessibility features that would be included. In the level there are a few moments where Mario can fall into the void because of the pits between platforms. It is necessary for the blocks of terrain that are close to a pit to have a **sensor** that creates feedback for players with vision problems, either through **haptic feedback** from the gamepad or through an audio cue of danger that players can detect before approaching the edge(**BVAG-2**). Adding an alternative input option to automate Mario's jumps when he is close to an edge thanks to these proximity sensors should be another useful Accessibility

feature. So if players who have difficulties to calculate the force and direction of the jump, now will be able to jump them correctly. It will be enough for them to press the jump button for Mario to automatically surpass the pits(**BVAG-4**).

Being Super Mario Bros. a 2d video game can easily **divide the graphics into layers** (such as the player layer and the enemies, for example). This allows the addition of visual accessibility features related to the contrast, since a slider could be created in the options that regulates the contrast of the "secondary" layers that are not as important as the ones in which the Mario sprite appears, the enemies, the terrain, the platforms etc to save players from having to look at extra elements while playing that can distract them. One could even go further and create a **high contrast mode** that could be turned on or off from the options menu. This mode would consist of secondary high contrast tone sprites for Mario, enemies, and interactable objects that would stand out above everything else and allow low-vision players to have a better experience(**BVAG-5**).

An **assisted navigation system** could also be added(**AVAG-3**). The navigation system would be simple to implement since the design of this level and the rest of the game's levels makes them easily dissectable(so much that they could even be drawn on paper). Therefore creating the points that make up the golden path of the level and adding a sound to guide players to the next navigable point would be a fairly simple and effective task, which would allow even blind players to complete the levels.

And as the last Accessibility feature that could be included both for the level and for the video game in general, it would be to add the option to activate and deactivate a **Godmode**. This is something very simple and that would allow many players stuck in a certain place of the video game to be able to advance.

Conclusions

This research has helped me, not only as a videogame developer but also as a player, to understand better what a big part of the gamer community suffers. It has helped me understand what Accessibility is in the video games environment, but above all it has helped me discover the problems and daily struggles that players with visual disabilities experience. With this thesis I've been able to discover the **current state of the video game industry in terms of Accessibility**, and I've also been able to investigate and learn about the **best guidelines and good practices** that some associations and companies promote to help developers make games more accessible.

After having done this research I have to say that I'm pleased with the results that I've achieved, more so coming from almost 0 knowledge and understanding of what Accessibility was and which paper it had in the video games industry. Thanks to having studied and analyzed in detail the most important Accessibility guidelines and the academic works that have delved into this issue, in addition to analyzing in depth one of the games with the best Accessibility features ever made(TLOU 2) **I have been able to develop my set of Visual Accessibility Guidelines**. I'm happy with the results because the guidelines have been applied to a real video game level where it has been proven that they make sense and that are useful in the development of a videogame.

Even so, I have to confess that I would have liked to test them with an existing video game in order to create a more visual and interactive prototype of the guidelines. **This prototype could have been tested by real players with visual impairments** from whom it could have received feedback to adjust and improve the guidelines. This was not possible mainly because from the beginning I conceived this thesis as something more **theoretical**, and when in the middle of the whole process I understood that by making it more practical I could obtain a better result, it was already too late. The "disadvantage" of working full-time

was also present, which has taken me more time than I wanted and I have not been able to dedicate as much time as I would have liked to dedicate to this thesis. It should also be said that although I tried to contact those responsible for the development of TLOU 2 Accessibility features to do an **interview,** in the end it was impossible for me to ask them the questions I would have liked or even to talk about the final result of this thesis to extract their feedback.

The subject of the thesis is something that has **motivated me from the beginning** of the development and has made me strive at all times to produce a good final result. During the development I have grown mentally and as a developer, since everything I have learned I take with me and it is something that I will not easily forget. What's more, I liked the topic so much that **it has made me decide to continue learning more about Accessibility in video games and about UX in general.** Thanks to this thesis I have realized that if I want to make video games, they have to be games that can be enjoyed by the vast majority of players, and this includes those with disabilities. In this particular thesis I have delved into visual Accessibility, but I have also discovered other types of impairments and conditions that **I would like to address in the not too distant future.**

Speaking of futures, if I wanted to continue where I left off in this thesis the first thing I would do would be to **study another video game in the industry** that has done a good job with Accessibility, such as **Spiderman: Miles Morales.** This would help me improve the guidelines and even make me create more. Another of the following steps would be to **apply these guidelines in a prototype or in a playable video game**, in order to test them correctly in playtesting sessions with players with different types of visual impairments.

I want to emphasize that the application of the developed guidelines on a game/level that had already been developed without having visual Accessibility in mind as it is the case with Super Mario Bros., makes everything more difficult and complex. This has led me to

determine that if you really want to make an accessible video game, it is **best to think about it from the beginning**. If you begin to design a video game taking into account the Accessibility guidelines the final result will be much more pleasant, and above all, the path will be much more pleasant **than if they are applied in a post-design process**. Even so with the Visual Accessibility Guideline application exercise in the World 1-1 level, it has been possible to determine that even by putting into practice half of the guidelines that are used in the exercise, a game that is not accessible to players with vision problems **can become minimally accessible** quite easily.

One of the beliefs that I had stuck in my head and that has disappeared during the development of this thesis is that making a video game without graphics for totally blind people is appropriate, when it is totally not true. **Accessibility is inclusion** and inclusion promotes that we can all enjoy something equally, so creating a video game that players that can use the sight in correct conditions will not be able to enjoy **is a mistake and does not solve anything**.

Another conclusion that I have been able to draw from this thesis is that Accessibility in general is not only for players who have disabilities, but rather **it is something that helps all players in certain moments and situations of their lives**. Much more work and effort would have to be invested in the Accessibility of video games so that the industry standards are minimally something similar to what Naughty Dog has done with TLOU 2, but **investing in Accessibility today will be beneficial tomorrow** since we all get older or at some point in our lives and we lose faculties that can limit us when it comes to enjoy a digital product such as video games.

And as a final conclusion to finish, I'm left with a phrase from the blind youtuber **Steve Saylor: "When everyone plays, we all win"**. This sentence sums up very well what many players with disabilities and developers who advocate for Accessibility feel. We are in the 21st century and everything revolves around technology. Ending Accessibility problems in video games is very easy if we really want to. Well-designed Accessibility will never disturb or harm the experience of the players, it will only help others to enjoy something that they like, video games.

Bibliography

Entertainment Software Association(ESA). *2021 Essential facts about the video game industry*. Recovered from https://www.theesa.com/

The International Agency for the Prevention of Blindness(IAPB). *Country map & estimates of vision loss - United States of America.* Recovered from https://www.iapb.org/

International Game Developers Association - Game Accessibility Special Interest Group(IGDA-GASIG). Recovered from https://igda.org/

The AbleGamers Charity. *Accessible Player Experiences (APX).* Recovered from https://ablegamers.org/

Barlet M. & Spohn S.(2012) for The AbleGamers Foundation. *Includification: A Practical Guide to Game Accessibility***.** Recovered from https://ablegamers.org/

Can I Play That?(CIPT). *The Last of Us Part 2 Lead Systems Designer Shows Vision Accessibility Prototype From 2018.* Recovered from https://caniplaythat.com/

Microsoft(2021). *Xbox Accessibility Guidelines v2.5.* Recovered from https://docs.microsoft.com/en-us/gaming

Jones K., Mortaloni A. & Zahand B.(n.d.) for Microsoft. *Gaming and Disability Player Experience Guide*. Recovered from https://docs.microsoft.com/en-us/gaming

Game Accessibility Guidelines. *Full list of Vision guidelines*. Recovered from https://gameaccessibilityguidelines.com/

Pérez L.(2012) for the CEAPAT. *Good practices of accessibility in video games*. Recovered from https://ceapat.imserso.es/ceapat_01/index.htm

Yuan B.(2009). *Towards Generalized Accessibility of Video Games for the Visually Impaired* [For the degree of Doctor of Philosophy in Computer Science and Engineering. University of Nevada, Reno]. Academic repository of the University of Nevada, Reno. https://www.unr.edu/cse/

Aguado J., Gutierrez J., Hilera J. & de-Marcos L.(2018). *Accessibility in video games: a systematic review.* [Department of Computer Science Superior Polytechnic School. University of Alcalá]. Recovered from https://www.researchgate.net/

Gilbert R.(2019). Inclusive Design for a Digital World: Designing with Accessibility in Mind (Design Thinking). Apress

PlayStation(SONY). *The Last of Us Part II: Accessibility features detailed.* Recovered from https://blog.playstation.com/

Naughty Dog(2020). The Last of Us Part 2 [Software]. Naughty Dog. https://www.playstation.com/en-us/games/the-last-of-us-part-ii/

Super Mario Wiki(n.d.). *World 1-1 (Super Mario Bros.).* Recovered from https://www.mariowiki.com/

United Nations Department of Economic and Social Affairs-Disability(2022). *Convention on the Rights of Persons with Disabilities (CRPD).* Recovered from https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

IGDA GASIG(2020). *The Accessibility in Last of Us Part II: A 3 Year Journey* [Video]. Youtube. https://www.youtube.com/watch?v=5HDdino-umA&ab_channel=IGDAGASIG

All About Vision(February 24, 2021). *What are the different types of color blindness?.* Recovered from https://www.allaboutvision.com/conditions/color-blindness/types-of-color-blindness/

National Eye Institute(April 15, 2022). *Low Vision.* Recovered from https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/low-vision#:~:text=The%20most%20common%20types%20of,to%20see%20in%20low%20light

People With Disability Australia(n.d.). *Social Model Of Disability.* Recovered from https://pwd.org.au/resources/disability-info/social-model-of-disability/#:~:text=The%20medical%20model%20of%20disability%20is%20all%20about%20what%20a,attitudinal%2C%20communication%20and%20social%20barriers