UNIVERSITY OF BEIRA INTERIOR
Engineering

Virtual Reality
Immersive user interface for first person view games

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Dedication

To my dear family, especially my grandmother, and all my teachers who supported me since the bachelor's and to my new teachers in the Master course thank you all for guided me in this master quest, I hope to see you all in another journey.

Acknowledgements

I dedicate this work to my family that supported me through all my academic years of study. I hope that all the effort and motivation that they gave me, I can demonstrate through this research, and to everyone who love video games, a knowledge capable to help game developers and designers to bring better games experiences to the people around the world.

A special thanks to my professors, Breno Carvalho and Anthony Lins, who always took care of me and motivated me in undergraduate and master's, there are no words that I can express my gratitude for you two, I am very proud to have these two as my mentors. Another thanks to Frutuoso Silva and Farley Millano, who helped me in researches and master's projects, thanks for everything.

Thanks to all of you that helped and believed in me throughout these years to make this possible, and the journey doesn’t stop here, there is a whole new frontier to come.

Resumo

Este trabalho se propôs a investigar a imersão que as interfaces de usuário trazem a jogos de primeira pessoa que utilizam a realidade virtual, baseada nos conceitos estabelecidos pela teoria da Diegese. Por fim, foi criado uma tabela com interfaces identificadas dos jogos que trazem mais ou menos imersão ao jogador. Através dos dados coletados foi desenvolvido um questionário para obter informações de desenvolvedores, designers e jogadores, em relação com os elementos mais imersivos, e outros com elementos menos imersivos, e concluímos que as interfaces Diegetic e Spatial são as mais imersivas para os jogos em primeira pessoa na realidade virtual, e menos imersivas são as interfaces Meta e Non-Diegetic. Através dessa informação, é possível que exista uma influência forte na criação de interfaces de jogos, afinal todos queremos ficar imersos enquanto jogamos.

Palavras-chave

Realidade Virtual; interface do usuário; jogos digitais; imersão; teoria diegesis.

Abstract

This study aimed to investigate the immersion of user interfaces that bring first person games using virtual reality based on the concepts established by the Diegesis theory. To conclude, a table has been created with identified elements of the games that bring more or less immersion to the player. Through the data collected, a questionnaire was developed to obtain information from developers, designers and players, in relation to the more immersive elements, and others with less immersive elements of the interfaces and concluding that the Diegetic and Spatial Interfaces are the most immersive for first-person games in virtual reality, and less immersive were the Meta and Non-Diegetic interfaces. Through this information, it is possible that there is a strong influence in the creation of games interfaces, after all we all want to be immersed when playing digital games.

Keywords

Virtual Reality; user interface; digital games; immersion; diegesis theory.

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List of Acronyms

VR	Virtual Reality
UI	User Interface
FPV	First Person View
POV	Point of View
UX	User Experience
UBI	University of Beira Interior
UNICAP	Catholic University of Pernambuco

1 Introduction

In this project, the theme of the study is on possible game interfaces settings in first person view, for use in virtual reality. We can see a gradual evolution of this concept of games interfaces, the extent to which we have more powerful technologies and modes of interaction.
We will explore and classify a wide range of first-person view games and their user interfaces for virtual reality on the Android system, in order to define and present a type of interface that allows greater immersion for the user, as well as pure interaction.

1.1 Background and Relevance

Virtual reality gaming is where a person can experience being in a three-dimensional environment and interact with that environment during a game. This is an essential part of the game [51].

For now, gaming is the biggest driver of VR, and will continue to be for the near future. But even among gamers, the most enthusiastic of early adopters in most cases, the potential of virtual reality gaming has been point of heated debate, and not just among fans, but developers as well [52].

First-person view (FPV), also known as first-person point of view (POV), is the ability of the user of some technology to see from a particular visual perspective other than one's actual location, such as the environment of a character in a video game, a drone, or a telemedicine client [4].

Let's mix First-person view and Virtual Reality. The Player will have the vision of the main character of a game, this may increase the immersion and make the player feel like he is this character.

By "becoming" the avatar, the player also embodies his character's traits and demeanor, and the intensity of in-game situations is ramped up considerably because of that [53]. For example, in Batman Arkham VR [54], the player will experience the death of Bruce Wayne's parents through Bruce's eyes, have a father/son relationship with Alfred (his butler), use the bat gadgets, look at himself by a mirror dressed as Batman and face the same challenge and fears. All this, can make the player play by the same sense of justice of our Dark knight.

Researchers, technologists and anyone else working in the field of virtual reality is all too aware of the dangers of hype and as a result, have tended to downplay its capabilities [38]. They often avoid the term “virtual reality” in preference to “virtual environment” which had a less negative connotation.

The Project aims to contribute to the development of research in the field of virtual reality digital games, more specifically the universe of User Interface (UI) and User Experience (UX), to improve and show effectiveness of immersion with a good UI/UX in a determinate game.
There are numerous ways virtual reality can be used and to our advantage, these will be discussed on this dissertation.

1.2 Objectives

General Objective: Define what kind of interface in virtual reality makes a first-person game more or less immersive.

Specifics Objectives: Analyze and Rank interfaces in virtual reality.

1.3 Methodology of Research

To achieve the objectives presented in this research, were followed these methodological steps:

1.3.1 Literature Review

To build the outlook of the research first were investigated the most relevant publications in virtual reality games and user interfaces, with both local databases, national and international. From that were researched published papers in proceedings of international conferences and national seminars that addressed the same keywords posted in the same period.

As a disciplinary activity in University of Beira Interior, was developed a paper to analyze and classified kinds of interfaces of virtual reality games, this paper was accepted in IV Congreso de Videojuegos y educación (CIVE 2016).

Finally, the last part of this work was to read and analyze the articles, and this way, find out what has been researched on interfaces within the game field in virtual reality. We attempted to also references to field of study, is the user experience, diegesis theory, digital games, psychological immersion, think-aloud methodologies.

1.3.2 Methodology

Choice of Virtual Reality Games:

At this stage, the objective was to define the artifacts for analysis. The games were found on Oculus Home [14] and they are all in first person view, but they have different settings from a static model to the playable model.

Model Analysis:

In this stage, they were defined the main features, founded by the diegesis theory, which an interface needs to present in a game. Furthermore, these features can be classified as four interface components: Diegetic, Non-Diegetic, Spatial and Meta.

Data Analysis:

This step was to analyze the selected games on virtual reality, through the leaderboard of interfaces, built after the search, trying to find the components and classify them in one of four categories. After that a questionnaire was made and responded by, developers, designer, and gamers to discover their opinion. Thus, parameters were observed with the purpose to establish a definition of what would be an ideal immersive game in virtual reality made by a game developer.

2 State of Art

Introduction

In this Chapter, will be discussed a little about digital games, like some concepts, kinds of games, new technologies applied to these games, methodologies and previous researches. Although, keep in mind this topic could have a whole research just about it but it is not the purpose of this study. It will be briefly presented to understand its structure and the new ways to play.

2.1 Game's Principle

In a classic definition of what are games, they are presented as a voluntary activity or occupation, performed during certain limits of time and space, to rules freely consented and

obligatory, accompanied by a feeling of tension and joy, as well as an awareness of be different from everyday life [1].

The game is older fact that culture as this, even in its less stringent definitions, always presupposes human society; but the animals do not expect men to initiate the playful life [2]. It can be argued that human civilization had not added essential characteristics that human civilization had not added any essential feature of the general idea of the game [2]. The animals play as men [2]. Huizinga [2] proposes that the game can be defined as a playful activity much broader than a physical phenomenon or psychological reflection, still, a voluntary act embodied as avoidance of real life, limited by time and space, creating the order through a temporary perfection. Additionally, presents tension, expressed in the form of random and uncertainty, to never know the outcome of the game [2]. The ignorance of the outcome in turn, is an important feature in the games because its development depends on more various factor, internal and external, as the adopted strategies and responses provided by the environment.

Crawford [3] highlights four key elements of all games representation, interaction, conflict, and safety.

- **Representation:** The game provides a simplified and subjective representation of reality, having a set of explicit rules. The Games feature essentially subjective representations, but originated and sustained by reality. Moreover, these representations provide a complete and self-sufficient environment, because its elements do not depend on any present reference in the world external to the game.
- **Interaction:** The crucial point in the representation of reality lies in the way how it changes and interactive representation, which the games are held, it is presented as the most complete form of representation. In it, the viewer capable of causing change and verify its consequences, thus being able to modify displayed reality.
- **Conflict:** The conflict arises naturally from the player interaction and this element is present in all games. The player actively seeks to achieve some purpose and there will be obstacles that hinder this objective to be reached easily. This opposing force occurs in many forms and may have, for example, the form of active agents, which through action, try to prevent the success of the player, or more subjective elements, such as a stopwatch.
- **Safety:** Because the conflict tends to create a risk scenario, it comes a physical risk. However, the game allows the player submit to the psychological experience of conflict and danger without damage physical, thus enabling disassociate the consequences of actions. Crawford [3] points out that this dissociation does not mean that there are no consequences in the games, but the penalties for defeat of a player can be deterrents or the absence of any reward.

Still according to Crawford [3], one of the main intentions of the games is to educate. All kind of contact with the games tend to add new knowledge and experiences to the player. The author shows various behaviors of beings in nature, as well as own human being, which can be described as the practice of games and whose main aim is to provide knowledge and experience essential for development of these beings, preparing them for adult and independent life. Also, that in humans for the development of other aspects, such as social life. Thus, Crawford [3] concludes that beyond the pursuit of pleasure, fun and the possibility of immersion in a fantasy world to escape the daily life, the need to learn and know are other factors that motivate practice games. This practice, for example, allows the maintenance and expansion of social interaction, allow individuals to know better and learn to respect their cultural and ethnic differences.

2.2 First-person view games

First-person view (FPV), also known as first-person point of view (POV), is the ability of the user of some technology to see from a visual perspective other than one's actual location, such as the environment of a character in a video game, a drone, or a telemedicine client [4].

In areas Including photography, film, video games, telepresence and virtual reality, first-person views allow the user to experience an environment in a way that they might not have been able to otherwise [4].

The first-person view is common in video games, allowing for immersive play as a character. FPV became common in first-person shooter games after ID Software popular Wolfenstein 3D [5], which put players in the shoes of an agent escaping a Nazi camp to ultimately kill Hitler.

In the FPV, the camera is placed behind the eyes of the main character. For many first-person games, particularly first-person shooters (FPS), players see their arms or items they may be carrying.

The first-person view has several potential advantages. First, some consider it to be the most immersive view because the player and character views are the same. Keeping the main character off-screen allows players to imagine that character in any way they wish, perhaps even as themselves! [6] this point is debatable and some would counter that a first-person view is less immersive than third-person; it is harder for players to identify with their character when they do not see them onscreen.

A non-controversial benefit of a first-person view is that required system resources are reduced, since one less character model that must be shown onscreen at any given time [6]. Also, a first-person view can result in more intuitive controls for some types of gameplay. For example, in certain implementations of shooting gameplay, the first-person view more easily allows players to see their targets and anticipate what will happen when they fire [6].

A primary disadvantage of the first-person view is that it can require greater player skill to master [6]. For example, because player can only see a small section of the world in front of them they might be attacked by unseen opponents with no idea of the direction of the threat [6]. These types of problems can be addressed through other aspects of the interface. For example, an icon could appear on the screen showing the direction of attackers, though this solution reduces the level of immersion [6].

2.3 Introduction to Virtual Reality

Virtual reality (VR) means experiencing things through our computers that don't really exist. From that simple definition, the idea doesn't sound especially new. When you look at an amazing Canaletto painting, for example, you're experiencing the site and sounds of Italy as it was about 250 years ago, so that's a kind of virtual reality. In the same way, if you listen to ambient instrumental or classical music with your eyes closed, and start dreaming about things, isn't that an example of virtual reality, an experience of a world that doesn't really exist? What about losing yourself in a book or a movie? Surely that's a kind of virtual reality?

If we're going to understand why books, movies, paintings, and pieces of music aren't the same thing as virtual reality, we need to define VR clearly.

Woodford [7] define it as: A believable, interactive 3D computed created world that you can explore so you feel you really are there, both mentally and physically.

- Believable: You need to feel like you're in your virtual world (on Mars, or Wherever) and to keep believing that, or the illusion of virtual reality will disappear.
- Interactive: As you move around, the VR world need to move with you. You can watch a 3D movie and be transported up to the Moon or down to the seabed, but it's not interactive in any sense.
- Computer-generated: Why is that important? Because only powerful machines, with realistic 3D computer graphics, are fast enough to make believable, interactive, alternative worlds that change in real-time as we move around them.
- Explorable: A VR world need to be big and detailed enough for you to explore. However realistic a painting is, it shows only one scene, from on perspective. A book can describe a vast and complex "virtual world", but you can only explore it in a linear way, exactly as the author describes it.
- Immersive: To be both believable and interactive, VR needs to engage both your body and your mid. Paintings by war artists can give us glimpses of conflict, but they can never fully convey the sight, sound, smell, taste, and fell of battle. You can play a flight simulator game on your home personal computer and be lost in a very realistic interactive experience for hours (the landscape will constantly change as your plane flies through it), but it's not like using a real flight simulator (where you sit in a

hydraulically operated mockup of a real cockpit and feel actual forces as it tips and tilts), and even less like flying a plane.

Virtual reality means blocking yourself off from the real world and substituting a computer-generated alternative. Often, it involves wearing a wraparound headset called a head-mounted display (HMD), clamping stereo headphones over your ears, and touching or feeling your way around your imaginary home using data-gloves (gloves with built-in sensors) [55].

2.3.1 How it Started

Virtual Reality is considered to have begun in the 1950's but early elements of It can be traced back to the 1860's and long before the development of digital technology [55].

360 degree murals which enabled the observer to engage with the artwork on a simple level it's an example of virtual reality, and could be found in the avant-garde work of French playwright Antonin Artaud [38] who considered illusion and reality to be the same. Nowadays (in 2016) it's possible to look at this kind of "murals" on Facebook with 360 pictures [55].

In the 20's, the first simulator device was developed by Edwin Link and it was a flight simulator [38]. This was designed as a training device for novice pilots, and today we have a lot kinds of simulators that which often contain complex rules and relationships which are based on real life situations [55].

Multimedia devices as The Sensorama was devised by Morton Heilig in 1957, had the form of an interactive theatre and consisted on the following elements, a screen displaying stereoscopic images, oscillating fans, speakers, and devices which emitted smells [55]. Similar as Oculus Rift [13] and Feel Real [37].

The first interactive map was in 1970, developed by researchers at Massachusetts Institute of technology (MIT) [38]. This was an innovative form of multimedia which enabled people to walk through the town of Aspen. The most famous interactive map nowadays its google maps, which can be used with virtual reality to see the street view.

In the 80's, virtual reality was used on projects for NASA as well as research into new forms of human-computer interaction (HCI) [38]. This was carried out by Dr. Michael McGreevy, an authority in this field and several other spheres who developed some innovative virtual reality systems [38]. We still have a problem with HCI and virtual reality, people are not accustomed to the idea of using every day. Adi Robertison (writer from The Verge) [39] made an experiment by using the Samsung Gear VR in the subway, a moving car, drinking a coffee, and other everyday settings, and prove that still uncomfortable using portable head mounted displays in our society.

After the 2nd World War, various studies were conducted to develop simulators for military training with a view to avoiding accidents to humans, besides which this reduced costs and pinpointed design flaws. These simulators did not have a system for obtaining visual feedback [9]. All they did was to simulate the ratio of movements in a three-dimensional spatial perspective when they were being used [9]. With the advances of computer vision technology, the first artifacts were created that enabled reality to be virtualized in a less complex way with regard to rendering graphics more realistic in addition to which they enhanced the user's experience of immersion [9]. In the 1980s, the term Virtual Reality (VR) was coined by the artist and computer scientist, Jaron Lanier, who thereby succeeded in expressing the search for the merger between what is real and what is virtual [8]. In mid-1982, the movie Tron by Steven Lisberger, spread this concept massively, by presenting the universe of VR as a technology for digital games, aided by quality graphics visuals that served as the standard for the digital entertainment industry [9]. As an example, there are the games Crysis and Halo, which provide the user with greater interaction with and immersion in the technology [9].

The term of virtual reality (VR) is old, the first hardware HMD was a toy named View Master [10]. It was launched in a New York Science Conference in 1939, this toy is based on card disk with little pictures that fool our eyes and make us see just one image. Today we have powerful head-mounted displays like Oculus Rift, Gear VR, HTC Vive, PlayStation VR and Google Cardboard/Daydream, which are examples of this evolution [10]. These hardware's are based on stereoscopic lens to make a depth illusion to do the immersion with the 3D environments, as with View Master, two images are generated by each eye and then the brain makes all the works turning two images in just one [11]. The Biggest change is the fact of the user can move your head to see another part of this 3D environments. On using Virtual Reality, software becomes more interactive, through which the user starts to become part of a virtual space, thus enabling data to be manipulated and exploited in real time by using one's senses in a three-dimension environment [8].

2.3.2 Virtual Reality Devices

First let's discussed more about the head-mounted displays (HMDs). There are two big differences between VR and looking at an ordinary computer screen: in VR, you see a 3D image that changes smoothly, in real-time, as you move your head [56]. That's made possible by wearing a head-mounted display, which looks like a giant motorbike helmet or welding visor, but consists of two small screens (one in front of each eye), a blackout blindfold that blocks out all other light (eliminating distractions from the real world), and stereo headphones [56]. The two screens display slightly different, stereoscopic images, creating a realistic 3D perspective of the virtual world [56]. HMDs usually also have built-in accelerometers or position sensors so they can detect exactly how you head and body are moving (both position and orientation) which way they're quite heavy, so they can be tiring

to wear for long periods, some of the heavy ones are even mounted on stands with counterweights [56].

2.3.2.1 Head-mounted Displays

I said the names of some famous HDM, in the last section, now let's see the curiosities specification and how each one of them started. A table of specs will be available in the end of HDM presentations.

- Oculus Rift: Invented by Palmer Luckey, the Oculus Rift is a set of virtual-reality googles that will work with your gaming desktop or laptop. After he debuting a prototype at E3 gaming convention in 2012, Luckey founded Irvine, California. Based Oculus VR with Brendan Iribe, who became CEO. The two launched a Kickstarter project in August 2012 to sell prototype developer versions of the Oculus Rift, raising $2.4 million. Since that auspicious launch, Luckey and crew went to work refining the HDM, releasing several prototypes including Development Kit 2 (DK2), Crystal Cove and Crescent Bay [12].

  Now let's see how Oculus Rift works. picture a set of ski goggles but instead of miles of fresh powder, you're transported into space or underwater [12]. The Rift accomplishes this using a pair of screens that displays two images side by side, one for each eye [12]. A set of lenses is placed on top of the panels, focusing and reshaping the picture for each eye, and creating a stereoscopic 3D image [12]. The goggles have embedded sensors that monitor the wearer's head motions and adjust the image accordingly [12]. The latest version of the Oculus Rift is bolstered by an external positional-tracking sensor, which helps track head movements more accurately. The result is the sensation that you are looking around a 3D world [12].

Figure 1: The Oculus Rift virtual reality headset [13].

What about the specifications? Well Oculus Rift include a 2160 x 1200 OLED display which delivers 1080p (HD) per eye, a 110-degree field of view with a 90Hz refresh rate [13]. The device will also feature a built-in accelerometer, gyroscope, magnetometer and 360-degree positional tracking that follows six axes of movement with a latency of milliseconds (that allows the player to move in real world and virtual smoothly at the same time) [13]. Packaged accessories include the sensor, remote, cables, and an Xbox One controller [13]. The latest version of the Rift requires a computer running Windows 7 or higher with a processor greater than or equivalent to an Intel i5-4590 with at least 8GB of RAM [13]. Regarding the graphics card, you need a Nvidia GeForce 980 desktop chip for laptops [13]. Desktops will require at least a Nvidia 970 card or an AMD 290 graphics card for desktops [13]. To plug the headset in, your system needs three USB ports, and HDMI 1.3. [13].
What can I play with Oculus Rift? You can find many of these listed on Oculus experiences site [14] and in the recently launched VR section of Steam, Valve's game download service [15]. There are also fan-made modifications to particular titles to get them working with Rift. Third-party programs such as TriDef [16], Vireio Perception [17] and VorpX [18] allow games that are not made for the Rift to work with it. The Rift are currently shipping with two free games: Lucky's Tale [19] and EVE: Valkyrie [20], sci-fi space combat simulator, set in the same world as popular massively multiplayer online EVE Online. However other titles like Insomniac Games Edge of Nowhere [21] and 505 Games Ad1ft [22] will also be making an appearance.

- Gear VR: This HDM is a mobile virtual reality headset developed by Samsung Electronics, in collaboration with Oculus, and manufactured by Samsung. The headset was released on 2015 [23]. When in use, a compatible Samsung Galaxy device as S6/S6 Edge+, S7/S7 Edge+, Note 5 or 7, acts as the headset's display and processor, while the Gear VR unit itself acts as the controller, which contains the high field of view, as well as a custom inertial measurement unit (IMU), for rotational tracking, which connects to the smartphone via micro-USB [23]. This IMU is more accurate and well calibrated with lower latency than internal smartphone IMUs [23].

Figure 2: The Gear VR virtual reality headset from Samsung [23].

The Gear VR also includes a touchpad and back button, as well as a proximity sensor to detect when the headset is on [23]. The touchpad and button allow for a standard minimum input capability for users to interact with the virtual environments. The device can be calibrated using the wheel at the top of the headset. The Trackpad is located on the right of the device and back button is located just above it. Volume can be adjusted through the volume rockers also found on the right-hand side.

What about the specifications? The Gear VR include a 2560 x 1440p OLED display which delivers 1280 x 1440 per eye, a 100-degree field of view with a 60Hz refresh rate [23]. The Gear also brings sensors as gyroscope accelerometer, proximity, and geomagnetic [23].

Where I can find Games/apps or experiences for Gear VR? Well this HDM has to be paired with the Oculus app called Oculus Home, is the main facility to download and use content on Samsung Gear VR. Oculus Home is also the main line for software distribution on the Gear VR. Like Oculus Rift, the Gear VR can use Third-Party apps such as Sideload VR [24] and Play Cardboard apps on Gear VR [25], to use these apps the Android must have root (which means unlock the Android to install apps who require internal privileges of the system).

- PlayStation VR (PS VR): This is the Virtual Reality Head-mounted display of Sony, produced for the PlayStation 4, unique to games. The accessory had been one of the sensation during the E3 2015 conference, in United States, with a separate stand so that visitors could test.

Figure 3: The PlayStation VR headset from Sony [26].

What about the specifications? The PlayStation VR include 1920 x 1080 OLED display which delivers 960 x 1080 per eye, with 100-degree field of view with a 90-120Hz refresh rate [26]. The PS VR has accelerometer, gyroscope, magnetometer and PS Eye Tracking sensors [26].

Launched in 2016 that device comes with the box following the display, processing unit, stereo headphone, HDMI cable, USB cable, Power adapter and adapter to own headsets [26]. There is also a game show that comes in the package, called PlayStation VR Worlds.

Where I can find Games/apps or experiences for Gear VR? As I already said, it requires a PS4 so the game will be available in PlayStation Store, games like Batman: Arkham VR, Resident Evil 7 Biohazard and RIGS Mechanized Combat League [27]. Still there is no information about Third-party ways to play in PlayStation VR. But it's possible to use the Cinematic Mode, it makes all the games available in the PS4 can be used with the display, for example: when you will play a game that has no VR functions or is not unique display, such as LEGO Batman 3 [28], it will be displayed in PS VR with a larger screen, like a movie screen in a virtual environment generated by the accessory.

- HTC Vive: Vive is the virtual glasses of HTC, launched in 2015 at the Mobile World Congress (MWC) in Barcelona [29]. Tipped as the main competitor of the Oculus Rift, the headset accessory had been developed in conjunction with Valve, owner of the largest virtual world game store and promises a variety of scenarios of options to enjoy during immersion in virtual reality. One of the greatest gadget of the highlights is the Lighthouse feature that track the movements measuring the position of the

hands and head [29]. Thus, it is possible to walk to the device without fear of tripping over furniture or hit walls.

Figure 4: The HTC Vive virtual reality headset [29].

What about the specifications? In the unit, there is also wireless connectivity, 2560 x 1200 OLED screen, which delivers 1080 x 1200 per eye with 90 fps [29], high-definition audio, front camera to see without removing the spectacles, and two controls that simulate weapons, hammers, among other things improve user experience and make the simulation even closer to the real.
Where I can find games or experiences? in VR section of Steam [15], or HTC store for the Vive, it's called Viveport [30], this store offers an alternative to Steam, which has become a de facto marketplace for HTC Vive virtual reality applications. Promising a comprehensive slate of VR-compatible apps across multiple categories, Viveport integrate with HTC's existing Vive Home VR hub, allowing HTC Vive owners to browse and purchase compatible apps without leaving the realm of virtual reality. Along with games, Viveport also host VR edutainment titles, creative apps, and 360-degree video content, in addition to VR-focused news, sports, health, travel, shopping information.

- Google Daydream: The VR headset was announced on 4 October 2016, during Google's event and named Daydream View. As for its competitors, Google's Daydream View sits between the cost of a Samsung Gear VR headset ($99) and a Bluetooth controller which is between $20-30 [57]. This makes it considerably cheaper than an Oculus Rift or HTC Vive.

Like the Gear VR, the Google Daydream its focused on mobile VR, bringing VR to the masses. Daydream is essentially the evolution of Google Cardboard and is not just a headset, but also a controller and part of Android 7.0 Nougat [57]. Manufacturers which are developing Daydream-ready phones include Samsung, LG, HTC, Huawei, Alcatel, ZTE and Asus. Google of course launched at the same day as Daydream the Google's Pixel X and Pixel XL, they are totally compatible with Daydream View VR headset [57].

Figure 5: The Google Daydream virtual reality headset [59].

The daydream controller is an integral part of the system: it needed to select things and play games, its's a bit like an Android TV or Apple TV remote, that it had a clickable touchpad and couple of buttons, so it's easy to use without looking at it, and It also had an orientation sensor so it knows where you're pointing [58].

What about the specifications? Well, the displays detail will depend on the phone, the Google Pixel have a 1080p display, and the Google Pixel XL have a 1440p display, these are the first Daydream ready phones released so far. The HMD from Google comes with the sensors Accelerator, gyroscope, proximity, wireless connection with the phone, and motion controller included [59].
Where I can find games or experiences? Like Gear VR, the Google Daydream has his own app, a version of Google Play for VR. Google made partnerships with Ubisoft, CCP, Netease, Electronic Arts, Otherside Entertainment, Minority VR, Resolution, Turbo Button, nDreams and Climax Entertainment [59].

Here down below you can see a comparative between each Head-mounted display with additional information.

Category	Oculus Rift	Samsung Gear VR	Sony PlayStation VR	HTC Vive	Google Daydream VR
Display	2160x1200 (1080 x 1200 per eye) OLED	2560x1440 (1280 x 1440 per eye) Quad HD super OLED	1920x1080 (960 x 1080 per eye) OLED	2160x1200 (1080 x 1200 per eye) OLED	Depends on Phone – Google Pixel 1920x1080 (960x1080 per eye) OLED
Refresh Rate	90Hz	60Hz	120Hz, 90Hz	90Hz	Depends on Phone
Field of View	110 degrees	100 degrees	100 degrees	110 degrees	Depends on Phone
Sensors	Accelerometer, gyroscope, magnetometer, 360-degree positional tracking	Accelerometer, gyroscope, geomagnetic, proximity	360-degree tracking, 9 LEDs	Accelerometer, gyroscope, laser position sensor, front-facing camera	Accelerometer, gyroscope, proximity
Tracking area	5x11 feet	Fixed Position	10x10 feet	15x15 feet	Fixed Position
Controller	Oculus Touch, Xbox One controller	Bluetooth controller	Sony DUALSHOCK 4 controller or PlayStation Move	Vive Controllers, SteamVR controller, any PC-compatible gamepad	Motion Controller (Included)
Minimum Hardware	Nvidia GeForce GTX 970 or AMD Radeon R9 290 GPU, Intel Core i5 - 4590 CPU, 8GB RAM, HDMI 1.3, 2X USB 3.0, Windows 7 SP1 or Higher	Samsung Galaxy Note 5,7. Galaxy S6 series or S7 series	Sony PlayStation 4	Nvidia GeForce GTX 970 or AMD Radeon R9 290 GPU, Intel Core i5 - 4590 CPU, 8GB RAM, HDMI 1.3, USB 2.0	Google Pixel, XL, Daydream ready phones
Price	$599	$99	$399	$799	$79
Consumer Release Date	March 28, 2016	November 27, 2015	October 2016	April 15, 2016	October 4, 2016

Table 1: Comparative between Oculus Rift, Gear VR, PlayStation VR, HTC Vive and Google Daydream specifications.

Seeing this comparative, the Gear VR has a better resolution per eye than the others HMD's thanks for the galaxy S6, S6+, S7, S7+, Note 7.

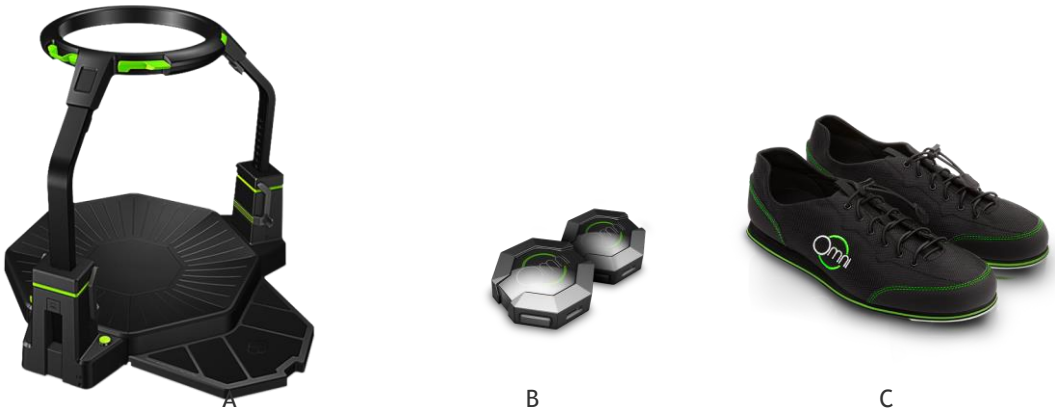
All this VR Headsets have support for two widely used game engines: Unity and Unreal. The result is that many indie titles and several larger games are compatible with the developer's kit.

2.3.2.2 Virtual Reality accessories to head-mounted Displays

In the context of digital games, researchers and developers are trying to find a way to improve the immersion with VR, consequently other hardware's has been built to work together with VR glasses (HDM) [10].

Here is a list of most famous hardware's compatible with HMDs.

- Omni: The goal of the Omni is to create a feeling of freedom in all direction [31]. It is a multidirectional treadmill it can be used as a gigantic game controller for your feet, this allows the user to walk and run through 3D environment, a giant circular structure you stand in with a sloping concave bottom. The user slide around inside, trying to walk up the side of any part of the bowl you're placed in, holding onto the side guardrails for support. For all its high-tech looks, you're basically slipping around on a smooth surface with low-friction shoes. And it is the shoes that are tracking your motion. The Omni comes with its own special shoes, included with the package [31]. These feels like slip-on sneakers, but slippery like bowling shoes [31]. They let you slip around in the Omni, while clip-on motion trackers (Virtuix Omni Tracking Pods) measure movement and turn your feet into game controls [31].



A B C

Figure 6: A) The Virtuix Omni treadmill; B) and Omni tracking Pods; C) Omni Shoes. [31].

The Virtuix Omni comes with large ring structure (the "guardrail") and base you see in the figure 5, a harness in a size you choose when you order, a pair of Omni shoes, and a pair of Omni motion trackers that clip on the shoelaces. It's strictly a walking peripheral [31].

Games interpret the Virtuix Omni like a regular game controller, so you could pair this with an Oculus Rift, HTC Vive (which Virtuix is officially partnering with,

marketing its treadmill as being ideal for Vive), and Samsung Gear VR. Not PlayStation VR, however. According CEO Jan Goetgeluk, he's hopeful to make that happen someday [32].

Virtual reality eventually needs to figure out how "walking around in VR" can be accomplished with everyday movements, without hitting into walls [32].

- Oculus Touch: Created by Oculus, the same developer of Rift. This device is a pair of gripped handles that approximate human hands to elevate gameplay from traditional to something truly unique [33]. In Gamescom 2016, the game "The Unspoken" from Insomniac Games was developed for Touch [33], in this action game, the user uses the controller to cast spells, defend against attack and collect items around a playing field [33]. In the end of 2016 the Touch controllers finally are released for consumer edition.

Figure 7: Oculus Touch controllers [34].

The stuff that comes out with Touch, you can see it is even more creative, more like this next evolution of VR content [33].

- Leap Motion: announced in 2012, this device can recognize hand gestures and translate them into interface commends to let the user "do things on the computer just like you do them in real life" [35]. Leap Motion use two cameras and infrared LEDS, to track movements of hands. When people first started using headsets like the Oculus Rift, the mouse and keyboard suddenly became inadequate: they were tough to find while effectively blindfolded, and they didn't take advantage of virtual reality unique feeling of 3D space [35].

A B

Figure 8: A) Leap Motion Device; B) Leap Motion Orion demo “Blocks”. [36].

The demo called Blocks, it’s a featureless landscape where you can conjure cubes (as well as rectangular boxes and dodecahedrons) out of thin air by pinching and pulling [36]. The motion makes total sense, like stretching invisible putty [36]. The tracker mimics your hand almost perfectly across a wide field of view [36]. Once the shapes are down, you can grab, throw, and push them, or turn off gravity altogether and bat them around.

2.3.4 Applications

The field of Virtual Reality is wide by encompass several fields of research and development such as Medicine, Education, Entertainment, Training, and a lot more.

Medicine examples:

Exposure therapy, is one treatment for patients with phobias is exposure therapy [40]. In one instance, Psychiatrists at the University of Louisville are using VR to Help patients deal with fears of things like flying and claustrophobia [40]. The VR experiences provide for a controlled environment in which patients can face their fears and even practice coping strategies, as well as breaking patterns of avoidance, all while in a setting that’s private, safe, and easily stopped or repeated, depending on the circumstances.

Treatment for PTSD, similar to exposure therapy for phobias and anxieties, virtual reality is being put to use to help soldiers with post-traumatic stress disorder [41]. More recently clinics and hospitals are using virtual reality simulations of warfare akin to Iraq and Afghanistan to help veterans who are, in many ways continually reliving the traumatic events they experienced [41]. In a safe and controlled environment, they can learn how to deal with instances that might otherwise be triggers to behavior that could be destructive to themselves and others [41].

Surgical Training, usually involves cadavers and a gradual process of assisting more experienced doctors before taking over tasks and bigger portions of the surgery [42]. Virtual reality could provide another means of practice, without any risk to real patients. Stanford University, for one, has a surgery simulator that even includes haptic feedback for those doing training [42]. Stanford's endoscopic sinus surgery simulation uses CT scans from patients to create 3D models for practice, and it's been in use since 2002 [42]. While this technology doesn't use a head mounted display, the groundwork that's been done could further the effectiveness of future virtual simulations [42];

Education examples:

Engage, is a free-to-use education and presentation platform, that seeks to transform how people share ideas and teach lessons [43]. Also, enables businesses to connect in a more intimate way, by accessing virtual meeting rooms and allowing users to collaborate using tools such as our interactive whiteboard system [43]. The engage platform is also Dropbox and OneDrive compatible, meaning you can share all your files and media inside a virtual environment. Power Points, video files, audio files and spreadsheets have never been easier to share, it's even possible to share YouTube videos [43].

Lecture VR is a VR app which simulates a lecture hall in virtual reality, while adding special effects which can't be utilized in a traditional classroom setting. Lectures are accompanied by images, videos, and immersive experiences which enhance the lesson [44]. Imagine leaning about Apollo 11 and while the instructor is lecturing, they can transform the classroom to be inside the space shuttle which they're lecturing about, adding much more to the lecture than would be traditionally possible [44]. Another major asset of this type of learning is that students and professors can remote in from anywhere in the world, which makes education more accessible on a global level.

Google Expeditions Pioneer Program, is for Expeditions teams from Google to visit schools around the world and provide everything teachers need to take their students on a journey anywhere, the team will also assist the teachers in setting up and utilizing this technology [43]. The VR experiences are meant to be like a cool field trip which teachers would ordinarily never be able to take their students on, whether it's to an underwater coral reef, or into a city like Barcelona, the potential is truly limitless here [43]. The way the app works is that students and the teachers will see the same things and be in the same session, but the teacher will be able to lecture and highlight certain things which are relevant to the lesson [43].

Entertainment examples:

The Void, is a blending of physical reality with virtual reality, and is building a physical environment, a virtual reality theme park, dubbed “Virtual Entertainment Centers” to work with the virtual environment that shows in the user’s field of view on their VR headset (HDM) [45]. The VOID is in partnership with Unity 3D, Evermore, and Optimal Design. In the Void’s virtual world, users will be exploring, battle, fight and warder through deep jungle, war-zone, other planet with robots and aliens, and the darkest dungeons with fierce, fire breathing dragon [45].

Figure 9: The Void virtual reality theme park [45].

Miami VR park, is a collection of virtual attractions. It consists of three different state of the art entertainment systems that gives an experience like you never had before [46]. These parks have a simulator called Space Blaster that simulates the experience of galactic warfare in space, as you are strapped into a full-motion seat and wear a head-mounted display, you are not only capable of possessing full control of an aircraft but also can have a 360-degree view of a galaxy. Another attraction is the Teleporter, which is a cabin that created a similar dynamic 5D cinema experience as our cinema system, however, here you are placed into a dynamic cockpit that simulates even more complex motions that make the viewer directly involved in the events of the 3D film Shown, the film is projected right below you on the cabin floor that is made of laminated glass [46].

A B C

Figure 10: A) Space Blaster; B) 5D Cinema; C) Teleporter [46].

The New Revolution Virtual Reality Coaster, in partnership with Samsung Gear VR and Oculus, The New Revolution is equipped with wireless headsets that, while wearing, allow you enter a virtual world with high resolution imagery and 360-degree views that synchronize to the action of the coaster [47].

Figure 11: The New Revolution Virtual Reality Coaster [47].

Training examples:

QinetiQ, is a VR training solutions that are improving health and safety in the commercial sector, specifically mining, reducing the frequency rates of lots time injuries and minimizing litigation costs [48]. Training using virtual reality is cost- effective, and boost learning and retention rates [48]. 'Rehearsing' operations in a realistic environment leads to increased operational efficiency and production, and cuts downtime required to carry out maintenance [48].

Figure 12: QinetiQ training solutions [48].

STRIVR LABS, it's a company solution, using virtual reality with immersive 360-degree training software for training NFL franchises that have invested in [49]. Football is a downright violent sport, if players aren't injured in the games themselves, there's a chance that they could be hurt in practice [49].

Figure 13: STRIVR LABS NLF training [49].

Novus-Res, it's a company that sells Virtual reality training simulators, to bring new levels of immersive game based learning to the training room. Their Simulators provide realistic virtual training environments and accurate simulation delivering efficient, safe and practical training especially useful in high risk training scenarios. Its available the following simulator, Mining Vehicle, Forklift and Heavy Vehicle like a truck [50].

A B C

Figure 14: A) Mining Vehicle simulator devices and screenshot; B) Forklift simulator devices and screenshot; C) Heavy Vehicle simulator devices and screenshot [50].

2.4 User Interface for digital games

User Interface (UI) in video games is the way players can interact with the game and receive feedback of their interaction. It generally applies to the interactivity and concepts of a game. This includes several aspects of gameplay such as the storyline, controls, graphics, visual perspectives (point-of-view), behaviors of AIs, and level designs. The experience generated from the resultant gameplay of interaction is the objective of the game. For more understanding, let's the evolution of UIs in games.

Mindless and Repetitive Games of skill examples:

Command-line Interface (CLI).

Is a means of interacting with a computer program where the user issues commands to the program in the form of successive lines of text (command lines). In games is used in storylines interaction.

While skill games were evolving to include scores and other added features, another genre was emerging within the industry to spice up the content of games [67]. Colossal Cave Adventure (1975) was known as the first computer adventure game that eventually brought storylines into games [67]. It had no graphical interface, only textual [67]. The draw of the game was story-rich content and the interactivity involved [67]. Players type in commands indicating what they wish to do next in each situation [67]. Depending on the choices the players make, the story unfolds in different ways with different endings [67].

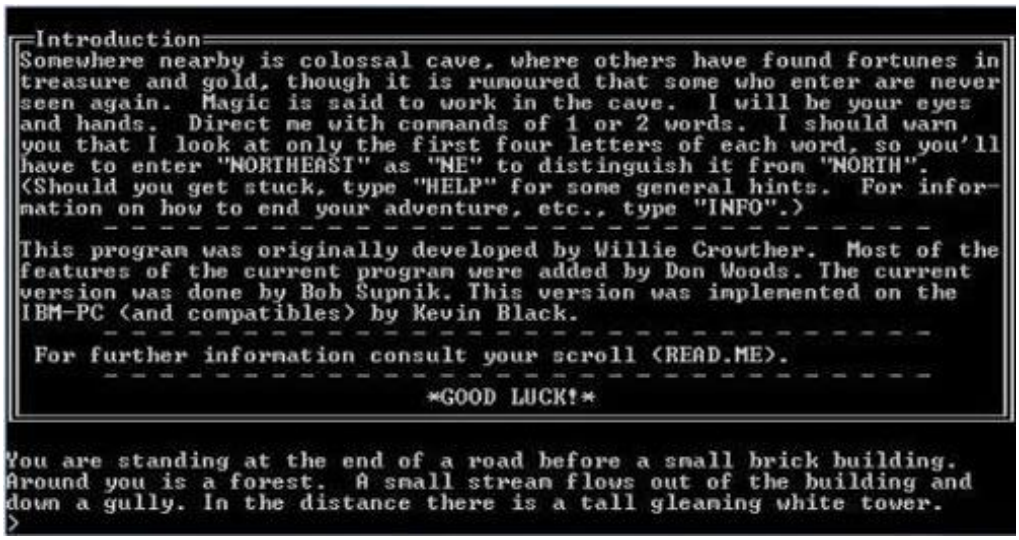


Figure 15: Colossal Cave Adventure (1975), a command line interface (CLI) game [67].

Analyzing the Colossal Cave Adventure, all interfaces and feedback is textual, with no symbols.

Graphical User Interface (GUI)

Is a type of user interface that allow users to interact with electronic devices through graphical icons and visual indicators, instead of CLI typed command labels or text navigation. In games is very common to have GUI in several genres.

One example of such primitive games is that of Tennis for Two (1958), a game which simulates tennis of ping pong where each player manipulates the ball trajectory over a simplified tennis court from the side [67]. Players simply press the button to hit the ball when it is at their side of the net after adjusting the hitting angle with a control knob [67]. The game goes on until a player misses [67].

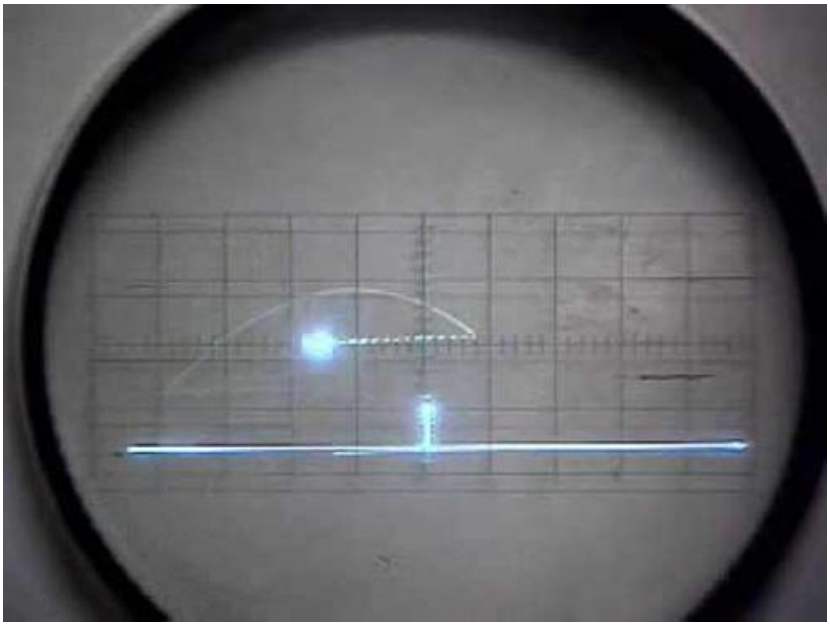


Figure 16: Tennis for Two, the second electronic game launched in the world in 1958 [67].

Analyzing the game Tennis for Two, it's possible to notice that there is no sign of feedback for the player who is winning the match, but we can assimilate the graphics with a tennis field and the ball with side vision.

Pong (1972), it's a game where two players battle in out with their paddles on screen and try to return the ball to their opponent without a miss [67]. When the opponent fails to hit the ball, the other player gains a point [67]. It was about this time that game developers realize that players get an extra incentive to play when thing start becoming competitive with player scores [67].

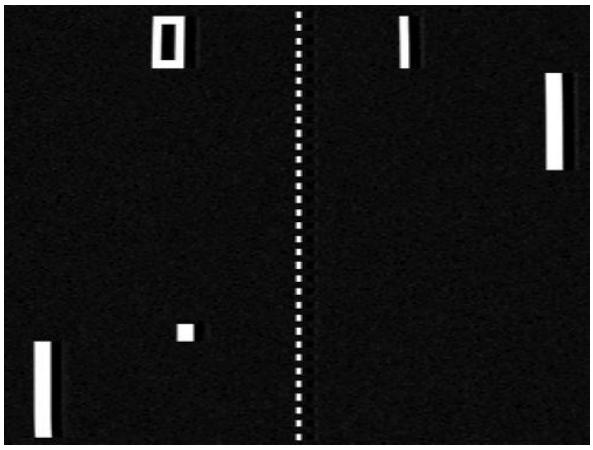


Figure 17: Pong (1972), the right player is winning the match for 1 point [67].

Analyzing the game Pong, we notice that finally we have feedback from the score, and now we know who is winning the match by just looking at the Figure 16. And still can assimilate like a tennis match with upper vision.

Developers eventually tried putting story elements and graphics together in their games, one of the pioneers was Donkey Kong (1981) [67]. It was one of the earliest game to have a storyline [67]. You play as Jumpman who had to rescue the Lady from Donkey Kong and in-game characters began to take form – with pink dresses, red overalls and villain-trademark smirks [67]. Such details allow for players to identify with the characters and immerse themselves into the story [67].

Figure 18: Donkey Kong (1981), the earliest game to have a storyline [67].

Analyzing the Donkey Kong, it's possible to notice some interfaces as a bonus box, actual score, the high score, symbols who represents how many life's the player has, items for bonus and textual storyline elements such as the Lady saying "Help!".

With the limiting graphical capabilities and computing power shifted the focus of games to the details like storyline and high scores [67]. Those were the times when "realism" had more to do with how players interact and relate with the game than just graphics per se [67]. But 3D graphics in the 1990s changed that, allowing us to skip from 2D to 3D [67]. It made possible the idea of a 'first-person' point-of-view (POV) gameplay explained before on First-Person Section introducing the game Wolfenstein 3D (1992).

Figure 19: Wolfenstein (1992), gameplay [67].

Analyzing the game Wolfenstein (1992), we notice icons to represent the character and the gun equipped, also textual information about level, score, lives, health, ammo.

Over the next two decades, the storylines in games continue to develop to the point of becoming movie-worthy [67]. As a matter-of-fact, some of them were made into movies [67]. For instance, the moderately successful film Lara Croft: Tomb Raider and its sequel, Lara Croft Tomb Raider: The Cradle of Life were created in 2001 and 2003 for the Tomb Raider video games series [67]. Other noteworthy game movies include Resident Evil (2002), Silent Hill (2006) and Prince of Persia: The Sands of Time (2010) [67].

Figure 20: Tomb Raider (1996), boss fight [67].

Analyzing Tomb Raider (1996), we notice a clear interface just with a life point bar as show in Figure 19, and sometimes a bullet counter in the bottom left corner. When cutscenes appears, some interface disappears, and its showed a text box with dialog.

Natural User Interface (NUI)

Is a system for human-computer interaction that the user operates through intuitive actions related to natural, everyday human behavior [68]. A NUI may be operated in several different ways, depending on the purpose and user requirements [68]. Some NUIs rely on intermediary devices for interaction but more advanced NUIs are either invisible to the user or so unobtrusive that they quickly seen invisible [68].

Touch Screen interfaces let users interact with controls and applications more intuitively than a cursors-based interface because it is more direct, instead of moving a cursor to select a file and clicking to open it, for example, the user touches a graphic representation of the file to open it [68]. Smartphones and tables typically enable touch input. Touch is being adapted for

non-screen applications as well [68]. For example, Microsoft is working on a touch interface called “skin put’ that allows users to interact by tapping their own skin [68].

Figure 21: New Nintendo 3Ds, Pokemon Sun gameplay [69].

Pokemon Sun is an example of a game with touch screen interface, Figure 21 shows 5 options of actions to touch on the bottom screen.

Gesture recognition systems track user motions and translate those movements to instructions [68]. Nintendo Wii and PlayStation Move motion gaming systems workthrough controller-bases accelerometers and gyroscopes to sense tilting, rotation and acceleration [68]. A more intuitive type of NUI is outfitted with a camera and software in the device that recognizes specific gestures and translates them to actions. Microsoft’s Kinect, for example, is a motion sensor for Xbox 360 and One gaming console that allows users to interact through body motions, gestures and spoken commands [68]. Kinect recognizes individual player’s bodies and voices. Gesture recognition can also be used to interact with computers.

Figure 22: Kinect, Star Wars Kinect gameplay [70].

In Star Wars Kinect, the player make gestures and poses, for the character do actions on the game.

Speech recognition allows users to interact with a system through spoken commands [68]. The system identifies spoken words and phrases and converts them to a machine-readable format for interaction [68]. Speech recognition applications include call routing, speech-to-text and hands-free computer and mobile phone operation. Speech recognition is also sometimes used to interact with embedded systems [68].

Figure 23: Binary Domain PC Game, gameplay with voice recognition [71].

An example of Voice Recognitions is the game Binary Domain, sometimes the other characters make some questions or need a command to do some action, the player can choose what to say between two or three different commands by pressing a button and speaking. In figure 22 it's possible to say, "No way" or My Bad", to respond a question made by the other character named Faye as its showing on the image.

Gaze-tracking interfaces allow users to guide a system through eye movements [68]. In March 2011, Lenovo announced that they had produced the first-eye-controlled laptop [68]. The Lenovo system combines an infrared light source with a camera to catch reflective glints from the user's eyes [68]. Software calculates the area of the screen being looked at and uses that information for input [68].

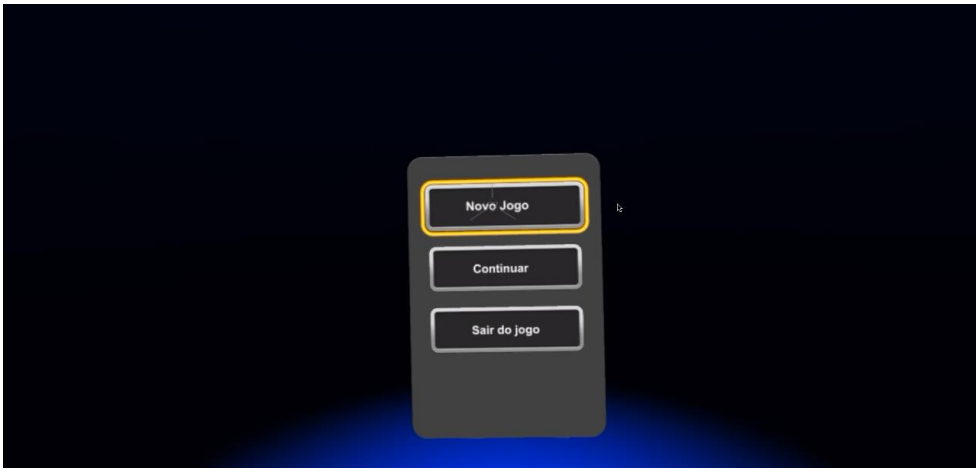


Figure 24: Forgotten Shaft, Oculus Rift DK2 platform, menu selection by gaze-tracking [65].

The game Forgotten Shaft is an example of Gaze Tracking, the user needs to select one of three options in the menu by looking at the option wanted. In Figure 24 the first option is selected.

At 2008 conference, Microsoft's August de Los Reyes spoke of the NUI as the next evolutionary stage in computing from the graphical user interface (GUI), as the GUI was from the command-line interface (CLI) [68].

2.5 What is Diegesis Theory

User interface design in games differs from other UI design because it involves an additional element as fiction [72]. The fiction involves an avatar of the actual user, or player [72]. The player becomes an invisible, but key element to the story, much like a narrator in a novel or film. This fiction can be directly linked to the UI, partly linked, or not at all [72]. Historically games didn't have any real link to the game's narrative, most likely because early games

rarely had strong story elements [72]. Erik Fagerholt and Magnus Lorentzon explored theories of game UI design in their thesis for Chalmers University of Technology titled: Beyond the HUD User Interfaces for Increased Player Immersion in FPS Games [72]. They introduce terms for different types of interfaces depending on how linked to the narrative and game geometry are [72].

We can ask ourselves two questions about any interface component: “is the component part of the game story?” (Is it part of the narrative?). “Is the component part of the game space? “(Is it behind the fourth wall?). Depending on the answers, we can classify the component into one of four representations: Diegetic, Non-Diegetic, Spatial, or Meta. The Terminology below shows how the questions relate to the representations.

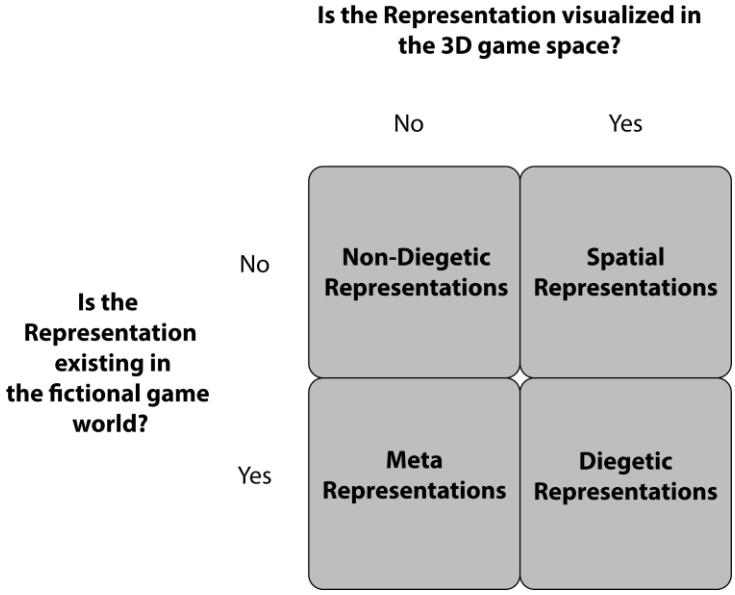


Figure 25: Terminology from Fagerholt, Lorentzon (2009) “Beyond the HUD – User Interfaces for increased Player Immersion in FPS Games. Master of Science Thesis, Chalmers University of Technology”.

2.5.1 Sample of Diegetic Interfaces

The Diegetic user interface elements exist within the game world (fiction and geometry) so the player and avatar can interact with them through visual, audible or haptic means [72]. Well executed diegetic UI elements enhance the narrative experience for the player, providing a more immersive integrated experience [72].

The game metro 2033 uses a complete Diegetic UI with no HUD elements to help to support the game’s narrative. It runs the risk of frustrating the player though slow response time but this forms part of the game mechanic. The character’s watch is used to measure how long the filter in the gas mask will last and how visible he is:

Figure 26: Metro 2033 game, watch for measure the filter [72].

Many games get away with using Diegetic patterns because their narrative is set in the future, where UI overlays in daily life are commonly accepted [72]. This is the case for the latest version of Syndicate game [72]. If the story was set in a different time period, the UI elements would be probably being considered Spatial instead of Diegetic [72]. The Dart overlay mode highlights enemies and allows the character and player to see through cover:

Figure 27: Syndicate game, dart overlay vision [72].

Assassin's Creed manages to use a lot diegetic pattern even through its's set in a historical world because the player of the player is using a virtual reality system in the future [72]. So, the story is in fact futuristic rather than historical [72].

The game uses its eagle vision to highlight enemies and their patrol track [72]. The player and the character see the same thing [72]. There are cases when diegetic UI elements aren't appropriate, either because they aren't legible in the geometry of the game world, or there's a need to break the fiction in order to provide the player with more information than the character should or does know [72].

Figure 28: Assassin's Creed game, eagle vision [72].

In Far Cry 2 an attempt is made to make the experience as diegetic as possible there is no HUD. The use of numerous in-game gadgets and items allows the player to get information without referring to elements outside of or superimposed over the reality of the game world [73].

Figure 29: Far Cry 2 game, map gadget [73].

While this is great for the immersion of the game, if it is not done correctly, it can have the opposite effect. For example, in the adventure game Grim Fandango the player is forced to search through their inventory one item at a time. This frustrating process breaks the player's suspension of disbelief, and he pops back into reality.

Figure 30: Grim Fandango game, Inventory house [73].

2.5.2 Sample of Non-Diegetic Interfaces

Non-Diegetic elements, these elements have the freedom to be completely removed from the game's fiction and geometry and can adopt their own visual treatment, though often influenced by the game's art direction [72].

World of Warcraft uses a mostly Non-diegetic UI, one exception being the Spatial player names [72]. It allows the user to completely customize it, hopefully ensuring a familiar experience [72]. Most of the UI elements in World of Warcraft sit on the 2D hub plane, some elements sit within the world's geometry such as the player names however the character isn't aware of any of the UI [72].

Figure 31: World of Warcraft game, HUB, spells, chat, and player's information [72].

The Mass Effect 3 uses many Non-diegetic UI elements in order to inform the player of the character selected weapon and power, among other things [72]. Given its futuristic setting I can't help to think if some of this information could have been integrated in to the game

world, narrative, or even both [72]. The Non-Diegetic elements still inherit the visual style associated with the game world.

Figure 32: Mass Effect 3 game, weapon, power selection, life points, and shield points [72].

Gears of War, have a minimalist approach which limits the number of HUD items, while others, such as World of Warcraft, provide extensive HUD information [73]. An Example a HUD being used poorly is the widget in Gears of War. This widget breaks the flow of the game, distracting the player from the world in which they have spent the last few minutes immersing themselves.

There are less intrusive user interface mechanisms one could use for a simple action such as selecting weapons. If the player is able to see the actual weapon in the game world there is little or no need to show a non-diegetic cue for swapping weapons.

Figure 33: Gears of War game, minimalist Weapon icon on top Left [73].

2.5.3 Sample of Spatial Interfaces

Spatial UI elements are used when there's a need to break the narrative in order to provide more information to the player than the character should be aware of [72]. They still sit within the geometry of the game's environment to help immerse the player and prevent them from having to break the experience by jumping to menu screens [72]. The closer these follow the rules of the game's fiction the more they can help immerse the player [72].

Splinter Cell Conviction also adopts Spatial elements in the form of projections that illustrate objectives within the game world [72]. Their scale does seem to challenge the fiction slightly more than other examples [72]. Type is overlaid in to the environment to communicate messages to the player rather than the character [72].

Figure 34: Splinter Cell Conviction game, Spatial elements tutorial [72].

Fable 3 is another example where Spatial elements are used to provide more information to the player and prevent them from jumping to a map screen [72]. The glowing trail almost fits within the friction given its magic aesthetic quality but the character isn't meant to be aware of it [72]. It guides the player to the next objective [72]. The sparkling trail allows the player to guide the character in the right direction [72].

Figure 35: Fable 3 game, sparkling trail [72].

Spatial elements can be beautiful pieces when they work with the geometry of the world. These Spatial elements from Forza 4 demonstrate a simple style can contrast the rich 3D qualities of the game. Bold iconography combined with strong typographic layouts help establish a beautiful art direction for Forza 4's UI.

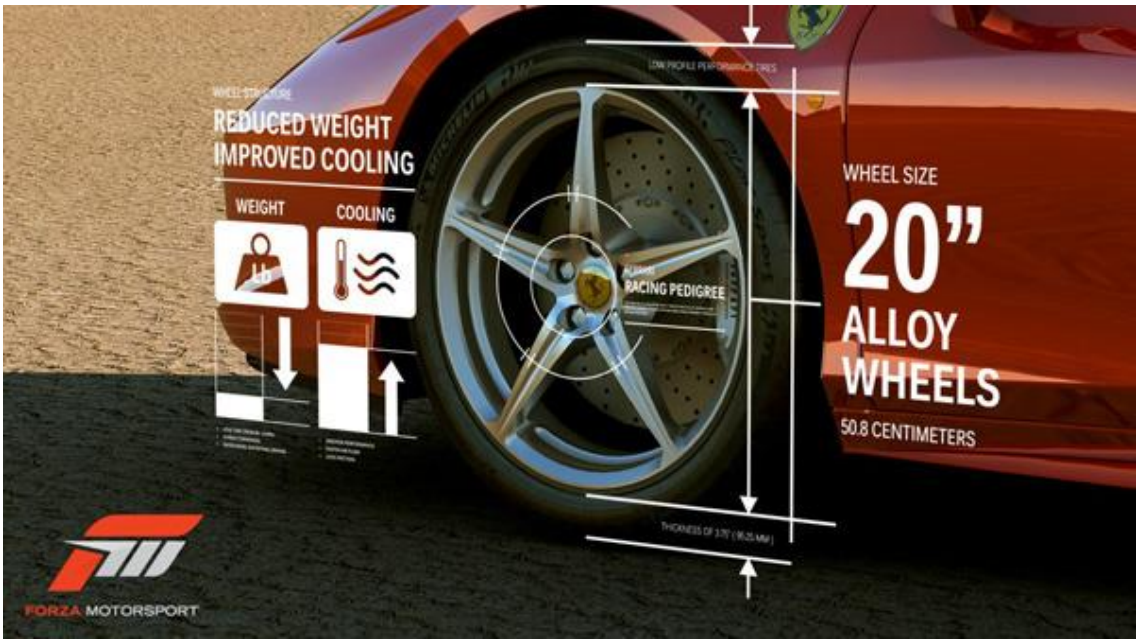


Figure 36: Forza 4 game, Wheels UI information [72].

A good Example of this are the auras in Warcraft 3 [73]. These indicate the gameplay effect that is currently in place and the range within which unit will be effected [73]. Another example are the icons that appear above the heads of characters in The Sims [73]. The select ion brackets in Warcraft 3 immediately make it clear which units the player has control of

[73]. The brackets location in space makes selecting appropriate units much easier [73]. Think of how difficult it would be the select them from a list in the HUD, it would be very difficult to see which units are closest to the action taking place in the game world [73].

Figure 37: On the left, Warcraft game, with units selected. On the right, The Sims game, emotion icons [73].

2.5.4 Sample of Meta Interfaces

Sometime UI elements don't fit within the geometry of the game world [72]. They can still maintain the game's narrative but sit on the 2D hub plane, these are called Meta Elements [72]. A common example of a Meta UI element is blood the splatters on the screen as a form of health bar, as in Call of Duty: Modern Warfare 2 [72]. Blood splashing on the screen within the 2D HUD plane to tell the player that the character is losing health [72].

Figure 38: Call of Duty: Modern Warfare 2, Blood splatter UI [72].

Interacting with the phone in Grand Theft Auto 4 is an interesting example [72]. It mimics the real-world interaction, you hear the phone ringing and there is a delay before the character and player answer it [72]. The actual UI element itself appears on the 2D hub plane though,

so it's actually a Meta element, Though the start of the interaction is Diegetic [72]. The character is answering the phone but the actual UI element is Placed within the 2D HUD plane that only the player sees [72].

Figure 39: Grand Theft Auto 4, Phone UI [72].

Meta UI elements can be difficult to define in game without a strong narrative element, such as sport or racing games [72]. In Need for Speed: Hot Pursuit, the speedometer in the 2D HUD is meta because the player's character the driver, would know what speed the car is traveling at and therefor it forms part of the narrative, as much as there is one [72]. Other HUD elements such as track position or track location can be more difficult to define, some could be considered Meta because the drive would have that information while the rest are simply Non-Diegetic [72]. The HUD elements such as the speedometer to relay information about the car to the player [72].

Figure 40: Need for Speed: Hot Pursuit, Phone UI [72].

2.6 What is Immersion?

Immersion is a term used by gamers and reviewers alike. Immersion is often viewed as critical to game enjoyment, immersion being the outcome of a good gaming experience. However, although there seems to be a broad understanding of immersion in the gamming community, it is still not clear what exactly is meant by immersion and what is causing it [75].

In an attempt to understand immersion further, Brown and Caims (2004) conducted a qualitative study in which they interviewed seven gamers and asked them to talk about their experiences playing computer games. As intuitive as the word suggest, the resulting grounded theory found that immersion is indeed used to describe the degree of involvement with a computer game. The theory also identified a number of barriers that could limit the degree of involvement. These barriers arose from a combination of human, computer and contextual factors (e.g. gamer preference, game construction, environmental distracters), and the type of barrier suggested different levels of immersion [76].

If you don't understand, I can give you an example of day-to-day immersion. When we start playing in the morning at the holidays a massive multiplayer online role playing game (MMORPG), we try to achieve things in the game and start to forget about the real world, and when we look at the window outside, its already at night, and we realize that we don't achieve too much things in the game but we wasted a lot of time playing. In movie theaters is very common losing track of time, the explanation of this, is our concentration on the movie, and the favorable environment because you are enjoying that moment by a long time.

In the context of virtual reality, the term Immersion is used to describe the user's emotional reaction to the virtual world in terms of feeling as if they are actually a part of the virtual world [75].

According to Fagerholt and Lorentzon [76], we can define Immersion as moments during the play when players access their real-world perception, reasoning skills, to play the game or voluntarily adopt the game world as primary world and reason from the characters point of view, rather than having to refer directly to the rules of the game. In these moments, the player grows beyond being simply a player, instead taking the role of an agent in the fictional world (no matter how limited).

From this definition, we can notice two factors:

Immersion concerning Reasoning, that factor consists in real world knowledge of genre conventions [76], for example, fire is weak against water. So, with this knowledge the player need to solve game world problems that enables the player to reside in a fictional frame rather than rule-oriented frame.

The following are some examples from the games where immersion through reasoning breaks down, these examples are similar than Fagerholt and Lorentzon:

In Dragon ball Xenoverse 2, there are rocks that the player can destroy, but on some places in the game these rocks cannot be destroyed and works as invisible walls that made to confine the players to the playable parts of a game level. This type of inconsistency in the game world will disturb the players: similar objects should always behave in similar manners to support the reasoning skills of the player.

In Uncharted 4, the player can fire a rocket into a wood ship and this ship cannot be destroyed or be moved. This is an example of real world objects behaving in unfamiliar or unrealistic ways and will obstruct the player's immersive reasoning.

Immersion concerning Perception, that factor consist imitate a real-world situation. Games player from a first-person perspective engage a player's perception in a way similar to real life [76]. Clues about the whereabouts of objects and enemies are elicited from the environment in largely the same way as it would in a similar, real world situation [76].

Still, contemporary games only offer a visual, auditory and haptic rendition of the game world, leaving out many of the subtle things that makes up our real-world perception (like our sense of balance, movement speed, etc.) [76].

Because of this, it is fair to argue that a UI element strengthening the player's in-game perception can increase player immersion. By bonding the player close to the perception of his or her avatar, a player presence within the game world can be manifested resembling human presence in the real world.

Overwatch game is the perfect example of immersion concerning perception, the player chose one character to play, and when the match starts the player assume de first-person view of the character chosen, this can influence the movement speed of the player, and the character design, like the figures bellow, it's possible to notice that this character called Tracer have two futuristic guns.

Figure 41: Overwatch game, Tracer first person view [78].

Another character called McCree on this figure bellow have just one gun similar to a Colt.

Figure 42: Overwatch game, McCree first person view [78].

With these examples, we can notice that the player assumes the perception of the character chosen, creating a bond between the player and the character and becoming one.

3 Work Plan

In this Chapter, will be discussed about a paper that I did on my master's, named Virtual Reality an analysis of immersive UI for first-person games. This paper was accepted on IV congreso de videojuegos y educación (CIVE2016) [60], unfortunately this paper wasn't presented by financial problems, but the paper was presented on the Unigames 2016 [66] event on Catholic University of Pernambuco.

Figure 43: Rennan Raffaele presenting the paper Virtual Reality an analysis of immersive UI for first-person games, on Catholic University of Pernambuco, Brazil [66].

The goal was to try and find a way to classify and validate user interfaces that brings more immersion in virtual reality games. After the result obtained previously I will tell a bit what I pretend to do to conclude the research.

3.1 Previously Research

This study aimed to investigate the immersion that the user interfaces (UI) bring the first-person view games who uses virtual reality based on the criteria established by the Diegesis Theory and validation method such as Think-Aloud.

3.1.1 Classification of UI components Through Diegesis Theory

First, were used Diegesis Theory to classify each game. To do so, were used expert evaluation (one game development specialist) to define if the UI component is part of the game story, and if the UI component is part of the game space, depending on the answers, we could classify the UI components into one of the four types: diegetic, non-diegetic, spatial or meta [10]. Were chosen 4 games and each game tested presented one predominant component of each type, and then the think-aloud method was applied to evaluate their immersion [10].

Though the Terminology in figure 25 (Diegesis theory section), we try to find components in Affected [62] game. Such as level selection the player begins on a room with an elevator, the buttons on this elevator is the level selection, after choosing one of the buttons, the elevator opens and the player is taken to the chosen level [10]. This interface component is in the game story and in the game space, so it's a Diegetic Component [10].

Figure 44: Diegetic Component, level selection buttons as elevator buttons, The Hospital is selected [10].

In the game InCell [63], the time left for the race ending and items collected are part of the HUD information, it's very simple, but the player is distracted about that information and this can break the flow of the game, distracting the player from the race in which they have spent the last few minutes immersing themselves [10]. These components aren't in the game story and in the game space, so it's a Non-Diegetic Components [10].

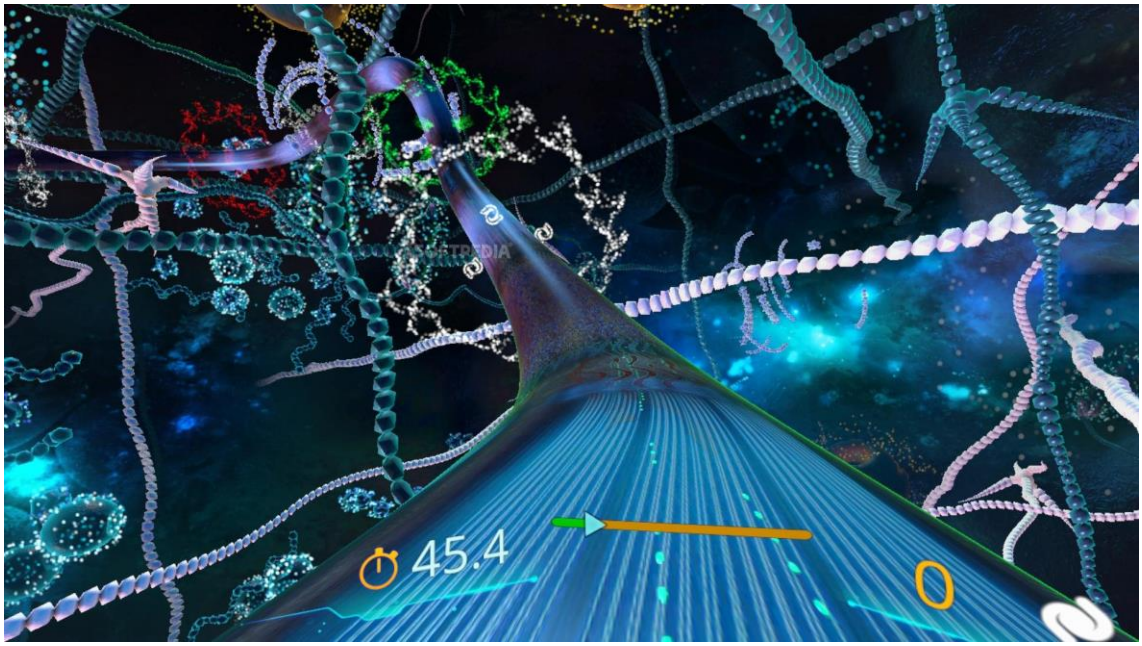


Figure 45: Non-Diegetic Component, Time 45.4s left for race ending and 0 items collected [10].

The Time Machine [64] game, has a repetitive gameplay based on selection. The Player can track and tag animals, by selecting them with high-tech tools [10]. These selections aren't in the game story, but they are in the game space. So, they can be classified as Spatial Components.

Figure 46: Spatial Component, a group of turtles selected by a track tool [10].

In the Forgotten Shafts [65], we find interesting UI components, such as underwater vision when the player enters on water, blood splatter when the player is damaged, a sonar shields, to protect the player from sharks [10]. These components are in the game story, but they aren't in the game space, so they are Meta Components. These components aim to draw the use into the reality of game by applying cues to the screen as if the game were directly interacting with the player [10].

Figure 47: Meta Component, effect when the player gets out of the water [10].

3.1.2 Test with Think-Aloud method

Each game tested have different types of User Interfaces, already described and identified on previous sections. To conduct the Think-Aloud test, we created a document describing all the tasks to be performed by the users and one questionaries' for each game to test their individual types of User Interface afterwards [10]. This way we could collect two sets of data for each participant and check the consistency between them [10].

For all games tested the questionaries' needed to be about the tasks to be performed and if they cause the sensation of immersion [10]. All the questions used the scale from 1 (less immersive) to 5 (very immersive) to be answered [10].

The following data were found after the testing each game, with students that play video games more than twelve hours per week, as we were interested in moderate to heavy videogame users [10]. So, we could enlist 10 participants (nine males and one female), having twenty-one to twenty-three years old [10].

Tasks	Questions
Initiate one level of the game	Evaluate the level of immersion when selecting a stage
Interact with objects	Evaluate the level of immersion when interacting with objects
Explore until fail the lantern	Evaluate the level of immersion when the lantern starts to fail
	Which part of the game do you think was more immersive?

Table 2: Tasks and Question during the gameplay of Affected [10].

On Affected game questionnaire, six users say that the mechanism to select a level was very immersive, and the player thinks that it is already started when actually it is not [10]. 100% of the users responded that when the level is loading it is very immersive too, because this part of the game is not just a static screen like other games on the market. Seven participants of ten said that when the lantern starts to fail/blink makes the game more immersive, because the player need to pay more attention on the environment [10]. One of the participants said that he feels like inside the game. This questionnaire has his focus on immersive Diegetic Components from Diegesis Theory [10].

Tasks	Questions
Initiate one level of the game	Evaluate the level of immersion when selecting a stage
Select one level	Evaluate the level of immersion when selecting a stage
Collect 10 items	Evaluate the level of immersion when collecting items
Upgrade a skill	Which part of the game do you think was more immersive?

Table 3: Tasks and Question during the gameplay of InCell [10].

On InCell game questionnaire, all participants say that it is hard to navigate through the menu in term of camera interaction, it is not done by VR googles, it is done by holding right button of the mouse [10]. All users said that they lost immersion when they are trying to select the levels too and everything is controlled by holding the mouse [10]. 90% of the players say that

they lost immersion when trying to look at the interface to see time left for the race [10]. This questionnaire has his focus on immersive Non-Diegetic components from Diegesis Theory.

Tasks	Questions
Initiate the game	Evaluate the level of immersion when initiate the game
Select items on tutorial	Evaluate the level of immersion when select items on tutorial
Tag an animal	Evaluate the level of immersion when tag an animal
Track an animal	Evaluate the level of immersion when track an animal”
	Which part of the game do you think was more immersive?

Table 4: Tasks and Question during the gameplay of The Time Machine [10].

On Time Machine game questionnaire, nine players said that the tutorial interface is very immersive, because of the audio that helps the user to complete the tasks [10]. 62% of the participants responded that the way to mark the animals is very immersive, because the player need to throw a device and hit the animal to “select” them [10]. 50% of user say that the way to track an animal is immersive too, and very easy to do. This questionnaire has his focus on immersive Spatial components from Diegesis Theory [10].

Tasks	Questions
Enter on the water	Evaluate the level of immersion when enter on the water
Get out of the water	evaluate the level of immersion when get out of the water
Hit the manta’s tail	Evaluate the level of immersion when hit the manta’s tail
Go deeper underwater	Evaluate the level of immersion when on high depths
	Which part of the game do you think was more immersive?

Table 5: Tasks and Question during the gameplay of Forgotten Shafts [10].

On Forgotten Shaft game questionnaire, eight users responded that when they are underwater they find it very immersive, the person really feels like is under the sea and this sensation is great, but this immersion is lost in the moment when the player gets out of the water [10]. 37% of the users said that when the player takes damage, and the blood appears on screen, they lost the immersion too [10]. Seven users say when the player gets on deep water they

notice that the atmosphere is changed and that brings more immersion to the game. The questionnaire focused on immersive Meta Components from Diegesis Theory [10].

3.1.3 Conclusion

From the research using the Diegesis Theory, even though most users do not identify differences in visual and physical interaction with the game, the Diegetic Component on Affected game, enable the player interact with a simple menu masked an environment, and the players don't notice, and that brings greater immersion than the other components from Diegesis Theory, another game that achieved to do that was The Time Machine with Spatial Component, by attributing the selection of objects by throwing and hitting another Object [10]. The game Affected with Diegetic and The Time Machine with Spatial Component was the most voted immersive components classified. Forgotten Shaft with Meta example and InCell with Non-Diegetic have problems of losing immersion for Forgotten Shaft when the interface shows up, and on InCell when the user try to look to the interface to get information while playing so they have the less immersive voted components Meta and Non-Diegetic. A Cybis [61] shows in the surveys on video games and experiences that arise from this interactive universe, this leads researchers in usability and playability to leave the comfort zone by showing that being concerned with only the user interface is not enough to understand good experience using a virtual reality game [10].

3.2 Further Research

Previously, in the final section of chapter 3, we presented the first part of the model created for analysis of games in first person view for virtual reality, with user interfaces classified and identified as immersive, by concepts of authors and data collected of the participants. In this first step, the interfaces were divided into four categories, but only two were immersive, classified as an interface component Diegetic and Spatial.

For further research, 20 Oculus Home games will be chosen for analysis, classified by Diegesis Theory terminology and analyzed by an immersion test. Based on the data collected, a questionnaire will be developed to obtain information from developers, designers and players, in relation to the more immersive elements, and others with less immersive elements of the interfaces.

In the next chapter, will be featured the 20 first-person games for Samsung Gear VR, published in the Oculus Home application, selected for the analysis. Also, will be reported the methodology used for the analysis, and the feedback obtained by participants, and finally prove what type of user interface in first-person view game on virtual reality can bring more immersion.

4 Data Analysis

In this Chapter, will be presented twenty virtual reality games in first person who were chosen to this analysis, all these games are available as free-to-play on Oculus Home for Samsung Gear VR. After the presentation, these games will have their interfaces classified by Diegesis Theory, the interfaces will be separated by menu, tutorial, gameplay and highscore. Since the gameplay can have a lot of different interfaces we will analyze the interfaces who are permanently or often showed to the player.

4.1 Classification of User interfaces of first person games through diegesis theory

Remember the section 2.5 in this dissertation? To understand how we can classify the user interfaces we need to answer two questions that I already show together with the Diegesis terminology.

Sky Fighter: Training Day [79]

This game it's a First-person shooter, based on missions. The player is a character with a Sky Fighter armor who allows the player to move faster, have protection, stabilization, shooting to defeat enemies and the environment. If the armor is destroyed, the player loses the game.

This game it's basically a training event, where you must follow the orders of Lt. Rita Velasco, who will teach combat skills and how to control your character.

The commands are simple, tap the Gear VR to shoot, slide to front to fly faster, slide back to fly slower, and look up to go up, look down to go down, and tilt your head to the sides to go left and right.

Menu: Non-Diegetic

This game Menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. To interact with this UI you need to look and tap the touchpad.

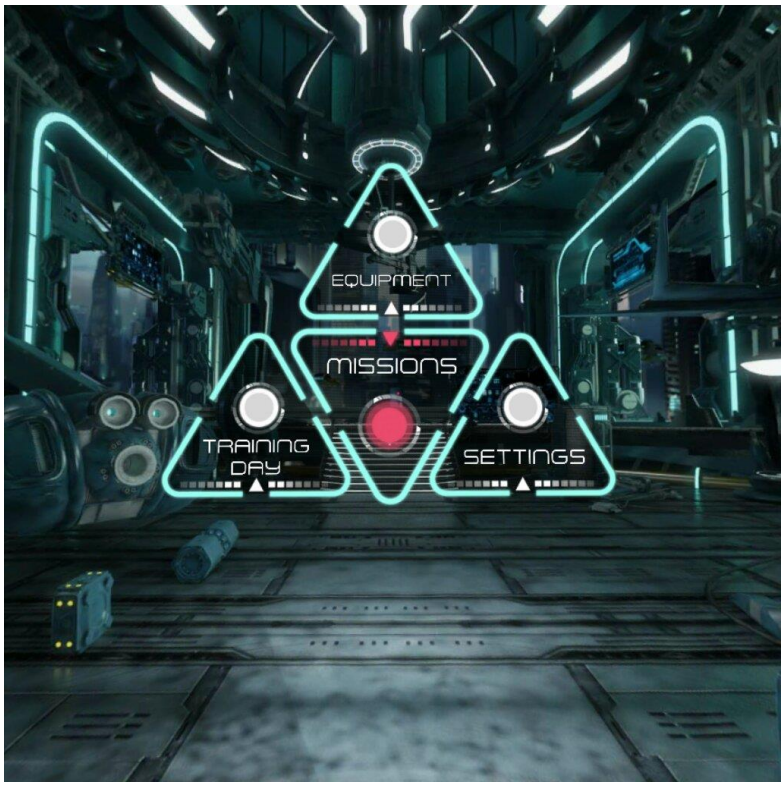


Figure 48: Sky Fighter: Training Day, Screenshot of the game menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game Tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. There is no kind of interaction, just a flat 2D UI, showing the commands with images and writing representations.

Figure 49: Sky Fighter: Training Day, Screenshot of the game tutorial, Non-Diegetic representation.

Gameplay: Meta

This gameplay UI is classified by Meta representation because it's not in A 3D game Space and exist in the fictional game world story. This representation is expressed as the part of narrative that are rendered on the screen, such as the number of items to collect and the low health points if the UI circle is Red.

Figure 50: Sky Fighter: Training Day, Screenshot of the gameplay, Meta representation.

Highscore: Non-Diegetic

This game high score is classified by a Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. To see the highscore the player needs to access the menu, the high score in this game is showed by a table with the rank, player name and record.

Figure 51: Sky Fighter: Training Day, Screenshot of the highscore, Non-Diegetic representation.

Temple Run VR [80]

This game it's a First-person Runner, with the same mechanics of mobile Temple Run, run, dodge obstacles, jump and slide. The history begins when the player steal an "idol" from the Arctic Monkeys, so the player starts run, and the game begins.

The player can move the head to see if the Monkey is close, but you can lose the game if you don't dodge the obstacles while looking at. The main goal is to keep running to have more high score than the other players who already played the game.
The commands are simple, the player automatically run by itself, in the Gear VR, slide up to jump, slide down to get down, slide to the front and back to dodge obstacles.

Menu: Diegetic

This game Menu is classified by Diegetic representation because it's in A 3D game Space and exist in the fictional game world story. To interact with this UI you need to look at the Idol and tap the touchpad, then an animation of the player hands will show and catch the idol. This kind of interface is tricky because the words who give information it's just a 2D Text and don't exist in the 3D game space and it's not exist in the game story, so it's a non-diegetic

text, so this menu interface is Diegetic or Non-diegetic? Since we don't interact with the text to start the game it can't be considered a menu interface, like the idol that we need to look at, tap to catch and start the game.

Figure 52: Temple Run VR, Screenshot of the menu, Diegetic representation.

Tutorial: Non-Diegetic

This game Tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. There is no kind of interaction, just a flat 2D UI, showing the commands with images and writing representations.

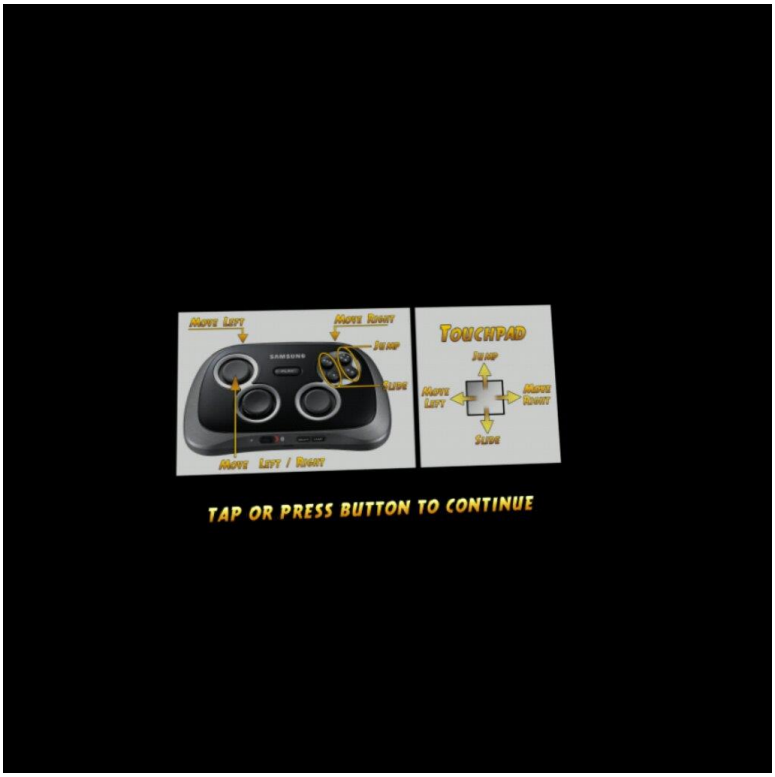


Figure 53: Temple Run VR, Screenshot of the tutorial, Diegetic representation.

Gameplay: Spatial

This gameplay is classified by a Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This UI fit the geometry of the street environment to give some information such how much meters the player needs to run to complete the game.

Figure 54: Temple Run VR, Screenshot of the gameplay, Spatial representation.

Highscore: Non-Diegetic

This game high score is classified by a Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. The highscore shows the distance, coins, score and how the player lost the game, the highscore is a 2D rendered text and only shows up when the player loses the game.

Figure 55: Temple Run VR, Screenshot of the highscore, Non-Diegetic representation.

Suicide Squad: Special OPS VR [81]

This game it's a Static First-person with guns, melee weapons, and powers. The player has no control of "walk" movement of the characters. But the player can move the head in 360 degrees to shoot and defeat the horde of enemies. The main goal is to survive as long as possible against the hordes and get high score by hitting combos.

Inspired on the Suicide Squad Film, the player can choose three different super villains to save Midway City, Harley Quinn with baseball bat and pistol, Deadshot with his rifle and El Diablo with fire power.

The commands are simple, tap the Gear VR to shoot, slide to front to fly faster, slide back to fly slower, and look up to go up, look down to go down, and tilt your head to the sides to go left and right.

Menu: Diegetic

This game Menu is classified by Diegetic representation because it's in A 3D game Space and exist in the fictional game world story. In this case, the menu is just the weapon, when the player looks at it, the game starts.

Figure 56: Suicide Squad: Special OPS VR, Screenshot of the menu, Diegetic representation.

Tutorial: Spatial

This game tutorial is classified by Spatial representation because it's in A 3D game Space and it's not exist in the fictional game world story. In this case, the tutorial is showed in a television in form of image and text, giving an information to the player.

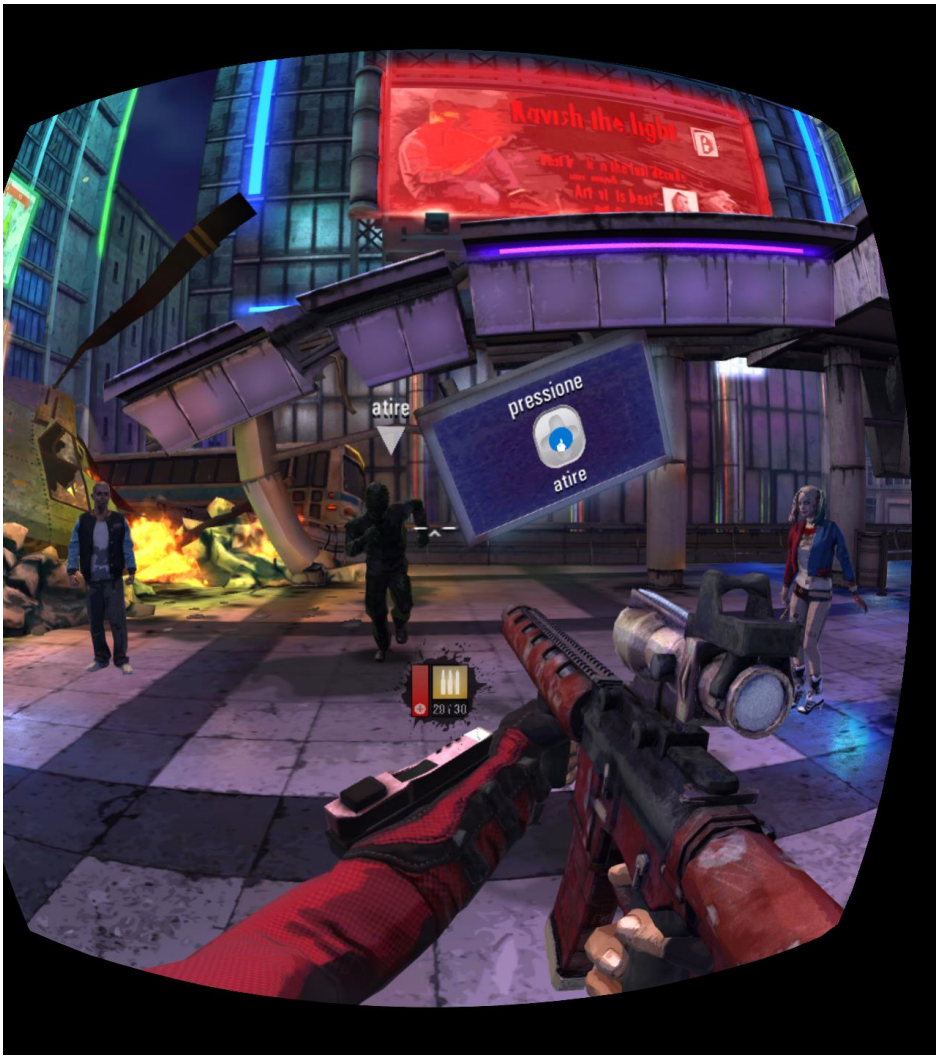


Figure 57: Suicide Squad: Special OPS VR, Screenshot of the tutorial, Spatial representation.

Gameplay: Non-Diegetic

This gameplay is classified by a Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. In this case, the User interface is always on the left side of the weapons, showing the health points remaining, and the number of bullets.

Figure 58: Suicide Squad: Special OPS VR, Screenshot of the gameplay, Non-Diegetic representation.

Highscore: Non-Diegetic

This game high score is classified by a Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. The highscore is a 2D rendered text and only shows up when the player loses the game, it shows how many waves the player survived, total score of the currently match, and three best scores of the player.

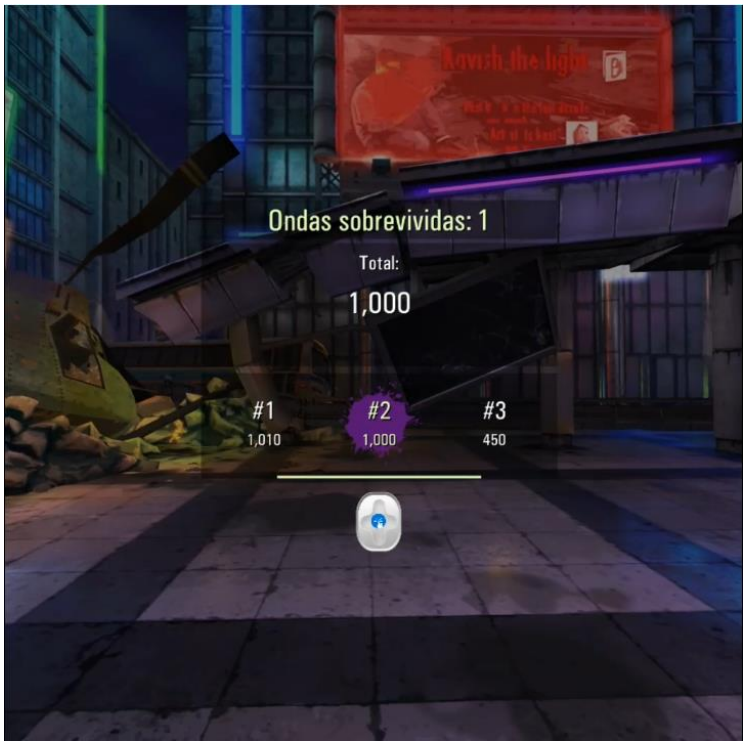


Figure 59: Suicide Squad: Special OPS VR, Screenshot of the highscore, Non-Diegetic representation.

Balloon Shooter [82]

This game it's a First-person shooter, the player is flying with a balloon and the enemies are trying to drop you down. The player needs to shoot the enemies with an arrow, which can be improved if the player destroys some magical boxes.

There are at least 100 levels to pass in this game, there are a lot of enemies, like archers, Vikings throwing hatchets, dragons spraying venom. The game has an upgrade system to the player be able to throw hand grandees, ice bombs, and even tracking missiles.

The commands are simple, tap or hold in the Gear VR to shoot. This game supports Xbox gamepad, you can press or hold the button A to shoot. The player must aim with the head, trying to align the tip of the arrowhead towards the enemy.

Menu: Spatial

This game Menu is classified by Spatial representation because it's in A 3D game Space and it's not exist in the fictional game world story. In this case, the menu is written in wood rectangles, such as update and Go! (to start the game), to select one of them, the player must hit the rectangles shooting arrows.

Figure 60: Balloon Shooter, Screenshot of the menu, Spatial representation.

Tutorial: Non-Diegetic

This game Tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. There is no kind of interaction, just a flat 2D UI, showing the commands with images and writing representations.

Figure 61: Balloon Shooter, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Diegetic

This gameplay is classified by Diegetic representation because it's in a 3D game Space and exist in the fictional game world story. In this case, the user interface in the gameplay is a blue capsule "fuel" who represents the health point of the balloon, every time the player take damage the fuel decreases.

Figure 62: Balloon Shooter, Screenshot of the gameplay, Diegetic representation.

High score: Spatial

This game highscore is classified by Spatial representation because it's in A 3D game Space and it's not exist in the fictional game world story. In this case, the highscore shows up when the player loses the game, is written in wood with images representations, showing how much coins the player earned, the time that last the match and the distance achieved.

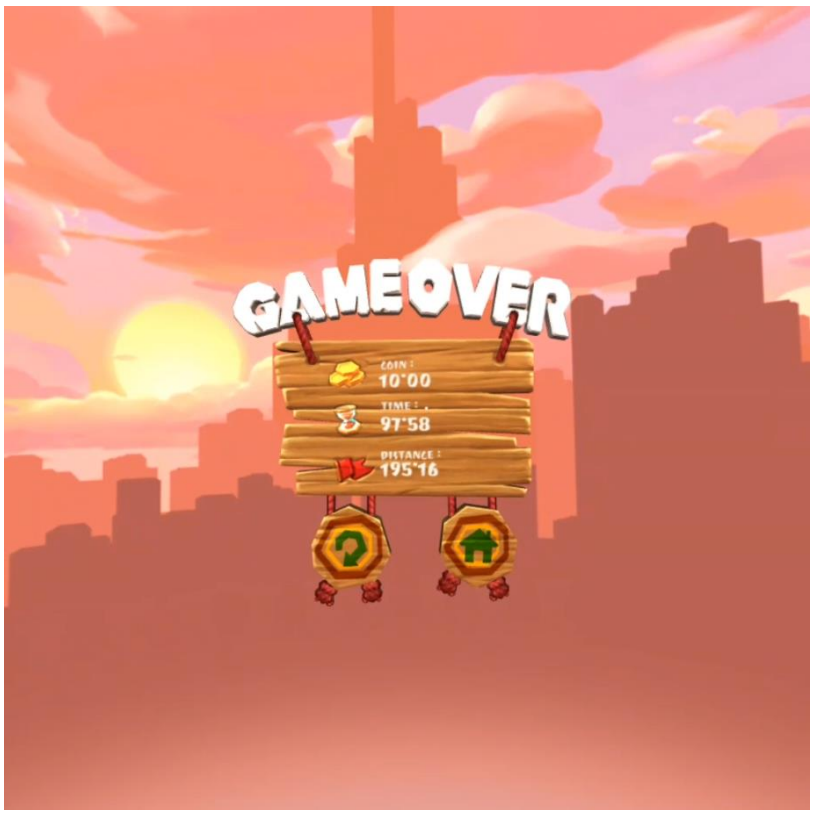


Figure 63: Balloon Shooter, Screenshot of the highscore, Spatial representation.

Cerevrum [83]

This game it's a First-person shooter, the player can use 3 different attacks, laser drones, pew-pew and solar wave. To use each skill, the player needs to use his cognitive skills such as memory, attentiveness, figural synthesis or spatial intelligence. Cerevrum have two mini-games, one to destroy enemy's spaceships, and another to defend soul crystals from enemies.

The commands are a little complex and depend of which skill the player is using, to use laser drones and pew-pew the player just need to tap in the Gear VR, on solar wave the player needs to swipe left or down to match the balls at the same color.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D icons floating around.

Figure 64: Cerevrum, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. The tutorial helps the player using audio, showing 2D flat images and writing, as you can see in the center of the image bellow, "Tap on lase drone to fire".

Figure 65: Cerevrum, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Non-Diegetic

This gameplay is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D icons and writing showing, the type of weapon selected, score achieved, the currently wave, shield points and health points.

Figure 66: Cerevrum, Screenshot of the gameplay, Non-Diegetic representation.

Highscore: Non-Diegetic

This game highscore is classified by a Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. The highscore is a 2D rendered text and only shows up when the player loses the game, it shows score of the match, coins earned, and an upgrade spaceship option.

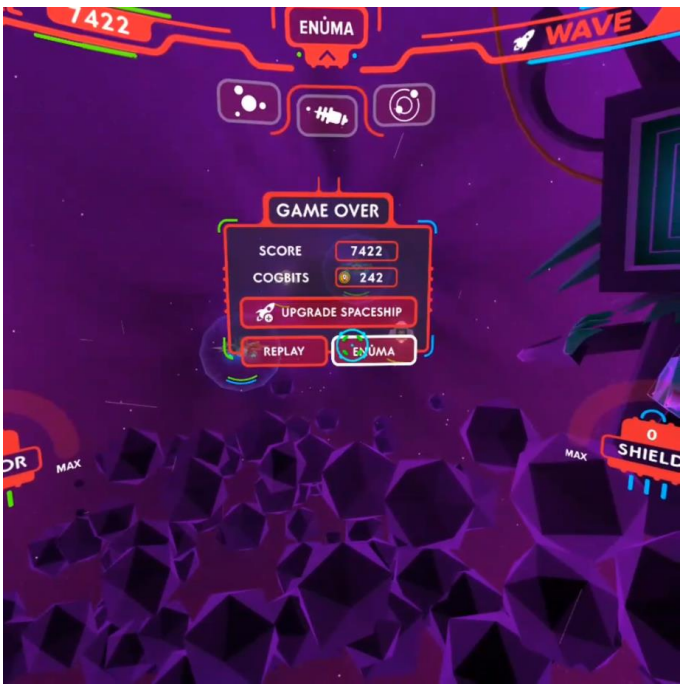


Figure 67: Cerevrum, Screenshot of the highscore, Non-Diegetic representation.

Doritos VR Battle [84]

This game it's a First-person shooter, the player use two guns to defeat their enemies. The main goal is to archive a great high score and compare to other players online. The player starts in a cave and needs to collect as much Doritos as he can, but will be necessary to defeat the golems who wander in these caves.

The commands are a simple, just tap the touchpad in the Gear VR to shoot and kill the enemies besides collect Doritos. This game just has one stage and it's just available on Gallery apps (a broad, less-filtered collection from VR creators), just developers has the access of Gallery apps in Oculus Home.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D icons floating around, with some information as the last highscore, and tutorial information.

Tutorial: Non-Diegetic

This game Tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. We can say that this menu is a part of the tutorial and vice versa, it's just flat 2D text floating around, with some information as the last highscore, and what the player need to do in the game.

Figure 68: Doritos VR Battle, Screenshot of the menu and tutorial, Non-Diegetic representation.

Gameplay: Non-Diegetic

This gameplay is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. There is no permanent user interface information, but when the player collect the Doritos or defeat an enemy, some points to sum to the highscore appears floating in the screen as flat 2D text.

Figure 69: Doritos VR Battle, Screenshot of the gameplay, Non-Diegetic representation.

Highscore: Non-Diegetic

This game high score is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. It's just flat 2D text floating around, with the information of new highscore or the best highscore, this is screen is only available when the player win or loses the game.

Figure 70: Doritos VR Battle, Screenshot of the highscore, Non-Diegetic representation.

Dragon Front [85]

This is a First-person Card Game, the player needs to use cards of Monsters, Magic, and Fort to win the match. The main goal it's destroy the enemy castle, to do that the player need to attack the castle using a monster card, each monster card has an attack and life points, if the life points is zero, the card is destroyed.

The game can be played online, and offers head-tracking and VOIP (voice over IP) to help communication between players. The game allows to construct a 30-card deck to use in a 4x4 grid battlefield.

The commands are a simple, just look up to see the deck, chose a monster card by looking and tap in the Gear VR, and them select the place that you want to put that monster, it works in the same way as the Fort card. To use magic cards just look and tap, depending on the card it will need to select a monster to use, just look at the monster and tap.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just buttons and imagens panels floating around, with some information as about the stage.

Figure 71: Dragon Front, Screenshot of the Menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. A touchpad image appears to show what movement to do, to complete the action, also a square with text and arrow showing where the player needs to look.

Figure 72: Dragon Front, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay is classified by Spatial representation because it's in A 3D game Space and it's not exist in the fictional game world story. In this case, the mana and life and defense points of the card is showed inside an orange arrow, red shield and in a blue sphere, that are inside the cards.

Figure 73: Dragon Front, Screenshot of the gameplay, Spatial representation.

Highscore: there is no highscore in the game.

Element Engine [86]

This game is a First-person shooter, the player needs to defeat enemies by hiding behind the environment and shooting at them. This game just has one level, because it's still in development and is only available on Gallery apps of Oculus home (just developers has the access to this games).

The commands are simple, the player can use a gamepad or the touchpad of Gear VR, look at a determinate place with a blue arrow and move the thumbs tick up or slide up to move yourself, press L1 or slide left to aim, and press the touchpad or button 1(gamepad) to shoot.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D text rendered in the screen.

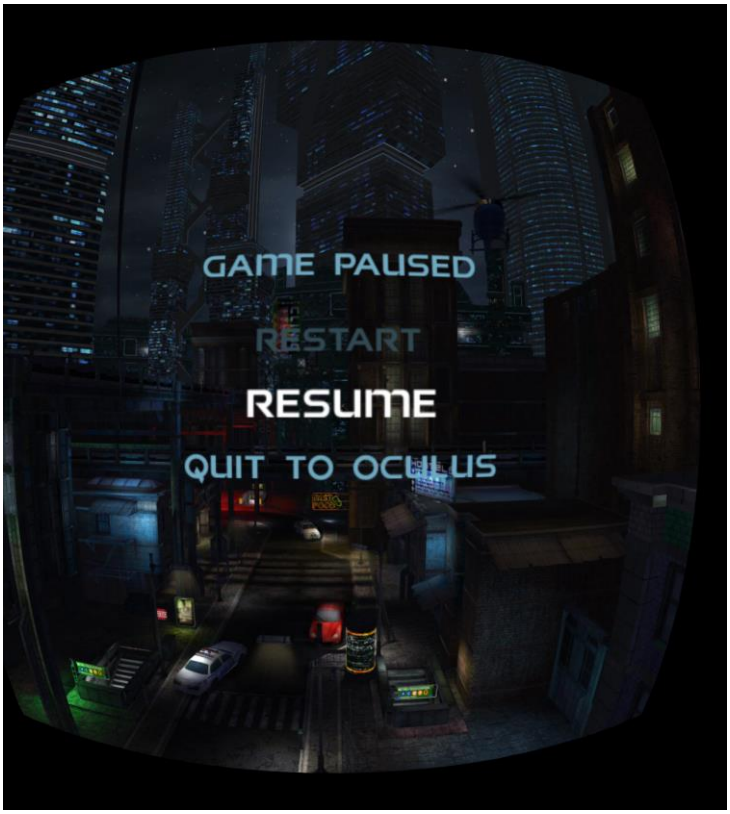


Figure 74: Element Engine, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D Image rendered in the screen while loading the game.

Figure 75: Element Engine, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Meta

This gameplay is classified is classified by Meta representation because it's not in A 3D game Space but exist in the fictional game world story. In this case, the red border indicates that the player is taking too much damage, representing the health points.

Figure 76: Element Engine, Screenshot of the gameplay, Meta representation.

Highscore: there is no highscore in the game.

Finding VR [87]

This is a First-person action/adventure game, the player needs to solve puzzles and defeat the boss of the level to complete missions. In the beginning, you must to find out what happened to this world and how to save it. The player can grab things of the environment like, barrels, bombs, roll stuff and even hold a fairy to be able to fly.

The commands are simple, the player can use a gamepad or the touchpad of Gear VR, to move yourself it need to move the thumb stick (gamepad) or slide and hold in the touchpad, to grab things the player needs to look at and press button 1 (gamepad) or just tap.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D text and image rendered in the screen with 2D animations.

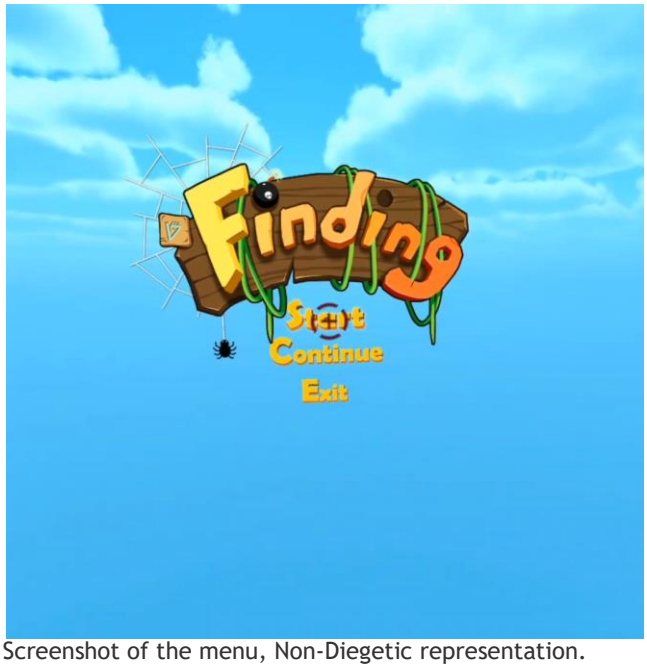


Figure 77: Finding VR, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Spatial

This game tutorial is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. The tutorial is graved in stones as images, text, and animations, providing the player how to play.

Figure 78: Finding VR, Screenshot of the tutorial, Spatial representation.

Gameplay: Non-Diegetic

This gameplay is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. In This case, the permanent interface is the Health points of the player is showed as 2D image and Text numbers.

Figure 79: Finding VR, Screenshot of the gameplay, Non-Diegetic representation.

Highscore: there is no highscore in the game.

One-Man VurgeR [88]

This is a First-person game, where the player is an owner of a hamburger shop, and need to deliver the right burgers as soon as possible to the costumers, the game has a "time-bomb" which represent the time of the costumers can wait, if the time it's over, they go back to their home without buying hamburgers. The secret is delivery the hamburgers fast to win a bonus score.

In this game, the player needs to cook the burgers, put the buns on microwave, and put the right ingredients in the right order to satisfy the costumer. The commands are very simple in this game, it's just using the touchpad of Gear VR, to grab the food and the kitchenware, the player needs to look at and just tap.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D text and image rendered in the screen.

Figure 80: One-Man VurgueR, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Diegetic

This game tutorial is classified by Spatial representation because it's in a 3D game Space and exist in the fictional game world story. The tutorial make the use of the restaurant menu, with all information about the meats, topping (lettuce, tomato, cheese), and buns to the player, if the player goes to the next page, will be more information about how to play.

Figure 81: One-Man VurgueR, Screenshot of the tutorial, Diegetic representation.

Gameplay: Diegetic

This gameplay is classified by Diegetic representation because it's in a 3D game Space and exist in the fictional game world story. The user interface here make the use of 3D boards to inform where is the tomato, lettuce, and cheese, another user interface here is the order, who appear as an image inside the restaurant menu showed by the costumer.

Figure 82: One-Man VurgueR, Screenshot of the gameplay, Diegetic representation.

Highscore: Diegetic

This game menu is classified by Diegetic representation because it's in a 3D game Space and exist in the fictional game world story. As the tutorial and gameplay, the highscore appears in the restaurant menu separated by the level played, easy, normal, or hard.

Figure 83: One-Man VurgueR, Screenshot of the highscore, Diegetic representation.

Bait! [89]

This is a First-person fishing game, where the player is a fisherman, the main goal is help your boss catch a rare fish and save the aquarium where you work. In the beginning the player needs to complete missions to get clues about the location of this rare fish and how to get it.

The player needs to collect a lot of fish to earn money, and buy equipment's as fishing rods, reel, and baits. It's possible to catch fishes in four different lakes, each lake has a different style environment fish species and challenges, the lakes are Ocean Lake, Shady Swamp, Cherry Falls, Secret Sanctuary.

The commands are simple, the player can use a gamepad or the touchpad of Gear VR, aim at a determinate place in the lake and tap the touchpad or press button 1 (gamepad) to release the rod, then when the fish catch your bait, reel them holding the touchpad or holding button 1 (gamepad) until you catch the fish.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just flat 2D text and image rendered in the screen.

Figure 84: Bait!, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D text and image rendered in the screen providing information about how to play.

Figure 85: Bait!, Screenshot of the Tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. The user interface here make the use of a "loading" bar to show if the fish will escape or the line was broken.

Figure 86: Bait!, Screenshot of the gameplay, Spatial representation.

Highscore: there is no highscore in the game.

Ohana Chan [90]

This is a static First-person shooter, where the player need to protect the flower from bees by shooting them down. The game has a timer, a high score, and the life of the flower to give some feedback to player. One tip is search for the bees by looking around to stop them before they get close.

The commands are simple, you can only use the touchpad of Gear VR, aim at the bees and tap to shoot. This game is on Gallery Apps of Oculus Home (just developers has the access to this games).

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This Menu it's just flat 2D big text and comes bigger when the player look at it.

Figure 87: Ohana Chan, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D text and image rendered in the screen providing information about how to play.

Figure 88: Ohana Chan, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. The game information appears on top of the flower who represents the actual score, and a timer on the front of the fairy.

Figure 89: Ohana Chan, Screenshot of the gameplay, Spatial representation.

Highscore: Non-Diegetic

This game highscore is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This highscore it's just flat 2D text and image rendered in the screen providing information about the score, and the rank of the match.

Figure 90: Ohana Chan, Screenshot of the highscore, Non-Diegetic representation.

Stern Pinball Arcade [91]

This is a static First-person Pinball game, like almost other pinball games, the player need to obtain a great high score, and complete missions to get a bonus score. This game offers a lot of different themed machines, like Star Trek, AC/DC, Frankenstein, Starship Troopers, Harley-Davidson, Phantom of the Opera, Last Action, Mustang, Ghostbusters, Whoa Nellie. Each one with a different mission.

The commands are simple, you can use a gamepad or the touchpad of Gear VR, tap left/right or Left Shoulder/Right Shoulder(gamepad) to use the flippers. To push the ball just slide up or Thumb stick left up.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This Menu it's just flat 2D panel with images and flat buttons.

Figure 91: Stern Pinball Arcade, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D panel with images and text.

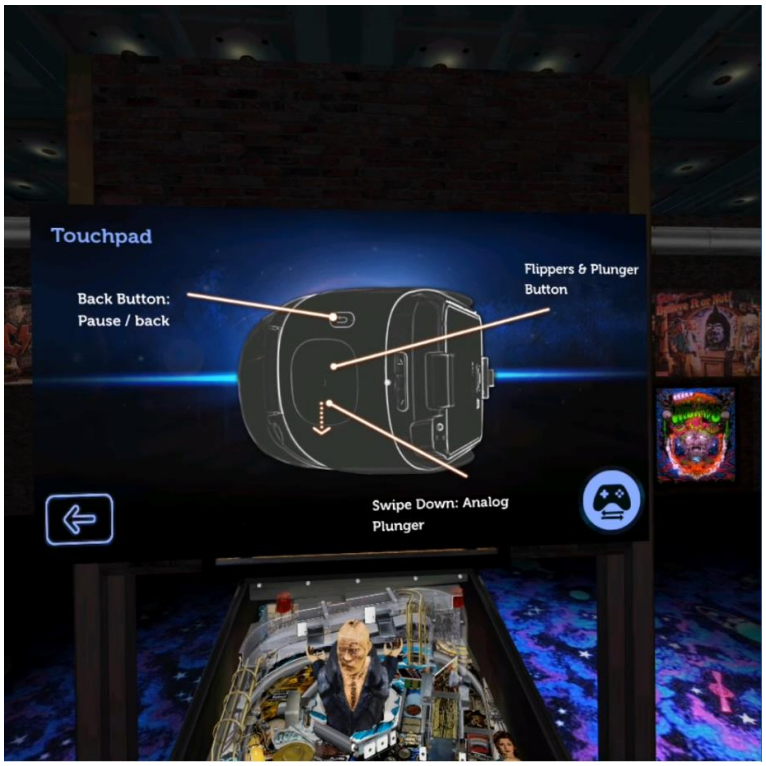


Figure 92: Stern Pinball Arcade, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. The game information appears on bottom of the theme panel, and on top of the table, providing information such as bonus, combos and scores earned.

Figure 93: Stern Pinball Arcade, Screenshot of the gameplay, Spatial representation.

Highscore: Spatial

This game highscore is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This highscore is showed on top of the glass of the table.

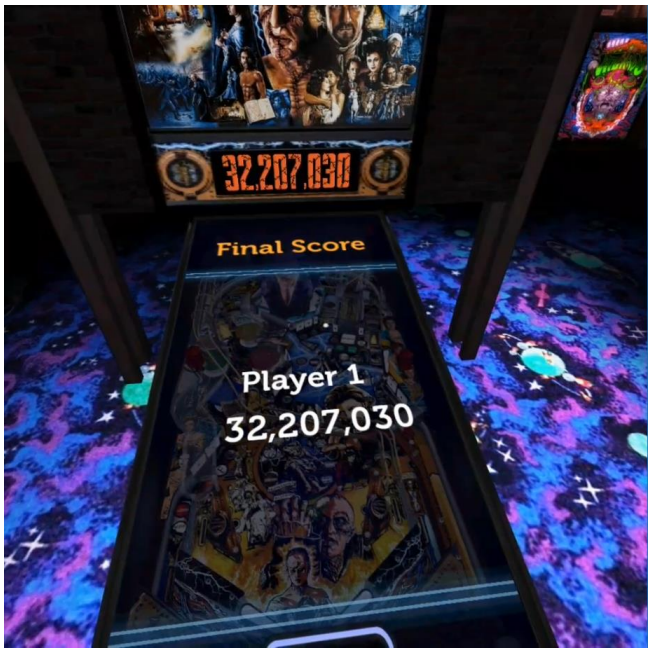


Figure 94: Stern Pinball Arcade, Screenshot of the highscore, Spatial representation.

Shooting Showdown 2 VR [92]

This is a static multiplayer First-person shooter game, in this game the player can compete with others by shooting plates, balloons, and others stuff. In this game, you can rank up by defeating the other players, upgrade and buy weapons. The commands are simple, you can only use the touchpad of Gear VR, by tapping to shoot.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This Menu it's just flat 2D panel with images and texts.

Figure 95: Shooting Showdown, Screenshot of the menu, Non-Diegetic representation.

Tutorial: there is no highscore in the game.

Gameplay: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This Menu it's just flat 2D little panels with icons and texts.

Figure 96: Shooting Showdown, Screenshot of the gameplay, Non-Diegetic representation.

Highscore: Non-Diegetic

This game highscore is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This highscore it's just flat 2D panel with icons and texts.

Figure 97: Shooting Showdown, Screenshot of the highscore, Non-Diegetic representation.

Casino VR Poker [93]

This is a static multiplayer First-person Poker game, in this game the player can compete with others in other to win a Poker match. In the game, you can choose the casino where you want to play, and then look for a table to start a match, you will have an employee of the casino (artificial intelligence) who give the cards and the rules of every bet. The player can communicate which other using a headset with mic. The commands are simple, you can only use the touchpad of Gear VR, by looking and tapping to choose the card, increase bets and move your head to see your hand.

Menu: Non-Diegetic

This game menu is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This Menu it's just flat 2D panel with texts and images.

Figure 98: Casino VR Poker, Screenshot of the menu, Non-Diegetic representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D panel with texts and images.

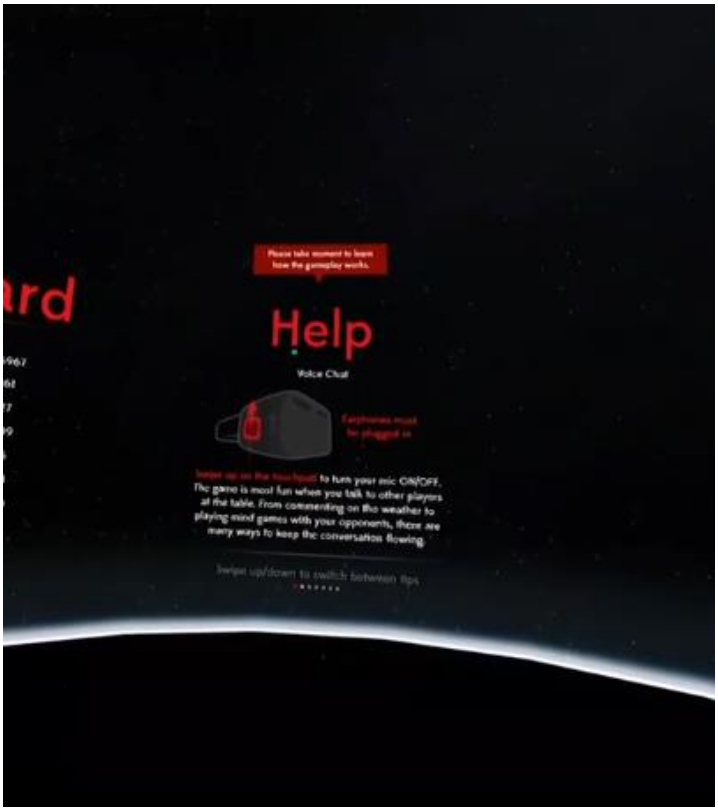


Figure 99: Casino VR Poker, Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This interface is three icons who appears on the players move, call, bet, and give up.

Figure 100: Casino VR Poker, Screenshot of the gameplay, Spatial representation.

Highscore: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D panel with texts, showing the weekly, daily and other scores.

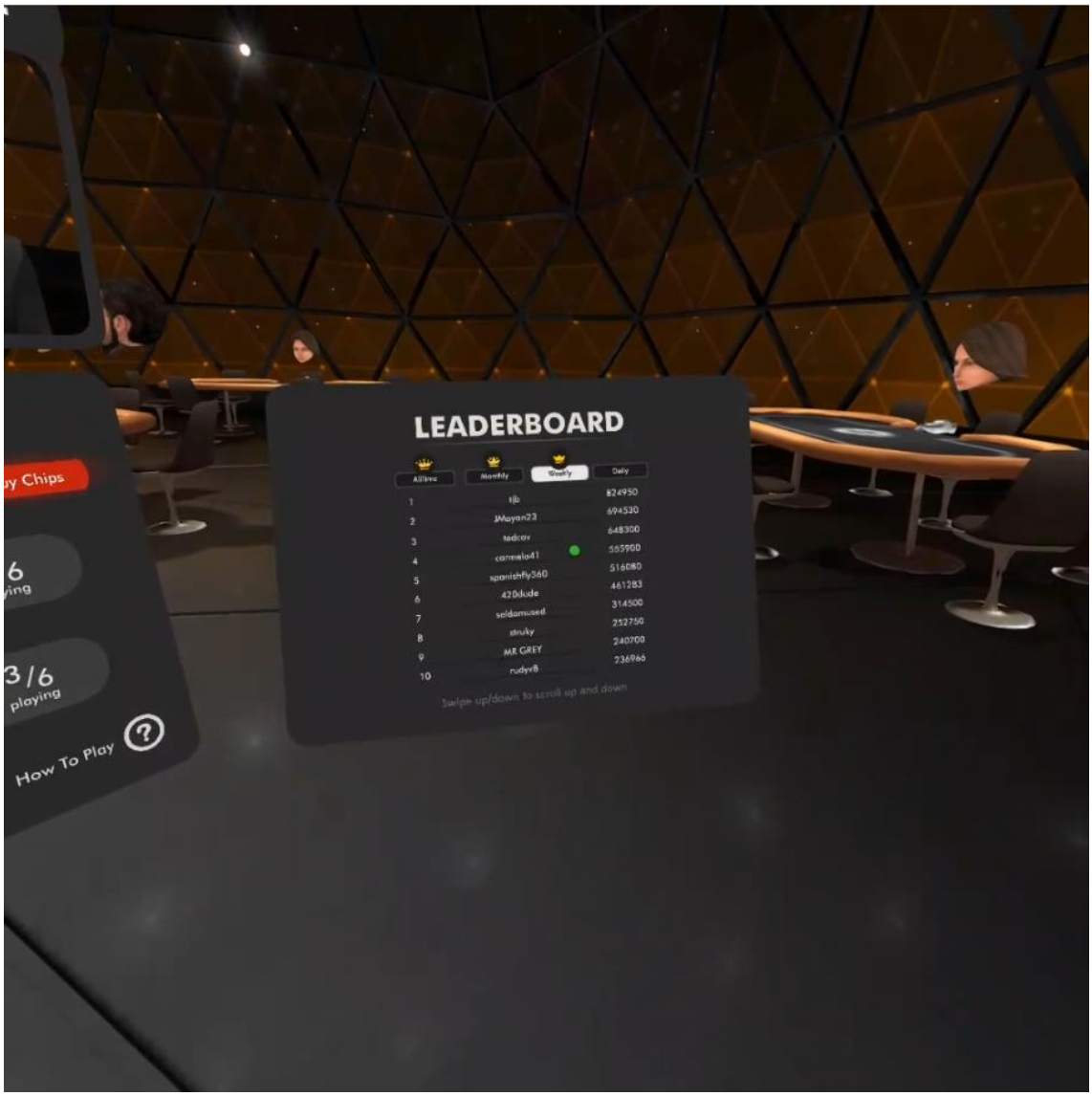


Figure 101: Casino VR Poker, Screenshot of the highscore, Non-Diegetic representation.

Solitaire Jester [94]

This is a static First-person card game, in this game the player experience the classic solitaire in a comfy library with a cozy fireplace and It's possible to listen some music with an old radio. In this game, the commands are very simples, isn't needed the touchpad in Gear VR, the player can make actions by looking at the cards.

Menu: Diegetic

This menu is classified by Diegetic representation because it's in A 3D game Space and exist in the fictional game world story. In this case, the user interface in the menu is a blue and red button on the table that's used to restart the game and draw a card, the deck is what makes the game start by looking at it, and in the old sound box the player can turn off or pass the current music.

Figure 102: Solitaire Jester, Screenshot of the menu, Diegetic representation.

Tutorial: there is no tutorial on this game.

Gameplay: Spatial

This gameplay interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This interface is the blank space rectangles, who alert the player that he can put a card there.

Figure 103: Solitaire Jester, Screenshot of the gameplay, Spatial representation.

Highscore: there is no highscore on this game.

VERTI-GO HOME! [95]

This game is a First-person runner, the player experience an intense, crazy procedural tunnel, with rolls, twists and colorful environment. This game is on Gallery Apps of Oculus Home (just developers has the access to this games).

Menu: Spatial

This menu interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This menu is the two kind of controllers, the Gear Vr touchpad or a gamepad.

Figure 104: VERTI-GO HOME! Screenshot of the menu, Spatial representation.

Tutorial: Non-Diegetic

This game tutorial is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This tutorial it's just flat 2D panel with texts showing how to play.

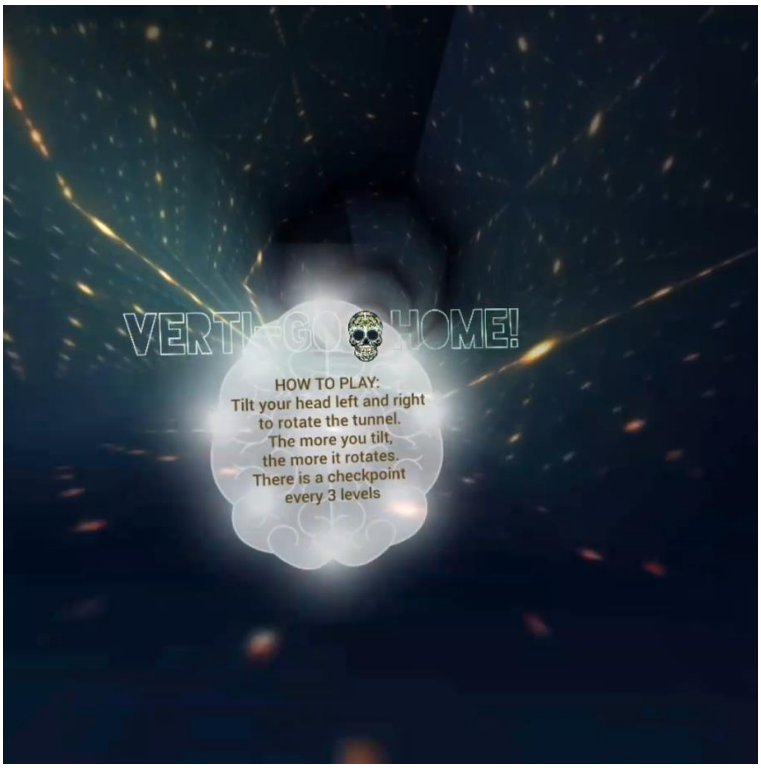


Figure 105: VERTI-GO HOME! Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Non-Diegetic

This gameplay interface is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This interface it's just flat 2D rectangles with texts showing how many meters to complete the stage, and how fast the player is showing the meters per second.

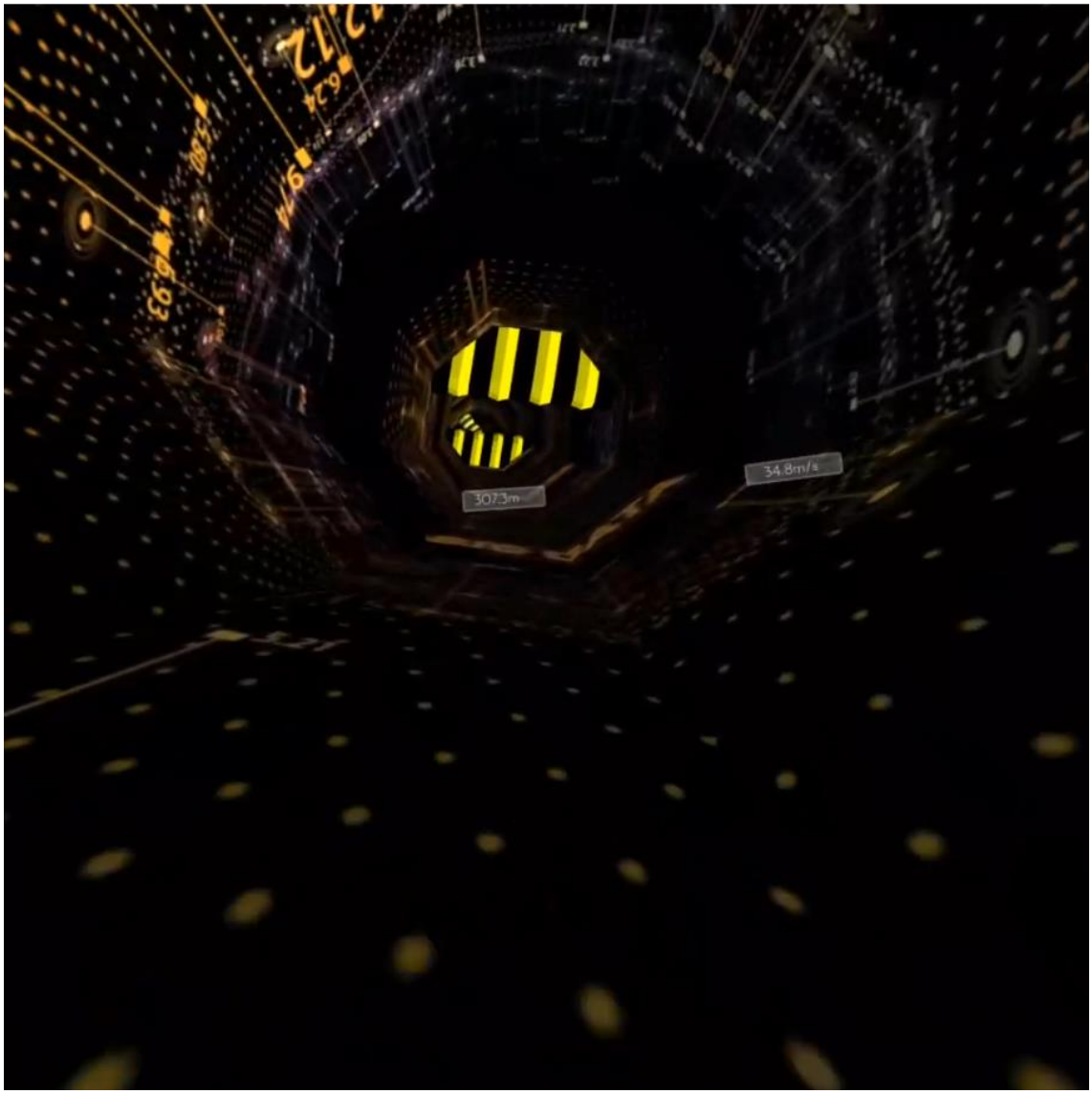


Figure 106: VERTI-GO HOME! Screenshot of the gameplay, Non-Diegetic representation.

Highscore: Non-Diegetic

This game highscore is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This highscore it's just flat 2D panel with texts and icon.

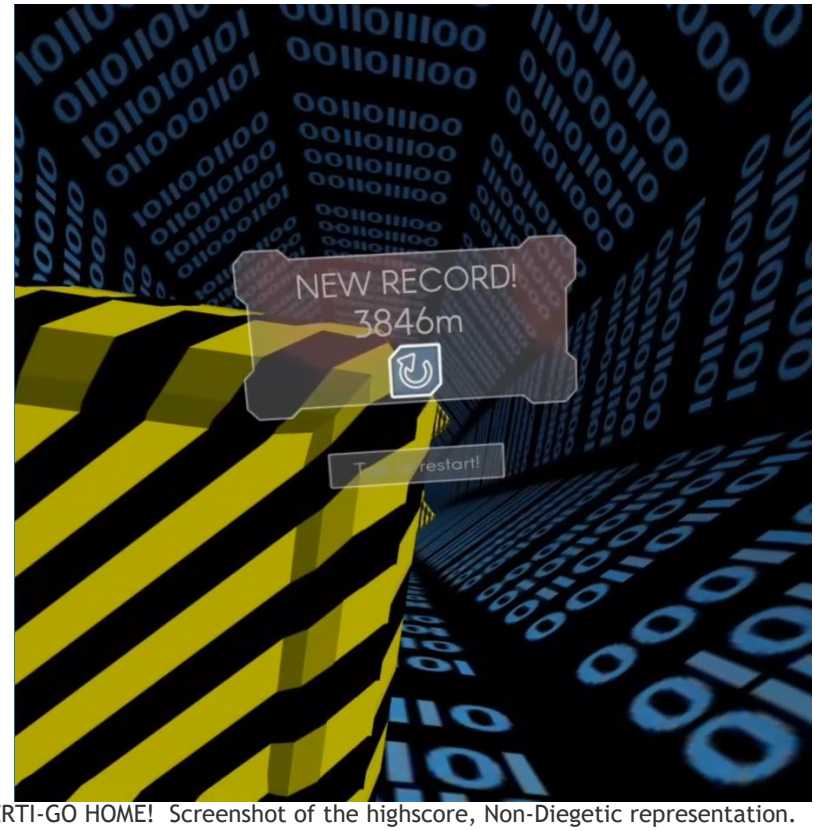


Figure 107: VERTI-GO HOME! Screenshot of the highscore, Non-Diegetic representation.

Oculus Arcade [96]

This is a First-person arcade game, the player experience an environment full of machines, there are three arcade rooms, Sega, Midway, or Namco, each environment and machines has with different games like, Pac-Man, Sonic the Hedgehog 1 and 2, Defender, Gauntlet, Galaga, Golden Axe, Streets of Rage, Virtual Fighter,

The commands are simple, you can use a gamepad, using the four buttons to complete actions, as jump, punch, kick, select and the thumb stick to move.

Menu: Spatial

This menu interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This menu interface is the logo and the name of the games who appears on top of the machines, each machine is a different game.

Figure 108: Oculus Arcade. Screenshot of the menu, Spatial representation.

Tutorial: There is no tutorial in this game.

Gameplay: Diegetic

This gameplay interface is classified by Diegetic representation because it's in a 3D game Space and it's exist in the fictional game world story. This interface is the machines that you can interact with the buttons, making actions in a game, Sonic in that case.

Figure 109: Oculus Arcade. Screenshot of the gameplay, Diegetic representation.

Highscore: There is no highscore in this game.

Bandit Six [97]

This game is a static First-person shooter, the player experience a World War 2 environment with cartoon aspects, the main goal it's to defend the military base from enemies who will come through the earth, water, and air to destroy you. The player can use three free weapons in the game, Machine Gun, Mortar, Artillery.

The commands are simple, you can use a gamepad and the touchpad of Gear VR, move your head to search for some enemies, tap or press button 1 (gamepad) to shoot, slide up to change weapons or press left/right shoulders (gamepad).

Menu: Diegetic

This menu interface is classified by Diegetic representation because it's in a 3D game Space and it's exist in the fictional game world story. This interface is the files that you can pick up and open to choose what level to play.

Figure 110: Bandit Six. Screenshot of the menu, Diegetic representation.

Tutorial: Non-Diegetic

This tutorial interface is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This highscore it's just flat 2D panel with text.

Figure 111: Bandit Six. Screenshot of the tutorial, Non-Diegetic representation.

Gameplay: Spatial

This gameplay interface is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This gameplay is the number of enemies to kill that is showed on the bottom of the gun.

Figure 112: Bandit Six. Screenshot of the gameplay, Spatial representation.

Highscore: Spatial

This highscore is classified by Spatial representation because it's in a 3D game Space and it's not exist in the fictional game world story. This highscore is written in a paper, showing the gold earned and the number of enemies defeated.

Figure 113: Bandit Six. Screenshot of the highscore, Spatial representation.

In Mind [98]

This is a static First-person educational game. The player experience a journey into a brain in search of neurons that cause mental disorder, the main goal is to neutralize these neurons that appear in a red color. The Commands are simple, the player just need to focus and look at the neurons and wait for neutralize. This game is on Gallery Apps of Oculus Home (just developers has the access to this games).

Menu: Non-Diegetic

This menu interface is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This menu it's just images and text rendered in the screen.

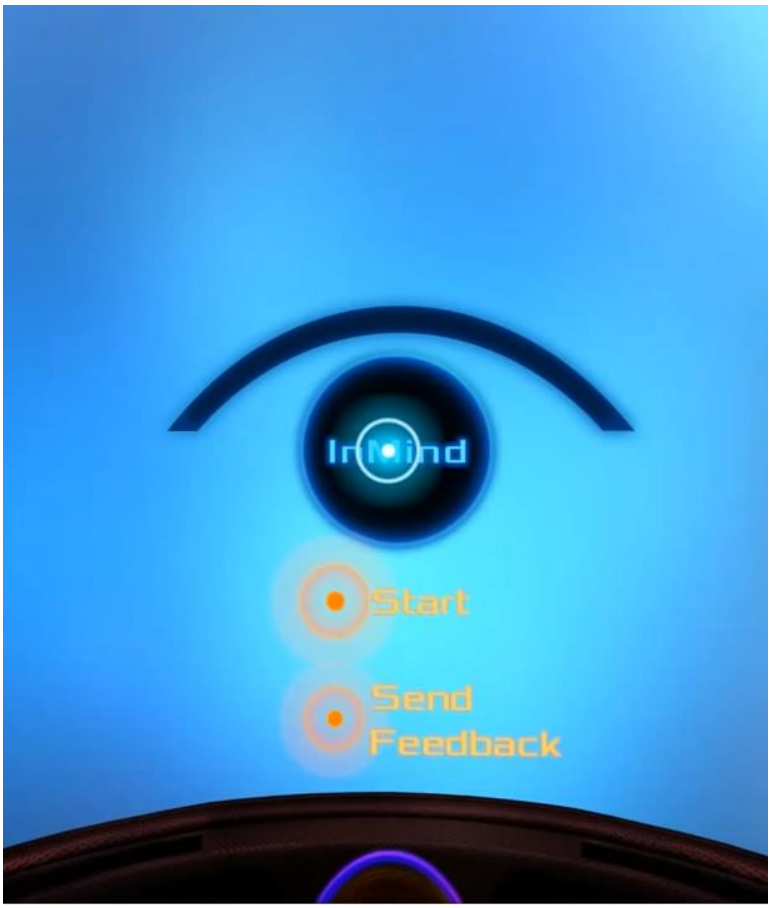


Figure 114: In Mind. Screenshot of the menu, Non-Diegetic representation.

Tutorial: Meta

This tutorial interface is classified by Meta representation because it's not in A 3D game Space but exist in the fictional game world story. This tutorial it's a text like subtitles to the player.

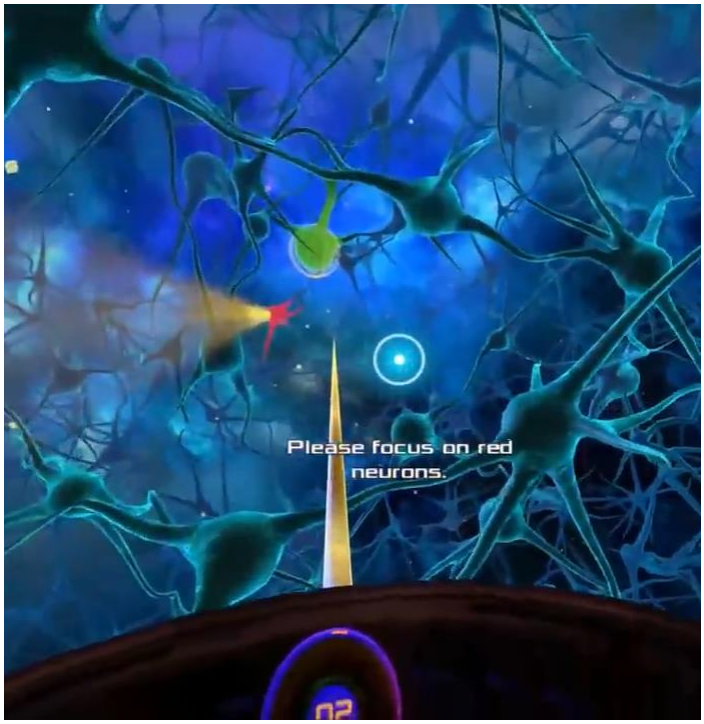


Figure 115: In Mind. Screenshot of the tutorial, Meta representation.

Gameplay: Meta

This gameplay interface is classified by Meta representation because it's not in A 3D game Space and but exist in the fictional game world story. This gameplay it's the crosshair that loads when focusing on red neurons.

Figure 116: In Mind. Screenshot of the gameplay, Meta representation.

Highscore: Non-Diegetic

This highscore interface is classified by Non-Diegetic representation because it's not in A 3D game Space and it's not exist in the fictional game world story. This highscore it's just flat 2D panel with text showing how many neurons neutralized.

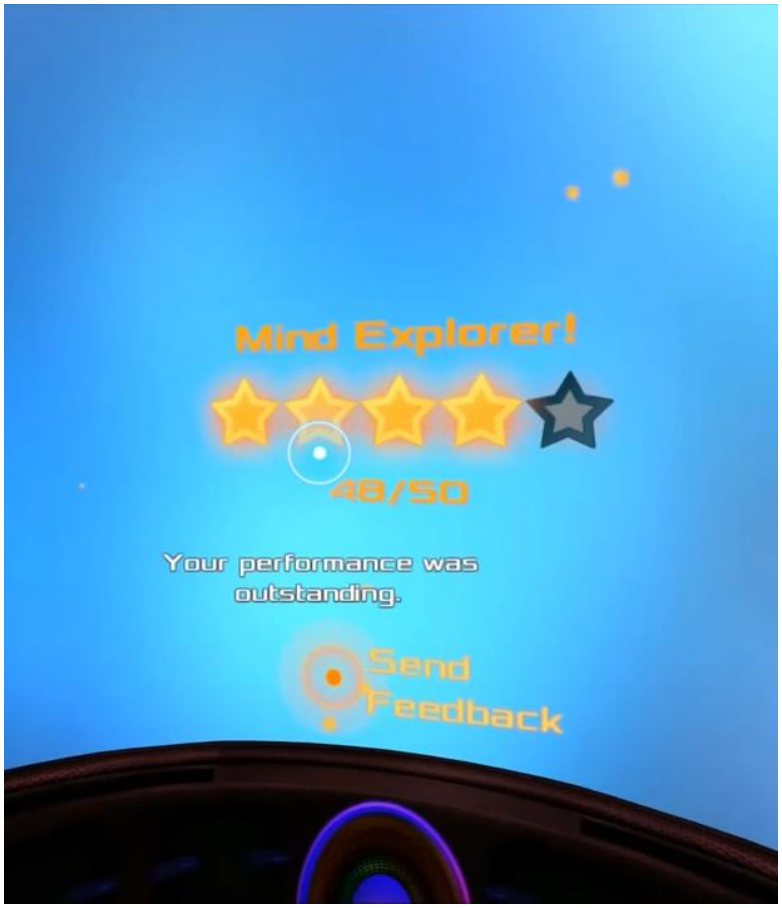


Figure 117: In Mind. Screenshot of the highscore, Non-Diegetic representation.

Overview of the classified interfaces

First Person Games in VR	User Interfaces	Classification by Diegesis Theory
Skyfighter: Training Day	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Meta
	High score	Non-Diegetic

Temple Run VR	Menu	Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	Non-Diegetic
Suicide Squad: Special OPS VR	Menu	Diegetic
	Tutorial	Spatial
	Gameplay	Non-Diegetic
	High score	Non-Diegetic
Balloon Shooter	Menu	Spatial
	Tutorial	Non-Diegetic
	Gameplay	Diegetic
	High score	Spatial
Cerevrum	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Non-Diegetic
	High score	Non-Diegetic
Doritos VR Battle	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Non-Diegetic
	High score	Non-Diegetic
Dragon Front	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	
Element Engine	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Meta
	High score	
Finding VR	Menu	Non-Diegetic
	Tutorial	Spatial
	Gameplay	Non-Diegetic
	High score	
One-Man Vurger	Menu	Non-Diegetic
	Tutorial	Diegetic
	Gameplay	Diegetic
	High score	Diegetic

Bait!	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	
Ohana Chan	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	Non-Diegetic
Stern Pinball Arcade	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	Spatial
Shooting Showdown 2 VR	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Non-Diegetic
	High score	Non-Diegetic
Casino VR Poker	Menu	Non-Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	Non-Diegetic
Solitaire Jester	Menu	Diegetic
	Tutorial	
	Gameplay	Spatial
	High score	
VERTI-GO HOME!	Menu	Spatial
	Tutorial	Non-Diegetic
	Gameplay	Non-Diegetic
	High score	Non-Diegetic
Oculus Arcade	Menu	Spatial
	Tutorial	
	Gameplay	Diegetic
	High score	
Bandit Six	Menu	Diegetic
	Tutorial	Non-Diegetic
	Gameplay	Spatial
	High score	Spatial

In Mind	Menu	Non-Diegetic
	Tutorial	Meta
	Gameplay	Meta
	High score	Non-Diegetic

Table 6: The 20 first person-view games in virtual reality, classified by Diegesis theory and their interfaces.

5 Type of user interface more and less immersive per results found

In this section, a questionnaire was made from the information collected in the previous section, four interfaces of each kind (Diegetic, Non-Diegetic, Spatial, Meta), sixteen interfaces in total were chosen to make a part in the questionnaire. There were 50 student's respondents and among them, game developers, designers and players. The questionnaire contains videos of the 16 interfaces to the respondents watch and rate them from 0 to 4 which type of interface is more or less immersive. The questionnaire model is available on Rennan Raffaele Portfolio [99].

Before applying the questionnaire, I needed to explain to the participants what is immersion, and how we can know that we are or can be immersed in a specific moment of the game, and the answer is just by concentrating at the game, and if something took out your attention of the game it's because the flow was broken by this something and the interface can be one of the responsible for that. The immersion concern Perception explained in the section 2.6 were also explained.

The questionnaire was applied with Students of Digital Games from Catholic University of Pernambuco, in Brazil, the participants were seventeen Designers, seventeen Developers and sixteen gamers, in total was 50 participants, from eighteen to twenty-six years old. Here is a table with the collected data of each game, the rate points of each interface and comments made by the participants.

First Person Games in VR	User Interfaces Types	Total Rate
1 – Skyfighter	Meta	133
2 - Solitaire Jester	Diegetic	149
3 - Finding VR	Spatial	124
4 - Doritos VR Battle	Non-Diegetic	106
5 - Element Engine	Meta	118
6 - One-Man VurgeR	Diegetic	152
7 - Suicide Squad	Spatial	107
8 - Cerevrum	Non-Diegetic	140
9 - InMind	Meta	107
10 - Stern Pinball	Spatial	127
11 - Dragon Front	Spatial	125
12 - One-Man VurgeR	Diegetic	145

13 - Balloon Shooter	Diegetic	154
14 - Bait!	Non-Diegetic	118
15 - VERTI-GO HOME!	Non-Diegetic	113
16 - InMind	Meta	129
Conclusion		**Total Rate**
Diegetic		600
Non-Diegetic		477
Spatial		513
Meta		487

Table 7: Results of the 16 user interfaces ranked by the participants.

On Diegetic Interfaces, here is some participant's comments:
"*People may not notice the interactivities, but in compensation it is very immersive*".
"*Perhaps changing the Brightness or Saturation of the objects that are part of the Menu compared to the other items in the scenario can help to bring the player's attention to them*".

On Non-Diegetic Interfaces, here is some participant's comments:
"*Too simple, could have more things on the interface. As a character shooting to show the bars or Doritos falling as score*".
"The interface should be all the time in the player's field of vision".
"Good, but it would be better if only plates were fish captured by the character".
"It does not look like it was meant to be there".

On Spatial Interfaces, here is some participant's comments:
"*I liked the interface type, but the information on the stones might look more like belonging to the game world*".
"*The issue of the moves he makes when the player picks up the weapon was cool, but still I do not think he has passed what the user expected*".
"*Good idea, get a gun to start the game, but you could have several weapons for each option, such as Continue Game, Settings, Highscores".*
"It would be even better if the cards appeared in the hands of the character (player)".

On Meta Interfaces, here is some participant's comments:
"*In some moments, the interface seems to hide the incoming missiles. Also, the interface seems so "flat" that makes me lose the sense of depth*".

"*I did not understand what was happening and the interface had me in too much trouble trying to look at the rest of the game*".
"*Not too discreet draws too much attention to it, with its colors, and does not fit perfectly with the scenery*".
"*The fact of reading subtitles takes the attention of the game, disrupting the fact of having to aim and shoot at objects*".

Through the data Collected, it's clear now that the Diegetic interfaces are the most immersive type of interface for virtual reality first person games, and the difference of the participants voted that for it is huge. The second most immersive interface was Spatial, the participants liked the idea to put information inside of 3D world, but there were some games where the interfaces didn't fit well. For the last the Meta and Non-Diegetic interfaces were classified as less immersive interfaces, the participants were concerned about the concentration in the game with these interfaces, because they break the concentration by suddenly showing up on the screen, or the user needs to look at certain point out of the main course.

6 Conclusions and Future Work

In the first level of the study, Chapter 1, we have discussed about how important Virtual Reality is, and his acceptance of the public in general. The first-person view was introduced and quoted where we are using this kind of view these day. After this introduction, we can explain and understand how we can mix virtual reality and person view into one great immersive experience.

In the Chapter 2, were presented the game's principle to show the rules of a game and how we know that's a game. We went deeper in the first-person view games, showing how it started, since photography to a video game. Again, we went deeper in Virtual Reality explanations, about how it started, what virtual reality devices exists, a comparison of head-mounted displays and they applications in diverse areas of expertise. Of course, we needed to explain how it come about User Interfaces in digital games, presenting the evolution of theses interfaces. Was explained what is Diegesis Theory and how can be used to classify user interfaces. For last were introduced and given examples of immersion, and how we can percept that we are immersed in a game.

For the Third Part, the Chapter 3, were presented a paper that give a start point for this research, about Diegesis Theory used in four interfaces, of four games, tested through Think-aloud method, and the results of this paper is the same of this dissertation, the Diegetic and Spatial interfaces were the most immersive.

In the methodology part, the Chapter 4, were shown the 20 first-person view games in virtual reality chosen, and almost four user interfaces of each of them, classified by the Diegesis Theory.

In Chapter 5, were applied a test with 50 participants, the collected data were compiled to us find out our final results, and some comments made by participants about a few interfaces

From the research using the Diegesis Theory, we could identify and classify interfaces in several games, was in total 20 games, almost each one with 4 interfaces classified, making a total of almost 80 interfaces identified for this research, but with the lack of some type of interface, we were able to use just 16 interfaces of this 80 in the questionnaire.

The Diegetic interfaces are masked as the environment so the participants said that was very immersive because they were receiving feedback but not noticing how, one of them said to make some changes in the colors to grab more attention, but that's the catch, maybe if the interface grab too much attention, the immersion could be lost. In the Spatial interfaces, like the Diegetic this interface uses the environment, but doesn't makes part of the history of the game, so the participants were very confused about the design who doesn't fit on the game, and some of participants tried to give tips to solve some problems, but this might change the type of interface. In the Meta Interface, the participants say that take too much attention distracting the user to the interface, and getting lost in the game flow, some of them couldn't see what's going on with the game with the interface on front of it. The Non-Diegetic interfaces made the participants feel that was something missing, because the interface was too simple, were not in the right place, and that doesn't bring immersion at all.

With this research, we have concluded that the Diegetic and Spatial Interfaces are the most immersive for first-person games in virtual reality, and less were the Meta and Non-Diegetic interfaces.

RESEARCH CONTRIBUTIONS

In the first place, the objective of the work was concluded, because it was possible to define which type of interface brings greater immersion to the user. Observing aspects in which each interface is inserted and how it can be improved or disrupted, through the concentration of the player

With the perspective of the research contributing to the academic scenario of future studies on immersive interfaces for first person games in virtual reality, the following contributions are scored:

A built-in model was developed to analyze and classify the possibilities of immersion in interfaces, starting from Diegesis theory: Diegetic, Non-Diegetic, Spatial, Meta.

It is demonstrated the existence of a gap in the studies on immersive interfaces for virtual reality, in compliance with the proposal of diegesis theory, initiated by Erik Fagerholt and Magnus Lorentzon in the year 2009 [77], with the publication of Beyond the Hud - User Interfaces for Increased Player Immersion in FPS Games.

It is hoped that the bibliographic model and survey will help in future theoretical-practical reflections in the academy, with the aim of forming User Interface designers more prepared and connected to the new practices of creating immersive first-person interfaces for virtual reality.

FUTURE DEVELOPMENTS

The gap on the virtual reality interfaces existing in the national and international bibliography of design studies stimulated the production of this dissertation. The challenge of collecting theoretical references on topics, so far, not available, on virtual reality and first-person games, and this allows to raise new studies and experiments on immersive interfaces.

To validate all data discovered in this research, one game will be developed, one level with the immersive interfaces, such as Diegetic and Spatial, and another level with the less immersive, such as Meta and Non-Diegetic. After the development will be possible to make some tests with the some of the participants of this research.

In the perspective of unfolding the presented research, it is proposed to use the research model, for decision making or user experience research when creating interfaces for games, whether in companies, startups, teaching schools or personal development.

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