Evaluation of Graphical User Interfaces Guidelines for Virtual Reality Games

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***Abstract*—Virtual Reality presents a new form of human-computer interaction for the video game world, introducing new challenges for various aspects of game development. Many of the traditional practices in the design and development of Graphical User Interfaces do not fit the context of Virtual Reality (VR), requiring adaptations or the creation of new solutions. This work proposes to analyze some of the GUI guidelines for VR, and from this, investigate the perception of players about the GUI guidelines. An analysis of some of the manufacturers and game engine guidelines for VR was carried out with the purpose of identifying which recommendations are more common. After that, a survey was applied with players to define, from the perspective of the user, the level of importance of each guideline. In addition to the analysis of the users' perspective, a set of games has been chosen and analyzed to understand the game's compliance with the guidelines. The results of the analysis showed that the games are respecting the guidelines, but users still perceive some issues with the VR games GUIs.**

***Index Terms*—virtual reality, user interface, guidelines, games**

I. Introduction

Virtual Reality (VR) is a technology that reproduces a digital environment and simulates the physical presence of the user allowing him to interact with this medium, giving a perception of being mentally immersed or present in the environment [1]. However, the concept of Virtual Reality is vast. It can cover different ways of interacting with the virtual environment and various types of devices, including HMDs (Head Mounted Displays, which are helmets and glasses for viewing the virtual world), gloves, or even motion mapping platforms [2].

The advancement of technology has allowed VR devices, such as the HTC Vive, Oculus Rift, and Playstation VR, to become the primary references in the HMDs for the VR market, becoming increasingly popular and accessible [3]. According to industry analyst Canalys, in the third quarter of 2017 alone, more than 1 million HMDs for VR were sold [3]. It is estimated that by the end of 2020, the installed base will reach 37 million units worldwide [4].

Due to the popularity of this technology, it is natural that there is a high demand for applications for it. One of the great potentials of VR is in the entertainment industry, specifically in the electronic games industry. In 2015, the global market for VR games was estimated at US$ 4.29 billion, with an estimate of reaching US$ 45.09 billion by 2025 [5].

However, VR presents a new form of human-computer interaction. Because the user is using helmets and/or gloves to extend the immersion, applications for the virtual environment cannot use classic interaction devices such as keyboards or mice. Another challenge is positioning messages or information that were previously fixed in a monitor position when the user can move freely in the 3D environment. Therefore, the VR games market has a significant challenge: rethinking how to build a User Interface (UI) and adapting classic concepts in order to expand user immersion.

These modern HMDs are relatively recent (for instance, Samsung Gear VR is from 2015), which means that research and production that address general usability and how these modern HMDs affect users still present their challenges [6]. A User Interface is an essential factor for VR applications since it is through it that the user interacts with the virtual world. There are several works addressing GUI for VR and AR applications, but this work focus on the user perception of these guidelines.

A guideline or design guideline can be defined as a "statement that suggests recommendations and considerations for communicating the design of a specific aspect or component of interaction in a certain context" [7]. Many of these guidelines are created from study data, but most of them come from principles, assertions, and experience [7].

Finally, the focus of this work is to understand the user perception of the guidelines to provide designers and programmers that develop games for Virtual Reality a way to understanding which aspects should be considered, by the user's perspective, in the construction of UI for HMD devices controlled by the orientation of the user's head as an input.

II. Theory

For this study, it is necessary to know concepts of terms relevant to this research as "virtual reality," "head-mounted display" (HMD), and "user interface for virtual reality".

A. Virtual Reality

Sherman et al. [1] defined VR as "a medium composed of interactive computer simulations that perceive the user's actions and position, giving a perception of being mentally immersed or present in the virtual world".

Virtual Reality provides a new way to interact with the virtual world, where the individual can perform interactions with the environment in a very natural way. Sherman et al. [1] define four key elements of the Virtual Reality experience: virtual world, immersion, sensory feedback, and interactivity.

The second key element, immersion, can be divided into two types: mental immersion and physical immersion. Mental immersion would be the state of deep involvement in something or its suspension from disbelief. Physical immersion, on the other hand, occurs when technology is used to create a "synthetic stimulus of the body's senses - not implying that it is all the senses of the body, or that the body is fully immersed". The ability to immerse participants in a virtual environment is one of the main assets of Virtual Reality. The VR community also uses the term presence to represent this concept. The users' sense of co-presence, as well as their understanding of the environment, are affected by the level of immersion they are in [8].

Sensory feedback, the third key element, is an essential ingredient for Virtual Reality. Sensory feedback is the feedback that the system must give the user based on their physical position. To convey the feeling of realism, VR must be interactive and respond to the user's actions. It is commonly used in the visual sense, where the user's body movements in the real world correspond to the virtual.

This work focuses on games for Virtual Reality and is mainly focused on the field of VR entertainment applications. However, this does not imply that the results of this work cannot be adapted to other fields of application.

B. Head-mounted display

According to Dorabjee et al. [9], HMDs are wearable devices in the form of glasses that provide the user with a fully immersive and/or semi-immersive experience. These glasses block the view of the physical world and project on two screens close to the user's view, stereoscopic images (an optical technique where a 3D view is created from the fusion of two slightly different views on each retina) generated by a computer.

Recent advances in hardware technology have made it possible to produce HMDs suitable for consumers, such as, for example, the Oculus Rift, suitable for immersive VR applications such as games, simulations, and films [10]. Different types of HMDs can use the processing power of different kinds of technology. The Oculus Rift and HTC Vive are connected to a computer, while Sony's Playstation VR uses the Playstation 4 console's processing power. Also, Samsung's Gear VR, like Google VR, uses a smartphone as a processor and a screen and also makes use of its sensors to track the positioning of the user's head.

Two essential characteristics of these devices are FOR (Field Of Regard) and FOV (Field Of View). The FOR refers to the amount of physical space surrounding the user, where images are displayed. This space can be measured through degrees of viewing angle so that if a cylindrical screen was built, the user would be in the center of it, and the screen would have 360 degrees of horizontal FOR. FOV, or field of view, refers to the maximum number of degrees of viewing angle that can be seen immediately on a screen. Its measurement is also done in degrees, where a flat projection screen could have a horizontal FOV between 80 to 120 degrees, depending on the user's position in relation to the screen. FOV must be less than or equal to the maximum FOV of human vision (approximately 180 degrees) [11].

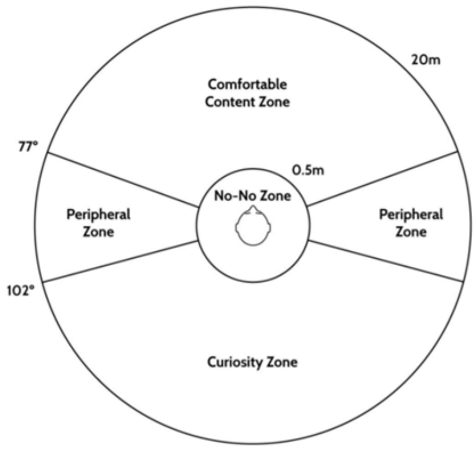

Fig. 1. Content Zones. Source: [15]

The FOV in commercial HMDs can vary from device to device. The Oculus Rift, for example, has a 94-degree FOV [12]. However, it is worth mentioning that HMDs like this allow the user to change the orientation of their head to see more of the environment around them.

Later, Alger [13] used the results of Chu [14] to combine these grades with the FOV in an HMD, resulting in the creation of five areas for content disposal, which can be seen in Fig. 1. They are Content Zone, Peripheral Zone, Curiosity Zone, No Zone, and the Background Zone.

The Content Zone, or comfort zone, is the comfortable area for viewing and rotating the head, where objects still pass a perception of stereoscopic depth.

The "peripheral zone" is the visible area with the maximum rotation of the head. It is not suitable for long-term content.

The "curiosity zone", or area of curiosity, is the area where the user will literally have to turn his shoulders and try with some effort to see what is behind him.

The "no-no zone" was created based on the results of Chu [14] on the scope of the vision. From the results, Alger [13] suggests that as the elements get closer to the vision, the user becomes cross-eyed, and the eye tension increases. He claims the minimum distance should be 50 centimeters from the user's head, and that nothing should be displayed within this radius.

The last zone is the "background zone". According to Alger [13], after 20 meters, the two HMD screens begin to show essentially the same image pixel, which decreases the perception of depth. He suggests that this area be used for flat objects that do not require depth and should be included in a spherical texture around the user.

These content areas described by Alger [13] are extremely relevant to Virtual Reality, as they assist the developer in creating User Interfaces for it, as well as contributing to good user experience. This work focuses on commercial HMDs that have the head orientation as a control input (e.g., Oculus Rift, HTC Vive, and Gear VR).

C. User Interface for Virtual Reality

According to Kolhe et al. [15], the graphical user interface is a type of user interface that allows the individual to interact with electronic devices using images instead of text commands.

According to Galitz [16], the entry is how users communicate their wants and needs to the computer. Mouse and keyboard are classic examples of input devices. However, their concept goes beyond those devices. In Virtual Reality HMDs, we can consider the orientation of the head as an input, since the movement of the head in the real world is captured by the sensors of the device, which uses this action as an intention to move the vision in the virtual world.

The output is how the computer transforms this input data and presents or displays this information to the user's perceptual system [11]. A classic example of an output device would be a display screen.

Buttons, menus, toolbars, scrollbars, windows, and taskbars are examples of GUI components with which the user interacts to perform a task [17], also called widgets [7]. However, these interface components are designed with input devices like a mouse and a keyboard in mind. As such, they are often unsuitable for the non-traditional environments and applications being developed today (e.g., Virtual Reality and Augmented Reality) [11].

Since Virtual Reality systems work in 3D environments, they need new interface components or some adjustments to existing components. These components can be called 3D UI or 3D user interface [11]. 3D UI can be defined as a "User Interface that involves interactions in three dimensions" [11].

In VR applications, the user often needs to correctly interpret a visual scene for effective use of the application, and this can be achieved through visual cues in the displayed content. An example of a visual tip is the depth, which helps users to interact with the application, especially when performing manipulation, selection, or navigation in 3D. Using perspective to your advantage is another way of giving visual cues in the content displayed to the user.

According to Sundstrom [18], designers use size, contrast, and color to denote a GUI hierarchy. The size is based on the distance between the user and the content. It defines three ways to display content. The first, called "Heads-up Display", locks the content in a specified position of the viewport and at a defined distance from the viewer. The second connects the content to the environment, so the users' view of the content changes as they move through the environment. The latter connects the content to the world so that it floats freely.

A type of User Interface widely used in Virtual Reality, which derives from the 3D UI, is the natural 3D User Interface, 3D NUI, or simply NUI (Natural User Interface). In it, the user's movements and actions in the real world are replicated by the 3D UI in a way that does not require any specialized knowledge from the user to perform the action in the virtual world [9]. A virtual experience where the user must rotate the wrist towards the eyes to make the character show his watch is an example of using this type of interface.

However, Sundstrom [18] describes that although Virtual Reality provided designers with a complete field of view to design GUIs, they still try to force 2D solutions into a 3D environment. He justifies that the reason why this happens is due to the blur that the vision naturally gives in the peripheral fields, focusing only on the center. In this way, only a small area of vision remains to work.

Considering these concepts, the focus of this work was the creation of GUI guidelines for Virtual Reality, also including 3D user interfaces (3D UI) and natural 3D user interfaces (3D NUI).

III. Related Work

Although its origin was dated over fifty years ago (Ivan Sutherland introduced the term in 1968), the concept of Virtual Reality was only popularized very recently (the Samsung Gear VR and the Oculus Rift were commercially released in 2015 and 2016, respectively). Yet, like any technology in the evolution stage, its application has changed over the years. The research aimed at commercial virtual reality systems still presents challenges as the use of virtual environments becomes more and more popular, and new requirements appear. Thus, the works of [19] [20] [21] are examples of relatively recent researches, which explore the concept of User Interfaces in Virtual 3D environments.

The work [19] is focused on the Augmented Reality (AR) area; however, because they are much related areas, their concepts and research methodology also apply to Virtual Reality. In [19], the author analyzes User Interfaces for various games and applications for Virtual Reality and other devices and determines a plausible use for them in Augmented Reality applications. He even adds his own guidelines. Bloksa [19] suggests that his work may help to design applications in Augmented Reality, either in the construction of the real application or in future research, to progress in this field of study with more standardized techniques and approaches.

Locomotion in VR environments occurs through locomotion systems, an essential component of interaction that allows navigation within the virtual space. However, mobility systems in Virtual Reality are still very limited. VR games have explored several ways to get around these problems, usefully informing the design of HCIs (Human-Computer Interfaces) for Virtual Reality. Habgood et al. [21] analyzed the titles released in the first three months of the Playstation VR Virtual Reality system life cycle, in order to find emerging solutions to these mobility problems. In the same work, these solutions are discussed concerning the lessons learned within the development, in progress, of an Environmental Narrative game for PlayStation VR as part of the Horizon 2020 REVEAL project.

Fricker [20] reports how usability principles can be implemented in a game development framework to create user interfaces in-game. The research explores User Interfaces for FPS (First Person Shooter) games from the usability perspective. The main objective of the study was to create a set of usability guidelines for the FPS game genre. To achieve results, the selected games were tested in weekly sessions during the survey. Also, a form was distributed to a small sample of the target audience of FPS players. The findings provided an understanding of some User Interface features that are used in FPS games and that players have found most useful, such as that visual hit markers help indicate when the player successfully hits an enemy, or that the radar helps to identify an enemy target and target locations before heading to the battlefield.

As in [19] [20], the work proposed here aims to obtain User Interface guidelines for 3D applications as a result. However, unlike the works cited that cover the entire concept of UI (presented in section II.C), this work focuses specifically on Graphical User Interfaces (GUI) for entertainment applications in Virtual Reality. As in the work of Habgood et al. [21], this work evaluates existing VR games in order to find emerging solutions to a given problem. However, the work cited focuses on locomotion in a virtual environment using Playstation VR. Besides, inspired by Fricker [20], this work selects the existing games based on an evaluation note. However, unlike Fricker [20] that used the notes from the Metacritic review site, the work proposed here uses the rating given by users on the Steam game platform.

IV. Methodology

The general objective of the research is to evaluate the main guidelines used by programmers and designers of Graphical User Interfaces of Virtual Reality Games that use HMD displays controlled by head orientation.

For this research, the specific methodology steps were:

1) Analyze guidelines for user interaction with VR applications available in the literature to search for common guidelines.
2) Evaluate five games positively ranked in the Steam[1] platform to understand if those games apply the guidelines found.
3) Identify visual elements that are recurrent during the evaluation of the popular, highly-rated games.
4) Evaluate user perception about these common elements and their suggestions.

V. Identification of New Interaction Requirements

In Sundstrom [18], the author pointed out that designers are trying to use the same solutions for 2D graphical interfaces in VR applications. Thus, he indicates an example where designers use flat GUI in a virtual world and point out that this may be a bad practice since perspective texts can make reading difficult. Thus, it is necessary to identify some solutions to prevent GUI elements from being shown in perspective.

In a VR device, the depth of nearby objects can be difficult to judge because, in the real world, your eyes dynamically assess the depth of nearby objects, flexing and changing their lenses, depending on how close or far the objects are in the environment [22]. In HMDs such as the Oculus Rift, the user's eye lens will remain focused on infinity [22]. Still, according to Oculus [23], failing to adequately represent the depth of objects will break the VR experience. Therefore, solutions that implement a notion of depth must be considered when designing GUIs for Virtual Reality.

Alger [13] suggests that content should not be placed too close to the user's view, as this can cause eye strain. It also suggests areas for content provision based on the comfort angles cited by Chu [14]. Also related to distance and size, texts are currently challenging to read in VR, and must be displayed large enough to be readable [24].

In games that do not use Virtual Reality, the User Interface is often superimposed at the top of the screen to show things like health, scores, menus, and so on. However, this approach generally does not work in VR, as our eyes cannot focus on something so close [25]. Therefore, when building applications in Virtual Reality, one should avoid GUIs that could obstruct the user's view.

Thus, the main problems identified are related to:

- The usage of 2D solutions;
- Content positioning in a 3D space (depth);
- The distance of content placement;
- Exhibition of textual information;
- Occlusion.

VI. Identification of Existing Guidelines

Many studies intend to identify issues and suggest solutions or guidelines for VR application graphical interfaces. Some predate the creation of modern HMDs, such as Samsung Gear VR [14] [20] [26] [27] [28], and some are after its creation [19] [10] [11] [13] [21] [29]. This is not an exhaustive list, and there are many works in the area indicating that creating VR graphical interfaces is still a challenge. For this work, some of the manufacturers' manuals (Oculus Rift and Leap Motion) and game engine guidelines (Unity3D) were used. Unreal does have a tutorial on how to implement to VR platforms[2] that contains some recommendations in it, but we could not find a set of guidelines separated that could be used "as is" and because of that, Unreal tutorial was not evaluated. The following will list some recommendations found in the manufacturer's guidelines.

- To increase the notion of immersion, depth tips can be used in GUIs [23] [22]. Some examples of depth tips are: parallax effect of movement, a technique where objects and different distances seem to move at different rates

[1]https://store.steampowered.com/

[2]https://docs.unrealengine.com/en-US/Platforms/VR/index.html

during head movement [23]; relative scales, where objects get smaller as they move away [23]; distant elements may lose contrast according to the distance [22]; lighting effects such as highlights and shadows help to perceive the shape and position of objects [23].

- Objects that will take the user's attention so that users will be staring at them for a long time (e.g., a menu) must be rendered at a comfortable distance, which can vary between 0.5 to 1 meter from the user's view [23].
- Incorporate the GUI element into the user's environment or character. Transferring GUI elements from a game that does not use Virtual Reality to a VR environment can be impractical or uncomfortable [23]. Instead, try to integrate the interface elements into the environment or the character. For example, selecting a weapon by grabbing a virtual backpack or holster [22] [25].
- Avoid content in peripheral areas. Reduce neck strain with experiences that reward (but don't require) a significant degree of observation of the user's surroundings. It is also possible to restrict content that requires more time to focus to the center of vision, while content that requires less attention can be arranged in the peripheral areas of vision [22].
- Use texts in UI that are easily read. Reading texts can be a challenging task to perform in VR, so it should be displayed in a size comfortable enough to be readable [23] [25].
- Use wearable menus. Static menus occupy ample space on the screen and can negatively influence the user's immersion. Thus, a solution to this problem is to integrate menus in the user's virtual hands, thus making interaction something more natural. Also, consideration should be given to using a specific initialization state (e.g., turning the arm) to ensure that it does not unnecessarily occupy valuable space in the user's view [22], in order to avoid occlusion.
- Put the GUI surrounding the user. GUI elements must be arranged in such a way that they appear to surround the user, thus facilitating their reading [18] [23] [25].
- Provide visual feedback on interactive elements. Interactive elements of a GUI should provide tips that inform its ability to interact [22]. Examples of tips are: using a hand shadow to indicate where the user's hand is in relation to the button; ensure that the button moves in relation to the amount of user pressure; create specific behaviors to indicate the state of focus on the element [22].
- Use scale and spacing suitable for interactive elements. Interactive elements must be appropriately sized to allow the user to perform the interaction easily. In addition, the spacing between the elements must also be considerable, reducing the chances of the user accidentally triggering neighboring elements [22].
- Prevent the virtual hand from obscuring interactive elements. In the real world, people routinely interact with objects that are hidden by their hands. Typically, physical contact provides feedback on the interaction with the object. In the absence of such physical contact, techniques such as making the elements large enough to be seen around the user's virtual hand can be used, or even making the user's hand semitransparent when it is close to the elements [22].
- Avoid pinning GUI in the user's view. Despite being used in applications that do not use Virtual Reality, linking UI with the user's vision in VR applications can cause a sensation similar to holding a book in front of the face while looking around, which can cause discomfort and nausea [25]. The users must be able to look around whenever they want without a fixed UI element obscuring their view [22] [25]. If there is a need to fix an element in the view, a technique can be used where the UI element follows the users' vision with a small delay, allowing the users to recognize their environment before the UI obscures it [25].

TABLE I
COMPARING GUIDELINES

Characteristics	Guidelines		
	Oculus	**Unity**	**Leap Motion**
Provide depth tip	x		x
Comfortable content distance	0.5m to 1m		
Incorporate the GUI into the user's environment or character	x	x	x
Use texts in UI that are easily read	x	x	
GUI surrounding the user	x	x	
Provide visual feedback on interactive elements			x
Use wearable menus			x
Scale and spacing suitable for interactive elements			x
Avoid pinning GUI in the user's view		x	x
Avoid content in peripheral areas			x
Prevent the virtual hand from obscuring interactive elements			x

Table I presents a comparison between the guidelines found and their authors.

The next section presents an assessment of some existing games to identify emerging standards and compliance with guidelines suggested by manufacturers.

VII. Evaluation of Existing Games

In this stage, five Virtual Reality games were selected from the Steam platform. The Steam platform was chosen because it is the most popular game distribution platform. However, it is worth mentioning that there are also VR games on other distribution platforms. One example is Google's Play Store, which distributes VR games and applications for Daydream

TABLE II
NUMBER OF POSITIVE AND NEGATIVE RATINGS PER GAME

Game	Positive	Negative	Total
Beat Saber	7.941	164	8.105
GORN	2.862	79	2.941
Hot Dogs, Horseshoes & Hand Grenades	2.584	70	2.654
Rec Room	3.111	174	3.285
Waltz of the Wizard	1.038	21	1.059

VR and Google Cardboard platforms. Another example is the Oculus Store that distributes games for Oculus devices, such as the Oculus Rift, Oculus Go, and Gear VR. However, in addition to Steam being the platform that has the most significant number of games, it was also the only one that presented a system for listing games with many different ordering criteria, such as relevance, name, price, and user rating, which facilitated the data collection.

One of the specific objectives of this research is to analyze the User Interface as an essential factor in the success of a VR game. Therefore, the criterion used to select the games was the evaluation of the users in the platform. Thus, a list was created based on the platform's search system using the ordering by user evaluation, and this ordering was made from the best evaluated to the worst evaluated VR games.

The five best-rated VR games on the platform according to the selected criteria were: Beat Saber, GORN, Waltz of the Wizard, Hot Dogs, Horseshoes & Hand Grenades, and Rec Room. Table II shows the user evaluation values according to the number of positive and negative ratings for each of the five highest rated games, listed in alphabetical order.

The games were ranked by the percentage of positive ratings in relation to the total of ratings, therefore considering the total number of ratings of a game. The ranking was as follows (in descending order):

1) Waltz of the Wizard with 98.0% of positive reviews;
2) Beat Saber with 97.9% positive reviews;
3) GORN with 97.3% of positive reviews;
4) Hot Dogs, Horseshoes & Hand Grenades with 97.3% of positive reviews;
5) Rec Room with 94.7% of positive reviews.

It is worth mentioning that the search was carried out during the month of July in 2018, and these values, as well as the ranking of the five best-rated games on Steam, may change depending on the date on which such search is performed.

After selecting the games, each game was rigorously analyzed through videos, seeking to find conformity with the guidelines already defined. The choice to evaluate the games through the videos was due to the unavailability of VR equipment. Therefore, given this limitation of this work, the games were not played for the analyses. Instead, videos of other players playing the game were used. These videos were visualized using a generic VR device (cardboard) to allow the immersion sensation of the VR interface. These videos commonly show two different views: the game being played and the player while playing the game. The video evaluation also considered whether the player who made the video looked tired or had difficulty interacting with the game. Table III shows the compliance of each game with existing guidelines.

TABLE III
COMPLIANCE OF GAMES WITH EXISTING GUIDELINES

	Waltz of the Wizard	Beat Saber	GORN	Hot Dogs, Horseshoes & Hand Grenades	Rec Room
Provide depth tip	X	X	X	X	X
Comfortable content distance	X	X	X	X	Partial
Incorporate the GUI into the user's environment or character	X	-	X	X	X
Use texts in UI that are easily read	X	X	X	Partial	X
GUI surrounding the user	-	X	X	X	-
Provide visual feedback on interactive elements	-	X	X	X	X
Use wearable menus	-	-	-	-	X
Scale and spacing suitable for interactive elements	X	X	X	X	X
Avoid pinning GUI in the user's view	X	X	X	X	-
Avoid content in peripheral areas	-	X	X	X	X
Prevent the virtual hand from obscuring interactive elements	X	-	X	X	X

It is possible to notice that all games evaluated meet the criteria of providing depth tips, using a comfortable distance for presented content, presenting texts that can be easily read and avoiding scale and spacing problems in interactive elements in the UI. Most games follow the guidelines identified by the manufacturers. The main unattended guideline was about using wearable menus, which most games did not used.

VIII. ANALYSIS OF THE GUIDELINES BY USERS

This work performed user evaluation of the guidelines. The goal is to understand the perception of the end-users about the guidelines. The evaluation was made by analyzing the opinions of players and users of any VR device through an online form.

TABLE IV
ANSWERS BY COUNTRY

Countries	Number of answers
USA	8
Brazil	4
United Kingdom	2
Austria	1
Germany	1
Australia	1
Taiwan	1

The form was distributed in two versions, one in Portuguese, distributed in some Brazilian online groups related to Virtual Reality, and the other in English, distributed in some Reddit Virtual Reality forums. The list of questions is available in [30].

In all, twenty responses were obtained, four of which came from the form in Portuguese and the other sixteen from the form distributed in English, with two of the sixteen participants in this version of the form answering "no" to the consent form and where discarded.

Of the eighteen valid responses, four came from the form distributed in Brazil (in Portuguese), and therefore were Brazilian responses. The other fourteen responses, as seen in Table IV with their quantities, were divided between the following countries: The United States of America, The United Kingdom, Austria, Germany, Australia, and Taiwan.

Of the participants, 88.9% were just players, while 11.1% were players and also game developers in Virtual Reality. The most popular device was the HTC Vive, which is one of the devices of at least 26.1% of the survey participants, followed by the Playstation VR, with 21.7% and the Oculus Rift, also with 21.7%. The Windows Mixed Reality and Daydream VR devices both had an 8.7% share, while the Gear VR, Oculus GO, and Google Cardboard devices had only 4.3%. Still on the players, when asked about the number of hours they spend playing video games (including VR games and non-VR games), the participants were divided, and most of them (33.3%) answered that they spend approximately two hours a day playing. Fig. 2 shows the total percentage of hours that the participants spend playing games, showing this division.

When asked how much time they spend specifically playing VR games, 77.8% said they spend approximately 1 hour, which indicates that compared to non-VR games, players spend little time playing VR games. It is interesting to perceive that while these players have access to VR devices, most of the time they dedicate to playing games is spent on non-VR games.

Respondents answered what the biggest problems with VR User Interfaces are and what solution they suggest for them. When analyzing the responses, readability was identified as one of the biggest issues of User Interfaces for VR. The interviewees pointed out that the texts are often blurred, pixelated, very small, or are arranged in the peripheral areas of the vision, which makes their visualization difficult. The interviewees did suggest some solutions to solve this problem. The main solutions cited were larger texts for readability, better choice of fonts, user-adjustable text sizes, and better screen resolution for the devices.

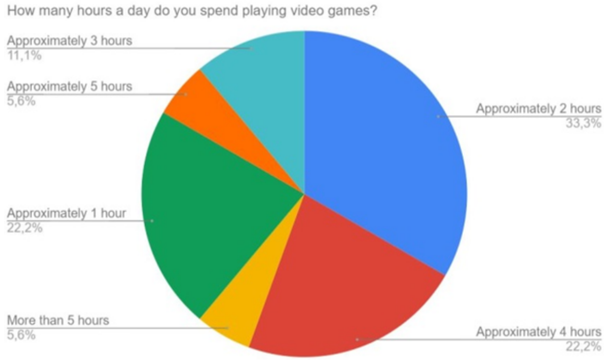

Fig. 2. Daily hours spent playing videogames.

Another major problem pointed out by the interviewees is related to the breaking of the immersion caused by the User Interface. It was pointed out that graphical interfaces such as text panels and floating menus are one of the causes for this immersion break, in addition to the fact that many times interfaces are confusing to access and control. One of the respondents said: "Developers are taking 2D design habits into Virtual Reality. Many things that worked very well and have been refined over decades just don't work in virtual reality." As a solution, most respondents said that transforming the interface into something more natural, such as objects or gestures, in addition to making the menus simpler, would be more effective.

The challenge in reaching the menus was another point identified by the interviewees. According to them, interfaces are often arranged over relatively long distances, making interaction difficult or impossible. The solution suggested by them was the use of some interface distance adjustment for the player.

Another difficulty presented by the interviewees is related to fixed elements in the user's view. The interviewees pointed out that the interfaces are in the middle of the character path or that they move along with the head, making it difficult to see anything that is behind the interface. As a solution, it was suggested to fix the graphical interface item in a certain place, so that it does not follow the vision. Another solution also pointed out was that elements should have a dynamic size so that when they are interacted with, they change their size.

Respondents also had difficulty related to orientation when interacting with menus and objects. Some pointed out that in some cases, it is not clear where the control is pointing because there is no indication. One of the interviewees said: "To collect a coin on a table is to hit or miss". As a solution, it was suggested to replace the interactions for graphical interfaces with more physical approaches.

The questionnaire focused on analyzing users' opinions about the guidelines found in Section VI. Therefore, users

TABLE V
EVALUATION OF EXISTING GUIDELINES

	Level 1	Level 2	Level 3	Level 4	Level 5
Provide depth tip	5,6%	-	16,7%	22,2%	55,6%
Comfortable content distance	-	-	22,2%	27,9%	50,0%
Incorporate the GUI into the user's environment or character	-	-	22,2%	33,3%	44,4%
Use texts in UI that are easily read	-	-	11,1%	16,7%	72,2%
GUI surrounding the user	-	17,6%	47,1%	23,5%	11,8%
Provide visual feedback on interactive elements	-	-	22,2%	27,8%	50,0%
Use wearable menus	5,6%	5,6%	27,8%	38,9%	22,2%
Scale and spacing suitable for interactive elements	-	-	50,0%	11,1%	38,9%
Avoid pinning GUI in the user's view	27,8%	27,8%	16,7%	16,7%	11,1%
Avoid content in peripheral areas	-	11,8%	23,5%	58,8%	5,9%
Prevent the virtual hand from obscuring interactive elements	-	25,0%	50,0%	12,5%	12,5%

were asked to assess the level of importance of a given characteristic using a scale ranging from 1 to 5, with 1 being unimportant and 5 very important. Table V lists the assessments of the level of importance that respondents pointed out for each of the guidelines identified.

Through Table V, it is possible to see that most of the existing guidelines were perceived as essential characteristics in a game for Virtual Reality. However, some guidelines were not pointed out as very important. One of these guidelines was "Avoid fixing the GUI in the view of the user", which, for the most part, was assessed by the interviewees as a not-so-important feature, which may indicate that most players do not feel much discomfort with static menus.

IX. CONCLUSION

This work aimed to analyze some of the GUI guidelines for VR games, and from this, investigate the perception of players about the GUI guidelines, as well as investigate whether some VR games are following the guideline recommendations.

As a main result, this work presents the user perception over the guidelines, helping developers and game designer to understand which guidelines are more important under their user's point of view. This result enables developers and game designers to prioritize aspects that bring higher satisfaction to RV game players. This work aims to serve as a support for developers during the creation of Graphical User Interfaces for VR games, thus ensuring that various practices that break the user's immersion or cause discomfort in VR games user experience due to incorrect usage of UI elements are avoided.

This work also consolidates the recommendation from 3 different guidelines by pointing to a set of guidelines that are common to the partners on commercial VR game development. These common guidelines were: providing depth tips, using a comfortable distance for presented content, presenting texts that can be easily read, and avoiding scale and spacing problems in interactive elements in the VR game UI.

The guidelines found were the result of the analysis of several VR applications in order to find solutions to common problems of GUIs for Virtual Reality. The initial planning for this analysis aimed to use a VR device to evaluate the games. However, access or acquisition of it proved to be unfeasible for this research. Due to this limitation, this analysis consisted of observing videos of the games, made by evaluators and using a generic VR device for games that require greater immersion to be evaluated. However, a better approach for such an analysis would be to use devices suitable to the chosen platforms for a better perspective of the elements of the games and a greater accuracy in the analysis. It is interesting to highlight that only 4% of the interviewees use cardboards and the research doesn't address differences in interviewees experience with different VR devices.

In order to conduct a more detailed analysis, a questionnaire was distributed to players and developers in order to collect their perspectives on the importance of solving the problems mentioned by the official guidelines. The results have shown that most guidelines are perceived as important to players and developers. The number of participants was limited. For a better representation of Virtual Reality game players, the questionnaire should be applied to a greater number of participants.

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