CRITERIA FOR THE ANALYSIS OF SERIOUS GAMES INTERFACES IN VIRTUAL REALITY

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ABSTRACT
The article presents an analysis of two games considered serious games in the context of virtual reality platforms: Bus Simulator Drive and EarthQuake Simulator VR. The objective is to analyze how the interaction process occurs in these types of games, which elements make up the interfaces in serious games, how they are used, how they integrate into the context, which aspects are relevant to virtual reality, among other aspects. Both games interfaces were analyzed according to the criteria: Virtual world, Interactivity, Graphical interface, Metaphors, and Feedback. The analysis possible to establish a systematic decomposition of the serious game itself, discussing the elements that make up the interfaces, how they are used, how they integrate into the context, which aspects are relevant to virtual reality, among other contributions.

KEYWORDS
Serious Games, Interface, Virtual Reality

1. INTRODUCTION
The games industry has transformed since its emergence, acting as an entertainment activity for certain groups of individuals and presenting as a culture in society, including exploring different areas such as education, business, and medicine (Santanella, 2013). In the maturing process of games, this characteristic provided the development of the so-called “serious games”, which are games that act to simulate ways of experiencing the real world, assisting in the acquisition of experience in activities and decision-making practices, in handling equipment, between others. Thus, it provides benefits for theoretical teaching and practical application of processes, aiding in knowledge and data production, allowing for professional improvement, and teaching in a controlled environment (Kapp, Blair & Mesch, 2014; Crookall, 2010; Michael & Chen, 2006).

LaValle (2017) argues that virtual reality is about the process to induce a specific behavior using artificial sensory stimulation, while the person has little or no notion of interference. Being inside the games means creating a mental immersion, putting the player inside a simulation, that is, a virtual world (Sherman & Craig, 2003). Due to technological advances and the ease with which information is propagated, the design process becomes more complex (Quintão & Triska, 2013).

Understanding this process, the purpose of serious games, the concepts of interfaces in the design area, and their application in the game universe are necessary to understand the complexity of building these games in virtual reality to work as knowledge for future research. Therefore, this article presents an analysis of two games considered serious games in the context of virtual reality platforms: Bus Simulator Drive and EarthQuake Simulator VR. The objective is to analyze how the interaction process occurs, which elements make up the interfaces in serious games, how they are used, how they integrate into the context, which aspects are relevant to virtual reality, among other aspects. Initially, there is a cut for the interface concepts used in the design environment and how they are applied in the games area. Afterward, the analysis criteria of how the interfaces are being worked in serious games and, consequently, in virtual reality are considered.
2. SERIOUS GAMES CHARACTERISTICS

The term serious games have its origin in the book by Clark Abt (1970). Although there are debates about the meaning, one of the considerations made is that they include games with the purpose of learning and training (Crookall, 2010). For Sherman & Craig (2003), serious games are games that use the medium to deliver a message, teach a lesson, or provide an experience. Zyda (2005) says that serious games aim to simulate practical situations of activities and can be used for training professionals and with an educational purpose, providing moments that encourage the precision of tasks and decision-making. In general, serious games have their goals aimed at learning certain situations, seeking to achieve specific results for tasks in the real world (Aldrich, 2009).

The design and creation process for serious games is not different from traditional games, however, while the later focuses on entertainment, the former focus on bringing these concepts and applying them in specialized content. Thus, they aim to train the user in an activity, through the simulation of a non-lethal environment, allowing the creation of a learning routine to improve the person’s skills (Crookall, 2010). Among serious games applications, there is consolidated development in the medical area, the automotive industry, the agricultural sector, equipment handling, among others (Machado et al., 2011; Michael & Chen, 2006), including cases such as the process of a vaccination (Ogilvy Brasil, 2017) or the simulation of an earthquake (Lovreglio et al., 2018).

The development of games, in general, includes fundamental areas such as programming, art, audio, and production (Chandler, 2012), based on what is intended to be obtained for the game experience, that is, the entire process of player interactivity with the game and its details (Rouse, 2005). The sharp difference between games and serious games that affects the approach to the design process is precision (Michael & Chen, 2006). As serious games depend on creating a virtual environment that simulates a real-life activity, whatever the goal, the aesthetic part of the game is not prioritized, but how close the simulated activity and environment are to reality. In this sense, the interface is the point of contact between the user and the system, establishing an interaction process (Preece, Rogers & Sharp, 2013). Likewise, in games, the interface has the function of being the access point between the player and the virtual world established by the game (Sherman & Craig, 2003). But now, the interface will have the objective of making the player feel in control of the experience (Schell, 2008), in a way that does not exclude the concepts proposed by Santa Rosa & Moraes (2008) and Johnson (2001) in Human-Computer Interaction, that address how systems affect people, concerning the stimuli, information, responses, and actions that guide this process.

2.1 Interface in Serious Games

According to LaViola, et al. (2017) concept of the user interaction process (Figure 1), the User element represents the player who will interact with the system. The System is that will receive the information coming from the player, process it, and respond accordingly. Input Device represents any device for the player to send information to the system. Output Device is understood as the device that will receive this information coming from the system and will change it into content that the user can perceive whether visually, or any other type of perception.

![Figure 1. System transfer function cyclical process](image)
While LaViola, et al. (2017) bring a more general approach to interfaces, Schell (2008) brings concepts to the scope of game design. According to Figure 2, it is noted that the concepts proposed by Schell (2008) about the interface in games are like those proposed by LaViola et al. (2017).

The term ‘User’ is the equivalent of the ‘Player’. To simplify, Input and Output will be kept, but System, in this case, is divided into two new categories: Virtual Interface and World. Schell (2008) considers Virtual Interface, a “conceptual layer” between the World and the Player. This layer is composed of all the elements that are not necessarily part of the virtual world in which the player is interacting, but that support the player, containing the player Input and Output commands for the player. Inside what he calls this subtle layer are the elements that support the Player to interact with the game, such as the camera that is used to see the world, menus, buttons, icons, and more. The term ‘World’ will be simplified in the system proposed by LaViola et al. (2017), as it contains only the elements that are parts of the virtual world, such as objects, game physics, scenarios, characters, and any other element that will make up the game universe. In Schell’s (2008) scheme, despite the separation of each part of a game’s interface, they work together, each step fulfilling a different role in the Player-World interaction.

This way the interface acts as an interaction tool between the systems, in this case, player, game, and the elements between them (Freitas, 2005), influencing how the player will fulfill the objective of serious games, as if the project if done poorly, noise is created between the player and the virtual world. In this sense, Moore’s (2011) ideas about Graphical User Interface (GUI) are added, which focuses on the graphical part of the user interface, being all the imagery types that the player sees on the screen during the game.

Moore (2011) determines two categories of information: firstly in-game screens, which are used during the game, and secondly shell screens, which are used outside the game. Thus, an in-game screen is any screen that performs a function within the game, usually intending to inform the player about some functionality or event. For example, screens like the player’s inventory, their combat screen, window, or menu with relevant types of information. This information can be static, meaning that the player does not directly interact with the information; or dynamic, meaning that it can interact with this interface.

In this context, it is relevant to understand how the player’s perceptual field works in moments of interaction with the interface. Swink (2009) addresses the concept of “feeling” games, seeking to understand how the perception of human beings when interacting with virtual worlds works. This perception exists in different
forms: visual, tactile, auditory, proprioceptive. Another point to be considered is that games allow the player to feel as if the virtual world were an extension of their body. Furthermore, these feelings are an ongoing process of skill-building and practice.

In figure 3, there is the field of perception that Swink (2009) adopted to explain how the player's perception process interacts with the virtual world. Note that the field has elements like the interface concepts proposed above. The player is divided into categories of brain processes. Input continues to play the same role. Output is included in the concept of feedback. Virtual Interface and World are contained in categories such as response, context, polish, metaphor, and rules. The ‘Response’ is how the system processes and modulates according to the player's input. Context is the space being simulated. Polish is the artificial effect that enhances the quality of the game. Metaphors are the representations that the game uses to generate an expected reaction from the player, with preconceptions that the player already has. Rules are arbitrary relationships between game variables that change the player's perception of game elements.

2.2 Criteria for Serious Games Analysis

To establish an analysis of interfaces in serious games, the criteria considered relevant for the proposal must be defined, to operationalize the comparison process. To conduct an analysis of interface elements in serious games, we sought to consider the main categories present in the literature by LaViola, et al. (2017), Schell (2008), Swink (2009), Moore (2011), Sherman & Craig (2003).

From this, the categories were separated into areas relevant to the Virtual Interface and World (Schell, 2008). The first will be deconstructed into two categories: Virtual World and Interactivity, while the second into three categories: Graphical Interface, Metaphors, and Feedback.

a) Virtual World: Sherman & Craig (2003) consider the virtual world to be any virtual space manifested through a medium and a description of the collection of objects in that space and its rules and governing relationships. In the gaming environment, the “context” of the game is the simulated space, that is, the physical space of the game's reality that includes the game rules (Swink, 2009).

b) Interactivity: In virtual reality, interactivity is any type of communication that takes place between the user and the virtual world mediated by input and output devices (LaViola et al., 2017). It is also considered how the player is placed in the scene, which avatar is used, that is, which character or object the player is incorporating and which tools he uses to interact with the virtual world (Sherman & Craig, 2003).

c) Graphical interface: It is divided into categories of the in-game screen and shell screen elements (Moore, 2011). The items on the player's screen environment that make up the interface are part of the information that guides the player, through images, texts, icons, and other options. In addition, some menus appear during or after the game, used to show information relevant to the player, such as their equipment list or score.

d) Metaphors: They relate to the player's perception of elements and interactions with objects within the game, in which experiences, ideas, and generalizations have a greater effect, as they are elements that come from the player's life experience (Swink, 2009). The function of metaphors in games is related to elements that are used in the interface to help the player's interaction in this world, these metaphors can be both visual and sound.

e) Feedback: It is the game's way of signaling information to the player on the interface if what he is doing is working or not (Moore, 2011; Swink, 2009). Feedback forms can be done in multiple ways, such as visual or audible. This element is fundamental in the context of Serious Games because it is how the game demonstrates the player's evolution in what is proposed as a goal.

3. METHODOLOGICAL PROCEDURES

This research aims to analyze how the interaction process occurs in serious games in virtual reality, seeking to operationalize the elements that make up the interfaces, understanding how they are used and how they integrate into the context. This research was carried out through an analytical study of serious games interfaces in virtual reality based on the criteria presented: Virtual World, Interactivity, Graphical Interface, Metaphors, and Feedback.
A survey was carried out on the Steam commercial game sales platform so that the selected games were commercially accessible to the public. It is important to consider that the goal of the game was within the concepts established by games that are considered serious games, simulating some type of real-world activity for training users in tasks that encourage decision-making in critical situations. In addition, we sought a serious game that also used the Virtual Reality system. Thus, the following games were selected: Bus Driver Simulator 2018 and Earthquake Simulator.

![Figure 4. Bus Driver game](image)

Bus Driver (Figure 4) is a game produced by the company KishMish Games, which aims to teach the user how to drive a bus. Thus, it is possible to interact with the bus from a touchscreen display, stopping at points for boarding and disembarking, in addition to finding different traffic depending on the time of day (Kishmish Games, 2018). EarthQuake (Figure 5) is a serious game launched in 2017 by the Lindero Edutainment company and applied to fire and earthquake survival training, teaching how to use the emergency kit and other actions to be taken (Lindero Edutainment, 2017).

![Figure 5. EarthQuake game](image)

### 4. ANALYSIS

After selection, both games interfaces were analyzed according to the criteria: Virtual world, Interactivity, Graphical interface, Metaphors, and Feedback.

#### 4.1 Analysis – Bus Simulator Drive

a) Virtual world: The objective of the game is to include the player as a public transport bus driver. The player must follow the work route, stop at bus stops for passengers to board and disembark, as well as comply with traffic rules. As an example of world simulation, there is at the beginning of the game a simple trip from the train station to Lenin Square, at lunchtime on a working day and it is explained that that is why the bus is not crowded. Thus, it is observed that the game context has as basic rules: location context, time of day, number of passengers. It is also noted that although the game simulates elements of a real city such as buildings, signs,
and traffic, the virtual world created is not a faithful representation of somewhere, in reality, it is just a fictional world called Virtual City. The elements that make up this world, such as scenery, buses, and people, are represented simply, with aesthetic fidelity only in form, but not in visual quality.

b) Interactivity: As the objective of the game is to create a simulation of how it is to drive a public transport bus, the player’s avatar is the bus driver himself. Despite this, the game does not allow for character customization. Thus, the interaction takes place only with the elements present inside the bus, such as the steering wheel, buttons for opening and closing the door, and other elements that belong to the work of driving. As the game is played in first-person mode, with the player representing the driver, the camera replicates the player’s movements with the virtual reality goggle. Thus, if the player looks to his right side in the direction where passengers board the bus, the game’s camera simulates this movement as if it were the driver looking. It is also possible to consider the player’s bus as an extension of the avatar, as the game does not separate the two during gameplay and interactions extend to elements found in traffic, such as other cars, signs, and the work route itself.

c) Graphical interface: At the beginning of the game, in virtual reality mode, there is the Menu with the basic options of Start, Options, and Exit the game (this screen is a shell-screen). When starting a game, there is a new interface, in which there is a list of scenario options for the player to select and where the context of the basic rules of the scenario is informed. During gameplay, the interface space is partially covered by the interior of the bus, including the steering wheel, bus buttons, and rearview mirror, with the rest of the space showing the simulated virtual environment around the bus. The dashboard for the driver to view data such as speed is considered an in-game screen. The bus has a screen on the right-hand side of the steering wheel with information about the route you should take, money earned from tickets, possible fines if you do something wrong. This monitor is inserted in the busy environment, working as if the driver had a tablet at his disposal while working. With this information, it is complex to classify it as a shell-screen or in-game screen, as this tablet plays the role of both, containing realistic information about a bus trip, such as passenger payment and the route you must take (in-game screen), but it is also used to inform the player of mistakes made (shell-screen). At the end of the journey, a new shell-screen menu appears to end the journey and take the player to the entry menu.

d) Metaphors: Several metaphors of the game Bus Driver are present in the context of the virtual world itself, such as traffic lights with red, yellow, and green, traffic signs with speed limits, bus stops, and pedestrian crossings. Others are inside the bus, such as the elements found on the driver's panel, such as speed markings and icons indicating functions such as opening a door, using a headlamp, among others. In addition to the visual part, the game tries to simulate the sounds of a traffic environment, such as horns and engine noise. All these elements are icons or symbols that players already live within everyday life. Two metaphors are not associative to the real world, such as the use of an imaginary line and arrows to indicate the path to be taken. However, this type of signaling is commonly used in GPS applications to guide the user on the route. In general, the game also uses green and red colors for positive and negative results.

e) Feedback: The first form of feedback found in the game is on the tablet, which contains information about whether the passenger boarded the bus and how much money he paid. During the course, lines and arrows are used to indicate if the path chosen by the player is correct. The game also uses a menu at the end of the route to inform the player's score, the amount earned in money with the tickets, in addition to approving or disapproving the activity performed.

4.2 Analysis – EarthQuake Simulator VR

a) Virtual World: The game teaches the user to survive disaster experiences such as fire and earthquake. These events are simulated with the player inside a house. In this scenario, the game explores areas of the house such as bedrooms, bathrooms, and kitchens. The context of the game is to simulate a dangerous event, such as a house fire, teaching the player how to react. For this, the player must fulfill a series of activities and instructions. The game has shortcomings in the aesthetic part, such as the unrealistic effect of fire and earthquake. However, it is noteworthy that the objective itself is to try to accurately simulate the necessary activities and movements that the player must do to survive such an extreme situation.

b) Interactivity: The EarthQuake game is performed in the first person, with the player in the avatar role. Therefore, the player's head movement works like the camera. During the game, objects scattered around the house such as fire extinguishers, books, and medicine chest are the interactive elements that the player has to
use to survive. This interaction is done through the player's own hands. The game projects the player's movements from real life to the virtual world. Although the game simulates the movement of the head and hands, the locomotion movements are made through the so-called point-and-click, in which the player must use the controller to go by clicking where he wants to reach.

c) Graphical Interface: The game starts with a shell-screen with basic instructions on how to play. After that, the game uses television as an interface to contextualize the player with what is happening inside this virtual world and give tips for the player's survival. This is followed by a checklist inside the kitchen, which works as an in-game screen interface, containing information on how to prepare for an earthquake. Screen space is not blocked by any element, with the player's view unobstructed, and only elements of the scene itself are used to convey information to the player. When the game needs to demonstrate something that is not naturally part of the scenario, a graphical interface with the information appears. In addition, a narrator is informing the activities to be done. With that, the game uses a lot of audio instead of visual.

d) Metaphors: The EarthQuake game simulates a circle interface to indicate where you want to go. Within the checklist that the player must complete, each completed step is marked with a green correct sign. When the player needs to be in a specific position in the scenario, the game demarcates this area in green lines indicating that it is a safe place. In addition, there is an indication of green arrows along the path that the player must take to accomplish the objective. All these elements are pertinent to everyday elements of a player's life.

e) Feedback: When the player must assemble a survival kit with the necessary items, the game provides an interface on top of the backpack that works as a counter indicating the total number of items needed and how many have already been collected. In the checklist present in the scenario, every time the player puts an object inside the backpack, there is a green line and a correct sign marked above the item in the response. When the player fails to collect an item, the narrator warns that something is missing. Another element of feedback is a dog's bark, which is used to signal that the earthquake is about to start, and which gets louder when the earthquake is closer to happening. Lastly, if the player followed the instructions and survived the earthquake, you get a message that the activities were completed.

5. CONCLUSION

This article aimed to analyze the interaction process in serious virtual reality games. Therefore, it was necessary to establish criteria for analyzing computer systems and games in general that could be adapted to the analysis of serious games. The categories present in the literature by LaViola, et al. (2017), Schell (2008), Swink (2009), Moore (2011), Sherman & Craig (2003), defining as common criteria: Virtual World, Interactivity, Graphical Interface, Metaphors, and Feedback.

In this sense, an analysis of the serious games Bus Simulator Drive and EarthQuake Simulator VR was performed. Among the elements analyzed, it is considered that "interactivity" was noted to have the most influence on virtual reality, as this method brings devices that go beyond the common control, increasing not only the possibilities of interaction but also of replicating movements of the human being in the game. The other elements had highlights with less impact on the functioning of the interface. “Virtual world” benefited from the player's immersion in the universe. The “graphical interface” had its adaptation more from a technical point of view, because of virtual reality, its elements had to be modified for the output type that the virtual reality devices have. The same goes for the elements of “Metaphors” and “Feedback”.

It is noteworthy that the analysis of serious games was not intended to determine whether a game is better than another or what problems the game presents. With this, the adoption of the criteria made it possible to establish a systematic decomposition of the serious game itself, discussing the elements that make up the interfaces, how they are used, how they integrate into the context, which aspects are relevant to virtual reality, among other contributions. To expand this research, it is proposed to analyze the user experience with games, addressing details of the player's interaction with the controls, how the player is being affected by changes, and how these actions are being reflected within the virtual world.
ACKNOWLEDGEMENT

We thank the Federal University of Santa Catarina. The financial support of CAPES. The Team in DesignLAB/UFSC and Tecmidia for the collaboration to this research.

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