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DESIGNING UI FOR A VR ENVIRONMENT: DIEGETIC AND NON-DIEGETIC APPROACHES

J. Sharples[1], B. Williams[1], and S. Reeves[1]

[1]Staffordshire Games Institute
School of Digital, Technologies, Innovation and Business
University of Staffordshire, UK

Abstract

The integration of effective user interfaces (UI) is critical in the rapidly evolving landscape of video games and particularly within virtual reality (VR). Poor UI design can have a negative impact on immersion by breaking such engagement, create cognitive overload, and detract from the overall experience of the player. This paper investigates a strategic implementation of two primary categories: diegetic interfaces, which are integrated into the game world, and non-diegetic interfaces, which exist outside the games fictional space. A simple VR game was created to test both diegetic and non-diegetic UI principles gaining feedback to assess the purpose and usability of the two methods for the application into future projects and research.

CCS Concepts

• ***Computing methodologies*** → *Perception;* • ***Human-centered computing*** → *Interactive systems and tools;* ***Virtual reality;***

1. Introduction

For this research paper, the primary focus is on the design and implementation of user interfaces (UI) within virtual reality (VR) environments. The paper aims to explore the various methods available, including key design principles and psychological considerations for user interaction. It will investigate the distinction between diegetic (in-world) and non-diegetic (overlayed) UI and analyse how each can be used to effectively relay information. By examining these methods, a design framework will be investigated with the goal of creating a seamless user experience that maintains immersion while still providing the necessary information to the user.

2. Related Work

User interface (UI) design for desktop is comparatively easy compared to the design of a virtual reality (VR) game [Nas]. When designing a UI for a desktop game, the industry default is to display information in a non-diegetic screen space, overlaying it on top of the game.

However, when designing for a VR game, a screen space UI is shown to not be as effective or immersive of an experience. A study comparing the two methods [WHSW18] showed that a 3-dimenstional (3D) user interface is more fun, immersive and generally satisfying in comparison to a 2-dimensional (2D) user interface. The study did however state that when there are large quantities of objects that need to be interacted with at speed, a 2D interface would be a better choice.

When looking at the industry standard as the point of reference on the matter, many AAA games utilise a 3D user interface, such as Beat Saber's non-diegetic approach (Beat Games, 2018), or Bonework's more diegetic method of implementation (Stress Level Zero, 2019).

Diegetic and non-diegetic is a term used in the movie and games industries, often referring to audio in films and games, while also applying to UI within video games. The term "Diegetic" means that the media feedback takes place in the world of the game/movie [Mas21] [Cas20], such as the TV screens utilised in Boneworks [Figure 1]. On the other hand, "non-diegetic" means that the media feedback is not in the world of the game, such as the hovering 2D UI from Beat Saber [Figure 2].

When looking to compare the effects of diegetic and non-diegetic UI, there cannot be bias based on the information displayed, or the environment it is displayed in. This is due to the fact that in differing settings and scenarios the same factors cannot be compared as the context for the content is not consistent. Therefore, a game system must be designed to contextualise the UI display. A study on removing the heads-up display (HUD) of a shooter game was performed to test if a non-diegetic UI would reduce immersion [ICK*15]. The paper used Battlefield 3 (DICE, 2011), a desktop shooter game that utilised a holographic style non-diegetic HUD [Figure 3].

In the study the HUD was removed entirely to create a more diegetic feeling game. While the final product did in fact show what a more diegetic approach would look like, what the study failed to

Figure 1: *Boneworks Diegetic Menu (Stress Level Zero, 2019)*

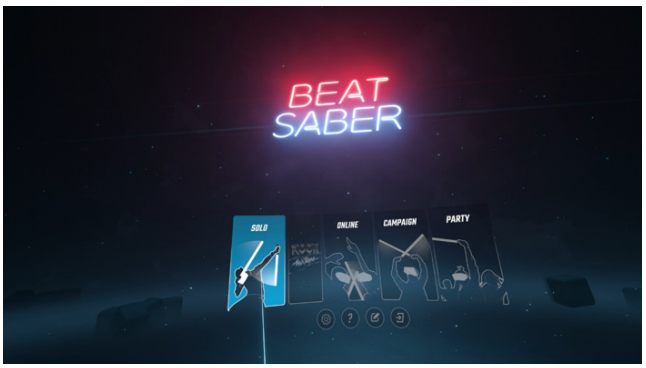

Figure 2: *Beat Saber Non-Diegetic Menu (Beat Games, 2018)*

show was the information required to play the game. By switching to the alternate interface, the player no longer knew key information such as ammunition count, map information, or saw any teammate markers. The fact that the new design lacked this information meant that the outcome of the study was rendered invalid when considering and comparing a diegetic and a non-diegetic design for use in play.

Nevertheless, selecting a shooter game in this instance still has merit. A shooter game has a plethora of information to display, such as health, ammo or relative location on the map. In a study on the health bar for VR shooter games many different approaches to implementation are outlined [KHSM21]. For a non-diegetic approach to the health bar, Köhle et al looked at the use of a simple health bar overlay which hovers below the player's weapon. For a diegetic approach, the paper looks at an alternate version of the wristwatch health display created for Half-Life: Alyx (Valve Corp,

Figure 3: *The holographic HUD used in Battlefield 3 (DICE , 2011)*

2020) in which the players health on a scale of 0-100 is displayed on a diegetic watch which the player character is shown to wear in a VR space.

The design of displaying ammo within a VR space is not a matter that many research papers have studied, but a similar study focusing on the display of ammo for a desktop game has been performed to show diegetic and non-diegetic approaches [PTCM15]. In their study, Peacocke et al looked at a selection of five UI options for showing ammo count, with the best diegetic UI option being when the ammo number is put on the gun. The best non-diegetic option was a number in game showing both max ammo and current ammo, in a similar style to that seen in Battlefield 3 [Figure 3].

For an approach to weapon or item selection, a study on diegetic tool management outlines two clear methods for both diegetic and non-diegetic item selection [DCP*21]. Using an adapted version of the VR CSI training simulator, the paper focused on selection of items using a non-diegetic radial menu interface and a diegetic toolbox.

For implementation into a shooter game, while the radial menu interface can be utilised, an alternate version of the toolbox will need to be used. Feedback from the study showed that the toolbox method caused high participant frustration and took a lot of effort [DCP*21]. By having fewer items, the game could implement an item stashing system, such as the one seen in Boneworks (Stress Level Zero, 2019), or could employ an item storage belt as seen in Phasmophobia (Kinetic Games, 2020).

The final UI attribute shared by most first-person shooter (FPS) games (Riot Games, 2020) (DICE, 2011) (Halo Studios, 2021) is the existence of a mini-map. The purpose of a mini-map is to display information such as the layout of the world around you, as well as your relative position in it. Mini-maps can also show the location of objectives, as well as the position of enemies as a warning system.

While a 3D map system within a VR space could be difficult to represent, using a 2D radar system, such as that seen in the Halo series, could be a more effective approach. When looking at a non-diegetic approach, a study performed on user interfaces shows that a radar floating at a set point can be a valid approach [MCS21].

However, Marre's diegetic approach in this case is no different from their non-diegetic approach – and this paper questions whether attaching the radar to the gun in the manner seen in the paper can really be considered diegetic.

A separate study uses a map system in which the player looks down as if holding a map [Gie14]. While this method is more diegetic, due to the nature of a shooter game the player requires one or both of their hands for the weapons in the game. It is for this reason that this paper proposes a method that merges a radar map with the health system from Half-Life: Alyx (Valve Corporation, 2020) as discussed earlier. In this method, the participant's left hand will display their health on a wristwatch, and the mini-map will be embedded in their character's forearm. If this were to be implemented within a game environment, this feature would be displayed on the non-dominant hand (selected in settings), but for the sake of this project, it will be ensured that those testing it will have their right hand as their dominant one.

To conclude, a diegetic and non-diegetic design has been outlined to show the players ammo count, health and map position within a VR FPS game – and a diegetic and non-diegetic approach to selecting weapons has been outlined for implementation.

3. Methodology

3.1. Base Game Outline

When creating the core game that the diegetic and non-diegetic assets would be added to, the context of the study was taken into consideration. Excessive assets, mechanics or features would take the user's focus away from the UI, and so a simplistic game was needed to help answer the question: how does the placement and type of user interface (diegetic vs. non-diegetic) in a virtual reality (VR) game affect a player's in-game experience, specifically concerning their ability to track enemies, manage health, and handle ammunition?

To create a simple enemy for the player to face, allowing the player to make use of their weapons, two designs were considered. Firstly, a simple stationary enemy with a gun. This enemy would mean that the player would be in a firearm fight and would use the mini-map to track down where they were being shot from. The issue with this option would be that the player wouldn't have much of a chance to shoot at enemies first even with the mini-map, as the enemy would have no reason not to shoot as soon as the player was in line of sight – without either breaking immersion or giving the enemy a chance to miss the player – requiring a longer development time.

The second option for an enemy would be a melee based one. This would give the player time to work out where they were being approached from and be able to use simple mechanics – with basic movement towards the player, then attacking movements once they reach them being the only AI required. This second option was the simplest and also made the best use of the mini-map – giving the player an incentive to reference it regularly. These enemies don't need to be difficult to kill, as the point of the game is utilising the UI rather than making hard enemies, so a single shot will be made to slay them.

This shot can be fired out of one of the two weapon options that will be created. The options for weapons will be a pistol or a shotgun/rifle. The trade-off between these two weapons will be a comparison between their ammunition count and the ease with which they can be reloaded. The pistol will have a lower ammo count, with six shots, but can be quickly reloaded. In comparison, the shotgun will have 10 shots, but be harder to reload.

As enemies will be easy to kill, the player is given a low health pool, with three melee attacks resulting in a game over. The aim of the player's game was to last as long as possible, with the game's difficulty ramping up as the game progressed.

As there was no benefit to traversing the map, the player did not need movement mechanics, which meant one less thing for them to focus on when testing the game. While movement mechanics were added as a Unity default, they were not needed and served more as a development tool than a game feature.

3.2. Diegetic UI Design

When designing the hand mounted diegetic UI outlined in the literature review, one issue that came across in the design was the selection between left-handed or right-hand UI. The choice was made that when the player equipped a weapon in hand, the wrist-mounted UI would disappear.

The health bar itself was added as a slider on the wrist, akin to a watch. While the health counter featured in Half-Life: Alyx (Valve Corporation, 2020) was docked on the back of the hand, due to a lack of design assets, both the slider and the mini-map were displayed on a simple forearm mounted display.

The display of ammunition on the weapon was done according to the designs of [PTCM15], with the bullet displayed on the weapon itself. To display in a fashion that is highly visible to the player, the ammo counter was placed above the grip of the gun. When a gun is held by the player, their hand would be placed over the grip, therefore when the player looks at their hand the ammo would be clearly and immediately visible.

The guns themselves were drawn using hip holsters and back holsters similar to the ones seen in Boneworks (Stress Level Zero, 2019). To ensure the player did not holster their weapon accidentally during the test, the grip button required to be held down to draw the weapon, or release the grip button while holstering to remove the gun from the hand.

3.3. Non-Diegetic UI Design

For the implementation of non-diegetic UI within VR, the head up display (HUD) will be rendered in world space, connected to the camera so that it follows the player's vision. The HUD will be placed close enough to the player that enemies, the floor and the player's guns will not overlap with the information.

The health bar will be placed across the bottom of the player's vision, large enough to be easily readable. The mini-map will be placed in the bottom left-hand corner of the HUD, similarly to how other games display mini-maps [Figure 3].

The ammo tracker will be floating off to the side of the weapon,

and slightly above it in a bold black number – so as to be quickly and easily visible to the player.

Weapons will be selected using a custom-made weapon wheel. This wheel will be spawned in via the player holding down the grip button, after which they may move their hand through the wheel to select their weapon of choice. The weapon wheel will be small enough for the player's hand movement to not be burdensome during gameplay, but large enough for the weapon options to be easily visible.

4. Results & Discussion

After 20 minutes of testing, four of the six participants recorded that they found the non-diegetic UI preferable to the diegetic UI [Figure 4]. While this is not a majority strong enough to decisively conclude the best overall UI use, it can be indictive to the opinion of the market.

However, when recording feedback, there were some stances that the entirety of the participants fed back. Firstly, within the context of VR, non-diegetic UI is more understandable and more accessible to the user [Figure 4]. Participants stated that this was due to the fact that in order to make UI diegetic within a VR space, it had to be limited to hands or the player's physical body. This made it harder to access during a game, especially during more fast-paced or time sensitive sections – whereas with the information always floating in front of you it was easier to see and know what was going on.

Furthermore, this floating information had significant drawbacks. All six participants agreed that the diegetic UI made for a far more immersive gaming experience [Figure 4]. Some participants addressed the ease of use, stating that even though the non-diegetic UI was easier to see and get information from quickly they preferred the harder-to-access diegetic UI, as it made them feel as though they were really within the game.

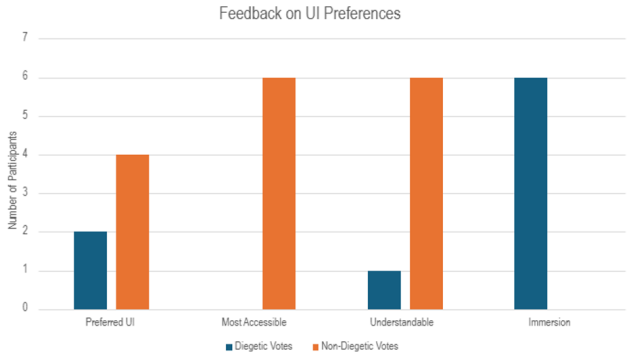

Figure 4: *Feedback from testing showing majority feedback*

In addition to the immersive factor of the diegetic UI, four of the six participants agreed that the diegetic UI made the game flow better. This was because, in a time sensitive situation, every movement counted, and so time spent checking information on the UI didn't break immersion, but rather increased it. By having to physically perform the actions of the game, participants felt more involved.

When asked preference on individual aspects of the game, such as the ammo counter placement or mini-map placement, no majorities emerged on any one option. This shows that diegetic and non-diegetic UIs are a sum of their parts, and individual factors don't matter so much as the overall immersive experience.

Neither UI showed significant proof that they make users more motion sick than the other, with both approaches having one participant stating that it made them feel slightly motion sick.

5. Conclusion

This project's aim was to create a user interface for virtual reality that displayed the necessary information without breaking immersion. By exploring diegetic and non-diegetic approaches to UI, the pros and cons to both have been outlined.

The benefit of a non-diegetic approach to UI is that information can be displayed in the most concise and clear way possible. Without having to consider what the UI means within the world space; information can be shown clearly. with all participants having given feedback which reported how easy it was to understand.

On the other hand, diegetic UI can be harder to access and more difficult to understand, which is supported by the findings of Dickinson et al [DCP*21]. However, the benefits of diegetic UI could be construed to outweigh the costs, with reports of a deepened sense of immersion felt when using diegetic approaches to the game. This deepened sense of immersion meant that participants flow better with the game, since they feel more in tune with the world around them.

Some participants fed back that they would rather UI be harder to use to feel more natural – while others said that the accessibility of the non-diegetic UI meant that they performed better in the game, thus increasing their enjoyment.

From the information gathered, the conclusion must be drawn that of the two options there is no definitively 'better option'. Rather, the context of a game must be taken into consideration before choosing which UI approach to take. For example, should a game be an immersive story game which makes the player feel immersed in the world, a diegetic approach to UI would be in order. On the other hand, if the game was an online, fast paced game where high skill levels are key, a non-diegetic approach would be the ideal solution. And whilst the purpose of this paper was to investigate the use of UI for a VR environment much of the feedback from the small study suggested a non-diegetic UI approach would be best suited.

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