Master's Thesis

Enhance Understanding of Place in Urban Planning through Game-Inspired Orientation Tools in VR

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Abstract

kommt zum Schluss

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1 Introduction

To provide a better quality of life and place, urban planning needs to adapt to the rapid growth of population and the resulting global urbanization (Mouratidis, 2021) (Trip, 2007). Creative and transdisciplinary movements are already working towards a sustainable and inclusive future and bring experts, businesses, institutions, and citizens together to address complex societal challenges through co-creation (Bauhaus, 2023). Such participatory planning with community involvement positively affects decision making and getting those decisions and design choices accepted and tested by different members of the community - including non-experts and citizens - can lead to a better working environment (Maffei et al., 2016).
Virtual Reality (VR) technology can help this public consultation process and has the potential to foster stakeholder participation (Howard & Gaborit, 2007). This technology's representation of the real world is a superior way of communicating and understanding the environment compared to mere description, and in creating a common language and empowering participants it helps the design and urban planning process (Kuliga et al., 2015) (Al-Kodmany, 1999) (Ball et al., 2007).
Being able to present additional information about the urban planning process, makes it an effective tool for communication plans and knowledge exchanges. This improves transparency. But to successfully present this information so non-experts are able to look and participate in the urban planning process, it needs to be prepared and presented in a comprehensive way (Dambruch & Kraemer, 2014).
Multiple studies have already been conducted about the depiction of the environment itself, focusing on the influence of realism, sound, and light (e.g. (Drettakis et al., 2007) (Maffei et al., 2016)). Therefore, this work will focus on different characteristics. Designing and planning a place is a dynamic process and its effectiveness relies on the human perception (Hu & Chen, 2018). Among other things, places can be characterized by their distinct cultural, social and economic attributes (Thomas, 2023).

This work will focus on how to communicate those attributes most effectively so that this knowledge might later be used for urban planning purposes.

The tools to realize this goal will be inspired by orientation and navigation systems predominately found in video games and then implemented into a VR experience. Videogame environments are complex and require players to orient themselves in multiple environments such as buildings, natural settings but also city streets (de Castell et al., 2019). They are visually realistic environments that evoke the same spatial abilities needed in the real world. An immersive VR supports this as well and has therefore the potential to be a useful tool for supporting architectural design and planning (Usman et al., 2017).
The game-inspired orientation tools this paper will focus on are markers in the user's field of view and a compass bar. In addition to those two tools, a more conventional orientation method, a map, will be added to the virtual environments. All three orientation tools will be compared in their ability to communicate information about the given space and how the understanding of the places differs between them.
For this purpose, the available amenities of the places will be classified into the previously

mentioned attributes that characterize a place - cultural, social, and economics. Participants will experience one of these three implemented orientation methods in the same place. An evaluation will then highlight how well those tools can communicate the information about the space.

The structure of this work is as follows:

- The first section of this work reviews existing literature, beginning with an exploration of the concept of "place" and its formation. It then examines the role of VR in the field of architecture and concludes with a brief overview of orientation, its significance in video games, and how game developers are assisting players in this regard.
- Chapter 3 details the design decisions, processes and implementation of the chosen orientations tools.
- This is followed by Chapter 4, which outlines the design of the user study and the methods of data collection.
- Chapter 5 presents the results, organized according to the implemented orientation tools.
- And Chapter 6 concludes this work with a conclusion, summarizing the findings.

2 Theoretical Framework

The following chapter explores the related work relevant to establish the theoretical foundation for the implementation of the prototype.
The first section examines the elements that define a place, followed by how VR can represent these elements and support the urban planning process.
The final section focuses on navigation tools in video games, assessing their potential and reviewing the available options.

2.1 What makes a place

The cultural geographer Tuan (1975) defined place, and its accompanying differences to space, as one of perception. Whereas space refers to environments with little meaning and emotional attachments to the beholder, so is place the opposite. A place holds value and importance to its users due to their personal and collective experiences. It is human interaction, activities and emotional connections associated with a space that transforms it into something more (Castello, 2010).
Factors that contribute to this creation of place are natural assets, narrative, reputation and political actions, local traditions, historic buildings, available sensory enjoyment and comfort, but also the availability of goods and services (Castello, 2010) (Ardoin, 2006). Castello (2010) therefore concludes that the perception of a place is influenced by socio-cultural stimuli (narrative, history and tradition), morphological-imaginary stimuli (natural assets, beauty, reputation) and enjoyment-functional stimuli (services, utilities, sensory enjoyment), all three of them a result form the interaction between people and their environment.
The concept of place has been explored across diverse disciplines, including geography (Kovel et al., 1998) (Massey, 1994), cultural anthropology (Brown & Altman, 2012), architecture (Hayden, 1996), leisure studies (Kelly S. Bricker, 2000), and forest science (Cheng et al., 2005). As the internet continues to permeate daily life, new areas of study such as educational technology and virtual places are emerging, further expanding the understanding of how people relate to and connect with places.

But quantifying the relationship between a physical environment's influence and a person's emotional experience has always been challenging (Hu & Chen, 2018). This emotional relationship between people and places is called “sense of place” (SOP) (Najafi & Mustafa, 2011). The earliest studies on SOP were made in urban design and social science and Hu & Chen (2018)believe, that it is something possessed by everyone, connecting us to the world. It is an essential part of our environmental experience and is defined by a place‘s physical, social, cultural and economic attributes (Ardoin, 2006) (Vecco, 2020) and as such integrates three intertwined components: the physical environment, human behaviour and social or psychological processes (Stedman, 2003). The sense of place is individual, the result of human interaction with the environment (Farshadi, 2017) (Najafi & Mustafa, 2011) and is a cognitive, affective and evaluative relationship (Ardoin, 2006). A relationship that plays an important role in urban architecture (Hu & Chen, 2018).

In considering not only the physical environment but perception and inter-human interaction in urban architecture, Hu & Chen (2018) argue that it could result in creating both meaningful and effective places. Creating a sense of place and community is a fundamental principle in creating a sustainable and high-quality built environment. It serves as an important building block in designing environments that prioritize sustainability and quality of life (Hu & Chen, 2018) (Najafi & Mustafa, 2011).
With the rapid growth of the population, improving the quality of life has become an important part of the urban planning process (Mouratidis, 2021). A process that can be supported by participatory planning and involving different members of the community - like non-experts and citizens (Maffei et al., 2016). A tool, that can support this process is VR technology (Kuliga et al., 2015).

2.2 Virtual Reality in Architecture

VR is increasingly recognized as a valuable tool in architectural research and practice, particularly in studies focused on human-environment interaction and urban planning (Kuliga et al., 2015). Some examples are virtual environments as a tool for stakeholder collaboration (Argelaguet et al., 2011), improving understanding between the relationship of design and function (Schneider et al., 2013) and evaluating human interaction before the construction phase (Palmon et al., 2006). VR has the potential as an empirical research tool, offering innovative ways to supplement behavioural validation and enhance our understanding of spatial perception and design (Kuliga et al., 2015).

VR as a tool

The understanding of design and the spatial skills required for it, are linked to the visual representation of the design solution (Lukačević et al., 2020). Visual representation provides crucial spatial information about objects and environments, as well as the relationships between objects, such as distance, direction, orientation and location. To accurately perceive this spatial information, the human perceptual system creates a three-dimensional mental model using visual cues along with internalized assumptions based on past experiences.

The two-dimensionality of a traditional monitor display can limit the fidelity and efficiency of these representations (Wann & Mon-Williams, 1996). A VR environment, on the other hand, offers an egocentric representation, allowing for a more immersive experience with better fidelity of representation (Lukačević et al., 2020). For example, Lukačević's (2020) research indicated that engineering students perceive spatial properties more accurately in immersive VR environments using head-mounted displays (HMD) compared to a 3D environment on screens. VR allows for a more comprehensive exploration of design solutions by enabling users to experience and interact with the space in a way traditional methods cannot.
This immersive experience is particularly beneficial for novices, who can gain a better understanding of potential design through VR. Personal experience with a design aids in communicating its spatial attributes, making VR an effective tool for education and stakeholder presentations (Argelaguet et al., 2011) (Schneider et al., 2013) (Lukačević et

al., 2020). Especially in architecture, where spatial features are important for planning and navigation, environmental layouts can become quite complex (Usman et al., 2017). Those layouts contain high-dimensional information that often need to be communicated to non-expert decision-makers. This can be difficult and potentially lead to loss of information.

VR can overcome these limitations by presenting information in a format that aligns with their common experience (Usman et al., 2017). Usman et al. (2017) concluded that people's perceptual understanding of the environment is more accurate in a VR environment compared to a 2D blueprint or 3D first-person interface. In VR, their perceptual understanding aligns with established quantitative measures of spatial organization, accessibility and visibility.
This immersive nature of VR allows users to feel as if they are in the real world, which is consistent with the feeling of "presence" (Slater et al., 2009). This sense of presence means, that the virtual world is perceived as a plausible environment where actions, movement and perception can be accurately directed (Maffei et al., 2016).
VR as a tool in architecture provides an immersive experience that enhances design understanding, spatial skills and communication (Lukačević et al., 2020) (Schneider et al., 2013). In conveying complex spatial information and creating a sense of presence, VR has the potential to be a powerful tool for architectural design and planning (Usman et al., 2017).

Virtual Environments for Architecture

Virtual Environments (VE) are built on the principle of imitating the spatial experience of real environments, giving them a predominant spatial character (Bourdakis & Charitos, 1999). These characteristics, among others, have made VR technology widely used to support the evaluation and communication of architectural design.

Szalapaj & Chang (1999) argue, that the constitution of a design scheme - such as the visualisation of the design idea, establishment of structural elements and assembling of spatial elements - plays an important role in understanding its original intention. The best way to present such an architectural design scheme is by allowing people to participate in the project's life cycle, allowing them to freely navigate and interact with it. Creating a virtual environment achieves this.
They have the potential to provide robust communication and navigation environments where users and developers can interact, and share their designs, knowledge and experiences (Maher et al., 2000). Those immersive 3D environments allow architects to visually walk through, inspect and present designs with the correct spatial proportions (Reffat, 2003).

Drettakis et al. (2007) categorize VR development for architectural design and urban planning applications into two categories: applications for designing and displaying detailed 3D CAD models, and rapid prototyping systems. The first category focuses more on the realistic display of the environment for presentation, recreation and educational purposes. In contrast, rapid prototyping systems are used in a much earlier stage of the design pro-

cess, featuring a higher level of interactivity and object manipulation. Drekkakis et al.'s (2007) work combines both features, presenting a user-centred design approach with both photorealistic realism and the ability to manipulate the environment. To enhance the understanding of the VE and improve task performance, they propose using both audio and visual realism, such as 3D sounds, shadows, sun coverage, vegetation and crowds. Maffei et al. (2016) study supports this, showing that acoustic and visual stimuli in a VE are congruent to their real counterpart, adding to the "sense of presence". Additionally, VE-specific aspects, such as multiple views, are important for an enhanced user experience (Drettakis et al., 2007).
This approach of using both realism and interactivity with object manipulation is particularly useful for architecture and urban planning.

Participatory Urban Planning in VR

One principle of community design is, that environments function better when those affected by its changes are actively involved in their creation and management (Sanoff, 2000). Citizens get actively involved in the development process instead of being treated as passive consumers. Genuine participation empowers the people involved and strengthens the legitimacy of policies and decisions (Maffei et al., 2016), which results in greater user satisfaction, a better-maintained physical environment and a greater public spirit (Sanoff, 2000). For it to be effective, decisions and design choices should be accepted by not just the experts involved, but also various members of the community (stakeholders) and non-experts (citizens). But to provide transparency about the planning process, information has to be prepared and made accessible to those without a background in urban planning (Dambruch & Kraemer, 2014).

Immersive VE technologies can serve as innovative tools to help visualize such information. Howard & Gaborit (2007) showed with their work, that VEs can enhance public consultations in the urban design context. They place participants directly into the design context and allow them to experience and engage with the envisioned designs. This creates an immersive experience that can support the decision-making process in architecture and urban planning (Dinh et al., 1999) (Ball et al., 2007) (Howard & Gaborit, 2007).
Studies also suggest that immersive VR is beneficial for recalling objects seen during the virtual experience, resulting in a more vivid memory of the environment (Dinh et al., 1999). Leeuwen et. al. argue that factors like this contribute to an informed decision-making process (van Leeuwen et al., 2018).
Especially visual representations of the real world offer better communication and understanding, making 3D technology a powerful medium for discussing planning issues and facilitating knowledge exchange (Ball et al., 2007). It increases engagement (van Leeuwen et al., 2018) and is better suited for gathering new information and performing evaluations (Hayek, 2011)(Williams, 2016).

Therefore, VR environments hold great potential to encourage stakeholder participation while promoting mutual learning in the planning process (Ball et al., 2007). Effective visual communication can provide a common language for all participants, empowering citizens to plan and design for their own community and support the process of collective decision-making (Al-Kodmany, 1999).

2.3 Orientation in Video Games

Spatial orientation can be defined as the ability "to orientate physically or mentally in space" (Maier, 1996) or "to self-orientate relative to the environment and the awareness of self-location" (Reber, 1985) and is a key ability to once spatial skills. References in the environment can assist the orientation process (Carrera et al., 2018).

With its increasing graphical realism, three-dimensional VEs are becoming a better tool for visualizing, manipulating, and processing information (de Castell et al., 2019). By displaying information in a realistic and intuitive way, they can allow users to navigate the environment using spatial cognition skills (Bowman et al., 2004).
Through navigation, the user explores the environment, creates a cognitive map of spatial connectors and uses this information to make decisions about further movement (Moura & El-Nasr, 2015). According to Lidwell et al. (2010), orientation is the first stage of navigation. Here the user determines their current location and analyses the environment for landmarks (Hellgren, 2020). Video-game environments, particularly those in 3D, can be complex. The player often has to orient themselves in diverse settings such as buildings, city streets and natural landscapes.
This orientation requires the same spatial abilities required in the real world (de Castell et al., 2019) (Khan & Rahman, 2018).

However, the player's own spatial abilities are not enough to navigate successfully through a video game. Games not only lead the player through the environment but also establish methods for informing the player what to do. With the increasing complexity of video games, it becomes difficult to navigate and interact without additional information (Moura & El-Nasr, 2015).
How this information is displayed and integrated into the game is an essential part of the game design and affects the player's experience (Moura & El-Nasr, 2015) (Wolf, 2011). With this complexity in games, additional navigation aids are a valuable tool for novices (Johanson et al., 2017) but also experienced players continue to rely on them. These aids are essential for maintaining entertainment and immersion, which makes them a valuable element of video games (Khan & Rahman, 2018). They are a complex process that relates to many different aspects of the game (Moura & El-Nasr, 2015). A balance needs to be found where the navigational aids assist the player without overburdening them and compromising the immersion. Especially VR game designers face this challenge.

2.3.1 Navigation Tools in Videogames

Depending on the type of game and the developer's goal, different interface mechanics can be used to present information to the player. In general, three different types of user interfaces can be distinguished - diegetic, non-diegetic and spacial interfaces.

One approach that enhances realism and immersion is the use of diegetic interfaces (Iacovides et al., 2015). This type of interface is integrated into the environment, it becomes part of the story and the player can perceive the information through the characters' reactions and changes in the environment - see Figure 1 (Broms, 2021). One example is the monsters in Capcom's game "Monster Hunter: World", where the only indicator of the enemy's health is visible through their injuries (Capcom, 2018). The game "Dead Space" also makes use of a diegetic interface, displaying the health and stasis meter as part of the player's space suit (Visceral Games, 2008).

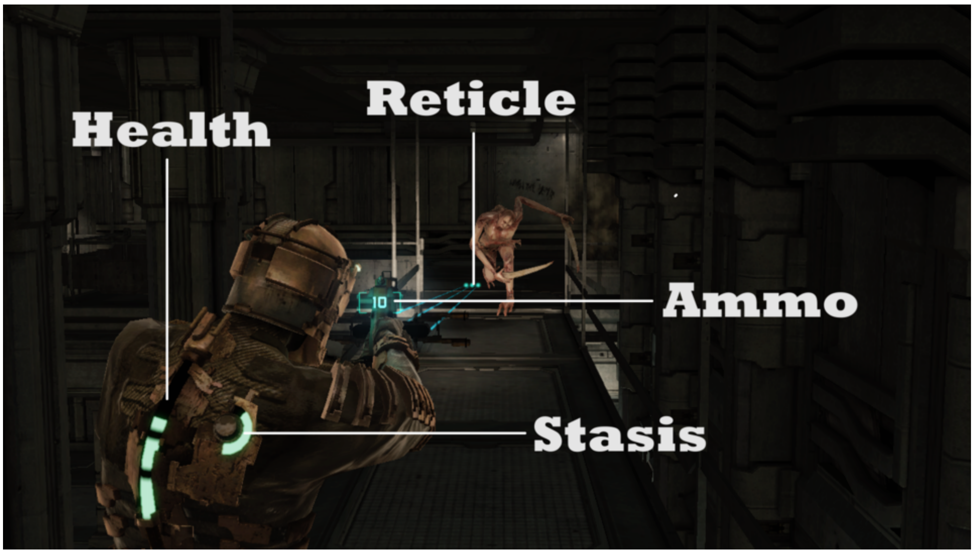

Figure 1: Examples for a dietetic interface: Left4Dead

In contrast to diegetic interfaces, non-diegetic interfaces display information that is not integrated into the game world - see Figure 2. These typically include health bars, item and ammunition counts within the heads-up display. But also menus and tools like maps and compasses are part of it (Broms, 2021). If implemented well, those interfaces are easy to learn and become an intuitive part of the game.

Figure 2: Examples for a non-dietetic interface: Dragon Age

Spacial interfaces exhibit characteristics of both diegetic and non-diegetic interfaces. They are integrated into the environment, but not part of the game's story, like a visual path-finding aid or an interaction pop-up - see Figure 3 (Broms, 2021). These interfaces can provide game-play-specific information and support storytelling, which can benefit inexperienced players. However, if done excessively, this may reduce immersion, as players feel overly guided.

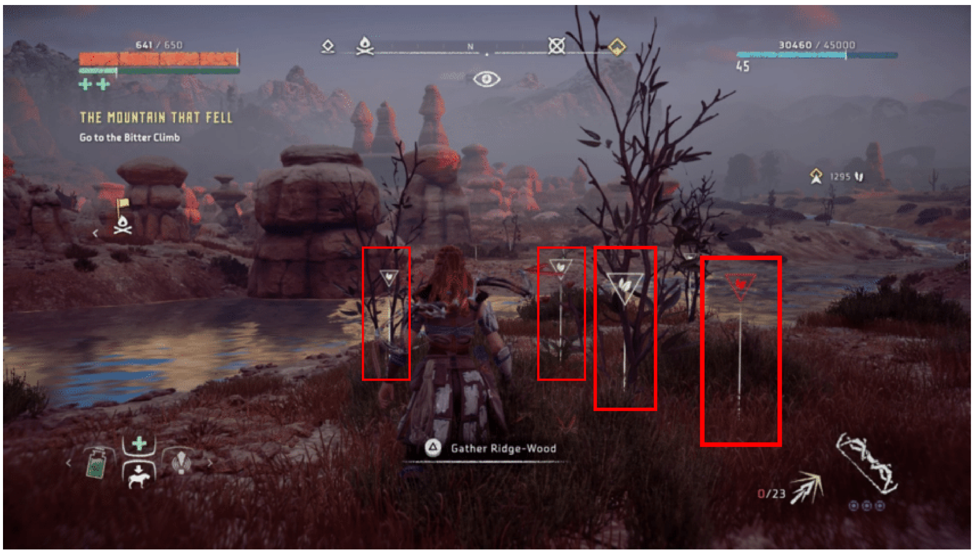

Figure 3: Examples for a spatial interface: Horizon: Zero Dawn

Navigation aids can fall into either of these three categories, depending on their design. Nerurkar (2009) categorizes them into two categories, discrete and immersive navigational

aids. He defines “discrete” as “tools that are separate from the environment”, which categorizes them as part of either a non-diegetic or spatial user interface. Examples he provides include maps, compasses, and markers. Immersed navigation tools, therefore, are part of diegetic user interfaces and are implemented with the use of contrasts, composition and landmarks.
Moura & El-Nasr (2015) cite in their work a lecture on Modern Level Design at the Simon Fraser University, where navigational aids also get classified based on their way of giving directions, either as implicit or explicit tools (Taylor, 2009). Implicit navigational aids like landmarks, lighting, NPC encounters and contrasts are used to pull the player into a certain direction while explicit navigational aids, including objectives, compass and spoken directions are meant to push the player.
According to Moura & El-Nasr (2015) research on design techniques for navigational systems in video games, navigational aids can be categorized into directional-, identification- and orientation signs. Directional signs are defined as elements that point the player towards a certain direction or objective, identification signs as elements that identify a place or object in the environment and orientation signs as elements that orient or locate the player´s relation to the world they are in. Liszio & Masuch (2016) also explored various design patterns for player navigation, including techniques such as focusing the player’s attention through light, colour and sound, integrating navigation aids like signs, maps and compasses and influencing players’ decisions using psychological techniques like rewards and punishments.

Based on these studies, maps, compasses and markers are among the most commonly evaluated and categorized navigation aids (Broms, 2021) (Nerurkar, 2009) (Taylor, 2009) (Moura & El-Nasr, 2015). Those are also the navigational aids appearing in most video games (Hellgren, 2020) (Johanson et al., 2017) (Moura & El-Nasr, 2015) and, therefore, will be selected as the orientation tools examined in this paper.

Markers

Markers are high-contrast interface elements placed within the game environment and can take the form of a 2D graphic or 3D model. Depending on the game, some markers are visible only when the associated location is in view, while others remain visible through walls (Moura & El-Nasr, 2015) (Nerurkar, 2009). They highlight important locations and objects and guide the players’ attention, helping them navigate and reach their goals. Markers come in different shapes and forms: while some markers, like in World of Warcraft and Skyrim, highlight NPC and objects relevant to the quest, others focus more on guiding players to important loot or indicating the position of teammates - see Figure 4. (Blizzard Entertainment, 2004) (Bethesda Game Studio, 2011) (Guerrilla, 2017) (Valve, 2008). However, while they can be a supporting element, poor implementation can make players feel overly guided (Moura & El-Nasr, 2015).

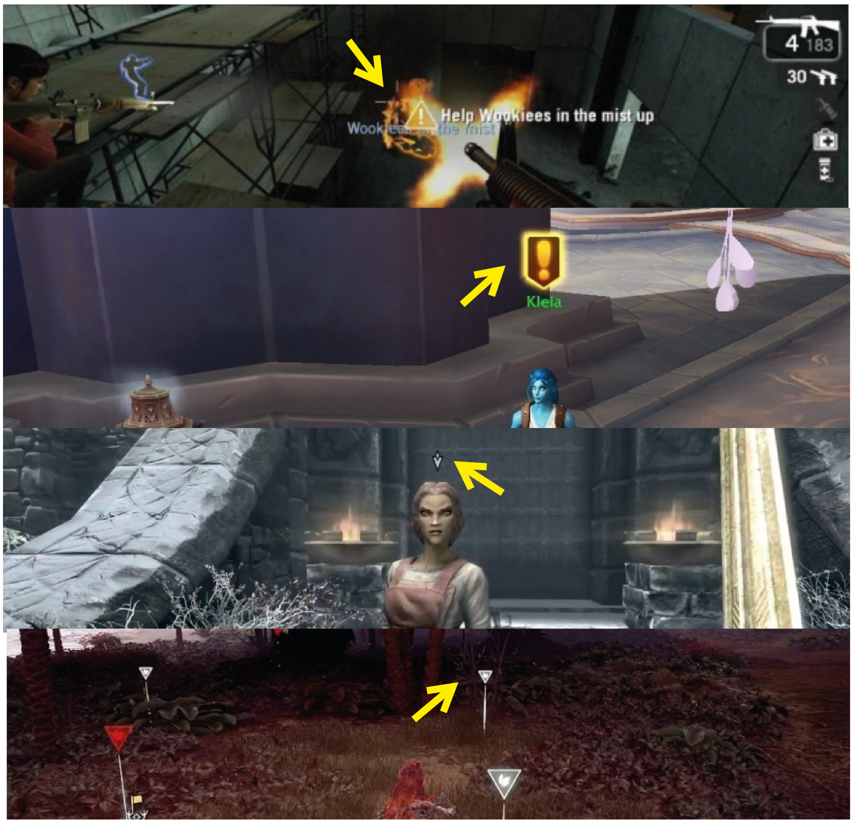

Figure 4: Examples for markers in video games: Left4Dead, World of Warcraft, The Elder Scrolls: Skyrim and Horizon: Zero Dawn - from top to bottom

Compass

The compass is a navigational aid that displays the target position relative to the player. Similar to markers, it points towards the destination without providing information about the path and is usually placed on the head-up display (HUD) - see Figure 5 (Moura & El-Nasr, 2015) (Nerurkar, 2009). One of the earliest compasses, made by the community for the community, was an add-on in World of Warcraft. A little arrow was added to the interface that points towards the direction of selected quests (Pepe, 2016). Over recent years, the compass has become integrated into more and more games, though its design varies. Oblivion, one of the first games to implement it, has a compass bar at the very bottom of the HUD, displaying quest-relevant items as icons (Bethesda Game Studio, 2007), whereas in The Witcher 3, a golden arrow on the mini-map points towards the direction of the selected quest (CD Project Red, 2015). While it serves as a useful guide, the compass has sparked considerable debate within the video game community (Pepe, 2016). Despite its growing presence, many players seek ways to remove or overhaul the compass in the interface (Pepe, 2016), as seen with mods - alterations made to the game by players or third-party developers - for Skyrim (Skyrim Mods, 2016) and Elden Ring (Elden Ring Mods, 2022). While the compass tool can benefit especially newer players, poorly designed implementations can become disruptive, drawing too much attention away from the gameplay and breaking immersion (Moura & El-Nasr, 2015).

Figure 5: Compass design for the video games: Horizon Zero: Dawn, The Elder Scrolls: Skyrim and The Witcher 3 - from top to bottom

Map

Maps in video games are representations of the environment, sometimes stylised but often simplified to provide a clear overview of the area (Usman et al., 2017) (Nerurkar, 2009). They provide spatial information to the player and help them navigate from point A to B (Maffei et al., 2016). Unlike markers, which are mostly categorized as spatial interfaces, maps offer a greater diversity. For example, in the VR game Half-Life:Alyx, when presented with the map, it is a hologram integrated into the environment and the VR version of Skyrim features the map as a “piece of paper” that players can use for navigation - see Figure 6 (Valve, 2020) (Bethesda Game Studio, 2011), both of which are examples of diegetic interfaces.
In contrast, the desktop version of Skyrim, provides a non-diegetic map interface, calling up a separate screen. Maps are a part of the majority of video games, playing an important role in navigating those digital environments (Maffei et al., 2016), and developers try to improve upon those cartographic elements to better understand the space (Zagata & Medyńska-Gulij, 2023).

An effective design and planning process relies on human perception (Hu & Chen, 2018) and by presenting additional information the urban planning process can be supported (Al-Kodmany, 1999).
The goal of this work is to analyse the three navigational aids mentioned above in the context of urban planning. While these tools typically highlight items or locations relevant to the video game, this study will re-purpose them to communicate social, cultural and economic information about urban places.

Figure 6: Example for a map in VR: The Elder Scrolls: Skyrim VR

However, this information can become quite complex, and the categories can start to blur together. Culture can be categorized into leisure (Hunt, 2017), but also gets economized by becoming a product and instrument in economic policies (Kloosterman, 2014) and Evans describes the arts as a growing element of urban, social but also economic development (Evans, 2001). Social attributes can include protecting safety and security, education and social integration but also social ties like community, social capital and relationships between friends and family (Hamam Serag El Din & Elariane, 2013) (Mouratidis, 2021). Due to this complexity, the social, cultural and economic information of the place in this work will refer to its amenities. The chosen orientation tools will depict those amenities in their associated categories and might improve the users understanding of the place.

3 Approach

To analyze the three navigational aids in their ability to communicate social, cultural and economic information about a place, a VR experience was implemented.
The medium of interaction is VR, chosen for its realistic and immersive representation of the real world and its ability to replicate the spatial experience of a real environment (Bourdakis & Charitos, 1999).
Although the selected tools are classified as navigational aids, this work only uses them solely for orientation purposes. Since orientation is a part of navigation (Lidwell et al., 2010) (Moura & El-Nasr, 2015), these tools will from now on be referred to as orientation tools or aids.
This chapter outlines the requirements set for the program to achieve this goal and illustrates the implementation- and design decisions in detail.

3.1 Requirements

To assess how video game-inspired orientation aids can enhance a user's spatial understanding, the following requirements were defined:

1. **Requirement R1 - Comparability**

   To enable effective comparison, all three orientation tools should be tested independently. However, to assess a change in the understanding of place, one of the three tools will be used as the baseline for reference.

   While markers, compasses and maps are concepts favourably used in video games, maps also remain a more conventional and frequently used method of navigation in the real world. It could be argued, that maps are also more familiar to non-gamers, who may feel more comfortable using maps than relying on compasses or markers.

   Therefore this work will compare the spatial understanding gained from using a map to that achieved with a marker and compass.

2. **Requirement R2 - Intuitive and User-Centric Design**

   As previously mentioned, the urban planning process is improved through the involvement of multiple stakeholders, including non-experts. For this reason, the design and usability of the orientation tools should be accessible as well, allowing for broad participation.

   The design should be user-friendly, enabling even those with little technical knowledge or VR experience to use the tools and making them accessible to a wider audience.

3. **Requirement R3 - Guided Attention** Since the focus is on the orientation tools, the environment and controls should be designed in a way that directs the user's attention to the tool or removes potential distractions.

3.2 Creating the VR Environment

Multiple studies are providing potential design guidelines for virtual environments to foster spatial orientation and urban design. They highlight the importance of realism and have studied the effect of a realistic depiction of the real world in a virtual environment (Drettakis et al., 2007) (Maffei et al., 2016).
The place mirrored in this study is a small city located in Austria. Spittal an der Drau has about 15.000 citizens (Stadtgemeinde Spittal an der Drau, 2023) and its main square is of manageable size to recreate it within the scope of this work. The choice of a real location was driven by the need for a place that is both coherent and urbanistically well-structured. This makes the presentation of the amenities clear and realistic.
During the study, the participant is positioned in the main square of this location, and will, with the assigned orientation tool, gain an understanding of the amenities available. As earlier established, a place's physical attributes are an important aspect of place, it is not the one this work focuses on. To ensure that the user concentrates solely on the orientation tools and the social, cultural and economic information they display, all potentially distracting factors have been removed from the environment - thus fulfilling R3.

Based on this requirement, shades of grey have been selected to be the sole colour scheme of the environment - see Figure 4. This decision was inspired by the game Superhot, which also keeps the entire environment grey and highlights enemies and interactable objects by making them the only coloured elements in the scene (Superhot Team, 2016).
To avoid a sterile and cold appearance, warm lighting was chosen, reminiscent of architectural renderings. The soft shadows are also intended to contribute to this effect. The 3d models themselves are held simple. The environment consists mostly of low-poly elements with not too many details to not grab the focus away from the orientation tool, contributing with this design decision to R3. However, there are enough assets to make the place look lived in. The user is still able to use buildings and streets as landmarks but the orientation tools are the primary element the user puts their focus on.

As the focus is on orientation and information gathering, additional navigation through the VR environment is not provided. The user interacts with the orientation tools in a stationary experience without the ability to move freely through the environment.
However, to offer an additional perspective, a teleportation point was implemented, enabling the user to jump across the street. This allows the user to view all the important streets where the amenities, displayed by the orientation tools, are located.
This teleportation not only provides the user with a different viewpoint of their surroundings but also allows the user to observe the orientation tools, such as markers and compass, from a different angle. These tools adjust their content according to the user's position within the environment.
As part of R2, teleportation was assigned to the A button of the right controller. The teleportation point itself was marked with a dark grey area, and the controls for both the teleportation and the orientation tools were thoroughly explained before the VR experience began, as well as in the form of a brief tutorial after the user put on the

headset.

To implement this mechanic and the virtual environment was created using Unity - Version 2022.3.2f1 - and Blender 3.6. Both programs are being used due to their widespread use, compatibility and access to extensive resources. Blender was used to create and adjust the 3D assets, which were then integrated into Unity to build the VR environment.
Additionally, the OpenVR plugin - Version 1.7.0 - was used to assist the creation of VR experience, which was then tested by participants using the Oculus Quest 3 with its standard controllers.
Regarding the teleportation mechanics, the standard teleportation of the OpenVR plugin uses a beam that is aimed at the desired location. However, for this experience, teleportation to the secondary location is triggered by pressing a button. With the standard teleportation mechanic of the plugin, the user would need to aim precisely at the predefined teleportation point. There were concerns that users unfamiliar with VR headsets and VR games might focus more on the controls than on the actual task. A valid concern, as later discussed in Chapter 6.

Figure 7: The Environment: view of the main square of the chosen place

3.3 Creating the Game-Inspired Orientation Tools

To depict the social, cultural and economic information of the place, the corresponding elements of the chosen place were identified. Spittal an der Drau has for every category a manageable amount of those elements.

Cultural elements are defined as activities that enable local consumption of assorted cultural services, such as museums, theatres, galleries, zoos but also festivals (Kloosterman, 2014). Spittal has few of those amenities and this is the category with the least amount of elements, consisting of a castle, a museum, two galleries and a theatre club.

Social attributes of a place consist of measurements to protect safety and security, but also educational institutions, and opportunities for social integration and interaction (Hamam Serag El Din & Elariane, 2013). Elements that fall into this category are the community centre, the school and kindergarten, as well as the soup kitchen. Because libraries are open to the public and a potential place for social interaction, it was also put into this category.

The economic elements of Spittal, those relevant to the production, distribution and consumption of wealth (Blaug, 2024), are the most numerous. Due to their potential to overwhelm the user with information and to meet R2, they were split into three subcategories: retail, hospitality and service. This subcategorization was inspired by Google Maps´ categorization of the amenities available in the area. Google Maps additionally differentiates between food and drink, shopping and services. Elements that have been classified as retail are shopping opportunities, grocery stores and a single bookshop. Another element added is the pharmacy. based on the argument that it specialized in the sale of medications. Hospitality includes the available coffee shops, restaurants, bars, bakeries and hotels while the service category brings together the rest: a copy shop, a car repair, and bike repair shop, a gym, a post office, a photographer and multiple doctors and hairdressers.

This encompasses all amenities relevant to the social, cultural and economic information of the place. They are depicted the same way through all orientation tools, the only difference being the manner of presentation. Design and meaning stay the same, making them comparable and therefore R1 is fulfilled.
Every amenity is represented by an icon and a colour, the design inspired by Google Maps. When releasing the new interface update in 2017, Google introduced Google Maps users to new icons and a colour scheme meant to make navigation and identifying points of interest more efficient (Hunt, 2017).
This work uses these icons and colour schemes as a guideline, with the underlying thought that something familiar might support the users' interpretation and interaction with the orientation tool (R2). The same colours and icons those amenities have on Google Maps have been added into the virtual environment, together with additional symbols selected from Google Icons for amenities that didn't have an icon of their own.
Supporting R2, the warm grey tone of the environment makes the vibrant colours of the icons stand out, directing the user´s attention to the orientation tool.
In total, there are 28 different icons that users need to assess. Although some users may be familiar with these icons from Google Maps or other Google services, a legend has been provided to ensure transparency.

Legend

The legend shows each category with its corresponding icons - see Figure 8. As a 2D interface, it appears in front of the user and aids in identifying unknown icons (R2).
The legend is designed to resemble the same functionality as a quest book. In video games, the quest book helps players organize their quests and provides additional information about each objective. Similar to a quest book, the legend is not visible throughout the entire experience but can be accessed by the user as needed.
The design features a dark background to make the user interface stand out from the environment. It also complements the icon's colours, which are kept bright and clear (R3). Unity's standard font was used for the description with the colour white to keep it readable but simple.

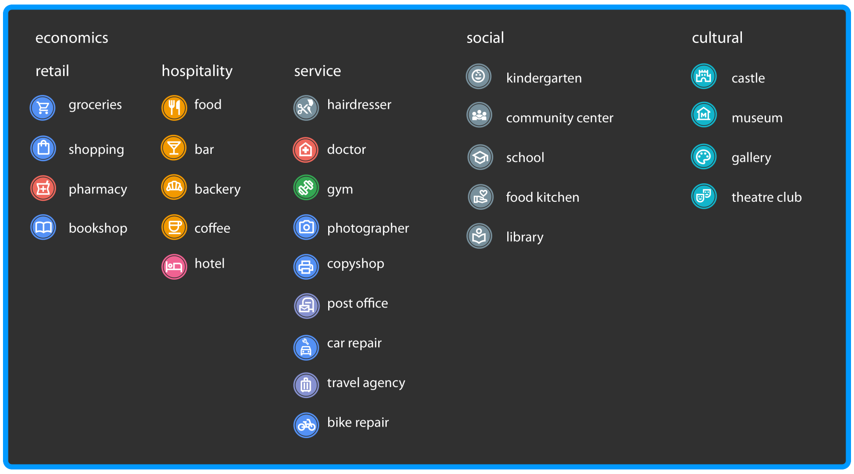

Figure 8: The Legend: explains the meaning of the icons

To open the legend, the user needs to press the grip button on the left controller. The left controller was chosen intentionally to create a simple mnemonic - both "Legend" and "Left" start with the same letter. The goal was to make the controls easier to remember, especially for users unfamiliar with controllers (R2).
When clicked, the legend appears directly in front of the user and follows their gaze. This design decision was made to discourage continuous use of the legend, as keeping it open limits the user's field of view and draws attention away from the orientation tool itself (R3).

Map

To ensure a cohesive design, elements from the legend were incorporated into the map. Since both the legend and the map are 2D user interfaces, employing different design styles could negatively impact the user's experience (IxDF, 2024). Due to the large number of elements, the economic category has also been divided into three subcategories: retail, hospitality and service.

To maintain consistency, the colour palette and font used in the legend were applied to the map's design - see Figure 9. To maintain familiarity, the map layout was based on Google Maps. However, to ensure the icons still stand out, the map's opacity was reduced, minimizing the visual impact of the map's yellow roads and green parks.

The map interaction was designed to mirror real-world experiences. Initially, map design approaches from VR video games were considered, but these typically involved the player holding the map in their hands. However, this approach made the symbols and map too small, compromising the quality and readability of the map.
As a result, a tablet-like design was chosen, enabling the user to navigate the map by clicking through the different categories. This approach allowed for the map to be displayed at a larger scale, significantly enhancing the readability of the icons.
Similar to the legend, the map appears in front of the user but remains stationary rather than following their gaze. This ensures that the view of the user does not get blocked by the map and allows the user to freely look around. If needed, the user can drag the map aside by aiming at the lower half of the map and keeping the right grip button pressed.

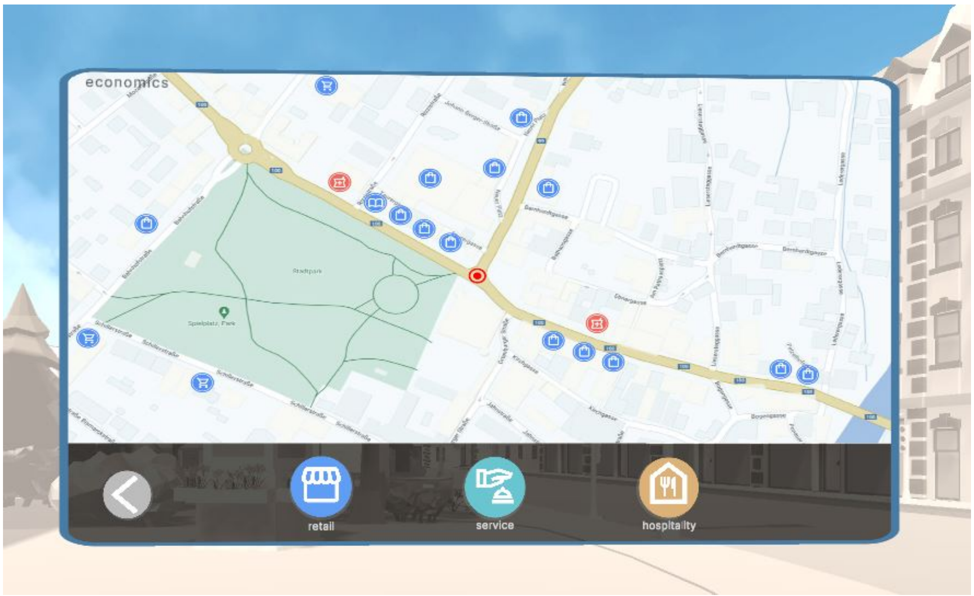

Figure 9: The Map: hovering in front of the player, displaying the subcategory "retail"

The currently displayed category is shown in the upper left corner and users can navigate through the different categories using a button. To aid navigation, each category is displayed by a distinctive symbol and a button that is coloured to match the most frequently occurring icon in that category (R2).

Markers

The design of the markers was based on those used in several video games. Fallout,

Skyrim and Horizon: Zero Dawn all made use of markers, whether to indicate quest-relevant items, loot or destinations. It is common practice in these games, to change the size of a marker based on its distance to the player—the smaller the marker, the further away the object of interest.
This work adopts this design approach. As the distance increases, the icon for the amenity becomes smaller but remains visible even at maximum distance. All markers are visible through buildings as well and always face the user to ensure readability - see Figure 10.
To ensure that the icons remain readable at all times, they always face the user, regardless of the user's position the the environment. To differentiate the different categories, the name of the respective category hovers above the user. It is visible from the users' field of view but not too close to interfere with the orientation process.

The user can switch between categories using the grip button on the right controller, which mirrors the control used to activate the legend. This way, the user only has to remember one kind of button, simplifying the interaction with the orientation tool and fulfilling R2.

Figure 10: The Markers: hovering in the user's field of view, displaying the subcategory "retail"

Compass

There are various design approaches for compasses in video games. While some games add degree markings to the tool (Respawn Entertainment, 2019) (Raven Software, 2020) (Ghost Ship Games, 2018), others use only cardinal directions to indicate the players' exact position in the world (Elden Ring Mods, 2022) (Ubisoft and Redstorm, 2018) (Santa Monica Studio and Jetpack Interactive, 2018). The level of detail of the displayed elements

also varies. Depending on the game, the size of symbols may adjust itself according to the distance (Bethesda Game Studio, 2011) (Ubisoft, 2018). Some developers also choose to use opacity or vary saturation as a tool to communicate distance.
Information regarding the exact distance also varies, but it is not uncommon for video games to provide the player with the exact distance in meters or feet of the object of interest (Ubisoft, 2020) (Avalanche Studios Group et al., 2019) (Guerrilla, 2017) (Santa Monica Studio and Jetpack Interactive, 2018).

It is also common practice to position the compass at the top of the screen, a design decision that was implemented in this project as well.
Regarding the distance indicators, those appear above the corresponding icon and are colour-matched to maintain visual coherence. The compass itself appears as a halo, hovering slightly above the user, and displays the elements of the selected category. The currently displayed category is indicated by a small text label beneath the halo - see Figure 8. The halo's colour has been matched to the environment, and its light grey shade enhances the visibility of the brightly coloured icons, making them stand out more and therefore supporting R3.

Although distances are included, they only appear for the element the user is actively looking at, to avoid overwhelming them with too much information (R2).
Depending on the user's position, the compass adjusts its display accordingly, whether they take a step forward, backwards, or teleport to the other side of the street. Its icons also adapt, depending on the user's position in the environment.

Figure 11: The Compass: hovering in front of the user, displaying the subcategory "retail"

Switching between categories works the same way as the previously mentioned markers - by clicking the grip button on the right controller.

4 Evaluation

This chapter provides an overview of the user study and its evaluation.
The first section explains the design of the user study and the task given to the participants, followed by details about the questionnaire's structure and the analysis of the collected data.

4.1 User Study

To determine whether the implemented orientation tools are able to enhance the users' understanding of place when compared to the map, each orientation tool was tested individually. Every participant experienced only one of the tools implemented and was then asked about the various amenities. The results of all three tools were then compared.

Before the participant started the VR experience, the user study and its procedure were explained in detail. A brief overview of the study's objective was given, followed by an introduction to the orientation tools and the kind of elements they depict. Additionally, the different categories were introduced, along with a few examples regarding the amenities. The participants were then instructed on their task: using their assigned orientation tools, they were to gain a good understanding of the place and observe which amenities were available. They were also informed that a questionnaire would follow, focusing on how well they had gotten to know the place.
Next, the headset and the controllers were introduced. Here the participants were given the opportunity to familiarise themselves with the controllers. They were shown how to hold the controllers, what buttons were available and which one they would use in the VR experience. Afterwards, the participant was asked to put on the headset and adjust its straps and lenses. Only once the headset was properly fitted and the participant confirmed that everything was clear and readable, the VR experience started.

The participants were assigned one of the three orientation tools. Before the tools appeared, however, the participants were guided through a brief tutorial to get a feel for the controls, now inside the VR environment. In the end, it was emphasised once more that the participants could take as much time as needed to gain a good understanding of the place.
There was intentionally no time limit set, as spatial orientation and perception vary from person to person and are influenced by gender (Shah & Miyake, 2005) (Halpern, 2000). This ensures that everyone has enough time to orient themselves and interact with their orientation tools.
However, a minimum duration of three minutes was established for this part of the study. Participants who felt they had gained a good overview of the place in less time were encouraged to take another look to ensure they were ready for the questionnaire.

After the participants explored their orientation tool, the headset was removed, and the questionnaire was handed to them. The first part of the questionnaire consisted of

demographic questions about age, gender, their highest form of education, and questions regarding their experience with VR and video games.
This was followed by a question regarding the participants' personal opinions and experiences with the orientation tool, asking them to list what they did and did not like.
After these introductory questions, the individual categories - social, cultural, and economics - were addressed, with economics again split into retail, service, and hospitality. These questions included two recall questions about the available amenities and one spatial recall question regarding the estimated distance to the amenities.

4.2 Data Collection

The process of spatial cognition involves three phases: acquiring information about the environment, capturing the morphological characteristics of the place, and constructing a cognitive map, storing the acquired information and obtaining an understanding of the environment. This questionnaire aims to access the stored information the participants have gained while exploring the place with their assigned orientation tool (Yuan et al., 2014). For this study, 30 participants were evaluated - 14 male, 15 female, and 1 non-binary. Each of the previously defined categories was tested individually. In three questions the participant was asked to recall, recognize, and map the amenities they encountered through the orientation tool.
The questions for each category were counterbalanced to avoid influencing the results.

The data collected was then analyzed as follows:

To understand the average performance of all participants, the recall accuracy for each category and all amenities in total was calculated:

$$\text{Recall (or True Positive Rate)} = \frac{\text{correctly classified actual positives}}{\text{all actual positives}} \tag{1}$$

This calculates the proportion of true positive elements correctly identified (Powers, 2011). For the comparison of a central tendency of two independent samples, the Wilcoxon-Mann-Whitney test (also known as the U-test) was used. The Wilcoxon-Mann-Whitney test is suitable for ordinal data calculated from the questionnaire. It does not require normally distributed data and is appropriate for smaller sample sizes (Bortz et al., 2008). In all statistical analyses of this study, a significant level of $\alpha = .05$ was used.

Open-Ended Recall Question

Starting with an open-ended question allows participants to freely recall what they remember without any prompts or suggestions (Reja et al., 2003). This approach helps avoid biases that could occur if a closed-ended question were asked first, which might influence the participants' answers later on. By beginning with an open-ended question, the questionnaire captures participants' experience and perception and offers deeper insights into their understanding (Patton, 2015).

For each category, the participant has been asked the following open-ended questions:

List all the **x** amenities you remember seeing in the VR environment. Include as many details as you can
x = the current category the participant is answering questions to.

To understand the average performance of the participant, the recall rate for each category and all amenities in total was calculated,

Recognition Question

It is common in research and evaluation studies to use a mix of methods, combining both open-ended and close-ended questions (Patton, 2015).
Including a multiple-choice question in this questionnaire allows for assessing how well participants can identify and recognize the amenities they previously encountered in the VR environment (Mahoney et al., 2015). Again, the questions were divided into categories and the following multiple-choice question was asked:

Which of the following **x** elements did you see in the VR environment?
x = the current category the participant is answering questions to.

For each question, about one-third of the available options were designed as distractors.
To understand the average performance of the participant, the recall rate for each category and all amenities in total was calculated,

Distance Recall Test

This distance recall test was designed to assess how well participants remember the environment. It is based on the spatial recall test, which is often used to study the cognitive mapping process - the process of encoding and storing geo-referenced information to later find routes and determine the relative position of places (Golledge et al., 2000) (Yuan et al., 2014).
A spatial recall test typically involves recalling the position of landmarks or routes and marking them on a map. In this study, however, a modified version of the spatial recall test was used. Since some participants would be at an advantage for having used a map as their designated orientation tools, a distance recall test was chosen instead.
During this question, participants were asked to estimate the approximate distances rather than the exact position of the elements. They were given a distance scale of 0 to 300m and instructed to mark the average distance of the amenities from the main square:

Please mark the following **x** amenities according to their average distance from the main square with the corresponding colour.
x = the current category the participant is answering questions to.

The marked amenities were analyzed according to their accuracy, The answer was considered correct if it fell within a 25-meter radius of the actual distance. Again, to analyze the average performance of the participant, the accuracy for each category and amenity was calculated.

5 Results

A total of 30 participants took part in the user study (14 male, 15 female, 1 non-binary), with most of them in their mid-twenties, placing the average age between 25 and 30 years old. Twelve participants had completed a Bachelor's degree, six had a diploma, two held a doctoral degree, and the remaining 23 % had either a secondary general school or technical college education. Regarding the participants familiarity with video games, 14 participants were highly familiar with the medium, while only six had no experience with it. In terms of VR experience, 22 of the 30 participants were using this technology for the first time, while six had some prior exposure and only two were regular users.

Map

Recall Accuracy: Participants who used the "map" orientation tool successfully recalled an average of 47.9 % of the amenities within their correct categories. When considering all recalled amenities, regardless of correct categorization, the recall rate per person increases to an average of 49.4 %.
The "culture" category stood out, with participants recalling 26 out of 36 amenities, resulting in an accuracy rate of 72.2 %. The "Gallery" amenity has an 81 % recall rate, and it was the one that was recalled the most frequently, whereas the "Post Office" was not recalled by any participant.

Recognition: The average recognition accuracy across all categories is 75.7 %, with the category "hospitality" leading at 97.7 % accuracy. "Hairdresser" and "Shopping" were the most accurately recognized amenities, each with a recall rate of 100 %. The "Bookshop" was the only amenity that none of the participants were able to recognize.

Distance Recall: For the distance recall test, the average accuracy was 17.51 %. The "cultural" category has the highest accuracy at 38.89 %. The "Castle" was the most accurately placed amenity, with 6 out of 11 participants correctly estimating its distance to the main square.

When asked about their opinion on the orientation tool "map", participants expressed that they found it to give a good overview and to be user-friendly. The symbols were intuitive, and it was easy to discern areas of high amenity concentration at a glance.
However, some participants noted drawbacks, such as the map's fixed size and its inability to be minimized.

Markers

Recall Accuracy: Participants who used the "Marker" orientation tools achieved an average recall rate of 47.4 % - see Figure 12. This rate reflects the average recall rate of amenities within their respective categories. When considering all recalled amenities, regardless of category accuracy, the average recall rate slightly increases to 49.6 % - see Figure 12.
The category with the highest recall rate is "culture", with an accuracy of 69.4 %. The

most frequently recalled amenity is the "Museum", recalled by 9 out of 10 participants. The amenities with the lowest recall rate are the "Gym" and the "Photographer", each remembered only by one participant.

Recognition: The average recognition accuracy for participants is 76 % - see Figure 12, with the "culture" category again leading, where participants identified 97 % of the amenities. The most recognized amenities are "Castle", "Shopping", and "Hairdresser", each recognized by all participants. On the other hand, the "Bookshop" wasn't recognized by any participant.

Distance Recall: For the distance recall test, the average accuracy of all participants is 18.5 % - see Figure 12. The category with the highest recall rate is again "culture" with 30.5 %. "Castle", within this category, is the most accurately placed amenity, with 8 out of 10 participants correctly marking its distance on the scale.

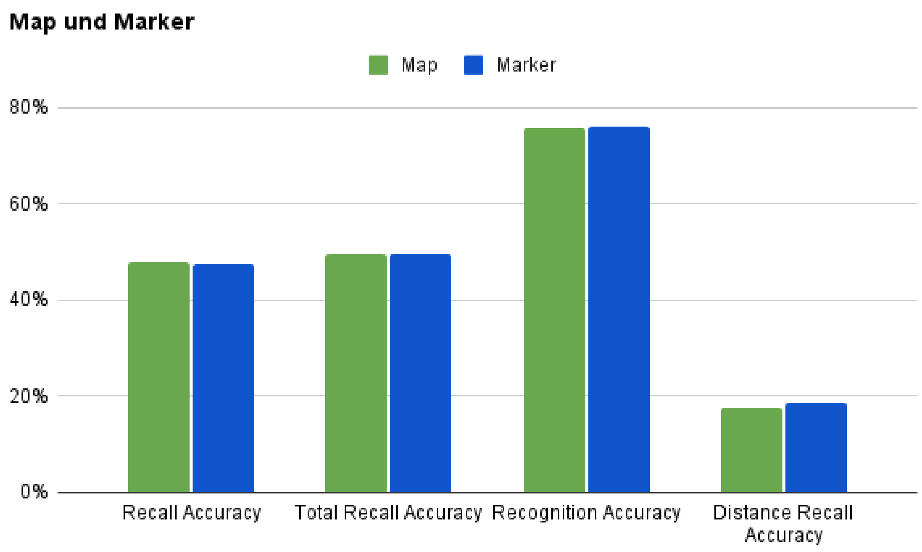

Figure 12: Difference throughout all tests - Map and Marker

A U-Test was conducted to compare the calculated recall rate of all three tests with those of the map - see Table 1. No significant difference was found in recall accuracy ($p = 0.751$), overall recall accuracy ($p = 0.777$), recognition ($p = 0.751$), or distance recall accuracy ($p = 0.801$), as $p > 0.05$

After experiencing the "marker" orientation tool, participants described the symbols as clear and easily recognizable. Participants also expressed that they found both the icons' colours and the legends helpful in assigning the icons to their respective categories and understanding the different symbols.
However, participants voiced disappointment with the limited movement and interaction

Table 1: Mann-Whitney U-Test

Map - Markers	U	df	p
Recall accuracy	50.500		0.751
Total Recall Accuracy	50.500		0.777
Recognition	60.000		0.751
Distance Recall	51.000		0.801

within the orientation tools. Some also found the floating text indicating the currently displayed category to be disorienting. Additionally, the design and colour of the icons were considered too similar by some participants, leading to difficulties in distinguishing between them.

Compass

Recall Accuracy: The average recall rate for participants who utilized the "compass" orientation tool is 37.3 % - see Figure 13. This figure represents the amenities correctly recalled within their respective categories. When disregarding the correct categorization of the amenities, the total average recall rate rises to 40.7 % - see Figure 13.
The category in which participants demonstrated the highest recall was "culture", with an average recall rate of 58.4 %. The most memorable amenities for participants were the "Grocery Store", recalled by 8 out of 9 participants, and the "Museum", recalled by 7 out of 9 participants.
No participant was able to recall the "Post Office" or the "Travel Agency".

Recognition: In the recognition task, participants achieved an average accuracy of 73.8 % - see Figure 13. The category with the highest recognition rate is "hospitality", at 86.6 %. Amenities that were recognized by all participants include the "Doctor", "Hairdresser", "Restaurant", "Pharmacy", "Grocery Store", and "Museum". The "Bookshop" was the only amenity that none of the participants recognized.

Distance Recall: The average accuracy for the distance recall test is 11.9 % - see Figure 13. Participants were mostly accurate in estimating the distances of amenities in the "hospitality" category, with an accuracy rate of 22.2 %. The "Coffee Shop" is the most accurately marked amenity, with 4 out of 9 participants estimating its distance correctly.

A U-Test was conducted to compare the calculated recall accuracy of all three tests with those of the map - see Table 2. No significant difference was found in recall accuracy ($p = 0.323$), overall recall accuracy ($p = 0.469$), recognition ($p = 0.503$), or distance recall accuracy ($p = 0.167$), as $p > 0.05$.

When asked about their opinion on the orientation tool "compass", participants described it as unintrusive and intuitive. They also remarked that the icons are easy to read and the amenities categorization is understandable.
However, they also pointed out, that the written distance above the icon was too small,

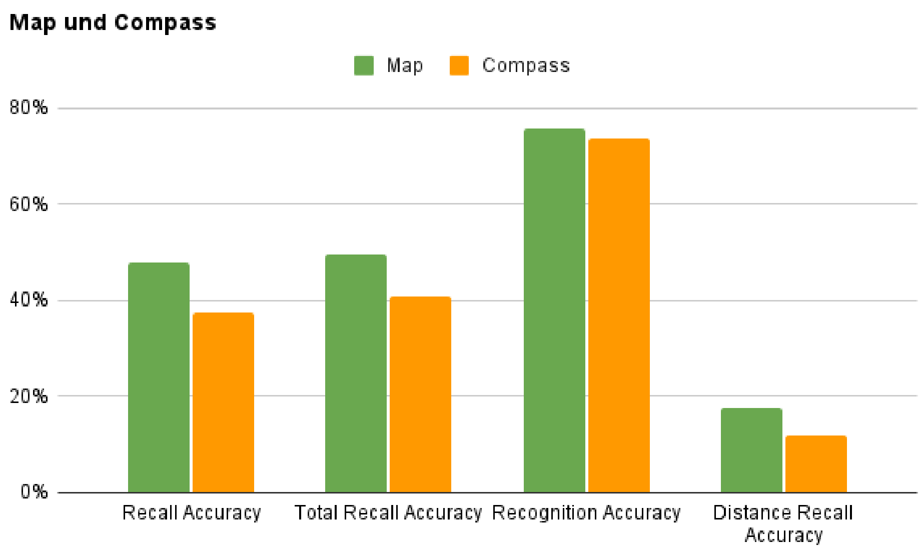

Figure 13: Difference throughout all tests - Map and Compass

Table 2: Mann-Whitney U-Test

Map - Compass	U	df	p
Recall Accuracy	63.000		0.323
Total Recall Accuracy	59.500		0.469
Recognition	59.000		0.503
Distance Recall	68.000		0.167

making it hard to read and that the overlapping of the many amenities made it harder to take in all the information. Here too they expressed disappointment in the inability to move around more freely.

A U-Test was also conducted to compare the calculated recall accuracy of all three tests with those of the marker - see Table 3. No significant difference was found in recall accuracy ($p = 0.086$), total recall accuracy ($p = 0.249$), recognition ($p = 0.682$), or distance recall accuracy ($p = 0.118$), as $p > 0.05$ - see Figure 14.

Table 3: Mann-Whitney U-Test

Compass - Marker	U	df	p
Recall accuracy	66.500		0.086
Total Recall Accuracy	59.500		0.249
Recognition	50.500		0.682
Distance Recall	64.500		0.118

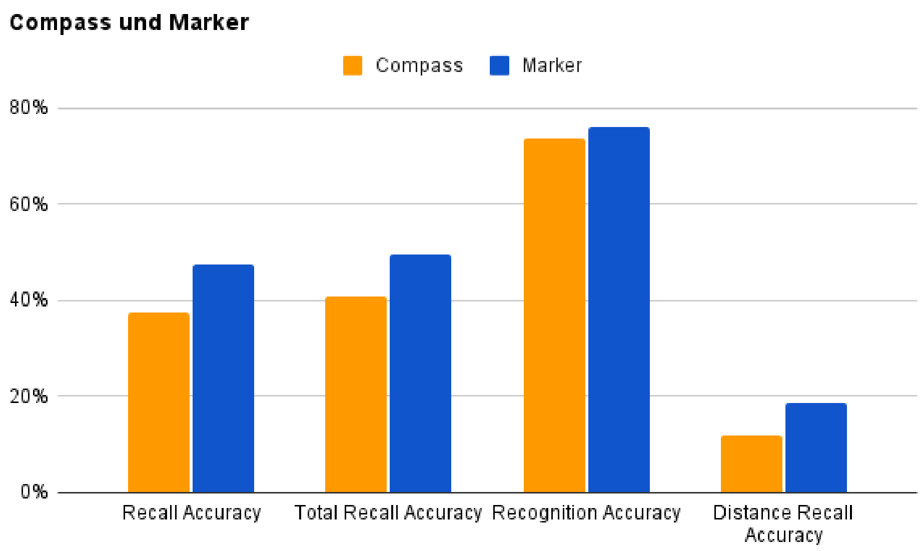

Figure 14: Difference throughout all tests - Compass and Marker

6 Discussion

This chapter discusses the results, starting with the calculated data regarding the orientation tool, followed by an analysis of the participant's feedback. The last section of this chapter deals with the limitations of this study and possible outlooks for the future.

The goal of this work was to analyse three game-inspired orientation tools and how they influence a person's understanding of place regarding the available amenities. The participant's recall, recognition and distance recall of the orientation tools compass and markers were compared to the map.

6.1 Orientation Tools

In the recall task for amenities - within and outside their respective categories - the recall rates for both the map and marker orientation tools were similar, ranging between 47 % and 49 %. However, the compass tool exhibited slightly lower performance, with an average recall rate of 37.3 % and 40 %. This disparity in recall rates was also observed in the recognition task and distance recall test, although the difference was less pronounced compared to the recall test.
These findings suggest that the map and marker tools may offer a slightly more effective overview of the amenities, potentially providing a more intuitive framework that aids participants in remembering amenities and their associated categories more easily.

The categories The "culture" category had the highest recall rate across all orientation tools. Participants most effectively remembered amenities within this category. This may be attributed to the fact that "culture" was one of the categories with fewer amenities.

The high recall rate could also be due to the distinctiveness or everyday familiarity of these amenities, making them easier for participants to identify within the virtual reality. Additionally, "culture" was also the category most accurately estimated during the distance recall test when participants used the map or the marker orientation tool. However, it is important to note, that the overall distance accuracy rate across all orientation tools was relatively low, ranging from 11.9 % to 18,5 %.
This low performance might reflect the challenges participants faced in gauging spatial relationships within the virtual environment, possibly due to the absence of physical cues or limitations in the tools themselves.

The amenities Despite these challenges, participants were still able to correctly identify and mark amenities on the distance scale. The "Castle", in particular, was the most accurately estimated amenity when using the map and marker orientation tool, likely due to its proximal placement directly next to the participant position in the virtual environment. This might have also aided participants who might otherwise struggle with distance estimation to correctly mark it on the distance scale.
However, the recognition test deviated from this pattern - across all orientation tools, the "Hairdresser" and "Shopping" categories achieved the highest recognition rates. This might be due to the participants' everyday familiarity with these amenities or their ability to make logical assumptions about likely amenities, thereby making them easier to recognize.
Conversely, certain amenities - particularly the "Post Office" and "Travel Agency" - were rarely recalled by participants, especially during the recall test. This may suggest a lower salience of these icons within the virtual environment.
Regarding recognition, the "Bookshop" was an amenity that was never recognized across any of the orientation tools. This consistent failure to recognize the "Bookshop" raises questions about the visibility or representation of this particular amenity. It suggests that certain amenities may require more distinctive visual cues or strategic positioning with the environment to be effectively recognised
But when comparing the three tools - map, marker, and compass - the statistical analysis using the U Test revealed no significant differences in recall rate, overall recall rate, recognition, or distance recall rate. This could be due to the relatively small sample size as there were observable differences in the performance metrics. The observed differences in the data might become more prominent if the number of participants increases.

6.2 Participants Feedback

Participants provided valuable qualitative feedback on the usability of each tool, consistently noting the clarity of the icons across all tools.
However, many participants highlighted the lack of interactivity, both in terms of navigating the environment and interacting with the orientation tools themselves. This issue was particularly pronounced with the map, where numerous participants expressed dissatisfaction with the inability to resize the map. Despite this limitation, the map was generally described as intuitive and well-organized, which may have contributed to its favourable performance metrics.

In contrast, the compass tool received the most criticism for its limitations regarding interactivity. Although participants appreciated the unobtrusiveness of the compass interface, they also noted that the small size of the text, displaying the distance, was difficult to read. The display of the icons was also criticized, with participants exclaiming that the compass displayed too many icons, leading to slight overlaps and a reported sense of information overload.
This issue was less evident with the markers, where the icons were more spread out, their size varying depending on distance. Some participants reported that this feature made it easier to estimate the distance. Although the difference in performance was not statistically significant, the marker tool achieved a higher distance recall accuracy of 18.5% compared to the other orientation tools.
Another aspect highlighted by participants was the legend. While it helped to categorize the amenities into their respective categories, many were irritated that the legend followed their gaze and obstructed the view, rather than remaining stationary. This may have contributed to difficulties in identifying certain amenities. Particularly, users of the compass tool expressed notable dissatisfaction with this aspect, which could have been a contributing factor to its slightly lower performance.

These insights highlight the importance of balancing interactivity, and usability in the design of orientation tools. While each tool demonstrated certain strengths, the feedback suggests that further refinement is necessary to address the identified shortcomings, such as enhancing readability and enabling a more interactive user experience.

6.3 Limitations

This study's limitations include the relatively small sample size and the specific demographic of participants, which may limit the generalization of the findings. Further research should aim to include larger and more diverse participant groups.
Initially, a comparison between gamers and non-gamers within the orientation tools was planned. However, the distribution of participants who played video games frequently and those who weren't familiar with this medium, was too uneven, making a meaningful comparison impossible. Similarly, comparing participants based on their VR experience was not feasible, as the majority of participants had little to no experience with the technology, with only 2 out of 30 regularly using the technology.
This lack of familiarity with the technology was also evident during the interaction with the orientation tools. Participants who had not previously encountered VR technology were more focused on the novelty of the VR experience at the beginning, rather than on the task explanation and controls. This occasionally resulted in the need to re-explain the controls even during the ongoing study.

7 Conclusion

This study aimed to explore how to enhance the understanding of place. The focus was on conveying the place's information in form of its cultural, social and economic amenities. To facilitate this, three orientation tools inspired by video games were implemented. The hypothesis was, that integrating video game-inspired orientation tools like markers and compasses, would, in comparison to familiar map-based systems, significantly improve the participant's understanding of place regarding its amenities.

To test this hypothesis, all three orientation tools were implemented into a VR environment. After interacting with one of these tools, participant's recall, recognition and distance recall performances were evaluated and compared.
The data revealed variations in the performance metrics, with the map and marker demonstrating higher accuracy across all tasks. Despite some participants expressing their frustration regarding the lack of interactive features, the map was generally perceived as intuitive and well-organized.
The marker tool also received positive feedback, with participants reporting that it was easier to estimate distance - which is supported by the better performance in the distance recall tasks.
In contrast, participants using the compass tool had a lower performance both in the distance recall and the other tasks. While participants appreciated its unobtrusive interface, the icons display was for many too cluttered, leading to a reported sense of information overload and difficulties with orientation.
A recurring theme across all three orientation tools was the positive feedback regarding the clarity of the icons, but also criticisms over the limited interactivity within the environment. While participants described the icons as comprehensible, they also expressed dissatisfaction with the lack of additional exploration of the environment.

However, although differences in the data and the participant's feedback can be observed, the statistical analysis using the U-Test did not highlight any significant difference between the three orientation tools.
But despite this lack of significance, the study highlights the importance of clarity, interactivity, and usability in the design of these orientation tools. While the design of the tools demonstrated certain strengths, the participants' feedback suggests that further improvement is needed, especially in the areas of interactivity of the map and reducing the cognitive load of the compass.
Further research should address these limitations and include a larger participant group. Also adding more interactivity and the option to explore the place by moving around and being able to approach the amenities might give a better insight into the orientation tools. This could offer a deeper understanding of usability and user experience, potentially leading to more effective and enjoyable experiences.

A Appendix

Additional material goes here

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