Master's Thesis

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

Department of Human-Computer-Interaction
Ludwig-Maximilians-Universität München

Daniela Köstenbaumer

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Supervised by Dr. -Ing. Gerhard Schubert and Nick Förster M.A.

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 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. 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 virtual reality (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 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 provides the conclusion.

2 Related Work

2.1 What makes a place

The cultural geographer Yi Fu Tuan 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 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 and Chen 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 (Hu & Chen, 2018) (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 including not only the physical environment but perception and inter-human interaction, Hu and Chen argue that it could result in creating both meaningful and effective places (Hu & Chen, 2018). 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

Virtual Reality 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). Argelaguet et. al. utilized VR technology to investigate the impact of augmented viewing techniques on the spatial understanding of a scene. They used VR as a collaboration tool for supporting stakeholders working in different locations (Argelaguet et al., 2011).
Another case is investigating students understanding of the relationship between their design and its function during early developing stages with the help of a virtual environment (VE) (Schneider et al., 2013). VR also has the potential to evaluate human interaction before the construction phase, as Paloma et. al. have shown in their study about its use for virtual pre-occupancy environmental evaluation (Palmon et al., 2006).
VR therefore 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).

2.2.1 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, Lukacevik's 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. 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).

2.2.2 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 and Chang 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 (Szalapaj & Chang, 1999).
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. 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 (Drettakis et al., 2007). 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 process, featuring a higher level of interactivity and object manipulation. Drekkakis et al.'s 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.'s study supports this, showing that acoustic and visual stimuli in a VE are congruent to their real counterpart, adding to the "sense of presence" (Maffei

et al., 2016). 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.

2.2.3 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. Howards and Gaborit showed with their work, that VEs can enhance public consultations in the urban design context (Howard & Gaborit, 2007).
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.(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. But regardless of the type of game, all design decisions should focus on maintaining the players' sense of autonomy while protecting the cognitive immersion (Liszio & Masuch, 2016).

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.
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 (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).
In contrast to diegetic interfaces, non-diegetic interfaces display information that is not integrated into the game world. These typically include health bars, item and ammo 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.
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 pathfinding aid or an interaction pop-up (Broms, 2021). These interfaces can provide gameplay-specific information and support storytelling, which can benefit inexperienced players. However, if done excessively, this may reduce immersion, as players feel overly guided.
Navigation aids can fall into either of these three categories, depending on their design. Nerurkar categorizes them into two categories, discrete and immersive navigational aids (Nerurkar, 2009). 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 et. al. 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 et. al.´s 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 (Moura & El-Nasr, 2015). Liszio et. al. 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 (Liszio & Masuch, 2016).
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).

2.3.2 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 (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 1: Examples for markers in video games: Left4Dead, World of Warcraft, The Elder Scrolls: Skyrim and Horizon: Zero Dawn

2.3.3 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 HUD (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 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 2: Compass design for the video games: Horizon Zero: Dawn, The Elder Scrolls: Skyrim and The Witcher 3

2.3.4 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 (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).
The goal of this work is to analyse these three navigational aids 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 information about urban places.
Out of the many factors that contribute to the creation of place and sense of place, this work will focus on social, cultural and economic attributes. All three navigational aids will display these attributes, and their effectiveness in communicating this information will be compared. This study aims to determine whether integrating game-inspired navigational tools like compass and markers, compared to a more conventional map-based system, can significantly enhance users' understanding of the place, regarding available amenities.

Figure 3: Example for a map in VR: The Elder Scrolls: Skyrim VR

3 Approach

This work analyses which of the three navigational aids mentioned above is best suited to communicate social, cultural and economic information about a place.
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).
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.
Navigation methods in video games are already assisting players by providing additional information. This study makes use of the developed design patterns of these navigational aids and uses them to communicate elements of place.
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.
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). The first part of this chapter will delve into the design process and how the selected navigational aids were adjusted to fit this virtual environment, followed by the implementation and controls of the navigational aids.
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.

3.1 Creating the Virtual Reality

This section covers the design decisions of the virtual environment and the orientation tools.

3.1.1 The VR Environment

Figure 4: The Environment: view of the main square of the chosen place

A real place was taken as a reference for the virtual environment. Spittal an der Drau is a small city in Austria with about 15.000 citizens (Stadtgemeinde Spittal an der Drau, 2023) with its main square being of manageable size to recreate within the scope of this work.
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).
Although 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. Therefore shades of grey have been selected to be the sole colour scheme of the environment. 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. 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.

3.1.2 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, 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.
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. 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.
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.

Legende The legend shows each category with its corresponding icons. As a 2D interface, it appears in front of the user and aids in identifying unknown icons. 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. Unity's standard font was used for the description with the colour white to keep it readable but simple.

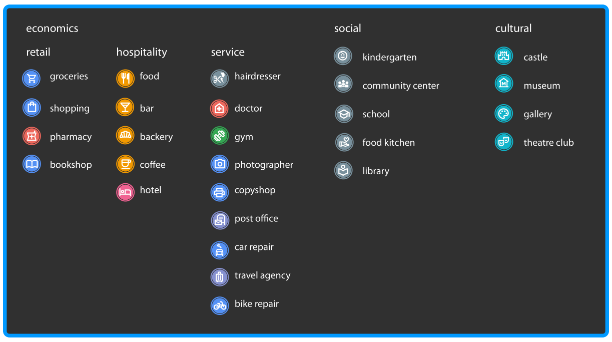

Figure 5: The Legend: explains the meaning of the icons

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). To maintain consistency, the colour palette and font used in the legend were applied to the map's design.
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, which compromised both the quality and readability of this work. 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.
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 currently displayed category is shown in the upper left corner and users can navigate through the different categories using a button. Each category is displayed by a distinctive symbol and a button that is coloured to match the most frequently occurring icon in that category.

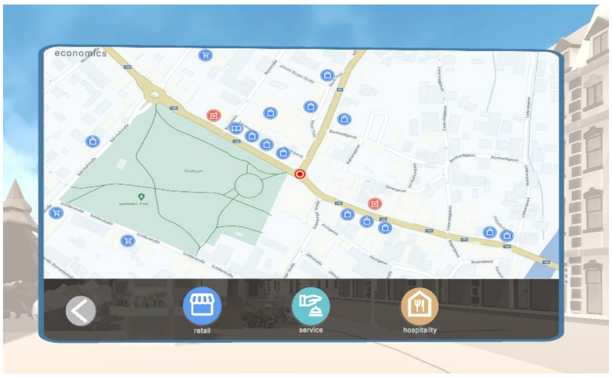

Figure 6: The Map: hovering in front of the player, displaying the subcategory "retail"

Marker 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 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.
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.

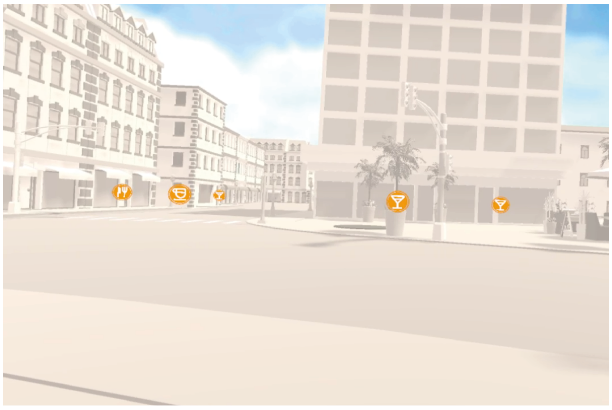

Figure 7: The Markers: hovering in the user's field of view, displaying the subcategory "hospitality"

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 and id Software and Fatalist Entertainment AB, 2019) (Guerrilla, 2017) (Santa Monica Studio and Jetpack Interactive, 2018).
In the design of this compass, distances are included but are only displayed for the element the user is actively looking at, to avoid overwhelming them with too much information. These distance indicators appear above the corresponding icon and are colour-matched to maintain visual coherence.
In video games, placing the compass at the top of the screen has become a common practice. This design choice was implemented in this project, with the compass positioned in the upper field of view. It 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.
Depending on the user's position, the compass adjusts its display accordingly. The halo's colour has been matched to the environment, and its light grey shade enhances the visibility of the brightly coloured icons.

Figure 8: The Compass: hovering in front of the user, displaying the subcategory "retail"

3.2 Study Design

This section covers the implementation of the virtual environment and its orientation tools.

3.2.1 The Unity Virtual Environment

The virtual environment was created using Unity and Blender. Blender was used to create and adjust the 3D assets, which were then integrated into Unity to build the VR environment.

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.
The user is positioned in the main square of the location. 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 according to the user's position within the environment.
The standard teleportation mechanic 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 XY.
For this reason, 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.

3.2.2 Game-Inspired Orientation Tools

This section will go into more detail about the implementation and use of the orientation tools.
Most parts of the legend and orientation tools were made using 2D sprites, edited in Illustrator and later added to the 3D virtual environment.

Legende 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.
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.
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.

Map 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.
At the bottom of the map, buttons represent the different categories. Due to the large number of elements, the economic category has also been divided into three subcategories: retail, hospitality and service.

Marker To ensure that the icons remain readable at all times, they always face the user, regardless of the user's position the the environment. The user can switch between categories using the grip button on the right controller, which mirrors the control used to activate the legend.
When switching categories, the user cycles through the available options. Both the compass and the markers sequentially display the economic subcategories, one after the other.

Compass The compass hovers slightly above the player and follows their movements, 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.
When looking at a specific icon, a ray is cast, signalling the UI to display the exact distance to the amenity. Looking away causes the additional information to disappear again.
Switching between categories works the same way as the previously mentioned markers - by clicking the grip button on the right controller.

4 Evaluation

4.1 User Study

Ablauf der User Study
warum, weshalb, wieso?

4.2 Data Collection

Wer mitgemacht hat - wieviele Leute Wie war der Fragebogen aufgebaut - welche Daten wurden erhoben

4.2.1 Open-Ended Recall Question

warum, weshalb, wieso?
wie hat diese Frage ausgesehen?
Wie wird diese Frage ausgewertet und warum?

4.2.2 Recognition Quesion

warum, weshalb, wieso?
wie hat diese Frage ausgesehen?
Wie wird diese Frage ausgewertet und warum?

4.2.3 Spatial Recall Test

warum, weshalb, wieso?
wie hat diese Frage ausgesehen?
Wie wird diese Frage ausgewertet und warum?

5 Results

5.1 Map

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

5.2 Markers

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

5.3 Compass

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

6 Discussion

This chapter discusses the results

6.1 Map

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

6.2 Markers

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

6.3 Compass

Open-Ended Recall Question

Recognition Question

Spatial Recall Test

6.4 Limitations

Additional notes: hätte vl noch mehr dazu nehmen können ein weiteres tool in games wäre enemies zu sehen durch die wand hätte jedoch rahmen gesprängt, weil man da auch mehr leute für die studie gebraucht hätte
steuerung -viele neu in vr - sehr focused darauf und schnell wieder vergessen - trotz doppelter erklärung haben es sich viele nicht gemerkt

legende schwebt im weg, leute fanden es schwer zu lesen, vorallem in kombie mit dem kompass, da sie die immer offen haben wollten - press down vl besser gewesen
environment - hätte alles real machen können, aber die leute waren ja jetzt schon überfordert und haben sich nicht so gut ausgekannt, trotz low stimuli

7 Conclusion

A concise summary of contents and results

A Appendix

Additional material goes here

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