Virtual Reality in Real Estate
House viewing in the form of VR game and its positive effects in the real world

Bachelor thesis

for obtaining the academic Degree

Bachelor of Science (B.Sc.)

at the

University of Applied Sciences (HTW) Berlin
Department 4: Computer Science, Communication and Economics
Study program *International Media Computing*

1. Reviewer: Prof. David Strippgen
2. Reviewer: Florian Wenk

Submitted by Nuri Son 564654

21.02.2024

Acknowledgement

I would like to express my gratitude to my supervisors, Florian Wenk and Prof.David Strippgen, who guided me throughout this project. I would also like to thank other professors in the Media Informatics Department at HTW Berlin, and other CEOs and employees at the real estate software company Vision Me GmbH.
I would like to extend my sincere thanks to my friends and people who supported this research and participated in the survey.
Lastly, I want to say thank you to my family, who supported me during the study, and also to Morgan.

Abstract

3D and VR technologies are powerful and effective tools in many different areas but especially in Real Estate. It allows buyers and the real estate agent to save time and expense by letting them free from visiting the property physically. Moreover, the convenient way of digital staging is one of the reasons why it is so attractive to both buyers and sellers.

While there are clear advantages, the practice of constructing 3D model houses exclusively for specific house viewings highlights the need to explore strategic reuse and broader utilization of these 3D models. This approach not only promises benefits for the companies involved but also contributes to societal advancements. This bachelor thesis proposes a VR game as a novel form of house viewing by presenting multifunctional utilization of 3D models. This study seeks to explore the positive impact and tangible benefits that VR house viewing games, developed through the reuse of such 3D models, can bring to the real estate market and related businesses, introducing a novel approach to house viewing. The VR game developed for this project was created reutilizing a 3D model house produced for sale by Vision Me GmbH, a real estate software company. In addition, the investigation includes a comprehensive review of academic literature, online resources, relevant publications, and a detailed user survey designed to investigate the research findings.

The findings of this research suggest that house viewing through VR gaming possesses the potential to positively impact the real estate market and its associated sectors. While the direct impact on real estate transactions appears to be limited, the overall evaluation suggests that house viewing in the form of a VR game created by repurposing 3D modeling certainly has its place as a device to help users become more familiar with properties and real estate companies. These findings suggest promising opportunities for mutual benefits among software developers, real estate firms, and end-users.

Keywords

Virtual Reality, Real Estate, House Viewing, VR Game, Marketing, In-Game Advertising, Reutilization, Reuse 3D Models

Table of contents

Abbildungsverzeichnis

.

1 Introduction

I. Background

In March 2016, with the release of the Oculus Rift, VR technologies began to be more widely commercialized. Since then, VR has been extensively researched and implemented across various domains, expanding its applications beyond gaming to encompass fields like psychology and education. Notably, the real estate industry has also embraced VR, demonstrating active utilization. [1]Recent studies show that VR tours can reduce the time it takes to sell a property by 6.4% and make the difference between what buyers are willing to pay and what sellers want to receive smaller by 2%, all other things being equal. This indicates that VR as an emerging property technology can enhance the purchase decision-making process and reshape the role of the real estate agent.
The growing demand for 3D and VR products from real estate companies due to their convenience and economic benefits has led to an increase in the supply of 3D models. Consequently, numerous 3D model houses are being produced for house viewing purposes, prompting the need to explore their reuse and diverse applications. In response to this trend, a VR game was developed as a proposed solution, and its positive effects, particularly in marketing and in-game advertising, were examined concurrently.

II. Problem Statement

The integration of 3D and Virtual Reality (VR) technologies in the real estate sector has transformed property showcasing and viewing processes, resulting in considerable time and cost savings for buyers and agents. Moreover, these technologies' digital staging capabilities have played a crucial role in their widespread adoption and appeal to industry stakeholders.
However, despite the evident advantages, a significant challenge persists in the limited strategic reuse and broader utilization of 3D model houses. The prevalent practice of constructing 3D models exclusively for specific house viewings overlooks the potential for these digital assets to be repurposed and utilized more extensively.

By addressing this challenge, several benefits can be achieved. Firstly, maximizing the strategic reuse of 3D models can lead to significant cost savings and efficiencies for real estate or software companies, thereby improving their competitiveness and profitability. Secondly, repurposing 3D models for various applications beyond singular house viewings can unlock new revenue streams and business opportunities within the real estate sector. For instance, VR Games as a method of such utilization can have a positive effect on advertising and marketing.

Moreover, by leveraging 3D and VR technologies more extensively, the industry can foster innovation, drive technological advancements, and contribute to economic growth. Furthermore, exploring avenues for the strategic reuse of 3D models aligns with broader societal goals of sustainability and resource optimization. By minimizing the duplication of efforts in 3D model creation and maximizing their utility, real estate and software companies can reduce their environmental footprint and contribute to sustainable development practices. This not only benefits the environment but also enhances the reputation of companies as responsible corporate citizens.

In summary, addressing the challenge of limited strategic reuse of 3D models in the real estate sector is crucial for improving operational efficiencies, competitiveness, and profitability. By exploring a VR game as an avenue for the strategic reuse of 3D models, this research aims to redefine the conventional approach to house viewing, allowing users to engage with real estate more easily by entertaining and engaging more. Thus, this research aims to explore innovative solutions utilizing VR games to drive positive outcomes for all stakeholders involved, while also seeking ways to increase additional benefits for companies and society by actively recycling the resources of real estate and software companies.

III. Structure

This bachelor thesis is structured to provide a comprehensive understanding of the implementation of 3D and VR technologies in real estate and the development of the VR Game for house viewing as a strategic reuse of 3D Models. The structure is as follows:
Chapter 2 reviews relevant literature and related works on this topic. The selected research works serve as the foundation idea of this thesis and by revealing its source, the research process is revealed and at the end, interesting prospects for future work are considered together.
Chapter 3 outlines the planned approach, including the game development process, data collection, research design, and ethical considerations.
Chapter 4 provides the study results and demonstrates that the methodology described in Chapter 3 was followed.
Chapter 5 makes conclusions of this thesis by summarizing the result of the research.

2 Fundamentals

I. 3D and VR Technologies in Real Estate

Prop-tech, a term that combines real estate and technology, refers to the application of advanced information technologies such as artificial intelligence, big data, and virtual reality to the real estate industry, [2] and has been around since the 1980s, when Apple and IBM introduced the first personal computers. [3] A recent study by KPMG, a global accounting and management consulting firm, found that investment in Prop-tech is expected to more than triple from 2022 to 2023, from $4.1 billion to $13.4 billion.

[4] This increased investment and interest in real estate applications that incorporate 3D digital technologies such as AR and VR is due to the multiple benefits they can provide to both real estate specialists and consumers. Research has shown that real estate applications using VR and AI technology can provide buyers with a more immersive and interactive property tour experience, allowing them to experience properties as if they were physically present and making it easier to find properties that meet their criteria.

These advantages of the real estate applications with advanced technologies are synergistic when it is combined with staging in the real estate market. [5] In the real estate market, staging works as a more cost-effective tool than undergoing expensive renovations. It is because people are more likely to be able to imagine themselves in the home by being increased presence at the property, which may lead people to put an offer in quicker.

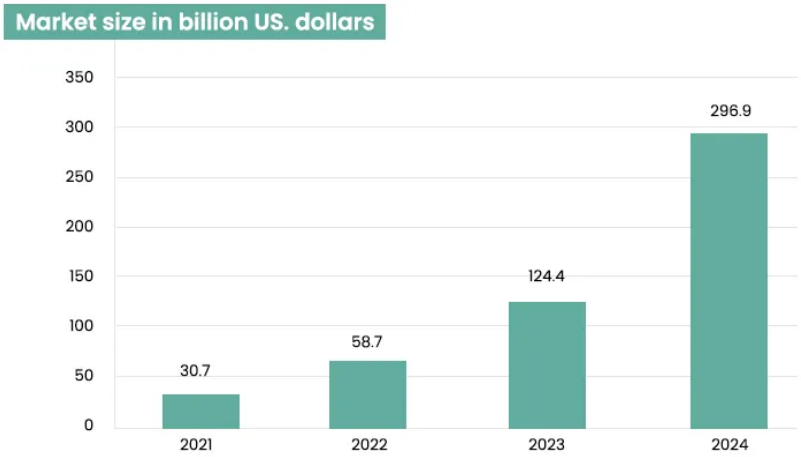


Abbildung 2.1: *Extended reality (XR) market size worldwide from 2021 to 2024 (in a billion U.S. dollars), Statistica [6]*

[7] Other studies on the importance of adopting VR technology in real estate have also found that it will help real estate agents solve the problem by allowing potential homebuyers to participate in virtual home tours that are less costly and time-consuming and have encouraged real estate industry stakeholders to embrace VR as a new real estate marketing strategy.

Table 1: Descriptive Statistics Analysis

Variables	Mean	Standard Deviation
1) VR uses in consideration	4.73	.548
2) Investing towards virtual reality technology	4.67	.572
3) VR enable to boost property sales	4.58	.671
4) VR enables buyers to access without cost and time.	4.43	.789
5) High quality photos can attract buyers.	4.42	.766
6) Detailed information in property is important	4.28	.804
7) Visual experience can stimulate physical presence in places in the real world.	4.55	.746

Source: Questionnaire survey (2022)

Abbildung 2.2: *The importance of Virtual Reality (VR) Technology Implementation in Real Estate [7]*

However, some real estate stakeholders have found that [8] despite the many advantages of Prop-tech products, the cost of managing them, both in terms of human resources and time, is a major drawback.

II. Re-utilization of 3D Models

[9] 3D modeling is the process of creating a three-dimensional representation of an object or surface using specialized software. This work is stored as data in a form that computers can understand and is usually rendered to have a shape and texture similar to the real object. The resulting product is called a 3D model, and the person who creates it is called a 3D artist or 3D modeler.
3D models can be created automatically or manually. The manual modeling process, which involves preparing geometric data for 3D computer graphics, is similar to formative arts such as sculpture. Popular three-dimensional modelers include Maya, Blender, SketchUp, and AutoCAD. [9] One way to automate 3D modeling tasks is through parametric modeling. It makes it easy to reproduce the shape and size of a 3D model by manipulating parameters such as length, width, height, angle, radius, etc.
There is a large market for individual or large collections of 3D models produced in this way. Several online marketplaces for 3D content allow artists to sell the content they create, allowing them to add value to assets they've created for previous projects. This allows artists to make more profits from their existing content, and companies can save costs by purchasing pre-made models.
Today, 3D modeling is used in a variety of fields, including film, animation, gaming, interior design, architecture, and the medical industry. The models used in advertisements also look like real products, but they are often 3D models.

III. In-Game Marketing

In-game advertising is a revenue strategy that allows game developers to monetize their games by selling advertising space in their games. [11] The goal of in-game advertising is to draw players' attention to ads without interrupting their game experience. [12] There are two main types of in-game ads: static and dynamic. Static ads are built into the game at the game development stage and are displayed on the ad spots in the game like a movie or music video. In-game ads are often used in advertising campaigns and have been shown to increase user purchase intent by up to 12% [13].

Unlike static ads, dynamic ads appear as banners during the game and can be updated in real-time. They have the advantage of being more flexible and easy to scale. They can also be geo-targeted to users who have opted in. Dynamic ads are preferred by advertisers because they offer a wide variety of ad formats[12], and advergames which are made to promote a specific product or brand are one of them. [15]According to statistics, the global in-game advertising market revenue has been steadily increasing and is expected to reach 109.6 billion U.S. dollars by 2024. When comparing the global market, China is expected to generate the most revenue in the in-game ad market in 2024, with an estimated 46.61 billion U.S. dollars, while the United States and Japan are also leading the way in terms of in-game ad revenue generation.

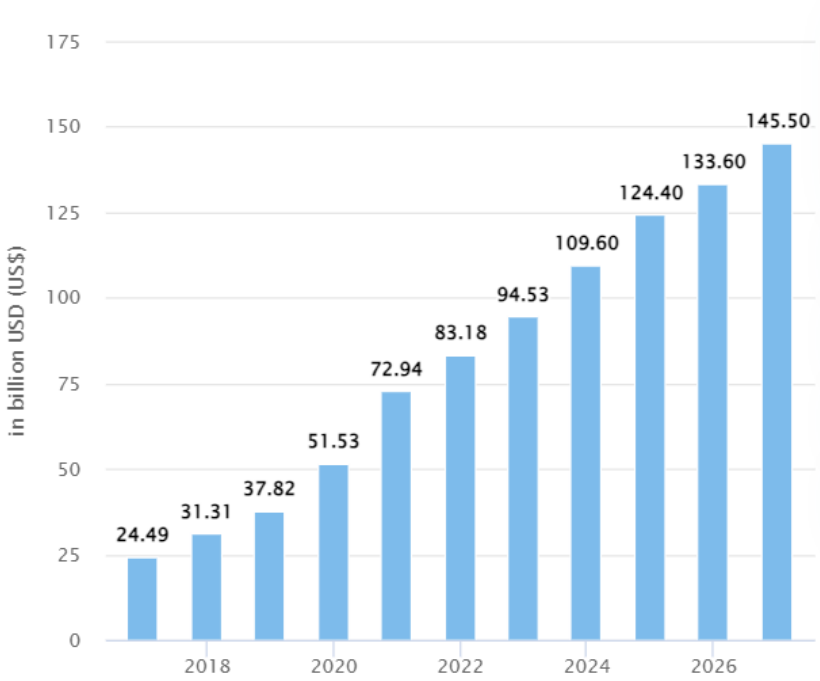


Abbildung 2.3: *In-game Advertising - Worldwide, Statista [15]*

[11]As a result, in-game advertising can be used as an alternative to traditional mass media advertising and has a positive impact on gamers' attitudes towards advertising. Furthermore, in-game advertising has been shown to have a positive impact on player experience and player engagement with the game, as well as brand attitudes and brand equity.

IV. VR for Advertising and Marketing

In the last decade, the concept of using VR as a marketing tool has significantly evolved with brands from various sectors such as automotive, real estate, travel, and retail. It is because [16]VR can provide a means of brand engagement, educating the consumer about a brand, reinforcing brand values, and building affinity and customer loyalty. More broadly, VR can be used for creating brand awareness and relationship building. One example where VR has been used for relationship building is that of Boursin Cheese's 'Sensorium', which allows customers in shopping centers to see inside the contents of a fridge (McLaren 2016). There appear to be many examples of car brands that have VR offerings. Nissan used Oculus VR at the Tokyo Motor Show to enable consumers to design their own Nissan car. Volvo has the XC90 app to explore a futuristic vehicle on a Google Cardboard. Honda has an app to experience driving the ultra-fast Honda-powered, Dallara car, set to coincide with the 100th running of the Indianapolis 500 on May 29, 2016. [17]The real estate industry was severely affected by the pandemic. The real industry is not only utilizing MR applications to advertise projects but also to facilitate virtual home visits for new buyers. Furnishing

and decor brands like IKEA and Home Depot also have launched their own AR platforms for potential buyers to visualize true-to-scale models of furniture before purchase.

Those specific examples listed above indicate that virtual reality technology is already being actively used in marketing. That's because, according to research on understanding virtual reality in marketing, [16]it offers marketers the opportunity to provide potential consumers with the most realistic experience of a product, service, or place yet without necessary physical co-location. This provides an advanced, rich, and immersive medium that can deliver distinctive, high-impact, and memorable messages, and engage audiences and potential consumers(Schmitt 1999; Pine and Gilmore 1998, 1999). [18]As Hunt (1983a,b) posited, "Marketing science is the behavioral science that seeks to explain exchange relationships (p. 12)." Expanding this view, VR can be seen as a technology directed at consummating or facilitating exchanges.
The main difference between a virtual experience, and an indirect experience derived from traditional advertising, is that the former provides a richer experience. This difference has its origin in a set of interface characteristics known as affordances. The affordances of human experience in marketing are the interactions expected between consumers and products (Norman, 1998). The affordances offered by virtual experiences (virtual affordances) can exceed the affordances the consumer is likely to find in physical environments (physical affordances). [18]Thus, one of the most exciting possibilities of the virtual experience is the fabrication of entirely new situations, impossible to create in the real world and the development of contexts that will never be experienced by most people in real life. That is, virtual affordances not only match physical affordances, they exceed them. Virtual affordances provide richer communication channels between the consumer and the product than traditional advertising, and much the same interaction with a product as direct experience.

Despite its advancements, virtual reality (VR) still faces limitations, notably in its prevalence; VR devices have not achieved the same widespread household presence as personal computers.
Google's initiative to introduce cardboard-based VR devices was designed to democratize virtual reality (VR), enhancing accessibility and fostering engagement with VR content. Nevertheless, a study investigating the influence of authentic VR content and the use of Google Cardboard goggles revealed that [19]although VR 360° video technology substantially heightens the sense of immersion compared to conventional media like blog posts, the employment of Cardboard goggles did not notably amplify this feeling beyond what was experienced through the mere use of a mobile phone.

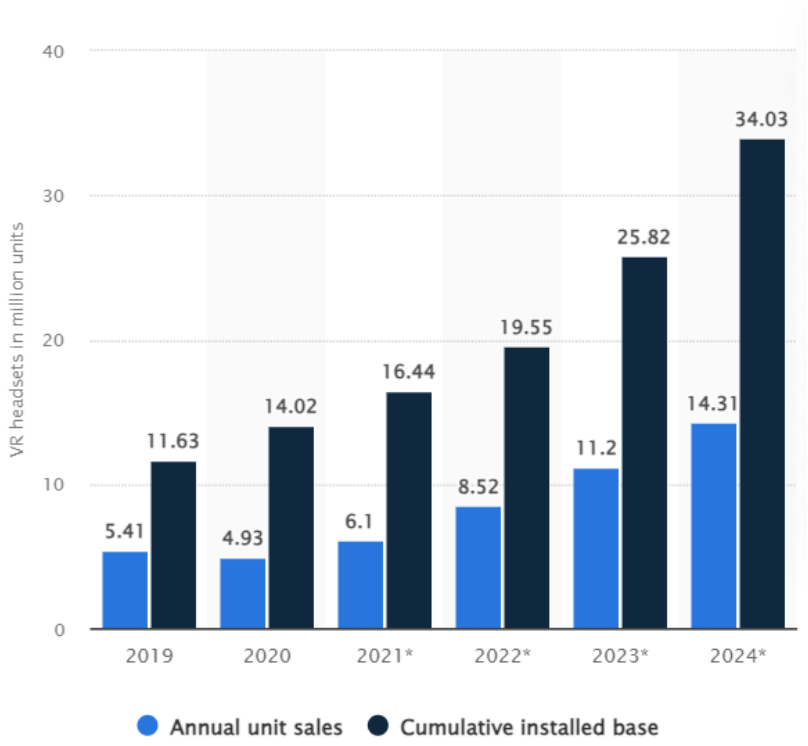


Abbildung 2.4: *Virtual reality (VR) headset unit sales worldwide from 2019 to 2024, (in a million units), Statista [20]*

Drawing on the foundational research and identified challenges, the following strategies are crucial for leveraging virtual reality (VR) technology in advertising communications:[21]

A. Goals and Quality Content

For VR advertising to truly resonate and enhance brand image, it must merge high-quality content with VR technology. Advertisers should deliver strategic, interlinked, and appealing content that enriches the audience's experience and elevates brand image and value.

B. Quality Distribution Channels

The success of VR advertising lies in blending creativity with technology and utilizing high-quality channels for distribution. Establishing professional VR platforms ensures ads reach effectively, improving ad accuracy and boosting user affinity towards virtual ads.

C. Talent and Technological Advances

Investing in talent and seeking technological breakthroughs are critical for leveraging core products and innovations in VR advertising, ensuring sustained brand impact and advancement.

3 Methodology

The ultimate goal of this research is to reveal the positive impact that the VR game created by reusing existing 3D modeling can have on real estate, software companies, and consumers.

I. Introduction

The four academic themes covered in the previous chapter were 1. 3D and VR technologies in the real estate market; 2. Reuse of 3D modeling; 3. In-game marketing; and 4. VR advertising and marketing. It enabled a detailed and academic analysis of house viewing through a VR game as a proposed solution to the problem presented in the first chapter: the strategic reuse and widespread utilization of 3D model houses. This chapter describes House Me, a VR game developed to evaluate the impact and effectiveness of house viewing through virtual reality. It also outlines the survey design conducted to determine the game's effectiveness.

II. VR Game Development

i. Conceptualization

House Me is an advergame that combines house viewing and VR games and has a mixture style of games between an escape room and a treasure hunt. As it is a game aimed at house viewing, it was created taking into account the fact that players will consider house viewing as the ultimate purpose of playing the game. Therefore, the game is for the entire family to enjoy, and considering both children and the elderly, dangerous elements or elements that may make game players psychologically or physically uncomfortable were excluded as much as possible. It was designed keeping in mind that one of the most important aspects of in-game marketing is the game should not interfere with gamers' gameplay or make players feel like they are overtly advertising.

Thus, the chips used as treasure in the game were designed to have a natural in-game marketing effect by using the company's logo on them. It's also designed to give customers experiences that they can't have in the real world, like having their home transformed or having another house across the street from them. Moreover, to amplify the house viewing experience by extending the time users spend inside the property, treasures were strategically placed in areas that show the characteristics of the house well and encourage more detailed exploration.

Lastly, a promotional coupon was devised that serves as an effect that transfers the

experience in virtual reality to the real world. In the prototype version of the game, when the user selects a coupon on the screen after finding the last treasure, the real estate company homepage is displayed on the actual monitor after the game. But later on, it can be replaced with the function that gives a certain percentage of discount to the customer, when he/she purchases a real estate property with the coupon on the webpage. It was designed with the expectation that it could be used for promotions in various formats in collaboration with other large companies. In addition, it is expected that this coupon function can be used for promotions in various formats through collaboration with other companies.

For other ideas, modeling, and programming, a lot of learning resources from YouTube and Unity tutorials, and communities like stack overflow, and ChatGPT were used. Among them, the YouTube tutorial Let's Make a VR Game by Valem provided the most inspiration and practical programming help.

Level 1			**Level 2**			**Level 3**	
1.	2.	3.	4	5	6.	7.	**Mission**
pink & skyblue			purple& yellow			black& mirror	
Bowl	Bowl	Vase	Bowl	Bowl	Vase	Vase	
1. House			2. House			3. House	**Reward**
Furnitures	Stairs	House Door Opening / Garden	House Transfor-ming	Room Doors Openin g	New House	Coupon	

Abbildung 3.1: *Game Level Design*

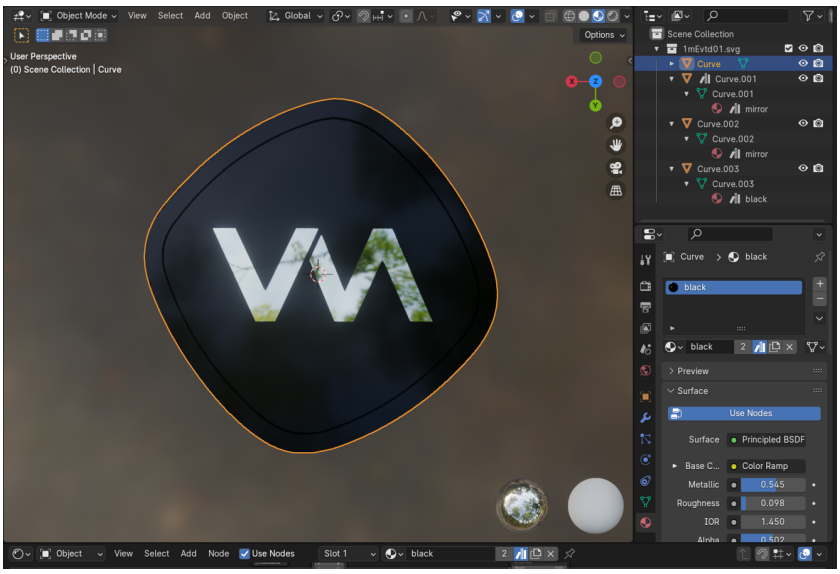


Abbildung 3.2: *Chip Designing on Blender*

ii. Design and Development Process

The fundamental design philosophy of this game centers on enjoying the process of house viewing, leveraging the convenience of digital technologies. It aims to offer both mental and material satisfaction harmoniously to individuals in the digital era. The most important functional part of this game is a Movement Controller, which controls the player's current movement according to the next timeline. The movement controller uses the Unity playable director with the signal receiver from UnityEngine.Timeline API. It works based on the movement description by pausing it before the player does a specific movement, such as triggering an object or pressing a button.

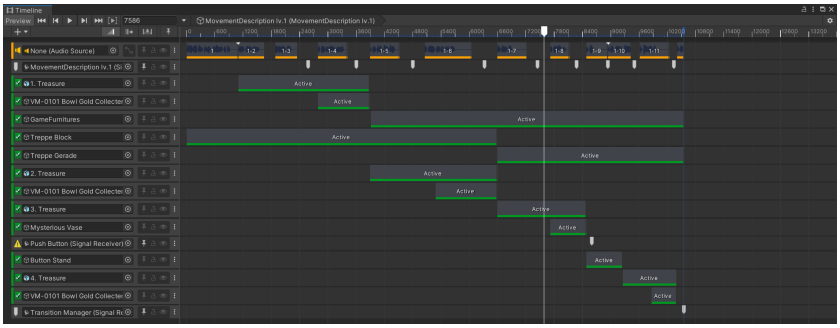


Abbildung 3.3: *Movement Controller Description on Unity*

Audio tracks serve as guided instructions, seamlessly integrating into the overall flow of the game, with the script unfolding as follows:

<Level 1 - Zeitlos>

1-1. Hello, I'm an audio-type AI, AudioBot Bobo. I will help you with your house view-

ing. During the house viewing, you will get some missions. If you complete them, you will have wonderful experiences in this house. No worries. I will help you.

1-2. Please find the seven treasures in the house. If you find and place them in the magic jar, you will experience amazing changes in the house.

1-3. The first lucky charm is very close to where you are located right now. Shall we take a look at the kitchen?

1-4. Good job. You found the first treasure! Now, please place it in that magic jar that you see over there. You will experience amazing changes in this house.

1-5. Great! You got new furniture. Let's keep finding the second treasure. Shall we take a look at that room over there? I see something on the bookshelf.

1-6. That's cool. You've even found the second one very quickly.
Please put it in the magic bowl again. It's over there.
As soon as you put it in the bowl, you will get the second prize.

1-7. Nice stairs. Let's go and check the second floor. There will be a third lucky charm.

1-8. Amazing. Please put it on the mysterious vase next to the house door. It's downstairs.

1-9. You made it! Shall we press this button now?

1-10. Cool. It's a nice garden. Here You will find the new lucky Charm for the new space. Let's check over there somewhere near the garden table.

1-11. Very nice. Go back to the house door, and please put it into the magic bowl. Then you are ready.

1-12. Wonderful. The house is transforming!

<Level 2 - Classic>

2-1. Welcome to the new House. Let's go in and see what features of the house have changed!

2-2. Very nice. You found the new treasure.

2-3. Let's keep looking into the rooms on the second floor

2-4. Great. Shall we put it on the mysterious vase behind?

2-5. You got a new house. You can go out and check how it is.

<Level 3 - Modern>

2-6. The last treasure is waiting for you to be found in your second house. Let's go!

2-7. Look! It's over there!

2-8. Congratulations. The last treasure is right in your hands. Please put it on the TV screen you see in front of you.

iii. Implementation

The prototype of this game is made using Oculus Quest 2 in an HDRP(High Definition Render Pipeline) VR setting. It is rendered with TPU 14 for the prototype of the game. The reason is that HDRP VR is quite demanding in terms of graphical resources, and it was impossible to render it with a high TPU like 100 since it was too intensive for the hardware or not optimally supported by the current settings or version of the used software. Thus, after checking hardware specifications like graphics cards or memory and optimizing scenes and assets properly it should be rendered again.

III. Survey Methodology

i. Objective

The primary objective of the user survey conducted as part of this research was to assess the effectiveness, engagement, and satisfaction levels of users' experience of house viewing through the innovative medium of a VR game. Specifically, the survey sought to understand how VR gaming as a form of house viewing could influence potential buyers' engagement and satisfaction compared to traditional viewing methods.
It also aimed to explore the tangible real-world benefits for real estate companies, related stakeholders, and customers such as increased interest in properties, prolonged interaction with listings, and potential for in-game advertising. Additionally, this survey intended to identify areas for improvement in the VR house viewing experience and gather insights on user preferences and expectations from such technology.
By achieving these objectives, this survey was designed to provide a foundation for assessing the viability and impact of VR games in real estate marketing strategies, contributing to the broader utilization of 3D models beyond single-use applications.

ii. Survey Design

The survey is designed to systematically collect data on individuals' experiences with VR house viewing, assessing various dimensions including engagement, realism, impact on memory and decision-making, brand perception, and marketing effectiveness. The questionnaire is developed around fifteen key areas, ranging from overall experience to long-term brand loyalty. It includes a mix of Likert scale questions, allowing

for quantitative analysis of participants' attitudes and perceptions, and open-ended questions designed to elicit qualitative insights into their experiences and suggestions for improvement. For the Likert scale items, participants were asked to rate their agreement or satisfaction on a 10-point scale, with 1 indicating "not satisfied at alländ 10 signifying "very satisfied."

<Research questions>

Do you have any digital(3D, AR, VR etc.) form of House Viewing Experience before?

1. Overall Experience:
- On a scale of 1 to 10, how would you rate your overall experience of house viewing through the VR game?
- What aspects of the VR house viewing experience did you find most engaging?

2. Perceived Realism:
- How realistic did you find the virtual environments and properties in the game?
- Did the VR experience give you a realistic sense of scale and space in the properties?
- Were there any moments in the game where you felt particularly immersed in the virtual environment?

3. Memory and Recall:
- How well do you remember the details of the houses you viewed in VR compared to traditional in-person viewings?
- Did the VR experience help you remember important features or aspects of the properties more effectively?

4. Decision-Making:
- Did playing the VR game influence your decision-making process when it comes to real estate-related choices?
- Were there any decisions you made in the game that you feel could translate to real-world scenarios?
- How confident do you feel in making real estate decisions after experiencing the VR game?

5. Overall Impact:
- Do you think VR technology has the potential to revolutionize the way people buy, sell, or invest in real estate?
- Would you recommend this VR experience to others interested in learning about real estate?
- In what ways do you think VR technology could further enhance the real estate industry?

6. Brand Perception and Awareness:
- Did the VR game house viewing experience positively influence your perception of the real estate company or agent associated with it?
- To what extent did the VR game enhance your awareness of specific properties or real estate services offered?

7. Brand Engagement and Interaction:
- How effectively did the VR game engage you with the brand or property listings?
- Did the interactive elements within the VR game encourage you to explore additional properties or services offered by the real estate company?

8. Targeted Marketing and Personalization:
- Did you feel that the VR game experience was tailored to your preferences and needs as a potential homebuyer?
- How well did the VR game showcase properties that matched your criteria or interests?

9. Social Media and Viral Potential:
- Do you think the VR game house viewing experience has the potential to generate buzz on social media platforms?
- Would you be likely to share your VR game house viewing experience with friends or followers on social media?

10. Digital Advertising Impact:
- How effective was the VR game in capturing your attention compared to traditional forms of digital advertising
(e.g., listings, photos, videos)?
- Did the VR game influence your likelihood to engage with other digital advertisements from the same real estate company?

11. Word-of-Mouth and Referral Potential:
- Would you recommend the VR game house viewing experience to friends or family members who are in the market for a new home?
- Do you think experiencing house viewings in the VR game could prompt you to refer others to the real estate company or agent behind the game?

12. Conversion and Lead Generation:
- Did the VR game house viewing experience increase your likelihood of inquiring further about specific properties or real estate services?
- How likely are you to take the next step in the home buying process after experiencing house viewings in the VR game?

13. Long-Term Brand Loyalty:
- Do you believe that experiencing house viewings in the VR game has the potential to foster long-term loyalty to the real estate brand or agent?
- How likely are you to continue engaging with the real estate company or agent after the VR game experience?

14. Feedback and Iteration:
- Would you be willing to provide feedback to the real estate company or agent to help improve future iterations of the VR game?

- How important do you think it is for real estate companies to incorporate customer feedback into their VR game development process?

15. Overall Marketing Impact:
- On a scale of 1 to 10, how would you rate the effectiveness of using a VR game for house viewing as a marketing tool?
- Would you recommend other real estate companies or agents to explore similar VR game initiatives for their marketing efforts?

Lastly, please let me know in which way you experienced the VR game "House Me". Thank you very much!

iii. Population and Sampling

The game and survey were designed for anyone interested in real estate and 3D and VR technologies. To protect the privacy of participants and the objectivity of the research, the survey was designed not to ask for personal information, such as participants' gender, age, or occupation.

The survey was conducted with participants of different nationalities, without discrimination on gender and age, and the main audiences were real estate software company in Hanover, Germany, student organizations in Berlin, Germany, and general households with an interest in real estate and 3D and VR technologies in Berlin and Hanover, Germany and South Korea. The questionnaire was translated into three languages, English, German, and Korean, distributed, and then retranslated back into English for statistical purposes.

At the beginning and end of the survey, participants were asked to answer questions about their previous experience with digital house viewing and whether they had played the game using a VR device and answered the questionnaire, or if they had watched a prepared gameplay video. Participants wore VR glasses in a room, played the prepared VR game without a time limit, and then took sufficient time to answer the survey. People who were unable to play the game directly using VR goggles due to conditions responded to the survey after watching a pre-recorded VR game-playing video of another participant.

There were a total of 23 participants, with ages ranging from early 20s to early 60s, with students being the largest occupation group. Among them, only one person owned a VR device, which is 4 percent of the number of the total participants. And 7 participants had previously house viewing experience in digital formats such as 3D or VR, accounting for about 30% of the total. A total of 4 participants, or about 17% of the total, answered the survey after actually playing the VR game "House Me", and the remaining 19 participants, or 82% of the total, responded to the survey after watching the video.

iv. Data Collection and Analysis

The survey data underwent analysis through two distinct methodologies.

Quantitative Analysis utilized statistical software to meticulously examine responses to Likert scale questions. It employed descriptive and inferential statistics to evaluate measures of central tendency, variability, and hypothesis testing, aiming to explore relationships between variables. Conversely, Qualitative Analysis delved into open-ended responses, employing thematic analysis to unveil patterns and themes within participants' qualitative feedback. This method aimed to provide deeper insights into the experiential and perceptual dimensions of VR house viewing.

Quantitative data from Likert scale questions were subjected to descriptive statistics to ascertain mean scores and standard deviations for each question. Qualitative responses underwent thematic analysis to identify common themes and insights related to the VR house viewing experience. This mixed-methods approach facilitated a comprehensive understanding of the impact of VR on house viewing, shedding light on both statistical trends and the depth of individual experiences.

IV. Ethical Considerations

All participants were informed about the purpose of the study, the nature of their participation, and how their data would be used and protected. Consent was obtained from all participants, ensuring they were aware that their participation was voluntary and that they could withdraw at any time without penalty. Anonymity and confidentiality of the responses were guaranteed, with data being stored securely and used solely for this research.

V. Limitations

There were several limitations to this study. First, during the development process of the game prototype, the rendering of the game did not reach the expected level. This research was planned to be answered after the participants played the game, but few participants had VR devices at home. Therefore, the study had to be continued in a very limited environmental situation with one VR headset. Additionally, the game has not yet been released, and it is not easy to set up equipment for VR games freely with fewer environmental restrictions.

4 Results

I. Likert Scale for quantitative analysis

A total of 23 participants responded to the survey over one week. The group is largely divided into two categories: one group participated after experiencing the game with VR glasses, while the other group engaged with VR gameplay through video presentations.

Through the 15 quantitative and qualitative questions listed in Chapter 3, Methodology, this research aimed to determine whether house viewing in the form of a VR game could positively impact both companies and consumers. Initially, a Likert scale analysis was conducted to quantify qualitative data, yielding the following results.

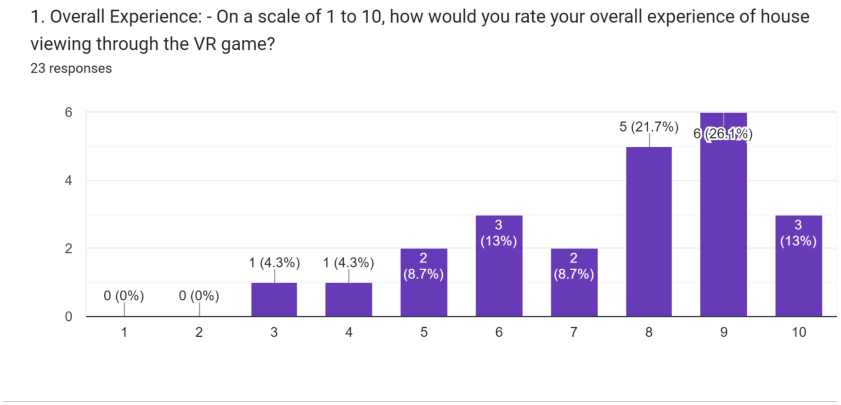


Abbildung 4.1: *Overall Experience of House Viewing through VR Game - Statistics*

The overall evaluation of house viewing through VR games ranged from 1 (very dissatisfied) to 10 (very satisfied), with 9 being the highest at 26.1%, followed by 8 at 21.7%, 6 and 10 at 13% each. The lowest score was 3 points, accounting for 4.3% of the total. As a result, the average score was 7.52, indicating that the participants had a fairly satisfactory experience through house viewing in the form of a VR game.

Among the 15 questions surveyed, the statement regarding the importance of incorporating customer feedback into the VR game development process, labeled "Feedback and Iteration,"received the highest average score. Notably, 9 participants, constituting 39.1% of respondents, rated its importance as a perfect 10, marking the most significant proportion. This was followed by 6 respondents assigning it a score of 9 (26.1%), and 3 participants each giving it scores of 6 and 7, accounting for 13% of the total responses,

respectively.

The second-highest average score, at 8.26, was for the item '15. Overall Marketing Impact.' The related question within this category, 'Would you recommend other real estate companies to use similar VR games as a marketing tool?' received the third-highest average value of 8.17. Notably, 8 participants, or 34.8 percent of the total respondents, awarded this question a score of 10, making it the question with the highest endorsement.

Conversely, the question that received the lowest average score from participants was the one related to Targeted Marketing and Personalization, specifically asking 'How well did the VR game showcase properties that matched your criteria or interests?' The average score for this question was 6.17. Five people, constituting 21.7 percent of the total, rated it a 6, while it received a low score of 1 and a high score of 10 from three people each.

When analyzing the statistical results by dividing the participants into two groups: the VR glasses group and the VR game-playing video group, the average value of the answers to the first question, asking about the overall evaluation, was 8 for the VR glasses group and 7.4 for the video-watching group. The highest mean value for the VR glasses group was 8.5, recorded for the question regarding long-term brand loyalty, while the highest mean value for the video-watching group was 7.73, noted for the question about the overall impact and whether they would recommend the VR experience to others interested in learning about real estate.
Overall, the quantitative analysis suggests that VR games have a positive impact, particularly in terms of enhancing brand loyalty and marketing effectiveness. However, there are areas for improvement, such as targeted marketing and personalization, to better align with participants' preferences and interests.

II. Qualitative Analysis

Qualitative data about what participants found most immersive about the VR House Viewing experience was received, and the results were summarized using only keywords.

- Immersive environment, Realistic expressions
- Convenience, Saving time and energy
- Treasure and reward, Finding Treasures, Magic pot
- Concept of playing in VR
- Interactive nature of the game
- Scale and propositions, 3D composition, Module and article configuration
- Interior of houses, House Design
- Feelings, Movement, Moving

When asked to describe their most immersive moments in the virtual environment, the following keywords emerged.

- Stairs, Going, Moving
- Exterior, Garden, Outside, Environment, VR Technology, Status
- Grip
- Levels, Curiosity, Task
- No, Only Video, Not really, Not rendered, Clipping errors
- Camera perspective, Height, Door, Eyes

When asked if VR games have increased awareness of a particular real estate property or service, the following key responses were given.

- The VR game significantly enhanced my awareness of specific properties and real estate services offered. It provided a comprehensive experience that allowed me to explore properties in detail, learn about different services, and gain valuable insights into the real estate market.
- Rather than enhancing existing perceptions, it helps to judge whether this house is appropriate based on already known knowledge. However, if real estate services offer such 3D services, they would be perceived as technologically advanced and likely to provide a wider range of services, which would be beneficial.
- I'm new to this, and didn't know it was even possible to view real estate this way, so it opened my eyes to the possibilities
- However, VR games can enhance awareness of specific properties or real estate services by providing immersive experiences that allow users to virtually explore properties, visualize designs, and understand services offered in a more interactive way than traditional methods like photos or videos.
- satisfactory level. Real estate business with the emerge of the viewer technology can play an important role in the future Real Estate industry.
- It gave me a good first overview.
- I would say pretty good
- I think that if a real estate agent offered me to view multiple properties through VR it could allow me to save time as I would not have to travel to each individual location. And then I could maybe select few of those and look at them in person.

In summary, the qualitative responses present diverse perspectives on the utility and realism of decision-making in the VR game. While some participants appreciate the immersive experience and its potential real-world impact, others express limitations or uncertainties, indicating the need for further research and development in VR technology for real estate applications.

Moreover, the responses highlight various engaging aspects of the VR house viewing experience, such as immersion, interactivity, convenience, design visualization, and spatial understanding. These insights can guide the development of future VR applications for house viewing and real estate exploration.

Furthermore, the responses underscore the potential of VR technology to revolutionize the real estate industry by improving the viewing experience, streamlining

decision-making processes, and enhancing asset management.

Overall, the collective responses suggest that VR technology holds promise in enhancing awareness of specific properties and real estate services through immersive, informative, and convenient experiences.

5 Summary

Although the technical limitation that VR has yet to fully permeate the average household, this research highlights the significant positive impact of utilizing VR games for house viewing in the real estate industry. The quantitative analysis strongly indicates that VR games contribute positively, especially in terms of enhancing brand loyalty and improving marketing effectiveness. Participants expressed satisfaction with the immersive experiences offered by VR games, which not only captivate their attention but also create lasting impressions, fostering stronger connections with real estate brands. As a result, this research demonstrates that repurposing existing 3D modeling to create an advergame can have a positive impact on the real estate industry, software companies, consumers, and the broader real world.

6 Literatur

[1] Author(s), “The effect of virtual reality on the marketing of residential property,"*Journal Name*, vol. xx, no. xx, pp. xx-xx, Month Year. Available online: https://www.tandfonline.com/doi/full/10.1080/02673037.2022.2074971

[2] Author(s), “The Evolution of Proptech: How it All Started,Ävailable online: https://www.linkedin.com/pulse/evolution-proptech-how-all-started-wes-snow

[3] Author(s), “KPMG survey finds proptech investment triples in 2023,Ävailable online: https://kpmg.com/xx/en/home/media/press-releases/2024/01/proptech-investment-more-than-triples-from-usd4bn-to-usd13bn-between-2022-2023-a-bright-light-in-challenging-year.html

[4] Ivana Miljkovic, Olena Shlyakhetko, Solomiia Fedushko, “Real Estate App Development Based on AI/VR Technologies,"Conclusions.

[5] Alexander Julian Brenner, “Virtual Reality: The Game Changer for Residential Real Estate Staging through Increased Presence,"Claremont McKenna College.

[6] Author(s), “Augmented Reality (AR) & Virtual Reality (VR) Trends For The Real Estate Industry in 2021,Ävailable online: https://kulmohan.medium.com/augmented-reality-ar-virtual-reality-vr-trends-for-the-real-estate-industry-in-2021-e121f10749e3

[7] Kholim Sahray, Anis Syazwani Sukereman, Siti Hasniza Rosman, Fatin Nur Hanis Jaafar, “THE IMPLEMENTATION OF VIRTUAL REALITY (VR) TECHNOLOGY IN REAL ESTATE INDUSTRY,"Figure 1.2.

[8] Teresa Florentinoa, “Real Estate using AR, VR, DR, Geo-referencing and other mobile applications,Ävailable online.

[9] Wikipedia, “3D modeling,Ävailable online: https://en.wikipedia.org/wiki/3D_modeling

[10] LinkedIn, “How can you automate 3D modeling tasks,Ävailable online: https://www.linkedin.com/advice/0/how-can-you-automate-3d-modeling-tasks-xsdoe

[11] Klose, Sonja; Truong, Ngoc Anh. “The effectiveness of in-game advertising in mobile games."Research Journal for Applied Management, 2.1. In-game advertising (IGA), 5.3. Advantages for players.

[12] Wikipedia. “In-game advertising.Ävailable online: https://en.wikipedia.org/wiki/In-game_advertising

[13] Net Imperative. “Does in-game advertising work? New research shows big uplift in purchase intent.Ävailable online: https://www.netimperative.com/2021/08/20/does-in-game-advertising-work-new-research-shows-big-uplift-in-purchase-intent/#:~:text=In%2dGame%20advertising%

[14] Wikipedia. “Advergame.Ävailable online: https://en.wikipedia.org/wiki/Advergame

[15] Statista. “In-game Advertising - Worldwide.Ävailable online: https://www.statista.com/outlook/dmo/digital-media/video-games/in-game-advertising/worldwide#revenue

[16] Barnes, Stuart J. “Understanding Virtual Reality in Marketing: Nature, Implications and Potential."Department of Management, King’s College London, Franklin-Wilkins Building, 150 Stamford Street, London SE1 9NH, United Kingdom, Section 3: Examples of Virtual Reality Applications in Marketing.

[17] Tiwari, Rajeev; Duhan, Neelam; Mittal, Mamta; Anand, Abhineet; Khan, Muhammad Attique (editors). “Multimedia Computing Systems and Virtual Reality.SSection 4.4.2.4: Extended Reality in the Real Estate Industry.

[18] Alcañiz, Mariano; Bigné, Enrique; Guixeres, Jaime. “Virtual Reality in Marketing: A Framework, Review, and Research Agenda.Ïnstituto de Investigación e Innovación en Bioingeniería, Universitat Politècnica de València, Valencia, Spain; Department of Marketing and Market Research, Faculty of Economics, University of Valencia, Valencia, Spain, Section 5: Definition of Virtual Experience in Marketing (VEM).

[19] Lo, Wai Han; Cheng, Ka Lun Benjamin. “Does virtual reality attract visitors? The mediating effect of presence on consumer response in virtual reality tourism advertising."Published: 28 November 2020, Section 6: Conclusion.

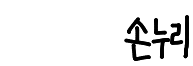
[20] Statista. “Figure 2.4. Virtual reality (VR) headset unit sales worldwide from 2019 to 2024.Ävailable online: https://www.statista.com/statistics/677096/vr-headsets-worldwide/

[21] Qin, Huimin; Lei, Jinfeng. “The Application of Virtual Reality Technology in Advertising Communication."College of Arts, Guilin University of Technology, Guilin, Guangxi, 541006, China, Section 5: The Application Strategy of Virtual Reality Technology in Advertising Communication.

https://github.com/NuriSon/HouseMe.git

Eidesstattliche Versicherung

Hiermit versichere ich an Eides statt durch meine Unterschrift, dass ich die vorstehende Arbeit selbstständig und ohne fremde Hilfe angefertigt und alle Stellen, die ich wörtlich oder annähernd wörtlich aus Veröffentlichungen entnommen habe, als solche kenntlich gemacht habe, mich auch keiner anderen als der angegebenen Literatur oder sonstiger Hilfsmittel bedient habe. Die Arbeit hat in dieser oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegen.



21.02.2024, Berlin, Nuri Son