VR Therapia: Utilizing Immersive Virtual Reality for Applied Psychology Interventions

Yulian Rusyn *
Supervised by: Zuzana Berger Haladová†

Abstract

Virtual reality (VR) holds the potential to positively impact mental well-being by transporting individuals to serene environments, such as a calming forest or a contrasting cityscape plagued by urban challenges. This study investigates the therapeutic effectiveness of VR experiences utilizing Head-Mounted Display (HMD), body position tracking and heart rate tracking.

By implementing full-body tracking users transition seamlessly to contrasting environments — a tranquil "Forest" with animals, the sound of wind, or a challenging "City" with rats, trash, and the cacophony of urban noise.

Our preliminary findings indicate a significant difference in relaxation levels between the "Forest" and "City" scenarios, highlighting the potential of VR to elicit distinct emotional responses. The incorporation of heart rate monitoring, emerged as a valuable component for estimation of the stress level of the participants. This research not only underscores the potential of VR applications in promoting relaxation but also contributes to a nuanced understanding of the emotional impact of contrasting virtual environments.

Keywords: Forest therapy, Full body tracking, immersive environments, Virtual reality

1 Introduction

In recent years, virtual environments have garnered increased attention as a promising tool for mental health intervention. Inspired by the calming effects of Japanese Forest Therapy, our paper aims to explore the efficacy of virtual environments in enhancing psychological well-being. Specifically, we focus on comparing the impact of virtual forests and virtual cities on key variables such as self-compassion, self-care, self-criticism, and stress levels.

Moreover, our study delves into the comparison between 360-degree videos depicting forests and cities and fully immersive 3D scenes. This broader exploration allows us to assess the nuanced differences in therapeutic outcomes between these modalities, contributing valuable insights to the evolving landscape of virtual interventions in mental health.

Drawing from the therapeutic potential of nature-based interventions, particularly Shinrin-yoku[3] principles, our research plan involves developing an application to assess the broad applicability and therapeutic value of virtual environments in non-clinical and clinical populations. This work is done in collaboration with applied psychology researchers from Faculty of Social and Economic Sciences Comenius University Bratislava. Its aim is to understand whether a virtual forest, compared to a virtual city, can effectively promote key psychological variables.

To conduct our research, we will employ Virtual reality setup consisting of HMD and position trackers to connect participants to the virtual world and record their movements. Heart rate measurement devices was used to collect accurate data throughout the intervention, stored for detailed analysis.

The paper is organized as follows. In the next section the review of previous work is presented. In the third part, we will address various aspects of developing our application, including technologies, devices, and programs.

2 Previous Works

In the area of virtual reality forest therapy, several works were published.

In 2022, the study by Leung et al. [5] examining the impact of VR exposure on nature connection and affective states in individuals with low affinity for nature. Two studies were conducted to test this hypothesis. In the first study, participants experienced three VR sessions, each with a unique 360-degree video, while the second study included a control group exposed to a virtual urban environment. Results showed increased nature connection and positive affect in the virtual nature group. The second study aimed to replicate these findings with fewer and shorter sessions. Both studies utilized HTC Vive Pro headsets and statistical analyses for evaluation. Participants completed the intervention over two weeks, with sessions spaced approximately 3,9 days apart, in a controlled environment. The VR system presented nine ultra-high-resolution 360° VR videos in a fixed order, demonstrating positive impacts on nature connection and emotional well-being.

Second article by Wang et al.[10] explored the impact of various forest settings on stress levels through virtual reality (VR) videos. Seven forest recreation sites in Beijing

*rusyn1@uniba.sk
†haladova@fmph.uniba.sk

were tested, with stress levels monitored using physiological and psychological indicators. Participants aged 18-35 with good health were enrolled. Before the experiment, an introduction covered its purpose, process, risks, and confidentiality. Subjects' baseline heart rates were measured, followed by the Trier Social Stress Test (TSST), inducing stress through a public speech and mental counting task. Pre-tests measured blood pressure, heart rate, salivary amylase, and mood. Subjects then viewed a 5-minute VR video of a forest environment to potentially reduce stress. Post-tests mirrored pre-tests. The UCVR EYE-01 camera captured images in seven forests, and videos were recorded in 33 areas. The HEM-7111 electronic sphygmomanometer measured blood pressure and heart rate. Results revealed varying stress-alleviating effects among forest scenes, with aquatic environments notably reducing stress. This study contributes to understanding forest therapy use.

The next study by Chia-Pin Yu et al. [11] utilized the HTC Vive VR system. 360-degree videos recorded by researchers were played on the HMD in this study.

For the urban environment, researchers selected Ximending in Taipei, Taiwan, known as a shopping paradise. The recorded video in Ximending captured urban elements such as crowds, noise, traffic, and low greenery coverage. To showcase the forest environment, researchers filmed in the recreational area of Aowanda National Forest in Nantao City, Taiwan. This area features water protection zones, coniferous and deciduous trees, and diverse wildlife. The video presented natural elements of Aowanda, including double waterfalls, a maple path, a pine zone, cypress trees, a spruce forest observatory, and the Cingshuei River.

A Kodak Pixpro SP360 4K camera was used for video recording in this experiment. Notably, this camera can capture 360-degree views in high resolution. With two lenses, each capturing 235 degrees, researchers created 360-degree videos by merging footage using Kodak-provided software. Two videos were generated, simulating urban and forest environments, each containing seven clips with associated sounds.

Study by Takayama et al. [9] explored the physiological and psychological benefits of a digital Shinrin-yoku environment indoors in an urban facility. It observed changes in 25 subjects physical and mental states before, during, and after exposure to digital elements replicating a forest setting. Results indicated increased parasympathetic nerve activity and decreased heart rate during exposure, alongside reductions in negative mood states and increased feelings of restorativeness.

However, virtual reality (VR) experiences, while immersive, may be inaccessible to certain demographics, such as older individuals, those with dementia, and children with attention-deficit hyperactivity disorder. Additionally, VR experiences tend to be solitary, limiting the opportunity for shared experiences, which is essential for human connection.

For the experiment, two rooms were prepared: a waiting room and an experimental room. The experimental room simulated a forest environment with visual, auditory, and olfactory cues projected using five projectors, aiming to provide an immersive forest bathing experience within an indoor urban setting.

Another work, by Lopes et al. [7] discuss an experiment which was conducted in the SENSIKS multisensory booth (SENSIKS, The Netherlands), where participants experienced a multisensory nature walk synchronized with a 360-degree video through an Oculus Quest VR headset. The setup included fans, heating elements, high-resolution speakers, an under-seat subwoofer, and a scent device. The experience lasted approximately one minute and involved participants immersed in a forest environment. Physiological data were collected using a BioHarness3 chest belt and an E4 wristband. The AV sessions included a main soundtrack with a whispering voice encouraging self-reflection. Participants experienced visual, auditory, olfactory, and tactile stimuli corresponding to elements in the video, such as leaves changing, sunlight streaming, and wind sound, with corresponding sensations like air currents and seat vibrations.

All of the aforementioned texts discussed the utilization of 360-degree video for various forms of therapy. Our project endeavors to adopt a similar concept, albeit with enhancements through the incorporation of a full-body tracking system.

3 Specification of the proposed VR system

In the following section, we will focus on choosing virtual reality devices, including a body tracking system.

Virtual reality (VR) is a simulated experience that employs 3D near-eye displays and pose tracking to give the user an immersive feel of a virtual world. Applications of virtual reality include entertainment (particularly video games), education (such as medical, safety or military training) and business (such as virtual meetings). VR is one of the key technologies in the reality-virtuality continuum. As such, it is different from other digital visualization solutions, such as augmented virtuality and augmented reality.[8]

3.1 Headsets for Virtual Reality:

VR headsets are equipped with high-resolution displays for each eye, projecting images or videos to create the illusion of a 3D environment. These displays offer a wide field of view, enhancing immersion. Modern VR headsets typically prioritize high frame rates, at least 80 frames per second (FPS), for a smooth and comfortable experience. Some newer headsets push the boundaries with a frame rate of 120 Hz or higher, improving realism and reducing motion sickness and eye strain. VR headsets usually feature high-resolution displays, often OLED or AMOLED screens. Each eye sees a slightly different perspective, mimicking how human vision works. Lenses placed between the user's eyes and the displays bend and focus light, ensuring proper image display and creating a wide field of view. Modern VR headsets come with various sensors, including accelerometers and gyroscopes, tracking the user's head movements. This tracking is crucial for real-time updates of visuals based on user's head movements, maintaining the illusion of a consistent virtual world. Some headsets also use external sensors or cameras to enhance tracking accuracy. Many VR headsets feature integrated headphones or spatial audio technology, providing a 3D sound experience. Precise audio feedback enhances the sense of presence and immersion. VR headsets often come with handheld controllers or gloves, allowing users to interact with objects and navigate in the virtual space. These input devices are tracked in the virtual reality environment, enabling accurate interaction. They are also equipped with sensors to track their position and movements. Depending on the type of VR headset, it may connect to a computer (tethered), operate independently (standalone), or use a smartphone (mobile) as its computing unit.

VR headsets come in various forms, each with its advantages and limitations, generally divided into the following categories:

Tethered VR Headsets: Connected to a powerful computer or gaming console using cables, providing high-quality graphics and immersive VR experiences but limiting user mobility.

Standalone VR Headsets: Have built-in computing power, eliminating the need for external devices. They offer portability and convenience but may have processing limitations compared to tethered headsets.

Mobile VR Headsets: Utilize smartphones as display and processing units. They are affordable and easily accessible but typically provide less immersive experiences compared to tethered and standalone headsets.

Main Differences Between Types Performance: Tethered VR headsets generally offer the best performance and graphic quality, followed by standalone headsets, while mobile headsets provide the least powerful experience.

Mobility: Standalone and mobile VR headsets offer greater mobility and can be used in a broader range of environments.

Cost: Mobile VR headsets are often the most cost-effective, followed by standalone and tethered headsets, which tend to be more expensive due to advanced hardware.

Selected Model: HTC Vive Pro 2 The HTC Vive Pro 2 was chosen for its exceptional performance and features, representing an advanced tethered VR headset suitable for various applications.

3.2 Body tracking in virtual reality

Tracking body movements in virtual reality allows transferring movements from the real world to the virtual environment, creating a more authentic experience. In our project, we integrate advanced body motion tracking, including optical motion sensing technology with HTC Tracker 3.0.

In virtual therapy, often only headsets and controllers are used, limiting tracking to the upper body. Our advanced method incorporates full-body tracking, enhancing the authenticity of the virtual experience.

There are several body tracking technologies in VR, including IMUs[1], depth sensors[4], optical motion sensing, EMG, magnetic tracking[6], ultrasound tracking, and camera-based systems.

For a comprehensive experience, we chose optical motion sensing technology with HTC Tracker 3.0, which enables full-body tracking with high accuracy and low latency.

HTC Tracker 3.0 offers a compact and lightweight design with wireless connectivity and infrared LEDs for precise tracking. The base station transmits infrared rays and uses triangulation for accurate position and orientation calculations.

Line-of-sight between tracking devices and base stations, optimal station placement, and accurate calibration are key to successful optical motion tracking in VR. HTC Tracker 3.0 with optical motion sensing delivers high accuracy, low latency and an immersive virtual reality experience.

3.3 POLAR H10: Heart Rate Monitoring

Heart Rate Variability (HRV) is crucial in psychology, offering insights into the autonomic nervous system. Psychologists use HRV to understand emotional states and stress levels, enhancing diagnostic accuracy. Integrating HRV into virtual reality therapy allows real-time monitoring of emotional reactions. Among heart rate monitoring devices, Polar H10 stands out for its accuracy and versatility.

4 Avatar tracking

Virtual reality enables users to embody virtual avatars from a first-person perspective, adapting their body image to various shapes, sizes, ages, ethnicities, or genders. Research in cognitive neuroscience reveals that this illusion of embodiment stems from multisensory correlations between real and virtual bodies, akin to the rubber hand illusion (RHI)[2]. When visual cues from the virtual body match physical sensations, such as touch and proprioception, the brain attributes them to a common source, leading to embodiment of the avatar. Spatial correspondence between virtual and physical bodies, even with static avatars, can induce strong illusions, but dynamic replication of movements in real-time enhances the effect. Embodiment in virtual avatars improves performance in VR scenarios, reducing cognitive load and offering potential applications in therapy, rehabilitation, education, and recreation.

We employ full-body tracking using 8 trackers: HTC Vive Pro 2 for the head and 7 HTC trackers for the legs, waist, and arms (2 on each arm and 2 on each hand).

We have obtained details on the Manus Dashboard, focusing on Manus Core 1.9.0—a tool for configuring tracking devices[1]. After connecting all devices and integrating them into Steam VR, we launched the Manus application.

On the ”Polygon” page, we create a user profile and ensure device connectivity in the ”Tracker” section. The interface simplifies this process, labeling inputs for body part identification.

4.1 Avatar creation

We then adjust avatar parameters to match user dimensions. Calibration involves two methods: step-by-step guidance or mimicking a white robot avatar's movements in VR. Users navigate using a hand-controlled button.

Different methods and software are used to create 3D avatars - 3D Laser Scanning, which uses laser triangulation, time-of-flight, etc.

In our efforts to use photogrammetry to create customized avatars for individual users within virtual reality (VR), we encountered problems that hindered the effectiveness of our system. Despite our best efforts, the process of generating avatars for each user proved to be time and resource consuming.

In order to optimize our approach, we made a strategic decision to streamline the creation of avatars. Instead of individual avatars for each user, we took a more practical approach and used only two avatars - one designed for male users and one designed for female users. To increase the realism and detail of these avatars, we sourced high-quality realistic models.

Utilizing pre-existing, carefully crafted avatars contributes to the overall efficiency and user satisfaction in our VR environment.

5 Recording video with 360-degree cameras

The essence of 360-degree videos lies in their ability to overcome the limitations of flat screens and immerse users into a truly surrounding experience. From the comfort of a VR headset, users can turn their heads in any direction and explore the intricacies of the captured moment as if they were physically present. This transformative capability has profound implications in various domains, ranging from entertainment and education to travel and training.

[1]MANUS Knowledge Center

In recent years, monoscopic 360-degree cameras have found new applications in the emerging field of virtual reality (VR). While stereoscopic 3D is often preferred for creating immersive VR experiences, monoscopic 360-degree cameras are valuable for capturing environments where depth perception is less critical. They are commonly used for VR video content creation, virtual tours, and live streaming of events in VR.

Advancements in camera technology have led to the development of compact and high-resolution monoscopic cameras capable of capturing stunning imagery in various conditions. These cameras are equipped with features such as image stabilization, high dynamic range (HDR), and advanced autofocus systems, making them suitable for a wide range of professional and consumer applications.

The Insta360 X3 is a monoscopic compact and versatile 360-degree camera designed for immersive panoramic recording. Its supplemented by two cameras positioned on opposite sides, it captures a complete view of the surroundings simultaneously, delivering high-quality video footage.

The integration of 360-degree video content into the Unity platform necessitates careful consideration of optimal methodologies. Upon thorough investigation, two viable approaches have surfaced. The initial method entails the creation of a spherical entity within the virtual environment, wherein the video content is mapped onto the surface material. Within this construct, the user assumes a position enveloped by the sphere, thereby facilitating immersive engagement with the content. However, a better alternative appears to be to set the video scene as a skybox, because then we have less visual artifacts.

6 VR application

6.1 Main Menu

The main menu scene serves as the initial interface visible only to the psychotherapist. Within this scene, the psychotherapist is offered the option to select an avatar, choosing between a male and female representation. A button to switch between avatars increases the flexibility of avatar selection. In addition, this scene facilitates the connection of a Bluetooth heart rate measurement device, namely the Polar H10, to the laptop running the app.

6.2 Preparation Room

The training room scene is designed with a dual view of both the psychotherapist and the user. The scene includes two distinct parts: one visible to the psychotherapist, which contains the menu, and the other experienced by the user.

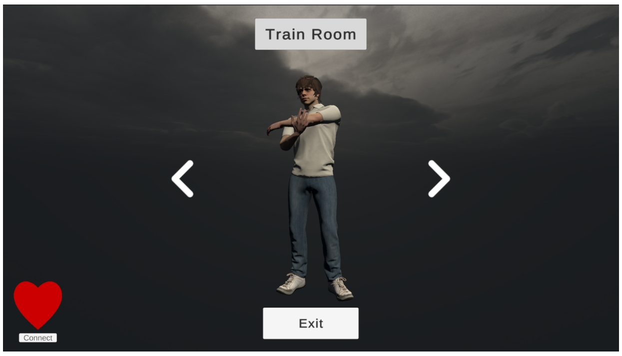

Figure 1: Main Menu scene

Figure 2: Preparation room scene: psychotherapist view

6.2.1 The psychotherapist's perspective

In the psychotherapist's interface, check figure 2, the menu offers basic functions:

Back button: Allows the psychotherapist to seamlessly return to the main menu scene.

Hide Menu Button: Facilitates the ability to hide the psychotherapist's menu, providing the user with an unobstructed view of their experience.

Scene overview image with arrow buttons: A visual display of the scene along with arrow buttons allows the psychotherapist to navigate between different perspectives. Clicking on the image loads the corresponding scene, offering a simplified selection process.

6.2.2 User experience

Upon entering the training room, the user finds themselves in a bedroom with various details, figure 3. Distinctive elements include a chair and a table that are decorated with various objects. To increase user engagement and adaptability, the user can touch and interact with the objects on the table, even throwing them.

The immersive environment encourages users to explore and gradually acclimate to the virtual reality environment. As the user engages with the room, the psychotherapist has ample time to reflect and select the next scene, which is consistent with the therapeutic process.

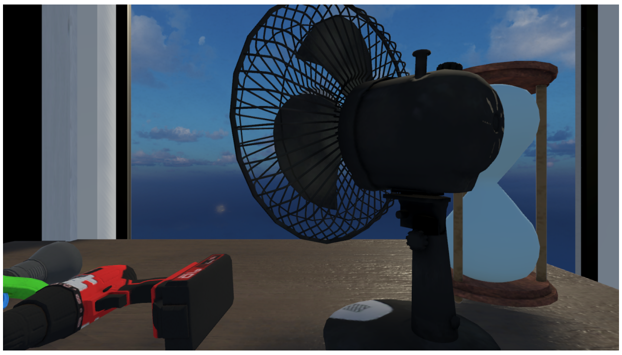

Figure 3: Preparation room scene: user view

Figure 4: Forrest scene

The thoughtful incorporation of interactive elements not only promotes user adaptation, but also serves as a valuable tool for the psychotherapist to gauge the user's comfort level before beginning a therapeutic intervention.

6.3 Forest Scene 3D

The forest scene is a relaxing place where the user can feel free in the forest, surrounded by nature, animals and pleasant weather with the sound of the wind.

Various pre-made elements from the Unity Asset Store were used to prepare the scene in the forest. A forest area with lots of different details and plants has been created, and the skybox has been changed. Other added details were rocks, stumps and altered forest sounds to add to the authenticity of the environment. Figure 4

One of the distinctive elements is the time dynamics. A script was created that steadily moves the light in the scene, creating a simulation of the progression of the day.

Another distinctive element is the addition of animals to the scene, which makes the environment even more realistic. Birds, squirrels, and butterflies were integrated into the scenery, which were obtained from the Unity Asset Store. Each of these assets had basic animations that were then used to create movement scenarios and animations for these animals.

To make it easier to write the paths that the animals move along, an object containing the script was created in the scene. This script is associated with a pre-made animal, for example a squirrel with a "move" animation. The script contains variables such as x, y, z position, rotation, clear time, and command line. The command line can be used to write commands to move the animal, for example: [L, 10, 4], [R, 90, 10]. These commands make two changes to the squirrel's movement, with each square bracket representing one command. The command [L, 10, 4] means to turn 10 degrees to the left in 4 seconds.

Another addition is the ability to create new animals at the same location with the same commands. This means that in a 30-minute intervention, a squirrel can take the same path as many times as we want.

6.4 City Scene 3d

The city scene, check figure 5, is designed with a more depressing atmosphere and depicts the drawbacks of an urban environment. This city scene is expected to be less comfortable compared to the forest scene.

Various pre-made elements from the Unity Asset Store were used to prepare the city scene, specifically the "Urban Construction Pack" which contains a large number of urban-themed elements. The visual content is dominated by buildings and elements typical of the urban outdoor environment, such as streets and traffic lights. Shades of grey predominate in the image, both in the foreground and in the background. The user sits close to the wall, from where he can see a road that extends straight ahead of him and another road that runs in a perpendicular direction.

The first important step was to add parked cars and cars moving further away. The various cars were obtained from the Unity Asset Store. To efficiently display the traffic in the city scene, a script was written that was able to create cars in positions at random time intervals from 7 to 15 seconds. These cars moved along the road, giving the impression of a realistic urban traffic flow.

The goal of adding the moving cars was to increase the dynamism and authenticity of the city scene. In this way, the user experiences the city not only as a static environment, but also as a place with a vibrant urban movement. The cars, which appear and move according to random time intervals, add an element of unpredictability to the scene and at the same time enliven the overall impression of the urban environment.

Another detail was the addition of trash cans, which were also obtained from the Unity Asset Store. Rats were also added; some are "static" and simulate that they are looking for something next to the trash cans. There is also another type of rat that spawns at some intervals and runs a certain route. As with the squirrels, a script was used with the same approach, in which the animal's position, rotation and movement commands could be entered. An array of strings was also added to indicate the times when the rat was to be created in the scene.

It is important to mention that all these created scenes were in accordance with psychologists from the Faculty of Social and Economic Sciences (FSEV), who will conduct interventions with VR therapy designed in this paper.

Figure 5: City scene

6.5 Forest Scene 360-degree video

We employ an Insta360 camera system. Resulted in a thirty-minute long panoramic video, crafted to encapsulate the serene beauty of the ancient forest. Subsequently, employing Adobe Premiere Pro 2020, we enhanced the vibrancy and contrast of the video, enriching the viewer's immersive experience. Finally, the video was integrated into a skybox of scene.

6.6 City Scene 360-degree video

Utilizing an Insta360 camera, we got a 30-minute long video encompassing the city's center. Subsequently, the preparatory steps undertaken to integrate this footage into Unity mirror those employed for the creation of our forest 360-degree video.

7 3D scene vs. 360 video

In this section, we will undertake a comparative analysis between 360-degree video and 3D scenes.

First, we will discuss the disadvantages associated with 360 video technology. First of all, it is worth emphasizing the significant file size due to the high resolution inherent in such videos. Rendering these videos can be a computationally intensive task, often requiring around 5-10 hours, even when using high-performance eight-core processors. However, this temporary investment becomes trivial if we have the necessary time to prepare.

The primary concern lies in the recorded resolution, typically set at 5.7K, and the perceived quality experienced when using Head Mounted Displays (HMDs). Despite the seemingly high resolution, the visual fidelity observed through HMDs frequently fails to meet expectations. Additionally, the inherent monoscopic nature of these videos precludes the simulation of depth perception, thereby diminishing the immersive potential. While the integration of stereoscopic cameras offers a potential remedy to this issue, the high associated with such equipment, ranging from 5000 to 6000 EUR, present a significant barrier to widespread adoption. Moreover, even with the deployment of these advanced cameras boasting resolutions up to 8K, the resultant quality remains suboptimal, failing to fully capture the desired immersive experience.

Furthermore, initial tests revealed a problem regarding the integration of three-dimensional models into the spherical structure of 360-degree videos. If a 360-degree video is within a sphere or created as a skybox, discrepancies arise when incorporating avatar bodies, where the spatial alignment of rendered elements appears incongruous within the scene. It seems as if the legs are not touching the ground. Additionally, perceptual anomalies arise when viewers direct their gaze downwards, wherein visual distortions lead to objects appearing disproportionately larger than anatomical elements, further compromising the immersive fidelity. These discrepancies are indicative of challenges inherent between two-dimensional video elements and three-dimensional objects within the context of a spherical environment.

In preliminary study we have tested both 360 and VR forest scenes with 5 participants. All of the 5 participants perceived the VR scene as more immersive, calming and possessing higher resolution. We are planning to carried out a user study with more participants to further validate our findings and assess any potential differences in the perception of different types of natural scenes in virtual reality environments.

8 Rotating chair for scenes

For better quality testing, psychologists added a chair on which the user can turn around. So then in each scene, the user will be situated in a chair capable of full 360-degree rotation. Consequently, it is imperative to incorporate this functionality within the application. Initially, we identified a suitable 3D chair model from the Unity Asset Store for seamless integration into the interactive environment. With the chair model now integrated into our scene, the primary challenge lies in enabling its rotation to coincide with the user's movements, thus simulating realistic behavior.

To address this challenge, we devised a solution leveraging two box colliders. The first collider is strategically positioned at the avatar's posterior, aligning with the optimal location for chair alignment. Subsequently, the second collider is placed on the chair itself. The mechanics operate as follows: upon collision detection between these two colliders, indicative of the user's seated position, the chair emulates rotational orientation along the y-axis of the collider situated at the avatar's posterior. This method facilitates seamless synchronization between the user's movements and the chair's rotation, thereby augmenting the realism of the simulation.

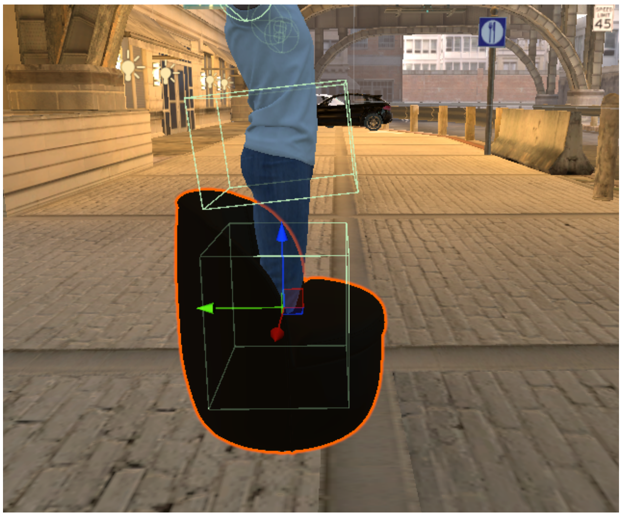

Figure 6: Chair & Avatar with colliders

The actual chair is virtually aligned during the initial calibration of the system and is positioned and rotated identically at the start of each intervention.

9 Future work

The developed therapy application is been currently used in interventions with participants across diverse demographics by doctoral students of the Faculty of Social and Economic Sciences COMENIUS UNIVERSITY BRATISLAVA (FSEV UK) for their applied psychology research. The undergoing study will include more than 50 participants and the results will be available in late 2025.

10 Conclusions

In this study, we embarked on an exploration of virtual reality (VR) environments and their potential implications for mental well-being. By contrasting 3D scenes with 360-degree videos, we aimed to shed light on the nuanced differences between these modalities in eliciting emotional responses and promoting relaxation.

Our preliminary investigation revealed several key findings. Firstly, while 360-degree videos offer immersive panoramic experiences, their limitations in capturing depth perception and spatial relationships challenges in delivering truly immersive environments. The integration of stereoscopic cameras may present a solution, albeit at a considerable cost. Conversely, 3D scenes afford greater flexibility and dynamic control over environmental elements, albeit with computational demands and potential fidelity limitations. Additionally, it's imperative to validate these findings through more extensive user studies. While our research underscores the importance of interactive elements within 3D scenes for fostering user engagement and immersion, further investigation is necessary to confirm these observations. Additional research is warranted to substantiate these claims and refine our understanding of their impact.

Unlike previous approaches/articles, we have added full-body tracking for better immersion.

The completed application has been forwarded to the researchers at FSEV UK.

References

[1] Javier González-Alonso, David Oviedo-Pastor, Héctor J Aguado, Francisco J Díaz-Pernas, David González-Ortega, and Mario Martínez-Zarzuela. Custom imu-based wearable system for robust 2.4 ghz wireless human body parts orientation tracking and 3d movement visualization on an avatar. *Sensors*, 21(19):6642, 2021.

[2] Mar Gonzalez-Franco, Brian Cohn, Eyal Ofek, Dalila Burin, and Antonella Maselli. The self-avatar follower effect in virtual reality. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pages 18–25, 2020.

[3] Margaret M. Hansen, Reo Jones, and Kirsten Tocchini. Shinrin-yoku (forest bathing) and nature therapy: A state-of-the-art review. *International Journal of Environmental Research and Public Health*, 14(8), 2017.

[4] Belinda Lange, A Rizzo, Chien-Yen Chang, Evan A Suma, and Mark Bolas. Markerless full body tracking: Depth-sensing technology within virtual environments. In *Interservice/industry training, simulation, and education conference (I/ITSEC)*, 2011.

[5] Grace Y.S. Leung, Hadar Hazan, and Christian S. Chan. Exposure to nature in immersive virtual reality increases connectedness to nature among people with low nature affinity. *Journal of Environmental Psychology*, 83:101863, 2022.

[6] Gabriele Ligorio, Elena Bergamini, Ilaria Pasciuto, Giuseppe Vannozzi, Aurelio Cappozzo, and Angelo Maria Sabatini. Assessing the performance of sensor fusion methods: Application to magnetic-inertial-based human body tracking. *Sensors*, 16(2), 2016.

[7] Marilia K. S. Lopes, Belmir J. de Jesus, Marc-Antoine Moinnereau, Reza A. Gougeh, Olivier M. Rosanne, Walter Schubert, Alcyr A. de Oliveira, and Tiago H. Falk. Nat(ur)e: Quantifying the relaxation potential of ultra-reality multisensory nature walk experiences. In *2022 IEEE International Conference on Metrology for Extended Reality, Artificial Intelligence and Neural Engineering (MetroXRAINE)*, pages 459–464, 2022.

[8] Paul Milgram, Haruo Takemura, Akira Utsumi, and Fumio Kishino. Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies*, volume 2351, pages 282–292. Spie, 1995.

[9] Norimasa Takayama, Takeshi Morikawa, Kazuko Koga, Yoichi Miyazaki, Kenichi Harada, Keiko Fukumoto, and Yuji Tsujiki. Exploring the physiological and psychological effects of digital shinrin-yoku and its characteristics as a restorative environment. *International Journal of Environmental Research and Public Health*, 19(3), 2022.

[10] Xiaobo Wang, Yaxing Shi, Bo Zhang, and Yencheng Chiang. The influence of forest resting environments on stress using virtual reality. *International Journal of Environmental Research and Public Health*, 16(18), 2019.

[11] Chia-Pin Yu, Hsiao-Yun Lee, and Xiang-Yi Luo. The effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban Forestry & Urban Greening*, 35:106–114, 2018.