VR Stage Rehearsal Application

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Content

This thesis aims to introduce the design, development and implementation of a speech training application based on virtual reality technology. We will explore the potential applications of virtual reality in speech training and how this technology can be used to improve a speaker's performance and confidence. In addition, we will discuss the design and user experience of the app, as well as the effectiveness evaluation in actual presentation training.

1. Introduction

1.1 Background and research motivation Background:

Public speaking is an important skill in interpersonal communication, and it plays a key role both in the workplace and in everyday life. A good speaker is able to effectively communicate information, build trust, and inspire emotion, which is essential for a successful career and social interaction. However, many people face issues such as speech anxiety, poor performance, and low self-confidence that can prevent them from reaching their full potential.

Traditional methods of speech training usually include classroom training, speech coaching, and self-practice. While these methods can help improve presentation skills, they have some limitations, such as high cost, time constraints, and limited opportunities to practice. In addition, speakers may find it difficult to realistically simulate speech scenarios, which prevents them from adequately preparing for different audiences and environments.

Research motivation:
In the context of the rapid development and wide application of virtual reality (VR) technology, it is expected to provide more effective training and support for speakers

through VR. First, with regard to speech anxiety management, which is a problem faced by many people, virtual reality can provide a realistic and controllable environment for speakers to gradually get used to the stress of speaking and help them better manage their anxiety.

We will design a variety of speech scenes, virtual reality can simulate a variety of speech scenes, including large conferences, academic lectures, sales speeches, etc., so that speakers can practice in different situations and improve their adaptability. In addition, real-time feedback and evaluation are also difficult to achieve in reality. Virtual speech training apps provide real-time feedback, including speed, tone, and body language Information on speech and other aspects to help the speaker improve in time.

Not only that, VR software can provide a learning experience that can be personalized, and virtual reality allows speakers to tailor training to their needs and level of progress, providing a more personalized learning experience. Finally, compared with traditional speech training, virtual speech training can reduce the training cost and enable more people to get high-quality speech training.

Virtual reality offers an innovative solution for speech training that can effectively address the challenges faced by speakers and improve their presentation skills and confidence. Therefore, the motivation of this study is to explore and implement a virtual reality speech training application to help speakers face different speech scenarios and audiences in a more confident and competent state.

1.2 Research objective and problem statement

Research objectives: The main objective of this research is to design, develop and implement a virtual reality-based presentation training application that will utilize Unity as a development platform. Specifically, the objectives of the research include:

Design a realistic virtual speech training environment: Create a virtual world capable of simulating a variety of speech scenarios, including different audience sizes, different speech venues and environmental Settings to provide a variety of practice opportunities.

Implement real-time feedback and evaluation features: Develop app features that provide instant presentation feedback, including language, pronunciation, presentation, and body language assessments, to help speakers improve their presentation skills.

Personalized Learning Experience: Allows users to customize training Settings and goals based on the speaker's needs and level of progress to provide a more personalized learning experience.

Evaluate the effectiveness of the application: Evaluate the effect of the virtual speech training application on the speaker's speech skills and self-confidence through experiments and user tests to determine its actual effect in speech training.

Problem statement: In the process of achieving the above research objectives, this study will address the following key questions:

How to design and create a realistic virtual presentation environment? This includes the challenges of choosing the right VR technology, modeling speech scenes, and creating virtual audiences and environments.

How to implement real-time feedback and evaluation? Research is needed to determine which aspects of speech need to be evaluated and how virtual reality technology can be used to capture and analyze this data. How to provide a personalized learning experience? Research needs to develop a user-friendly community It allows speakers to customize training Settings according to their needs and goals.

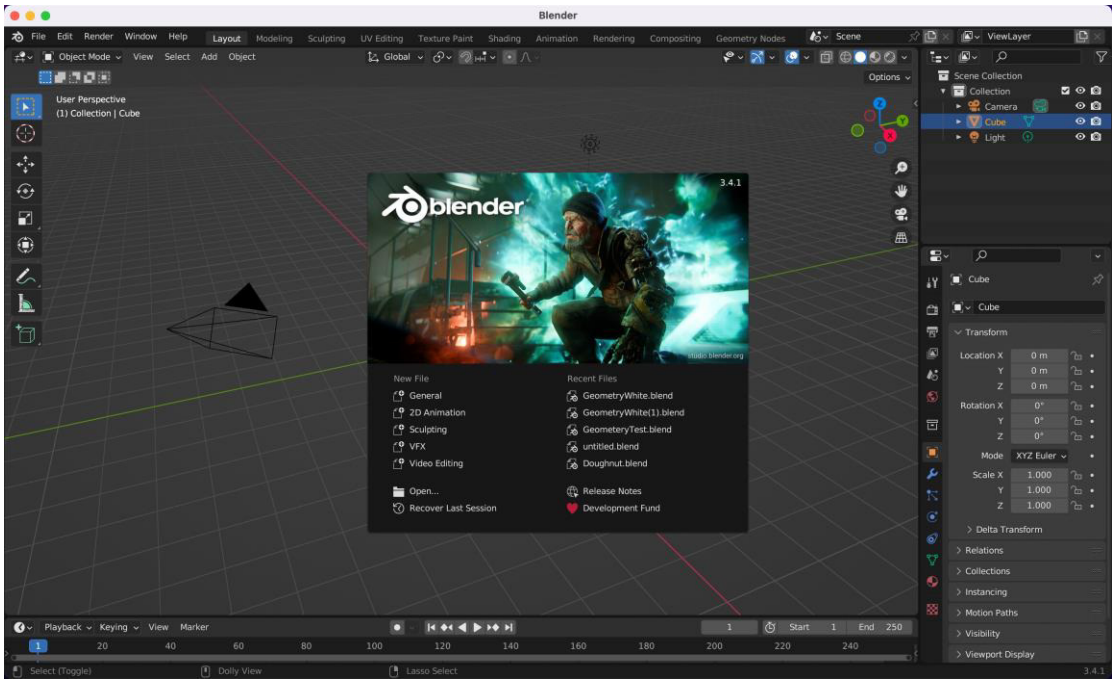
What effect does virtual speech training have on speakers' presentation skills and confidence? This study will evaluate the effectiveness of the application through experiments and user feedback to determine its practical value in speech training.

By addressing these questions, this study aims to provide speakers with a powerful virtual speech training tool to help them overcome speech anxiety, improve their presentation skills, and perform more confidently in speech scenarios. At the same time, using Unity as a development platform will provide the foundation for technical implementations to achieve these goals.

2. Virtual reality technology and tools

2.1 Overview of virtual reality technology

Virtual Reality (VR) is an advanced computer technology designed to simulate and create an immersive experience that interacts with the real or fictional world. VR technology typically involves the creation of three-dimensional virtual environments that allow users to move through a head-mounted display, hand, etc Devices such as handles and sensors interact with these environments in real time. In our research, we used Blender for modeling and Unity, Visual Studio, etc. for development, and finally HTC Show it on Vive.



(Figure 1)

2.2 Virtual reality hardware and software tools

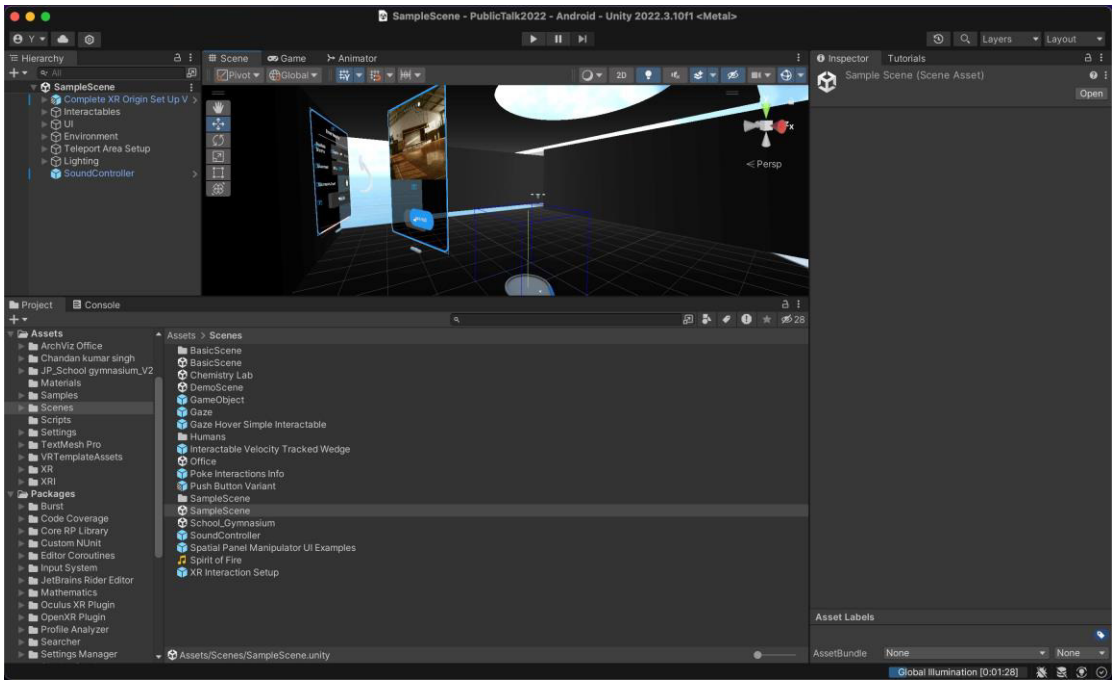
Virtual Environment Modeling (Blender): Blender is a free, open source 3D modeling and animation software that can be used to create scenes, objects and characters in virtual environments. Pass Blender allows you to design realistic presentation scenes,

virtual audiences, podium and environmental elements to provide an immersive presentation training experience.

Virtual Reality Device (HTC Vive): allows users to perceive and interact with virtual environments. The device provides high-resolution displays, panoramic viewing angles, spatial tracking and touch control to enhance the realism of virtual reality. At the same time, the device has an eye-tracking function, which can be used to evaluate the feedback of the speaker's performance.

Real-time rendering and physics simulation: Unity as a game engine provides powerful real-time rendering capabilities to render realistic virtual environments. It also supports physical simulation, including collision detection, object interaction, and natural physical behavior, making virtual environments more realistic.

3D sound: Virtual reality also includes 3D sound technology that simulates sound based on the user's position and orientation in the virtual environment. This can increase immersion, for example in speech training applications that simulate vocal feedback from audiences in different locations.



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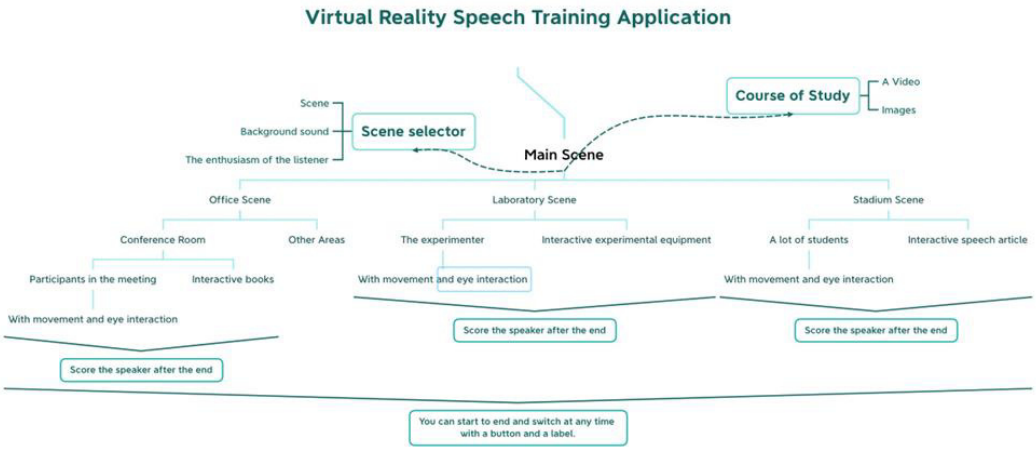
3. Design and development of virtual speech training application

3.1 User requirements analysis



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Our analysis of user requirements includes two main aspects: functional requirements and non-functional requirements. Functional requirements relate to the functionality, features, and operation of the application, while non-functional requirements focus on the performance, availability, security, and so on of the application.

For functional requirements, we cover scene selection: users can select different presentation scenarios from offices, LABS and gymnasiums to suit their specific needs. This requires virtual environment modeling, and the application needs to be able to accurately model and render each scene, including the physical layout of the scene, objects, and viewers. For the user's speech practice, in the VR application, the user should be able to conduct actual speech practice, including the recording and playback of the speech content, as well as the interaction of the virtual audience. This requires us to design and develop the movements and eye interactions of the virtual audience.

Our analysis of users' non-functional needs includes practicability and reliability: In the voice training end of the voice training system, in order to enhance the user's sense of experience and create immersive virtual reality experience for users, it is necessary to use more advanced virtual reality head-mounted display equipment to connect with the

host with higher configuration, the display picture is clear and smooth, and there will be no stuttering phenomenon The user will not be affected by external interference during the entire training process.

In addition, for maintainability, our system is hot updated. The so-called hot update is to achieve timely updates while the system is running, without requiring users to download and run new programs. All UI components and scene models in the system need to be loaded dynamically.

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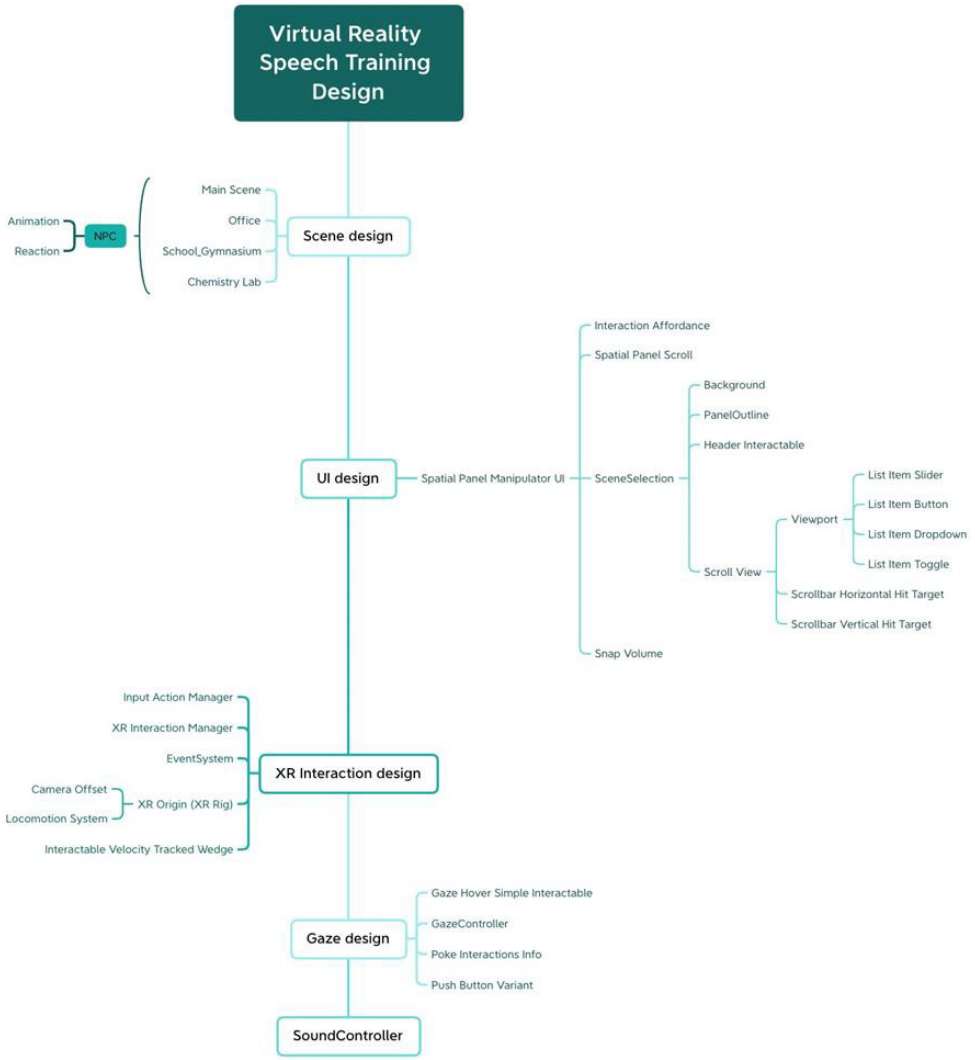
3.2 Application Architecture and Functions



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Overall, the design of the application is divided into five parts, namely Scene design and UI design, XR Interaction design, Gaze design and Sound Controller design. For the Scene design part, we designed four scenes, which are Main Scene, Office, School_ Gymnasium and Chemistry Lab. among The Main Scene is the first scene that the user will enter, and it contains a graphic tutorial and a video demonstration tutorial that will explain the entire application. In addition, the Main Scene contains selection capabilities for the remaining three scenes. Depending on the user's needs, they can access Office, Lecture in the School_ Gymnasium or Chemistry Lab.

In the UI design part, we designed a four-layer architecture to complete the standardized

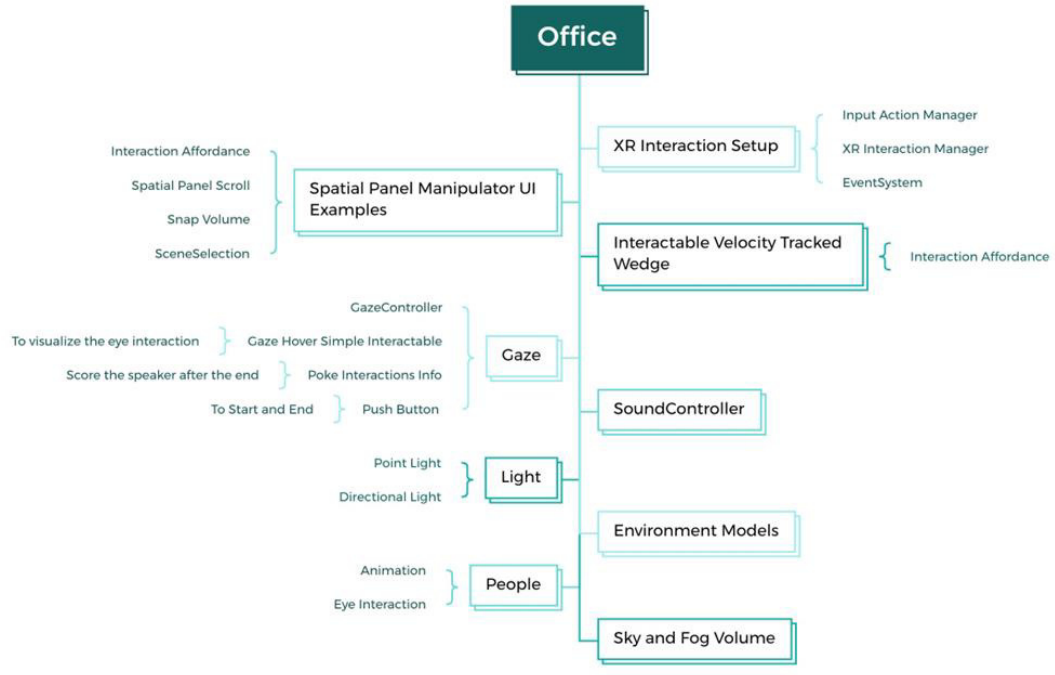
UI design in VR List Item Slider, List Item Button, List Item Dropdown, and List Item Toggle.

For XR Interaction design, we designed five parts, which are Input Action Manager, XR Interaction Manager, Event System, XR Origin (XR Rig) and Interactable Velocity Tracked Wedge. These modules influence each other and work together.

Gaze design is a part of the design for the interaction between the audience and users in virtual reality, focusing on the interaction of the eyes, the rating of speeches in virtual reality and other feedback to the players. The final Sound Controller uses 3D sound to truly simulate a real ambient sound, giving the user the feeling of being there.

By combining Blender's modeling capabilities with Unity's development environment, we have implemented a powerful virtual presentation training application to help speakers improve their presentation skills and boost their confidence. The user can choose the following three scenarios:

Office:



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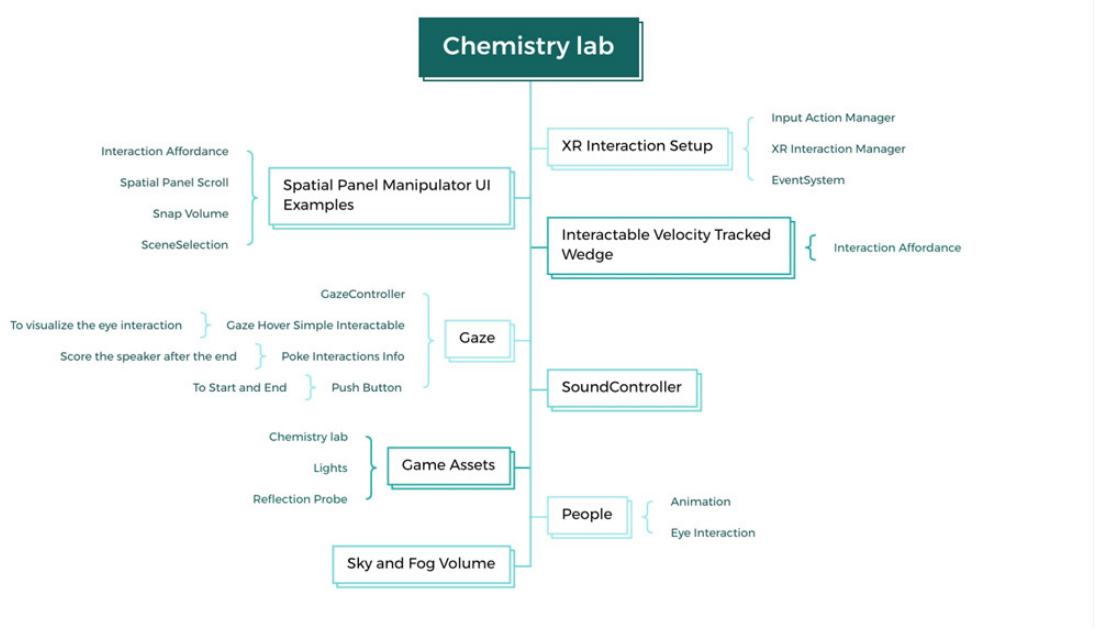
The office scene simulates a typical office environment, including desks, chairs, computers, filing cabinets, and other office furniture. This scenario provides users with a suitable opportunity to practice speaking in a work environment.

Challenges and goals: In an office scenario, users can practice presentation skills in small team meetings, business presentations, or workplace situations. Challenges may include how to communicate effectively with colleagues or superiors, explain complex work assignments or projects, and maintain a professional presentation style.

Chemistry lab:



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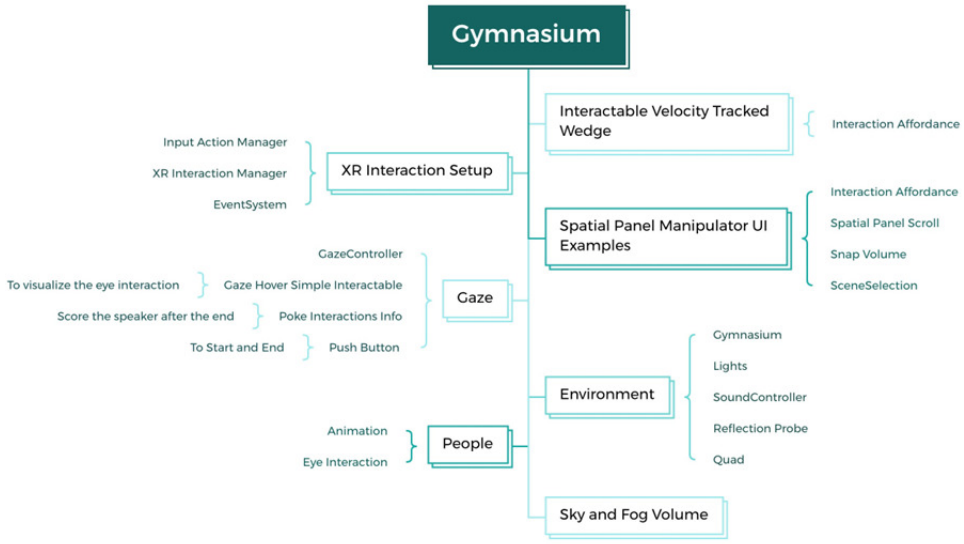
Laboratory scene: The laboratory scene simulates a scientific research laboratory,

including an experimental bench, scientific instruments, computers and research equipment. This scenario is suitable for users to practice their skills in giving presentations in academic or scientific fields.

Challenges and goals: In lab scenarios, users can practice how to communicate complex research results, experimental methods, and scientific findings to colleagues, research teams, or audiences in academia. Challenges may include clearly articulating the purpose of the experiment, interpreting data and results, and answering questions in the area of expertise.

Gymnasium:



(Figure 10)

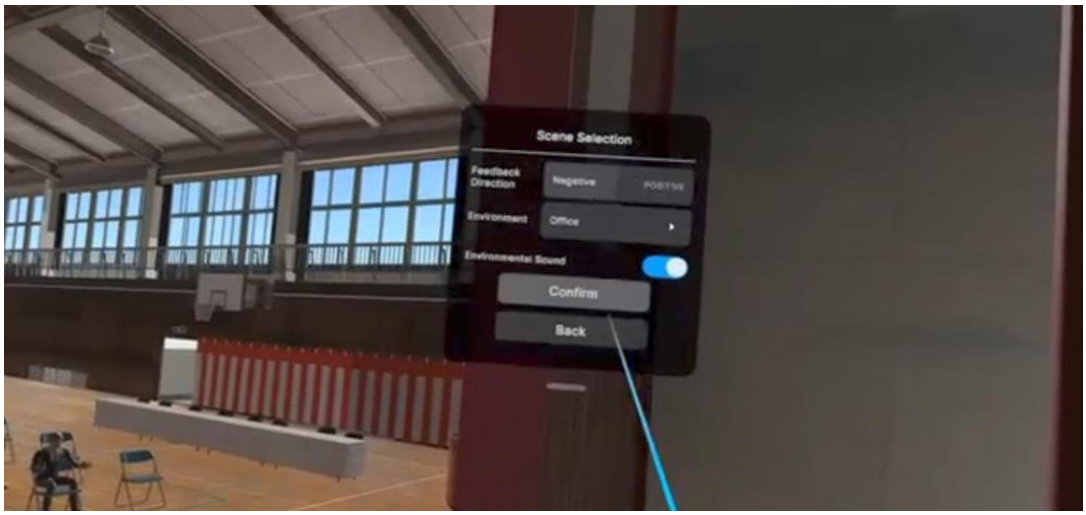
Stadium scene: The stadium scene simulates a large indoor stadium, including stands, basketball courts, sports equipment and large screens. This scenario presents the user with the challenge of speaking in front of a large audience.

Challenges and goals: In a stadium scenario, users can practice how to attract and manage the attention of a large audience, such as promoting a sporting event, hosting a concert, or speaking at a large event. Challenges can include maintaining high-energy

presentations, interacting with audiences, and getting the message across in large venues.

Each scenario offers unique presentation opportunities that help users personalize their training according to their interests and needs. This variety allows speakers to practice their presentation skills in different situations, improving their performance and confidence. This is a very valuable feature that allows users to be well prepared for a variety of speaking occasions.

In each scenario, users can choose from two modes of speech training: One is autonomous training mode, users can choose their own speech theme and speech scene, control the speech duration, and choose whether to conduct relaxation training according to their own situation;



(Figure 11)

In each scenario, users can choose from two speech training modes: The first one is independent Training Mode: Users have the option to choose their own speech topics and settings, control the speech duration, and decide whether to engage in relaxation training based on their own preferences; the second oneis monitoring mode: The entire training process is monitored by the system personnel. These monitors can oversee the trainee's state in both real and virtual scenarios in real-time. They can also intervene in the training process based on the trainee's performance. This intervention includes

selecting speech topics and settings for the trainee, controlling the training duration, providing real-time assessments of the trainee's performance, and giving an overall performance rating.

In the positive feedback mode, the audience pays closer attention and exhibits behaviors such as applause during and after the speech. Conversely, in the negative feedback mode, the audience is more distracted and may boo or express disapproval during and after the speech. This feedback helps users adapt to various complex environments in advance, enabling them to better acclimate to real speech environments.

3.3 User interface design

User interface design plays a key role in virtual speech training applications because it directly affects the user experience and interaction. The following is a detailed description of the user interface design, including user selection of audience feedback and environmental influence factors:

User selection Audience feedback:

In the main interface or Settings page of your speech training app, you should include an option for users to select audience feedback. This option can be used to let users choose the nature of audience feedback before each presentation exercise. Consider the following factors when designing this interface:

Sliders or selectors: Use sliders or selectors to represent the nature of audience feedback. Users can swipe or tap to select positive feedback, negative feedback, or some value in between. Text description: Provide a short text description for each choice to help users understand the meaning of the different choices. For example, positive feedback may include applauding and positive reactions from the audience, while negative feedback may include booing and unsatisfied reactions from the audience.

Visualizations: ICONS, colors, or other visualizations can be used to highlight user choices to increase the intuitiveness of the user interface

User selection of environmental impact factors:

In the Settings page of the speech training app, you should include the option for users to select environmental influences to allow users to customize the virtual speech environment. Here are some considerations for designing this interface:

Environmental Parameters Slider: Use the slider or input box to let the user adjust environmental parameters such as brightness, color temperature, sound intensity, etc. Users can customize these parameters by swiping or entering numeric values.

Preset options: Provide some preset environment configuration options, such as bright gymnasium, warm room, quiet meeting room, etc., for users to choose quickly.

Real-time preview: When you adjust environment parameters, you need to provide a real-time preview so that you can see the impact of environment parameter changes on the virtual environment. This helps users get a better feel for the virtual environment.

Save and Load: Allows users to save their preferred environment configuration and load it later in the presentation practice. This allows users to easily switch between different environment Settings.

Reset option: Provides a reset option that allows users to reset environment parameters to their default values at any time.

These interface design elements will enable users to customize the virtual presentation environment, setting it up according to their preferences and training needs. This not only increases the user's interactive experience, but also provides a more realistic speech training environment, which helps users better cope with the challenges of different situations.

3.4 Data Acquisition and Processing

In virtual speech training applications, data acquisition and processing are critical because they provide users with personalized feedback and assessments that help improve their presentation skills. The following is a detailed explanation of data acquisition and processing, including the processing of audio and eyeball interaction data:

Audio data acquisition and processing: Audio recording: The application needs to be able to capture the audio of the user's speech. This can be recorded via a microphone on a virtual reality device. The recorded audio data should include the speaker's voice as well as various background sounds.

Data Privacy and security: The privacy and security of the user's audio and eyeball interaction data must be ensured during data collection and processing. This includes taking appropriate measures to encrypt and protect data from unauthorized access.

Data storage and backup: The collected data needs to be stored and backed up effectively to prevent data loss. The backup data can also be used to track the user's learning history and progress.

4: Design and development of speech feedback system based on eye tracking

4.1 Hardware

Support Eye-tracking devices: In order to collect eye-interaction data, apps need to be integrated with hardware that supports eye-tracking technology, such as the eye-tracking sensor in HTC vive pro's virtual reality head-mounted display.

4.2 Scoring principles:

100 points: Presentation performance is expressed on a scale of 0 to 100, with 100 representing perfect performance. Point system: Users start with a low initial score and increase their score through continuous improvement and practice, encouraging active participation and skill improvement.

4.3 Scoring factors and weights:

Gaze logging (70%): The application can record the user's gaze data, that is, the location and object of the user's attention in the virtual environment. This helps analyze the distribution of the user's attention during the presentation. When the user's attention is

focused on the audience but not elsewhere (e.g., looking down, squinting, looking up, etc.), the program records how long the speaker is focused on the audience and gives the user points based on the proportion of that time. Users often establish direct eye contact with the virtual audience, which increases the sense of interaction with the audience, so bonus points.

Eye movement analysis (30%) : Analyzing the user's eye movement patterns, including saccades, gaze duration, and gaze sequence, to determine the user's focus during the presentation. Steady eye contact is important for speech performance, but always looking in a fixed position can make a speech rigid. Therefore, appropriate scanning will increase the vividness and interest of speech performance. The program records the user's eye movements, such as saccades, and gives them points based on their proportion of total eye movements.

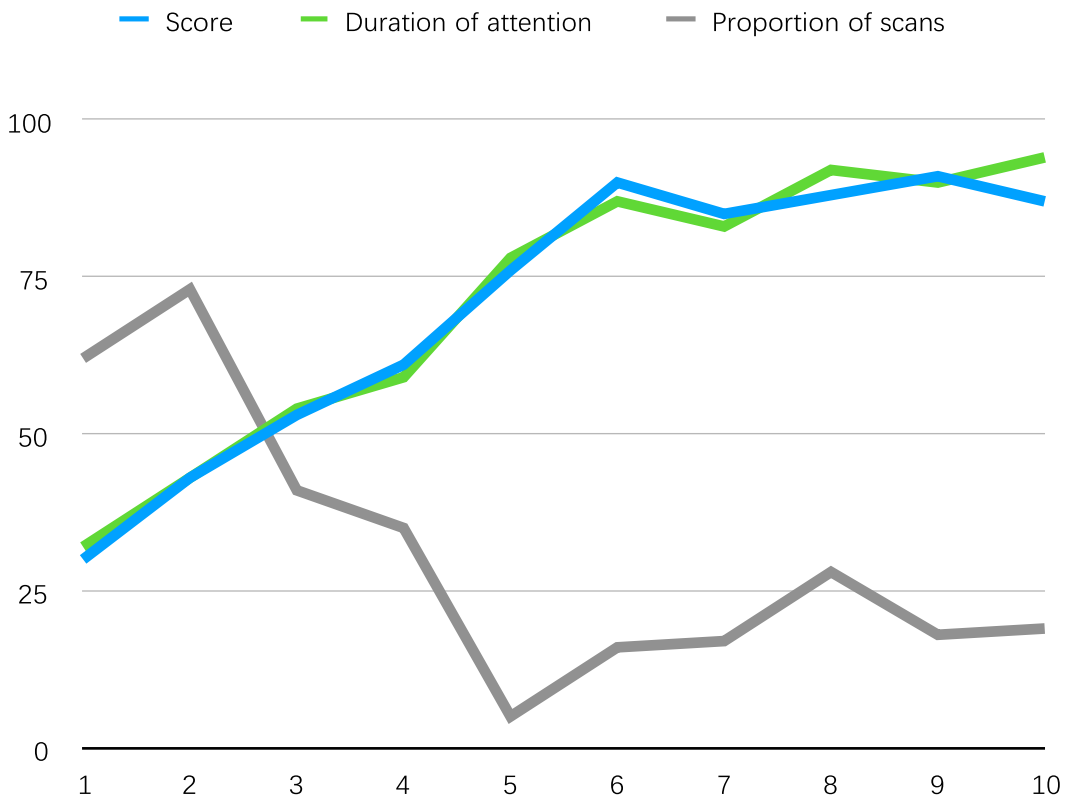
After our test, about 20% of the saccade behavior of the speech performance is the best, of course, for different scenes, this proportion is not constant. For example, in our three scenes In the study, the proportion was: 10%(Chemistry Lab), 15%(Office),20%(School_ Gymnasium).Therefore, it is not that the more the proportion of saccades, the more points, but the need to fit the appropriate proportion.

4.4 Feedback and evaluation

Using eye-interaction data, we provide users with powerful feedback tools to help them better understand their visual behavior in virtual speech scenarios. This can not only improve the user's self-awareness, but also help them improve their presentation skills. The app shows the user's gaze time, which is the length of time they look at a specific area during a virtual presentation. This data not only helps users understand their focus, but also serves as a starting point for improvement. The virtual speech training app provides users with real-time ratings of their speeches. The initial rating may be low, but it will gradually increase as users practice repeatedly to encourage them to keep improving.

For different scenarios, we also provide feedback according to specific criteria. For

example, offices and laboratories, these indoor Settings often require more formal and professional presentation skills, so the application encourages the user to maintain a steady line of sight, provide clear expression and confident posture. In the gym, speaking usually requires more confidence and movement. The app encourages users to show more confidence and vivid expression in the big scene, and the feedback of eyeball interaction pays more attention to the confidence and movement of the speech.



(Figure 12)

Through personalized feedback and scoring mechanisms, we test data for Office scenarios as shown above, and virtual speech training apps can help users understand their own presentation performance, gradually improve their skills, and show more confidence and vivid expression. This not only helps speakers overcome their fears, but also enables them to perform better in a variety of speaking environments.

5. The implementation of virtual speech training application

5.1 Application testing and optimization

We conducted the following tests:

Functional test: Unit tests: We perform unit tests to verify that the various functional modules in the application are required to function properly. This includes testing functions such as user selection of scenes, audience feedback, and environmental impact.

Integration testing: The integration relationship between different modules is tested to ensure that they can work together and ensure functional consistency across the application.

User scenario testing: Simulate the use of users in different scenarios to ensure that the application can work properly in various scenarios. Test scenarios include offices, laboratories, and gymnasiums.

Performance test: Load testing: We test the performance of the application when processing multiple users or large amounts of data simultaneously. This can help determine the application's performance limits and potential bottlenecks. For example, for the stadium scene, we drastically reduced the number of people and modified some movements to make it run smoothly.

Response time testing: Tests the response time of the application to ensure that users do not experience unreasonable wait times when using the application.

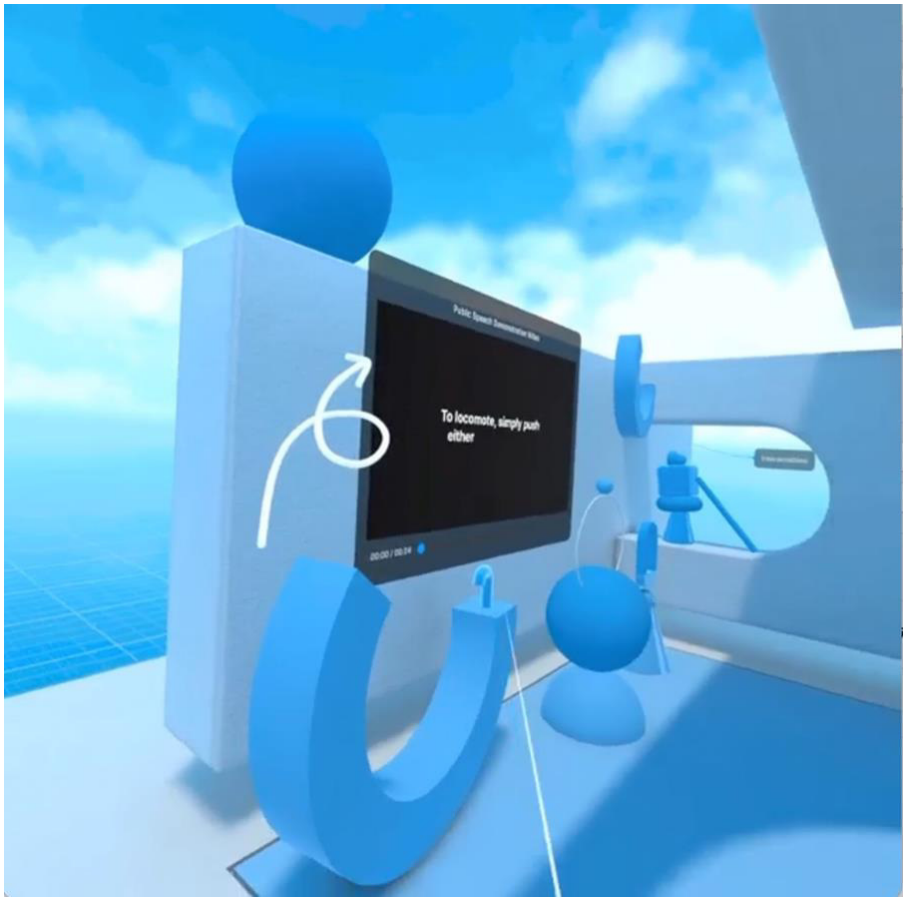
Frame rate testing: For virtual reality applications, check the framerate stability of the application on different hardware (Oculus quest2, HTC vive pro, etc.) to ensure a smooth virtual experience.

5.2 User training and support

Sample speech videos:

Purpose: In the main interface scenario, we provide a demo video of the presentation, the purpose of which is to let the user understand how the application works and how

to use it. Demo presentation videos can demonstrate the basic features of the app, such as scene selection, audience feedback, and environmental impact Settings, while demonstrating how to improve the application Practice effective speech.



(Figure 13)

Content: A sample video can include a demonstration of a virtual speech scenario, including a virtual corner for the user How color interacts with the audience, how to adjust environmental parameters, etc. Videos can also show how users can use the feedback and assessments provided by the app to improve their presentation skills.

Easy to access: Demo videos of presentations are easy to access and users can watch at any time, whether they are using the app for the first time or when they need help or review.

Pictures related to the scene:

Purpose: In the main screen scene, we have added scene related introduction images, the purpose of which is to provide the user with information about each selectable scene.

These pictures can help users understand the characteristics and uses of the scene so that they can choose according to their needs.

(Figure 14)

Content: The introductory images for each scene can include information about the visual effects of the scene, a description of its use, possible challenges, and applicability. This helps users choose the scenario that best suits their training needs.
Visualization: Through the combination of images and words, convey information in a visual way, so that It is easier for users to understand the characteristics of the scene.

6. Discussion and future work

6.1 Research findings and discussion

In this study, I conducted autonomous testing and evaluation of virtual speech training applications and collected some initial feedback from autonomous testing and previews. Here's a detailed discussion of my findings: Based on repeated self-testing and previews, the overall user experience is relatively good, and the software runs smoothly. Virtual speech environment has a high sense of reality and can provide audience feedback effectively. However, there is still room for improvement in the interface, such as more intuitive controls such as speech length Settings and more customization options that are currently not covered.

In terms of scene selection, considering that different users have different experiences and preferences for different scenes, we also designed different scenes for this purpose. The scope of the office scene is smaller and will be more question-and-answer oriented, so the voice requirements for the speaker are not very high, more interactive. The gymnasium scene is more inclined to exercise confidence and expression in speech, and has higher requirements for the speaker's voice and body movements. These preference designs help us better understand the appeal of different scenes to users, and also make it easier for users to choose their own scenes for training, so that the training results are more effective, and can help overcome stage fear.

6.2 Application limitations and room for improvement

While our virtual speech training app has had some success in initial testing, we're also honest to admit that there are some limitations that need further improvement:

Due to the limited number of participants in the autonomous test and preview, there are no more experimental samples, which may affect the credibility of the study. In the future, we plan to expand the sample size to more fully evaluate the performance of the application and to have access to more data.

At the same time, the user feedback will also be more realistic, such as different feedback for more detailed speaker data during the speech, applause enthusiasm, emotional giving, and so on. The performance of simultaneous applications may be affected by different virtual reality hardware platforms. For HTC vive focus 3, our application performs well, but for some other devices whose performance is not strong enough, our application will have problems such as stalled, flash back, especially in the stadium scene, due to large resources, similar problems occur frequently. We need to further optimize the application to ensure compatibility and performance stability across different devices.

6.3 Future work and development direction

Based on our initial research and findings, we have identified some directions for future work and application development: First of all, we plan to expand the sample size of participants, and we will convene volunteers to experience in the future research process. In order to collect better user feedback, we will also design questionnaires to collect user information and feedback on experience. To more fully assess your application's performance and user satisfaction.

At the same time, we will continue to improve the user interface of the app to provide more intuitive and easy-to-use controls and allow more customization options to meet the needs of different users. In terms of initial user instructions, we will also provide user training that is not limited to simple videos and graphics. In terms of data analysis and feedback improvement, we will continue to optimize the data analysis and audience feedback mechanism, and break down the scoring system in more detail to provide more accurate and targeted speech suggestions.

And we plan to increase the compatibility of applications, optimize scene resources, and do targeted optimization for scenes with more resources such as stadiums to support more virtual reality hardware platforms to expand the user base. We are also facing some challenges in data processing, especially when processing eye-tracking data, how to use the performance and efficiency of the sensor to balance its accuracy. We plan to continue to improve our data collection methods.

7. Conclusion

7.1 Summary of key findings

This study developed and tested virtual speech training applications to explore their potential in improving speech skills to help users overcome stage fright and user experience. In the course of our research, we found that the virtual speech training application initially performed well and did not have serious experience problems in

the autonomous test. It can provide a highly realistic speech environment, which can help the speaker better substitute the real scene, and has a good audience feedback and evaluation mechanism.

Different speech scenes have different appeal and influence on users. The office scene is suitable for simulating the formal speech environment and question interaction, while the gymnasium scene is more suitable for exercising the confidence and expression of the speech. We know that user feedback is valuable and can be used to improve an app's functionality, user interface and performance. The user suggestions collected in the future will become an important basis for future improvements.

7.2 Practical significance of the research

The application of virtual speech training is of great importance in today's society and has potential value in many fields. By providing a highly realistic speaking experience, it helps users improve their speaking skills, reduce their speaking anxiety, and increase their self-confidence, which is the purpose of our study, to help users overcome their stage fear. In education, vocational training, public speaking, medical rehabilitation and other fields, virtual speech training applications can provide users with effective tools to address different speech challenges and goals.

At the same time, this study provides valuable insights for the development and improvement of virtual speech training applications. Through testing and user feedback, we are able to better understand user needs and improve the functionality and user interface of the app to provide a better user experience. In addition, this study highlights the potential applications of virtual speech training applications in different fields, such as education and rehabilitation, which have important practical implications for improving speech skills, increasing self-confidence, and reducing speech anxiety.

Our virtual speech training application represents an important innovation in virtual reality technology to improve individual speech skills and user experience. With continuous improvement and research, we can expect to see more developments regarding virtual speech training applications in the future to meet a wide range of user

needs and application scenarios.

References

Rizzo, A. S., & Kim, G. J. ,2005. A SWOT analysis of the field of virtual reality rehabilitation and therapy. Presence: *Teleoperators and Virtual Environments, 14(2), 119-146.*

Wiederhold, B. K., & Wiederhold, M. D. ,2005. Virtual Reality Therapy for Anxiety Disorders: *Advances in Evaluation and Treatment. American Psychological Association.*

Bohil, C. J., Alicea, B., & Biocca, F. A. ,2011. Virtual reality in neuroscience research and therapy. *Nature Reviews Neuroscience, 12(12), 752-762.*

Slater, M., & Wilbur, S. ,1997. A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. Presence: *Teleoperators and Virtual Environments, 6(6), 603-616.*

Witmer, B. G., & Singer, M. J. ,1998. Measuring presence in virtual environments: A presence questionnaire. Presence: *Teleoperators and Virtual Environments, 7(3), 225-240.*

Cummins, N., Scherer, S., Krajewski, J., Schnieder, S., Epps, J., & Quatieri, T. F. ,2015. A review of depression and suicide risk assessment using speech analysis. *Speech Communication,* 71, 10-49.

Fox, J., Arena, D., & Bailenson, J. N. ,2009. Virtual reality: A survival guide for the social scientist. *Journal of Media Psychology, 21(3), 95-113.*

Won, A. S., Perone, B., Friend, M., & Bailenson, J. N. ,2017. Identifying social presence in digital spaces: Measures, mechanisms, and outcomes. *In Human-computer interaction: Interaction technologies (pp. 201-218). Springer.*

Matheus, R. J., & Henderson, L. ,2011. Virtual reality in speech-language therapy: Research findings and implications for practice. *International Journal of Telerehabilitation, 3(2), 31-38.*

Holden, M. K. ,2005. Virtual environments for motor rehabilitation: *Review.*

CyberPsychology & Behavior, 8(3), 187-211.

Ma, M., & Zheng, H. ,2011. Virtual reality and serious games in healthcare. *In Handbook of research on serious games as educational, business and research tools (pp.*

313-331). IGI Global.

Lee, S. Y., & Lee, J. H. ,2016. The efficacy of virtual reality for persons with mild cognitive impairment or dementia: *A meta-analysis. BMC Psychiatry, 16(1), 342.*

Biocca, F., & Delaney, B. ,1995. Visually controlled locomotion and presence in virtual environments. Presence: *Teleoperators and Virtual Environments, 4(2), 184-201.*

Carrió, M., & Pérez-Navarro, A. ,2017. Virtual reality and serious games in the rehabilitation of neurological patients: *A systematic review. Revista de Neurologia, 64(12), 554-564*.

Bohil, C. J., & Beall, A. C. ,2017. Virtual reality for psychotherapy: *Current reality and future possibilities. Psychotherapy, 54(4), 329-333.*

McMahan, R. P., Bowman, D. A., Zielinski, D. J., Brady, R. B., & Velasquez, L. ,2001. Experimental evaluation of a virtual environment for training firefighters. Presence: *Teleoperators and Virtual Environments, 10(4), 360-371.*

Gaggioli, A., Pallavicini, F., Morganti, L., Serino, S., Scaratti, C., Briguglio, M., ... & Riva, G. ,2014. Experiential virtual scenarios with real-time monitoring (interreality) for the management of psychological stress: *A block randomized controlled trial. Journal of Medical Internet Research, 16(7), e167.*

Rizzo, A. S., Bowerly, T., Buckwalter, J. G., Klimchuk, D., Mitura, R., & Parsons, T. D. ,2006. A virtual reality scenario for all seasons: *The virtual classroom. CNS Spectrums, 11(1), 35-44.*

Riva, G. ,2014. Out of my real body: *Cognitive neuroscience meets eating disorders. Frontiers in Human Neuroscience, 8, 236*.