A framework to conduct psychoacoustic experiments in virtual reality

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Motivation

Virtual reality (VR) has become more crucial during the last years and a great opportunity to extend research in acoustics more towards controllable, reproducible research in virtual environments. For this, auditory cues are important for the immersion into the virtual scenes. Many fields can benefit from an extension in VR, such as: architectural acoustics, psychological experiments, psychoacoustic experiments and soundscape research [1][2].

In this work, we will focus on conducting listening experiments in VR. To make it easier for researchers, we developed a framework with the help of Unity® Software [3] from Unity Technologies and Virtual Acoustics (VA) [4] from the Institute for Hearing Technology and Acoustics, RWTH Aachen University, Germany. In this way researcher can focus on the research itself. There is no need for programming, because it is included in Unity® Software's GUI. Different virtual scenes with changing conditions can be auralized and used with the framework. In Figure , an example is given. A person wearing a Head-mounted display (HMD) is in a virtual soundscape and experiencing the scene while doing a questionnaire.

Concept

To create virtual scenes in VR, Unity® Software [3] is used. Unity® Software is a state-of-art game-engine, which is covering different platforms, such as mobile devices, PC as well as different devices for virtual reality (VR) and augmented reality (AR). The engine is based on so-called 'GameObjects'. These GameObjects can have different properties and extensions, such as sound sources or listeners. The extensions are written in C# language.

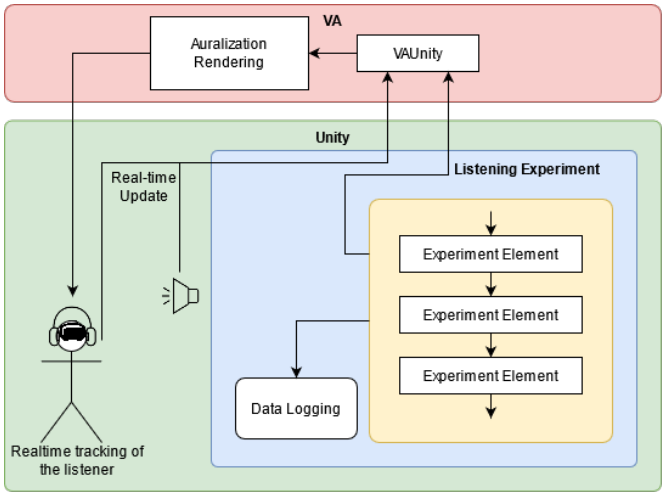

Figure 1: Integration of the framework in VR

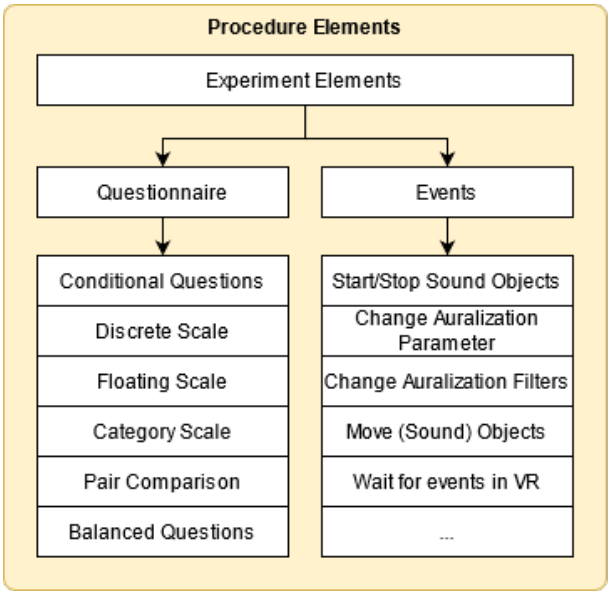

Figure 2: Different kinds of elements for a listening test

Virtual Acoustics (VA) is a real-time auralization framework for scientific research, providing modules and interfaces for experiments and demonstrations. It is open source and designed for controllable reproducible research[4]. For best performance VA, is implemented in C++ and has a commutation API through network. This has interfaces to several other programming languages, e.g. Matlab, Python, C++, and C#, as well as a plugin for Unity® Software, which is called VAUnity. This plugin can be used with GameObjects and can communicate with VA Software.

The listening experiment framework is built on top of VAUnity, as shown in in Figure 1. In this way, it manages the virtual sound sources and listeners in the scene. It comprises different extensions for questionnaires, events in a soundscape or events in the virtual environment. The listening experiment is structured as a queue containing different experiment elements. In this way, source playback can be stopped and started whenever a curtain point in the questionnaire is reached. Additional other events such as, waiting for a certain time or event can be included easily.

Functionality

The framework has different kinds of element types, that can be separated into two categories. The first is re-

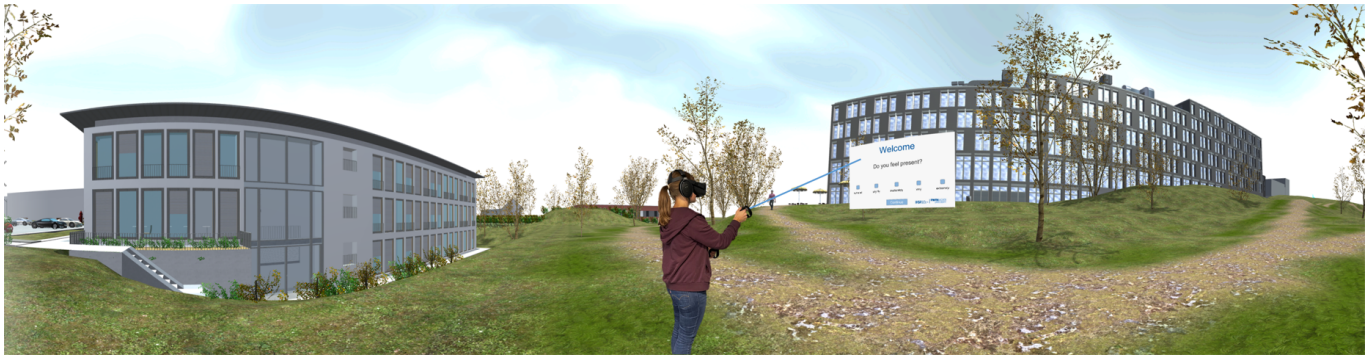

Figure 3: A 360° picture, with a participant wearing a head-mounded display and conducting a listening experiment in a virtual environment with the help of the listening experiment framework

lated to the questionnaire and the second to events or commands in Unity® Software or for VA, as depicted in Figure 2.

The questionnaire category contains different types of questions, such as conditional questions, pair comparisons, or questions with the possibility to answer on a discrete, categorical or floating scale. All question types can be organised into sets of trials, which can be balanced.

The second category, events, can change the virtual environment by moving or manipulating GameObjects. The sound GameObjects are connected via VAUnity to VA, delivering real-time updates such as positions, rotations or states. Likewise, auralization parameters and settings can be manipulated through GameObjects.

Publication

The Framework is open source. It is available for open access under the link `https://git.rwth-aachen.de/ita/IHTAUnityListeningExperiments`.

Conclusion

A framework to conduct listening experiments in VR and/or AR in Unity Software was presented. The framework manages the auralization of whole scenes by using VA [4] and create interactive questionnaire into VR or AR. The Framework is open source and enables easy usage of listening experiments with little technical background.

Acknowledgement

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References

[1] André Fiebig. The perception of acoustic environments and how humans form overall noise assessments. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, Madrid, Spain, 2019.

[2] Michael Vorländer, Dirk Schröder, Sönke Pelzer, and Frank Wefers. Virtual Reality for Architectural Acoustics. *Journal of building performance simulation*, 8(1):15–25, 2015. Place: 2014 Publisher: Taylor & Francis.

[3] Unity Technologies. Unity Real-Time Development Platform | 3D, 2D VR & AR Engine, 2021.

[4] Institute for Hearing Technology and Acoustics, RWTH Aachen University. Virtual Acoustics – A real-time auralization framework for scientific research, 2021.