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AN APPROACH TOWARDS VIRTUAL STAGE EXPERIMENTS

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ABSTRACT

The main goal of this project is to address how the perceived spatial distribution of sound energy (sound diffuseness) affects the acoustic quality perceived by musicians at the stage. To that end, experiments of rehearsals with two musicians playing into real-time virtual acoustics scenarios are carried out. Sound diffuseness characteristics for each virtual scenario are set according to a strategic design of the experiment. The proof of the approach is challenging because the short path between the ear and the musical instrument of musicians requires fast processing for real-time purposes. The performances are recorded for further analysis. After performing in each scenario, the perceived acoustic quality of the musicians are collected through questionnaires. Using statistical and signal analysis, the performance of descriptors related to stage acoustics and sound diffusiveness will be evaluated. The currently available results include the proof of concept and a detailed analysis of the sources of uncertainty.

Keywords: *stage acoustics, virtual reality, room acoustics.*

1. INTRODUCTION

The acoustics of music performance spaces does not only depend on the room itself but also on the musical instruments and listeners. The musicians are important listeners because their performance is affected by what they hear.

From a musician standpoint, the sound diffuseness of the sound field can be described as the spatial distribution of the arriving sound pressure due to each sound source (balance between direct and reflected sound). Hence, preferred sound diffuseness characteristics may be accounted with current knowledge on preferred values of stage acoustic parameters like omnidirectional (e.g. stage support ST), spatial (above-to-horizontal energy SH), or architectural (depth, weight, height relationships) [1]. Additionally, experimentation may yield to new descriptors and preferred values. This article shows the state of advance of this project including the system configuration and preliminary results.

2. STATE OF ADVANCE

2.1 System configuration

An interactive auralization system for two musicians was implemented in cross-coupled Virtual Reality environments. Fig. 1 shows a scheme of the system for two musicians.

Each musician is placed in a separated hearing booth equipped with a microphone M_i and a pair of headphones H_j. The two input signals are mixed after convolution with their respective impulse responses (IRs) in order to render the two stereo output signals to the two pairs of headphones.

The IRs are simulated using the software RAVEN [2-3], which is based on the concept of geometrical acoustics. Define $h_{i,j}$ as the impulse responses applied to input signal i to be mixed into output signal j. The direct sound is skipped for IR of musicians hearing themselves (i.e. for $h_{i,j}$ with $i = j$) and musicians hear the actual direct sound trough open headphones. The latencies $l_{i,j}$ due to the audio system

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and the microphone-source distance are measured and compensated in each IR. Working with an interface with a latency of about 4 ms, the virtual distance between musicians should not be closer than 2 m in order to avoid cropping the impulse response when applying the time compensation.

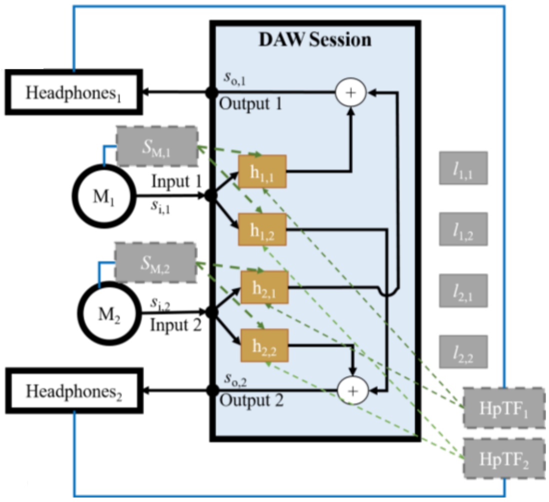

Figure 1. Scheme of a system for virtual stages experiments

Each $h_{i,j}$ is also calibrated for the entire frequency range of hearing. The effect of the microphone sensitivities $S_{M,i}$, headphones related transfer functions H_j, and sound interface, are compensated with a FFT filtering technique.

2.2 Sources of uncertainty

Mainly two sources of uncertainty are analyzed in the main project. The first one is the uncertainty due to specifying directivity input data in third octave bands [4]. The second is the uncertainty due to errors specifying the following two distances: d_1: distance from the instrument to the microphone and d_2: distance from the instrument to the head [5].
The sound pressure level was estimated with two methods for specifying directivity: directivity averaged in bands and directivity for each partial of each tone. The anechoic signals are single notes of a classical acoustical guitar playing fortissimo. The distribution of the differences of the sound pressure level estimations for each note are reported. These differences were estimated in a concert hall model for each of the eight combinations resulting from four receiver positions and two source positions. For some tones, the differences are between ±5 dB but may exceed that for other tones. The interquartile range for the whole instrument notes range is between ±10 dB [4].
For most musical instruments, the position of the acoustic center of the source may differ for each partial. Hence, the error due to specifying a distance to the source with just one number depend on each partial. Typical errors of these two distances from microphone and head to the source may yield errors close to ±5 dB [5].

2.3 Preliminary results

A proof of concepts was recently carried out [5]. Six guitar duets played in seven scenarios simulated with this system. After playing in the scenarios they were asked to rate on a linear scale how similar the experience was compared to playing in a real room. Assigning 0 and 100 to the extreme values of the scale, respectively, no participant rated this question with less than 50, the average was 73, and the mode was 80.

3. DISCUSSION AND CONCLUSIONS

A system consisting of two cross-linked interactive systems for virtual stage acoustics experiments was introduced.
The main sources of error were analyzed in detail. The results suggests that the system may be a good starting point for experiments on stage acoustics. However, improvements may be developed in order to enhance the ecological validity. Visual feedback, source and receiver position and orientation, directivity issues, and distance issues are some examples on open topics that are challenging because of latency issues.

4. ACKNOWLEDGMENTS

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