Evaluation of Perceptual Accuracy in Simulated Room Impulse Responses

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1 Introduction

The accurate simulation of Room Impulse Responses (RIRs) is important in a variety of applications in acoustics such as automatic speech recognition, speech enhancement, and architectural acoustic design. While objective metrics for evaluating RIRs have been researched extensively, the subjective perceptual accuracy of the simulations is largely overlooked. This paper seeks to address this gap, designing a subjective testing methodology for evaluating the perceptual accuracy of simulated RIRs.

2 Methods

Subjective Testing Methodology

- **Participants**: 50 participants with varying levels of expertise.
- **Stimuli**: Audio samples convolved with real and simulated RIRs.
- **Procedure**: Combination of ABX testing and modified Multiple Stimuli with Hidden Reference and Anchor (MUSHRA) approach.
- **Attributes Evaluated**: Clarity, Warmth, Environment, and Reverberation.

ABX Testing

Participants were given a reference audio and two test audios (A and B), and they were asked to identify which test audio matched the reference exactly. This tested the ability to distinguish between the real and simulated RIRs when convolved with anechoic audio samples.
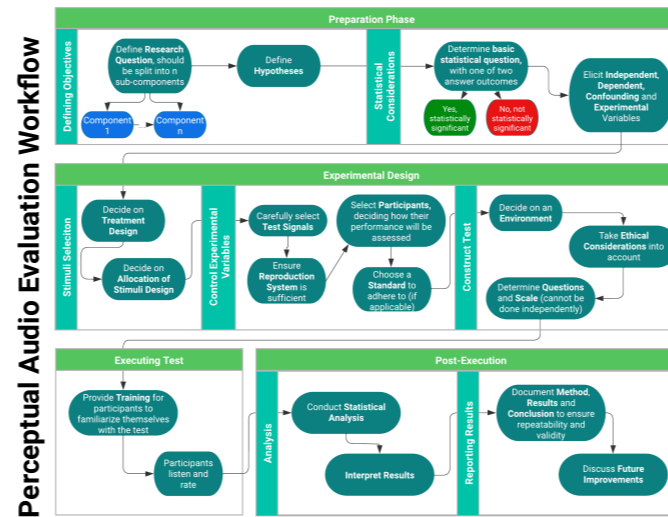
3 Results

ABX Test Results

- **Overall Findings**: Participants seem to be able to distinguish between real and simulated RIRs
- **Simulation Methods Compared**: Pyroomacoustics and Mirror Image Source method.
- **Statistical Analysis**: Binomial and chi-squared tests indicated significant perceptual differences.

MUSHRA Test Results

- **Attributes with Significant Differences**: Clarity and Reverberation.
- **Clarity**: Real RIRs rated higher in clarity compared to simulated RIRs.
- **Reverberation**: Participants noted perceptual differences in reverberation between real and simulated RIRs.

Modified MUSHRA

Participants rated audio samples on a scale from 0 to 100 for the evaluated attributes. This provides the subjective evaluation of the perceptual differences.

Results per attribute for the modified Multiple Stimuli with Hidden Reference and Anchor (MUSHRA) test (0-100)

4 Discussion

- The findings suggest that current RIR simulation methods do not fully capture perceptual aspects of acoustic environments.
- **Key Attributes**: Clarity and Reverberation were the most affected attributes.
- **Implications**: These results can inform future improvements in RIR simulation techniques to enhance perceptual accuracy.

5 Conclusion

This study highlights the need for incorporating subjective evaluation in RIR simulation research. The proposed methodology provides a framework for assessing perceptual accuracy, revealing potentially significant differences in perceived Clarity and Reverberation between real and simulated RIRs.

Future Work

Future research should include a larger, more diverse participant group and explore additional subjective attributes. Further investigation into optimizing simulation methods to better match perceptual qualities is also recommended.

Additional Information

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- **References**: