MRSP Seminar project report - Group 1

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We made a Github repo for the project:

https://github.com/NiklasNymark/MRSP_Seminar_Project_Group1

Table of Contents

Used audio files

In this project, our task was to study how sounds are affected by the surrounding environment (acoustics). We chose 5 different audio samples, each with unique spectral characteristics. The chosen audio samples were:

- drum
- instrumental mix
- piano
- speech
- trumpet

After choosing the audio samples, we created new versions of them by applying Room Impulse Responses to our dry audio samples. We chose 3 environments for this:

- small office
- opera hall
- reverb hall

With 5 different audio samples and 4 different environments (including just the original dry audio), we created 20 audio files to use in our research.

Listening experiment (MUSHRA)

We were to analyze, how different these same sounds are in different environments. We conducted both an objective test and a subjective test. For the subjective part, we performed a MUSHRA listening test on volunteers. We had 18 participants. A few of them were from the list of participants provided to us on Moodle, but we were not able to reach most of the people on the list. Most of the participants were our friends, that we asked to help us. Of all 18 participants, half of them (9) had previous experience with similar tests. No one had hearing difficulties. The participants were from ages 24-28. 15 participants were male, 3 were female.

In the experiment, the participants were asked to rate the heard audio on a scale of 0 to 100 in comparison to the reference sound. 100 would be the most similar to the original sound, and 0 would be the most different. Each person listened to all 20 audio files (including the reference sounds).

ANOVA test between different environments

We performed an "Analysis of Variance" (ANOVA) test on the collected data from the MUSHRA experiment. The ANOVA test is used to determine, if the results of our subjective listening experiment are statistically significant or not. For the ANOVA test, we use an alpha value of 0.05 (5%). This means, that we want to be 95% sure that our results are statistically significant.

We performed the ANOVA in two different ways. First of all, did the participants hear differences in the various environments? Or in other words, does the same audio sound different with a different Room Impulse Response? Our null hypothesis is: If the same sound was played in different environments, it sounds the same to the listener.

The results for the ANOVA tests were calculated using the Matlab ANOVA function. The used code is in our github repository:

https://github.com/NiklasNymark/MRSP_Seminar_Project_Group1/blob/master/MUSHRA_results/average%20result/analysis.m

The resulting p-values for this ANOVA test:

- 0.00014818 for drum
- 0.003438 for instrumental mix
- 0.0001407 for piano
- 0.000092682 for speech
- 0.01008 for trumpet

All of the p-values are smaller than our alpha = 0.05. Therefore our null hypothesis is incorrect, and we can say, that the used Room Impulse Response caused the same audio to sound different in our subjective listening test with a certainty of 95%.

Conclusion: statistically significant differences between environments

ANOVA test between different sounds

The second ANOVA test was also conducted with an alpha value of 0.05 (5%). This time we want to know, if different heard instruments (piano, drum, ...) had different effects on the answers of

the participants. In other words, does the used Room Impulse Response have the same effect on all of our audio samples? Our null hypothesis is: The spectral characteristics of the played sound have no impact on the result of the experiment.

The resulting p-values for this ANOVA test:

- 0.28032 for small office
- 0.64077 for opera hall
- 0.48427 for reverb hall

All of the resulting p-values are significantly higher than our alpha of 0.05. Therefore our null hypothesis is correct.

Conclusion: no statistically significant differences in result between different sounds/instruments

Perceptual Loss Function

In addition to the subjective differences between sounds that we studied with the MUSHRA test, we also performed an objective analysis of the differences using the Perceptual Loss Function. The Perceptual Loss is used to tell the difference between two audio files. In this case, we compared the original dry audio file to the audio file, which was modified with a Room Impulse Reponse. For this analysis we used the Perceptual Loss function provided to us by the professor:

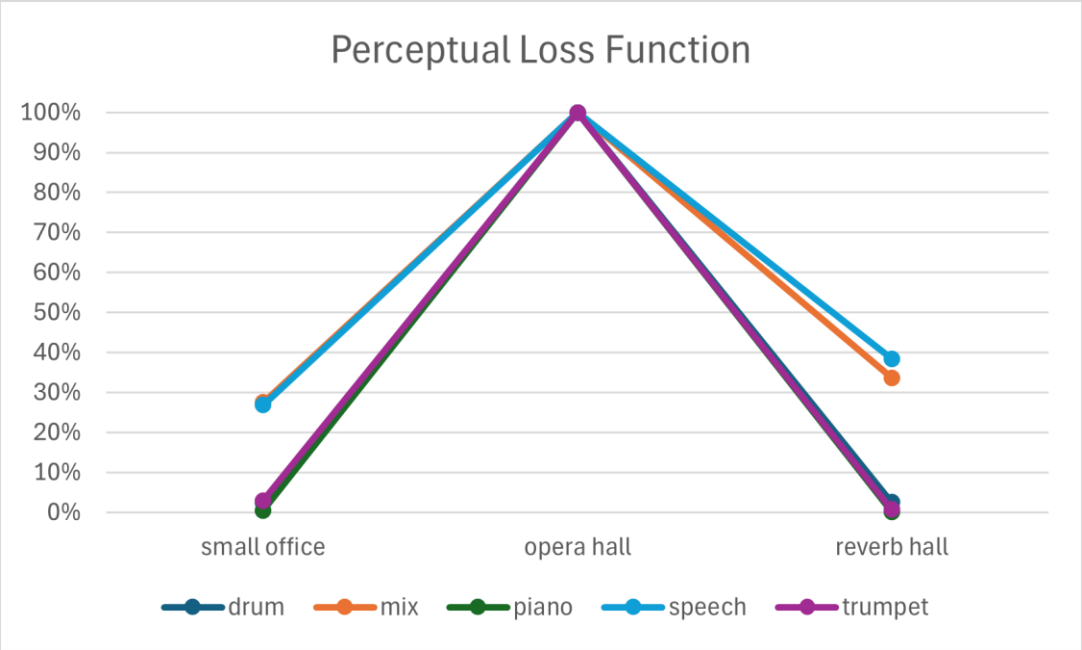
https://github.com/TUIlmenauAMS/Python-Audio-Coder

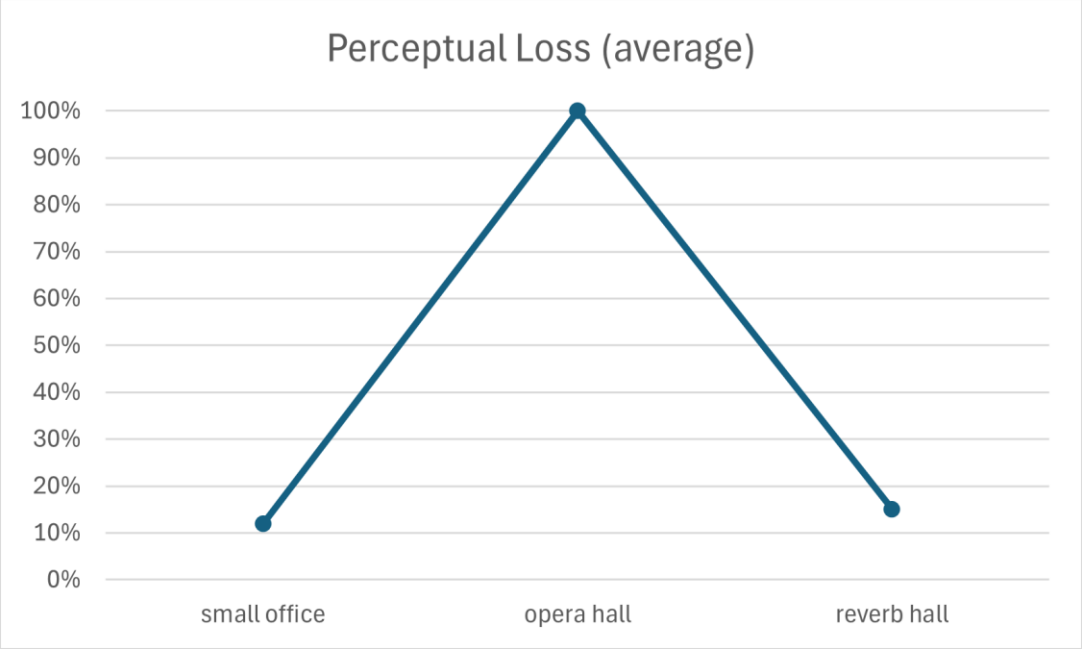
We used Microsoft Excel to analyze the results of the objective test:

https://github.com/NiklasNymark/MRSP_Seminar_Project_Group1/blob/master/Task_5_analysis.xlsx

Objective results

For the results of the Perceptual Loss Function, the following figures were created:

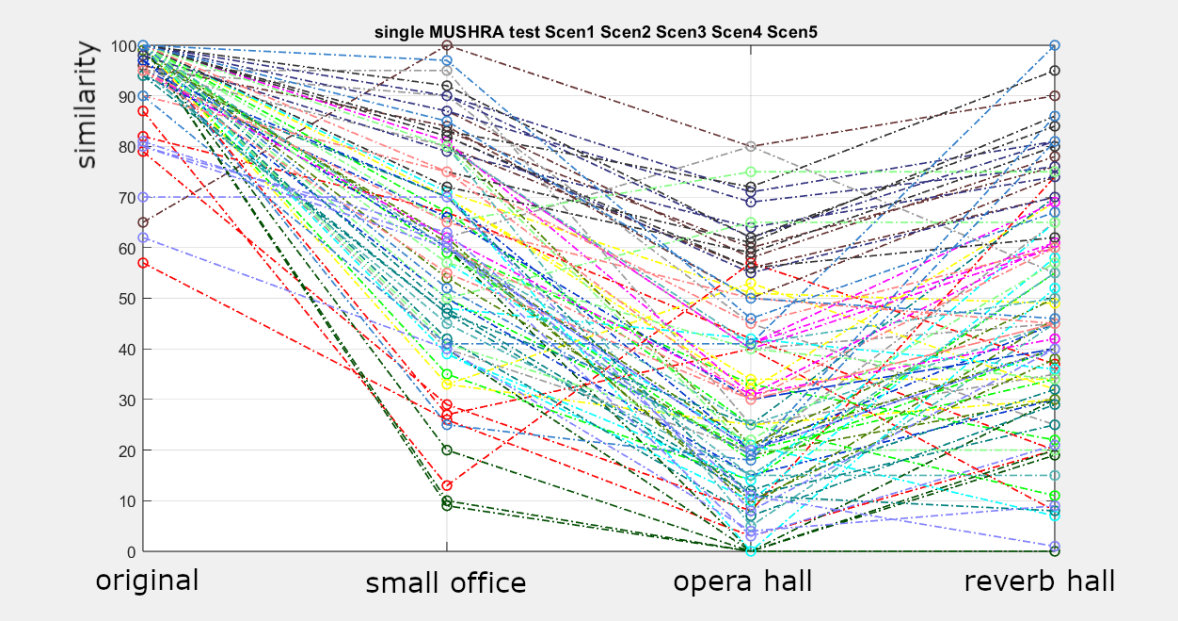




100% means the biggest difference compared to the original. 0% means that there was no difference when compared to the original. The percentages were obtained by dividing all of the resulting numbers with the highest of those numbers. In each case, the highest Loss value was obtained from the "Opera Hall" environment. The "Small Office" and "Reverb Hall" environments were both deemed much more similar to the original audio. There is no clear difference in the Loss values between these two environments.

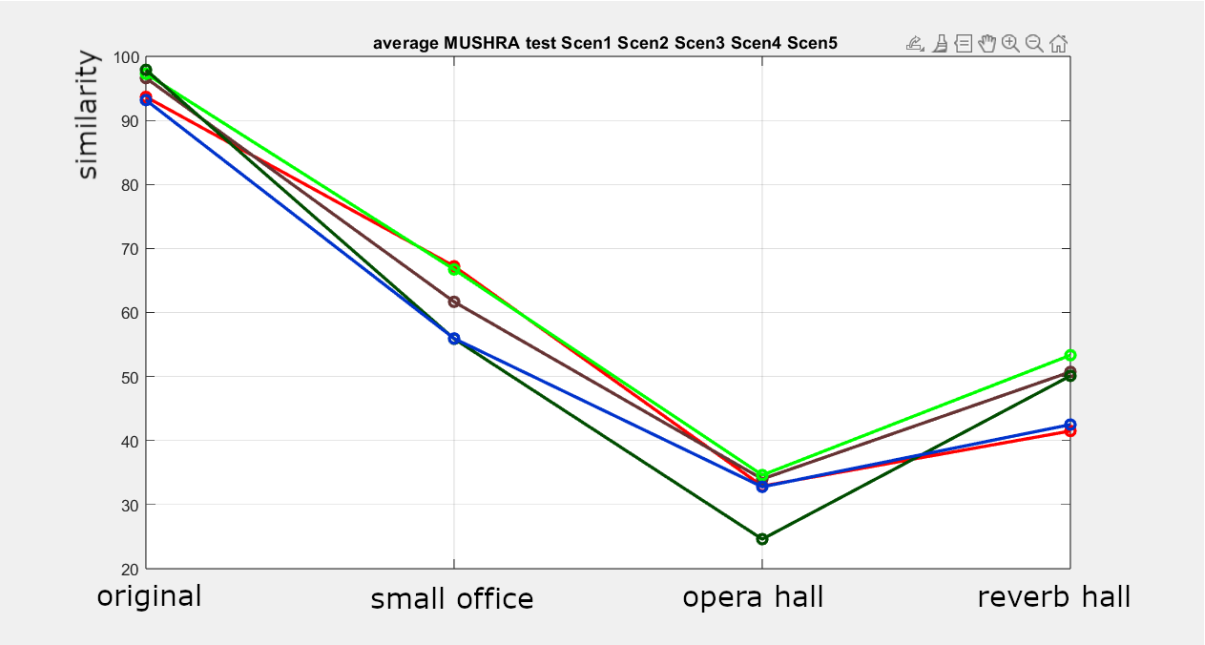
Subjective results

The figures for the MUSHRA test were created by the SCALE application. The first figure shows all of the results together:



Not much can be analyzed from the first figure. It's only clear, that all of the participants came up with very different numbers for each sound.

The second figure depicts the average results of all of the participants:



In this figure, the different colors of the lines represent different sounds/instruments:

- drum: red
- instrumental mix: brown
- piano: light green
- speech: dark green
- trumpet: blue

However, we cannot say that there is a clear difference between these instruments. All 5 lines are very close to each other. However, we can see a clear difference between the different environments. A value of 100% means that the sound is identical to the original, while a value of 0% means that the sound is very different from the original. We can see that once again, the "Opera Hall" environment is the least similar to the original. The "Reverb Hall" is also quite different. The "Small Office" environment seems to produce sounds that are most similar to the original sound.

Conclusion

After looking at the results for MUSHRA, ANOVA and Loss Function, we can make some conclusions. Both objective and subjective test came to the result, that the "Opera Hall" Room Impulse Response caused the most significant change to the sound it was applied to. For the other 2 environments, no clear difference could be found by the Perceptual Loss Function. Based on the MUSHRA test however, the "Reverb Hall" was more different than the "Small Office" environment. In terms of different instruments, neither the objective nor the subjective test was able to find significant differences. For the most part, the results from both tests seemed to be in agreement. Thus we can conclude, that the Perceptual Loss Function could be used to analyze the difference between different audio stimuli. However, more accurate results can most likely be achieved by conducting a listening experiment.