

Chapter 10

Conclusion

10.1 Summary

The Sound Spatialization Resource Management Framework was tested with three different kinds of sound spatialization backends, based on different technologies including HRTFs, stereo intensity panning, and loudspeaker array sound field control. The Sound Spatialization Resource Management Framework was deployed and tested in the Multimedia Center at the University of Aizu, which features the PSFC system, with more than 15 loudspeakers.

An overview of different applications (e.g., chatspace, Helical Keyboard) which require sound spatialization were presented. Based on those, requirements were developed and reflected in the algorithms presented in this thesis.

A simple resource management algorithm was developed and then extended for clustering of sound sources. The clustering algorithm applies psychoacoustic data (localization errors dependent on listener orientation) as optimization criteria. The advantages and disadvantages were discussed. The developed sound spatialization resource manager improves spatialization fidelity under runtime constraints. Application programmers and virtual reality scene designers are freed from the burden of assigning and predicting the sound sources. The system has been verified with a virtual world animated by a polyphonic MIDI stream.

The extension of resource management to include obstructions like occluders and reflectors in realtime environments was also presented. Furthermore, a discussion describes how to compare, test, optimize, and calibrate sound spatialization backends and controlling algorithms. Finally, a section explains how to do sound spatialization authoring, including steering and predicting resource management, based on tools that are part of the system developed by the author. Novel authoring tools are a soundscape deformer,

a 3D widget that controls the scene space → soundscape mapping, and an inspector for sound objects in the soundscape, which is a visual debugger for sound objects in virtual reality environments. The tools enable spatial sound authoring for multimedia content. The system can be easily integrated into a virtual reality authoring system and its principles are widely applicable.

10.2 Future research

10.2.1 Visualization

A module for sound source tracing using trajectories and visualizing the convex hull to find out if a source covers a given area for the dynamic behavior could further enhance the system regarding authoring and studying requirements of VR applications. Also a module to visualize statistical data like average orientation, maximum velocity, average velocity, maximum intensity, average intensity, average audible range, etc., would complete the system. Such visual tools could further enhance the spatial sound authoring process.

10.2.2 Visual editing

The editing features of sound objects in the authoring part of the system are restricted to textual input. A better user interface would incorporate manipulators for the different object attributes to allow instantaneous object changes.

10.2.3 Abstract spatialization backend interface — fine grained control for frequency range requirements

The introduced interface for spatialization backends in Chapter 6 provides only a coarse control. A fine grain control would allow better resource management with less computational costs. The specified interface is strongly influenced by the interfaces of available spatialization backends.

A better system would allow to pass for each spatialization channel the frequency range and application specific resolution requirements. If the frequency range is low then the audio renderer might not calculate for different elevation because those cannot be distinguished by a user in such cases. Also the sampling rate could be reduced.

10.2.4 Control over distance modeling to enhance clustering

The clustering algorithm described in Chapter 4 can be further enhanced if the resource manager gets control over the distance modeling before mixing of sound sources for a representative virtual sound source is done. Then all sound sources on one resolution cone can be clustered together regardless of their distance from a sound sink. In the described algorithm, sound sources are not clustered together if the distance is larger than a certain perceptual threshold. Good distance modeling requires reverberation handling separately from distance attenuation (see Section 3.4). Usually, distance modeling is done by the spatialization backend and is a rendering issue.

10.2.5 Control over Doppler shift rendering to enhance clustering

In the clustering algorithm of Chapter 4, sources are not clustered together if their to be generated Doppler shift (i.e., velocity and moving direction) differs more than a specified threshold. This is necessary because the Doppler shift rendering is done in the spatialization backend. A different approach could apply the Doppler shift rendering before mixing the sound sources. In such case, no Doppler shift would be calculated for the virtual (i.e., representative) sound source. More sound sources could be clustered and the overall system performance enhanced, similar to the suggestion in the previous Section 10.2.4.

10.2.6 Standard tests for spatialization backends

For testing and comparing sound spatialization systems, standard tests are required, as are already done for graphics systems. Those tests will enable better calibration of the backends.