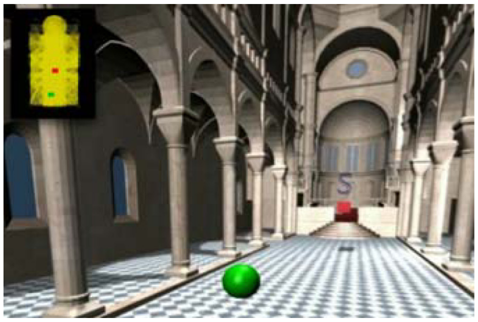
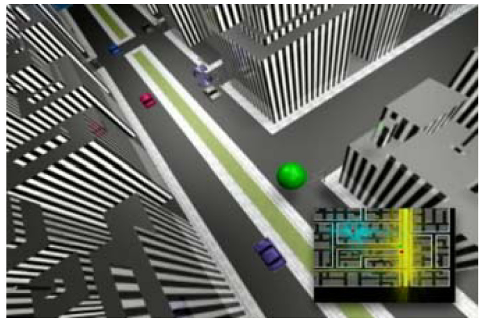
Interactive Geometric Sound Propagation for Games

Department of Computer Science University of North Carolina at Chapel Hill March 2008


Background and Challenges

Modeling the acoustic properties of a virtual environment is an important step in simulating the acoustic response of building such as auditorium. It is also gaining importance for interactive applications such as games or virtual environments, where spatialized sound adds a stronger immersion effect. In practice, realistic sound can only be achieved by simulation of the sound waves from the source sources to the listener. The result is spatial sound that adds directly to the immersion of the application by giving an intuitive impression of the environment.

Due to the complexity of numerical simulation, current interactive sound simulators commonly use geometric methods that explicitly simulate the propagation of sound as it is reflected and refracted in the environment. However, existing algorithms have limitations that prevent them from being used in current interactive applications: they are mostly limited to static scenes, do not scale well with scene complexity or introduce aliasing artifacts. However, both dynamic and geometrically complex environments are very common in those applications.

Frustum Tracing

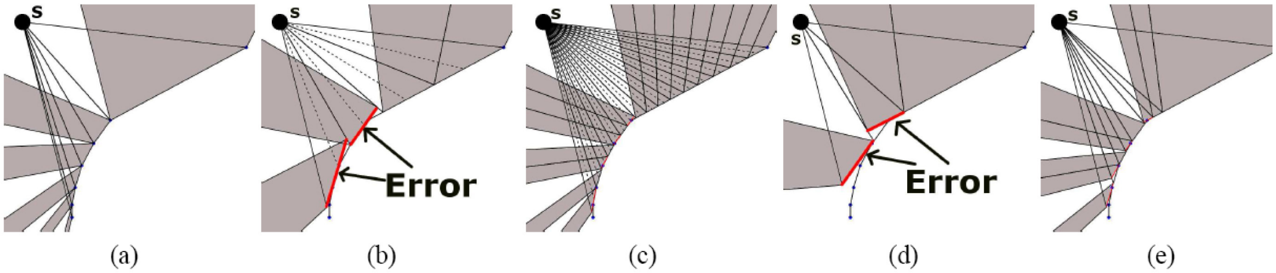
We present a novel approach for interactive sound rendering in dynamic and complex environments. We build on the recent results in the field of interactive ray tracing, and specially ray-packet tracing. However, we use a volumetric tracing representation using frusta as opposed to tracing individual rays, in order to overcome aliasing artifacts. An adaptive approach ensures that the size of the frusta is chosen as needed and also allows to trade off quality for speed when needed. In addition, we show how to perform diffraction using our algorithm.

Advantages

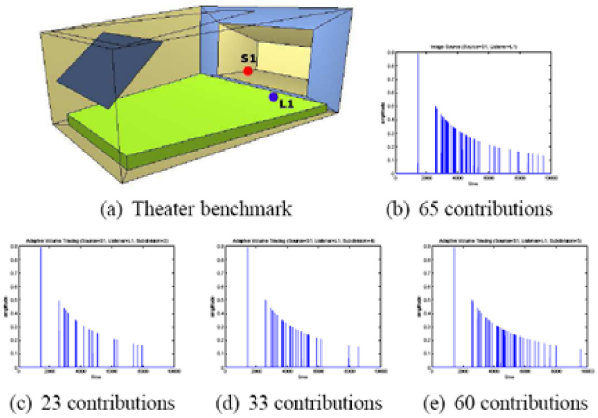
Our new approach has several advantages on previous methods: first, since we can use standard ray tracing structures such as bounding volume hierarchies (BVHs), we are much more general in the kind of scenes that can be handled by the algorithm, and we can also use dynamic environments by updating the BVH structure at runtime. Second, the fact that we use a volumetric representation allows us to preserve the advantages of beam tracing in that there is no aliasing problem such as in stochastic path tracing, which is important in interactive applications where such artifacts would be noticeable. Finally, the frustum subdivision in our algorithm introduces a sampling parameter that can be changed at any time to easily trade off speed for quality, which is an important aspect in many applications where guaranteed speed is paramount.

Results

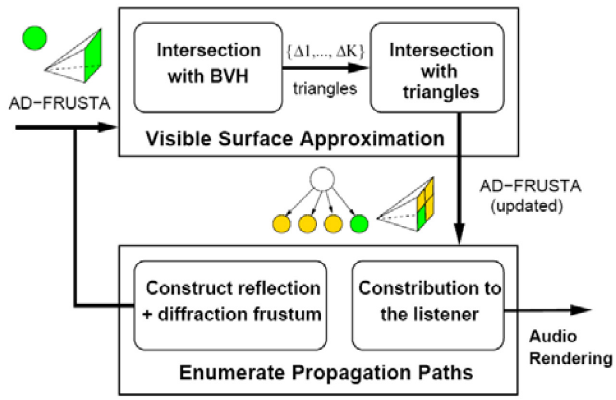
We tested the algorithm on a variety of scenes from games and architecture with complexity ranging from 14k to 196k triangles, including dynamic scenes and moving sound sources. Even with reflection depth up to 6 reflections, we show that our system is capable of performing sound simulation at interactive rates on a current multicore desktop machine.



(a) Exact specular reflection for 2D case. (b)-(c) Reflected frusta generated with uniform frustum tracing. Increasing the sampling decreases the error. (d)-(e) Reflected frusta generated with adaptive frustum tracing. Notice that samples are generated only in the region with errors.



Accuracy Comparison: Comparing the accuracy of our approach with CATT-Acoustic software. With increasing sub-division (c)-(e) we converge to the exact solution.



System Overview: Overview of our system for adaptive frustum tracing. The simulation runs asynchronously to the audio rendering process.

Members

Dinesh Manocha, Phi Delta Theta/Matthew Mason Distinguished Professor
Christian Lauterbach, Graduate Research Assistant
Sean Curtis, Graduate Research Assistant
Micah Taylor, Graduate Research Assistant
Zhimin Ren, Graduate Research Assistant
Anish Chandak, Graduate Research Assistant

Research Sponsors

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Publications

Lauterbach, C.; Chandak, A.; Manocha, D., “Interactive sound rendering in complex and dynamic scenes using frustum tracing,” Visualization and Computer Graphics, IEEE Transactions on, vol.13, no.6, pp.1672-1679, Nov.-Dec. 2007

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A. Chandak, C. Lauterbach, M. Taylor, Z. Ren, and D. Manocha. “Adaptive Frustum Tracing for Interactive Sound Propagation”, Technical Report, Department of Computer Science, University of North Carolina at Chapel Hill, 2008