ABSTRACT

Charles Auston Baker Sterling: Audio-Material Modeling and Reconstruction for Multimodal Interaction
(Under the direction of Ming C. Lin)

Interactive virtual environments enable the creation of training simulations, games, and social applications. These virtual environments can create a sense of presence in the environment: a sensation that its user is truly in another location. To maintain presence, interactions with virtual objects should engage multiple senses. Furthermore, multisensory input should be consistent, *e.g.*, a virtual bowl that visually appears plastic should also sound like plastic when dropped on the floor.

In this dissertation, I propose methods to improve the perceptual realism of virtual object impact sounds and ensure consistency between those sounds and the input from other senses. Recreating the impact sound of a real-world object requires an accurate estimate of that object's material parameters. The material parameters that affect impact sound—collectively forming the audio-material—include the material damping parameters for a damping model. I propose and evaluate damping models and use them to estimate material damping parameters for real-world objects. I also consider how interaction with virtual objects can be made more consistent between the senses of sight, hearing, and touch.

First, I present a method for modeling the damping behavior of impact sounds, using generalized proportional damping to both estimate more expressive material damping parameters from recorded impact sounds and perform impact sound synthesis. Next, I present a method for estimating material damping parameters in the presence of confounding factors and with no knowledge of the object's shape. To accomplish this, a probabilistic damping model captures various external effects to produce robust damping parameter estimates. Next, I present a method for consistent multimodal interaction with textured surfaces. Texture maps serve as a single unified representation of mesoscopic detail for the purposes of visual rendering, sound synthesis, and rigid-body simulation. Finally, I present a method for geometry and material classification using multimodal audio-visual input. Using this method, a real-world scene can be scanned and virtually reconstructed while accurately modeling both the visual appearances and audio-material parameters of each object.