Modeling the Sound of Music

October 3 2005

If a musical instrument has never been built before, how can you know what it will sound like? That's the question UC Berkeley graduate student Cynthia Bruyns is answering with Vibration Lab, software she's designing to simulate the sound of any percussive instrument, real or imagined, in a computer.

Her system could someday enable musicians to play instruments that exist only on the screen, enable the interactive design of new physical instruments, and even boost the realism of immersive virtual environments for education and training.

"Every object's sound comes from the way it's vibrating, and every object vibrates differently depending on its shape and material," says Bruyns, a student of computer science professor Carlo Séquin, an affiliate of the Center for Information Technology Research in the Interest of Society (CITRIS). "Instruments like violins are shapes that have been perfected over many years to produce a certain tone."

Bruyns' software enables users to take a computer-generated 3D model of a complex object and, essentially, bang it with a virtual stick to hear how it vibrates. For example, thin and flat metal objects sound very different from thick, curved wooden instruments. This is a giant leap in ease-of-use compared to state-of-the-art virtual instrument software.

Previously, Bruyns explains, some computer musicians have created virtual instruments from shapes like circles, squares, and rectangles that are relatively easy to model on a computer. The software then calculates how a vibration wave propagates through the shape, resulting in a tone. More commonly, electronic musicians create instrument sounds by manipulating digital oscillators and tweaking a host of other parameters until they hear the tone they're after. Someday, Bruyns hopes her software could lead to a user-friendly library of 3D instrument models that a composer could modify without much programming knowledge.

Bruyns' software is based on techniques of modal analysis, the mathematical process of breaking a vibration down into its component parts, such as frequency and damping. Beginning with a 3D model built with commercially-available software, the Vibration Lab system adds mass and stiffness properties that mimic the characteristics of a real material like wood or bronze. The frequencies of the object are then calculated. Users can then "strike" the object in various places by hitting keys on an electronic piano keyboard connected to the computer using a standard digital music interface.

To test the system, Bruyns recorded the sound of striking real world objects she fabricated and compared that frequency spectrum with a hit on the object's virtual counterpart. The structures were metal letters that spelled out SIGGRAPH, the name of a scientific conference where she presented her work last year. The difference in frequency between the real and virtual objects ranged from just seven to 10 percent. Room acoustic effects can also be added using additional pieces of software.

Along with applications in electronic music, Bruyns hopes that her software could be used as a tool for real world instrument designers. She was inspired by the work of Séquin's friend Steve Reinmuth, an Oregon artist who sculpts exotic bells out of bronze.

"These sculptors make futuristic shapes that look like alien instruments and have very pretty tones," she says. "But a lot of that is trial and error. It would be nice to give the artists a tool to predict what their shapes will sound like."

Eventually, the system could also add realistic audio to an immersive computer-generated environment in development within CITRIS. The idea of the project, led by former CITRIS director Ruzena Bajcsy, is to enable individuals in remote places to gather via the Internet in a shared virtual environment created with digital cameras, computer graphics, and synthesized sound.

Not surprisingly, Bruyns has already been approached by companies interested in commercializing Vibration Lab. Right now though, she's focused on completing her PhD, probably in the next year or so. The next stage in the research is to simulate how air enclosed in the body of an instrument will affect its sound. To start, she's studying the timpani, a large drum with a sealed enclosure full of air.

"In the future, the software might enable me to take a 3D model of a tabla drum, for example, and know what it would sound like if it was made from solid gold."

Source: UC Berkeley, by by David Pescovitz

Citation: Modeling the Sound of Music (2005, October 3) retrieved 26 April 2024 from https://phys.org/news/2005-10-music.html