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# Modular acoustic filters simplify design of mufflers, musical instruments, audio tags

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Credit: Disney Research

Designing acoustic filters that can block out a certain sound or produce a certain pitch can be hit or miss, but researchers have discovered a way to predict acoustic qualities 70,000 times faster than current algorithms, paving the way for new, computationally driven designs.

The researchers from Disney Research, the Massachusetts Institute of Technology and Columbia University opted to use a simple shape - a hollow cube with holes on some of its six faces - that could be produced with a 3-D printer as their base module.

In work to be presented July 24 at the ACM International Conference on Computer Graphics & Interactive Techniques (SIGGRAPH) in Anaheim, Calif., they show how their new, ultra-fast simulation method can be used to optimize filter designs to selectively reduce sounds at certain frequencies, such as wind noise or the whine of an electric motor, or to produce desired sounds in a wind instrument.

"Most acoustic filter design now is limited to simple geometries, such as pipes, because the acoustic behavior of more complex shapes is difficult to characterize," said Jessica Hodgins, vice president at Disney Research. "This new research suggests that significantly faster simulation methods will allow a better exploration of the design space computationally, making possible new uses for these filters."

For instance, the researchers showed that by using their computational design approach - which they call Acoustic Voxels - they could design acoustic tags into seemingly identical objects, giving each a distinctive sound when they are tapped.

Acoustic filters all work the same way: as sound waves pass through a cavity, some are reflected back and forth and either boost or suppress certain frequencies. Exactly which frequencies are affected will depend largely on the shape of the cavity, said David Levin, associate research scientist at Disney Research. But the influence of shape is complicated and unintuitive, so improving the quality of a filter requires quite a few trial-and-error iterations, he added. Due to the performance burden of predicting acoustic response, even computational design tools are limited to simple geometries.

With Acoustic Voxels, however, the researchers were able to precompute the acoustic properties of each module and how changing the size of the module would alter its properties, said Changxi Zheng of Columbia University. The researchers also developed a computational technique for optimizing how the modules could be attached to each other and arranged to achieve a certain effect.

Dingzeyu Li, a Disney intern and a Ph.D. student in graphics at

Columbia, and his colleagues demonstrated the method by designing ear muffs that selectively filtered out engine noise or wind noise, as well as a trumpet-like wind instrument. In addition to objects with acoustic tags, they designed objects that actually could encode binary bit strings in the form of white noise, potentially enabling new applications.

Thus far, the method is mostly suitable for controlling impedance and transmission loss at discrete frequencies, such as in a traditional muffler design, said Wojciech Matusik, associate professor of electrical engineering and computer science at MIT's Computer Science and Artificial Intelligence Laboratory. But this study was limited to only one shape of Acoustic Voxel made of just a single material.

"Extending our method to additional shapes and materials could offer a larger palette for better acoustic filtering control," Matusik said.

**More information:** "Acoustic Voxels Computational Optimization of Modular Acoustic Filters-Paper" [PDF, 28.83 MB]

Provided by Disney Research

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