Researchers use technology to virtually recreate concert hall acoustics

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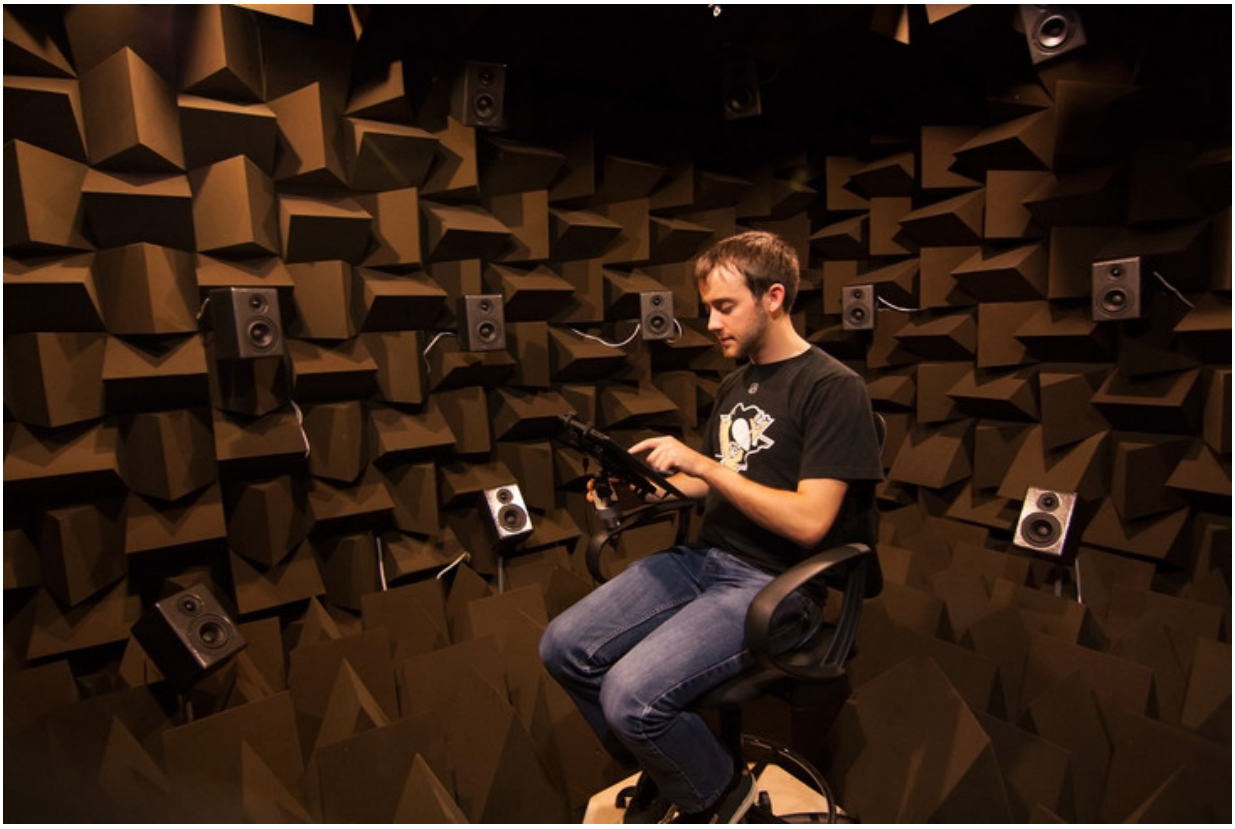

Matthew Neal, a doctoral candidate studying acoustics, uses technology to virtually recreate concert hall acoustics. Credit: Rachel Garman

From the sweeping sounds of strings to the full and hearty woodwinds, live orchestral performances have a way of enveloping listeners within

musical compositions. But not all symphonies are created equal—much of what determines whether or not a listener enjoys a live concert relies on the venue itself.

With diverse architectural differences (for example, the narrow, rectangular layout of Boston Symphony Hall or the expansive circular seating of Royal Albert Hall in London), concert halls come in many shapes and sizes, appealing to different listener preferences. Now, researchers at Penn State are using technology to study these individual differences in acoustic design and listener tastes.

"In concert hall acoustics, a lot of consultants and musicians know they like the sense of being enveloped or feeling immersed and surrounded by sound in a room. Despite this fact, there's not a lot of research into what aspects of the sound field make you feel enveloped or how to predict a given hall is going to sound enveloping," said Matthew Neal, a doctoral candidate in Penn State's graduate program in acoustics.

With the support of faculty adviser Michelle Vigeant—an assistant professor of acoustics and architectural engineering—and a National Science Foundation CAREER Award, Neal is working in the College of Engineering's Auralization and Reproduction of Acoustic Sound Fields (AURAS) facility to measure subjective perceptions by virtually recreating concert hall acoustics.

Creating virtual concert halls

To collect the data necessary for these virtual concert experiences, Neal and his fellow acoustics graduate student, David Dick, traveled across Pennsylvania and New Jersey to measure sound fields in various performing arts venues, including Eisenhower Auditorium and Esber Recital Hall (both located on Penn State's University Park campus), as well as the Weis Center for the Performing Arts at Bucknell University

in Lewisburg, Pennsylvania.

According to Neal, advances in acoustics technology have made collecting data in the field easier and more robust.

"With a typical microphone, we can only capture the time and frequency information about a particular room with no spatial information about where in the room reflections and acoustic energy is collected," Neal said. "Instead, we use a spherical microphone array called the Eigenmike by mh acoustics, which has 32 microphones evenly distributed around a sphere. This tool allows us to collect all three dimensions—time, frequency and space—so that we can virtually recreate the experience of each hall in our facility."

By using the Eigenmike to collect spatial acoustic data in a variety of concert halls, Neal and his fellow graduate students can virtually recreate the sound of each venue in the AURAS facility.

"We can take this microphone array between different halls, place it in a similar seat location and use an identical arrangement of sound sources to create comparable measurements between many different concert halls," Neal said. "Then we bring all that data back and reconstruct those measured sound fields for listeners."

Once back in the AURAS facility in the basement of Hammond Building at University Park, musicians can virtually travel across the country to hear how a musical composition sounds in varying venues.

Equipped with 30 loudspeakers and two subwoofers surrounding a chair in the center of the anechoic chamber, the AURAS facility immerses participants in recorded pieces of music from measured concert halls. Thanks to a tablet digitally displaying each venue and piece of music, participants can easily sift through venues and rate their perception of

the room in terms of reverberance, envelopment, overall quality and many other factors.

"Now participants don't have to fly to Los Angeles, New York or Berlin to experience these concert halls," Neal said. "Instead, they can switch between them at the click of a button and hear how a solo violinist playing on a stage sounds in each."

Having real-world impact

According to Neal, having access to advanced acoustics technology within the AURAS facility is an advantage for Penn State researchers in comparison to similar programs across the country.

"The fact that we can bring participants into this room and have them directly compare all of these halls at once is an amazing resource that very few facilities around the world—and especially in the U.S.—have the ability to do," Neal said.

In addition to studying listener preferences, Neal says these virtual acoustics technologies also allow acoustic consultants to demonstrate value to stakeholders early on in the venue design process.

"In architecture, we have computer models to simulate what a space will look like for a client and give the design more aesthetic and sensory value," Neal said. "Acoustically, we can talk all we want about what a concert hall is going to sound like, but if we can recreate the sound field for a client, that helps them understand and hear the value of certain design elements."

According to Vigeant, Neal's adviser, research in the AURAS facility has the potential to have a lasting impact in the acoustics field.

"Matthew's research will allow us to develop better tools that can be used for the design of acoustically sensitive spaces, in particular concert halls for symphonic music," Vigeant said. "And improving our tools should be helpful to the acoustical design industry as a whole."

In the future, the research team hopes to travel nationally and internationally to collect more concert hall data from venues varying in design and size.

"Our plan is to measure more halls around the Northeast by next spring, and then next summer, expand to the Midwest and California," Neal said. "If all goes well, we will also travel to Europe, specifically to France, Germany, Austria and the Netherlands, to include European halls in our research and testing."

But as for the best seat in the house at the nearest concert hall, if Neal has learned one thing through his research, it's that preference is all in the ear of the beholder.

"If you like to have a really clear, crisp sound and hear every small detail, you'll probably want to sit closer to the stage where you're getting a strong surge of sound directly from individual instruments," Neal said. "But if you like a lot of reverberance from the full orchestra, you might want to sit farther back so the sound is more balanced and subtle. Really, it all comes down to personal preference."

Provided by Pennsylvania State University

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