INDEPENDENT RESEARCH / SPRING 2023

Spatializing Sound

Acoustically-driven parametric form-finding for performance spaces.

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INSTITUTION	The University of Texas at Arlington, CAPPA
PROGRAM	Independent Study, B.S. Architecture
DURATION	Spring 2023
TOOLING	Rhinoceros 7 / Grasshopper / Kangaroo
RECOGNITION	AARC Research Medal (sole recipient, undergraduate & graduate)

“Rather than treating acoustics as a corrective layer applied after form is set, the project asks what happens when sound reflection becomes a generator of geometry from the start.”

01 / ABSTRACT

Designing with sound, not around it.

This independent study developed a parametric workflow that integrates acoustic performance into the earliest stages of architectural design. Rather than treating acoustics as a corrective layer applied after form is set, the project asks what happens when sound reflection becomes a generator of geometry from the start.

Working in Rhinoceros and Grasshopper, the study produced a real-time tool that shapes reflective surfaces between a sound source and a defined audience region. Geometry updates live as design parameters are adjusted, allowing the architect to explore concert and recital hall configurations as an active dialogue between spatial intent and acoustic behavior.

The work was carried out during the Spring 2023 semester as an independent study under the guidance of Prof. Cord Read. This study, together with a follow-up independent research the subsequent semester, was recognized at graduation with the AARC Research Medal, awarded to a single student across the undergraduate and graduate cohorts.

02 / MOTIVATION

Why acoustics, why parametric.

Concert and opera halls remain one of the few building typologies where measurable performance is inseparable from spatial experience. A symphonic space succeeds or fails on whether sound arrives clearly and evenly across the audience. Acoustic consultants are typically brought into a project late, after massing decisions have already constrained what is possible.

The study set out to invert that order. Grasshopper offered a way to encode the mathematics of reflection directly into geometry, so that an architect could explore acoustically optimized form during concept development rather than retrofit it later. A secondary aim was personal: to build genuine fluency in parametric scripting through a project complex enough to demand it.

03 / METHOD

From a single panel to a finished space.

Development proceeded through five stages, each one a generalization of the last. The first stage is purely mathematical. The remaining stages were tested live in Rhino and are documented as videos on the project page.

Stage 1 / Single reflective panel

The first script computes the orientation of a single planar panel that reflects sound from a defined source point to a defined target point. The angle of the panel is derived from the angle bisector between the incoming and outgoing rays. There is no animation to show here. It is a geometric primitive: one panel, one source, one target. Everything that follows is a generalization of this single move.

Stage 2 / Distributed panel array

The single-panel logic is generalized to a grid of panels arrayed off a host surface. Each panel orients independently toward a different point in the audience zone, so the array distributes reflections across the seating rather than focusing them. This stage also explored how the tool responds to different surface types and different panel sizes. Panel count, panel size, source position, and the reflecting and target surfaces are all exposed as live parameters.

Stage 3 / Concept Development 1 — panels on a real-time catenary

A test of whether the tool could co-exist with a more complex parametric structure. The host surface here is a catenary mesh being balanced in real time by Kangaroo, and the acoustic panels re-optimize alongside it. As the structure flexes, the panel array adapts continuously. This demonstrates that the tool is not limited to flat or fixed surfaces. It can participate in a design environment where the envelope itself is still being negotiated.

Stage 4 / Concept Development 2 — panels meet to form a surface

A simpler host geometry but the next step up in conceptual complexity. The panels are scaled and positioned so that their edges meet, and the discrete array starts to read as one continuous reflective skin. The same acoustic function still drives every panel, sound from the source is distributed evenly across the audience, but the result no longer looks like an array. It looks like a surface.

Stage 5 / Tool demonstration

A walkthrough of an enclosed space produced by the finished script. This is not a final design proposal. It is a demonstration of what the tool generates: a naturally curved enclosure whose geometry is driven by reflecting sound to the audience. The intent is to show how an actual room could begin to come about by running the tool on a real source location and audience footprint.

04 / THE SCRIPT

Encoding acoustics as geometry.

The Grasshopper definition distills the core logic. Source and target surface inputs feed the math that derives reflection vectors, which drive panel positioning and the surface normals behind the final reflecting geometry. Panel count, panel size, source position, and the reflecting and target surfaces are all exposed as live parameters.

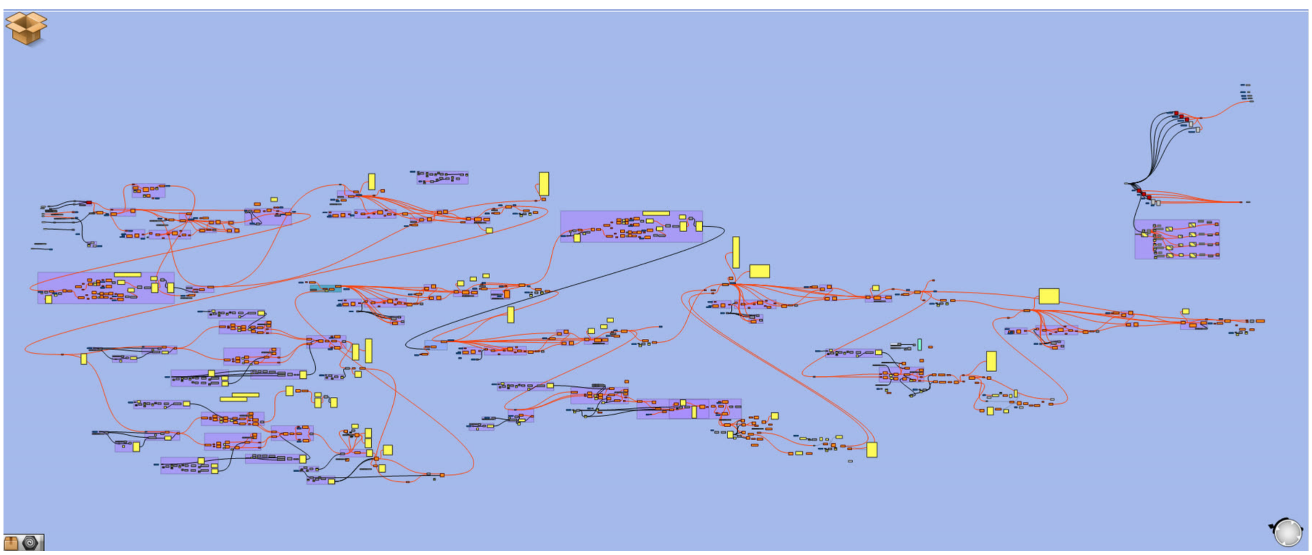

FIG. 01

The full Grasshopper definition with an optimized layout. Repetitive connectors are hidden so the active logic reads as a single, continuous flow across the canvas.

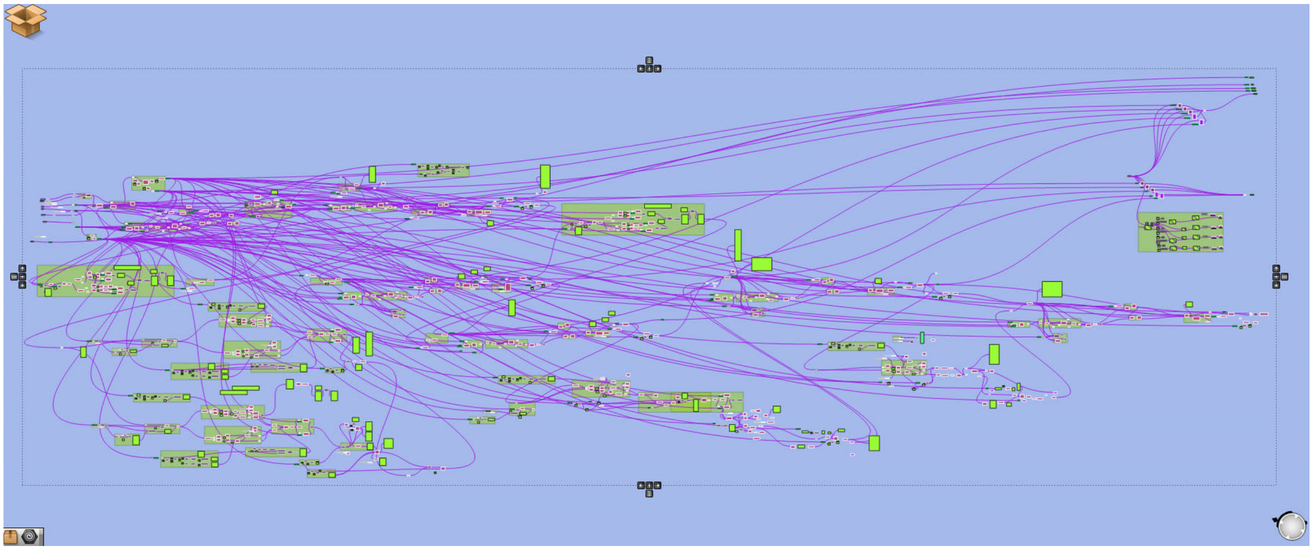

FIG. 02

The same definition with every internal wire drawn at once. This is the actual depth of connection behind the parametric controls.

Packaging it as a usable design tool.

For the script to function as a real design instrument and not just a research artifact, the entire definition was wrapped into a single Grasshopper cluster. The result is a clean component, with named inputs and outputs on either side, that another designer can drop into their own definition without ever opening the underlying math.

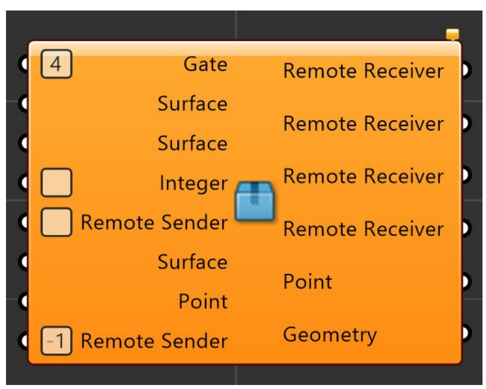

FIG. 03

The packaged cluster. Inputs (gate, reflecting surface, target surface, panel count, source point, audience zone) enter on the left. Geometry outputs (panel surfaces, reflection vectors, target points) flow out on the right.

05 / REFLECTION FIELDS

Visualizing the acoustic geometry.

Across the development cycle, the tool produced reflection diagrams as a side effect of its geometry computation. These diagrams are not visualizations added after the fact. They are the working data the script uses to position panels and shape surfaces, drawn directly in the viewport.

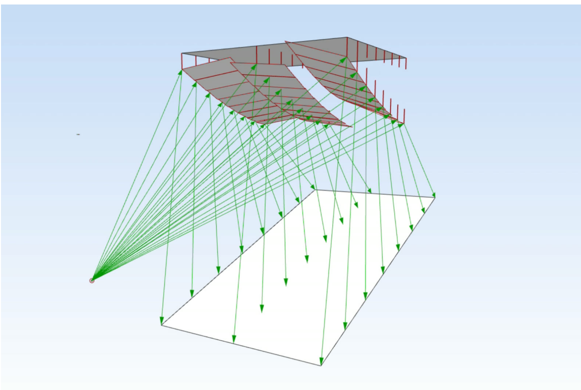

FIG. 04

Discrete panel array. Each panel rotates to target a unique audience point.

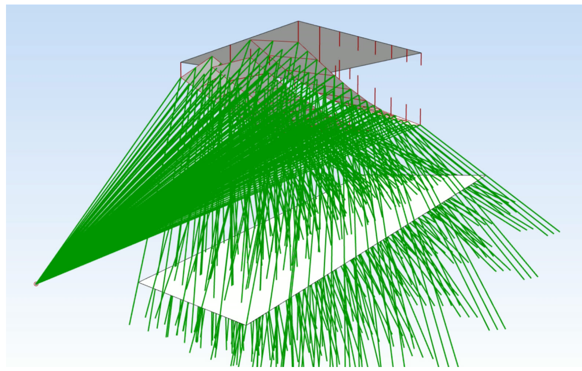

FIG. 05

Reflections emanating from a single source point and arriving across the target audience plane. The distribution shows the array working effectively across the seating: in aggregate it begins to behave as a continuous reflecting surface.

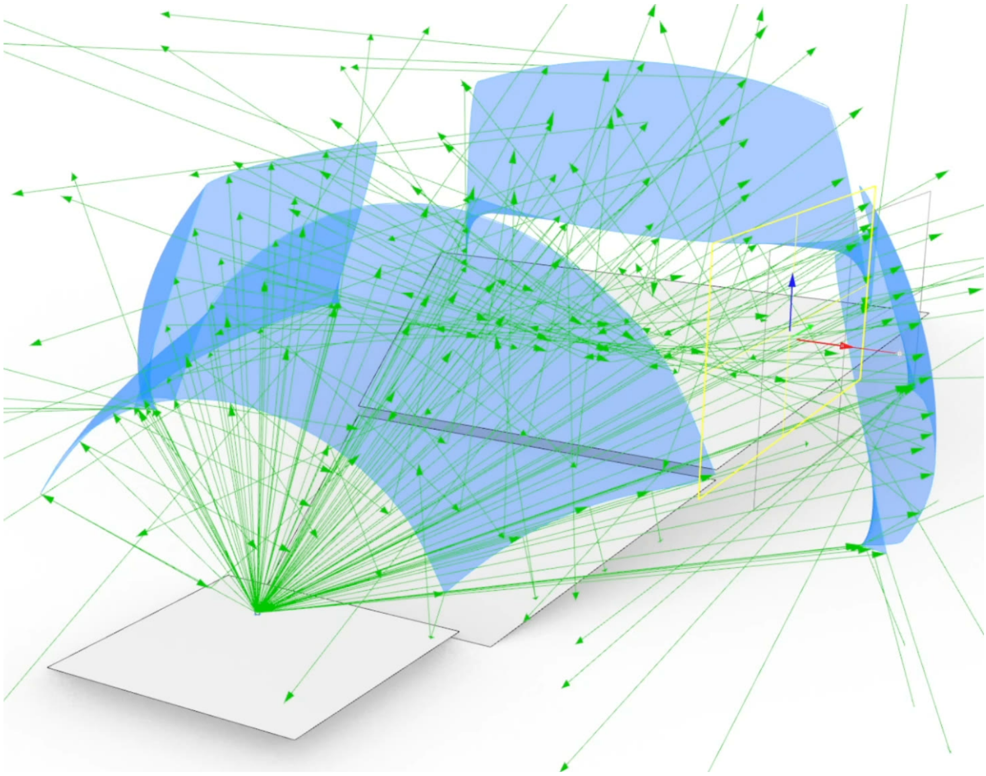

FIG. 06

Transition from discrete panels to continuous form. The reflecting geometry wraps the source and audience as a single spatial gesture.

06 / OUTCOMES

What the work demonstrated.

Three results stand out. First, that the mathematics of specular reflection are tractable enough to drive form directly inside a design environment, with no external simulation step required. Second, that the same logic scales cleanly from one panel to a continuous surface, which means it scales from interior detail to room massing without changing tools. Third, that the surfaces this process produces have an architectural quality of their own. They are not arbitrary parametric gestures. They are shaped by something physical.

The framework also generalizes. Acoustics was the test case, but the underlying pattern (encode an environmental control system as geometry, expose it as a live parameter set, let it shape the design) applies equally to daylighting, solar gain, thermal massing, and air movement. The same way of working continues to inform the rest of this portfolio.

07 / RECOGNITION

AARC Research Medal

This study, together with a follow-up independent research conducted the subsequent semester, was recognized at graduation with the AARC Research Medal from the University of Texas at Arlington College of Architecture, Planning & Public Affairs. The award was given to a single student across the undergraduate and graduate cohorts. Both semesters were carried out under the guidance of Prof. Cord Read.

/// Spatializing Sound, 2023. Independent Study, The University of Texas at Arlington.