DESIGNING, SIMULATING, AND PROTOTYPING ACOUSTIC ARCHITECTURE

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Résumé

The John H. Daniels Faculté d'Architecture, Landscape et Design, à l'Université de Toronto développe un programme de recherche solide en mettant l'accent sur l'architecture acoustique. Construire sur des projets de recherche antérieurs qui ont démontré comment le son peut être intégré dans l'architecture des flux de travail de conception, de nouvelles recherches cherche à construire sur les progrès dans la conception architecturale et de calcul de la fabrication numérique pour développer des méthodes de conception sur mesure et des surfaces innovantes. Machines robotique avancée de fabrication permet la production de prototypes complexes, et des outils numériques permettent des performances acoustiques de la pièce peut être simulée. Détails du passé et les recherches futures seront mis en évidence dans ce bref résumé.

Mots clefs : Acoustique architecturale, simulation acoustique, fabrication numérique

Abstract

The John H. Daniels Faculty of Architecture, Landscape, and Design, at the University of Toronto is developing a robust research program focusing on acoustic architecture. Building on past research projects that have demonstrated how sound can be integrated into architectural design workflows, new research seeks to build on advances in architectural computational design and digital fabrication to develop bespoke design methods and innovative surfaces. Advanced robotic fabrication machinery enables the production of complex prototypes, and digital tools enable room acoustic performance can be simulated. Details of past and future research are highlighted in this short summary.

Keywords: Architectural acoustics, acoustic simulation, digital fabrication

1 Introduction

Human activities produce sound, and architecture constantly interacts with us through its modification of sounds; we hear space as much as we see it. Despite the uncontested fact of the importance of sound, acoustic performance is often an afterthought in current architectural practice, and so there is a pressing need to incorporate sound in architectural design processes. Virtually all architectural design is carried out using computer-aided design (CAD), making it the ideal platform in which to develop new techniques.

The aims of our research is to bring the developed aspects of acoustic science into the practice of architectural design; to study the relationship of complex surfaces and the resulting acoustic characteristics of the space; to create innovative acoustic surfaces that can be deployed within the architectural interior; to develop design workflows for architects that incorporate acoustic performance parameters; and to study the potential of digital manufacturing for the production of performance-based architecture. Advances in scripting interfaces are empowering architects to create their own bespoke design tools, the digital design environment is undergoing a perceptible shift in authorship [1].

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2 Capabilities

Our research prioritizes a performance-driven design paradigm, but considers this paradigm within the complexity of the architecture project and its social and cultural context. Projects use a research-by-design methodology in which experiments progressively gain more focus: “design probes” test formal aspirations and concepts; "design prototypes” study 1:1 detail, manufacturing tolerances, and material properties; and finally "demonstrators"—full-scale working prototypes test the architectural and acoustic condition under study. Established quantitative scientific methods for simulation, measurement, and qualitative listening tests are used to evaluate design proposals.

The primary design tools used are: digital 3D modelling (using Rhino or MicroStation), parametric modelling to create variable geometries (Grasshopper or Generative Components), computer programming to create new design tools (Visual Basic or Java), rapid prototyping for to create scale models (3d printing and laser cutting), digital fabrication to produce 1:1 prototypes (various kinds of CNC cutting and milling), and simulation to predict acoustic performance (Odeon or Pachyderm). The developed digital tools and workflows are evaluated within the context of specific projects and are modified throughout the design process in response to developments in the design brief.

Figure 1: The computational model as organising element

3 Results and Discussion

The research is focused on the development of design tools, and on the development of new types of acoustic surfaces. The first prototypes—*Manufacturing Parametric Acoustic Surfaces* (Barcelona, 2010) [2], and *Distortion I* (Copenhagen, 2010) demonstrated that architectural surfaces can be formed and their material properties modified to define perceptually different types of acoustics spaces. In both experiments, the parametric model became a synthesis of all design ideas and contained multiple representations of project: for visualization, for simulation, and for fabrication.

Figure 2: Distortion I, Copenhagen, Denmark

Distortion II (Copenhagen, 2011) further developed the concept of "acoustic subspace", and introduced a new quantitative parameter (STV IA-diff) for the evaluation of personal acoustic experience [3]. The *FabPod* project (Melbourne, 2012) further investigated the potential to "tune" performance through material differentiation. Four digital workflows were developed to integrate acoustic simulation into architectural design: using computer acoustic simulation software, using plug-in software in architectural CAD, using a Boundary Element Method (BEM) simulation for calculating sound scattering, and developing a Finite-Difference Time-Domain (FDTD) technique for visualizing sound waves and sound scattering [4].

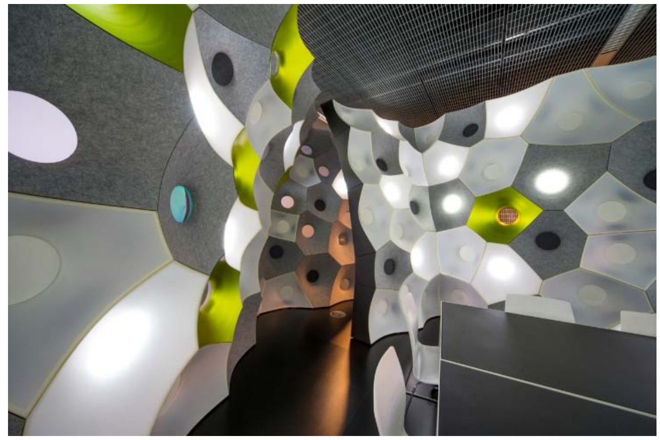

Figure 3: FabPod, Melbourne Australia.

4 Future Projects

Our research continues investigate the architectural potentials of parametric design, computer simulation, and digital fabrication through the prototyping and analysis of acoustic surfaces, and continues to develop the acoustic architecture toolkit. However, beyond coupling digital design to performance simulation, future projects will link acoustic design to robotic constructive processes. In the new Daniels Architecture building, our new lab will develop innovative complex surfaces that offer improved architectural acoustic performance, which will inspire new attitudes towards the role of sound in architectural design, and new limits for the potentials of robotic digital fabrication will be established.

Architecture is an instrument. Through the manipulation of geometry and surface, designers create spatial and experiential sonic effects. To design acoustic architecture is not to merely meet minimum standards, but to inspire new cultural and social meaning through extraordinary sound. There is a need for design tools that support this acoustic exploration and creative innovation. Architecture is a design process that extends from ideation through to realization; and, the incorporation of acoustic performance must therefore be considered in the design phase and integrated into the constructive logic of fabrication and assembly.

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