Acoustics Oribotics:
The Sonic impact of Heterogeneous Parigamic shapes

Mostafa Refat A. Ismail, Department of Architecture Engineering, Ain Shams University, Cairo, Egypt

Hazem Eldaly, Department of Architecture Engineering, Ain Shams University, Cairo, Egypt

ABSTRACT

There is a great demand in multipurpose elements design for use adaptation. This in turn requires great flexibility in design strategies, as well as a wider spectrum of space settings to achieve the required environment that special activities imply. Acoustics is an essential factor influencing cognitive acts and behavior as well as on the extreme end the physical wellbeing inside a space. The complexity of this constrain is fueled by the extended geometric dimensions of multipurpose halls, making acoustic adequateness a great concern, that could not easily be achieved for each purpose. To achieve a performance oriented acoustic environment, various parametric shaped false ceilings based on origami folded notion are simulated. These parigamic shapes are able to fold and unfold forming an oribotic structure, and changing the mutual acoustic environment according to the geometric shapes position and its changing exposed surface areas. The mobility of the facets in the parigamic surface can stretch up the range from a complete plain surface to an unfolded element where a considerable amount of absorption is added to the space. The behavior of the parigamic shapes are being modeled employing a ray tracing computer simulation package for various shapes topology. Results revealed a divergence of results that is caused by the folded facets to shorten the mean free path thus introducing more reflections and consequently quicker decay curves.

Keywords: Acoustics, Mobility, Oribotics, Origami, Parametric

INTRODUCTION

Various methods to optimize the acoustic environment to specific design criteria that meets a pre-conceived design proposal exist, using various mathematical and geometrical prediction methods that are adapted to indoor environments (Ismail, 2013) or external propagation modeling (Ismail & Oldham, 2002; 2003; 2005). However approaches to adapt to a certain acoustic requirement used a search method that alters the design to reach an optimal target performance. Through this approach acoustic notions are used to drive the morphogenetic process of the building design. These search methods could be Neural Networks, Simulated Annealing and Genetic Algorithms (Brownlee, 2011). Genetic Algorithm developed by John

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Holland in the 1960’s and 1970’s (Holland, 1992) has been chosen by (Isak et al., 2012) to switch from a conventional ‘model-simulate’ approach to a ‘generative-model’, more on GA could be found in the work of Fogel (1997; 2000) and Goldberg (2002).

In their work the three essential operational parameters namely a) the fitness function, b) Algorithm variables and c) Genotype and phenotype, are set according to acoustic optimum design aspect, in this case Sabine’s equation for RT, and the geometric parameters of the site and the internal building shell. They found employing the GA model with an organizational algorithm, that acoustic aspects can be used in the morphogenetic of the building shape, and to generate spatial volumes and expressive surfaces.

Based on performance-driven morphogenetic (Banda, 2010) Pablo developed a modular acoustic ceiling based on the design of Helmholtz Resonators (Ismail, 2013), the results of a physical model measurement positively supported the modeling process.

In another attempt to make architectural design acoustically driven, (Peters, 2009) introduced possibly a wider spectrum of solutions, namely absorbers, resonators, and diffusers that were integrated in his modeling environment. He concluded that if calculation routines of acoustic prediction software such as ODEON (Lynge, 1999) could be accessed, this could form an exciting new performance driven architectures if integrated as a plug-in in CAD. Brady further demonstrated in his work (Peters & Brady, 2011) how his model was used in terms of six parametric design strategies to design a school project in Copenhagen, Denmark. It was practically demonstrated that the acoustic performance can guide morphology and material strategies selection in the design, and through this approach performance can be shape linked. In further extension to his work (Brady et al., 2011) he designed a responsive acoustic surface that was designed with fixed acoustic criteria for a decided sonic experience. In this work the parametric design model was linked to fabrication machinery, which required to waive some design ideas, since the complexity of linking shape, performance and fabrication formed a competing demand and the balance could not be easily achieved.

It is obvious that the previous work demonstrates the linking of acoustic performance and the morphological aspects of the building shape. Whether in some cases external shapes were performance driven or internal shapes to reach a decided sonic experience. For all the cases outlined the resultant is a fixed shape that responds to a single ended acoustic performance environment. However in most cases in open plan design and multipurpose halls in buildings there is a need to optimize the sonic experience to suit a changing use of a multipurpose element.

Thus parametric shapes based upon origami folding notions are being examined for the acoustic performance. The so called parigamic shapes have the benefit of being modulated of small facets that can each be assigned responsive acoustic characteristics, and on the other hand due to its morphological aspects can be folded and unfolded, thus creating an adaptable sonic environment.

**THE PARIGAMIC SURFACE**

The acoustical ceiling for our multipurpose element will initially be constructed of folds deformed from an initial flat surface, according to space usage to optimize the acoustical performance of the hall. To fulfill this aim the ceiling should be easily deformed from a flat to a folded surface with many faces according to certain inputs that when changed generate variations for the folded ceilings. It is clear that this concept will be based upon folding flat surface according to certain parametrical variables, which is an intertwine ment between parametric design and the origami art.

**THE ORIGAMI FOLDS**

The origami (Lang, 1988) is a Japanese traditional art which its goal is to fold a flat paper into a certain form, based on folding techniques
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