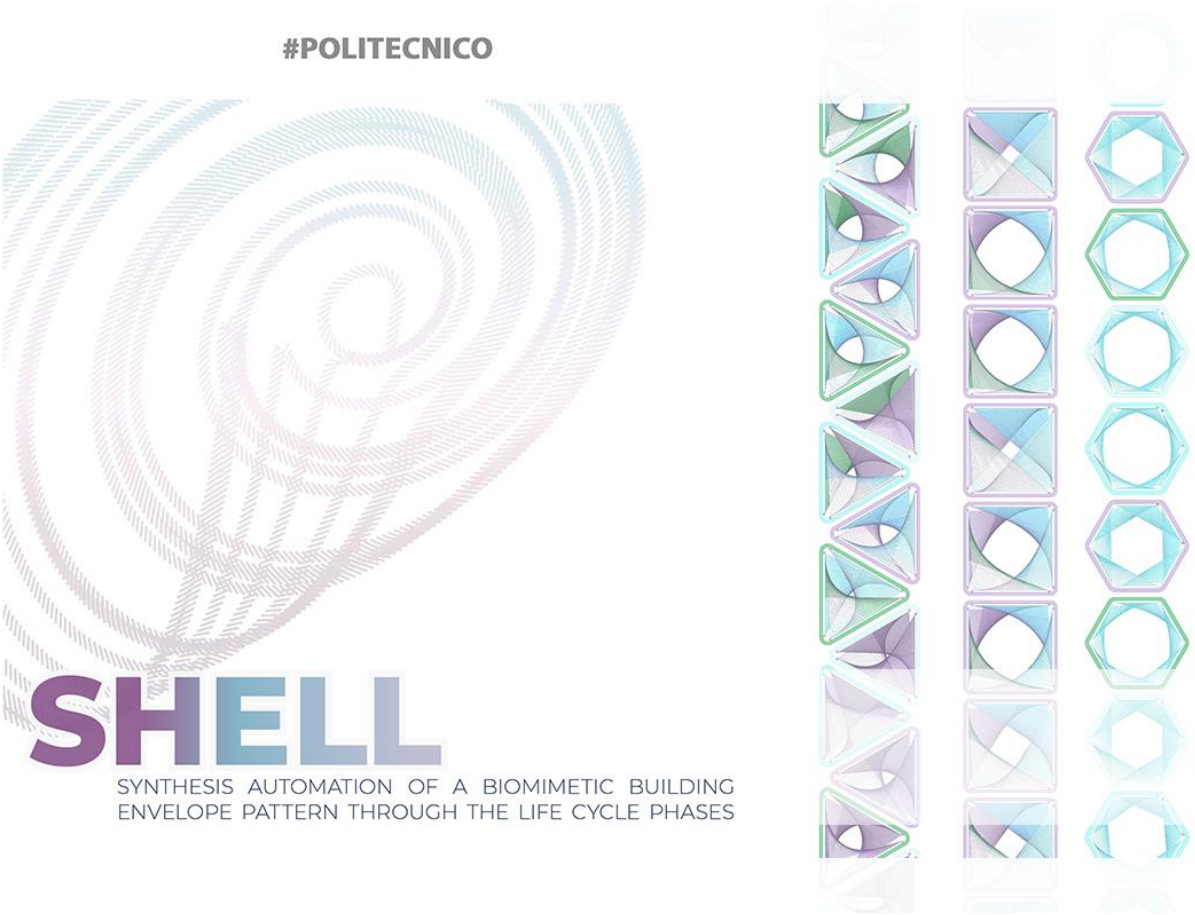
Politecnico di Torino

Honors Thesis

Master of Science degree in ARCHITECTURE FOR SUSTAINABILITY
Degree Class LM4-ARCHITECTURE AND ARCHITECTURAL ENGINEERING

Abstract

SHELL
Synthesis automation of a biomimetic building envelope pattern through the life cycle phases.



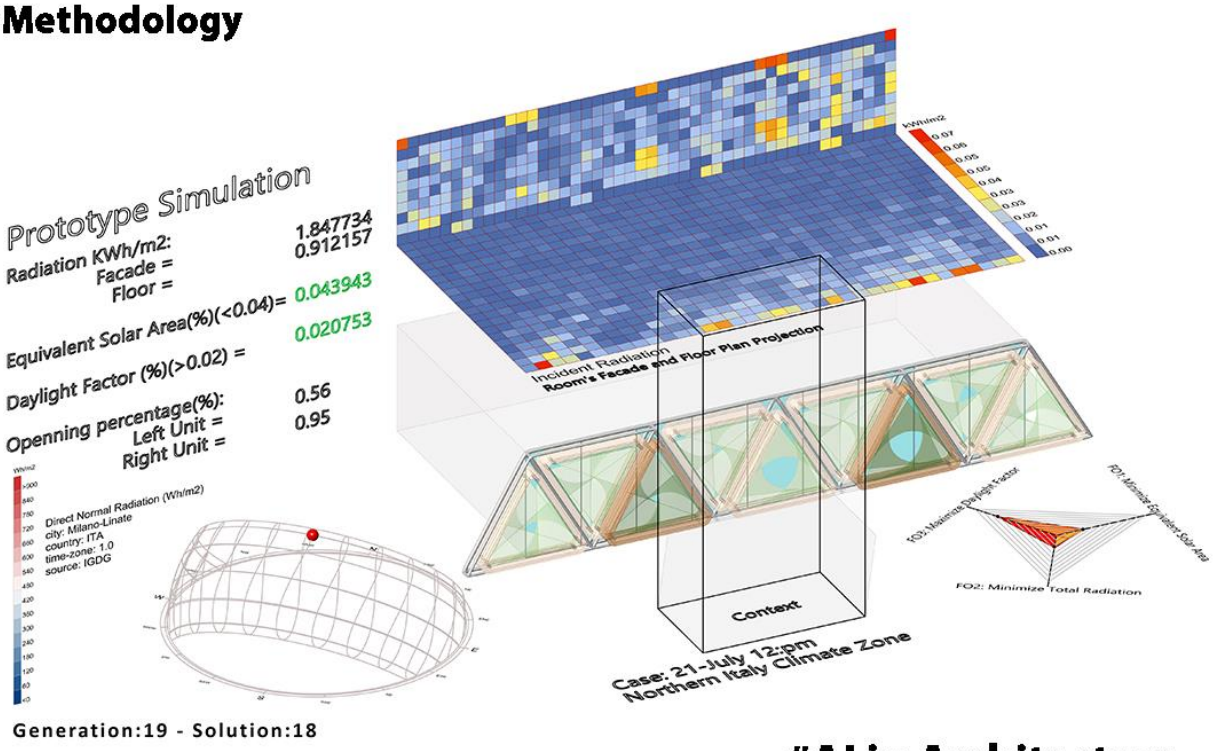
In a remarkable way, Computational Design (CD) methods have enabled architects to enhance their design. Thereafter, one of the main aspects to manage is the Indoor Environment Quality (IEQ).

This research aims to automate the building envelope design process and adaptively respond to various climatic conditions through Computational Design (CD) methods. These methods enable architects to enhance the architectural practice of building envelope design. The GOAL is to develop a new software called "SHELL" that automates the design process of a building envelope and creates two adaptable scenarios: fixed and kinetic (Trinary, Quaternary, and Hexa) units. These units form the customized envelope by utilizing a Multi-Objective Optimization Algorithm (MOEA) to enhance the Indoor Environment Quality (IEQ) of the space. The software controls and adjusts the units to achieve the targeted values of the Building Physics objectives.

Multi-Objective Optimization Algorithm (MOEA) is defined by four parts: a set of decision variables, objective functions, bounds on the decision variables, and constraints. Objectives can be either minimized or maximized to find a set of optimal solutions that satisfy the involved constraints. This method is inspired by the biomimicry philosophy, where nature's occupants like animals, plants, and microbes have already figured out how to survive on Earth in their specific environments through well-adapted mechanical and geometrical properties that change through mutation, recombination, and selection.

Automating this process will affect the pre-design and design development process, as well as the operation process, effectively enhancing its Life Cycle Assessment (LCA). The research core consists of three main steps. Firstly, the Design Proposal aims to create and improve adjustable units with different polygonal options and geometry possibilities to serve different analyses. Secondly, targeted values of IEQ and Building physics objectives are set using computational tools and scripts to adapt the envelope units for different morphological outputs through an optimization process. Finally, the envelope solutions (adapted Units) tailored to the selected scenario and optimized for its context.
A case study was conducted in the climate zone of northern Italy, specifically in the context of Milan City, using a prototype and an architecture project (TRIO) skyscraper. The optimization method was utilized and interpreted, fixing the thermal transmittance factors (H'T) in the dedicated face and applying adiabatic conditions in the other parts. The targeted comfort values of IEQ, such as the Equivalent solar area (Asol, est), radiation levels, and Daylight factor (DF), were achieved by optimizing the internal parameters through the Evolutionary Multi-Objective Optimization process.

#SHELL
#Methodology



Generation:19 - Solution:18

#AI in Architecture

The project follows the environmental analysis factors in the architectural design field, using Visual Programming Language (VPL) approaches. Environmental analysis factors are derived from Rhino program and grasshopper plugin, particularly ladybug and honeybee, to have a comprehensive approach to the internal and external building environment. Furthermore, the preferred panels are distributed as required, ensuring they do not conflict with the structural elements while checking the results of the optimization process.

This practice is followed by the production principles applied to the unit design, which lead to mass customization by addressing users' preferences. The users, in this case, are the designers who will use the automated Addin software to create their preferred envelopes. The digital building envelope elements are then transferred into a production line for both fixed and kinetic scenarios. This technology requires a significant investment in terms of time and money, as well as a high level of precision and efficiency, which promotes the distribution and marketing of this customized product.

For info:
nagysyd.m@gmail.com
arch-maher@hotmail.com