



AI APPLICATIONS IN ARCHITECTURE – (SYNTHESIS AUTOMATION OF BUILDINGS ENVELOPES)

1. Workshop Instructor Information

Name	Nagy Elsayed - Maher Aakel.
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Short Biography (150 words max.)	<p>Nagy is an award winning Architect and a researcher with interest in AI applications in architecture, in collaboration with his colleague Maher, they delivered last year an Honors thesis at Politecnico di Torino – Italy chosen for the university’s online Publication 2022 https://webthesis.biblio.polito.it/25991/</p> <p>Abstract</p> <p>The traditional design had many obstacles when adapting to a specific design in certain conditions, the process of producing shop drawings takes a lot of time and effort. This research explores, by working on the design of a building envelop derived from biomimicry architecture, the possibility of automating the above-mentioned processes through the computational tools.</p> <p>Research Questions:</p> <ol style="list-style-type: none"> 1- How can we enhance Indoor Environmental Quality (IEQ) by developing an envelope based on a biomimetic architecture. 2- How can we improve and customize the design of a building envelope by automating the process? 3- How can we improve the design of an envelope unit by improving its morphological shape and characteristics to enhance environmental performance based on mass customization manufacturing principles? 4- Is it possible to improve the quality of algorithmic design tools by controlling the backend script design through the programming features?



Head Shot



2. Workshop Information

Length	3 to 4 Hours <u>Please note that workshops will be held on November 7.</u>
Short Abstract (500 words max.)	<p>This workshop aims to provide a new approach from early design till operation depends on the AI and Genetic algorithms as it could deliver an introduction to the evolutionary algorithm's tools (Wallacei as a sample).</p> <p>The workshop will be a kind of active presentation to understand the used technique with open discussion to the attendance and then a brainstorming session to include this technique in relevant projects based on the experience of attendees, finally We can practice using one of these tools with the audience.</p> <p>Research Abstract:</p> <p>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.</p> <p>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</p>

	<p>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.</p> <p>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.</p> <p>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.</p>
Handouts and Materials	Presentation – Brainstorm session – Training (Introduction to Evolutionary Algorithms tools) (Optional – in case of student attendee)
Learning Objectives	<p>(A) Introduction to AI Applications in Architecture</p> <p>(B) Understand the Multi-Objective Evolutionary Algorithm (MOEA) as a technique and how it could be applied in Architecture Practice</p> <p>(C) How can we apply AI techniques to serve Building Physics (BP) and Indoor Environmental Quality</p> <p>(D) the integration needed between Computer science and Architecture Knowledge. (What should we learn)</p> <p>(E) Holistic approach to serve one coherent product</p>
Sample Outcome	Research Outcome and its application in skyscraper Project in City life Milan.



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ASCAAD 2023

11th International Conference of the Arab Society
for Computation in Architecture, Art and Design



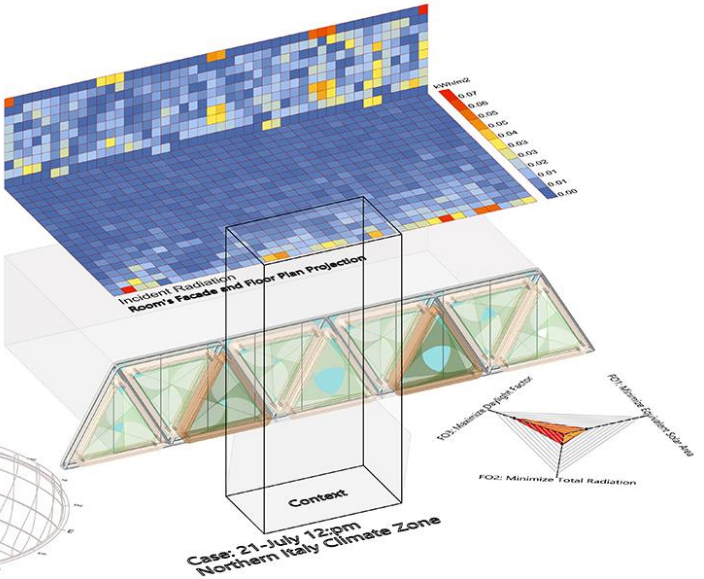
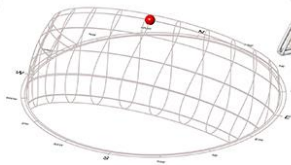
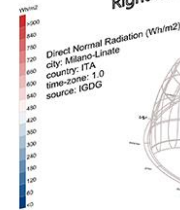
#SHELL #Methodology

Prototype Simulation

Radiation KWh/m2:
Facade = 1.847734
Floor = 0.912157

Equivalent Solar Area(<0.04) = 0.043943
Daylight Factor (>0.02) = 0.020753

Opening percentage(%):
Left Unit = 0.56
Right Unit = 0.95

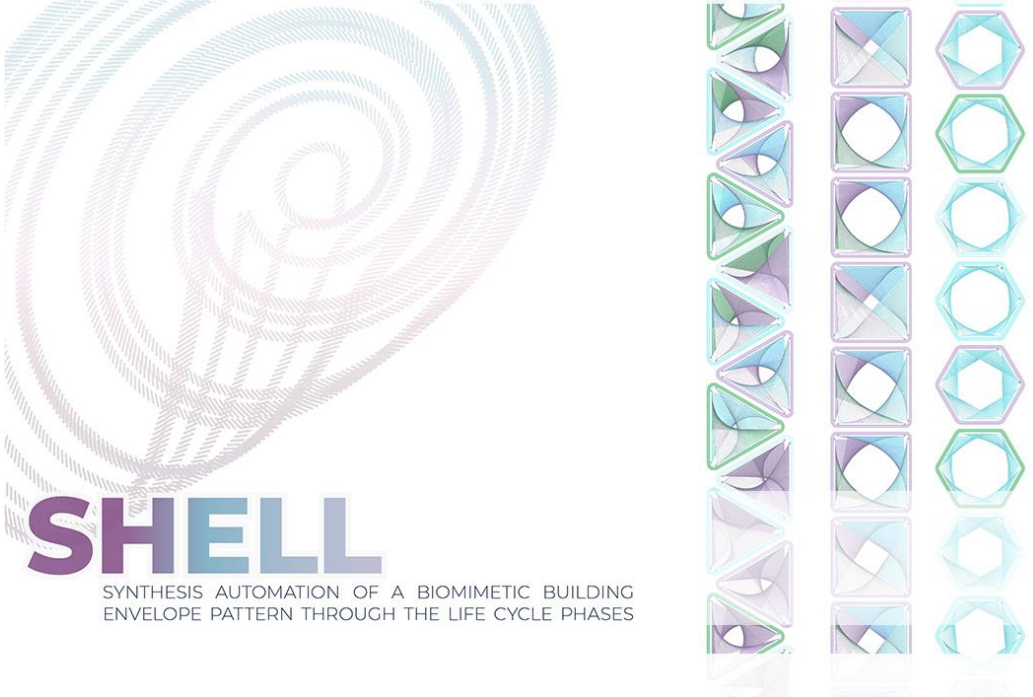


Generation:19 - Solution:18

#AI in Architecture

#SHELL #case study



	<p style="text-align: center;">#POLITECNICO</p>  <p style="text-align: center;">SHELL SYNTHESIS AUTOMATION OF A BIOMIMETIC BUILDING ENVELOPE PATTERN THROUGH THE LIFE CYCLE PHASES</p>
<p>Corresponding Conference Theme</p>	<p>(A) Smart Cities and Buildings (B) Building Informatics and Parametrics (C) Performative-Driven Design and Digital Green</p>

3. Attendees Information

<p>Who should attend this workshop?</p>	<p>Architects and designers, Envelope specialists</p> <ul style="list-style-type: none"> <i>Note : students attending is an added value for us as an educational part, but the proposal needs to be reformulated and developed especially in the practical part.</i>
<p>Prerequisites</p>	<p>Principles of Architecture, and visual programming languages</p>