IDEAS-BE Fall 2020 Grad Seminars

Morteza Hazbei

September 2020

Research I am going to do with **Dr. Carmela Cucuzzella**

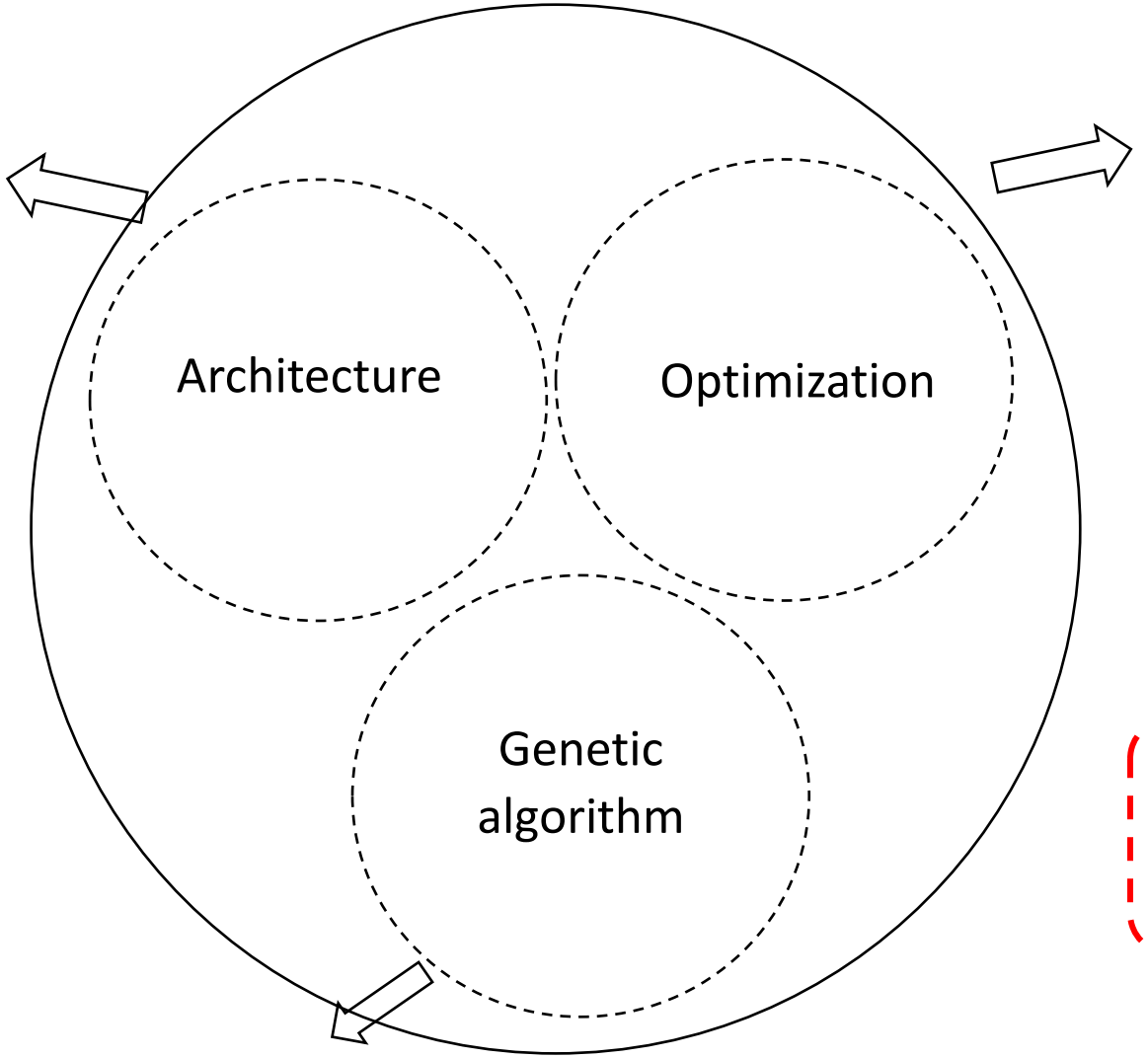
Research questions:
What are the effects of using algorithmic tools in the design process on contemporary architecture's forms and aesthetics?

Does the overemphasis on the computational power in parametric design lead to a weakness in the meaning of architectural form with regards to context, locality, site, or program?

Objective: 1) identifying characteristics of algorithmic architecture and its aesthetic features 2) construct a theoretical framework that links parametric design and formal qualities of architecture

Methods: A qualitative comparative approach will be applied to assess the formal qualities of parametrically designed buildings

Proposed paper: Formal Characteristics in Parametric Architecture



Research I am going to do with **Dr. Bruno Lee**

Research questions:

How could we optimize visual comfort, glare, and energy performance of complex architectural forms/shapes such as patterns in double- facades buildings?

How several design factors which might have contradictory effects on each other can be optimized in a holistic way?

Objective: Designing a workflow to assess visual comfort, glare, and energy performance of complex forms in building façades in a holistic way.

Methods: A parametric tools will be applied for this comparative quantitively method

Proposed paper: Parametric design of the façade patterns on an office building in Montreal regarding energy performance and visual comfort.

Research I am going to do with **Dr. Nawwaf Kharma**

Research questions: What kind of algorithms are suitable for Architectural Design Optimization (ADO)? And why?

Specifically, what kind of algorithms are practical for optimizing complex architectural forms which have a lot of variables?

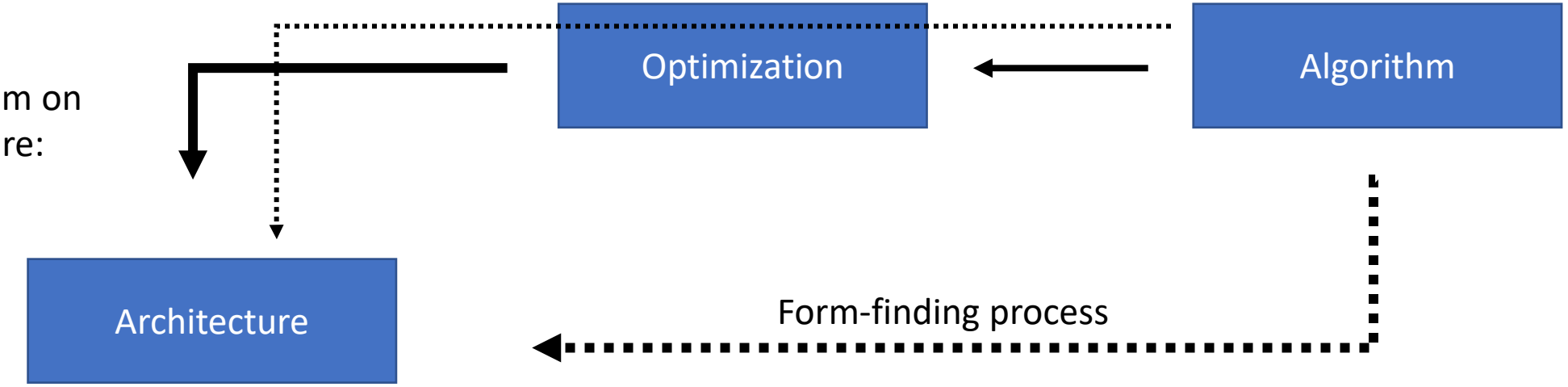
Objective: Investigate the advantages and disadvantages of using the evolutionary algorithms in Architectural Design Optimization (ADO) and justify the proper algorithm for complex forms such as patterns
Methods: I will conduct comparative research in which I will assess the advantages, disadvantages, process, and characteristics of three kinds of optimizations -direct search, model-base, and metaheuristic methods. I will assess conventional algorithms that have been used in Architectural Design Optimization (ADO).

Question 1:

What are the effects of using algorithmic tools in the design process on contemporary architecture's forms and aesthetics?

Main changes of algorithm on contemporary architecture:

- Complex forms
- Free forms
- Animated forms
- Evolutionary forms

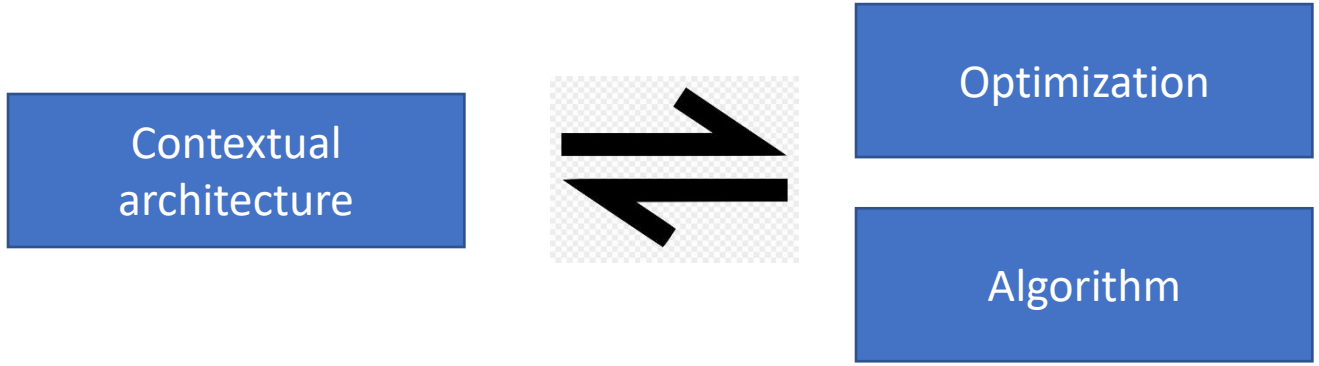


Advantages of choosing this question as the main question of architectural part	Disadvantages of choosing this question as the main question of architectural part
Specifically, investigate the role of optimization and algorithms in architectural forms in parametric era	Needs to theorize the basic of form theories in parametric architecture (the research will be inductive not deductive)
Finally, there will be a meaningful relation between three discipline of my PhD research /thesis chapters	Limited research has been done in this area

Question 2

Does the overemphasis on the computational power in parametric design lead to a weakness in the meaning of architectural form with regards to context, locality, site, or program?

The assumption for this research is that optimization and algorithm tools lead to acontextual architecture. What about modernism?



Advantages of choosing this question as the main question of architectural research	Disadvantages of choosing this question as the main question of architectural research
This research is clearly doable since it use a survey method	The connection between technical part and architectural prat is not as strong as the last question.
The research results are easily provable (Survey method)	In the architectural part of my research, I will criticize the parametric and algorithmic tools which lead to acontextual architecture. However, in the other chapters of my research, I am trying to find the best algorithmic and optimization tools for complex architectural problems. In other words, the different parts of my research contradict each other.

Parametric design of the façade patterns on an office building in Montreal regarding energy performance and visual comfort

Morteza Hazbei, Bruno Lee

Problem Statement:

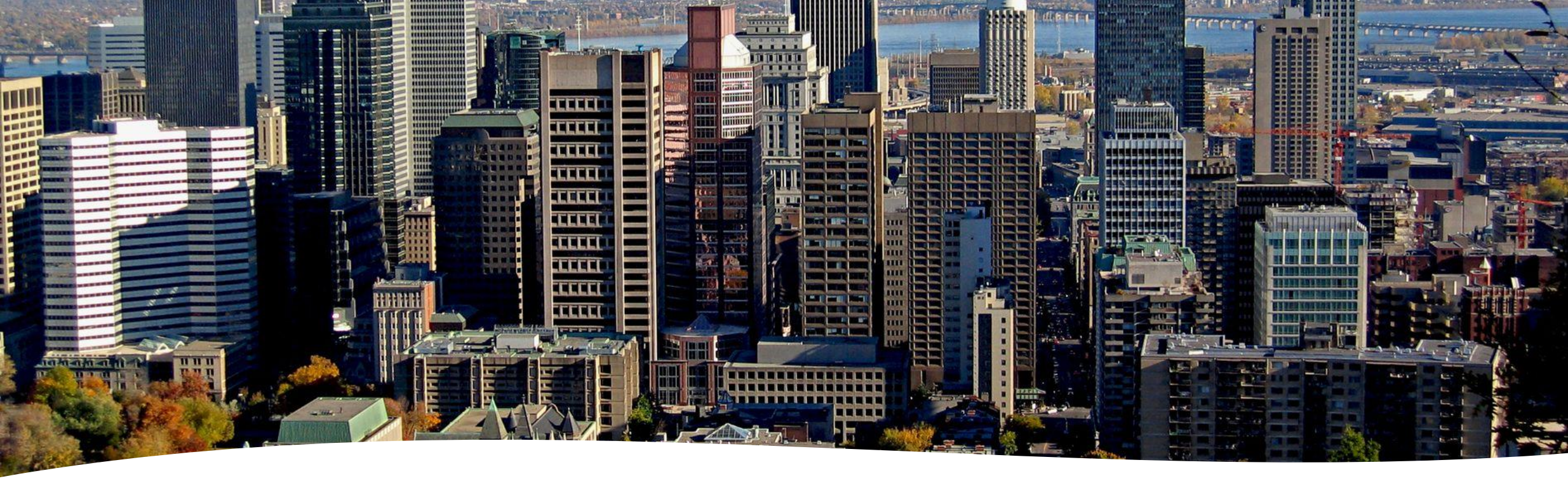
1. Multi-objective optimization will be challenging to achieve when the number of analyzing factors increases.
2. Patterns have different formal characteristics which make the optimization process problematic to achieve.
3. Applying patterns on the double façade increases the number of influential factors to achieve an optimized building and makes the process more complicated.

Objectives:

This research aims to make a road map to facilitate optimization and simulation of complex forms on building façades. Two tools will be deployed in this process—parametric design to address different formal configurations and genetic algorithms for achieving multi-objective optimization.

Methodology:

To achieve the objectives of this research, we design a workflow that integrates the parametric design and genetic algorithm. This workflow controls several pattern designs and their effects on visual and thermal comfort parametrically.



- **Outcomes :**

- This workflow demonstrates how a parametric design approach provides the designer with ideas of different alternative designs and various potential solutions which meet both energy performance and thermal and visual comfort in a holistic manner.

- **Limitations:**

Large glazing areas in facades

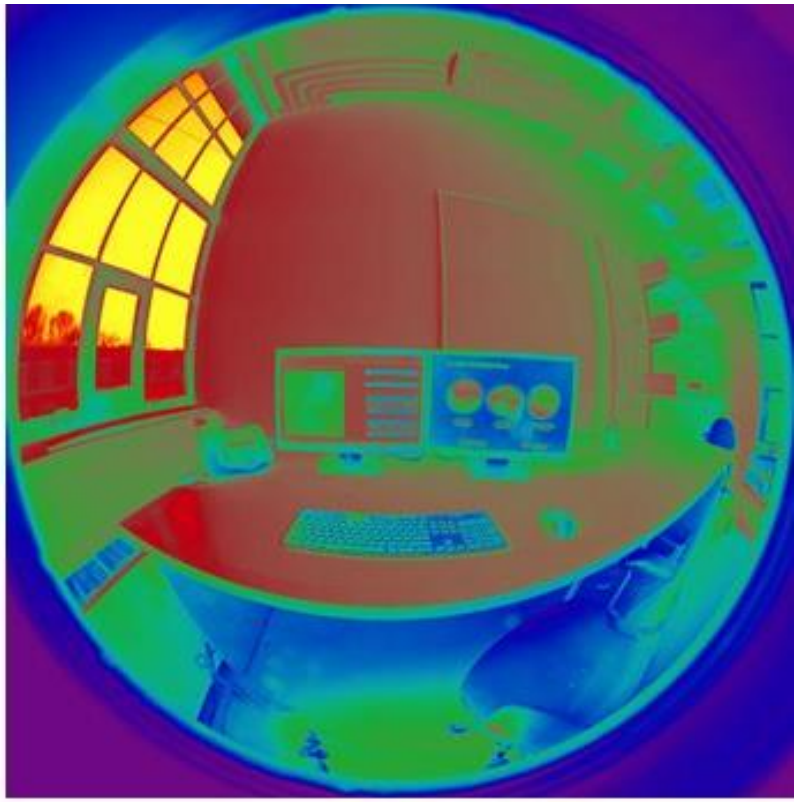
Pic source: https://mobsea.com/World-Architecture/Curtain-walls

Visual comfort and its indices

Discomfort can be caused by either too low or too high level of light as glare [19].

However, it needs to define what is meant of being too high or too low and valid evaluation of them.

- DA
- sDA
- ASE



- **Glare:**

- the possible glare discomfort relies on incoming daylight, in which direct sun exposure over 1000 lx enhances the glaring risk for occupants [21]. Furthermore, the data can be filtered by analyzing the period and view angle domain or just evaluating a total discomfort glare for all indoor view directions throughout the year on each test point.

Table 1 Glare comfort criteria (adapted from Wienold and Christoffersen [23])

Daylight glare probability	Glare comfort
DGP < 0.35	Imperceptible glare
0.35 < DGP < 0.4	Perceptible glare
0.4 < DGP < 0.45	Disturbing glare
0.45 < DGP	Intolerable glare

Table 1. recent published paper that on energy saving, thermal and visual comfort

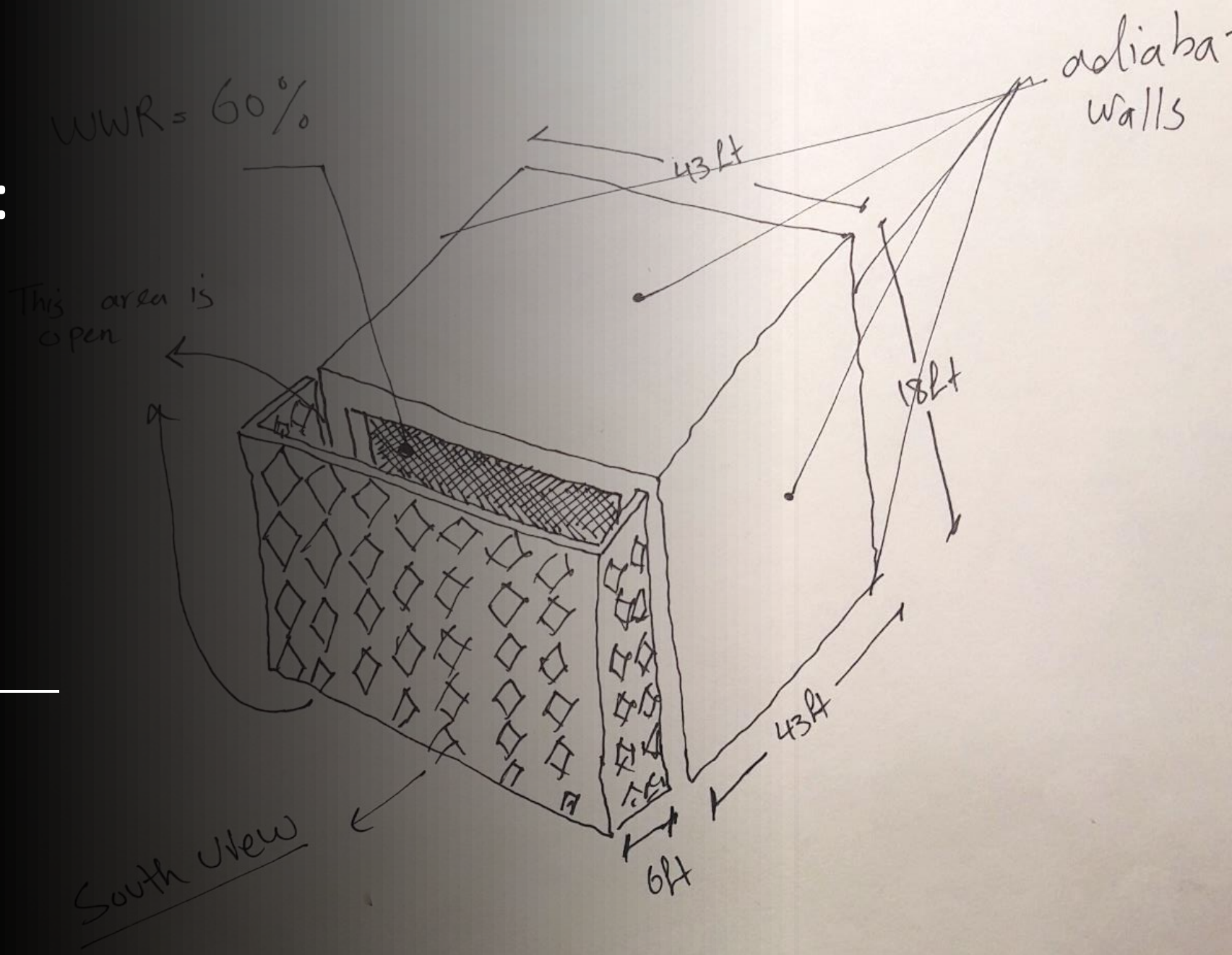
Reference and year	title	Problematic	Building type	method	Analyzing visual factors	Analyzing thermal factors	Energy factors	Optimization algorithm	Simulation platforms
[29] 2020	"Multi-objective optimisation framework for designing office windows: quality of view, daylight and energy efficiency"	"optimising parameters on the building energy loads via window system design can reduce the quality of the view to outside"	office	PB-MO	sDA ASE QV	------	(EUI)	Pareto Frontier	Grasshopper honeybee
[30] 2019	Design optimization of building geometry and fenestration for daylighting and energy performance	Generate optimized results from numerous design options	office	PB-MO	UDI	-----	EUI	Genetic algorithm	Grasshopper Honeybee Ladybug Octopus
[31] 2019	Multi-objective energy and daylight optimization of amorphous shading devices in buildings	The conventional shading device types are non-amorphous shapes providing limited improvement of the energy performance	office	PB-MO	UDI	-----	EC	NSGA-II JcGA-DE	Radiance energyPlus
[32] 2019	Buildingfacademulti-objectiveoptimizationforday lightandaestheticalpercepti on	much engineering in the envelope system creates a problem with the identity of the façade.	Just mentioned the name of building	PB-MO	sDA ASE	-------	------	NSGA-II	DIVA

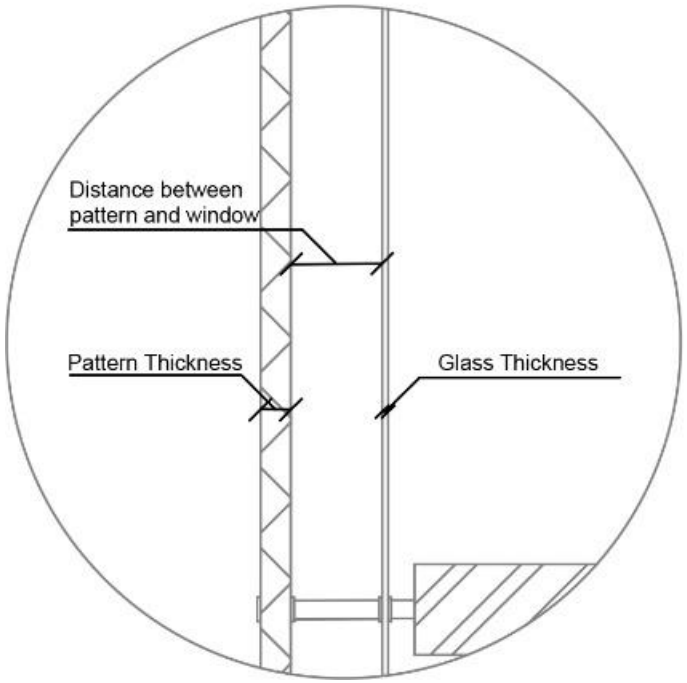
Table 2. recently published paper applying complex forms on building facades for optimization

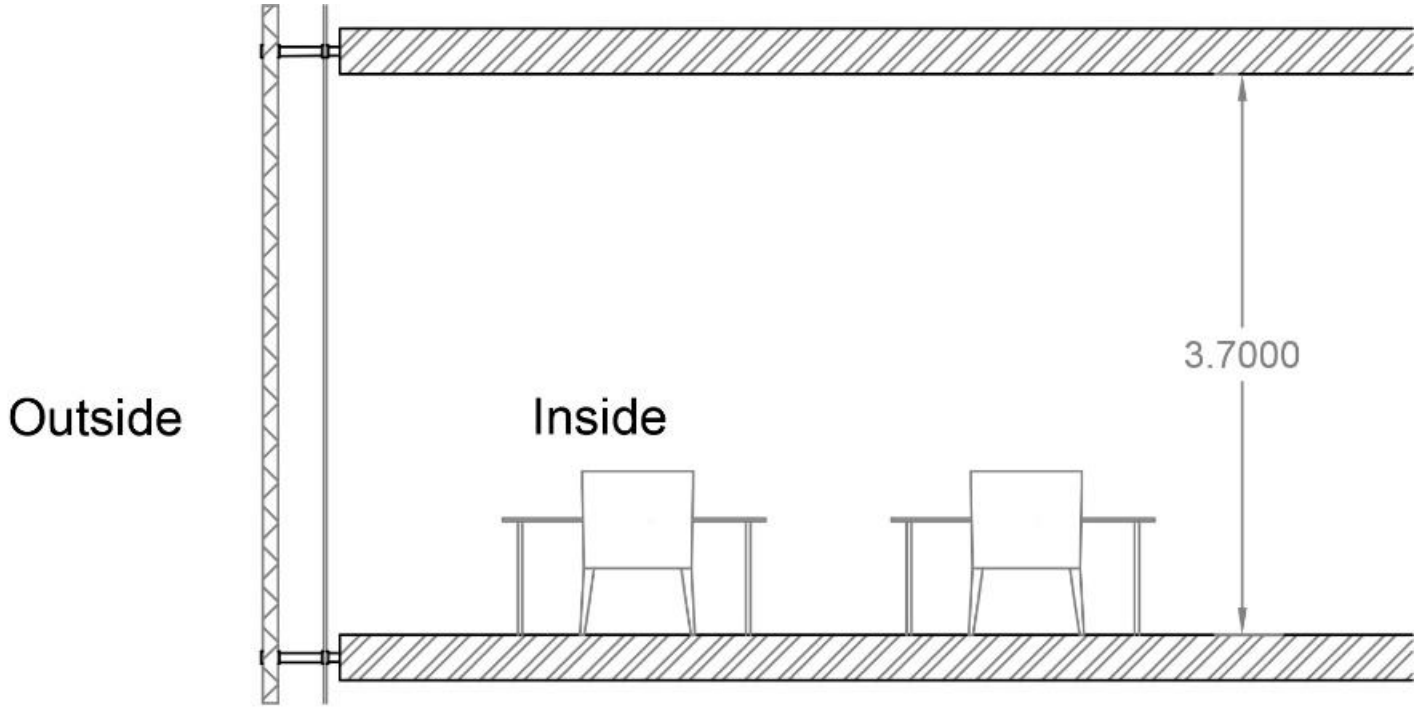
Reference	Title	problematic	Regular or irregular forms	Assessing visual /thermal comfort, glare energy performance	Parameters that analyzed	Which part of the building they applied	In which climate	Simulation platform
[33] 2014	Design of Shading Screen Inspired by Persian Geometric Patterns: An Integrated Structural and Daylighting Performance Evaluation	patterns can function as a design agency, an environmental control system, and a cultural element.	regular	Visual comfort	DA	facade	Michigan	DIVA Flamingo nXt
[34] 2019	Integrated parametric design of adaptive facades for user's visual comfort	Adaptive Solar Facade (ASF) has the potential to integrate with pattern design to maximize visual comfort.	regular	Visual comfort	UDI DGP	facade	hot-arid climate	Honeybee Ladybug
[17] 2016	Patterns of facade system design for enhanced energy performance of multistory buildings	highlighting the role of facade geometrical design in controlling, capture and utilization of solar energy, as compared to a regular flat facade module	Modular/regular	Energy performance/	Heating and cooling load	South facade	Calgary-Canada	Energy plus/ grasshopper
[34] 2019	Integrated parametric design of adaptive facades for user's visual comfort	Investigating the development of Adaptive Solar Façade (ASF) in parametric design and their functions regarding visual comfort	origami-based	Visual comfort/	UDI DGP DGI	facade	Tehran, Iran	Honeybee Ladybug
[35] 2012	External perforated Solar Screens for daylighting in residential desert buildings: Identification of minimum perforation percentages	the sunny conditions of the desert skies result in the admittance of direct solar radiation, which leads to thermal discomfort and the incidence of undesired glare	Perforated panels	Visual comfort glare	DGP DDPM DA	Façade Different directions	Egypt	Diva
[36] 2012	External perforated window Solar Screens: The effect of screen depth and perforation ratio on energy performance in extreme desert environments	Analyzing perforation and deeps of solar screens on annual energy load	Perforated panels	Energy performance	Cooling and heating load	West, south, north, east facade	Kharga Oasis, Egypt	Design Builder EnergyPlus
[24] 2016	Geometric Patterns, Light and Shade: Quantifying Aperture Ratio and Pattern Resolution in the Performance of Shading Screens	This research shows how the geometric patterns can function as a design agency, an environmental control system, and a cultural element.	Persian geometric patterns	Visual comfort	DA	facade		DIVA Flamingo
[37] 2018	The Relationship between Sunlight Pattern Geometry and Visual Comfort in Daylit Offices	Since there is a lack of literature review on applying patterns on façades, this paper tries to assess three different patterns and their effects on visual comfort.	Fractal Pattern, Striped Pattern, and 'No-Pattern'	Visual comfort	DGP SHGC	North-east facade	Portland, OR.	--

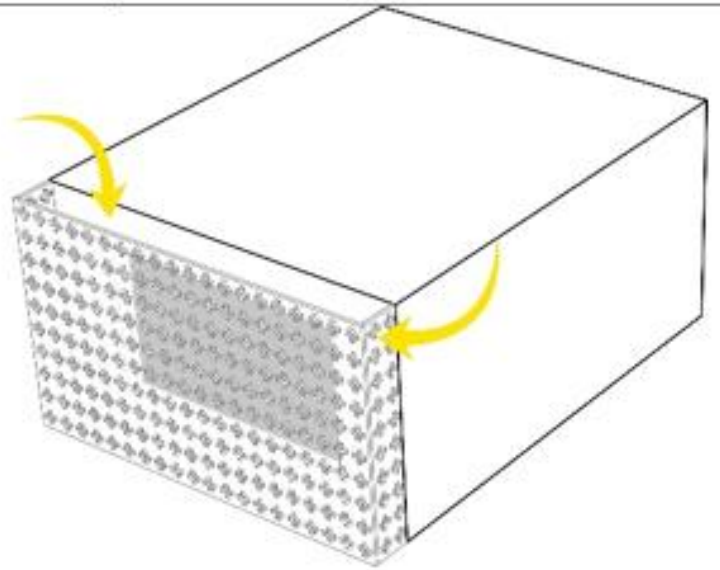
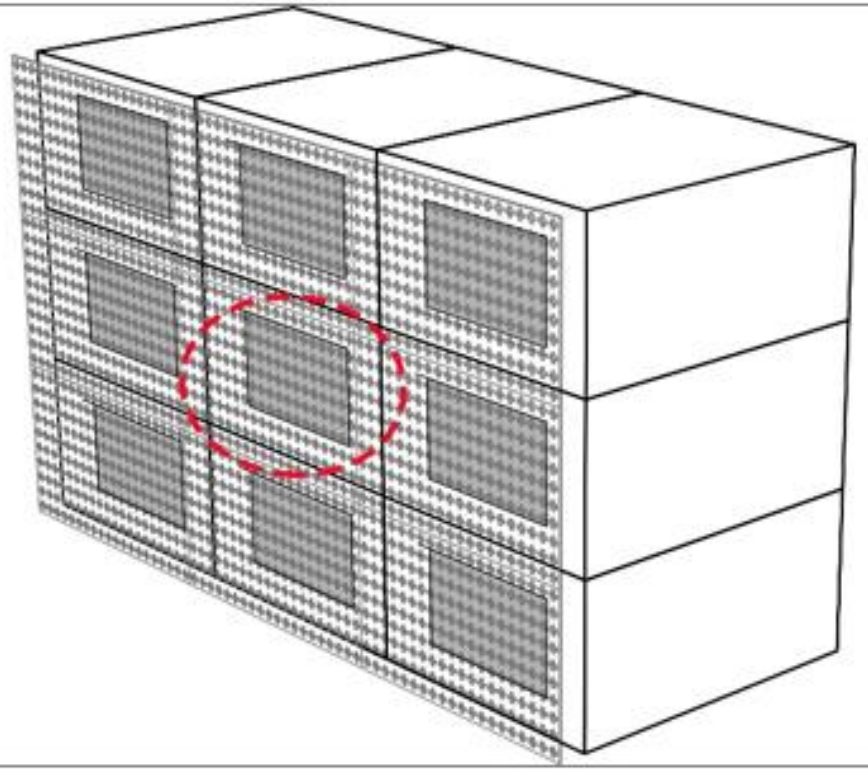
Simulation process:

Office space model and location




Distance between
pattern and window
Pattern Thickness
Glass Thickness


Outside
Inside
3.7000

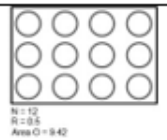
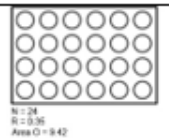
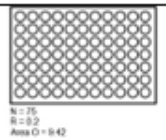
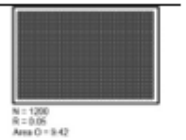
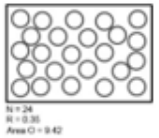
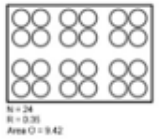
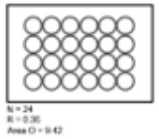
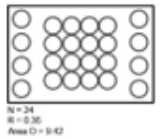
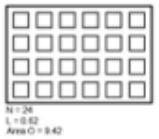
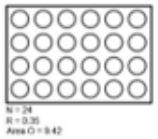
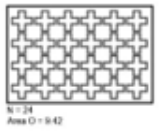
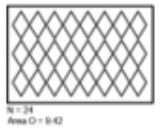
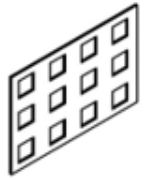
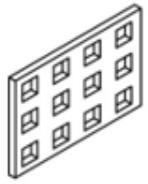
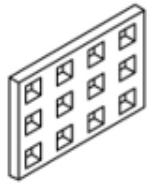
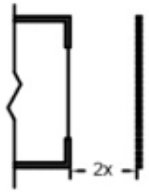
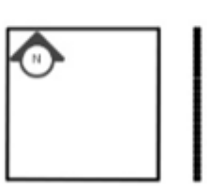
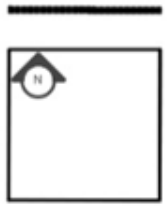
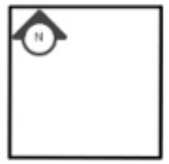
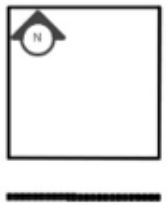
Preliminarily alternative	Final alternative
	

Time and date

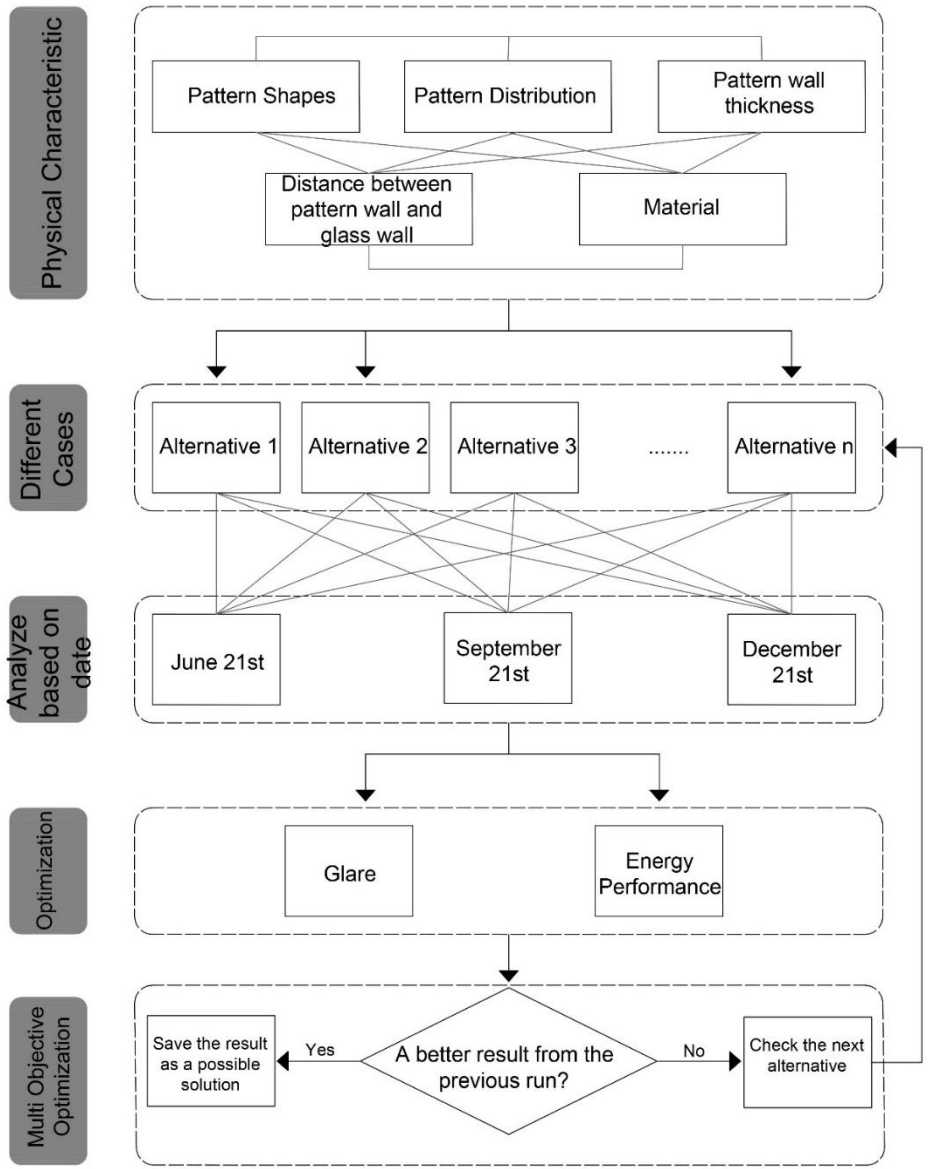
The simulation experiment was conducted for several different pattern designs in different time periods. June 21st, September 21st, and December 21st.

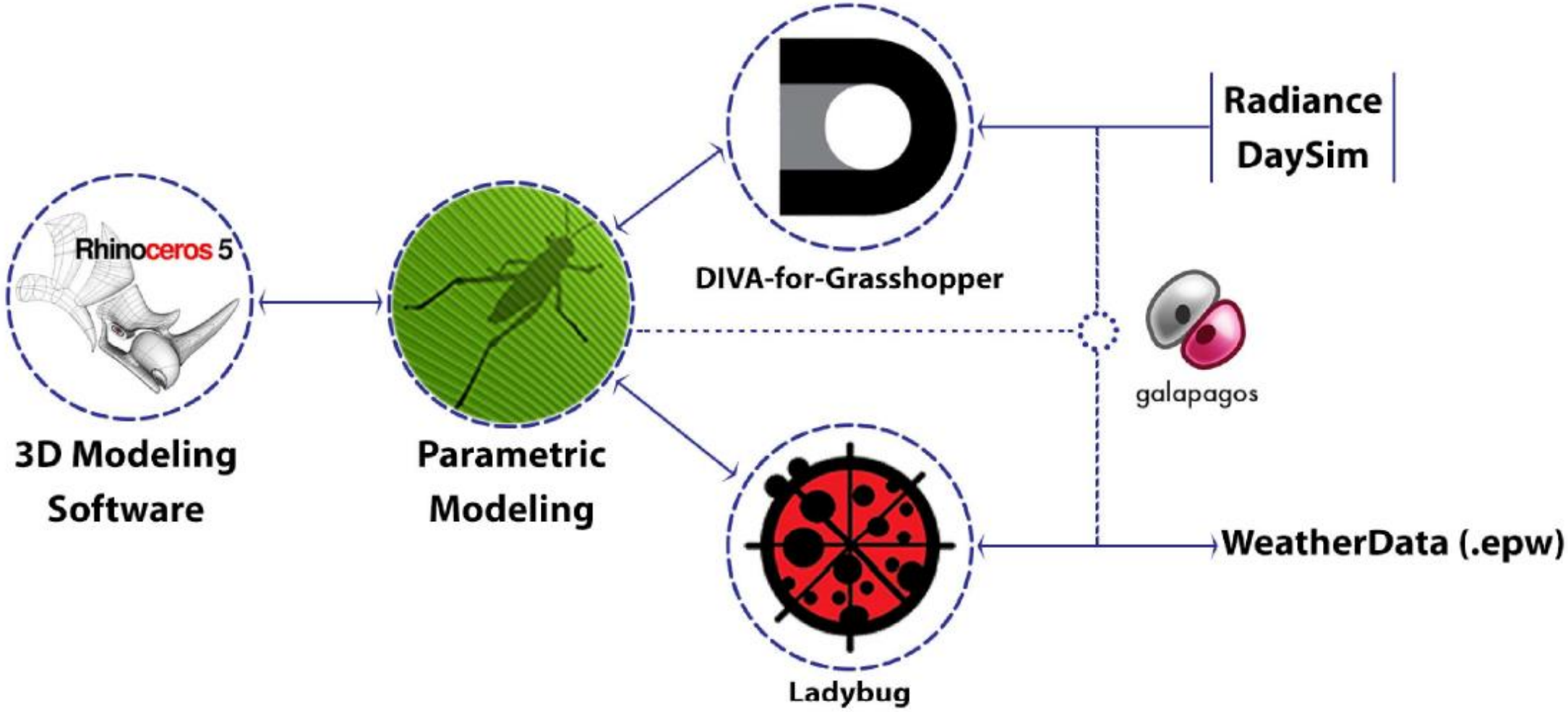
Based on the Reinhart model [25] the occupancy schedules generally vary from weekdays 8 AM to 8 PM down to 9 AM to 5 PM.

Table 2. different patterns formal configurations for simulations

Number of patterns (shapes) All cases have same WWR				
distribution of patterns				
Pattern forms				
Thickness of patterns				
Distance from the windows				
Perforated (pattern) wall in different facades				

Proposed workflow:




Rhinoceros 5
3D Modeling Software
Parametric Modeling
DIVA-for-Grasshopper
Radiance
DaySim
galapagos
Ladybug
WeatherData (.epw)