

Design Information Modeling:

A Dynamic and Interactive

Knowledge Integrated

Performance Driven Design Methodology

(DIM)

PhD candidate : Sina Mostafavi

Promoter: Prof. Kas Oosterhuis

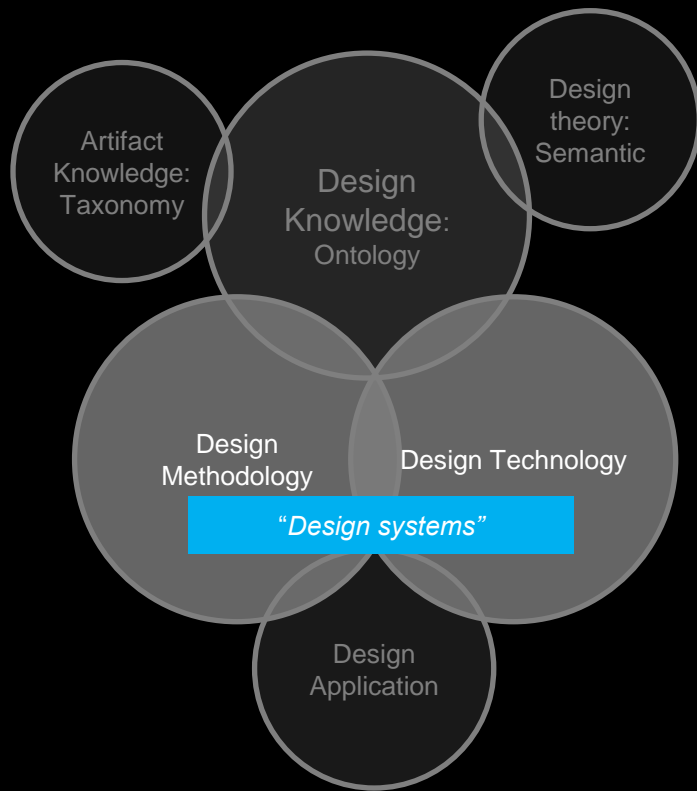
Co-Promoter: Dr. Nimish M. Bitoria

A Scopes & focuses

B Questions & Objectives

C Approaches & prototypes

D Realized, ongoing & Future plans



Modelling _ Synthesis _ generation _
parameterization methods and processes

GEOMETRY



Geometric
Information

AND



Non-Geometric
Information

PERFORMANCE

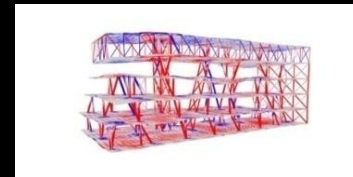
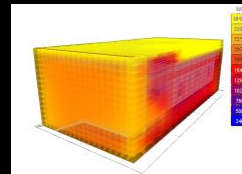
Measurement _ Analysis _ evaluation _
optimization methods and processes

PERFORMANCE



Environmental
Structural

...



...

In prototyping phase, structural and environmental systems are the main focus to be considered for knowledge integration.

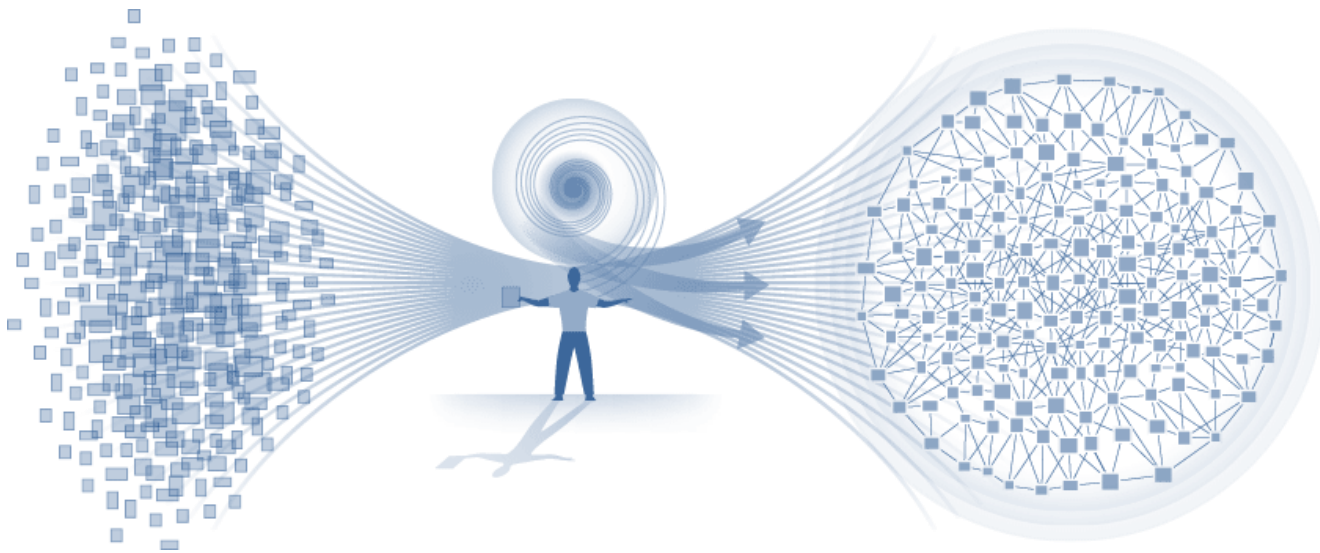
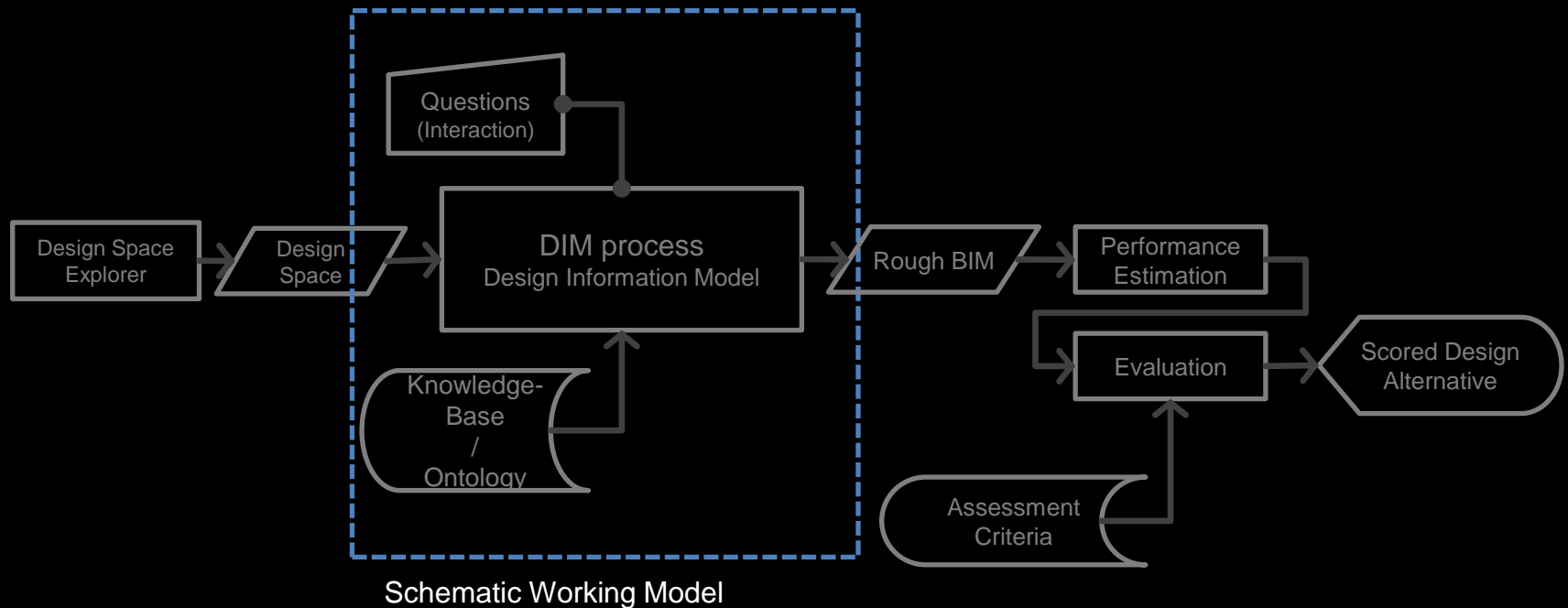


Diagram from: [idiagram /ideas/knowledge_integration](#)



Question:

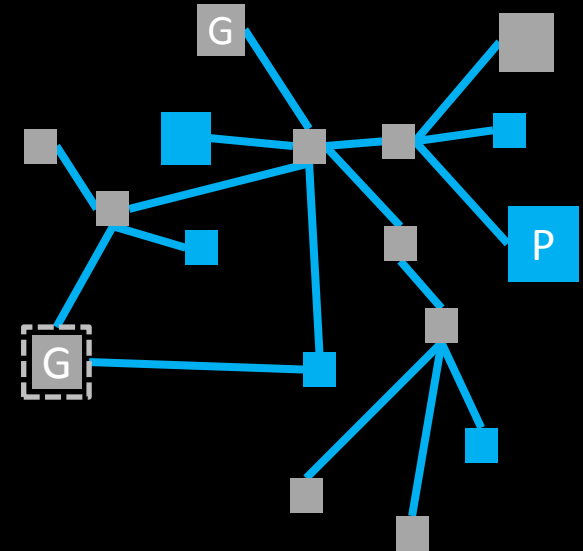
How, in architectural design decision making processes, can one **interactively inform geometric models** at the early stages of design; in order to have **co-evolving and interdependent design models** and to dynamically **measure and evaluate the quality and performance** of the design proposals?

Objective

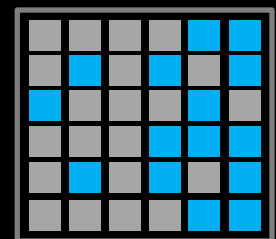
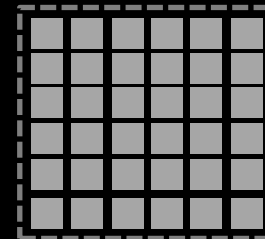
DIM is aimed to propose a framework, **a methodology** and a **set of tools** for facilitating information modeling and structuring in correlation with multi-layered geometric models in architectural design processes to support **real-time analysis, evaluation and decision-making**.

DIM approaches

- 1 One is Through focusing on *design information exchange* between different geometric modelling and analysis/simulation/optimization platforms and techniques to establish **DIM Flows**.(Links)



- 2 The second approach is based on *embedding evaluation subroutines in generative/complex systems* to formulate **bottom up DIM** methods which leads to knowledge integrated performance driven solutions.



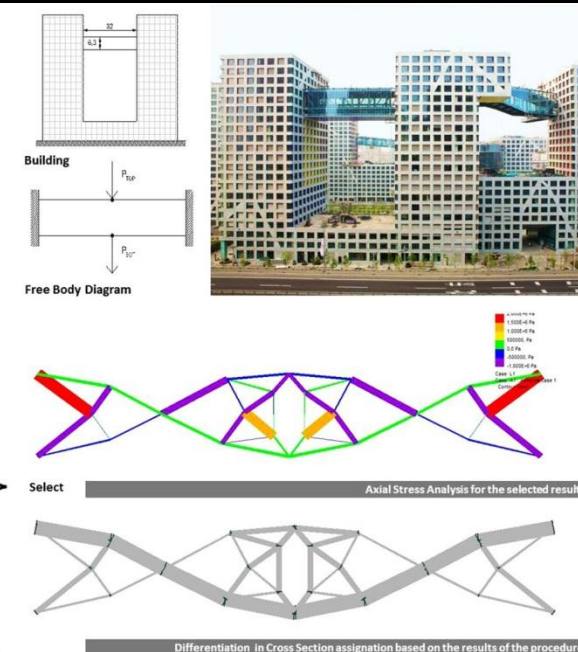
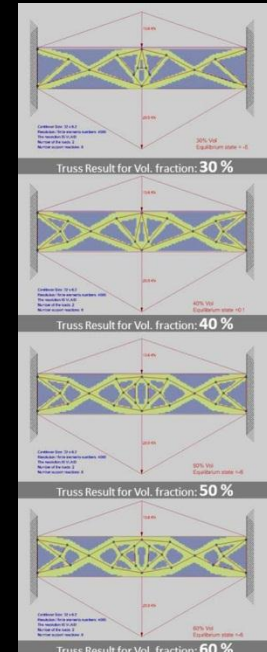
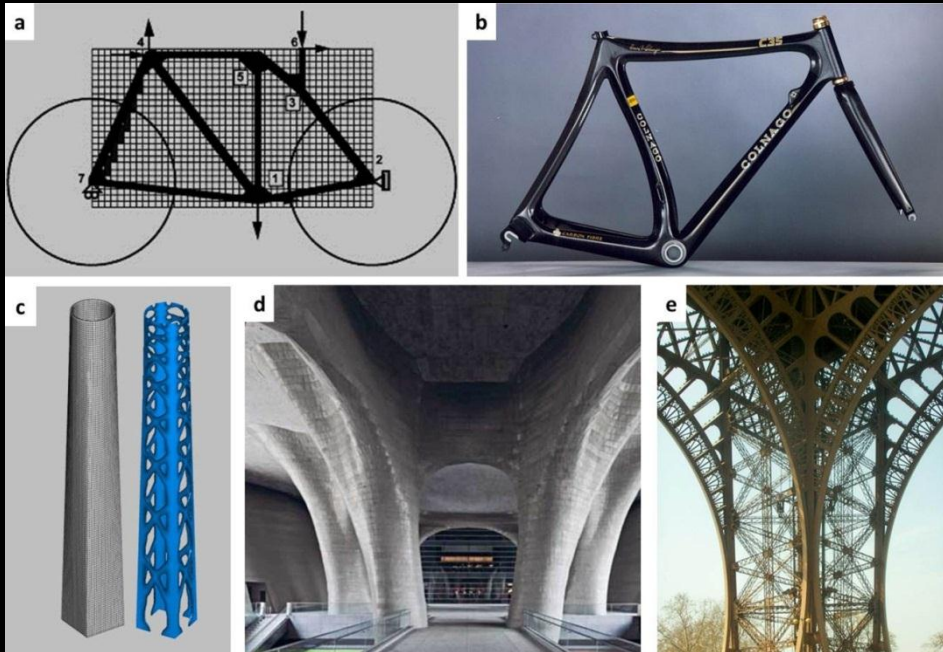
DIM Case with focus on structure

Performance driven design and design information exchange

Establishing a computational design methodology for parametric and performance-driven design of structures via topology optimization for rough structurally informed design models

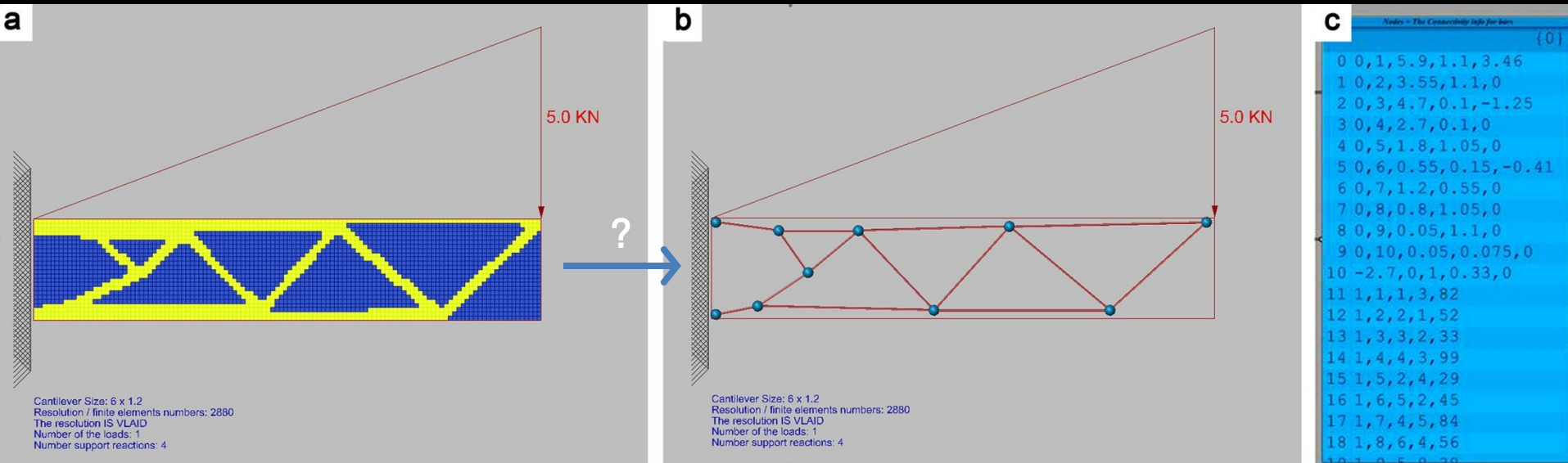
Sina Mostafavi¹, Mauricio Morales², Nimish Bitoria³

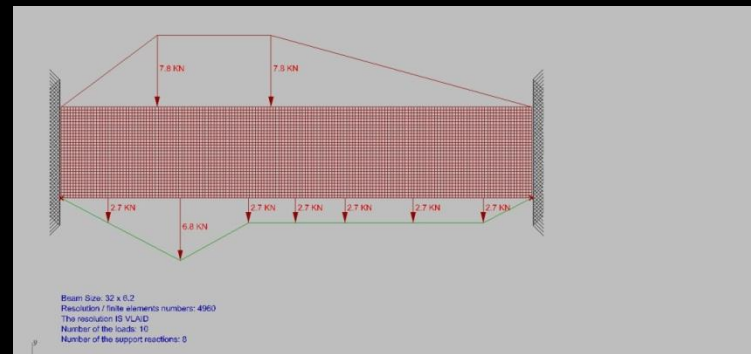
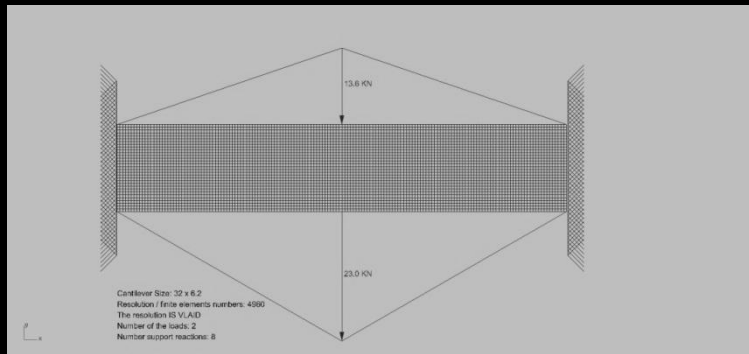
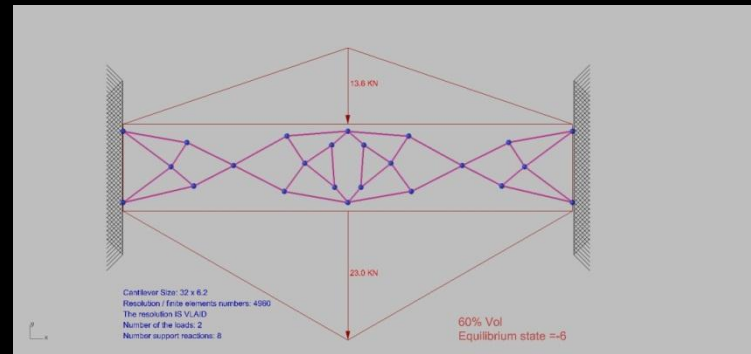
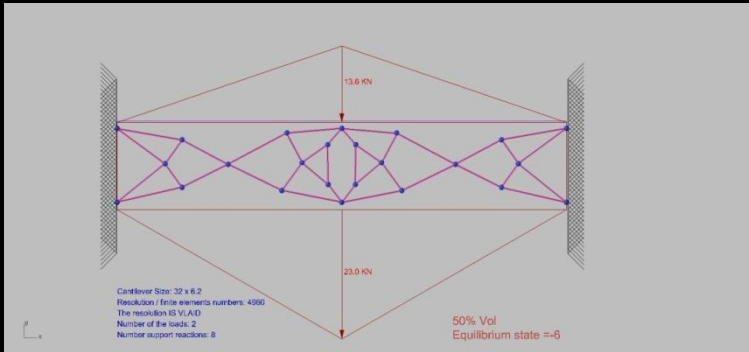
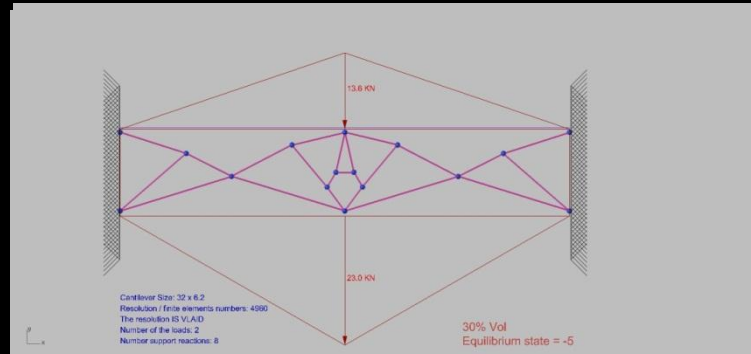
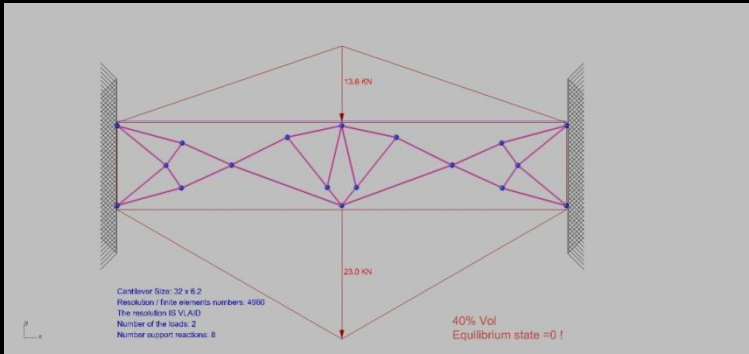
^{1,3} TU Delft, Hyperbody, AE+T, Faculty of Architecture, The Netherlands, ² TU Delft, Structural Design, AE+T, Faculty of Architecture, The Netherlands. eCAADe2013

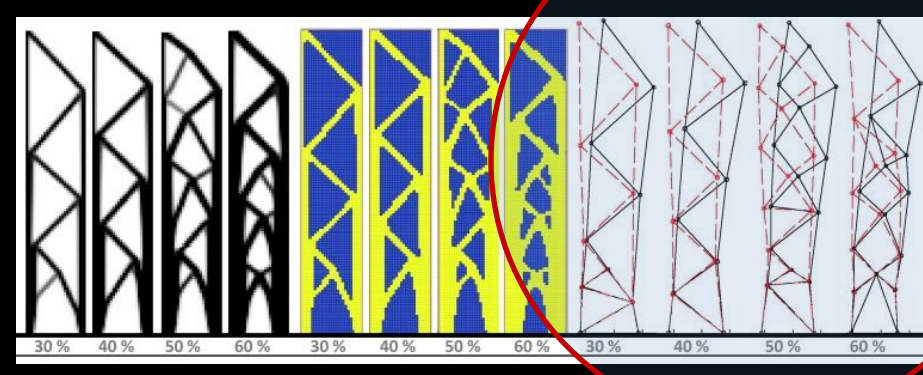
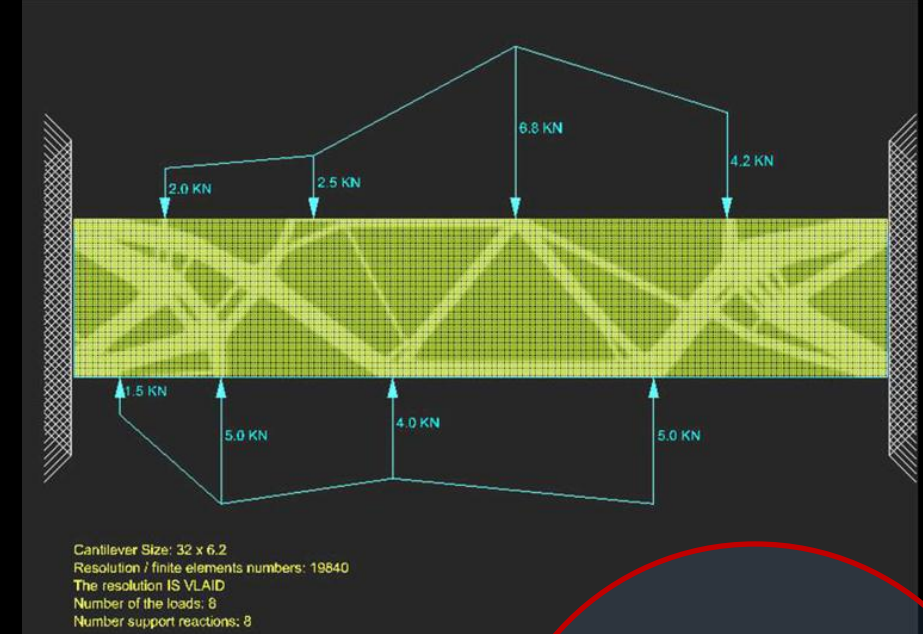
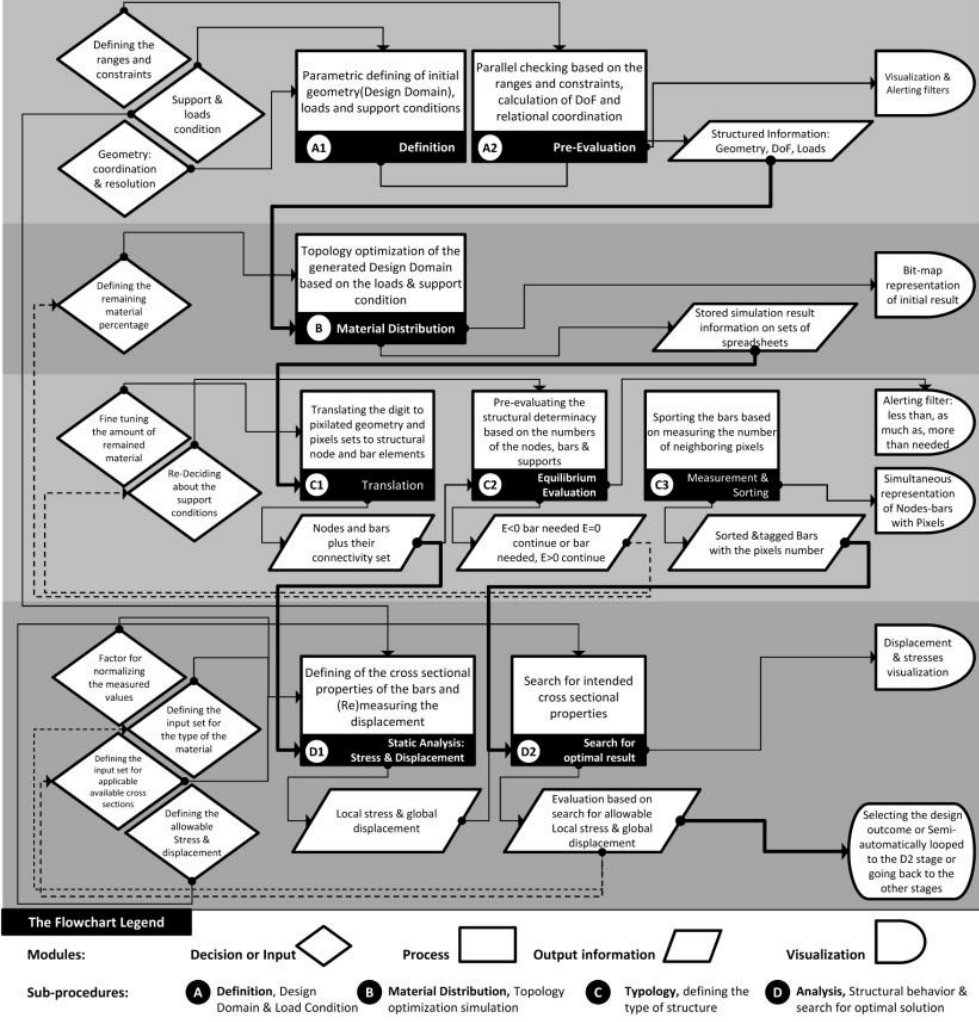


Goals and Challenges

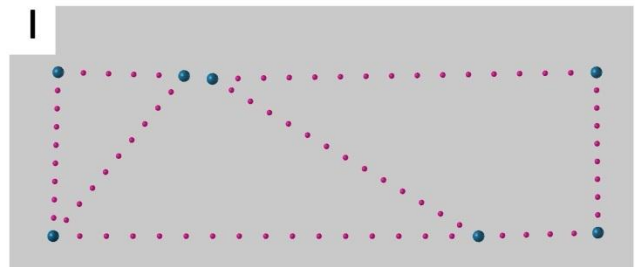
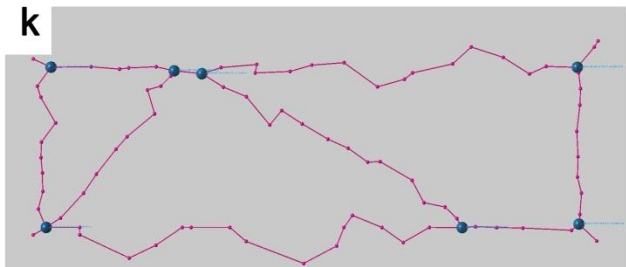
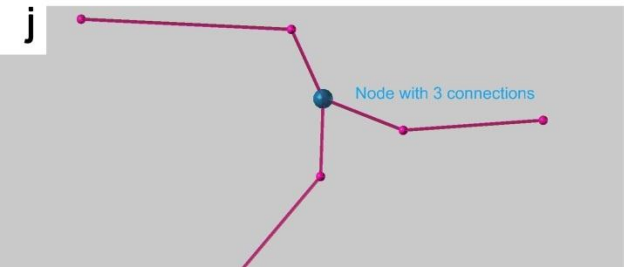
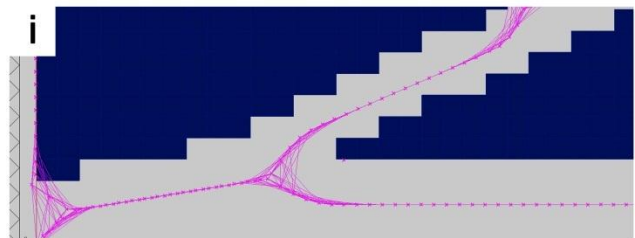
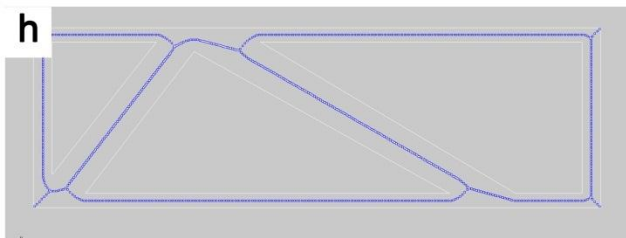
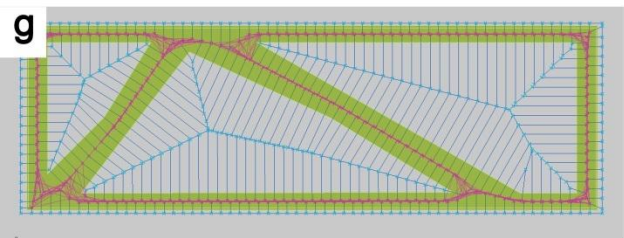
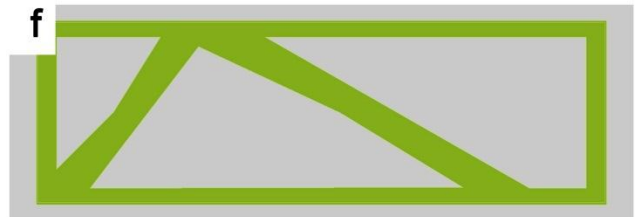
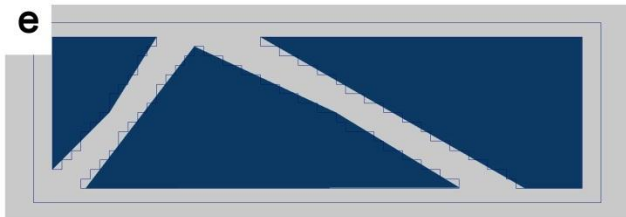
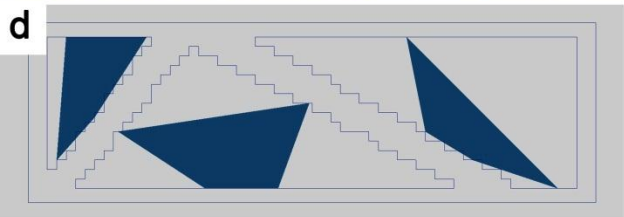
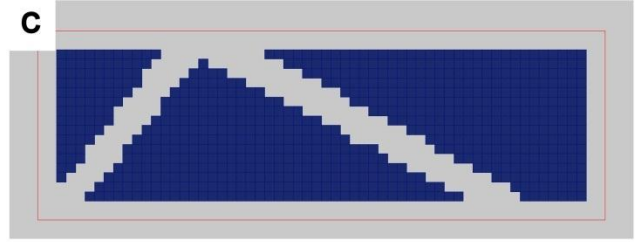
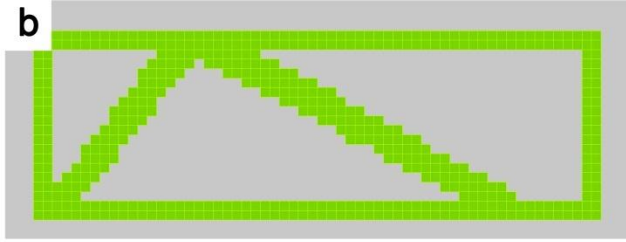
- Develop a dynamic/ interconnected process in which optimization and evaluation routines are embedded
- translate discrete geometry to vector-based geometry system with nodes and lines
- Although detectable with the eye, they are not automatically distinguishable for the CAD platform.
- challenges is to extract the nodes and define the bars by applying and developing appropriate algorithms in a way that the topologies don't change.



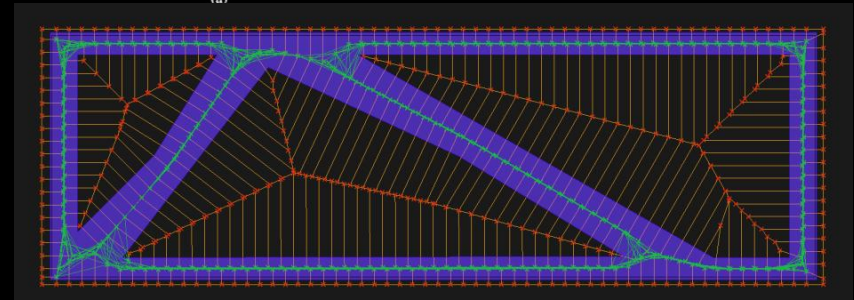
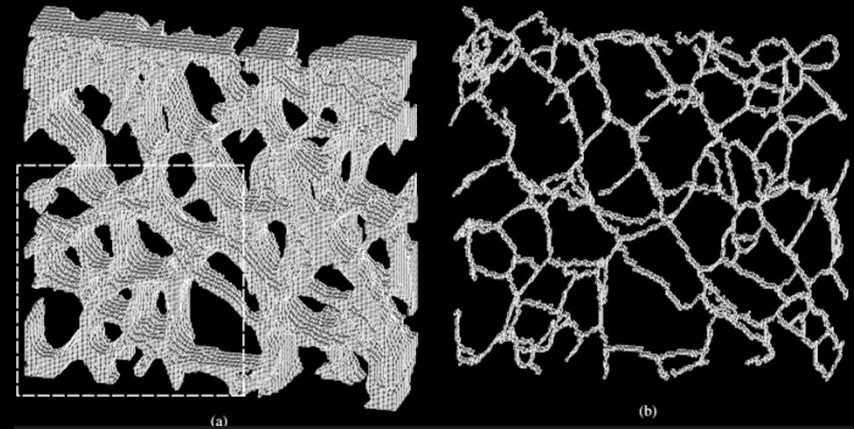
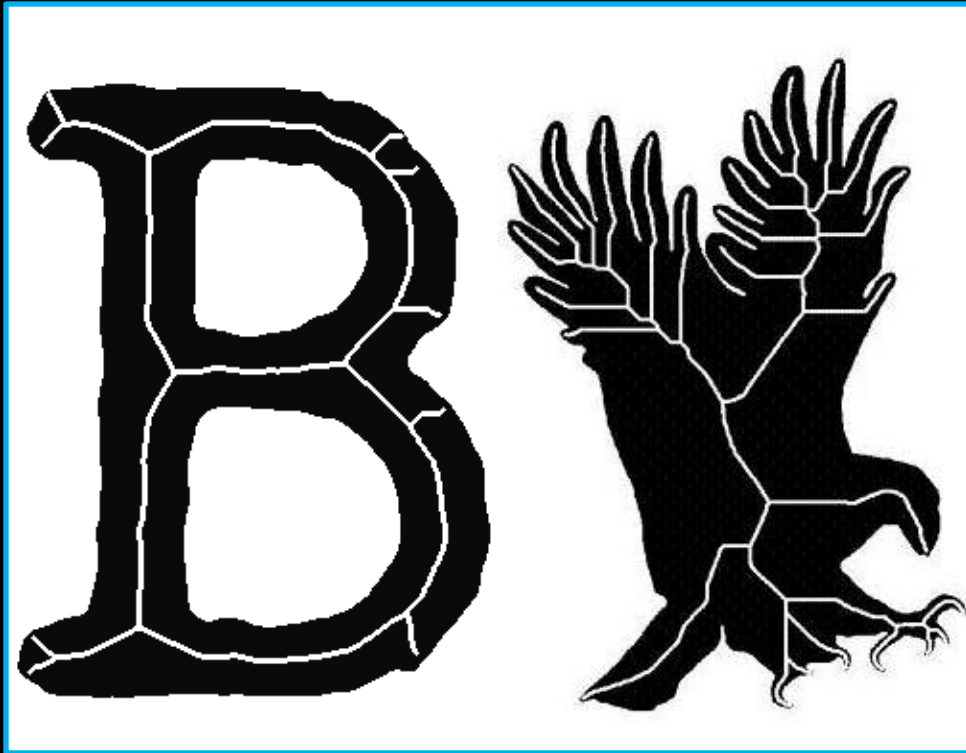




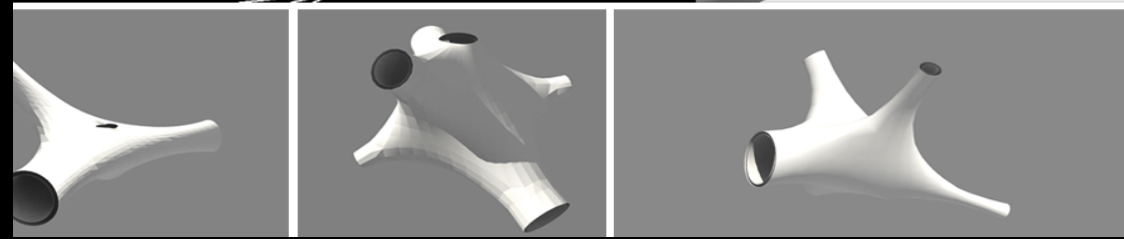
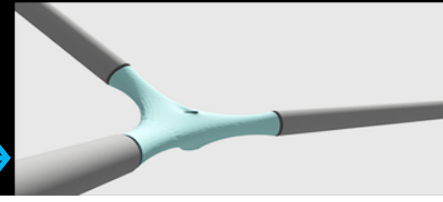
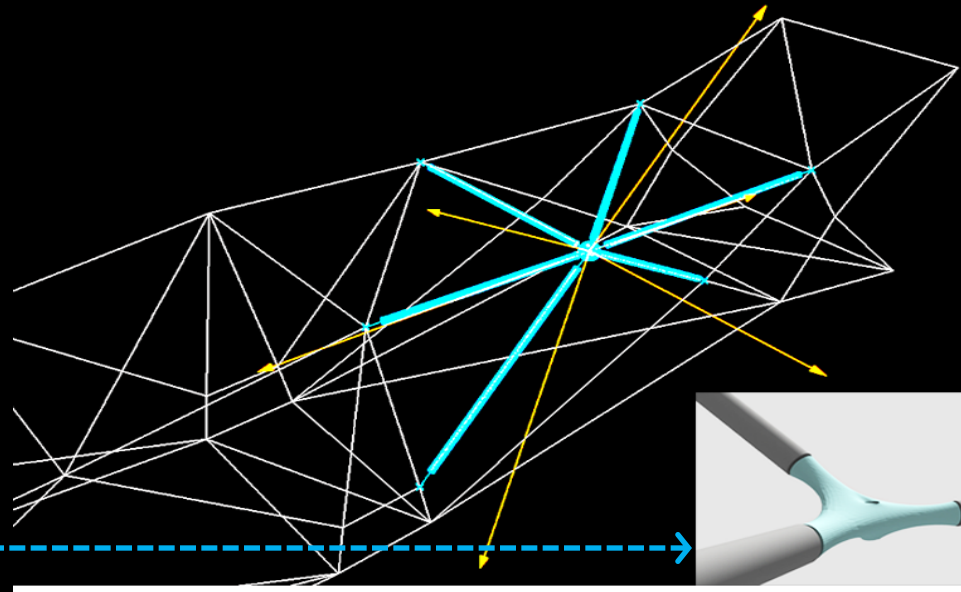
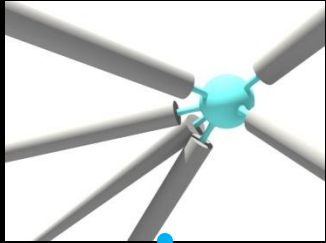
Left: Flowchart process designed based required interoperability between parametric model and analysis/simulation optimization platform. Right: a snapshot of the interface in which geometrical and non geometric parameters can be defined and a set of vector based optimized solutions will be derived with different attributes



An overview of performance driven design of a structural system, using and developing different optimization, parameterization and information tagging, retrieving and visualization techniques.



Customizing, developing and implementation of skeletonization algorithms for translating the finite geometry to infinite geometry

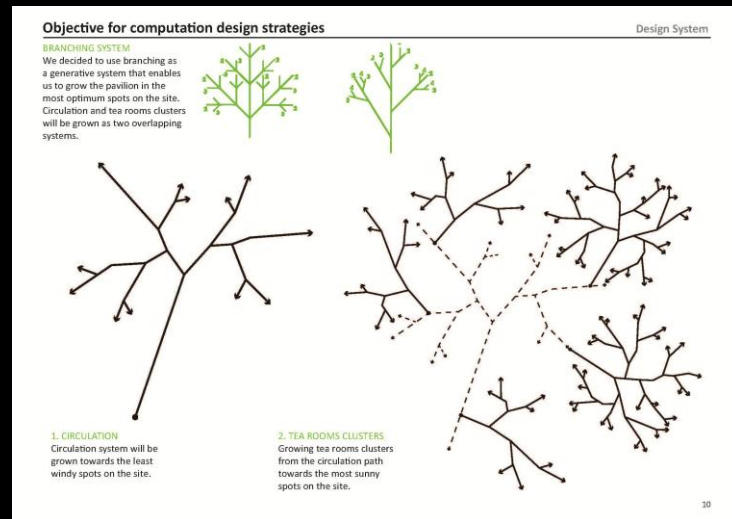
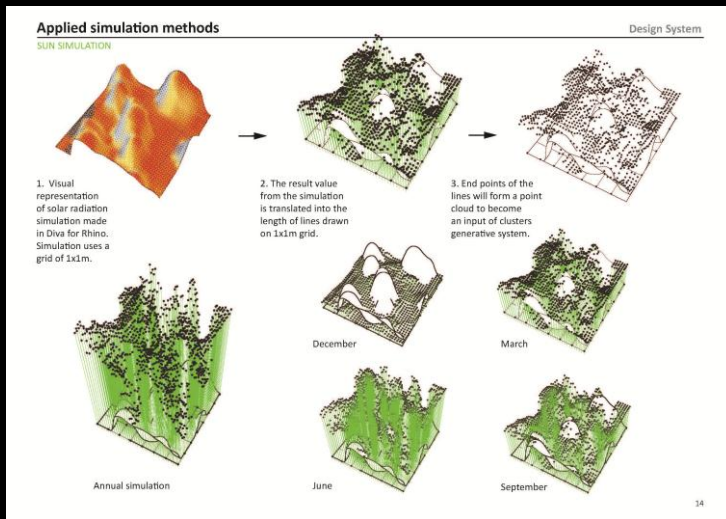
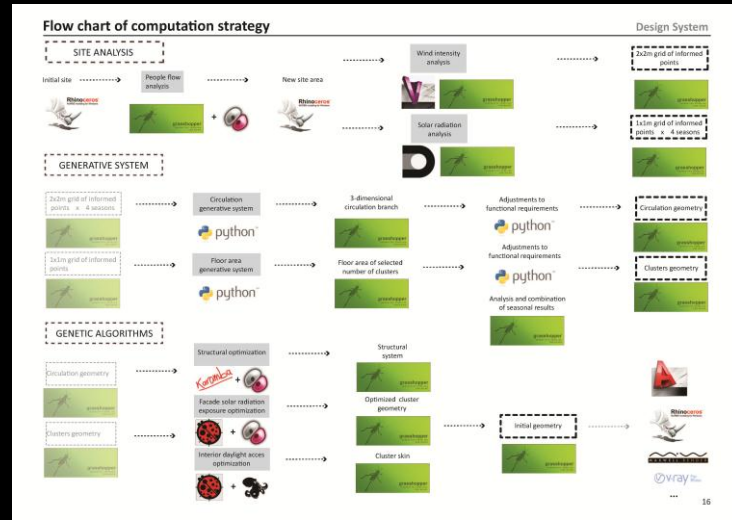
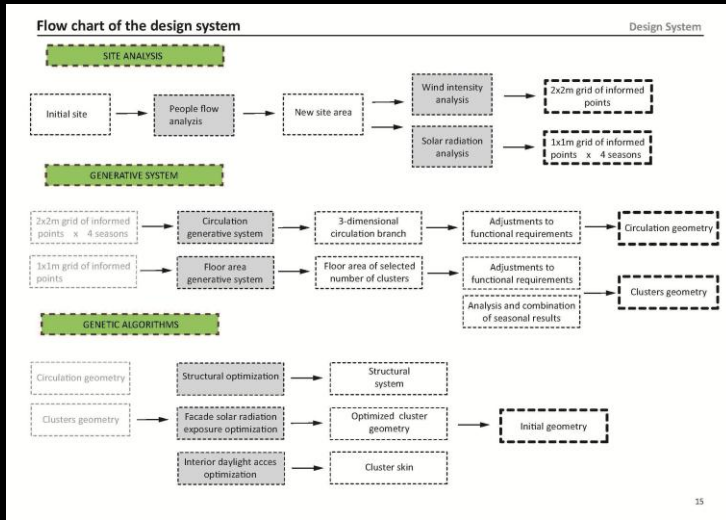


Ongoing studies on performance driven design of a joint system, considering structural performance, manufacturing techniques and differentiation in size and local conditions.

Workshops

MSc3_Oct_2013

On Generative systems and Heuristic search and optimization methods



Workshops

MSc3_Oct_2013

On Generative systems and Heuristic search and optimization methods

Generative logic Generative System

1. Grid of points from wind simulation. Generative system starts with the point with the highest value.
2. Circulation system is grown as recursive branching based on the logic of searching for the closest neighbor.
3. Grid of the points from Sun simulation is added to the system.
4. System starts cluster branches from the point on the circulation with the highest sun radiation value.
5. Floor area pixels of 1x1m are added to each point of the cluster branch to create initial floor footprint of the pavilion.
6. System grows branches until the total area of the floors equals 400m2.

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Graphical illustration of the growth behavior - GS 2 Generative System

1. First cluster branch is grown from the most sunny point on the circulation branch.
2. Next clusters are grown from next points on the list.
3. The system keeps branching until it collects 400 points. Each point gives 1m2 of footprint.
4. Area pixels of 1x1m are added to each point.
5. Initial points generating each clusters. Offset with the desired interior height to inform ceiling geometry. Original points are scaled on z-axis to create valid floor slab geometry.
6. Delaunay mesh is applied to generate ceiling and floor surfaces of each cluster.

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Defining input and output sets Generative System

GS 1 recursive branching

INPUT: List of points from wind simulation

OUTPUT: List of points, List of branches (lines) for evaluation: Total length of branches

VARIABLES: Number of ramifications, Number of points to look for while in for loop

GS 2 recursive branching

INPUT: List of points from sun simulation

OUTPUT: Tree of points selected for each cluster, Tree of branches generated for each cluster, Tree of floor areas generated for each cluster for evaluation: Total area of clusters

VARIABLES: Number of ramifications, Number of points to look for while in for loop

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Program Diagram of the Pavilion Design Project

- Main entrance Bar - 57m2**: First space at the entrance to the pavilion. Accommodates the bar and services. Circulation pathway to the tea rooms starts here.
- Game room Children room - 24m2**: Bigger tea room to be used by kids or groups playing games.
- Quiet small Tea room - 9m2**: For traditional tea house experience in a cosy space, individual or in small groups.
- Outdoor terraces - 53m2**: Outdoor spaces were merged between enclosed tea rooms to enhance seasonal experience, connection with nature.
- Quiet small Tea room - 20m2**
- Music room - 44m2**: The biggest room with music for group meetings.
- Circulation**: Circulation provides a path meandering through the pavilion. It can be used as an extension of outdoor terraces spaces.
- Quiet small Tea room - 15m2**
- Large ground floor terrace - 67m2**: Can be used as outdoor tea room during warm months.
- Tea shop - 38 m2**: Store selling tea products provided with the separate entrance.

Legend:
 - Enclosed spaces: ground floor enclosed spaces (grey), first floor enclosed spaces (light grey)
 - Open terraces: ground floor open terraces (green), first floor open terraces (light green)

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Workshops

MSc3_Oct_2013

On Generative systems and Heuristic search and optimization methods

4.2.6 PANELS

The panels have been optimized Ladybug and Galapagos plug-ins (Fig. 128), to create a gradual variation in the folding angle (Fig. 129). Fig. 130 shows the results before and after optimization.

Fig. 128 - Gradual Variation in Angle of Roof Openings.

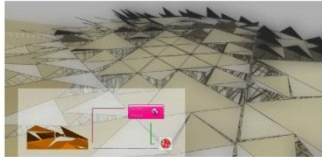


Fig. 130

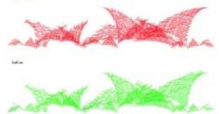
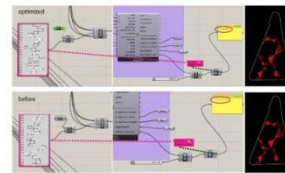
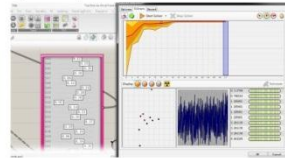


Fig. 128 - Panels Optimisation



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4.2.5 STRUCTURE

The structural analysis was carried out using Karamba (Fig. 126). It was then optimized using the Gecko plug-in (Fig. 127).

Fig. 126 - Structure Analysis (Using Karamba)

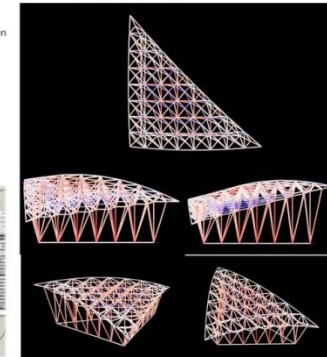
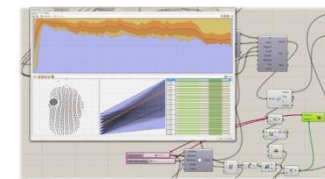


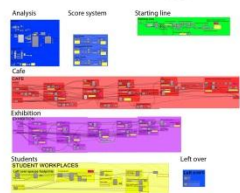
Fig. 127 - Optimization (Using Gecko)



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Fig. 125

Final program



After this compiler grass hopper recursive system all functions are embedded into the site. To optimize this final footprint program we will have one last optimization criteria. The fitness is the collected points by All fun ctions.

Cafe function is the most important so it will be twice as important as the other functions while calculating this final program.

By connecting all sliders (which will change the chosen option of the possibilities) we will change the entire system.

By changing the first cafe location all others will have other possibilities because of the set rules. This will change the entire outcome.

Since there are so many possibilities we decided to use this final evaluation system to determine the final function placement. Taking in consideration the cafe is most important and the points collected by the cafe will give them twice the points, it will find an optimal resulting score. And there for optimal placement.

The grasshopper file in the appendix will give you a closer view on the final grass hopper file behind this recursive system.

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4.2.7 FACADE

The effects of solar radiation on the glass panels were analyzed using the Gecko plug-in (Fig. 131). The results were subsequently used to determine the transparency of the panels (Fig. 132).

Fig. 131 - Glass panels analysis

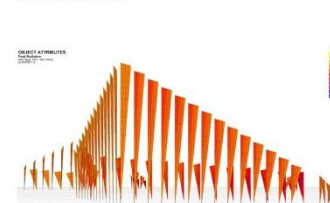
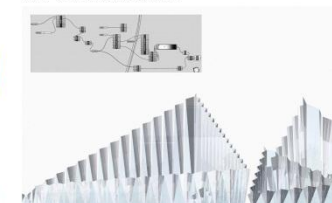


Fig. 132 - Optimized transparency of panels



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Submitted and accepted papers:

FoAR (Frontiers of Architectural Research) International journal 2012

**Informed Geometry and Explorative Methods for Dynamic Information Modeling /
Strategies for Informed 3D Clustering and Spatial Arrangement**

eCAADe 2013

Performance driven design and design information exchange / Establishing a computational design methodology for parametric and performance-driven design of structures via topology optimization for rough structurally informed design models

SimAUD 2014

Performance oriented generative design methodology
integrating generative systems with evaluation methods and optimization strategies considering structural and environmental criteria

CAADRIA 2014

Knowledge integration in computational design methodology

Submitted grants

NOW creative industry 2012

STW Open Technology Platforms 2013

Thank you for your attention