

# **MASTER THESIS WHITE PAPER DRAFT**

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# 01 | RESEARCH STATEMENT

**Interactive Structural Exploration** is a research on **structural optimization** with the goal of enabling **interactive, performance-based design during early stages of the design process** through the use of **machine learning techniques** for the benefit of the **enhanced collaboration between architects and engineers**.

# 02 | RESEARCH FRAMEWORK - STATE OF THE ART

**Data-Driven Design: Exploring new Structural Forms using Machine Learning and Graphic Statics** Lukas FUHRMANN , Vahid MOOSAVI , Patrick Ole OHLBROCK , Pierluigi D'ACUNTO

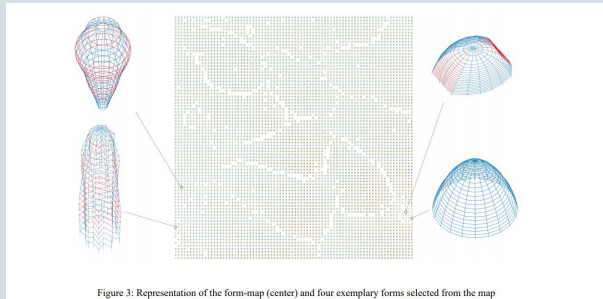
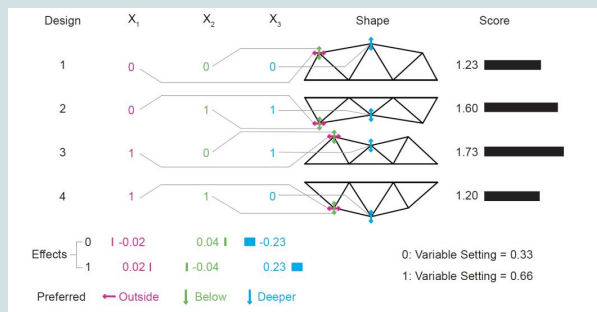


Figure 3: Representation of the form-map (center) and four exemplary forms selected from the map

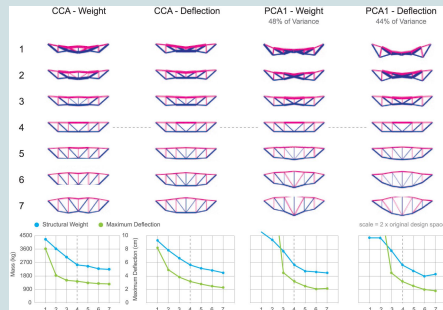
**Automated performance-based design space simplification for parametric structural design** Nathan C. BROWN, Caitlin T. MUELLER



The aim of this research is to introduce a novel structural design process that allows architects and engineers to extend their typical design space horizon and thereby promoting the idea of creativity in structural design. The theoretical base of this work builds on the combination of structural form-finding and state-of-the-art machine learning algorithms.

This paper proposes two new applications of traditional optimization methods that can help simplify early-stage architectural or structural parametric design. The first involves analyzing the design variables considered in the problem, ranking their importance, and determining which ones should be eliminated or emphasized during exploration. The second method clusters designs into families and enables designers to cycle through these families during exploration

**Design variable analysis and generation for performance-based parametric modeling in architecture,** Nathan C. BROWN, Caitlin T. MUELLER



This article proposes and tests the extension of machine learning and data analysis techniques to early problem setup in order to interrogate, modify, relate, transform, and automatically generate design variables for architectural investigations.

**"Combining parametric modeling and interactive optimization for high-performance and creative structural design"** Renaud Alexis DANHAIVE, Caitlin T. MUELLER

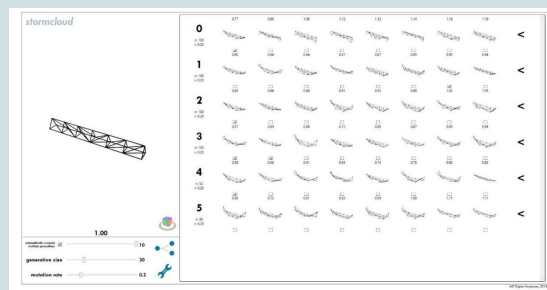
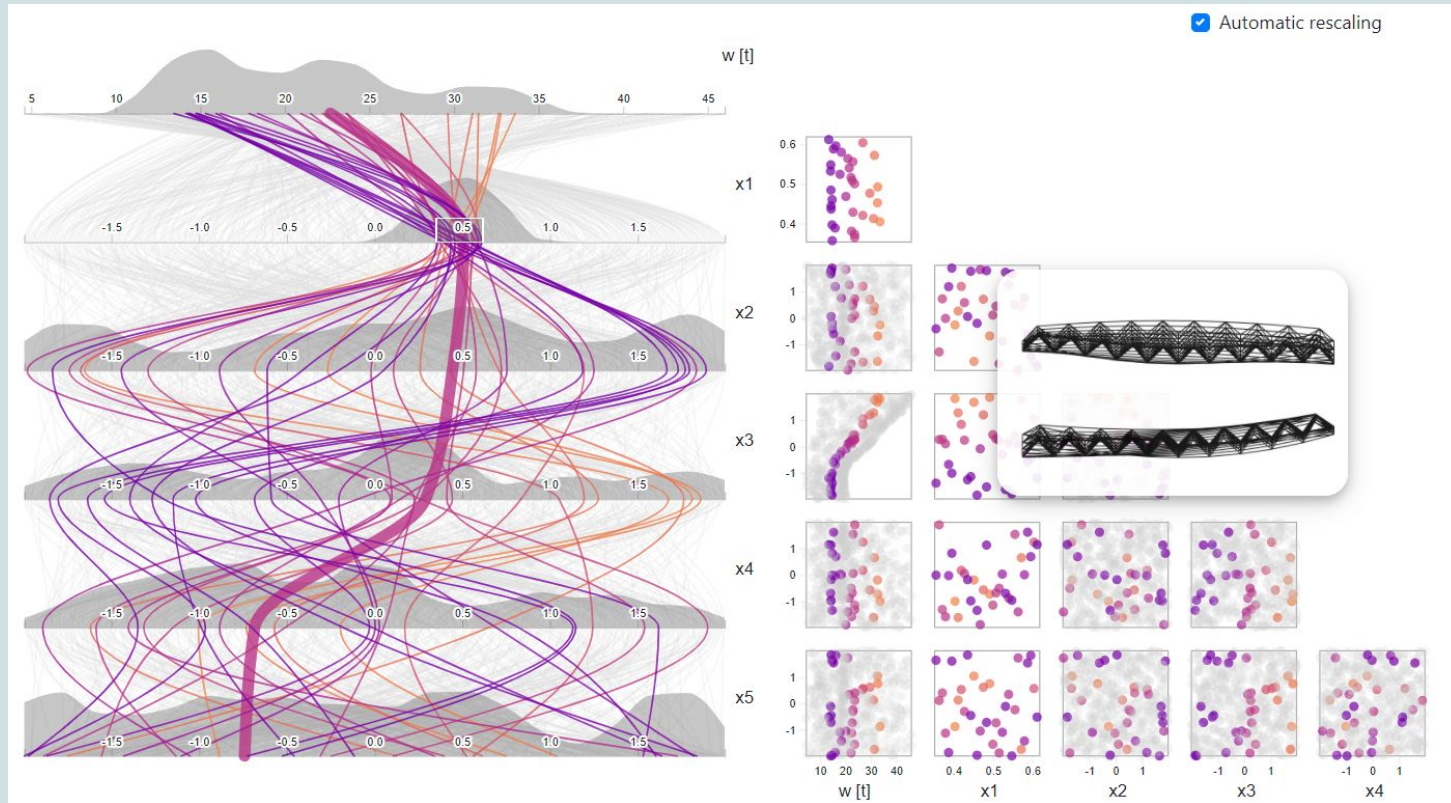


Figure 3: Graphical user interface of *stormcloud* (exploration of the case study developed in 4.1)

"This paper develops an approach that seeks to connect interactive evolutionary optimization to parametric design in such a way that all the features offered by parametric design in terms of geometry generation can be used to explore innovative structural systems."

# 02| RESEARCH FRAMEWORK - STATE OF THE ART



## 03| RESEARCH QUESTION / HYPOTHESIS

State of the art shows an interactive tool that enables exploring different parametric model versions. Each model version is represented as a dot on a interactive scatter plot. When the user hovers the mouse over one of the dots, the tool shows on the right rendering of the model. This enables the user to quickly explore the space of possible models. This tool is enabled by unsupervised machine learning techniques that compress multi-dimensional space of different parameters into 2d space that can be shown to the user.

While easy to use, this tool enables interacting with only a limited set of different options that can be still shown in the limited space. In the master thesis project I would like to extend the tool with complementary techniques for exploring the space, such as ability to zoom into a particular region of interest.

# 04| RESEARCH OBJECTIVES AND EXPECTED RESULTS

**Objective-** efficiently explore a design space of multiple dimension parameter problems that are difficult to analyse using existing tools

**Expected results** - to create an interactive web-based environment that visualizes design space, focused on structural performance for a specific type of structure

# 05| BIBLIOGRAPHY

[Design variable analysis and generation for performance-based parametric modeling in architecture - Nathan C Brown, Caitlin T Mueller, 2019 \(sagepub.com\)](#)

[\(PDF\) Combining parametric modeling and interactive optimization for high-performance and creative structural design \(researchgate.net\)](#)

[Automated performance-based design space simplification for parametric structural design | Semantic Scholar](#)

[Beyond typologies, beyond optimization: Exploring novel structural forms at the interface of human and machine intelligence | Request PDF \(researchgate.net\)](#)

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[\[PDF\] Designing With Data : Moving Beyond The Design Space Catalog | Semantic Scholar](#)

[\(PDF\) A machine-learning model driven by geometry, material and structural performance data in architectural design process \(researchgate.net\)](#)

[Emerging artificial intelligence methods in structural engineering - ScienceDirect](#)

[\(PDF\) Dimensionality Reduction for Parametric Design Exploration \(researchgate.net\)](#)

[\[PDF\] An Integrated Computational Approach for Creative Conceptual Structural Design | Semantic Scholar](#)