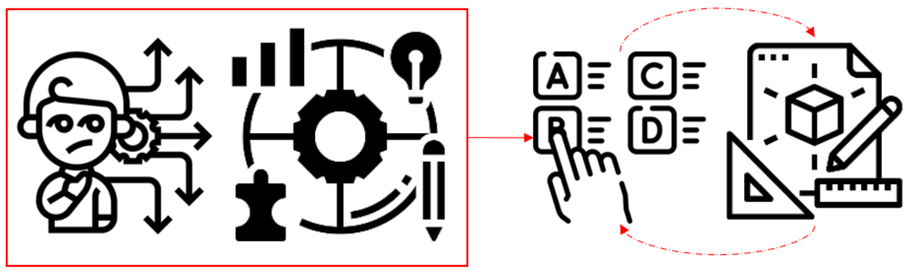
HSLU Hochschule Luzern

Technik & Architektur
iHomeLab
Master of Science in Engineering

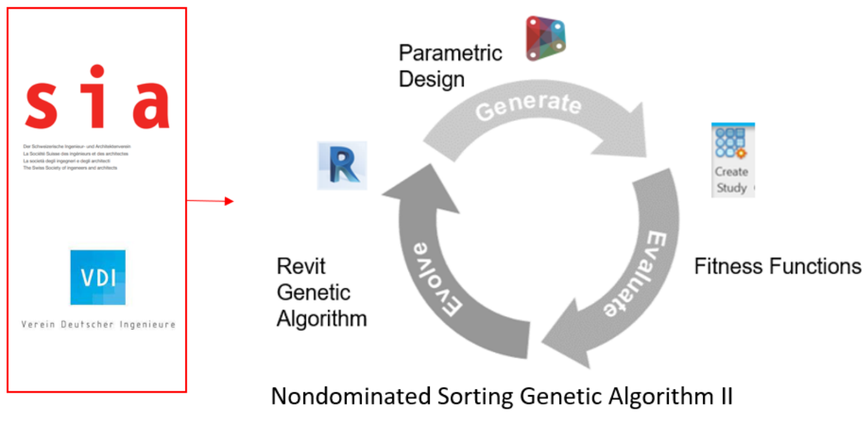
Master Thesis - Business Engineering and Production

Generative Design of Technical Space for Residential Buildings

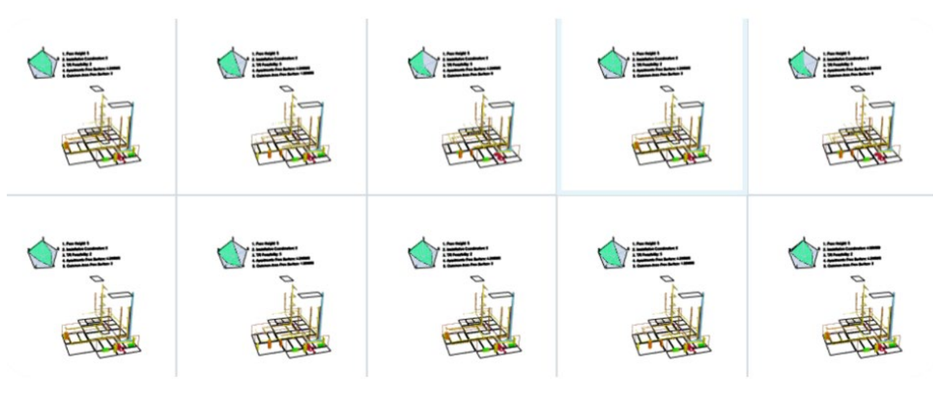
© MEP Project Early Phase Traditional Workflow



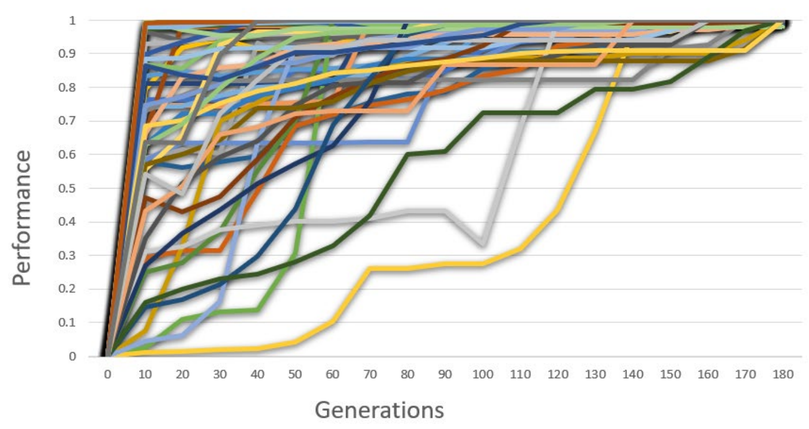
© Generative Design Process Developed



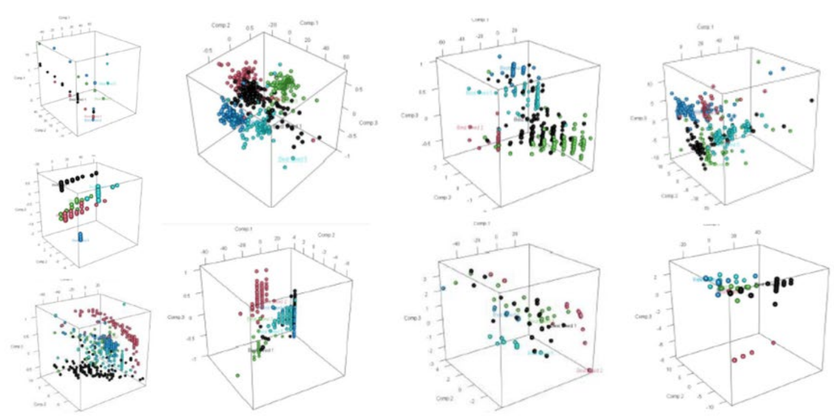
© Generative Design: Pareto Front Results



©Genetic Algorithm: N. of Generations vs. Performance



© PCA: Initial Seed Influence



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Problem Description
In the early phase of a residential building project, it is mandatory to reserve the space for the MEP (Mechanical Electrical and Plumbing) installations to finalize the architectural layout. The space reservation should represent the technical rooms, and the horizontal and vertical distribution networks. In the traditional workflow, an MEP expert usually gives this estimation. Together with the architect, they explore and evaluate different solutions regarding the MEP system type and how to distribute it in the building. The final definition involves various alternative analyses, calculations, and model representations in BIM (Building Information Modeling). This workflow consumes company resources and may have errors that are only discovered later in the project, causing additional costs and delays. Thus, there is a need to develop an automated process that can effectively answer this question.

Solution Concept
In other industry sectors, such as architecture or structural engineering, Generative Design technology is used in highly complex projects to create and evaluate a wide range of initial concepts, which would not be possible to accomplish in proper time through the conventional processes.

This Master Thesis presents a proof of concept using Generative Design to optimize the early Residential MEP design. The proposed method uses the architectural layout (IFC) as input and customizable MEP solutions as variables. The tool iteratively generates intelligent variants based on the input objectives, such as minimizing technical space while ensuring the feasibility of the installation. The Parametric Design was developed with SIA and VDI standards conformance.

Robustness was further evaluated using Monte Carlo Simulation (MCS) and Principal Component Analysis (PCA) as test methodologies. The results enable us to conclude with a 95% confidence that the Failure Probability of the Parametric Design should not exceed 19.3%.

The algorithm demonstrated a capacity to converge successfully for an acceptable solution with a running time of fewer than 12 hours.

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