Metaheuristics in Architecture : Using Genetic Algorithms for Constraint Solving and Evaluation

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Computer-aided design (CAD) has been extended in various ways during the last decades. This evolution resulted in worldwide adoption in the domain of architecture, engineering and construction (AEC), making CAD systems an essential tool for AEC specialists. However, research has shown that recent developments in CAD, such as building information modelling (BIM) and simulation-based design, have mainly affected the later stages of the design process (Penttilä, 2006). In these stages, the designer's concept is already fixed and the influence of recent CAD tools is then limited to very specific fields, most often related to building performance only. However, there is an increasing demand for modelling tools that allow the designer to explore essential variations in an early outlet and scheme design phase.

This paper outlines our findings concerning the use of constraints as design drivers in a design exploration process and investigates a possible application of a heuristic search and optimization method in architecture as a means for constraint solving. In particular, we propose genetic algorithms as a useful, but under-explored, generation and optimization technique for architectural design. It is possible to extend this concept of metaheuristic optimization by simultaneously incorporating a number of different solution spaces. This method, applied in other engineering fields such as automobile, aircraft and spacecraft design, is called 'multidisciplinary design optimization' (MDO). The combination of metaheuristics and MDO can increase the efficiency of the design exploration, by taking into account the interactions between the different disciplines. This approach can be most appropriate for architectural design because it enables the satisfaction of multiple performative, geometric, dimensional and topological constraints.

In order to test this proposed design method, a number of simple experiments are discussed in this research. Different constraints such as dimensions, aspect ratio, relations between spaces, orientation and views can be optimized using genetic algorithms (Holland, 1975). These will inform the user with possible alternative design solutions during the early design process. A specific test case – social housing in Belgium - has been chosen in order to test the application's potential and usability.

[1. Penttilä, H. (2006). Describing the changes in architectural information technology to understand design complexity and free-form architectural expression. ITcon Vol. 11, pp. 395-408.]
[2. Holland, J. (1975). Adaption in natural and artificial systems. University of Michigan Press.]

Metaheuristics in architecture: Using Genetic Algorithms for constraint solving

POSTER

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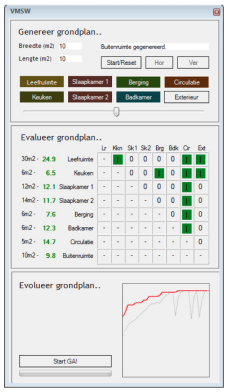
Metaheuristics for constraint solving and evaluation

This poster outlines our findings concerning the use of constraints as design drivers in a design exploration process and investigates a possible application of a heuristic search and optimization method in architecture as a means for constraint solving. In particular, we propose genetic algorithms as a useful, but under-explored, generation and optimization technique for architectural design. It is possible to extend this concept of metaheuristic optimization by simultaneously incorporating a number of different solution spaces. This method is called '*multidisciplinary design optimization*' (MDO). The combination of metaheuristics and MDO can increase the efficiency of the design exploration, by taking into account the interactions between the different disciplines. This approach can be most appropriate for architectural design because it enables the satisfaction of multiple performative, geometric, dimensional and topological constraints.



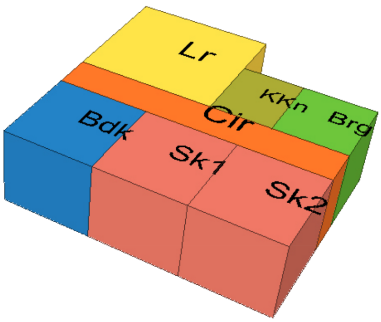


Fig. Optimal floorplan generated using a GA. The constraints are: area, aspect ratio, orientation and relations.

Example of GA in architectural design

In order to test this proposed design method, a number of experiments are discussed in this research. Different constraints such as dimensions, aspect ratio, relations between spaces, orientation and views can be optimized using genetic algorithms. A tool is developed to inform the designer about his constraints and freedoms. A specific test case – social housing in Belgium - has been chosen in order to test the application's usability. Also, a GA is implemented to inform the designer about good alternatives.

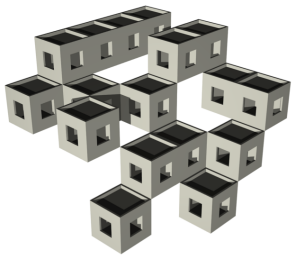


Fig. Optimal configuration of housing units generated using a GA.