Abstract

Ph.D. Dissertation

Author: Agnieszka Mars
Supervisor: Ewa Grabska

Title: Generation and Aesthetic Evaluation of Architectural Forms with the Use of Evolutionary Design

The aim of the dissertation is to propose a generative system for architectural forms which is able to take into account the designer's aesthetic preference based on the provided examples.

The state of the art in the research regarding computational aesthetics and generative design is discussed. The approaches to measuring the aesthetics of generated designs are presented, as well as an overview of generative tools with selected examples. Genetic algorithms are described in the context of their applicability in creative design.

The model of visual perception developed by I. Biederman is used to construct an alphabet of geometric primitives that can be widely used in designing artifacts, especially architectural forms. The simplicity and versatility of Biederman's model allow for organizing design spaces in a way that corresponds to human perception. Referring to human perception seems necessary to make design spaces explorable for solutions that meet certain aesthetic criteria, as the sense of aesthetics is specific to humans.

The internal representation of the designs is performed by graphs. Labeled attributed composition graphs (CP-graphs) are proposed to denote the design's components and the relations between them. Once the graph representation of the reference building is created, it can be used to construct a graph grammar. For this purpose, simple CP-graph grammars are proposed. A simple CP-graph grammar constructed based on the reference building's internal representation generates a language composed of graphs that represent designs. These designs are supposed to have the characteristics of the reference building, however, more validation is necessary to reject designs that do not fulfill basic aesthetical or functional criteria.

The task of validation and exploration of design spaces for the most optimal solutions is performed by a genetic algorithm , which is proposed as a generative tool. The genetic algorithm presented in this dissertation uses phenotypes based on Biederman's perception model and genotypes in the form of a sequence of simple CP-graph grammar rules. The fitness function of the genetic algorithm evaluates the design's aesthetical coherence with the reference building, as well as some basic aesthetical and functional properties.