Customizing mass housing: a dual computer implementation design strategy based on shape grammars

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Abstract

This research aims at developing a system for automatic generation of designs that allows housing customers to participate in the design of their house by using mass-customization design. The proposed system is based on shape grammars and will allow future owners to acquire houses that fit their needs while simultaneously complying to a language of design (Stiny 1980). Such a system will enable to deliver design solutions with quality (Eloy et al. n.d.) and at affordable prices improving satisfaction of clients and their quality of living. The system encodes knowledge on housing design principles (sizes of rooms, types of rooms and there preferable connections) as well as in the construction techniques that underlies the shape composition principles.

To make the system available for future inhabitants a computer implementation is being developed so that it could be made available online or at the housing construction company. The envisage design tool will: i) deliver design solutions answering the client's' requirements based on a design grammar therefore maintaining a language of design, ii) be feasible to be used by non-designers (e.g. clients, sales staff of a construction company). With the aim of finding a good technical solution to satisfy users' needs we have been developing computational tools for shape computing and working on its application in the generation of urban and architecture designs. For this aim two strategies of implementation are being developed simultaneously and in close collaboration. One is based in shape grammars supplemented with processes (Santos et al. n.d.) and the other based in genetic algorithms (de Almeida et al. 2016).

Research in mass-customized design using shape grammars have been developed over the years and several shape grammars have addressed the housing problem and the need to make available design systems that respond to the inhabitants needs (Duarte 2005; Benrós et al. 2011; Eloy & Duarte 2015). The main difficulty to fully use these systems in design practice is the delay of the computer implementation of architectural design processes, namely by the use of shape grammar logics. Computerized design tools that offer design alternatives supporting the design ways of thinking and working are still rare.

The case study used is this research is mass construction of wooden houses in Poland (Kwieciński & Slyk 2014). Timber construction systems are very popular in several countries like Poland and the construction industry provides future owners a catalogue of standardized solutions for them to choose. Those solutions are restricted to a small number of possibilities and the act of choosing is based on looking to all solutions and not to the ones that may respond to the clients need. In this research we aim at developing automated design systems that allow users to play with the house design tool enabling them to find the best fit house to their own personal wishes.

ISTAR team combines several expertise: Filipe Santos develops the shape grammar tool supplemented with processes; Ana Almeida develops the genetic algorithm application approach together with Master student Bruno Taborda; Sara Eloy collaborates with the architecture perspective on design processes and the use of shape grammars for architecture.

Krystian Kwiecinski is a PhD student from Warsaw University of Technology that collaborates in this research. The project evolved recently to a submission to FCT transnational projects in a collaboration with Universidade Federal do Rio de Janeiro. To this submission a new ISTAR collaborator José Pinto Duarte, expert in shape grammars, was added to the team.

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Developing and assessing shape grammar design systems

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Abstract

The ongoing and future research focus on the developing and assessing shape grammars design systems for architecture. The work started by the join paper from Eloy (ISTAR-IUL), Vermaas (TU Delft) and Andrade (ISTAR-IUL) (Eloy, Vermaas, & Andrade, n.d.) where the quality of designs generated by shape grammar systems with designs created by professional architects was compared. In this work authors collaborated in defining and analysing an experiment in which evaluators rank the quality of preliminary designs for refurbishing Lisbon's *Rabo-de-Bacalhau* apartments, and that makes plausible that the design quality of the grammar solutions for this task is similar to that of the designs of the professional architects. It was argued that shape grammars can therefore be used as stand-alone design systems in architecture. The practical value is that shape grammar systems become alternative means to