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GUEST EDITORIAL

Generative Systems in Design

Samir Emdanat,[1] George Stiny,[2] Emmanuel-George Vakaló[1]

[1]Doctoral Program in Architecture, The University of Michigan, 2000 Bonisteel Blvd., Ann Arbor, Michigan 48109
[2]Department of Architecture, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Bldg. 10 Room 431M, Cambridge, MA 02139

Generative research in design investigates compact representations that facilitate the rapid exploration of large design spaces. It includes among other things: rule-based systems, feature structures, and genetic algorithms. Generative systems are being applied to a variety of design problems from various disciplines including engineering, product design, and architecture. The objective is to further our understanding of the design operations and manipulations to create systems that better support the designers' activity.

The papers selected for this special issue of ***AI****EDAM* provide a sample of the state-of-the-art applications of generative systems in design with emphasis on grammar-based approaches. A design grammar encodes design changes in the form of rules that apply repeatedly to a partially specified design state until a fully specified design solution that satisfies the initial problem requirements is reached. The main strength of the grammar approach is that it provides a concise and computable representation of a design space. Using a finite set of rules, a grammar can represent an infinite range of design solutions that can be explored systematically.

This special issue begins with two papers that represent applications of generative systems in engineering and product design. These two papers explore new approaches for associating syntactic shape representations with semantic descriptions that may be used to guide the process of rule application to create designs with desired properties.

The first paper: "Languages and Semantics of Grammatical Discrete Structures," by Shea and Cagan, explores associations between syntax and semantics in structural design languages that are used for the generation of discrete structures. The paper suggests that the differentiation between syntax and semantics is essential for understanding how semantics can be used to affect design generation. Syntax represents the essential constraints and local parametric properties defining a feasible design space, while semantics represents the global design requirements. The paper applies shape annealing, an extension to the well-known stochastic simulated annealing search technique, to the problem of generating structural layouts and in particular truss designs. In the paper, shape rules are used to represent and derive the valid variations in truss structures in terms of their topology and geometry. The design generation is directed towards semantically valid structures that exhibit specific aesthetic as well as desired performance objectives.

The second paper: "Influencing Generative Design through Continuous Evaluation: Associating Costs with the Coffeemaker Shape Grammar," by Agarwal, Cagan, and Constantine, demonstrates how descriptive functions can be associated with grammar rules to generate designs in a particular style and satisfy a set of constraints. The discussion is presented in the context of product designs, and in particular, coffee maker grammars. The paper illustrates how the shape rules of the coffee maker grammar (Agarwal & Cagan, 1998) can be associated with manufacturing costs and how this knowledge can be available at the various stages of the generation. The paper includes an extensive appendix illustrating the grammar rules and their associated cost expressions making it possible for others to either extend this work or carry out similar investigations in other domains.

The third paper: "Generated Designs, Structure and Composition," by Earl, builds upon earlier work in the area of representing design parts and their descriptions using well-defined algebraic representations for shapes (see Stiny 1994). One of the distinguishing features of this approach is representational flexibility. On their own shapes that make up designs have no explicit structure and no differentiated subparts. They can be structured according to the kind of rules that will apply to them to reflect the final product properties and behavior. A structure of design descriptions is represented in terms of the relationships among compositions of parts of a design. The paper discusses the closure properties of these descriptions and some of the formal tools, which can be used in constructing design descriptions.

The following paper: "Typed Feature Structures and Design Space Exploration," by Woodbury, Burrow, Datta, and Chang discusses a more restricted shape representation and explores the idea of design space exploration in the context of typed feature structures. They suggest that one role of generative design systems is to facilitate the exploration of design alternatives and present typed feature structures as a model for design space exploration. A typed feature structure is a design representation that supports objects and relations. It allows for notions of intentionality, partialness, and structure sharing and cycles.

Finally, the paper: "Interactive Generative Systems for Conceptual Design: An Empirical Perspective" by Eckert, Kelly, and Stacey examines the uses of generative systems in aesthetic design and in particular in the context of knitwear and graphic design. The paper argues that generative systems work best if they are used interactively and in conjunction with a human user. Humans rely on perceptual evaluation criteria that are difficult to program into generative systems while automatic form generation systems are good at exploring large design spaces quickly and assessing their performance. The paper discusses examples of how humans can provide evaluations for guiding evolutionary generative systems in the domain of color scheme design and explores the use of generative systems in completing partial designs that are controlled by human designers.

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Samir Emdanat is a Ph.D. candidate in the Doctoral Program in Architecture at the University of Michigan. His research interests are in the area of generative systems in design and in the applications of virtual reality in architectural design. He is currently a designer at Albert Kahn Associates, Detroit, Michigan.

George Stiny is Professor of Design and Computation at the Massachusetts Institute of Technology. He pioneered the field of shape grammars, opening numerous lines of research in shape computation, design, and aesthetic and stylistic analysis.

Emmanuel-George Vakaló is an associate professor in architecture at the College of Architecture and Urban Planning at the University of Michigan and serves as the chair of the Doctoral Program in Architecture. His research interests are in generative systems in design, visual studies, and morphological analysis.