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GUEST EDITORIAL

Design spaces: The explicit representation of spaces of alternatives

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This Special Issue is in an exceptional format. Starting with an invited Keynote by Rob Woodbury and Andrew Burrow, the rest of the issue is taken up by invited papers that are responses to Woodbury and Burrow's paper, written by selected authorities on design. A final short section is devoted to Woodbury and Burrow's reactions to the responses.

Rob Woodbury and Andrew Burrow set the stage in their paper "Whither design space?" The exploration of design spaces is a long-standing focus in computational design research. Design space exploration is the idea that computers can be used to help designers by representing many designs, organizing them in a network structure that forms the space, and by assisting designers to explore this space: that is, to make new designs and to move among previously discovered designs in the network.

Three main areas of research into design space exploration can be distinguished. The first area of research concerns accounts of designer action and aims to reproduce and extend the behavior of designers. It is based on the premise that exploration is a good model for designer action. The second area of research aims to develop strategies and tools that amplify designer action in exploration. The third area of research concerns the discovery and development of computational structures to support exploration, including representations of the design space itself.

Woodbury and Burrow specifically focus on computational access to the design space and the implications of having a design space representation in reference to the premise that exploration is a good model for designer action. Possible structures for a design space are conditioned by models of exploration behavior, by choices of strategies for amplifying designer action, and by the limits imposed by both computation itself and our knowledge of it. Formalisms for design space exploration must simultaneously accord with designer action, implement a useful amplification strategy, and be both formalizable and computationally tractable.

Woodbury and Burrow raise, and answer, a number of questions, for example, what defines a good representation? Are design rules or, instead, design operators, the appropriate encoding mechanism for design moves in the design space? What is the role of the explicit design space, that is, the part of the design space the designer has previously visited, and what is the role of trajectories of design moves in design exploration? These questions, and others, form the basis for a discussion that can serve as a stepping stone for future research into design spaces.

Ömer Akın distinguishes the paper by Woodbury and Burrow from previous efforts at exploring and studying the design space as taking an axe to an old growth trunk, compared to whittling away at the bark. Even then, the trunk remains massive and vast. In "The Whittled Design Space," Akın examines Woodbury and Burrow's paper according to four criteria: completeness, discrimination, alternative approaches, and combining exploration in different problem domains. With respect to the latter criterion, the author suggests the structure–function–behavior model as an analogy for the central parameters of the search space paradigm. He concludes with a number of questions both for this Special Issue and for future research.

Ulrich Flemming indicates having no fundamental difficulties with Woodbury and Burrow's paper, apart from some quibbles here and there. In "Yes, and by the Way . . . ," Flemming picks up on the issue raised by Woodbury and Burrow of taking the specific domain representation too seriously, in particular, confusing the knowledge level with the underlying symbol level. He suggests that "mixed-initiative" design support systems need a symbol level consisting of a distinct task layer on top of the computational layer where the computational power of the system rests. The author also expresses unease with some details of Wood-

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bury and Burrow's paper, including their criticism of standard rule-based accounts of design space exploration.

Ramesh Krishnamurti compliments Woodbury and Burrow for exploring a new kind of navigation. In "Explicit Design Space?" Krishnamurti examines the need for an explicit representation of the design space, along with an explicit representation of a particular search strategy, as proposed by Woodbury and Burrow. He does so by exploring issues with respect to design search and representation in general, in relation to specific issues raised by Woodbury and Burrow. The need for exogenous properties in design representations, the role subsumption plays in information restructuring, and the notion of replay, are some of the issues that are reviewed.

Gabriela Goldschmidt opts in "Quo Vadis, Design Space Explorer?" to bring to the discussion some additional concerns rather than respond directly to points raised in the paper. Goldschmidt broadens the notion of exploration and bases it on a more cognition-oriented footing, concluding that the design space should be conceived as a multilevel and multifaceted construct that supports on the spot experimentation and provides essential feedback also concerning the process of designing.

Pieter van Langen and Frances Brazier argue in "Design Space Exploration Revisited" that design space exploration involves exploration in three related spaces. Besides the space of partial descriptions of design artifacts that Woodbury and Burrow describe, these are the space of design requirements and the space of design process objectives. Van Langen and Brazier propose to make the information compiled in the paths of exploration across these three spaces explicit, thereby increasing options for accessibility.

Gerald Penn offers in "Design Space and Typed Feature Logic" some insights into the logic of typed feature structures, including some of its weaknesses, recounting how Woodbury, Burrow, and colleagues have adapted it to design space navigation.

Sambit Datta, in "Modeling Dialogue With Mixed Initiative in Design Space Exploration," addresses human–computer interaction over typed feature structures in the context of design space exploration and presents a visual notation for representing dialogue between designer and computational formalism.

Rob Woodbury and Andrew Burrow get the last word in this issue. In "A Typology of Design Space Explorers," they map the various responses, and their own work, according to two axes: the spectrum of strengths and needs that stretches from the machine to the human, and the time scale of events in design. They argue that the resulting landscape, reflecting on apparent differences of opinion, is in fact the result of differences in emphases, rather than actual disagreements.

I believe that this issue will be a valuable source for designers and researchers, for at least three reasons. First, it serves as an important account of research into design space exploration that can serve as a reference for this subject in literature. Second, it raises fascinating issues related to design space exploration that can be the subject of future research and investigations. Third, it provides for a unique account of a lively discussion between a number of authorities on design.

I am indebted to Tim Smithers, who came up with the idea of this Special Issue, as I recall, in a conversation with Rob Woodbury during the Design Computing and Cognition Conference in Boston in July 2004. It is an honor to bring to fruition this special experiment. I also thank all the authors for their enthusiastic participation in this Special Issue. Finally, I express thanks to Dave Brown, Editor in Chief of *AIEDAM*, for his advice and support during the process of editing this Special Issue.

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