

GUEST EDITORIAL

Special Issue: Design Computing and Cognition

ANDY DONG¹ AND JOHN S. GERO²

¹Key Centre of Design Computing and Cognition, University of Sydney, Sydney, Australia

²Krasnow Institute for Advanced Study and Volgenau School of Information Technology and Engineering, George Mason University, Fairfax, Virginia, USA

How can we characterize the promulgation of computing in design? At the outset, computing was conceived predominantly in terms of design automation. It was quickly realized that this medium offered a great deal more than automation, and computing rapidly became a mode of conception for designing. At the juncture of art, design, and computing, however, we recognize computing as becoming loaded with cultural meanings that are enacted through designed works, and designed works that reinterpret a range of assumptions about computing. Design and computing are intervening and lending each other ever-accruing layers of possibilities. The arena of design and computing is producing a new object of knowledge from which *they* effect: a mode of inquiry, a form of critique, a constitution of practices of subjectivities, and an articulation of objective and subjective investigations. The four papers selected for publication in this Special Issue triangulate these perspectives, providing a new vision for the direction of design and computing and emerging research themes.

Design computing has historically focused on the generation of computational theories and systems that enact design practices. The maturation of the field is evidenced by the promulgation of computation into design practices in nearly every discipline that engages in designing. However, uncritically, or perhaps unimaginatively, transcribing computation into designing limits how we can conceptualize computing in relation to various design practices. To do this, we need to draw on the vocabulary of computing while considering the theoretical and practice-based requirements of designing. It is probably obvious to state that designing is a process that relates intentional human practice to physical and social processes located in time and space toward the production of a work. Given the complexity of these processes, we should ask what kind of designing computing can perform. If designing is produced through computer-bounded processes, which are likely subaltern to human cognitive processes, what kind of design is possible? Although we are not yet close to fully knowing the answers to these questions, it is essential that our

research work make transparent how the quality of the design experience is fixed by computers. Designing with computers fixes design into sequences of actions embedded in algorithms and code; the ability of computing to produce design means that we should continue to come up with new stories and new methods of making these stories computationally from which new types of design works can emerge.

The papers in this Special Issue start to write these stories in the direction of design and computing. In addition to presenting the authors' research, the papers include responses to questions posed during the conference. The questions were provided to each of the authors submitting papers to the Special Issue. The authors were asked to respond to the questions in their manuscript. Notably, reviewers were asked to consider their responses to the questions. We hope that the question and answer section in each paper will provide you with an opportunity to engage in a dialog with the authors' research, a dialog we hope you can continue electronically or at the next Design Computing and Cognition Conference (see below for details).

In the first paper, José P. Duarte, João M. Rocha, and Gonçalo Dulca Soares present a shape grammar formalizing the structure and growth of a complex urban settlement, the Medina of Marrakech in Morocco. (To see a satellite photo of the Medina of Marrakech, search for +31° 37' 53.00", -7° 59' 12.00" in Google Maps.) Here, we see the articulation of objective and subjective investigations operating. Although shape grammars are intended to provide both formal representations of objects and formal procedures for operating on shapes, the grammar for the Medina of Marrakech is "non-deterministic and open ended" as a consequence of multiple rules applying at any given step and multiple possible values assigned to the parameters. Interpretations of the parameters by the designer would necessarily lead to different solutions satisfying particular design requirements. Transcribing the formality of shape grammars into the spatially embedded, intentional human practice of urban design opens up a more thoughtful and nuanced view on "traditional spatial and compositional principles" of the Medina of Marrakech.

Sean Hanna's paper applies the machine-learning technique of support vector machines to inductively learn optimal

Reprint requests to: Andy Dong, Key Centre of Design Computing and Cognition, University of Sydney, Wilkinson Building (G04), Sydney NSW 2006, Australia. E-mail: andy.dong@usyd.edu.au

structures. Support vector machines (SVM) have been successfully applied in a wide range of classification problems, ranging from predicting protein structures to text classification. The SVM-based inductive learner was able to generate optimal structures with much less compute time than gradient descent methods. Hanna's work showed that SVM can also be adapted to simulate the acquisition of experience that designers gain by designing similar works over time. Interestingly, his work connects SVM to another algorithm that has been used to simulate the induction of language learning—latent semantic analysis (LSA; Landauer & Dumais, 1997). The cognitive equivalent to the effect of the linear matrix decomposition of LSA and the selection of the basis function for SVM suggest that subjectivities might be involved in choosing the optimal dimensionality for representing representations as with LSA or the order of the basis function for organizing perceptual data.

The paper dealing with design cognition in this Special Issue is contributed by Jeff W.T. Kan, Zafer Bilda, and John S. Gero. The authors merge Shannon's information theory metric of entropy with Goldschmidt's technique of linkography to measure quantitatively the productivity of idea generation in design. Based on experiments of experienced architects designing blindfolded, the authors found empirical evidence that entropy can provide a meaningful measurement of ideational productivity. Quantitative language analysis as a method of inquiry and critique is one that has been pursued by other papers published in this journal including "Word graphs in architectural design" (de Vries et al., 2005) and "Concept formation as knowledge accumulation: a computational linguistics study" (Dong, 2006). Language is providing both a way to quantify the productivity of design, as with this paper and Dong's research, and stimulate designers to inquire into their design work, as with the de Vries research.

Finally, the paper by John S. Gero and Udo Kannengiesser extends Gero's (1990) function-behavior-structure (FBS) ontology for objects to describe processes. The FBS for processes aims to create rigorous means that lend themselves to computational implementations to critique, interrogate, and generate processes. Gero and Kannengiesser demonstrate the ontology to describe the design process and to describe design optimization. Readers interested in this line of thought might find the article "On the conceptual framework of John Gero's FBS model and the prescriptive aims of design methodology" by Pieter E. Vermaas and Kees Dorst (2007) insightful in its philosophical clarification of the notion of function. Such constitution of the practices of philosophy, critical theory, and design theory may help to address problems with which design science struggles.

The authors in this Special Issue originally presented their papers at the Second International Conference on Design Computing and Cognition (DCC'06) convened July 10–12, 2006, at the Technical University of Eindhoven, The Netherlands. Sponsored by the Key Centre of Design Computing and Cognition at the University of Sydney and the Department of Building and Architecture at the Technical University

of Eindhoven, the conference created a forum for the discussion of research ranging from agents in design to computational theories applied to organizational design and management. With DCC'08 set to take place June 23–25, 2008, at the Georgia Institute of Technology, we look forward to another stimulating conference presenting the latest research in design computing and cognition.

Authors presenting at DCC'06 were invited to submit extended and revised versions of their original contributions, which had already been independently reviewed by three readers, for this Special Issue. The papers selected for presentation in this Special Issue were also reviewed by at least three independent reviewers and then revised incorporating the referees' comments. The editorial team thanks all of the authors from DCC'06 who contributed their papers to this Special Issue and the authors whose papers appear in this Special Issue for their significant effort in revising their manuscripts. Special thanks are extended to the referees for giving their valuable comments on the papers.

Finally, the Guest Editors express thanks to Professor David Brown, Editor In Chief of *AI EDAM*, for his advice during the process of editing this Special Issue.

REFERENCES

- de Vries, B., Jessurun, J., Segers, N., & Achten, H. (2005). Word graphs in architectural design. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 19(4), 277–288.
- Dong, A. (2006). Concept formation as knowledge accumulation: a computational linguistics study. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 20(1), 35–53.
- Gero, J.S. (1990). Design prototypes: a knowledge representation schema for design. *AI Magazine* 11(4), 26–36.
- Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: the latent semantic analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review* 104(2), 211–240.
- Vermaas, P.E., & Dorst, K. (2007). On the conceptual framework of John Gero's FBS-model and the prescriptive aims of design methodology. *Design Studies* 27(2), 133–157.

Andy Dong is a Senior Lecturer in Design Computing and Cognition at the University of Sydney. His research studies design by studying language use in design by theorizing how language is constitutively involved in the enactment of design. Dr. Dong was the recipient of the Design Studies Award in 2005.

John S. Gero is a Research Professor at the Krasnow Institute for Advanced Study and in the Department of Computer Science, George Mason University, and Visiting Professor at the Massachusetts Institute of Technology. Formerly he was a Professor of Design Science and Co-Director of the Key Centre of Design Computing at the University of Sydney. Dr. Gero is the author/editor of 43 books and has published over 550 research papers. He has been a Visiting Professor of architecture, civil engineering, cognitive psychology, computer science, design and computation, and mechanical engineering in the United States, United Kingdom, France, and Switzerland. His research focuses on computational, cognitive, and neurocognitive studies of designing.