Artificial Intelligence for Engineering Design, Analysis and Manufacturing (2006), *20*, 163–165. Printed in the USA.

DOI: 10.1017/S0890060406060148

GUEST EDITORIAL

Special Issue: Understanding, representing, and reasoning about style

CLAUDIA M. ECKERT[1] AND ELLEN YI-LUEN DO[2]

[1]Department of Engineering, University of Cambridge, Cambridge, UK
[2]College of Architecture, Georgia Institute of Technology, Atlanta, Georgia, USA

Style is a word that people think they understand. Most people recognize artifacts like buildings and clothes as being exemplars of particular styles, and they know words like Rococo and Art Deco as names for styles. They can recognize stylistic similarities not only in one sort of artifact but also across wide ranges of different things, such as buildings, furniture, artworks, clothes, music, and even manners. However, "style" is a slippery notion: the word has been used in a variety of senses since the ancient Greeks first thought about the differences in how people wrote or painted, and it is still used to refer to different things.

Our notions of style encompass both the characteristics of the procedures through which people create artifacts and the characteristics of the artifacts themselves. Designers have creative styles: their characteristic designing and making procedures, which are influenced by the designers' personal experiences as well as the training they received, the tools they have available, and the questions that they are pursuing through their work. In design practice, designing actions are inseparable from perceptions of the styles of artifacts and style is inescapable: in visual design fields (e.g., graphic, fashion or industrial design), designing actions are tightly coupled with the perceptual recognition of the characteristics of partial designs, including stylistic characteristics. This is also the case in branches of engineering design that depend on the perceptual evaluation of features in conceptual design, before mathematical modeling techniques can be applied, such as the design of turbine blades.

Style perception is subtle. It depends as much on other artifacts as the one seen, as it depends on awareness of similarities and differences. It also depends on context and how we attribute meaning to things and situations, such as a 1950s dress in a 1980s movie or 19th century public buildings with columns adopted from classical Greek architecture. Even when we can recognize the exemplars of a style and agree on what is and is not an exemplar of the style, characterizing it is problematic. Style recognition depends on emergent perceptual features that can be difficult to define clearly or even identify. We may find it hard to define what constitutes a style, and even among experts there is rarely complete agreement. Different characterizations of a style, focusing on different features, may serve equally well to distinguish exemplars from nonexemplars, for instance, Frank Lloyd Wright's Prairie house style has been analyzed in different ways (see Kimberle Koile's paper in this issue; Koning & Eizenberg, 1981). Which features are truly essential to the style, and which are merely insignificant consequences of the essential features?

Moreover, artifacts are often not merely exemplars of single styles, but also expressions of different, overlapping styles. For example, a BMW 535 saloon car is clearly recognizable as a "5-series" (it belongs to a range of products sharing many features), but it also has a BMW look that gives it a brand identity. In addition, it is similar both to other large, relatively expensive saloon cars (executive-type cars) and to many other contemporaneous cars, as different manufacturers' cars change over time in similar ways, creating clearly recognizable time-period styles. The features that characterize some of these styles can be identified. Jonathan Cagan's group at Carnegie Mellon has sequenced the "brand DNA" for Buick cars (McCormack et al., 2004) and Harley-Davidson motorcycles (Pugliese & Cagan, 2002).

The different contributors to this Special Issue employ different notions of style and pick different aspects of the styles for the artifacts they examine. What unites them is a

Reprint requests to: Ellen Yi-Luen Do, College of Architecture, Georgia Institute of Technology, 247 4th Street, Atlanta, GA 30332-0155, USA. E-mail: ellendo@cc.gatech.edu

cognitive science approach to style research: the development of rigorous theories using computational modeling techniques, which can then be evaluated in terms of how much of the real phenomena for which they actually account. The research reported in this Special Issue is concerned with the application of systematic methods for achieving clarity about working definitions of style concepts and clarity about how to characterize the styles of particular classes of artifacts. Martin Stacey's contribution to this issue, although sympathetic to this computationalist strategy, points out some of the complexities of human perceptions of styles and argues that research on what styles *are* should be linked to research on how styles are seen.

This Special Issue began with the Editor in Chief's question: "Is there an emerging field of style research?" To answer this question, we carefully drafted the Call for Papers to encourage submissions from a wide range of perspectives. What does style in different disciplines have in common? Are there rules and constraints embedded in the style definition? Can we use systematic approaches and methodologies to describe, understand, and generate style? To our delight, we received over 20 initial inquiries and sent 13 papers out for peer review. Each paper received between three and five reviews. Six papers emerged that represent a broad spectrum including psychological challenges of style analysis, Bayesian network analysis of lines, the use of curves in product design and generative mechanisms for car design, the experiential style of building, and perceptual approaches to understanding design style.

In this Special Issue we have tried to fuel a discussion on style by showing different forms of style arising from different design domains and different methodological approaches. This shows that there is a common interest in style and a common core understanding of what style is, as well as a wide variety of perspectives.

The first paper, "Psychological Challenges for the Analysis of Style" by Martin Stacey, provides an extensive and thorough review of what psychology can tell us about style and how psychological research can be combined with computational research on the nature of style. Psychological evidence indicates that style recognition and creation involve complex mental functions, which depend on knowledge, and involve the interaction of perceptual recognition of style features and explanatory inference processes that create a coherent understanding of an object as an exemplar of a style. To understand the psychology of style the paper brings together insights from research on several aspects of cognition, such as visual object recognition, memory, similarity and analogy, and the formulation of concepts and categories.

The second paper, "Atoms of EVE′: A Bayesian Basis for Esthetic Analysis of Style in Sketching" contributed by Kevin Burns, sees style as an esthetic agreement between people, which the author is trying to measure and model. He proposes a theoretical framework describing esthetic experiences in terms of their smallest constituent parts: atoms. Drawing on Shannon and Weaver's information theoretical view of communication, he describes esthetic experiences in terms of expectations of signals and violation of these expectations; he employs Bayesian theory at a semantic level to measure explanations of meaning for the signals. This allows him to measure the tensions and pleasure at an esthetic level. This is illustrated using an example of stylistic interpretation of sketches.

"Shape Exploration of Designs in a Style: Toward Generation of Product Designs" by Miquel Prats, Chris Earl, Steve Garner, and Iestyn Jowers is concerned with providing designers with a tool to generate families of artifacts within a particular style in the early stages of product development, so that designers can maintain stylistic consistency through changing structures through generative rules. A model of exploration is proposed with four types of descriptions: description of contour, decomposition, and structure, plus a design description where the results are presented. The application of generative design methods demonstrates a logical pattern for early stage design exploration.

How style can be maintained across and within a family of products is also the topic of "Creating Cross-Over Vehicles: Defining and Combining Vehicle Classes Using Shape Grammars" by Seth Orsborn, Jonathan Cagan, Richard Pawlicki, and Randall C. Smith. This paper uses shape grammars to quantify the differences between vehicle classes through the application of class-specific rules and constraining rule applications to within parametric ranges determined for each class. This allows for the development of new vehicle forms that clearly fall within a class or purposefully cross over the boundaries of classes and mix rules and ranges to create unique and interesting cross-over vehicles.

"Visual Style: Qualitative and Context Dependent Categorization" by Julie Jupp and John S. Gero sees style as an ordering principle by which artifacts in a design domain can be structured through the visual similarity of its constituent members. Computational models are developed based on qualitative context dependent categorization based on semantic feature extraction and self-organizing maps. This paper proposes a method for classifying unstructured data in the following stages: initial feature detection and extraction, selection of feature sets corresponding to different spatial ontologies, unsupervised categorization of design diagrams based on appropriate feature subsets, and integration of design context via relevance feedback.

"Formalizing Abstract Characteristics of Style" by Kimberle Koile developed a partial characterization of Frank Lloyd Wright's Prairie house style in terms of experiential features of houses, such as "prospect" and "refuge," computed from the relationships between physical features (see also Koile, 2004, for an application of this approach to generating house designs). A program (The Architect's Collaborator) was written to test floor plan designs against these predicates. Five statements of experiential qualities (building, entry, fireplace, main living space, exterior liv-

ing space) and 33 physical form characteristics were implemented in the system to evaluate both Prairie and non-Prairie houses.

Finally, we thank the authors for the efforts they made to incorporate reviewer comments in their revised manuscripts. We are truly grateful to the reviewers who gave insightful remarks and suggestions to the authors, and to Professor David Brown, Editor in Chief of *AIEDAM*, for his advice, patience, and support. We feel that the papers in this Special Issue represent a snapshot of the recent developments and research on the analysis of style and hope the readers find them as interesting and relevant as we did.

REFERENCES

Koile, K. (2004). An intelligent assistant for conceptual design: informed search using a mapping of abstract qualities to physical form. In *Design Computing and Cognition '04* (Gero, J.S., Ed.), pp. 3–22. Cambridge, MA: Kluwer Academic.

Koning, H., & Eizenberg, J. (1981). The language of the prairie: Frank Lloyd Wright's prairie houses. *Environment and Planning B: Planning and Design*, *8(3)*, 295–323.

McCormack, J.P., Cagan, J., & Vogel, C.M. (2004). Speaking the Buick language: capturing, understanding and exploring brand identity with shape grammars. *Design Studies*, *25(1)*, 1–29.

Pugliese, M., & Cagan, J. (2002). Capturing a rebel: modeling the Harley-Davidson brand through a motorcycle shape grammar. *Research in Engineering Design*, *13(2)*, 139–156.

Claudia M. Eckert is a Senior Research Associate and Assistant Director of the Engineering Design Centre in the Department of Engineering at the University of Cambridge. She studied mathematics and philosophy before obtaining a MS in applied artificial intelligence at the University of Aberdeen in 1990 and a PhD in design at The Open University in 1997. Before joining the University of Cambridge, she was a Research Fellow at The Open University studying inspiration processes in the knitwear industry. Her current research interests are in understanding design practice for complex products in order to improve design practice and to inform the development of effective design support tools. Her interests include the comparison of design practices in different design domains.

Ellen Yi-Luen Do is an Associate Professor of design computing in the PhD Program in the College of Architecture and the Interactive and Intelligent Computing Division in the College of Computing at the Georgia Institute of Technology. Prior to Georgia Tech she was an Associate Professor at Carnegie Mellon University and the University of Washington. She obtained a BS from National Cheng-Kung University in 1988, an MS in design from Harvard Graduate School of Design in 1991, and a PhD from Georgia Institute of Technology in 1998. Her research focuses on the development of better computational tools to support design and intuitive human computer interaction.