

INFORMATION VISUALIZATION

Guest Editors' Foreword

Information visualization, an increasingly important subdiscipline within the field of Human Computer Interaction (HCI) [13], focuses on visual mechanisms designed to communicate clearly to the user the structure of information and improve on the cost of access to large data repositories. In printed form, information visualization has included the display of numerical data (e.g., bar charts, plot charts, pie charts), combinatorial relations (e.g., drawings of graphs), and geographic data (e.g., encoded maps) [1, 9, 16]. In addition to these "static" displays, computer-based systems, such as the Information Visualizer [2] and Dynamic Queries [15] have coupled powerful visualization techniques (e.g., constraints, 3D, animation) with near real-time interactivity, i.e., the ability of the system to respond quickly to the user's direct manipulation commands. Another important aspect of computer-based information systems concerns the dual communication with user and machine, which motivates the concept of *visual formalism* that has been introduced by Harel: "The intricate nature of a variety of computer-related systems and situations can, and in our opinion should, be represented via visual formalisms; visual because they are to be generated, comprehended, and communicated by humans; and formal, because they are to be manipulated, maintained, and analyzed by computers" [12].

While historically HCI and database research were kept separate, the interests of both research communities have been converging, mainly in what concerns the topic of information visualization. In the database community, the focus on information visualization started with research in visual query languages, where the visualization of schema and/or database instances is common (for a survey, see [4]). Recently, a new generation of database systems is emerging, which tightly combine querying capabilities with visualization techniques and are information visualization systems in their own right [3, 8, 11]. Database applications that access large data repositories, such as data mining and data warehousing, and the enormous quantity of information sources on the WWW available to users with diverse capabilities also provide HCI researchers with new opportunities for information visualization (see, for instance, the ACM report on Strategic Directions in HCI [13], the

reports of the "FADIVA" Working Group [10], and the work presented in [14]).

The objective of this special issue is two-fold: to compile some of the most recent research on information visualization from both communities, and to make it available to a large readership whose main interests lie in the management of data. The eight papers in this issue cover fundamental topics in information visualization, including tailorable multi-visualizations (i.e., the ability of the system to provide the user with alternative visualizations, depending on their suitability to different data, tasks, and users' preferences); near real-time interactivity when dealing with very large data sizes; effective display and color usage, and multidimensionality. A short overview of each paper follows.

Dynamic Information Visualization by Yannis E. Ioannidis.

This paper conceptualizes and extends dynamic queries [15] using relational theory. The work covers a wide range of aspects, including implementation considerations.

Incremental Data Structures and Algorithms for Dynamic Query Interfaces by Egemen Tanin, Richard Beigel, and Ben Shneiderman.

This paper concentrates on the problem of ensuring an adequate system response time when the user directly manipulates displays of large databases using dynamic query techniques. To achieve this, the authors propose new data structures and algorithms.

Spotfire: An Information Exploration Environment by Christopher Ahlberg.

This paper introduces a comprehensive visualization system, also based on the dynamic query approach. It describes a variety of data visualization, browsing and querying mechanisms, and implementation issues.

A Framework for Information Visualisation by Jessie B. Kennedy, Kenneth J. Mitchell, and Peter J. Barclay.

This paper presents a framework for the construction of information visualization systems, which suggests to the designer the most effective visualizations

with respect to the type of information and the application domain.

Pixel-oriented Database Visualizations by Daniel A. Keim.

This paper gives a survey and comparison of several pixel-oriented visualization techniques that are used to support querying and exploration of very large databases.

To Table or Not to Table: A Hypertabular Answer by Giuseppe Santucci and Laura Tarantino.

This paper extends the well-known form-based visualization approach, and shows how it can be used in novel applications, such as those on the WWW. The main idea consists of displaying the information on demand as a set of interconnected "hypertables" dynamically generated by the system.

Applying Database Visualization to the World Wide Web by Masum Z. Hasan, Alberto O. Mendelzon, and Dimitra Vista.

This paper shows how visual queries can be used to display the addresses of WWW documents and the structure of the navigation during a browsing session.

3D Geographic Network Displays by Kenneth C. Cox, Stephen G. Eick, and Taosong He.

This paper describes 3D graph drawing techniques for large networks, which may incorporate geographical information, as supported by the SeeNet3D system.

The references in the papers of this special issue provide further reading material. In addition, we recommend other recent publications on the same subject, such as the proceedings of AVI [5, 6, 7], which has been a common forum for HCI and database researchers.

The editors are indebted to the authors of the papers submitted to this issue and to Jennifer Widom for recognizing the timeliness of the topic of this issue and for providing useful advice. Partial support for this project was given to Tiziana Catarci by CM Sistemi srl and to Isabel Cruz by the National Science Foundation under CAREER Award IRI-9625105 and by the Department of Computer Science at Brown University.

Tiziana Catarci, Università di Roma
"La Sapienza", Italy
Isabel F. Cruz, Tufts University, USA
October 1996

References

- [1] J. Bertin. *Semiology of Graphics*. The University of Wisconsin Press, Madison, Wisconsin, 1983.
- [2] S. K. Card, G. G. Robertson, and J. D. Mackinlay. The Information Visualizer: an Information Workspace. In *Proceedings of the ACM Conference on Human Computer Interaction*, pages 181-183, 1993.
- [3] T. Catarci, S. K. Chang, and G. Santucci. Query Representations and Management in a Multiparadigmatic Visual Query Environment. *Journal of Intelligent Information Systems*, 3:299-330, 1994.
- [4] T. Catarci, M. F. Costabile, S. Levialdi, and C. Batinì. Visual Query systems for Databases: A Survey. *Journal of Visual Languages and Computing*, March 1997. To appear.
- [5] T. Catarci, M. F. Costabile, S. Levialdi, and G. Santucci, editors. *Advanced Visual Interfaces, AVI'92*, volume 36. Scientific Series in Computer Science, World Scientific, Singapore, 1993.
- [6] T. Catarci, M. F. Costabile, S. Levialdi, and G. Santucci, editors. *Proc. Int. Workshop on Advanced Visual Interfaces AVI'94*. ACM Press, 1994.
- [7] T. Catarci, M. F. Costabile, S. Levialdi, and G. Santucci, editors. *Proc. Int. Workshop on Advanced Visual Interfaces AVI'96*. ACM Press, 1996.
- [8] I. F. Cruz. User-defined Visual Query Languages. In *IEEE Symposium on Visual Languages (VL '94)*, pages 224-231, 1994.
- [9] G. Di Battista, P. Eades, R. Tamassia, and I. G. Tollis. Algorithms for drawing graphs: an annotated bibliography. *Comput. Geom. Theory Appl.*, 4:235-282, 1994.
- [10] Foundations of Advanced 3D Information Visualization, 1996. European (ESPRIT) Working Group <http://www-cui.darmstadt.gmd.de/visit/Activities/Fadiva/>.
- [11] E. M. Haber, Y. E. Ioannidis, and M. Livny. OPOSUM: Desk-Top Schema Management through Customizable Visualization. In *Intl. Conference on Very Large Databases*, pages 527-538, 1995.
- [12] D. Harel. On Visual Formalisms. *Communications of the ACM*, 31(5):514-530, May 1988.
- [13] B. A. Myers, J. D. Hollan, and Isabel F. Cruz, eds. Strategic Directions in Human Computer Interaction. *ACM Computing Surveys*, 28(4), 1996.
- [14] P. Pirolli and S. Card. Information Foraging in Information Access Environments. In *ACM SIGCHI '95*, pages 51-58, 1995.
- [15] B. Shneiderman. Dynamic Queries for Visual Information Seeking. *IEEE Software*, 11(6):70-77, 1994.
- [16] E. R. Tufte. *The Visual Display of Quantitative Information*. Graphics Press., Cheshire, Conn., 1983.