Guest Editorial: Special Section on Visual Analytics

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Visual analytics is the science of analytical reasoning supported by highly interactive visual interfaces. People use visual analytics tools and techniques to synthesize information; derive insight from massive, dynamic, and often conflicting data; detect the expected and discover the unexpected; provide timely, defensible, and understandable assessments; and communicate assessments effectively for action. The issues stimulating this body of research provide a grand challenge in science: turning information overload into the opportunity of the decade.

Visual analytics requires interdisciplinary science beyond traditional scientific and information visualization to include statistics, mathematics, knowledge representation, management and discovery technologies, cognitive and perceptual sciences, decision sciences, and more. An important research agenda to develop the next generation suite of visual analytics technologies is described in the book *Illuminating the Path: The Research and Development Agenda for Visual Analytics*, which is available at http://nvac.pnl.gov/agenda.stm. The papers in this special section address a number of the issues described in the visual analytics research agenda. They are grouped into five major areas: multidimensional data, graphs and networks, communication network analysis, space and time, and fundamentals.

The first two papers address issues of visual analysis of multidimensional data. The first paper, "High-Dimensional Visual Analytics: Interactive Exploration Guided by Pairwise Views of Point Distributions," by Leland Wilkinson, Anushka Anand, and Robert Grossman, describes some high-dimensional multivariate visual analytic techniques for the analysis of several examples of complex data through guided pairwise views of point distributions. This is founded in Tukey's work on Exploratory Data Analysis (EDA).

The paper "Interactive Visual Analysis of Families of Function Graphs," by Zoltán Konyha, Kresimir Matković, Denis Gračanin, Mario Jelović, and Helwig Hauser, describes a new approach to visual analysis of multidimensional data. Multiple, linked views are used to assess data, supported by user-defined complex brushes which span multiple views.

The second group of papers describes various new techniques for visual analysis of graphs and networks. The first paper in this group, "Generating Graphs for Visual Analytics through Interactive Sketching," by Pak Chung Wong, Harlan Foote, Patrick Mackey, Ken Perrine, and George Chin Jr., describes an interactive graph generator, called GreenSketch, which is designed to facilitate creation of descriptive graphs required for different visual analytic tasks. One of the key problems in visual analytics research and development is access to good representative data; this graph generator addresses that problem.

The next paper, "Graph Signatures for Visual Analytics," by Pak Chung Wong, Harlan Foote, George Chin Jr., Patrick Mackey, and Ken Perrine, describes a visual graph analysis technique that uses data signatures which reveal local topology information around graph nodes. The technique assists an analysis in identifying the overall structure of a graph and some of its key features. For example, in a social network graph, the technique can help identify the most influential node.

The next paper, "TreePlus: Interactive Exploration of Networks with Enhanced Tree Layouts," by Bongshin Lee, Cynthia S. Parr, Catherine Plaisant, Benjamin B. Bederson, Vladislav D. Veksler, Wayne D. Gray, and Christopher Kotfila, describes a new visual analytics component, called TreePlus, which is designed to produce effective layouts of large graphs. The approach uses a tree-style layout to show hierarchies embedded in the graph, and interactive techniques to explore and reveal the missing graph structure.

The fourth paper in this group, "Visual Analysis of Large Heterogeneous Social Networks by Semantic and Structural Abstraction," by Zeqian Shen, Kwan-Liu Ma, and Tina Eliassi-Rad, presents a visual analytics tool for understanding large, heterogeneous social networks. The nodes and links of the network represent different concepts and relations which are semantically related and pruned through an ontology. Several case studies illustrate the capabilities of the tool.

The third group of papers focuses on analysis of communications networks. "Interactive Exploration of Data Traffic with Hierarchical Network Maps," by Florian Mansmann and Svetlana Vinnik, describes a new interactive visualization technique, called Hierarchical Network Map, for gaining insight in network flow behavior. These techniques aid in discovering anomalies in and misuse of communication networks.

The other paper in this group, "Visualizing Internet Routine Changes," by Mohit Lad, Dan Massey, and Lixia Zhang, describes a tool, called Link-Rank, which can visualize Internet routing changes at the global scale. It

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helps network operators identify and diagnose problems occurring in data delivery, including the root causes of observed routing changes.

The fourth group of papers concern visual analysis in space and time. The first paper in the group, "A Visualization System for Space-Time and Multivariate Patterns (VIS-STAMP)," by Diansheng Guo, Jin Chen, Alan M. MacEachren, and Ke Liao, describes a geovisual analytic approach for exploring and understanding spatio-temporal data with multivariate attributes. The tool is designed to help analysts investigate complex patterns across multivariate, spatial, and temporal dimensions via clustering, sorting, and visualization.

The next paper, "VU-Flow: A Visualization Tool for Analyzing Navigation in Virtual Environments," by Luca Chittaro, Roberto Ranon, and Lucio Ieronutti, describes a tool, called VU-Flow, used for visual analysis of navigation patterns of moving entities (e.g., people) in 3D virtual environments. It can be used to discover interesting navigation behavior of either individuals or groups. It can be used for urban planning, transportation, and emergency response.

The third paper of this group, "Summarizing Dynamic Bipolar Conflict Structures," by Ulrik Brandes, Daniel Fleischer, and Jürgen Lerner, describes a method for visualizing conflicts in temporal event data. It reveals the main opponents of a conflict in a series of tens of thousands of events. It also uses animation to show how a conflict evolves over time.

The final group of papers addresses some fundamental issues. The first of these, "Provenance and Annotation for Visual Exploration Systems," by Dennis P. Groth and Kristy Streefkerk, presents a method for annotation by recording the history of user analytic explorations in visualization environments. A prototype system is used to demonstrate how this provenance information can be recalled and shared.

And, the final paper, "An Insight-Based Longitudinal Study of Visual Analytics," by Purvi Saraiya, Chris North, Vy Lam, and Karen A. Duca, presents a longitudinal study of a real-world bioinformatics data set analysis using three visualization tools, with the main focus to capture the entire analysis process that an analyst goes through from a raw dataset to the insights sought from the data.

As is evident from this collection of papers and from the visual analytics research agenda described in the book *Illuminating the Path*, there is a wide variety of work taking place in this new field of visual analytics. We hope that this sampling of papers has given you some insight into the nature of this field. We gratefully acknowledge the work of the many reviewers who were involved in the process of assembling this special section, and to David Ebert, Editor-in-Chief of *TVCG*, for his strong support and assistance.

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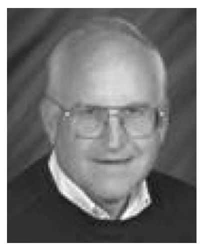

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