Big-Data Visualization

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We've entered a data-driven era, in which data are continuously acquired for a variety of purposes. The ability to make timely decisions based on available data is crucial to business success, clinical treatments, cyber and national security, and disaster management. Additionally, the data generated from large-scale simulations, astronomical observatories, high-throughput experiments, or high-resolution sensors will help lead to new discoveries if scientists have adequate tools to extract knowledge from them.

However, most data have become simply too large and often have too short a lifespan. Almost all fields of study and practice eventually will confront this big-data problem. Government agencies and large corporations are launching research programs to address big data's challenges. Visualization has proven effective for not only presenting essential information in vast amounts of data but also driving complex analyses. Big-data analytics and discovery present new research opportunities to the computer graphics and visualization community. This special issue highlights the latest advancements in solving the big-data problem via visual means, with four articles on new techniques, systems, or applications.

In "Customizing Computational Methods for Visual Analytics with Big Data," Jaegul Choo and Haesun Park discuss the interplay between precision and convergence—two aspects that haven't received appropriate consideration in visual analyses so far. The authors propose customizing computational methods to include low-precision computation and iteration-level visualizations to ensure real-time visual analytics for big data.

In "Feature Tracking and Visualization of the Madden-Julian Oscillation in Climate Simulation," Teng-Yok Lee and his colleagues present an integrated analysis and visualization framework for scientists to better understand the Madden-Julian oscillation (MJO) phenomenon from large-scale spatiotemporal climate simulation data. The authors demonstrate how the tight integration of MJO domain knowledge, data analysis techniques such as feature tracking, and visualization methods such as Hovmöller diagrams and a virtual globe can lead to a powerful system for climate research.

In "Visualizing Large, Heterogeneous Data in Hybrid-Reality Environments," Khairi Reda and his colleagues show how a new kind of visualization space called *hybrid-reality environments* can achieve scalable visualization of heterogeneous datasets. These environments synergize the capabilities of VR and high-resolution tiled LCD walls, letting users juxtapose 2D and 3D datasets and create hybrid 2D-3D information spaces. The authors introduce two such environments—Cyber-Commons and CAVE2—and some real-world applications.

Finally, in "Exploring the Connectome: Petascale Volume Visualization of Microscopy Data Streams," Johanna Beyer and her colleagues describe a system for interactive exploration of petascale volume data of neural tissues generated by high-throughput electron microscopy imaging. This visualization-driven system lets users handle multiple volumes and incomplete data, restricts most computations to a small subset of the data, and achieves scalable computing with a multiresolution virtual memory. The authors applied the system to a mouse cortex volume with a resolution of $21,494 \times 25,790 \times 1,850$ voxels.

We hope you enjoy these articles, which provide a very small sample of big-data visualization problems and solutions. We anticipate that

the emerging big-data applications will present new challenges, drawing new interest and research that leads to many innovations and advancements.

We thank all the editors, authors, and reviewers who helped make this special issue a success. Those of you who wish to learn more will find a number of workshops, conferences, and committee reports devoted to big data. Several of these meetings feature sessions on visualization and analytics research. Examples include the First Workshop on Big-Data Visualization with the 2013 IEEE Conference on Big Data (http://vis.ucdavis.edu/Workshops/BigDataVis2013), the IEEE Symposium on Large-Scale Data Analysis and Visualization with IEEE VIS 2013 (www.ldav.org), and the Ultrascale Visualization Workshop with Supercomputing 2013 (http://vis.cs.ucdavis.edu/Ultravis13).

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