Guest Editorial:
Special Section on Visualization 2005

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This special section contains extended versions of nine papers published at the IEEE Visualization 2005 (VIS 2005) conference. The program committee chairs selected these papers by taking into account the detailed reviews from external referees and program committee members. Authors were invited to submit a substantially revised and extended version of their manuscripts. Each submitted paper went through the complete IEEE Transactions on Visualization and Computer Graphics (TVCG) peer review process, including multiple rounds of reviews. For VIS 2005, the application and research papers were folded into a single track, and all papers were published together, without explicit classification information. At the conference, the talks were organized by topic, with both application and research papers presented in the same session, when appropriate. This special section contains revised versions of both application and research papers.

The first paper, “Views on Visualization,” by Jarke J. van Wijk, is based on his “best research paper award winning” paper. It provides a thought-provoking look at the state of visualization research, with an emphasis on the effectiveness of visualization techniques on a number of particular applications. It builds on the author’s extensive experience and stature as one of the leading figures in the field, having published extensively in the IEEE Visualization and Information Visualization conferences. We note that this is not a typical research paper, however, it is important reading for anyone who has interest in visualization as a scientific discipline.

The goal of visualization is not necessarily to generate beautiful pictures, but to create insightful visual representations that faithfully represent the scientific truth. Issues of precision are extremely important. Xiaoru Yuan, Minh. X. Nguyen, Baoquan Chen, and David H. Porter present a set of techniques for faithfully rendering high-dynamic volume data in their paper, “HDR VolVis: High Dynamic Range Volume Visualization.” They received the best application paper award for their groundbreaking work in this area. Their paper provides convincing evidence that properly handling precision and dynamic range issues are key to maintaining the integrity of the scientific data, and are bound to be ever more important as the field expands.

In modern applications, many numerical solutions of simulations of experiments are done using high-order basis functions. This trend is likely to increase as we understand the numerical methods better, and are able to develop more stable and efficient techniques for handling high-order finite elements, which often lead to a substantially smaller number of elements for a given accuracy of the solution. The paper by William J. Schroeder, Francois Bertel, Malaterre Mathieu, David Thompson, Philippe P. Féray, Robert O’Bara, and Sarabdh Tendulkar, “Methods and Framework for Visualizing Higher-Order Finite Elements,” addresses the visualization issues related to coping with high-order elements. The authors propose a general visualization framework (based on element subdivision) that is implemented in the highly successful VTK library, which is freely available as an open-source package.

At the core of the paper, “Projected Tetrahedra Revisited: A Barycentric Formulation Applied to Digital Radiograph Reconstruction Using Higher-Order Attenuation Functions,” by Ofri Sadowsky, Jonathan D. Cohen, and Russell H. Taylor, is an improvement to the “classical” Projected Tetrahedral (PT) algorithm of Shirley and Tuchmann published in 1990, which is one of the most cited visualization papers. The PT algorithm, coupled with visibility ordering, is heavily used in the rendering of unstructured volume data. It turns the problem of rendering tetrahedra into rendering triangles, which can be efficiently computed using standard graphics hardware. The authors propose a new, simple, and efficient technique for performing perspective-correct rendering of tetrahedra. This addresses a shortcoming of the original approach. Their paper also shows how to use their new technique in a new medical application.

Scientific data is increasing larger and more complex. A common way to handle such large data is to attempt to “simplify” and somewhat reduce its overall size, making it easier to analyze, and to create visual representations. Many techniques are ad hoc and can miss features. In “A Topological Approach to Simplification of Three-Dimensional Scalar Functions,” Attila Gyulassy, Vijay Natarajan, Valerio Pascucci, Peer-Timo Bremer, and Bernd Hamann propose a new simplification technique with a solid theoretical foundation on Morse theory that has certain theoretical guarantees. They are able to simplify the data set, but not compromise certain “features” of the underlying data.

Knot theory is an intriguing area of topology that deals with the properties of mathematical knots and links. The paper, “Visualization of Seifert Surfaces,” by Jarke J. van Wijk and Arjeh M. Cohen, provides a set of beautiful and insightful visualizations of Seifert surfaces, which are connected, oriented, and compact surfaces that are defined

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by having a given knot as their boundary. (Seifert surfaces are used to define the genus of a knot or link.) In an elegant paper, the authors show how to use spheres and tubes as a way to compute a Seifert surface from a given knot. Although schematic images of these surfaces are routinely shown in mathematical textbooks, it is hard to imagine their real shape. The techniques presented in this paper can be used for the visualization and “concrete” generation of Seifert surfaces directly from a knot representation.

The study of the function of expressed proteins, proteomics, is of major concern in the understanding of complex biological processes. In “Visual Analysis of Gel-Free Proteome Data,” Lars Linsen, Julia Löcherbach, Matthias Berth, Cörte Becher, and Jörg Bernhardt present a novel interactive visualization tool for the analysis of differential protein expression and protein identification. Their tool replaces the traditional approach of using a large number of 2D displays, with a single integrated 3D display. In their paper, they provide evidence that their 3D approach allows for the improved understanding of the data set by providing a global view of the data.

A central issue in visualization is determining the relative effectiveness of alternative methods. Controlled studies are often not feasible due to the large space of possible alternatives. The issue is further complicated by the mix of perceptual and aesthetic issues involved. In “An Approach to the Perceptual Optimization of Complex Visualizations,” Donald H. House, Alethea S. Bair, and Colin Ware present a new framework for exploring the space of possible solutions. They propose using genetic algorithms guided by human interaction to generate a database of assessments. They then use data mining techniques to gain insight into the visualization method. They demonstrate this approach on the specific problem of evaluating visualizations of layered surfaces.

In “Explanatory and Illustrative Visualization of Special and General Relativity,” Daniel Weiskopf, and a sizeable group of collaborators, explore explanatory and illustrative visualizations to communicate aspects of special and general relativity to a general audience of interested laypersons. They investigate different types of media and immerse the participants into visually enriched thought experiments to explore relativistic scenarios. The work is an excellent example of integrating the domain knowledge of experts from diverse disciplines like visualization, computer graphics, relativistic physics, physics education, modeling, and museum design. The paper contains some thought provoking images. The paper further reports on several public exhibitions where the egocentric and exocentric illustrative visualizations where met with great enthusiasm from the lay audience.

We hope the reader enjoys reading these extended and revised papers from VIS 2005. Given the high number of high-quality papers published at the Visualization conference each year, it is increasingly hard to select these papers. For 2006, this will not be necessary since the VIS 2006 proceedings will be published as part of a special issue of TVCG.

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