



Guest editors' introduction

Data visualization

Data visualization is a dynamic discipline in order to quickly react to new developments in graphics hardware, virtual environments or network technology, to new computer graphics algorithms, and last but not least to the ever growing size of scientific datasets. The field of visualization has been most creative in application areas where datasets are large enough either in size or dimensionality to require an intelligent type of data reduction. One such class of datasets are volumetric data where grids are three-dimensional and of high resolution. Another one is vector fields or other multivariate data which call for the simultaneous display of multiple scalars at any position. It is the purpose of this special issue to give an overview of recent research in visualization. Six outstanding papers have been selected. It is not surprising that they all fall into one (or both) of the two categories just mentioned.

The paper by Liu, Finkelstein and Li and the paper by Gerstner together define the state of the art in isosurface extraction. They nicely demonstrate the progress that has happened in the 14 years since the publication of the original Marching Cubes algorithm by Lorensen and Cline. The two algorithms presented are multi-resolution and view-dependent. Multi-resolution techniques enable progressive transmission of the surface geometry and at the same time avoid unnecessary computation in grid areas not contributing to the surface. The latter problem kept research busy for a decade and besides the octree approach led to various other solutions such as span spaces or extrema graphs. View-dependent rendering techniques have become a major research area in visualization as they make it possible to visualize very large datasets over low-bandwidth networks and on computers with limited memory and graphics performance.

Liu, Finkelstein and Li address the problem of efficiently extracting the non-occluded parts of an isosurface for a given view. They present an innovative hybrid technique: the ray casting method is used for finding visible seed triangles and geometric isosurface extraction is used for finding adjacent triangles. The paper reports impressive performance figures, in particular very short times for computing near-correct progressive approximations.

The work by Gerstner addresses an often neglected aspect of isosurfacing: Probably everybody involved in

practical visualization has experienced the dilemma that a single surface is not sufficient while it is difficult to display multiple semitransparent surfaces unless triangles are sorted by depth prior to rendering. It is therefore a nice property of the presented algorithm that it generates triangles in back-to-front order by using a special traversal order through the hierarchical tetrahedral grid.

Direct volume rendering, and in particular the splatting technique, is investigated by Hladuvka and Gröller. Their paper focuses on speeding up the splatting process by subsetting the voxels. Yet, in contrast to the first two papers, extraction is not based on absolute levels but on first and second derivatives, an alternative having its benefits if “interesting” levels are not known *a priori* or not spatially constant. Techniques for extracting features such as edges or ridges are commonly used in computer vision. We believe that the field of computer vision has a rich set of methods which are worth trying to adapt to the needs of scientific visualization. The paper by Hladuvka and Gröller is a successful example for this: Starting from a 3-d edge extraction, they define a feature-type behaving similar to a ridge for thin structures and similar to an edge for larger structures.

As a data analysis technique, visualization is often criticized for ignoring the uncertainty of the data. While competing techniques like statistical analysis can naturally deal with uncertainty, it is far from obvious how to incorporate uncertainty into visualizations since it means to handle at least one additional data channel. Djurcilov, Kim, Lermusiaux and Pang attacked the particularly hard problem of adding uncertainty to a direct volume rendering. Their proposed techniques such as the depth-shaded holes are intuitive and give a surprisingly good understanding of the data and their confidence. When looking at the printed images, one should keep in mind that, as for any direct volume rendering technique, its true power is revealed in animated views.

Visualization of vector fields is another area where the data reduction aspect of scientific visualization becomes apparent. When data are 3-d and/or time-dependent, a high degree of data reduction is unavoidable and that has led to the research for controlled ways of doing this reduction. A current research trend is to extract flow

features of different dimensionalities and to use them for guiding or at least for complementing conventional types of visualization. In the work by Tricoche, Wischgoll, Scheuermann and Hagen flow features are defined in terms of vector field topology. Their paper presents a visualization technique for time-dependent 2-d flows at a high level of mathematical rigor.

A different approach to dealing with multiple data channels is presented in the paper by Harding, Kakadiaris, Casey and Loftin. This case study presents a multi-sensory virtual environment for investigating geoscientific data. Besides displaying the surface morphology as a height field, their system can use color-coding, haptics and sound for conveying independent scalar data such as various surface properties. The paper also presents detailed user studies the results of which are valuable for anyone designing or

just using a virtual environment for scientific visualization.

Even though there are many more areas of visualization which cannot be covered, we believe that this collection of papers can give a good idea of visualization as a versatile and lively research area.

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