Hans Hagen, Heinrich Müller,
Gregory M. Nielson (editors):

Scientific Visualization

Dagstuhl-Seminar-Report; 19
26.8.-30.8.91 (9135)

ISSN 0940-1121

Das Internationales Begegnungs- und Forschungszentrum für Informatik (IBFI) ist eine gemeinnützige GmbH. Sie veranstaltet regelmäßig wissenschaftliche Seminare, welche nach Antrag der Tagungsleiter und Begutachtung durch das wissenschaftliche Direktorium mit persönlich eingeladenen Gästen durchgeführt werden.

Bezugsadresse: Geschäftsstelle Schloß Dagstuhl
Informatik, Bau 36
Universität des Saarlandes
W - 6600 Saarbrücken
Germany
Tel.: +49 -681 - 302 - 4396
Fax: +49 -681 - 302 - 4397
e-mail: office@dag.uni-sb.de

Report

of the 1st Dagstuhl Semniar on

Scientific Visualization

August, 26–30, 1991

Organized by

Hans Hagen, Universität Kaiserslautern

Heinrich Müller, Universität Freiburg

Gregory M. Nielson, Arizona State University

The first Dagstuhl Seminar on Scientific Visualization brought together researchers from Austria (1), France (2), Germany (17), USA (12), USSR (2), and The Netherlands (1).

The contributions reflected the heterogenous structure of the whole area of scientific visualization. Presentations were given e.g. in volume visualization, rendering techniques, correlative data analysis, and surface interrogation. The heterogeneity concerned the applications as well as the methods by which the problems were attacked. Areas of application were computer aided geometric design, earth and space sciences, fluid flow, mathematics, medical imaging, physics, and statistics. Methods were of algorithmic, software, hardware, but also physiological/psychological flavor. Video and software presentations helped to make the ideas more clear, even in spite of the troubles with the technical equipment which partially did not survive its first longer operation.

Although there were some voices which had preferred the concentration on a special topic, the main opinion was that this wide spectrum was fruitful for own ideas and own future work. In contrast to usual conferences the atmosphere of Dagstuhl supported this exchange in particular manner. It was a pleasure to see the always well occupied audience and to follow the surprisingly extensive and intensive discussions after the talks.

The occasion of the Dagstuhl Seminar was taken to start the initiative for a book on Scientific visualization edited by the organizers and contributed by the participants of the seminar. The idea is not to produce a proceedings volume but an edited book containing tutorial-like sections as well as recent original work. One intention of the book is to use it as material in courses and seminars on Scientific Visualization.

Participants

R. Daniel Bergeron, University of New Hampshire
William R. Feeney, San Diego State University
Martin Frühauf, Fraunhofer-Arbeitsgruppe Graphische Datenverarbeitung
Bernhard Geiger, INRIA, Sophia Antipolis
Michael Gervautz, TU Wien
Bernd Girod, KHM Köln
Martin Göbel, Fraunhofer-Arbeitsgruppe Graphische Datenverarbeitung
Michel Grave, ONERA DMI/CC
Thomas Griesbaum, Universität Karlsruhe
Georges G. Grinstein, University of Massachusetts at Lowell
Vladimir G. Grishin, Institute of Control Siences, Moscow
Hans Hagen, Universität Kaiserslautern
Pat Hanrahan, Princeton University
Karl-Heinz Höhne, Universität Hamburg
Philip Jacob, Universität Kaiserslautern
Arie Kaufman, SUNY at Stonybrook
Fred Kitson, Hewlett Packard Labs, Palo Alto
Stanislav Klimenko, Institute of High Energy Physics, Protvino, USSR
Wolfgang Krüger, GMD, Sankt Augustin
Ulrich Lang, Universität Stuttgart
Rolf van Lengen, Universität Kaiserslautern
Creon Levit, NASA Ames Research Center
Nelson Max, University of California and Lawrence Livermore National Laboratory
Heinrich Müller, Universität Freiburg
Stephan Neunreither, GMD-FIRST, Berlin
Gregory M. Nielson, Arizona State University
Theo Plesser, Max-Planck-Institut für Ernährungsphysiologie
Frits Post, TU Delft
Alfred Schmidt, Universität Freiburg
Alfred Schmitt, Universität Karlsruhe
Thomas Schreiber, Universität Kaiserslautern
Heidrun Schumann, Universität Rostock
Werner Stuetzle, University of Washington, Seattle
Lloyd Treinish, IBM, Thomas J. Watson Research Center
Jane Wilhelms, University of California, Santa Cruz

Integrating Data Management, Analysis and Visualization for Collaborative Scientific Research

R. Daniel Bergeron, Ted M. Spark, Loren D. Meeker
University of New Hampshire, Durham, USA

The goal of this multidimensional project is to design and prototype a new approach in database environments aimed at supporting collaborative scientific research. The prototype will integrate scientific data visualization and mathematical and statistical analysis tools with database support in a highly interactive environment. A new schema model for scientific data will be defined and implemented. The new scientific database conceptually creates new derived data whose relationship to the parent database is defined by the query. The system uses a process flow graph as the mechanism for representing queries. Each query, in principle, leads to the discovery of some form of structure in the data which is explicitly represented by the results of the query, or which is hypothesized by the scientist as a result of the current and previous queries.

Integration of Different Primitives for Scientific Visualization

Martin Frühauf
FhG-AGD, Darmstadt

Volume data are discrete sampled data in 3D space. Geometric objects are represented as a list of vertices and connecting lines or surface patches. Independent algorithms for rendering the two different categories of data are used. The system combines the results of the different algorithms into one image. A set of common parameters influencing the different rendering algorithms and ensuring the consistency of the resulting merged image is identified. The system is able to handle opaque and translucent objects by merging lists of image space elements. The independence of both rendering modules allows to employ a wide range of algorithms for rendering of geometric objects, even rendering in hardware.

Time in Visualization

Martin Göbel, Peter Astheimer, Wolfgang Felger
FhG-AGD, Darmstadt, Germany

Current visualization approaches focus on presenting dates in spatial models, i.e. map data to space, color, ... Time variant behavior is visualized by various techniques, e.g. histograms, image sequences, animated image sequences. One problem in visualizing time dependencies is that process time and visualization time are completely different and that – up to now – no generally accepted concepts do exist to model time as the fourth dimension.

A concept is presented that is strongly influenced by "standard" computer graphics techniques for modeling in space. According to this concept, time underlies two transformations, time modeling for scene composition from objects in different time domains, and time windowing to allow the user to select portions of the time axis for presentation.

Today, workstation performance and image quality define a limitation in speed. Therefore digital video recording techniques are going to be integrated parts of visualization systems.

Exploratory Visualization of Data Using Perception-Based Techniques

Georges Grinstein
University of Massachusetts at Lowell, USA

ur overall approach to the exploration of data is focussed on addressing the perceptual process the human being. Because of this we have been researching novel multidimensional data pre- ntation techniques based on visual geometric and color encodings that produce display textures id more general techniques based on motion and auditory perception. We have applied these chniques to fusion problems in medical and satellite imagery, and in fluid flow problems. We ive also begun to apply the same techniques to categorical databases such as census data and BI homicide data. Here the visualization problem is more complex as we now need to provide lditional tools when dealing with large data bases. Tools such as interactive scatterplot ma- pulations and statistical computation support. In these database cases our techniques provide creasing interactive extensions of modern scatterplot techniques. Problems in the area of data sion and interaction are presented.

Pictorial Analysis of Multidimensional Nonlinear Structures of Heterogeneous Data

Vladimir G. Grishin
Institute of Control Sciences, Academy of Sciences, Moscow, USSR

he general problem is dependencies research or model choice. Data are numerical sets, signals, id fields. Applications are basic research, technical and medical diagnostics, social and ecological onitoring, and economical forecasting. The problem takes into consideration pattern recognition, ustering, and structure identification. The main purpose of conventional methods is to simplify ie man's problem by computer. The computer finds decision rules for 2-D projections of initial -D space of data. The substance of pictorial methods is to use unique abilities of human vision system of pictures comparison, analysis and description for detection and description of multi- mensional nonlinear structures right in initial N-D space of data by transformation each point of iis space in a separate picture. The computer is used mainly for these pictorial representations.

The theoretical, experimental and practical experience of many years research and develop- ent of pictorial methods showed their big advantages for nonstationary, nonlinear and very high mensional problems,

- parallel choice from many extremal solutions,
- perfect interpretability of results,
- expendability of results to all new classes,
- simplicity and low cost of solving.

Surface Interrogation Algorithms

H. Hagen, S. Hahmann, Th. Schreiber
Universität Kaiserslautern, Germany
Y. Nakajima
Nissan Motor Ltd., Japan
B. Wördenweber, P. Hoffmann-Grundstedt
Hella GmbH

Free-form curves and surfaces are of a central importance for sophisticated CAD systems. Apart from the geometric modeling aspect of these curves and surfaces, the analysis of their quality is equally important in the design and the construction process. The purpose of this talk is to give a critical survey on surface interrogation methods and to present generalized focal surfaces as a new surface interrogation tool.

Two Projects in Progress – "Interactive 3D Segmentation" and "3D Anatomical Atlas"

Karl Heinz Höhne
Institut für Mathematik und Datenverarbeitung in der Medizin, Universität Hamburg, Germany

3D medical images suffer form the fact that there are no general segmentation algorithms. An approach is presented in which a user has a set of low level segmentation tools, the results of which he can see immediately as a 3D rendered image. The tools are: thresholding, 3D erosion/deletion, 3D connected component analysis. In this approach the task of object recognition is done by the user, while the relatively simple but computing intensive segmentation task is done by the computer. Preliminary results show that this method can solve the problem of 3D viewing for a large class of applications when there are workstations at hand that are about one order of magnitude faster than those of today.

An application that lends itself to volume visualization is medical education. As a basis for a true 3D atlas of the human head we use a 3D magnetic resonance data set. Using interactive segmentation tools and a 3D editor each voxel of the volume is labeled by an expert according its membership to structural and functional primitives. A data base describing the correlations between the primitives is added. With standard volume visualization methods the head can be explored and the data base interrogated in the pictorial context.

An Improved Shading Method for Radiosity Based Rendering

P. Jacob
Universität Kaiserslautern, Germany

This talk presents an improved shading method especially useful for non-interactive radiosity based renderers. This method can be used to generate smooth realistic images while reducing the number of patches needed during the rendering process. It may be used for the visualization of radiosity scenes in combination with raytracers, painters or depth-buffer systems to reduce the Mach-bands and other unwanted effects of linear interpolation.

Volume Synthesis Principles

Arie Kaufman
State University of New York at Stony Brook, USA

There is a recent increase in the use of discrete voxel representation for a variety of geometry-based applications. These include CAD, simulation, and scientific visualization, as well as those that intermix geometric objects with 3D sampled or computed datasets. In these applications the inherently continuous 3D geometric scene is sampled employing voxelization (3D scan conversion) algorithms, which generate a 3D raster of voxels. The voxelized objects have to conform to some 3D discrete topological requirements such as connectivity and absence of tunnels. During the voxelization process, termed also the volume synthesis process, each voxel is assigned precomputed numeric values that represent some measurable viewing-independent properties of a tiny cube of the real object. These values are then readily accessible for speeding up the rendering or the discrete ray tracing process. The voxelization algorithms are the counterparts of the 2D scan conversion algorithms, and the 3D raster generated by them is the 3D counterpart of conventional 2D raster.

Advances in Volume Rendering

Fred Kitson, Tom Malzbrender, Bulas Natarajan
Hewlett Packard Labs, Palo Alto, CA, USA

Our global objective is to research and develop algorithms and architectures that facilitate the seamless integration of graphics, modeling, image processing and numerical simulation. Such a "Visual Computing Environment" will be able to manipulate and process multidimensional data such as video and 3D surfaces and volumes as in Scientific Visualization. To this end, we present two advances in 3D volume data visualization. The first algorithm presented has the potential to generate "X-ray like" 2D projections of 4D data orders of magnitude faster than conventional volume rendering techniques. The process is a frequency domain one as opposed to spatial ones and is based on the "Fourier Projection Slice Theorem" in 3D. The algorithm is similar to the inverse of the C.A.T. scan reconstruction problem. Several 3D filtering and sampling techniques are covered. The second algorithm is a functional enhancement for generating isosurfaces from uniform 3D data samples. It improves on the standard "marching cubes" algorithm by not only eliminating C^0 discontinuities in the generated surface but also produces a "topological consistent" result. That is, the resultant piecewise polygonal surface is topological equivalent to that of a trilinear approximation to the $f(x, y, z) = a$ constant (threshold). The improved algorithm has about a 15% computational penalty while retaining a good geometric approximation with a small number of polygons.

Visualization in High Energy Physics

Stanislav V. Klimenko
Institute of High Energy Physics, Protvino, Moscow Region, USSR

This talk addresses the number of problems of visualization in High Energy Physics (HEP). A brief review on the problems of particle physics is made. The current status of accelerator centers, including HEP in Protvino, is described. The requirements arising from the HEP research and development structure and the HEP experiment loop are presented. The roles of human beings and visualization in the research loop are discussed. Visualization has proved to be an effective tool for the solution of a variety of problems arising in HEP research,

- to investigate theoretical models,
- to design and arrange construction elements of the detectors,
- to analyze the results of numerical modeling of physical characteristics for the constructions under development,
- to monitor and control the operation of experimental systems during data taking,
- to visually analyze the data processing,
- to compare visually the obtained statistic distributions with one another and with theoretical predictions during data analysis,
- to prepare illustrations for scientific reports and publications,
- to produce graphics review atlases on particle and reaction properties.

The visualization paradigm based on geometric mentality and geometrical design is discussed. Examples of HEP applications are presented. The special interest of visualization for the 3-body problem is noted. As conclusion expected benefits for HEP in visualization are presented.

Towards a 3D Volume Renderer

Wolfgang Krueger
Scientific Visualization Department, Supercomputer Center at GMD, Sankt Augustin, Germany

One of the main goals in visualization of 3D scalar data fields is interactivity. The project addresses the problem of mapping features of the data set onto a 5D information field which can be generated by a generalized transport theory approach. The discussion concentrates on the theoretical advantages of such a general approach and on its computational limitations. Examples for the interactive rendering of the 5D information field by projecting it onto a 2D sub-manifold (image plan) for a selected viewing direction are given. Possible applications of this general approach might be generalizations of the radiosity method for image synthesis (inclusion of volumetric effects such as smoke, dust, etc.), and the combination of surface rendering (via radiosity with specular reflection) with the visualization of related physical parameter fields, e.g. light distribution, temperature, noise, etc..

Visualization within a Scientific Software Environment

Ulrich Lang
Computer Center, University of Stuttgart, Germany

Visualization of scientific data should be just one part of an overall environment to deal with scientific and technical problems using computers. At the University of Stuttgart Computer Center such a software system, called RSYST, is under ongoing development. Basic properties of such a system should be a consistent environment during simulation and visualization offering a modular extensible framework with programming capabilities like looping, branching, recursive execution of module sequences, etc.. A central component of RSYST is the database, which was specifically designed for the requirements of scientific calculations. The database contains data objects of certain types. A class concept allows to design arbitrary new classes and then generate objects of these classes. Functionalities like information feedback and steering of ongoing calculations is easier to support when consistent software systems without remodeling between simulation and visualization are used.

Some New Techniques for Numerical Flow Visualization

Creon Levit
NASA Ames Research Center, USA

We describe several new techniques in use for numerical flow visualization at NASA Ames research center. Automatic identification of topological features in scalar, vector, and tensor fields is one. Realtime interactive exploration of flow-fields using virtual environments ("virtual reality") is another.

Combining and extending these techniques to meet the challenge of visualizing large (1.0E11 bytes) unsteady three dimensional numerically generated flow fields is currently being researched.

Computer Assisted Sphere Packing in Higher Dimensions

Nelson Max
University of California and Lawrence Livermore Laboratory, USA

A computer was used to help study the packing of equal spheres in dimension 4 and higher. A particular candidate packing, D4, was described in 4 dimensions, in which each sphere is surrounded by 24 others. A system for interactively manipulating and visualizing configurations of spheres in 4 dimensions surrounding a central one was described, involving stereographic projection into 3-space, and then stereo pairs on the computer screen.

The Voronoi cell for a sphere in a packing is the set of points closer to its center than to the center of any other sphere. The packing density is the ratio of the sphere's volume to the average of the volumes of the Voronoi cells. A method of constructing Voronoi cells and computing their volumes was described which works in any number of dimensions.

Sorting for Polyhedron Compositing

Nelson Max
University of California and Lawrence Livermore National Laboratory, USA

Polyhedral compositing is a method for volume visualization of irregular data, which sorts the volumes and semi-transparent surfaces from back to front, and composites them into frame buffers. For scattered data points, the Delaunay triangulation by tetrahedra can always be correctly sorted. This work describes two methods of sorting for specialized data. The first is for adaptive mesh refined data, which is created automatically by certain partial differential equation solvers, to concentrate cells at regions of high variation like shock fronts. The base cells are easily sorted in their rectilinear array, and subdivided cells have their subcells sorted similarly. The second kind of data arises from climate modeling on a grid of equally spaced meridians of longitude, unequally spaced parallels of latitude, and 19 levels in height, which follow the variations of terrain altitude. The vertical columns can be easily sorted in latitude and longitude, and then the cells (prisms or eight vertex columnar cells with triangulated tops and bottoms) can be sorted separately within each column.

3-D Structures from Slices

Heinrich Müller, Hansjörg Scherberger
Universität Freiburg, Germany
Arnold Klingert
Universität Karlsruhe
Bernhard Geiger
INRIA, Sophia Antipols, France

Suppose we are given a sequence of raster images showing parallel slices of a 3D solid. The question is for a polygonal representation of the solid, for example of its surface. There are two main approaches attacking this question: 3D image processing followed by a marching cube step, or 2-D image processing for polygonal contour extraction followed by a polygonal contour interpolation step. We focus on the second approach which seems to be preferable for badly sampled or distorted data.

One of the most successful approaches to data goes back to Boissonnat (in CVGIP, 1989) and is based on a nearest neighbor argument leading to 2.5D Delaunay triangulations. Its main advantage is that it can handle also branchings in a quite natural manner. However, there are still drawbacks. The method does not work for cross sections showing quite different contours due to a large distance between slices. Further, it insists on a unique solution although there might be other geometrically feasible solutions too.

The shape oriented approach sketched in this talk overcomes these problems by carrying out an enumeration of feasible solutions, based on a shape-based divide&conquer approach. The arrangement of the enumeration is optimized in the sense that enumerating the more likely solutions first, based on feature based supervised learning.

Modeling and Animation for Scientific Applications

Stephan Neunreither
GMD First, Berlin, Germany

The MARCOS (Modeling Animation and Rendering of Complex Objects and Scenes) project is a joint project of TU Berlin and GMD First. The main objective is to provide a flexible tool for all modeling and animation tasks. The modeling component is designed to handle heterogeneous models (hierarchies) and model representations. The MARCOS system is conceived as an extensible system to which add-ons can be programmed. We believe we can achieve this by using an object-oriented approach. In the talk an overview of the main design decisions is given and some possible outlines for applications are presented.

The Analysis and Visualization of Multivariate Data

Gregory M. Nielson
Arizona State University

An introduction and survey of methods for modeling and visualizing multivariate data is presented. The emphasis is on the case where one variable is identified as being dependent on the other, independent variables. Data of this type arises often in practical problems of science and engineering. The modeling portion is concerned with finding a mathematical relationship which represents the underlying phenomenon or physical system which produced the data. Visualization is concerned with using computer generated images to convey information so that the user can learn about the relationship. The discussion on modeling methods will concentrate on the application areas of surface-on-surface and volumetric data. Volumetric data covers the case where the independent data values represent points in a three dimensional domain. The surface-on- surface case is where the independent data is restricted to lie on some surface such as the earth or the surface of an airplane wing. Two general approaches, global distance and local continuity constrained methods, will be discussed relative to these two application areas.

Graphing and visualizing multivariate relationships is quite challenging. Extending methods which have proven to be successful in other situations is a starting point. A review of methods for bivariate surfaces provides a source of ideas and techniques. The resulting modifications and extensions for the case of surface-on- surface and volumetric data are presented, discussed and compared. This includes some interactive techniques, isosurface algorithms, volume rendering and the new hypersurface projection graph.

Interrogation methods for multivariate data are now just beginning to be developed. Gaussian curvature has proven to be a useful tool for surface interrogation. This concept is extended to case of volume domains and examples are presented. It is shown how vector field visualization can be used to interrogate volumetric relationships and a survey of these methods is presented.

Fluid Flow Visualization

Frits Post
Department of Technical Informatics
Delft University of Technology, The Netherlands

The demand for new visualization techniques for 3D fluid flow has recently increased due to developments in computational fluid dynamics, leading to large scale 3D numerical simulations. Our research focuses on new techniques to present an intuitive, global impression of 3D flow patterns. As an example, surface particle animation was developed, a combination of particle tracing and shaded surface rendering. Spatial information is transferred by directional lighting, showing the flow pattern as a moving textured surface consisting of many particles. The surface particles are points with an associated surface normal and object colour to allow the use of a light reflection model. Collectively, the particles behave as moving reflective surface, deformed by the flow field. Cyclic animation using pre-computed frames very clearly demonstrates the reflection and deformation effects. Other cues to enhance depth perception were added: shadows and distance attenuation. Various types of particle sources are available giving different visual effects.

Current developments include visualization of turbulent flow, development of new visual primitives, and extraction of important sub-patterns (such as eddies) from the flow field. Also, an integrated hybrid rendering system is being developed, allowing simultaneous animated display of several types of data: particles, volume and surface data.

Visualization of 3-manifolds in 4-space

Alfred Schmidt
Universität Freiburg, Germany

Out of FE-like numerical simulations of curvature-dependent motion of 3-manifolds in $\mathbb{R}^4$ we get the following data for each discrete time step,

- a FE-discretized 3-manifold, built for example out of tetrahedra,
- FE-type data on the manifold of various type: scalar (e.g. mean or gaussian curvature), vector fields, and tensor-valued (metric, second fundamental form, Ricci tensor).

The 3-manifold can be visualized using two methods, both of which should be used with multiple simultaneous views and/or animation,

- Using a projection onto a 3D-hyperplane, we get a 3D volume that can be displayed using volume visualization techniques. Care should be taken since the projection is not injective, so different 4D points project to the same 3D point, and data is not uni-valued. So projection is not well suited to display a manifold with data.
- Use a hyperplane in 4-space and display the intersection with the manifold (usually a 2-manifold) as a surface in 3D, using the local coordinates of the hypersphere. This intersection operation is injective, so no problems with data display arises.

Scalar and vector valued data can be displayed using the usual techniques, like isolines, colormaps, and arrows. Visualization of tensor-valued data (here: 3×3 motions) is an open problem. Tests have been made with the display of indicatrices of a tensor T, i.e. the "unit sphere" of the induced metric $|v| = (v^t T v)^{1/2}$. This works for symmetric positively definite tensor fields. Another possibility is to display unit spheres transformed by the tensor, i.e. all Tv for $v \in S^2$. But for general tensors, both methods are not satisfactory. So a new or improved method is required.

X-ray Tracing and Possible Applications

Alfred Schmitt
Universität Karlsruhe, Germany

We discuss the following problem. Given a complex 3D scene, numerous solid parts and lot of details. Improve and generalize the basic ray tracing algorithm in such a way that visible and covered details can be percepted, and that the 3D configuration of the different details, holes, etc. is correctly interpreted by the human eye. One possible answer can be the X-ray tracing procedure. Instead of tracking recursively the rays of reflection and refraction the X-ray is a straight line intersecting all objects, normally surfaces, of the 3D scene. The colour of the respective pixel is calculated by function (algorithm) using all parameters and information available along the X-ray. In addition some preprocessed context information is used, e.g. enhanced contours. Several effects can be realized: fog, camera lens blur, contour and corner enhancement, generation of X-ray pictures and so on. It is planned to define and specify such an X ray tracing software in the near future.

Correlative Data Analysis using Visualization

Lloyd Treinish
IBM T.J. Watson Research Center, USA

Many scientific disciplines involve the study of multiple sources of disparate data, be they observational or computational in origin. The structure of these data may be point or sparse, uniformly or irregularly meshed, in rectilinear or curvilinear coordinates, etc. For example, in the earth and space sciences it is very common to look at measurements from multiple instruments, some operating in situ while others are remote sensors. These data each tell some aspect of a physical phenomenon of interest, and may be combined with empirical models or numerical simulations. If visualization is to be effective in the interpretation of such multi-parameter data sets then systems need to uniformly support (i.e., provide access to and services on) data of disparate structure while preserving fidelity, and provide mechanisms for data registration in space and time. Correlative data analysis implies the ability to look at different data in the same way, yet be able to apply multiple methods. The challenge for builders of systems is to support the knowledgeable scientist who is not an expert at visualization – to know what techniques work with what kind of data under what circumstances. In the earth sciences, for example, geographic registration of multiple data sets using similar cartographic warping of the underlying data structures shows promise as an alternative to interpolating the original grids of each data set to a common grid in projected space. Such an approach can preserve the fidelity of the data and appear applicable to a number of visualization primitives, yet is generally unknown to earth scientists. Hence, this situation crys out for the development of a taxonomy of different types of data and the heuristics associated with how they should (or should not) be mapped to a taxonomy of visualization primitives and associated transformation techniques.

Addresses

R. Daniel **Bergeron**
Department of Computer Science
Kingsbury Hall
University of New Hampshire
Durham, NH 03824
USA
`rdb@cs.unh.edu`

William R. **Feeney**
Information and Decision Systems
College of Business Administration
San Diego State University
San Diego, CA 92182-0127
USA

Martin **Frühauf**
Fraunhofer-Arbeitsgruppe
Graphische Datenverarbeitung
Wilhelminenstr. 7
6100 Darmstadt
`fruehauf@agd.fhg.de`

Bernhard **Geiger**
Projet Prisme
INRIA
Sophia Antipolis
2004 Route de Lucioles
B.P. 109
06565 Valbonne, Cedex
France
`geiger@sophia.inria.fr`

Michael **Gervautz**
Institut für Computergraphik
Technische Universität Wien
Karlsplatz 13 / 180 A
A -1040 Wien
Österreich
`GERVAUTZ@EIGVS4.una.at.as`

Bernd **Girod**
KHM Köln
Abt. Computergraphik/Computeranimation
Peter-Welter-Platz 2
5000 Köln 1
`bernd@khm.uni-koeln.de`

Martin **Göbel**
Fraunhofer-Arbeitsgruppe
Graphische Datenverarbeitung
Wilhelminenstr. 7
6100 Darmstadt
`goebel@agd.fhg.de`

Michel **Grave**
ONERA DMI/CC
B.P. 72 F-92322 Chatillon Cedex
France
`grave@bora.inria.fr`

Thomas **Griesbaum**
Institut für Betriebs-
und Dialogsysteme
Universität Karlsruhe
Postfach 6980
7500 Karlsruhe
`griesbaum@ira.uka.de`

Georges G. **Grinstein**
Graphics Research Laboratory
Department of Computer Science
University of Massachusetts at Lowell
Lowell, MA 01854
USA
`grinstein@cs.ulowell.edu`

Vladimir G. **Grishin**
Institute of Control Sciences
ul. Profsojuznaja, 65
Moscow, 117806
USSR

Hans **Hagen**
Fachbereich Informatik
Universität Kaiserslautern
Postfach 3049
6750 Kaiserslautern
`hagen@informatik.uni-kl.de`

Pat **Hanrahan**
Department of Computer Science
Computer Science Building
35 Olden Street

Princeton University
Princeton, NJ 08544-2087
USA
`hanrahan@princeton.edu`

Karl-Heinz **Höhne**
Institut für Mathematik und Datenverarbeitung in der Medizin
Universität Hamburg
Martinistraße 52
2000 Hamburg 20
`hoehne@imdm.uke.uni-hamburg.dbp.de`

Philip **Jacob**
Fachbereich Informatik
Universität Kaiserslautern
Postfach 3049
6750 Kaiserslautern
`jacob@informatik.uni-kl.de`

Arie **Kaufman**
Computer Science Department
SUNY at Stonybrook
Stonybrook, NY 11794-4400
USA

Fred **Kitson**
Hewlett Packard Labs
1501 Page Mill Road
Building 3U
P.O. Box 10490
Palo Alto, CA 94303-0969
USA
`kitson@hplabs.hp.com`

Stanislav **Klimenko**
Institute of High Energy Physics
P.O. 142284, Protvino
Serpukhov Moscow Region
USSR
`klimenko@m9.ihep.su`

Wolfgang **Krüger**
GMD-Z1.HR
Supercomputer Center
Postfach 1280
5205 Sankt Augustin
`krueger@gmdzi.gmd.de`

Ulrich **Lang**
Rechenzentrum der
Universität Stuttgart
Allmandring 30
7000 Stuttgart 80
`ulang@rus.uni-stuttgart.de`

Rolf van **Lengen**
Fachbereich Informatik
Universität Kaiserslautern
Postfach 3049
6750 Kaiserslautern
`lengen@informatik.uni-kl.de`

Creon **Levit**
MS T 045-1
NASA Ames Research Center
Moffet Field, CA 94035
USA
`creon@nas.nasa.gov`

Nelson **Max**
L-301
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550
USA `max2@llnl.gov`

Heinrich **Müller**
Institut für Informatik
Rheinstr. 10
Universität Freiburg
7800 Freiburg
`mueller@informatik.uni-freiburg.de`

Stephan **Neunreither**
GMD-FIRST
Hardenbergplatz 2
1000 Berlin 12

Gregory M. **Nielson**
Computer Science Department
Arizona State University
Tempe, AZ 85287
USA
`nielson@enuxva.eas.asu.edu`

Theo **Plesser**
Max-Planck-Institut für
Ernährungsphysiologie
Rheinlanddamm 201
4600 Dortmund 1
`plesser@mpi-dortmund.mpg.dbp.de`

Frits **Post**
Delft University of Technology
Faculty of Technical Mathematics
and Informatics
P.O. Box 356
2600 AJ Delft
Netherlands
`frits@duticg.tudelft.nl`

Alfred **Schmidt**
Institut für Angewandte Mathematik
Universität Freiburg
Hermann-Herder-Straße 10
7800 Freiburg
`alfred@titan.mathematik.uni-freiburg.de`

Alfred **Schmitt**
Institut für Betriebs-
und Dialogsysteme
Universität Karlsruhe
Postfach 6980
7500 Karlsruhe
`aschmitt@ira.uka.de`

Thomas **Schreiber**
Fachbereich Informatik
Universität Kaiserslautern
Postfach 3049
6750 Kaiserslautern
`schreib@informatik.uni-kl.de`

Heidrun **Schumann**
Universität Rostock
Fachbereich Informatik
Albert-Einstein-Straße 21
O-2500 Rostock

Werner **Stuetzle**
Department of Statistics, GN-22
University of Washington
Seattle, Washington 98195
USA

Lloyd A. **Treinish**
SK-Y57
IBM Corporation
Thomas J. Watson Research Center
P.O. Box 704
Yorktown Heights, NY 10598
USA
`lloydt@watson-ibm.com`

Jane **Wilhelms**
Dept. of Computer and
Information Sciences
University of California
Santa Cruz, CA 95064
USA
`wilhelms@cs.ucsc.edu`

Bisher erschienene und geplante Titel:

W. Gentzsch, W.J. Paul (editors):
Architecture and Performance, Dagstuhl-Seminar-Report; 1, 18.-20.6.1990; (9025)

K. Harbusch, W. Wahlster (editors):
Tree Adjoining Grammars, 1st. International Worshop on TAGs: Formal Theory and Application, Dagstuhl-Seminar-Report; 2, 15.-17.8.1990 (9033)

Ch. Hankin, R. Wilhelm (editors):
Functional Languages: Optimization for Parallelism, Dagstuhl-Seminar-Report; 3, 3.-7.9.1990 (9036)

H. Alt, E. Welzl (editors):
Algorithmic Geometry, Dagstuhl-Seminar-Report; 4, 8.-12.10.1990 (9041)

J. Berstel , J.E. Pin, W. Thomas (editors):
Automata Theory and Applications in Logic and Complexity, Dagstuhl-Seminar-Report; 5, 14.-18.1.1991 (9103)

B. Becker, Ch. Meinel (editors):
Entwerfen, Prüfen, Testen, Dagstuhl-Seminar-Report; 6, 18.-22.2.1991 (9108)

J. P. Finance, S. Jähnichen, J. Loeckx, M. Wirsing (editors):
Logical Theory for Program Construction, Dagstuhl-Seminar-Report; 7, 25.2.-1.3.1991 (9109)

E. W. Mayr, F. Meyer auf der Heide (editors):
Parallel and Distributed Algorithms, Dagstuhl-Seminar-Report; 8, 4.-8.3.1991 (9110)

M. Broy, P. Deussen, E.-R. Olderog, W.P. de Roever (editors):
Concurrent Systems: Semantics, Specification, and Synthesis, Dagstuhl-Seminar-Report; 9, 11.-15.3.1991 (9111)

K. Apt, K. Indermark, M. Rodriguez-Artalejo (editors):
Integration of Functional and Logic Programming, Dagstuhl-Seminar-Report; 10, 18.-22.3.1991 (9112)

E. Novak, J. Traub, H. Wozniakowski (editors):
Algorithms and Complexity for Continuous Problems, Dagstuhl-Seminar-Report; 11, 15-19.4.1991 (9116)

B. Nebel, C. Peltason, K. v. Luck (editors):
Terminological Logics, Dagstuhl-Seminar-Report; 12, 6.5.-18.5.1991 (9119)

R. Giegerich, S. Graham (editors):
Code Generation - Concepts, Tools, Techniques, Dagstuhl-Seminar-Report; 13, 20.-24.5.1991 (9121)

M. Karpinski, M. Luby, U. Vazirani (editors):
Randomized Algorithms, Dagstuhl-Seminar-Report; 14, 10.-14.6.1991 (9124)

J. Ch. Freytag, D. Maier, G. Vossen (editors):
Query Processing in Object-Oriented, Complex-Object and Nested Relation Databases, Dagstuhl-Seminar-Report; 15, 17.-21.6.1991 (9125)

M. Droste, Y. Gurevich (editors):
Semantics of Programming Languages and Model Theory, Dagstuhl-Seminar-Report; 16, 24.-28.6.1991 (9126)

G. Farin, H. Hagen, H. Noltemeier (editors):
Geometric Modelling, Dagstuhl-Seminar-Report; 17, 1.-5.7.1991 (9127)

A. Karshmer, J. Nehmer (editors):
Operating Systems of the 1990s, Dagstuhl-Seminar-Report; 18, 8.-12.7.1991 (9128)

H. Hagen, H. Müller, G.M. Nielson (editors):
Scientific Visualization, Dagstuhl-Seminar-Report; 19, 26.8.-30.8.91 (9135)

T. Lengauer, R. Möhring, B. Preas (editors):
Theory and Practice of Physical Design of VLSI Systems, Dagstuhl-Seminar-Report; 20, 2.9.-6.9.91 (9136)

F. Bancilhon, P. Lockemann, D. Tsichritzis (editors):
Directions of Future Database Research, Dagstuhl-Seminar-Report; 21, 9.9.-13.9.91 (9137)

H. Alt , B. Chazelle, E. Welzl (editors):
Computational Geometry, Dagstuhl-Seminar-Report; 22, 07.10.-11.10.91 (9141)

F.J. Brandenburg , J. Berstel, D. Wotschke (editors):
Trends and Applications in Formal Language Theory, Dagstuhl-Seminar-Report; 23,14.10.-18.10.91 (9142)

H. Comon , H. Ganzinger, C. Kirchner, H. Kirchner, J.-L. Lassez , G. Smolka (editors):
Theorem Proving and Logic Programming with Constraints, Dagstuhl-Seminar-Report; 24, 21.10.-25.10.91 (9143)

H. Noltemeier, T. Ottmann, D. Wood (editors):
Data Structures, Dagstuhl-Seminar-Report; 25, 4.11.-8.11.91 (9145)

A. Borodin, A. Dress, M. Karpinski (editors):
Efficient Interpolation Algorithms, Dagstuhl-Seminar-Report; 26, 2.-6.12.91 (9149)

B. Buchberger, J. Davenport, F. Schwarz (editors):
Algorithms of Computeralgebra, Dagstuhl-Seminar-Report; 27, 16..-20.12.91 (9151)