

Advances in Scientific Visualization

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Abstract

This paper discusses scientific visualization of scalar and vector fields, particularly relating to clouds and climate modeling. One cloud rendering method applies a 3-D texture to cloudiness contour surfaces, to simulate a view from outer space. The texture is advected by the wind flow, so that it follows the cloud motion. Another technique simulates multiple scattering of incident light from the sun and sky. This paper also presents a simulation of the microscopic cross-bridge motion which powers muscle contraction. It was rendered by ray-tracing contour surfaces of summed gaussian ellipsoids approximating the actin and myosin protein shapes.

Key Words: scientific visualization, scalar fields, vector fields, flow visualization, muscle, cross-bridge, contour surface.

Climate Visualization

Climate simulations calculate several 3D scalar variables like temperature, humidity, and cloudiness at millions of spatial/temporal sample points. In order to make sense of this massive amount of data, it is useful to produce time-varying computer animated renderings. At Lawrence Livermore National Laboratory, we have concentrated on visualizing cloudiness, a scalar quantity, in conjunction with wind velocity, a vector quantity [1]. As we discuss the rendering techniques for scalar fields below, we will write in terms of cloudiness, but they are equally applicable to any other 3D data. However, our flow visualization techniques are more appropriate to velocity fields than to other vector fields, since they use motion along the flow direction.

We used global climate data output by the Cray 2 for every hour in a 10 day simulation for the beginning of January, using an algorithm from the European Center for Medium Range Weather Forecasting. The data is given on a curvilinear 320x160x19 longitude/latitude/altitude grid. This grid is not in simple spherical coordinates, because the lowest altitude level bends to follow the height of the terrain, and the higher levels also bend to accommodate.

The grid spacing is larger than one degree on a side, so the model cannot represent individual clouds. Instead, the cloudiness variable represents the fraction of the sky that is covered by clouds at the level of the altitude coordinate. Cloudiness is a scalar field, so standard volume rendering techniques can be used. These include contour surfaces, as in figure 1, and direct volume rendering, as in figure 2.

Contour surfaces are built from polygons, and can take advantage of polygon rendering hardware. For figure 1, we divided the hexahedral volume cells defined by 8 sample vertices up into 5 tetrahedra, and interpolated the cloudiness function linearly across each tetrahedron. If a contour surface of the linearly interpolated function intersects a tetrahedron, it does so in a planar triangle or quadrilateral.

To produce figure 2, we used a different interpolation scheme across the cell bounded by the 8 sample points. We interpolated the cloudiness linearly along the projections of the edges, and then linearly across horizontal scan lines to get the value at each pixel center on the projection of each boundary face. Each viewing ray intersects the cell in a segment between two boundary face pixel center positions, so we can linearly interpolate these values across the segment. Such a scheme defines a piecewise trilinear interpolation over any convex polyhedral cell [3]. The shapes of the pieces depend on the cell orientation and projection direction, so the interpolation is not invariant under rotation. (A similar problem occurs with the piecewise bilinear interpolation used with Gouraud shading.) However, this method allows the faces to be scan converted coherently, which increases efficiency, as does treating the cell as a whole instead of dividing it up into tetrahedra.

Advances In Scientific Visualization

Theodore Simos, George Maroulis



Advances In Scientific Visualization:

Advances in Scientific Visualization Frits H. Post, Andrea J.S. Hin, 2012-12-06 Scientific visualization is a new and rapidly growing area in which efforts from computer graphics research and many scientific and engineering disciplines are integrated Its aim is to enhance interpretation and understanding by scientists of large amounts of data from measurements or complex computer simulations using computer generated images and animation sequences It exploits the power of human visual perception to identify trends and structures and recognize shapes and patterns Development of new numerical simulation methods in many areas increasingly depends on visualization as an effective way to obtain an intuitive understanding of a problem This book contains a selection of papers presented at the second Eurographics workshop on Visualization in Scientific Computing held in Delft the Netherlands in April 1991 The issues addressed are visualization tool and system design new presentation techniques for volume data and vector fields and numerous case studies in scientific visualization Application areas include geology medicine fluid dynamics molecular science and environmental protection The book will interest researchers and students in computer graphics and scientists from many disciplines interested in recent results in visual data analysis and presentation It reflects the state of the art in visualization research and shows a wide variety of experimental systems and imaginative applications *Scientific Visualization* Lawrence J. Rosenblum, 1994 Numerical simulations of global warming Mars observation data and aircraft design are but a few of the topics where the use of human visual perception for data understanding are considered essential Ten years ago a handful of pioneers professed the value of visualization to skeptical audiences Today with supercomputers and sensors producing ever increasing amounts of data scientific visualization is accepted throughout much of science and engineering as the fundamental tool for data analysis Written by a world wide panel of visualization experts *Scientific Visualization Advances and Challenges* presents astute coverage of prevailing trends issues and practice of scientific visualization From algorithmic topics such as volume graphics and the modeling and visualization of large data sets to foundations perception and interface technology including virtual reality this book provides the latest advances in the area The book demonstrates new techniques examines diverse application areas and discusses current limitations and upcoming requirements *Scientific Visualization Advances and Challenges* presents readers with a unique opportunity to examine expert thinking and current practice and to obtain a vision of potential future directions It will be essential reading for scientific and engineering practitioners and visualization researchers alike Offers extremely topical and timely coverage of a rapidly evolving area Includes contributions from an international panel of visualization experts in one accessible volume Provides scientific and engineering practitioners as well as visualization researchers with an essential guide to the literature **Advances in Visualization and Optimization Techniques for Multidisciplinary Research** Dean Vucinic, Fabiana Rodrigues Leta, Sheeja Janardhanan, 2019-09-27 This volume presents several multidisciplinary approaches to the visual representation of data acquired from experiments As an

expansion of these approaches it is also possible to include data examination generated by mathematical physical modeling Imaging Systems encompass any subject related to digital images from fundamental requirements for a correct image acquisition to computational algorithms that make it possible to obtain relevant information for image analysis In this context the book presents selected contributions of a special session at the Conference on Advanced Computational Engineering and Experimenting ACE X 2016

Scientific Visualization Patrizia Palamidese,1993 Illustrating recent developments in the software design and graphics techniques used to visualize scientific concepts this study takes a broad view examining visualization architectures development methods and tools and visualization techniques and algorithms

A Concise Introduction to Scientific Visualization Brad Eric Hollister,Alex Pang,2022-01-01 Scientific visualization has always been an integral part of discovery starting first with simplified drawings of the pre Enlightenment and progressing to present day Mathematical formalism often supersedes visual methods but their use is at the core of the mental process As historical examples a spatial description of flow led to electromagnetic theory and without visualization of crystals structural chemistry would not exist With the advent of computer graphics technology visualization has become a driving force in modern computing A Concise Introduction to Scientific Visualization Past Present and Future serves as a primer to visualization without assuming prior knowledge It discusses both the history of visualization in scientific endeavour and how scientific visualization is currently shaping the progress of science as a multi disciplinary domain

Advances in Computational Methods in Sciences and Engineering 2005 (2 vols) Theodore Simos,George Maroulis,2022-05-04 This volume brings together selected contributed papers presented at the International Conference of Computational Methods in Science and Engineering ICCMSE 2005 held in Greece 21 aEURO 26 October 2005 The conference aims to bring together computational scientists from several disciplines in order to share methods and ideas The ICCMSE is unique in its kind It regroups original contributions from all fields of the traditional Sciences Mathematics Physics Chemistry Biology Medicine and all branches of Engineering It would be perhaps more appropriate to define the ICCMSE as a conference on computational science and its applications to science and engineering Topics of general interest are Computational Mathematics Theoretical Physics and Theoretical Chemistry Computational Engineering and Mechanics Computational Biology and Medicine Computational Geosciences and Meteorology Computational Economics and Finance Scientific Computation High Performance Computing Parallel and Distributed Computing Visualization Problem Solving Environments Numerical Algorithms Modelling and Simulation of Complex System Web based Simulation and Computing Grid based Simulation and Computing Fuzzy Logic Hybrid Computational Methods Data Mining Information Retrieval and Virtual Reality Reliable Computing Image Processing Computational Science and Education etc More than 800 extended abstracts have been submitted for consideration for presentation in ICCMSE 2005 From these 500 have been selected after international peer review by at least two independent reviewers

Scientific Visualization of Physical Phenomena Nicholas M. Patrikalakis,2012-12-06 Scientific Visualization of

Physical Phenomena reflects the special emphasis of the Computer Graphics Society's Ninth International Conference held at the MIT in Cambridge Massachusetts USA in June 1991. This volume contains the proceedings of the conference which since its foundation in 1983 continues to attract high quality research articles in all aspects of Computer Graphics and its applications. Visualization in science and engineering is rapidly developing into a vital area because of its potential for significantly contributing to the understanding of physical processes and the design automation of man made systems. With the increasing emphasis in handling complicated physical and artificial processes and systems and with continuing advances in specialized graphics hardware and processing software and algorithms visualization is expected to play an increasingly dominant role in the foreseeable future.

Scientific Visualization Gregory M. Nielson, Hans Hagen, Heinrich Müller, 1997. Scientific Visualization presents the state of the art in scientific visualization techniques both as an overview for the inquiring scientist and as a basic foundation for developers. The three sections present an overview, explain frameworks and methodologies and present techniques and algorithms. Extensive bibliographies are included.

Argonne Computing Newsletter, 1990-07. **Progress in Scientific Visualization**, 2004. Visualization of observed data or simulation output is important to science and engineering. I have been particularly interested in visualizing 3D structures and report here my personal impressions on progress in the last 20 years in visualizing molecules, scalar fields and vector fields and their associated flows. I have tried to keep the survey and list of references manageable so apologize to those authors whose techniques I have not mentioned or have described without a reference citation.

Advances in Computer Graphics, 1991. **Visualization in Scientific Computing '98** Dirk Bartz, 1998-07-28. In twelve selected papers common problems in scientific visualization are discussed: adaptive and multi-resolution methods, feature extraction, flow visualization and visualization quality. Four papers focus on aspects of mesh reduction, mesh compression and increasing the quality of the resulting mesh. Two extensions on particle tracing are presented as well as a paper on the simulation of material transport. Two papers are on feature extraction in dynamics systems and on the accuracy of algorithmic extracted features. Three papers focus on stereoscopic volume rendering on the visualization of atomic collision cascades and of quality of visualization systems in general.

Applied Parallel Computing: Advanced Scientific Computing Juha Fagerholm, Juha Haataja, Jari Järvinen, Mikko Lyly, Peter Raback, Ville Savolainen, 2003-08-03. This book constitutes the refereed proceedings of the 6th International Conference on Applied Parallel Computing PARA 2002 held in Espoo, Finland in June 2002. The 50 revised full papers presented together with nine keynote lectures were carefully reviewed and selected for inclusion in the proceedings. The papers are organized in topical sections on data mining and knowledge discovery, parallel program development, practical experience in parallel computing, computer science, numerical algorithms with hierarchical memory optimization, numerical methods and algorithms, cluster computing, grid and network technologies and physics and applications.

Advances in Computer Graphics Gerald Garcia, Ivan Herman, 1991-06-06. This book is a collection of several tutorials from the

EUROGRAPHICS 90 conference in Montreux The conference was held under the motto IMAGES Synthesis Analysis and Interaction and the tutorials partly presented in this volume reflect the conference theme As such this volume provides a unique collection of advanced texts on traditional computer graphics as well as of tutorials on image processing and image reconstruction As with all the volumes of the series Advances in Computer Graphics the contributors are leading experts in their respective fields The chapter Design and Display of Solid Models provides an extended introduction to interactive graphics techniques for design fast display and high quality rendering of solid models The text focuses on techniques for Constructive Solid Geometry CSG The following topics are treated in depth interactive design techniques specification of curves surfaces and solids graphical user interfaces procedural languages and direct manipulation and display techniques depth buffer scan line and ray tracing techniques CSG classification techniques efficiency improving methods software and hardware implementations

Advances in Bioengineering ,1998 *Scientific Visualization of Physical Phenomena* Nicholas M Patrikalakis,1991-07-25

Proceedings of the Workshop on Advanced Visual Interfaces Tiziana Catarci,1994

Computer Visualization Richard S. Gallagher,Solomon Press,2019-10-17 Rapid advances in 3 D scientific visualization have made a major impact on the display of behavior The use of 3 D has become a key component of both academic research and commercial product development in the field of engineering design Computer Visualization presents a unified collection of computer graphics techniques for the scientific visualization of behavior The book combines a basic overview of the fundamentals of computer graphics with a practitioner oriented review of the latest 3 D graphics display and visualization techniques Each chapter is written by well known experts in the field The first section reviews how computer graphics visualization techniques have evolved to work with digital numerical analysis methods The fundamentals of computer graphics that apply to the visualization of analysis data are also introduced The second section presents a detailed discussion of the algorithms and techniques used to visualize behavior in 3 D as static interactive or animated imagery It discusses the mathematics of engineering data for visualization as well as providing the current methods used for the display of scalar vector and tensor fields It also examines the more general issues of visualizing a continuum volume field and animating the dimensions of time and motion in a state of behavior The final section focuses on production visualization capabilities including the practical computational aspects of visualization such as user interfaces database architecture and interaction with a model The book concludes with an outline of successful practical applications of visualization and future trends in scientific visualization

Course Notes ,1994

Proceedings of the International Conference on Web-Based Modeling and Simulation Philip A. Wilsey,2000

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