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Interactive Visualization and Web-Based Exploration in the Physical and Natural Sciences

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course notes

ACM SIGGRAPH 98 Course #35

**Interactive Visualization & Web-Based
Exploration
in the Physical and Natural Sciences**

Course Organizer:

**Theresa Marie Rhyne
Lockheed Martin Services Group
U.S. EPA Scientific Visualization Center**

Instructors:

**Mike Botts
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**Bill Hibbard
University of Wisconsin at Madison**

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Abstract: This course examines the convergence of visualization methods with the World Wide Web as well as the relationship between real-time interactivity and scientific information exploration. The application of visualization tools and interactive techniques to the examination and interpretation of scientific data sets is also discussed. Highly illustrative atmospheric, oceanographic and geographic examples are demonstrated in real time. The process of developing effective visualization paradigms for supporting high speed networking, database management, heterogeneous computing platforms, user interface design, collaborative computing, science education and the implementation of animation techniques are also highlighted.

ACM SIGGRAPH 98 Course #35 Notes

Interactive Visualization & Web-Based Exploration in the Physical and Natural Sciences

Introduction

The visual presentation of large amounts of scientific information and data often requires the merging of image processing methods with computer-generated color displays. The exploration of complex physical and natural sciences data sets involves the application of interactive computer graphics tools and techniques. Visualization tools are just one component of an integrated decision support system for Scientists, educators, and the general public.

In this course, we highlight the convergence of visualization environments with the World Wide Web, multi-media tools for desktop videoconferencing, statistical and plotting functions, computer algorithm exploration, perceptual thinking and computer animation techniques. The visual display criteria for research, policy analysis, decision making and science education are not necessarily the same. Therefore, visualization tools need to be flexible in their design to support these different viewpoints and

interpretations of data.

Additional issues for consideration include:

- a) the integration of terabyte or gigabyte distributed scientific databases and digital libraries with visualization systems ;
- b) the display and interpretation of data and information using statistical analyses, cartography, computer aided design (CAD) and geographic information systems (GIS) techniques in conjunction with visualization systems;
- c) the design of visualization tools, user interfaces, and animations that support the specific needs of scientists, policy analysts, regulators, educators and the general public;
- d) the development of collaborative computing tools that allow the integration of multi-disciplinary data and information (e.g. atmospheric, oceanographic, and geographic) into visualization systems to foster cross-disciplinary exploration and communications.

This full day tutorial will address these issues with illustrative examples of visualization software and animations designed to support the examination of large scientific data sets and information archives. We will specifically highlight the impact the Web and the Internet are having on interactive and collaborative visualization. Each of us have prepared a visualization demonstration based on our own customized software tools which will (hopefully) be executed (in real time) on a workstation during the tutorial.

We have divided these course notes into four sections and have included the demonstration discussions (case studies) at the end. During the delivery of the course, each section presented will be followed by a case study demonstration. To clarify this matter, we have included both a Table of Contents for the Course Notes and an Outline of the Presentation of the Course.

We hope that you enjoy attending this tutorial and that these notes are insightful to you.

Theresa Marie Rhyne, Bill Hibbard, Lloyd Treinish, and Mike Botts

Table of Contents for the Course (#35) Notes

I. Scientific Data Models for Interactive and Distributed Visualization

II. Applications of Data Management to the Design of Effective Interactive and Web-Based Visualizations

III. Collaborative Computing and Integrated Decision Support Tools for Scientific Visualization

IV. Methods for Interactive Visualization and Comparative Analysis of Large, Multisource Data Sets

Case Study #1: Collaborative Geographic Visualization

Case Study #2: Tools for Interactive Exploration & Visualization of Dynamic Spatial Data

Case Study #3: Correlative Visualization Techniques for Disparate Data

Case Study #4: Interactively Visualizing and Steering Computations

ACM SIGGRAPH 98 Course (#35) Outline:

Interactive Visualization and Web-based Exploration in the Physical and Natural Sciences

Introduction/ Course Organization Remarks: Rhyne - 5 minutes

Topic #1: Scientific Data Models for Interactive and Distributed Visualization (Bill Hibbard - 45 minutes)

Case Study #1: (30 minutes) Collaborative Geographic Visualization - Rhyne (AVS, WWW & VRML demonstrations for examining geographic data like digital elevation models.)

Morning Break

Topic #2: Applications of Data Management to the Design of Effective Interactive and Web-Based Visualizations (Lloyd Treinish - 45 minutes)

Case Study #2: (30 minutes)

**Tools for Interactive Exploration and Visualization of Dynamic Spatial Data - Botts
(Two toolkits will be shown - the Observations Dynamics Model and the Space-Time Toolkit)**

Lunch

Topic #3: Collaborative Computing and Integrated Decision Support Tools for Scientific Visualization (Theresa Marie Rhyne - 45 minutes)

Case Study #3: (30 minutes)

**Correlative Visualization Techniques for Disparate Data - Treinish
(IBM Data Explorer based demonstrations that apply interactive and web based visualization techniques to earth and space sciences applications)**

Afternoon Break

Topic #4: Methods for Interactive Visualization and Comparative Analysis of Large, Multisource Data Sets (Mike Botts - 45 minutes)

Case Study #4: (30 minutes)

**Interactively Visualizing and Steering Computations - Hibbard
(Vis5D and/or VisAD demonstration(s) for examining atmospheric and oceanographic models and datasets.)**

Wrap-Up Discussion: (All Instructors) (10 minutes)

Speakers' Biographical Information:

Mike Botts: University of Alabama in Huntsville

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Mike Botts is a Principal Research Scientist in the Earth System Science Laboratory at the University of

Alabama in Huntsville. In 1992, he served on temporary assignment, at NASA Headquarters, to evaluate the state of scientific visualization for NASA's EOS Mission. Botts' report, entitled "The State of Scientific Visualization with Regard to the NASA EOS Mission to Planet Earth", established many of the guidelines for visualization requirements for NASA EOS. He is presently Principal Investigator on several research and development grants for NASA, EPA, and NRL-Monterey, involving the challenge of interactive visual integration of multisource data sets which are disparate with regard to native spatial and temporal domains. These efforts all involve development of cross-platform and web-based applications, using a combination of Java, C++, Open-GL, and VRML. Dr. Botts is also currently looking into new Web-based methods for describing spatial and temporal domains of data and is chair of the international CEOS Task Team for Global Mapping.

Bill Hibbard: University of Wisconsin at Madison

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Bill Hibbard is a scientist at the University of Wisconsin-Madison and the principal author of the 4-D McIDAS system, Vis5D and VisAD. The 4-D McIDAS system, begun in 1984, is an early effort to apply three-dimensional animated graphics to earth science data. The Vis5D system extended this in 1988 to interactive 3-D animations of numerical weather simulations, using high-performance graphics workstations. The VisAD system provides interactive steering and visualization of general scientific computations. The Vis5D and VisAD systems are freely available over the Internet. Vis5D is used as a medium for distributing 3-D environmental simulations over the Web. Dr. Hibbard is currently rewriting VisAD in Java, in order to support distributed computation and visualization over the Web.

Lloyd Treinish: IBM T.J. Watson Center

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Lloyd A. Treinish is a research staff member in the Visualization Solutions group at the IBM Thomas J. Watson Research Center in Yorktown Heights, NY. He works on techniques, architectures and applications of data visualization and methods of data management for a wide variety of disciplines. This includes a focus on earth, environmental and space sciences. His research interests range from visualization systems, data models, and perceptual rule-based tools to study of atmospheric and space

physics phenomena, and cartography. This work involves the development and application of IBM Visualization Data Explorer, and the implementation of interactive tools for correlative visualization of data from diverse sources. Recently, these efforts have expanded to include WWW- based access and dissemination of data and visualizations for both research and operational utilization.

Theresa Marie Rhyne: Lockheed Martin/ U.S. EPA Visualization Ctr.

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Theresa Marie Rhyne is responsible for the research and development activities at the United States Environmental Protection Agency's Scientific Visualization Center and is employed by Lockheed Martin Technical Services. She has organized courses and panels for previous IEEE Visualization and ACM SIGGRAPH conferences. Her research interests included visualization toolkit development, collaborative computing in a networked environment, and the integration of geographic information systems with scientific visualization methods. Working with geographers, Theresa-Marie has recently expanded her geographic visualization efforts to address Web, Java and VRML applications. She is also a director-at-large on ACM SIGGRAPH's Executive Committee and the project director of SIGGRAPH's Carto Project, an effort to explore cartographic visualization. Theresa-Marie is also an accomplished artist and art educator in computer graphics. She authored the "Portrait of a Computer Artist" discussion which appears in the 1991 edition of the ACM SIGGRAPH Computer Graphics Career Handbook.