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COURSE NOTES C7

INTRODUCTION TO VOLUME VISUALIZATION

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Wolfgang Kreuger
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COURSE ABSTRACT

The last five years have seen a revolution in techniques for visualizing volume data. This course was organized to provide an overview of these new techniques to attendees of ACM SIGGRAPH '91. The emphasis of the course is on algorithms and their relationship to theory, not on applications, and the format of these notes is designed to facilitate comparisons between techniques.

The first paper in the notes presents a taxonomy of volume visualization algorithms, briefly summarizing the advantages and disadvantages of each approach. The remainder of the notes is divided by topic (rather than by speaker) into four sessions, as follows:

Session I: polygonalization of volume data. The focus of this session is on techniques for converting volume data into polygons for display on conventional graphics workstations. This approach is sometimes referred to as surface-based volume visualization. The speaker is Bill Lorensen, author of Marching Cubes and Dividing Cubes, two of the dominant algorithms in this area.

Session II: semi-transparent volume rendering - resampling. The focus of sessions II and III is on so-called direct volume rendering, a family of techniques that approximate the appearance of semi-transparent clouds or gels. Following an introduction to sampling theory (Pat Hanrahan), authors of three semi-transparent volume rendering algorithms describe their approaches to handling volume resampling. These are multi-pass warping (Pat Hanrahan), ray tracing (Marc Levoy), and splatting (Lee Westover).

Session III: semi-transparent volume rendering - shading. Following an introduction to light transport theory (Wolfgang Kreuger), two of the authors listed for session II describe their shading and projection algorithms and how these algorithms approximate light transport. Topics include surface extraction, shading, and rendering using the digital compositing approach (Pat Hanrahan), and shadows, textures, and other photorealistic and artistic techniques (Marc Levoy).

Session IV: volume visualization workstations and software. In this last session, Scott Dyer offers a survey of for-sale and for-free volume visualization software and commercial workstations. Although this topic is not strictly in keeping with the course's focus on algorithms, researchers who are interested in understanding but not implementing the rendering algorithms described herein should find this information helpful.

SPEAKER BIOGRAPHIES

Marc Levoy is a research assistant professor of Computer Science and Radiation Oncology at the University of North Carolina at Chapel Hill. He received a B. Architecture in 1976 from Cornell University, an MS in 1978 from Cornell University, and a PhD in computer science in 1989 from the University of North Carolina at Chapel Hill. He was principal developer of the Hanna-Barbera Computer Animation System and served as its director from 1980 through 1982. His research interests include scientific visualization, volume rendering, medical imaging, and molecular graphics.

William Lorensen is a Graphics Engineer in the Information Systems Laboratory at GE's Corporate Research and Development Center in Schenectady, NY. He is currently working on algorithms for 3D medical graphics and scientific visualization. His other interests include computer animation, color graphics systems for data presentation, and object-oriented software tools. Lorensen is the author or co-author of 35 technical articles on topics ranging from finite element pre/postprocessing, 3d medical imaging, computer animation and object-oriented design. Prior to joining GE in 1978, he was a Mathematician at the US Army Benet Weapons Laboratory where he worked on computer graphics software for structural analysis. He has a BS in Mathematics and an MS in Computer Science from Rensselaer Polytechnic Institute.

Lee Westover is a staff engineer for Sun Microsystems Inc. He received a B.S. Computer Science from Michigan State University in 1979 and a M.S. Computer Science from the University of North Carolina at Chapel Hill in 1986. He is currently finishing up his Ph.D. from the University of North Carolina with a dissertation on Feed Forward Volume Rendering. Prior to joining Sun in June 1990, Lee worked from 1984 until 1990 for Numerical Design Ltd., a graphics software company based in Chapel Hill that specializes in photorealistic rendering packages. His research interests include volume rendering, scientific visualization, photorealistic rendering, and real time image compression/decompression.

Pat Hanrahan is on the faculty of the Computer Science Department at Princeton University where he teaches computer graphics. In 1990 he received the E-Council Award for Excellence in Teaching. His primary research interests are in the fundamental algorithms and computer architectures underlying computer graphics. Before joining Princeton, Dr. Hanrahan was a Senior Scientist at Pixar in San Rafael, CA. While at Pixar he developed software for the Pixar image computer, and was the chief architect of the RenderMan(TM) Interface - a protocol that allows modeling programs to describe scenes to high quality rendering programs. Previous to Pixar he directed the 3D computer graphics group in the Computer Graphics Laboratory at New York Institute of Technology.

Wolfgang Kreuger is head of the visualization department of the German Supercomputer Center at Bonn. His research interests include physically based image synthesis algorithms. Currently, he works on the development of enhanced visualization models for 3D data with special emphasis on applications in physics and medicine. He received his MS and PhD in Theoretical Physics from the University of Berlin.

Scott Dyer is Associate Director for Graphics Development at the Ohio Supercomputer Center. He is responsible for a large software development project that has yielded a popular toolkit for scientific visualization and animation called apE. Dyer's experience includes consulting in the academic and commercial sectors in animation, educational software, vectorized rendering techniques, and data manipulation and representations. He has held positions at Evans and Sutherland and Cranston/Csuri Productions.

SCHEDULE OF SESSIONS

8:30	Introduction (Levoy)
	Session I: polygonalization of volume data
9:00	Marching Cubes (Lorensen)
9:30	Dividing Cubes (Lorensen)
10:00	Break
	Session II: semi-transparent volume rendering - resampling
10:15	Introduction to sampling theory (Hanrahan)
10:30	Multi-pass (Hanrahan)
11:00	Ray tracing (Levoy)
11:30	Splatting (Westover)
12:00	Lunch
	Session III: semi-transparent volume rendering - shading
1:45	Introduction to light transport theory (Kreuger)
2:15	Gels and surfaces (Hanrahan)
2:45	Shadows, textures, and other artistic devices (Levoy)
3:15	Break
	Session IV: volume visualization workstations and software
3:30	Workstations (Dyer)
4:00	Software (Dyer)
4:30	Panel discussion
5:00	Course ends

TABLE OF CONTENTS