SIGGRAPH 1990

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COURSE NOTES 11

VOLUME VISUALIZATION ALGORITHMS AND ARCHITECTURES

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Marc Levoy
University of North Carolina

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Karl-Heinz Hoehne
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Mark Levoy
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COURSE ABSTRACT

The last three 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 '90. The emphasis of the course is on algorithms and architectures, not on applications, and the format of these notes is designed to facilitate comparisons between alternative approaches.

The first paper in the notes presents a taxonomy of volume visualization algorithms, briefly summarizing the advantages and disadvantages of each approach. The next four sections is devoted to traversing this taxonomy. Authors of key papers representing nodes in the taxonomy describe their algorithm through a combination of papers written expressly for this course and reprints from the literature. Algorithms to be presented include marching cubes, dividing cubes, gray-level gradient shading, and object-order and image-order semi-transparent volume rendering.

Beginning with section six, the focus switches from algorithms to architectures. The first paper of this set surveys custom and non-custom machines for volume visualization. In subsequent sections, four specific architectures are presented. These include the CUBE architecture, the Pixar Image Computer, the University of North Carolina's Pixel-Planes 5 architecture, and General Electric's Dividing Cubes architecture.

The notes end with a section devoted to algorithms for scan-converting 3D geometric primitives into voxel arrays, an ancillary but important problem in volume visualization. The course itself ends with a panel discussion focusing on unsolved technical issues in volume visualization.

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.

Karl-Heinz Hoehne is a professor of medical informatics and director of the Department of Computer Science in Medicine at the University of Hamburg. His current research interests include techniques for the visualization and management of pictorial information for medical diagnosis, treatment, and education. Hoehne received his MS in physics from the University of Wurzburg and his Ph.D. from the University of Hamburg, Germany.

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.

Arie E. Kaufman is currently a Professor of Computer Science at the State University of New York at Stony Brook. Professor Kaufman is the director of the Cube project for volume visualization supported by the National Science Foundation, Hughes Aircraft Company, Hewlett-Packard Company, Silicon Graphics Company, and the State of New York. He has held positions as a Senior Lecturer and the Director of the Center of Computer Graphics of the Ben-Gurion University in Beer-Sheva, Israel, and as an Associate and Assistant Professor of Computer Science at Florida International University in Miami. His research interests include computer graphics architectures, algorithms, and languages, volume visualization, user interfaces, computer vision, and scientific visualization. Professor Kaufman has published over 70 papers in these areas, has received 23 grants and awards, and has filed 5 patent applications. He received a BSc in Mathematics and Physics from the Hebrew University of Jerusalem in 1969, an MSc in Computer Science from the Weizmann Institute of Science, Rehovot, in 1973, and a PhD in Computer Science from the Ben-Gurion University in 1977. He is a member of ACM, SIGGRAPH, IEEE-CS, EUROGRAPHICS, NCGA, and IPA.

SCHEDULE OF SESSIONS

Time	Topic	Speaker
8:30	Introduction	Marc Levoy
9:00	Surface-based techniques	Bill Lorensen
9:40	Binary voxel techniques	Karl-Heinz Hoehne
10:20	Break	
10:40	Object-order volume rendering	Pat Hanrahan
11:20	Image-order volume rendering	Marc Levoy
12:00	Lunch	
1:45	CUBE architecture	Arie Kaufman
2:15	Pixar Image Computer	Pat Hanrahan
2:45	Pixel-planes 5 architecture	Marc Levoy
3:10	Break	
3:30	Dividing cubes architecture	Bill Lorensen
4:00	3D scan-conversion	Arie Kaufman
4:30	Panel discussion	All speakers
5:00	Course ends	

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