

# Computer Vision for Computer Graphics

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**Course**

**25**

**NOTES**



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# **Computer Vision for Computer Graphics**

## **Course Notes for SIGGRAPH'95**

### **Course Organizer**

**Ingrid Carlbom**  
**Digital Equipment Corporation, Cambridge Research Lab**

### **Course Speakers**

**William Freeman**  
**Mitsubishi Electric Research Laboratories**

**Gudrun Klinker**  
**ECRC**

**William E. Lorensen**  
**GE Corporate Research and Development**

**Richard Szeliski**  
**Digital Equipment Corporation, Cambridge Research Lab**

**Demetri Terzopoulos**  
**Computer Science Department, University of Toronto**

**Keith Waters**  
**Digital Equipment Corporation, Cambridge Research Lab**

### **Abstract**

In recent years, two traditionally separate fields – computer graphics and computer vision – have begun to merge. This course investigates the increasingly important role that computer vision plays in 3D graphics model building, user interfaces, biomedical applications, and animation. The course demonstrates how similar computer vision techniques are used in the following diverse areas: (1) 3D shape recovery from geometric and photometric properties; (2) user interfaces based on faces, hands, and gestures; (3) biomedical applications, such as 3D serial reconstructions, virtual endoscopes, brain atlases, and the use of computer graphics and computer vision in the operating room; and (4) 3D modeling from video for animation, and modeling perception for animation of humans and other living creatures.

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## **Course Overview**

### **Course Introduction**

### **Definition of Basic Terms and Concepts**

#### **Session A: 3D Shape Recovery**

##### **A1: Shape from Geometric Properties**

Stereo

Image Mosaics

Motion Recovery/ Camera Calibration

Structure from Motion

##### **A2: Shape from Photometric Properties**

Shape from Shading

Shape from Specular Reflection

Photometric Stereo

##### **A3: Estimation of Material Properties**

Physical Reflection Modeling

Camera Modeling

Forward versus Inverse Modeling

#### **Session B: Video-Based User Interfaces**

##### **B1: Faces**

Extraction and Manipulation of Facial Models

Tracking Facial Features

##### **B2: Hands and Gestures**

Marked Hands, Unmarked Hands, Whole Body

An Easy-to-Implement Hand Gesture Recognition System

#### **Session C: Biomedical Applications**

##### **C1: 3D Reconstruction from Serial Sections**

##### **C2: Exploration of Cross-Sectional Data with a Virtual Endoscope**

##### **C3: Brain Atlases**

##### **C4: Enhancing the Reality in the Operating Room**

#### **Session D: Animation**

Motion Capture

3D Physical Models from Video

Perception for Animated Agents/Characters

#### **Questions and Answers**

## Speaker Biographies

**Ingrid Carlbom** is Manager of Visualization Research at Digital Equipment Corporation's Cambridge Research Lab. From 1980 to 1986 she was a member of the professional staff at Schlumberger-Doll Research, Ridgefield, Connecticut, where she also served as Program Leader for the Graphical Modeling Program. Her research interests include scientific visualization, biomedical imaging, geometric modeling, and computer graphics system architecture, and she has published and lectured on all these subjects.

Dr. Carlbom received a PhD in computer science from Brown University, a MS in computer science from Cornell University, and a Fil.Kand. from the University of Stockholm, Sweden. She was a director of SIGGRAPH from 1982 to 1986 and the chair of the SIGGRAPH Advisory Board from 1986 to 1988. She served on the *IEEE Computer Graphics and Applications*' Editorial Board, 1985-1989, and is currently serving on the editorial boards for *Graphical Models and Image Processing* and *IEEE Transactions on Visualization and Computer Graphics*. She is a member of the External Advisory Board for the *NSF/ARPA Science and Technology Center for Computer Graphics and Scientific Visualization*. She is a member of ACM, SIGGRAPH, IEEE, and Sigma Xi.

**William Freeman** is a senior research scientist at Mitsubishi Electric Research Laboratories. Dr. Freeman's research interests are computational vision, image processing, and electronic imaging. As part of his thesis work, he developed "steerable filters," a class of oriented filters with wide application in image processing and computer vision. His current research involves hand gesture recognition by computer and Bayesian models of perception. His research at the Polaroid Corporation from 1981 to 1987 led to nine patents and a successful product, the Polaroid Palette film recorder. In 1987, Dr. Freeman was a Foreign Expert at the Taiyuan University of Technology, P. R. of China.

**Gudrun Klinker** is a senior member of the User Interaction and Visualization Group at the European Computer-Industry Research Centre (ECRC) in Munich, where she conducts research on topics and applications of augmented reality and distributed graphics. Prior to joining ECRC, Dr. Klinker worked in the Visualization Group at the Cambridge Research Lab of Digital Equipment Corporation, developing data exploration environments for telecollaborative analysis of empirical data. She received a Ph.D. in Computer Science from Carnegie Mellon in 1988 for research using a physical approach to color image understanding. She received a Diplom in Informatik from the Universitaet Hamburg in 1982. Dr. Klinker is a member of IEEE and ACM.

**William Lorensen** is a Graphics Engineer in the Imaging and Visualization Laboratory at GE's Corporate Research and Development Center in Schenectady, NY. Bill 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. Bill is the author or co-author of over 60 technical articles on topics

ranging from finite element pre/postprocessing, 3D medical imaging, computer animation and object-oriented design. He is a co-author of "Object Oriented Modeling and Design" published by Prentice Hall, 1991. Bill holds fifteen US Patents on medical and visualization algorithms. In 1991, he was named a Coolidge Fellow, the highest scientific honor at GE's Corporate R&D.

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.

Richard Szeliski is a member of the research staff at the Cambridge Research Lab of Digital Equipment Corporation. In 1989 he was a Visiting Scientist at the Artificial Intelligence Center of SRI International, Menlo Park. In 1988, he was a Member of Scientific Staff at Schlumberger Palo Alto Research, Palo Alto. From 1982 to 1983 he was a Member of Scientific Staff at Bell-Northern Research, Montreal. His research interests include 3-D computer vision, geometric modeling, medical image registration, and parallel programming and algorithms.

Dr. Szeliski received a Ph.D. in Computer Science from Carnegie Mellon University, a M.A. Sc. in Electrical Engineering from the University of British Columbia, and a B. Eng. degree in Honours Electrical Engineering from McGill University. He has published over 30 research papers in computer vision, computer graphics, medical imaging, neural nets, and parallel numerical algorithms, as well as the book "Bayesian Modeling of Uncertainty in Low-Level Vision". He is a member of AAI, ACM, IEEE, and Sigma Xi.

Demetri Terzopoulos (PhD '84 EECS, MIT; MEng '80 EE, BEng '78 Hons EE, McGill U) is Professor of Computer Science and Electrical and Computer Engineering at the University of Toronto, where he directs the Visual Modeling Group. He is a Fellow in the Artificial Intelligence and Robotics Program of the Canadian Institute for Advanced Research. From 1985-92 he was affiliated with Schlumberger, Inc., serving as Program Leader at its research labs in Palo Alto, CA, and Austin, TX. During 1984-85 he was a research scientist at the MIT Artificial Intelligence Lab, Cambridge, MA. He has published more than 150 scientific articles primarily in computer vision and graphics but also in computer-aided design, medical imaging, artificial intelligence, and artificial life, including the recent edited volumes "Real-Time Computer Vision" (Cambridge Univ. Press '94) and "Animation and Simulation" (Springer-Verlag '95).

He has been a SIGGRAPH course and panel organizer and has produced seven SIGGRAPH technical papers in his eight years of graphics research. His graphics and vision work has been recognized with several awards, including 3 university Excellence Awards, an award from the American Association for Artificial Intelligence in 1987 for his work on deformable models in vision, an award from the IEEE in 1987 for his work on active contours (snakes), an award from the Canadian Academy of Multimedia Arts and Sciences in 1994 and an award from Ars Electronica in 1995 both for his work on artificial animals. He serves on the

editorial boards of *Graphical Models and Image Processing* and the *Journal of Visualization and Computer Animation* and on advisory committees for the Advanced Research Projects Agency and the National Institutes of Health.

**Keith Waters** is a member of the research staff at Digital Equipment Corporation's Cambridge Research Lab, where he is involved in scientific visualization. From 1988 to 1991, he was a member of the technical staff at Schlumberger Laboratory for Computer Science in Austin Texas, where he worked on 3D visualization of seismic and borehole data. Keith received a Ph.D in Computer Graphics from Middlesex Polytechnic London in 1988 for his thesis on the Computer Synthesis of Expressive Three-Dimensional Facial Character Animation.

His current research interests include computer vision, computer-based facial synthesis, medical facial applications, physically-based modeling, and volume visualization. Dr. Waters has published papers in computer graphics, computer vision, and biomedical visualization. He is a member of ACM SIGGRAPH and IEEE, and is on the editorial board for the *Journal of Visualization and Computer Animation*.