SIGGRAPH'03 Tutorial Course #11

Interactive Geometric & Scientific Computations Using Graphics Hardware

http://gamma.cs.unc.edu/SIG03_COURSE

Organized by

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Speakers

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Abstract

Fast graphics hardware including dedicated vertex processing, 3D rasterization, texturing, and pixel processing is becoming as ubiquitous as floating-point hardware. The ubiquity and performance of this hardware leads us to consider the extent to which this hardware can be harnessed to solve geometric and scientific problems beyond the conventional domain of image synthesis for the sake of pretty animation. In particular, there are a number of complicated geometric and scientific problems whose solutions provide the basis for many application areas in graphics, robotics, vision, simulation, computer gaming, visualization and high-performance computing. Many of the sophisticated "behind-the-curtain" geometric computations are often hard to perform accurately and robustly with reasonable efficiency. At the same time, the graphics processing units offer a lot of potential as generally programmable SIMD and streaming units. This course covers all aspects of using graphics rasterization hardware for interactive geometric and scientific computations.

This course will start with an overview with some of the graphics hardware features that lend themselves to solving geometric and scientific problems. Next we will talk about software APIs and issues in implementing some basic geometric queries on this hardware. After that the course will deal with three main different application areas: geometric arrangements, collision and reconstruction problems, scientific computation including linear solvers, Fast Fourier transforms dynamic and fluid simulation and finally global illumination and interactive walkthroughs. Each talk will present some novel algorithms for these geometric or scientific problems that make use of the capabilities of the rasterization hardware. The speakers will also summarize their experiences in implementing different algorithms on graphics processors, surprises and technical lessons

Course Presenters Information

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Biography: Dinesh Manocha is currently a professor of computer science at the University of North Carolina at Chapel Hill. He received his B.Tech. degree in computer science and engineering from the Indian Institute of Technology, Delhi in 1987; M.S. and Ph.D. in computer science at the University of California at Berkeley in 1990 and 1992, respectively. During the summers of 1988 and 1989, he was a visiting researcher at the Olivetti Research Lab and General Motors Research Lab, respectively. He received Alfred and Chella D. Moore fellowship and IBM graduate fellowship in 1988 and 1991, respectively, and a Junior Faculty Award in 1992. He was selected an Alfred P. Sloan Research Fellow, received NSF Career Award in 1995, Office of Naval Research Young Investigator Award in 1996, and Hettleman Prize for scholarly achievement at UNC Chapel Hill in 1998. His research interests include geometric and solid modeling, interactive computer graphics, physically based modeling, virtual environments, robotics and scientific computation. He has published more than 120 papers in leading conferences and journals on computer graphics, geometric and solid modeling, robotics, symbolic and numeric computation, virtual reality, molecular modeling and computational geometry. He has served as a program committee member for many leading conferences on virtual reality, computer graphics, computational geometry, geometric and solid modeling and molecular modeling. He was the program co-chair for the first ACM Siggraph workshop on simulation and interaction in virtual environments and program chair of first ACM Workshop on Applied Computational Geometry. He was the guest editor of special issues of International Journal of Computational Geometry and Applications. He has also edited and co-authored two research monographs and consulted for a number of companies including Intel, Mechanical Dynamics, Boeing, Division, TC2 corporation etc.

He has been working on topics related to interactive computer graphics and geometric algorithms for more than ten years. These include collision detection, proximity computations, interactive walkthroughs, visibility, motion planning, multi-pass rendering, and discretized geometric computations. Some of the software systems developed by his research groups have been widely used. He has taught courses on computer graphics, computational geometry and scientific computing at the University of North Carolina for the last six years. He has given invited talks at a number of conferences and workshops and has been a speaker in SIGGRAPH courses. He has also organized other SIGGRAPH courses in the past.

- **Michael Doggett**

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Biography: Michael Doggett works as an architect on graphics hardware at ATI Research. He completed his B.S. degree in Computer Science in 1990, B.E. degree in Electrical Engineering in 1992, and Ph.D. in 1997 all at the School of Computer Science and Engineering at The University of New South Wales, Sydney, Australia. From 1996 to 1998 he worked as Chief Engineer at Conja Pty Ltd, a Special Effects, Animation and Design company. From 1998 to 2001 he was a member of the research staff of the Computer Graphics Laboratory (GRIS) at the Computer Science Department of the University of Tuebingen as a PostDoc where he worked on custom hardware for Volume Rendering and Displacement Mapping. He has been involved in teaching courses at the University of New South Wales and the University of Tuebingen. He is the paper co-chair for Graphics Hardware 2002 and has served on the program and review committee for several conferences. He has published numerous papers and is a member of IEEE Computer Society, and ACM.

- **Shankar Krishnan**

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Biography: Shankar Krishnan is a Principal Technical Staff Member at AT&T Labs Research and a member of the Information Visualization and Display Research department, where he contributes towards the development of practical new techniques for working with geometric representations of information, with a particular emphasis on problems concerning large-scale networks and services. Prior to joining AT&T Labs, Shankar graduated with a Ph.D. from the University of North Carolina at Chapel Hill. Shankar's primary research interests include 3D computer graphics, hardware-assisted geometric algorithms, and reliable geometric and numeric computation. Shankar has authored several papers in these areas and has given a number of technical presentations in leading conferences in computer graphics, computational geometry and geometric modeling.

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Biography: Ming C. Lin received her B.S., M.S., Ph.D. degrees in Electrical Engineering and Computer Science in 1988, 1991, 1993 respectively from the University of California, Berkeley. She is currently an assistant professor in the Computer Science Department at the University of North Carolina (UNC), Chapel Hill. Prior to joining UNC, she was an assistant professor in the Computer Science Department at both Naval Postgraduate School and North Carolina A&T State University, and a Program Manager at the U.S. Army Research Office. She received the NSF Young Faculty Career Award in 1995 and Honda Research Initiation award in 1997. Her research interests include real time 3D graphics for virtual environments, applied computational geometry, physically based modeling, robotics and distributed interactive simulation. She has served as a program committee member for many leading conferences on virtual reality, computer graphics, and computational geometry. She was the general chair of the First ACM Workshop on Applied Computational Geometry and the co-Chair of 1999 ACM Symposium on Solid Modeling and Applications. She is also a guest editor of the International Journal on Computational Geometry and Applications, the co-editor of "Applied Computation Geometry", and the Category Editor of ACM Computing Reviews in Computer Graphics. She has also consulted for a number of companies including Intel, Mechanical Dynamics and Division.

Ming has been working in computational geometry, computer graphics and virtual environments for more than nine years. Over the last five years, she has led the development of a number of algorithms and systems for interactive collision detection. These include I-COLLIDE, RAPID, V-COLLIDE, S-COLLIDE, H-COLLIDE, SWIFT, SWIFT++, PIVOT, PQP and DEEP. They have been widely used by a number of researchers and the technology has been licensed by more than 30 commercial organizations. Over the last five years, she has taught courses on computer graphics, physically based modeling, computational geometry and robotics at Naval Postgraduate School, NC A & T University and the University of North Carolina at Chapel Hill. She has given invited lectures at many conferences and meetings, including Computer Games Developers Conference and SIGGRAPH.

- **Marc Pollefeys**

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Biography: Marc Pollefeys is an Assistant Professor of Computer Vision in the Department of Computer Science at the University of North Carolina at Chapel Hill. Previously he was a postdoctoral researcher at the Katholieke Universiteit Leuven in Belgium, where he also received his M.S. and Ph.D. degrees in 1994 and 1999, respectively. One of his main research goals is to develop flexible approaches to capture visual representations of real world objects, scenes and events. Dr. Pollefeys has received several prizes for his research, including the prestigious Marr prize at ICCV '98. He is the author or co-author of more than 70 technical papers. He is a regular reviewer for most of the major vision, graphics and photogrammetry journals. He has organized workshops and has served on the program committees of many conferences.
He has organized courses on 'obtaining 3D models with a hand-held camera' at SIGGRAPH 2000, 2001 and 2002, as well as related courses at ECCV 2000, 3DIM 2001. He has co-organized a course on 'multiple view geometry' at CVPR 2001 with Anders Heyden and will be co-organizing a similar course at CVPR 2003 with Andrew Zisserman. He has also contributed to the course on /'acquisition and rendering of surface lightfields/Image-based modeling/' organized at SIGGRAPH 2001 and 2002.

- **Timothy Purcell**

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Biography: Tim Purcell is currently finishing his Ph.D. in computer science at Stanford University. He received a B.S. in computer science from the University of Utah in 1998 and an M.S. in computer science from Stanford University in 2001. He is a recipient of the National Science Foundation Graduate Research Fellowship, and is a 2002-03 NVIDIA fellowship winner. His current research interests include stream programming, ray tracing, and leveraging GPUs for non-traditional uses. He has given a number of technical presentations including a SIGGRAPH course in 2001 and paper talk in 2002. He has also given several invited talks about his

research to various companies and organizations including Intel, NVIDIA, and the Silicon Valley ACM SIGGRAPH Chapter.

- **Peter Schröder**

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Biography: Peter Schröder is a professor of computer science and applied & computational mathematics at Caltech where he directs the Multi-Res Modeling Group. His research focuses on efficient and robust numerical methods for computer graphics and simulation applications. He is best known for his contributions to the theory and algorithms underlying wavelets, subdivision surfaces, and more broadly, Digital Geometry Processing. In recognition of this work he has received many awards including Sloan and Packard Foundation Fellowships. His work has been published widely including many contributions to the SIGGRAPH conference. As organizer and speaker he has been involved in many highly successful SIGGRAPH courses on Wavelets, Subdivision, and Digital Geometry Processing. He is now applying his experience in massively parallel computers to programmable graphics cards and recently taught a new undergraduate class at Caltech on ``Hacking the GPU."

- **Matthias Wloka**

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Biography: Matthias Wloka works in the technical developer relations group at Nvidia. There, he gets to collaborate with game-developers on, for example, performance-optimizations and advising how to efficiently implement desired effects into their game. Matthias is always tinkering with the latest graphics hardware to explore the limits of interactive real-time rendering. Before joining Nvidia, Matthias was a game developer himself, working for GameFX/THQ Inc. He received his M.Sc in computer science from Brown University in 1990, and his B.Sc from Christian Albrechts University in Kiel, Germany in 1987.