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COURSE NOTES 22

Making Radiosity Practical

ORGANIZER
Holly E Rushmeier
National Institute of Standards and Technology

LECTURERS
Christoph Borel
Los Alamos National Laboratory
Michael F Cohen
Princeton University
Julie Dorsey
Cornell University
Pat Hanrahan
Princeton University
Campbell McKeller
CRL, Ltd
Rod Recker
Lightscape Graphics Software, Ltd
Francois X Sillion
Ecole Normale Superiere
John R Wallace
3D/EYE Inc
Dieter Zembrot
Zumtobel Licht Gmbh

ABSTRACT

Radiosity methods are used to compute the interreflections of visible light Modeling the transfer of light is one step in rendering physically accurate images of numerically defined environments Physically accurate, rather than plausibly realistic looking, images are required in applications such as illumination design, product design, remote sensing and machine vision Initially radiosity was only a research topic in computer graphics However, it has now passed from being a topic primarily of concern to researchers, to being a method of interest to people with practical problems to solve

In the first part of the course, the key aspects of radiosity methods are presented To start with, some basic terms, notation and equations are needed Then, the original radiosity method for ideal diffuse surfaces is presented An outline is given of all the steps in a solution – data input, form factor calculations, solution of simultaneous equations and rendering of the radiosity solution as an image

The second part of the course deals with improvements to the original radiosity method which were necessary to make it a viable method for applications When it was originally introduced to computer graphics, the radiosity method suggested many interesting possibilities for image synthesis, but there were severe problems in using the method Major difficulties were the lengthy computation time, the assumption of ideal diffuse emission and reflection, the necessity to mesh all surfaces in the environment, and the lack of a non arbitrary method for mapping the radiosity results to a display device Solutions to these problems which are presented include restructuring the solution method, extensions for non diffuse surfaces, advanced meshing techniques and perceptually based tone reproduction methods

In the last part of the course, a number of examples of the application of radiosity are presented These applications include using radiosity as a research tool in other disciplines such as remote sensing and vision, using radiosity in education, and using radiosity in architectural and lighting design These applications are discussed by active practitioners in these areas

SPEAKER BIOGRAPHIES

Christoph Borel is on the staff of the Space Science and Technology Division of the Los Alamos National Laboratory He received the diploma in electrical engineering in 1981 from the Swiss Federal Institute of Technology (ETH) in Zurich, receiving first prize in a student paper contest for his diploma thesis on speech signal processing From 1981 to 1983 he held a research position at ETH In 1983 he joined the Microwave Remote Sensing Laboratory at University of Massachusetts He received the PhD degree in electrical and computer engineering in 1988 from the University of Massachusetts, Amherst His current research interests are vegetation modeling in the visible and infrared using the radiosity method, computer graphics, image analysis, and atmospheric corrections Address Space Science and Technology Division, SST 9, MS D436, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, E-mail ccb@eos1 lanl gov Phone (505) 667 8972 Fax (505) 665 3332

Michael Cohen is an assistant professor of computer science at Princeton University He holds a PhD from the University of Utah, an MS from Cornell University, a BS from Rutgers University and a BA from Beloit College Until 1988 he was on the faculty of the Program of Computer Graphics at Cornell University where he conducted research in the area of realistic image synthesis In particular, he worked on the development of the Radiosity method which has been reported in publications at SIGGRAPH conferences and elsewhere Prof Cohen has lectured widely in the area image synthesis Current interests include constrained optimization for animation, image synthesis, interactive graphical user interfaces, and scientific visualization Address Dept of Computer Science, 35 Olden Street, Princeton, NJ 08544 2087, E mail mfc@princeton edu, Phone (609) 258 4633, Fax (609)258 1771

Julie Dorsey is an assistant professor of Architecture at Cornell University, where she teaches in the areas of computer graphics and computer aided design She received an undergraduate education in architecture (BArch, BS 1987) and a graduate education in computer graphics (MS 1990, PhD 1993) at Cornell University Her research interests include realistic image synthesis, interactive simulation, and lighting design Address Program of Computer Graphics, 580 Engineering Theory Center, Cornell University, Ithaca, NY 14853, E-mail job@graphics cornell edu Phone (607) 255 6713 Fax (607) 255 0806

Patrick Hanrahan is an associate professor of computer science at Princeton University where he teaches computer graphics Before joining Princeton, he worked at Pixar where he developed volume rendering software and was the chief architect of the Render Man 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 Dr Hanrahan is the author of numerous articles on image synthesis and scientific visualization His current research involves volume rendering, image synthesis, and graphics systems and architectures Address Dept of Computer Science, 35 Olden Street, Princeton, NJ 08544-2087, E-mail pmh@princeton edu, Phone (609) 258 5756, Fax (609)258 1771

Campbell McKeller is a Senior Research Engineer at Central Research Laboratories (CRL), Ltd He received the B Sc (Hons) in computer science from Edinburgh University in 1989 At CRL he is responsible for the development of lighting simulation, architectural visualization, and virtual reality applications Address CRL, Dawley Rd, Hayes, Middlesex UB3 1HH, London, UK E-mail cmckellar@thorn emi clr co uk Phone +44 81 848 6544 Fax +44 81 848 6565

Rod Recker is in charge of new program development for Lightscape Graphics Software He graduated from the Cornell University College of Engineering with a Bachelor of Science degree in 1987 and the Program of Computer Graphics with a Master of Science degree in 1990 After graduating, he worked as Member of Technical Staff for ATT Bell Laboratories He received an Individual Performance Award for his development of a radiosity library for the second generation ATT Pixel Machine Address Lightscape Graphics Software, Ltd , 2 Berkeley Stree/Suite 600, Toronto, Ontario MSA 2W3, CANADA E-mail rrecker@attmail com, Phone (416) 862 2628, Fax (416) 862 5508

Holly Rushmeier (chair) is on the staff of the Computing and Applied Mathematics Laboratory at the National Institute of Standards and Technology She received the BS(1977), MS(1986) and PhD(1988) degrees in Mechanical Engineering from Cornell University Following receipt of the BS she worked as an engineer at the Boeing Commercial Airplane Company, and at the Washington Natural Gas Company (both in Seattle, WA) Upon completion of the PhD, she served on the Mechanical Engineering faculty at Georgia Tech, where she was the recipient of an NSF Presidential Young Investigator Award She is the author of articles in the fields of computer graphics and in radiative heat transfer Her research interests include computer graphics synthetic image generation, scientific visualization, and radiant heat transfer Address Bldg 225,Rm B 146, NIST, Gaithersburg, MD, 20899, E-mail holly@cam nist gov, Phone (301)975 3918, Fax (301)963 9137

François Sillion is a researcher at the Ecole Normale Superieure, in Paris, France He received an undergraduate education in math and physics, a graduate degree in Solid State Physics in 1986, and a PhD in computer science in 1989 at the Ecole Normale Superieure From 1989 1991 he was a post doctorate associate in the Program of Computer Graphics at Cornell University He has co-authored several research papers on the topic of image synthesis, including several published at the SIGGRAPH conference His research interests include light reflection modeling, global illumination algorithms, interactive simulation, and evaluation of image quality Address Laboratoire d'Informatique, Ecole Normale Superieure, 45 rue d'Ulm, F 75005 Paris, France, E-mail sillion@dmi ens fr, Phone (33) 1 44 32 20 42, Fax (33) 1 44 32 20 80

John Wallace is a software engineer at 3D/EYE, Inc , where he is the project leader for the development of Hewlett Packard's ARTCore radiosity and ray tracing library He received his MS in 1988 from the Program of Computer Graphics at Cornell and a BS in physics from the University of Maryland in 1980 He is the author of several articles on the topic of radiosity that have appeared in the SIGGRAPH proceedings His research interests include image synthesis, lighting specification, reflection models and computer generated illustration Address 3D/EYE, Inc ,2359 N Triphammer Rd ,Ithaca, New York,14850 E-mail johnw@eye com Phone (607)257 1381

Dietmar Zembrot is Project Leader for the development of lighting design software at Zumtobel Licht He received a Masters degree (Diplom Ingenieur) in Electrical Engineering from the Technical University Karlsruhe His areas of expertise include accurate illumination calculations, luminance representation that takes into account human visual perception, and the use of visualization in the lighting design process Address Zumtobel Licht , Schweizerstrasse 30, A 6850 DORNBIRN, AUSTRIA, E-mail dz@cophos co at, Phone +43/5572/390 697, Fax +43/5572/22826

Schedule

Introduction (Rushmeier, 15 min) (i to vi)

Fundamentals
Basic Radiative Transfer Concepts (Hanrahan, 30 min) (1-1 to 1-25)
Overview of the Radiosity Formulation (Cohen 35 min) (2 1 to 2-34)

Practical Issues
Progressive Radiosity (Cohen 25 min) (2 35 to 2 49)
Hierarchical Radiosity (Hanrahan 25 min) (3 1 to 3 12)
Radiosity With Changing Input (Sillion 25 min) (4 1 to 4-16)
Non-Diffuse Radiosity (Sillion 30 min) (5 1 to 5-25)
Meshing and Reconstruction (Wallace 60 min) (6 1 to 6 30)
From Solution to Image (Rushmeier 20 min) (7 1 to 7 10)

Applications
Overview (Rushmeier, 15 min) (14 1 to 14-16, 15-1 to 15 16, 16 1 to 16 5, 17 1 to 17-4, 18 1 to 18 6)
Remote Sensing (Borel, 30 min) (8 1 to 8 15)
Architectural Education (Dorsey, 15 min) (9 1 to 9 5)
Stage Lighting (Dorsey, 15 min) (10 1 to 10 7)
Lighting Design (Zembrot 25 min) (11 1 to 11 6)
Architectural Visualization (McKellar, 25 min) (12 1 to 12 3)
Architectural Visualization (Recker, 25 min) (13 1 to 13 6)

Conclusion (Rushmeier 5 min) (19 1 to 19-2)

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