Light and Color in the Outdoors

A SIGGRAPH 2003 Course

Course Organizer

Simon Premože
University of Utah

Lecturers

Mark J. Harris
University of North Carolina at Chapel Hill

Nathaniel Hoffman
Naughty Dog

AJ Preetham
ATI Research

Simon Premože
University of Utah

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Time and Day

Sunday, July 27, 2003 from 8:30 AM to 12:15 PM

Course Organizer

Simon Premože
Computer Science Department
University of Utah
50 S Central Campus Dr. Rm 3190
Salt Lake City, UT 84112
email: premoze@cs.utah.edu

Presenters Contact Information

Mark J Harris
University of North Carolina at Chapel Hill
harrism@cs.unc.edu

Nathaniel Hoffman
Naughty Dog
naty@io.com

AJ Preetham
ATI Research
preetham@ati.com

Simon Premože
University of Utah
premoze@cs.utah.edu

Course Level

Advanced

Abstract

Simple and practical methods for daytime and night-time skylight illumination and the appearance of clouds, including approximate and practical methods for outdoor global illumination. Special focus: practical methods appropriate for real-time applications.

Prerequisites

A good understanding of basic physics. Familiarity with illumination models and light-surface interactions. Familiarity with modern graphics hardware.

[0]Image on the front page is courtesy of AJ Preetham and Natty Hoffman.

Topics List

Fundamentals of scattering, scattering in the atmosphere, appearance and modeling of daytime and night-time sky, aerial perspective, practical cloud illumination models, interactive methods for rendering sky and clouds, approximate methods for outdoor global illumination.

Throughout the course, attention will be paid to most recent developments and practical problems. In addition, the course will begin with a talk covering relevant background and end with a panel discussion.

Course Presenters' Biographies

Mark J. Harris has been a PhD student in Computer Science at The University of North Carolina at Chapel Hill since 1998. He received a BS in Computer Science from The University of Notre Dame in 1998. His dissertation research, supervised by Dr. Anselmo Lastra, is on real-time cloud rendering and simulation. His other research interests include global illumination, graphics hardware, and physically based simulation. Mark taught an undergraduate programming course at UNC in 2002. He presented a short course on real-time cloud rendering for games at the 2002 Game Developers Conference, and co-presented a short course at GDC 2003 on simulation and procedural animation using graphics hardware.

Nathaniel Hoffman received the BSc degree in computer engineering from the Technion - Israel Institute of Technology in 1993. Until 1997 he was a microprocessor architect at Intel where he contributed to the Pentium Processor with MMX Technology and the SSE and SSE 2 instruction set extensions. From 1997 to early 2003 he worked at Westwood Studios as a graphics and optimization specialist, where he also did research into outdoor rendering. Recently he has joined Naughty Dog (a wholly owned subsidiary of Sony Computer Entertainment America Inc.). Naty has presented various real-time techniques at the Game Developers Conference over the past three years: outdoor illumination in 2001, skylight and aerial perspective in 2002, and advanced illumination in 2003.

AJ Preetham is a software engineer working on various rendering techniques for next generation graphics hardware at ATI Research. Prior to this, he developed 3D modeling and reverse engineering software at Paraform Inc., and worked on rendering atmospheric effects for flight simulators at Evans & Sutherland. He graduated with an MS degree in Computer Science from University of Utah under supervision of Peter Shirley and with Bachelors of Technology from Indian Institute of Technology, Madras, India. While a graduate student at the University of Utah he developed a practical skylight model. He presented real time techniques for skylight and aerial perspective at the 2002 Game Developers Conference.

Simon Premože is a Ph.D. student in Computer Science at the University of Utah working with professor Peter Shirley. He obtained a BS degree in Computer Science from the University of Colorado at Boulder in 1996. Part of his degree was completed at the University of Ljubljana, Slovenia while pursuing a degree in Applied Mathematics. His current research interests include global illumination and rendering algorithms, modeling natural phenomena and reflectance models. He has done research on modeling and rendering natural phenomena (snow, water,

night sky). Previously he worked on computer simulation and visualization of liquid crystal phase transitions and dynamics of liquid crystals. He previously participated in Siggraph 2000 course titled *Image-Based Surface Details*.

Course Schedule

8:30 AM **Introduction** **Premože**

8:35 AM **Background and Overview** **Premože**

1. Complexity of Light Transport in Outdoors
2. Overview of Scattering
   a. Definitions
   b. Basic Physics Overview
3. Overview of Existing Methods of Solving Light Transport in Outdoors
4. Practical Issues for Modeling and Rendering

8:50 AM **Global Illumination in Outdoors** **Premože**

1. Overview of Light Transport in the Outdoors
   a. Modes of Transport
   b. Interaction with Geometry
   c. Existing Methods
   d. Shortcomings
2. Approximations to Global Illumination
   a. Environment Mapping
   b. Spherical Harmonics
   c. Ambient Occlusion
   d. Semi-Local Illumination Models

9:15 AM **Skylight Modeling and Aerial Perspective** **Preetham**

1. Theory of Scattering in Atmosphere
   a. Atmosphere
   b. Scattering
2. Skylight Models
   a. Simulation Based Methods
   b. Analytic Models and Approximations
3. Aerial Perspective Model
4. Accelerated Techniques for Modeling Sky and Aerial Perspective

10:05 AM **Night Sky Illumination** **Premože**

1. Sources of Illumination at Night
2. Methods and Algorithms for Night Sky
   a. Sky Modeling
   b. Appearance of Moon
   c. Star Modeling
3. Tone Mapping Problems

10:15 AM **Coffee Break**

10:30 AM **Practical Global Illumination** **Hoffman**

1. Terrain
   a. Horizon mapping for Sun's contribution
   b. Hemispherical lighting factor
   c. Polynomial Texture Mapping
   d. Spherical Harmonics Transfer Functions
2. Objects
   a. Environment mapping
   b. Local Illumination with Spherical Harmonics
3. Terrain-Object interactions
   a. SH 'contact texture' for ground objects
   b. Combining illumination and shadowing
4. Demonstration

11:20 AM **Real-time Rendering of Clouds** **Harris**

1. Cloud Illumination Model
   a. Overview of Scattering in Clouds
   b. Illumination Approximations
   c. Simple Cloud Illumination Model
2. Accelerated Cloud Rendering
   a. Impostors
   b. Extensions to Traditional Impostors
3. Writing Cloud Rendering Engine
   a. Implementation Issues
   b. Demonstration

12:10 AM **Summary, Questions and Answers** **Harris, Hoffman, Preetham, Premože**