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COURSE NOTES 28

PARALLEL ALGORITHMS AND ARCHITECTURES FOR 3D IMAGE GENERATION

Chair
Scott Whitman
The Ohio State University

Lecturers
Kurt Akeley
Silicon Graphics Computer Systems
Dan Baum
Silicon Graphics Computer Systems
Wm. Leler
Independent Consultant
Doug Voorhies
Apollo/HP
Scott Whitman
The Ohio State University

Siggraph '90

Parallel Algorithms and Architectures for 3D Image Generation

Scott Whitman
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Course Chair

This course presents the latest information on software and hardware parallel algorithms used in high performance 3D computer image generation. This year, we build on the direction of last year's course and delve deeper into specific parallel algorithms and commercially available architectures. Significant progress has been made in the area of parallel rendering in the last year alone and we will expand upon the issues, problems, and solutions regarding development of these algorithms. High performance graphics hardware has always been an exciting area of research as well and this year we venture into the commercial sector to investigate the designs used in these products.

Initially, we will introduce the programming methodologies used for supporting development of parallel graphics algorithms on general purpose multiprocessors. Then, specific rendering algorithms which have been implemented on these architectures will be discussed. In the second half of the course, the architectures of high performance graphics superworkstations will be the topic and several of the current commercially available products will be described in detail. Finally, to tie the whole course together, two software algorithms which take advantage of the special purpose hardware in these graphics workstations will be presented.

The course notes offer a wealth of information on the topics described above. Articles specifically written for these notes by Andrew Burke & Wm Leler, Scott Whitman, and Dan Baum provide the course participant with the latest research in this exciting field from a software development point of view. Kurt Akeley and Doug Voorhies have been at the forefront of graphics workstation research for some time and the reader is encouraged to review their articles in this year's Siggraph proceedings for a complete update on their latest research. Other articles which relate to each speaker's subject areas are included for reference.

Biographies

Kurt Akeley

Kurt Akeley is chief engineer in the Advanced Systems Division of Silicon Graphics Computer Systems. He has been with Silicon Graphics since its founding in 1982 and has contributed to the development of both CPU and graphics subsystems. He received a BSEE from the University of Delaware in 1980 and an M.S. in electrical engineering from Stanford University in 1982. His interests include hardware systems design, high-performance graphics, and schematic and simulation tool development.

Dan Baum

Dan Baum received an A.B. in Engineering Science from Dartmouth College and an M.S. from The Program of Computer Graphics at Cornell University. After graduating from Cornell, he joined Silicon Graphics where he currently manages the graphics software group in the Advanced Systems Division. In addition to developing high performance graphics workstations, his interests include realistic image synthesis and parallel graphics algorithms.

Wm. Leler

Wm Leler received undergraduate degrees in Fine Arts and Electrical Engineering from Rice University in 1978, and a Ph.D. in Computer Science from the University of North Carolina in 1987. He teaches animation, advanced compute graphics, and parallelism at the Oregon Graduate Institute of Science and Technology. He was employed until February 1990 at Cogent Research, Inc. in Beaverton, Oregon, where he worked on a parallel window system based on Postscript, parallel rendering techniques, and a distributed version of the UNIX operating system based on the Linda paradigm. He is the author of the book *Constraint Programming Languages, Their Specification and Generation.*

Doug Voorhies

Doug Voorhies graduated from Yale(BSEE '69) and has pursued a 20 year technical career in industry which has spanned a wide range of fields. These have included FORTRAN applications programming at Allen-Bradley, Computer Science research at MITRE, CPU design at Prim, PC word processor software at Leading Edge, graphics hardware architecture at Interwork, plus simulation hardware and graphics hardware architecture at Apollo. Most recently, he was responsible for the graphics hardware for Apollo's DN10000VS high-end workstation. He is an author of SIGGRAPH papers entitled "Virtual Graphics" (1988) and "The Rendering Architecture of the DN10000VS"(1990).

Scott Whitman

Scott Whitman is a Ph.D. candidate in the Computer and Information Science Department at The Ohio State University with an expected graduation date in 1990. He has been a graduate research assistant with the Ohio Supercomputer Graphics Project since 1986, developing high performance graphics renderers for various advanced architectures such as the Convex C-1, Cray X-MP, and BBN Butterfly GP1000. Previously, he worked at Cranston-Csuri Productions and Evans & Sutherland as a computer graphics programmer. He has a M.S. in Computer Science from The Ohio State University and a B.S. in Applied Mathematics-Computer Science from Carnegie-Mellon University.

Topics

I. Introduction/Scott Whitman

II. Programming Parallel Computers for Graphics/Wm Leler

- A. Benefits of parallelism
- B. Sources of parallelism
- C. Amdahl's Law
- D. Parallel architectures
- E. Parallel programming models
- F. High level programming models
- G. Linda
- H. Examples

III. Issues and Algorithmic Techniques for Parallel Display Algorithms/Scott Whitman

- A. Ray tracing on distributed memory parallel computers
  - 1. Data partitioning schemes
  - 2. Ray dataflow approach
  - 3. Object dataflow approach
- B. Graphics rendering on shared memory multiprocessors
  - 1. Shared memory methodologies
  - 2. Data non-adaptive approach
  - 3. Locally cached memory methodology
  - 4. Data adaptive approach
  - 5. Task adaptive approach
- C. Conclusion

IV. High Performance Graphics in Hardware/Doug Voorhies

- A. Overview of problem
  - 1. Need for power
  - 2. Parallel methods in hardware
  - 3. Shared memory access
- B. Products
  - 1. HP Turbo VRX
  - 2. Apollo DN10000VS
- C. Future Directions
  - 1. Animation & modelling

Schedule

	TIME
I. Introduction (Speaker - Scott Whitman)	8:30-8:45
II. Programming Parallel Computers for Graphics (Speaker - Wm Leler)	8:45-10:00
BREAK	10:00-10:15
III. Issues and Algorithmic Techniques for Parallel Display Algorithms (Speaker - Scott Whitman)	10:15-11:30
IV. High Performance Graphics in Hardware I (Speaker - Doug Voorhies)	11:30-12:00
LUNCH	12:00-1:30
V. High Performance Graphics in Hardware II (Speaker - Doug Voorhies)	1:30-2:15
VI. Parallelism in the IRIS PowerVision Graphics System (Speaker - Kurt Akeley)	2:15-3:30
BREAK	3:30-3:45
VII. Parallel Rendering Applications on Graphics Superworkstations (Speaker - Dan Baum)	3:45-5:00

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