History of Computer Graphics at Utah

1. David Evans (Ivan Sutherland)
   - Founded CS Dept at the U of I in 1968
   - Ivan Sutherland - Turing award
   - Founded Evans & Sutherland Company

2. Nolan Bushnell
   - Invented Pong
   - Founded Atari

3. John Warnock
   - Worked at Evans & Sutherland
   - Founded Adobe
   - Hidden Line Removal Algorithm
   - Helped invent Postscript @ Adobe

4. Tom Stockham
   - Known for work in Signal Processing
   - Helped to invent the CD player

5. Ed Catmull
   - Worked at Lucas Film
   - Co-Founded Pixar
   - President of Disney Animation Studios
   - Chair of CoE External Advisory Board

6. Alan Kay
   - Personal Computer
   - Turing Award Winner
   - Object Oriented Languages

7. Jim Kajiy
   - VP Research at Microsoft

8. Jim Clark
   - Founded SGI, Netscape, Healtheon
   - Work in Geometry Pipelines

9. Jim Blinn
   - Invented Blinn-Phong Shading Model

10. Henri Gouraud
    - Invented Gouraud Shading Model

11. Allen Ashton
    - Word Perfect
    - My CFO Founder

12. Bui Tuong Phong
    - Invented Phong Reflection and Shading Models

www.cs.utah.edu
SCI Institute Faculty
Research Centers We Direct

NIH/NIGMS Center for Integrative Biomedical Computing

Center for Extreme Data Management, Analysis, and Visualization

CEDMAV

Utah Center for Neuroimage Analysis

UTAH Center for Computational Earth Sciences
Research Centers We are Affiliated With

SDAV
Scalable Data Management, Analysis and Visualization

NIH NAMIC

IAMCS
Institute for Applied Mathematics and Computational Science

www.citeseer.edu
FOR IMMEDIATE RELEASE:

NVIDIA RECOGNIZES UNIVERSITY OF UTAH AS A CUDA CENTER OF EXCELLENCE
University of Utah Latest in a Growing List of Exceptional Schools Demonstrating Pioneering Work in Parallel Computing

SANTA CLARA, CA & SALT LAKE CITY, UT—JULY 31, 2008—NVIDIA Corporation, the worldwide leader in visual computing technologies, and the University of Utah today announced that the university has been recognized as a CUDA Center of Excellence, a milestone that marks the beginning of a significant partnership between the two organizations.
Every two days we create as much data as we did from the beginning of mankind until 2003!

Sources: Lesk, Berkeley SIMS, Landauer, EMC, TechCrunch, Smart Planet
How Much is an Exabyte?

1 Exabyte = 1000 Petabytes = could hold approximately 500,000,000,000,000 pages of standard printed text

It takes one tree to produce 94,200 pages of a book

Thus it will take 530,785,562,327 trees to store an Exabyte of data

In 2005, there were 400,246,300,201 trees on Earth

We can store .75 Exabytes of data using all the trees on the entire planet.

Sources: http://www.whatsabyte.com/ and http://wiki.answers.com
Brain Information Bandwidth

sight

touch

computer network

USB key

hard disk

pocket calculator

hearing/smell

taste

amount we're actually aware of (0.7%)
Feynman: “What I am really try to do is bring birth to clarity, which is really a half-assedly thought-out-pictorial semi-vision thing. I would see the jiggle-jiggle-jiggle or the wiggle of the path. Even now when I talk about the influence functional, I see the coupling and I take this turn - like as if there was a big bag of stuff - and try to collect it in away and to push it. It's all visual. It's hard to explain.”

New Visualization Techniques
More New Visualization Techniques
Even More New Visualization Techniques
Watson and Crick - DNA

James Watson and Francis Crick - 1953
Nobel Prize - 1962
X-ray diffraction data from Maurice Wilkins
and Rosalind Franklin
Mario R. Capecchi, Ph.D., distinguished professor of human genetics and biology at the University of Utah's Eccles Institute of Human Genetics has won the 2007 Nobel Prize in Physiology or Medicine.
Image Based Phenotyping

“Virtual Histology of Transgenic Mouse Embryos for High-Throughput Phenotyping,”
Statistics of Shape, Connectivity, and Function

- Computational Statistics in Nonlinear Spaces
- Anatomical shape averaging and variability
- Diffusion Tensor Image Analysis Autism project
- Combined PET + MRI analysis Alzheimer’s disease project
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Volume Rendering
RGB $\alpha(f, |\nabla f|, D^2_{\nabla f} f)$
Volume Rendering

1D: not possible
2D: specificity not as good

Scientific Computing and Imaging Institute, University of Utah
ImageVis3D and Tuvok

IO
- Understands various file formats including DICOM
- Reads and handles data of up to 18 EB
- Provides Bricking and LoD computations

Renderer
- Supports Raycasting and Slicing
- Supports 1D, 2D TFs, Isosurfacing, and ClearView
- Provides extensive support for older hardware

General
- Cross platform
- Intuitive and Configurable UI
- Supports multiple windows
- Open Source - MIT License
NIH Visible Male
Visible Human - High Resolution

Scientific Computing and Imaging Institute, University of Utah
The Need for High Resolution Visualization

“...the data show for the first time how detailed transport and chemistry effects can influence the mixing of reactive scalars. It may be advantageous to incorporate these effects within molecular mixing models. It is worth noting that at present it is impossible to obtain this type of information any other way than by using the type of highly resolved simulation performed here.”

Jacqueline Chen, Sandia National Laboratories
Topological Analysis of Massive Combustion Simulations

- Non-premixed DNS combustion (J. Chen, SNL): Analysis of the time evolution of extinction and reignition regions for the design of better fuels
New Parallel Topological Computations Achieve High Performance at Scale

Total & Compute+Merge Time For Rayleigh-Taylor Mixing

- Computation + I/O
- Pure Computation

Number of Processors

- Total time
- Compute + merge time
- Perfect scaling
ImageVis3D - Mobile
ImageVis3D Mobile
ImageVis3D Mobile DBS App

Introduction

Deep Brain Stimulation
DBP: Chris Butson

C. Butson, G. Tamm, S. Jain, T. Fogal and J. Krüger
FluoRender Ver 2.9

Mouse hindLimb
A. Kelsey Lewis, Human Genetics, Univ. of Utah
Parallel Rendering - Ray Tracing
Rendering Algorithms

Basic idea: modeling the physics of light

Rasterization (Z-buffer)
- Invented at U of U in 1974
- Hardware in every modern PC
- High interactivity, increasing quality

Ray tracing
- Whitted 1980
- High quality, increasing interactivity

As datasets get bigger, ray tracing is faster!
One billion polygons to billions of pixels
Welcome to the first gigapixel, multi-view rendering of The Digital Michelangelo Project's David

Scientific Computing and Imaging Institute, University of Utah
ViSUS Framework for Scalable Data
The ViSUS Parallel I/O Infrastructure (PIDX) Adopts a 3–Phase Data Transfer Model

One-Phase I/O:
(A).1 HZ encoding of irregular data set leads to sparse data buffers interleaved across processes.
(A).2 I/O writes to underlying IDX file by each process, leading to a large number of small accesses to each file.

Two-Phase I/O:
(B).1 HZ encoding of irregular data set leads to sparse data buffers interleaved across processes.
(B).2 Data transfer from in-memory HZ ordered data to an aggregation buffer involving large number of small sized data packets.
(B).3 Large sized aligned I/O writes from aggregation buffer to the IDX file.

Three-Phase I/O:
(C).1 Data restructuring among processes transforms irregular data blocks at processes P0, P1 and P2 to regular data blocks at processes P0 and P2.
(C).2 HZ encoding of regular blocks leading to dense and non-overlapping data buffer.
(C).3 Data transfer from in-memory HZ ordered data to an aggregation buffer involving fewer large sized data packets.
(C).4 I/O writes from aggregation buffer to a IDX file.
Large Scale Galaxy Simulation

Scientific Computing and Imaging Institute, University of Utah
341 Sections
90nm thick sections
~32GB/Section
~1000 tiles/section
4096x4096 pixels/tile
2.18 nm/Pixel
16.5 TB after processing
... my work, which I've done for a long time, was not pursued in order to gain the praise I now enjoy, but chiefly from a craving after knowledge, which I notice resides in me more than in most other men. And therewithal, whenever I found out anything remarkable, I have thought it my duty to put down my discovery on paper, so that all ingenious people might be informed thereof.

Antony van Leeuwenhoek. Letter of June 12, 1716
PROBLEM-DRIVEN VISUALIZATION RESEARCH for biological data

- target specific biological problems
- close collaboration with biologists
- rapid, iterative prototyping
- focus on genomic and molecular data
Genome-wide synteny through highly sensitive sequence alignment: Satsuma
Uncertainty Visualization

When is the last time you’ve seen an error bar in a 3D visualization?
Uncertainty Visualization

Surfaces imply certainty
Uncertainty Visualization

Surfaces imply certainty
Uncertainty Visualization

Surfaces imply certainty

Scientific Computing and Imaging Institute, University of Utah
Visualizing Uncertainty

Fuzzy Sensitivity Confidence

Scientific Computing and Imaging Institute, University of Utah
QuizLens: A Multi-lens approach for uncertainty exploration

- Global information important for qualitative evaluation & context
- Local information necessary for quantitative understanding
- Interchangeable lenses to explore various data characteristics
Productivity Machines
Acknowledgements

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KAUST
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