Large-Scale Visual Analysis

Chris Johnson
Scientific Computing and Imaging Institute
University of Utah
History of Computer Graphics in Utah

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

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

3. Tom Stockham
   - Known for work in Signal Processing
   - Helped to invent the CD Player

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

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

6. Jim Kajiya
   - VP Research at Microsoft

7. Jim Blinn
   - Invented Blinn-Phong Shading Model
Research Cores

Visualization

Scientific Data Management

Computing

Image Analysis
Centers We Direct

NIH/NIGMS Center for Integrative Biomedical Computing

Centers for Extreme Data Management, Analysis, and Visualization

CEDMAV

Utah Center for Neuroimage Analysis

NVIDIA CUDA Center of Excellence at the Scientific Computing and Imaging Institute

UTH Center for Computational Earth Sciences

CDE₃M
National Centers We are Affiliated With

- SDAV: Scalable Data Management, Analysis and Visualization
- IAMCS: Institute for Applied Mathematics and Computational Science
- CDC Decision-Support for Infectious Disease Epidemiology
- NIH NAMIC
- Center for Exascale Simulation of Combustion in Turbulence
Every two days we create as much data as we did from the beginning of mankind until 2003!
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

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.”

Volume Rendering
Volume Rendering

Maximum Intensity Projection (MIP)  Full Volume Rendering
Multi-Dimensional Transfer Function

\[ \alpha(f, |\nabla f|, D^2 \nabla f) \]

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Volume Rendering

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

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NIH Visible Male
Visible Human - High Resolution

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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

Lower Resolution  High Resolution
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

- Total time
- Compute + merge time
- Perfect scaling

Number of Processes

Computation + I/O

Pure Computation
Visualization of 10D Combustion Simulation of Jet CO/H2-Air Flames

10 dimensional data set describing the heat release wrt. to various chemical species in a combustion simulation
Combustion Simulation of Jet CO/H2-Air Flames

**Input:** Composition of 10 chemical species

**Output:** Temperature
One billion polygons to billions of pixels
Welcome to the first gigapixel, multi-view rendering of
The Digital Michelangelo Project's David
ViSUS Framework for Scalable Data

[Diagram showing the framework's components and dependencies.]
341 Sections
90nm thick sections
~32GB/Section
~1000 tiles/section
4096x4096 pixels/tile
2.18 nm/Pixel
16.5 TB after processing
Antony van Leeuwenhoek (1632-1723)

... 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
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

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Uncertainty Visualization

Surfaces imply certainty

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Topological Uncertainty

Figure 6: Increasing the uncertainty of a random vector field: a) certain topology of mean vector field; b) $\|T\|_F = 0.2$; c) $\|T\|_F = 2.0$; d) $\|T\|_F = 5.0$.

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
The SCI Institute
Productivity Machines
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www.sci.utah.edu

crj@sci.utah.edu