Visualization Techniques for Big Data on Big Displays

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and a whole bunch of graduate students
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Electronic Visualization Laboratory, UIC

- Established in 1973
- Co-directors: Tom DeFanti, Dan Sandin, Jason Leigh
- 10 staff, 15 related faculty, 45 students (50% Art and CS)
- Main areas of research: advanced display systems, visualization, high speed networking, and collaboration tech
- Funded mainly by NSF and DoE
- Additional funding by Microsoft, NTT, General Motors
CAVE and ImmersaDesks

- 1992 - developed the CAVE
- 1995 - developed the ImmersaDesk
- 2001 - over 500 CAVEs & IDesks around the world
CAVE + Networking + Computation

- EVL’s history has been in building Infrastructure
  - Visualization Devices - CAVE and ImmersaDesk, newer devices such as GeoWall, GeoWall-2, Varrier
  - High Speed Networks - STARTAP, StarLight
- Allows us to do collaborative work
Motivation for Collaboration

- Olson & Olson – Michigan
- Study of 9 project rooms
- Comparison of these groups with norm showed performance well above corporate average (doubling for software design case)
- How do we amplify these benefits and support distributed teams using modern collaboration technology?
The Continuum at EVL

- Collaborative passive stereo display
- Collaborative Tiled Display
- AccessGrid multisite video conferencing
- Collaborative touch screen whiteboard
- Wireless laptops & Tablet PCs to steer the displays
2 More Continuum Spaces

- 2nd Continuum Room at EVL allows us to do user studies conveniently, and to participate in multiple events simultaneously.

- Continuum Space at TRECC at DuPage County airport west of Chicago in Illinois.
Newer Display Devices

- Based on experiences with the CAVE and ImmersaDesk, but taking advantage of increased power of commodity workstations and graphics cards

- 2000 - GeoWall - sub $10,000 passive stereo display
- 2003 - GeoWall 2 - high resolution tiled LCD display
- 2004 - Personal GeoWall 2 - passive stereo + LCDs
- 2004 - Varrier - auto-stereoscopic tiled LCD display
- 2004 - LambdaVision - 100Mpixel tiled LCD display
• Geoscientists have a lot of 3D visualization needs
• Over 300 in use for research & education in the Geosciences
• Portable, made from off-the-shelf components
• Supported by NSF
• Hardware info & open source software at www.geowall.org
The GeoWall Consortium

• Provides open source software and data sets for Windows, Linux, Mac to Geoscience researchers and educators
• Integration into Univ. Michigan, Minnesota and Arizona State curriculum-25% of non-major undergraduate geoscience students now use GeoWall
• Deployment at various museums around the country e.g. Adler, SciTech
GeoWall 2

- Geoscientists also have high resolution visualization needs
- 5x3 LCD tiles, 1600x1200 per tile, 8000x3600 total
- Driven by 10 Linux PCs
- Shows detail and context at same time
Scientific Need for High Resolution

- **US Geological Survey**
  - 51TB of aerial photos
  - 133 cities of the US at 1 foot/pixel resolution
  - 365,000 x 365,000 pixel maps
  - Each city distributed on 1 or 2 firewire drives

- **Core Lab (Geology / Oceanography)**
  - 300 km of core samples, scanned at 1200dpi

- **NCMIR** (National Center for Microscopy and Imaging Research)
  - Rat Cerebellum Map
  - Montage of 43,200 images
  - 4,000 x 4,000 pixels sensor (soon 8k x 8k)
USGS red/blue Stereo Topographic Map
Looking for Correlations

• Tile displays are also good for viewing and manipulating multiple related images at the same time to look for correlations.
Rat Cerebellum Microscopy (NCMIR)
Seismic reflectivity across East Pacific Rise
Personal GeoWall 2

- Combines ability to do GeoWall passive stereo and a high-resolution 4-tile display in a single shuttle PC
- Installed one on IRIS core drilling ship in September
Varrier - Auto-stereoscopic Display

- Also working on getting rid of the glasses for seeing stereo
- Can do this with some laptops now, but lose resolution
- We gain resolution back by using many LCD panels
- Works like a 3D baseball card
- We use camera tracking to find user and then draw the graphics for that user’s viewpoint
LambdaVision: > 100,000,000 pixels
LambdaVision: 100Mpixels

- 11x5 21” 1600x1200 LCD tiles
- 30 dual AMD Opteron 2Ghz nodes
- 2 LCD screens per Quadro 3000 graphics card
- 250 GB local storage - 1.5TB shared storage
- 10Gigabit/s interfaces
- Supported through NSF MRI (EVL’s 4th)
- Still show less than 0.1% of the Chicago aerial photography at full resolution
SAGE: Scalable Adaptive Graphics Environment

- Multiple simultaneous apps on the display
- Controlled from Tablets, Laptops, etc allows local control and casual sharing
- Networked rendering resources
- Rendering decoupled from the display
- Designed for data fusion among distributed work groups
SAGE: to Manage Content on Tiled Displays

Scalable Networked Frame Buffer
(LambdaVision Display)

Visualization Broker
Distributed Rendering Resources
(Visualization Clusters)
Streaming graphics

FreeSpace Manager informs each rendering resource where to stream its graphics when windows are moved or resized.
Adaptive Rendering

• Adapt to the display client
  – Laptop, high-resolution monitor, tiled display

• Networked rendering
  – Leveraging existing infrastructures

• Adapt to output resolution
  – “resize” and “move” events
  – Pixel up-scaling or down-sampling
  – Increase rendering resolution
Pixel Sources

• Visualization applications
  – Software rendering
  – Hardware rendering
• Legacy applications
  – Remote desktop protocols (RDP, ARD, VNC)s
  – TeraVision
• Video streaming
SAGE Primitives

• Currently
  – Everything is pixel based
  – RGB uncompressed

• Future
  – Color + depth
  – Compression
  – Screen updates (Digital Video Pack Link ?)
  – 3D primitives
    • Polygons, 2D and 3D textures, …
The OptIPuter Project –
Removing Bandwidth as an Obstacle In Data Intensive Sciences

- NSF Large Information Technology Research Proposal
  - UCSD and UIC Lead Campuses—Larry Smarr PI
  - USC, UCI, SDSU, NW, TA&M Partnering Campuses
- Industrial Partners: IBM, Sun, Telcordia/SAIC, Chiaro, Calient
- $13.5 Million Over Five Years
- Optical IP Streams From Lab Clusters to Large Data Objects
Current Progress

• Demo at Supercomputing, AGU
Summary - Overview

• Leveraging our experience with advanced displays, networks, and collaborative applications
• Working with real users with real big data needs
• Conduct human factors studies
• Develop new immersive display technology
• Developing open-source software designed for these displays
Summary - SAGE

- Decoupling of rendering and display
- Adaptive to various displays
- Network-centric environment
- Research issues
  - Data management and retrieval
  - Human-computer interaction
  - Remote Collaboration
  - Adaptive rendering techniques
Thank You

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