HPC Bootcamp 2010: Visual Computing

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Thursday Outline

• “Visualization”
• Deep Media Tour
• VT Resources
  – break
• Principles of Perception
  – lunch
• Tools: Paraview
  – break (*)
• Tools: Visit +
Visualization

• A Core Competency for this century’s scientist:
  – Drives hypothesis generation, analysis, **insight**
  – Enables communication, collaboration
• Understanding data requires exploration, search, comparison and pattern recognition
• Larger and more complex systems require tools with computational and cognitive scalability!
Human Vision

- Highest bandwidth sense
- Fast, parallel
- Pattern recognition
- Pre-attentive
- Extends memory and cognitive capacity
  - (Multiplication test)
- People think visually
- Brain = 8 lbs, vision = 3 lbs

Impressive... Let's use it!
A Definition

• Generally:
  – The use of computer-supported, interactive, visual representations of data to amplify cognition
  Card, McKinlay and Schneiderman

  – Scientific Visualization
  – Information Visualization
  – Virtual Environments
Visual Thinking

• Many of the great scientists were good at visual thinking:
  – Leonardo da Vinci
  – James Clerk Maxwell
  – Michael Faraday
  – Albert Einstein

• This was often at the expense of verbal skills

• Tom West : “In the Mind’s Eye”
  – See also http://www.krasnow.gmu.edu/twest/maxwell_visual.html

Maxwell’s clay model now in New Cavendish Laboratory, Cambridge (picture by Tom West)
The Big Problem

Data

Human

Data Transfer

How?

“! GROK!” (Eureka)

Data

Vision
Aural
Smell
Haptics
Taste
Goal

Data transfer
(learning, knowledge extraction)
**Method**

Data → Data transfer → Insight

- Map: data → visual
- Visual transfer (communication bandwidth)
- ~Map⁻¹: visual → data insight
Visual Mappings must be:

- Computable (math)
  \[ \text{visual} = f(\text{data}) \]
- Comprehensible (invertible)
  \[ \text{data} = f^{-1}(\text{visual}) \]
- Creative!
Visualization Overview

Figure 2.1: Processing in a typical visualization pipeline (from Card et al, 1999)
Visual Encoding Examples

Sci Vis

• Spatial substrate
• Visual ‘marks’
  – Visual properties
  – Time-varying
Visualization

• An instrument / tool to
  – look at your data and see things otherwise hidden...
  – Amplify Cognition

• 3 key stages:
  – Transforming data
  – Encoding data
  – Delivering / Rendering
Deep Media Tour

- Web3D & ISO Technology
- Web3D & ISO Applications
- Emerging Paradigms
Once upon a time
The ISO Standard for 3D on the Web

“X3D enables the communication of real-time 3D across networks and XML-based web services”

Shared worldwide

Shared between applications

Shared between systems

Lasts the Test of Time

Royalty-free Open source
Open Standards

www.web3d.org

• Portability
• Durability
• IP independence
• International recognition and support
Adoption
Foundations

- ISO standard, openly published and royalty-free
- A layer above media and rendering libraries
- Multiple implementations including open source codebases
- X3D Scene graph includes the *Transformation graph* and the *Behavior graph*
Standard Scope

Scene graph for real-time interactive delivery of virtual environments over the web:

- Meshes, lights, materials, textures, shaders
- Integrated video, audio
- Animation
- Interaction
- Behaviors
- Scripts
- Application Programming Interfaces

- 3.3 examples for Medical Imaging, CAD and Geospatial support!
The Scene graph

• De-constructing Reality to re-construct it in a computer ... and present it interactively
• Provides a layer of abstraction above multimedia formats and rendering libraries
• Efficient traversal for manipulation and drawing
• A data representation (Directed Acyclic Graph, DAG) which includes a
  – Transformation graph and a
  – Behavior graph
Standardized Scenegraph

- **Extensible 3D (X3D):**
  - ISO spec suite describing 4D assets, behaviors and interactive scenarios (scene graph)
  - Extensible: Profiles aggregate Components
  - Multiple Encodings and APIs
- **Efficiency:** Binary encoding, compression
- **Fidelity:** double precision floats
- **Portable:** Hardware & Platform Independent
- **Interoperable:** WWW, Semantic web, ...
- **Durable:** archive-quality format
- **Proven:** Network-aware, Enterprise-ready, Royalty-free
Source of Specs, Models, Links, Bulleting boards, Blogs, Mailing lists, ...

http://www.web3d.org
SIGGRAPH 2010

• N-D Presentation States
• Volume Rendering Component
Perspectives on Web3D

Content publishing:
• Delivery by existing stand-alone app or plug-in
  – See: http://legacy.caus.vt.edu/setareh/archresearch/Module_2/How_to_X3D.html

Application Development:
• Integrate a run-time engine into your application (numerous SDKs and codebases)
Web Integration Historically

• A URL/URI resource a piece of 4D content
• Objects, Worlds and media are aggregated with Inlines and connected with Anchors
• Worlds can be dynamically built and served (e.g. Web 2.0)
• Worlds can also be included inside HTML pages with <Object> tag and runtimes connects (ecmascript/ajax, Java, ...
Tool Independent Workflow

Data or Content Authoring

Robust ISO Standards

X3D Browser & Scene tools

Rich Media 3D Applications

3ds max
Maya
Blender,
...

Simulation

Generate

Export

Convert

X3D & VRML

Publish

Contact

Vivaty

Octaga

Xj3D

Instant Reality

...

Simulation
Explore!

Open up new worlds on the web!

(examples w/ Instant Player)

One place to start now:

http://people.cs.vt.edu/~npolys/IT/2010_bootcamp
Emerging Paradigms

Online, Multi-User Collaborative Spaces
Web Browser Evolution

- Stand-Alone ->
- Plug-in ->
- Native Support via
  - WebGL (ES)
  - Optimize ECMA script
  - www.X3dom.org
  - HTML 5

In dev builds of:
- Mozilla
- Chrome
- Safari
- Opera
- ...?
Delivery to Mobiles

Hardware and software profiles are a moving target, but:

• Also expect rendering on top of OpenGL ES
• Likely includes HTML 5 too
• X3D apps on iPhone, Android now (e.g.):
  – Raygun (www.planet9.com)
  – InstantPlayer port
  – …
Remote Cluster Rendering

- Data is too BIG!
- Must analyze *in situ*
- A paradigm reflected in the National Labs, DOE, NSF
- Interactive and Batch sessions possible
- ... Athena !, HokieSpeed !
- GPUs can also be used for general computation (e.g. CUDA, OpenCL)
Virginia Tech ARC Resources

Visual Computing

• Developing new website, currently at:
  – http://Snoid.sv.vt.edu
  – New Immersive Theater (VisCube) available in Visionarium Lab this month!
  – Athena Vis services rolling out this semester
Visual Computing Group

Provide staff to:

• Consult with researchers about applications of visualization technology
• Train faculty and students on how to use, develop, and demo visualization equipment
• Develop visualization solutions for domain experts / HPC users
• Develop additional grants and funding streams with domain experts to include visualization tools and HPC
Visual Computing Group

- Provide ‘World-Class’ visualization facilities for university researchers, faculty, and students
- Build cutting-edge software stack for domains, emphasizing content portability and ease-of-use
- Deploy visualization web services middleware to HPC systems
- Build and maintain online multi-user collaborative spaces
- Upgrade and proliferate display hardware for speed, resolution, and brightness
Facilities / Labs – VT ARC

- **VT Visionarium** (TORG 3050)
  - Immersive Theater (VisCube) w/ tracking
  - Stereo wall w/ tracking
  - Stereo TV (65”)
  - MultiTouch Screen (52”)
  - Video Conferencing
  - lab machines

- Other depts have stereo walls (architecture, art, civil engineering, geo)
Software Stack

Support for many data & disciplines:

• X3D/VRML
• CFD
• CAD
• Architecture
• Molecular Dynamics
• DIVERSE VR (Win, Mac, Linux)
• ... documentation available!
Faculty & Student Training

• FDI classes in Visualization Technology & production skills 6-session track run in spring, 2 x 2-session tracks in fall; summer Bootcamp/FDI

• VisCube & Vis Equipment training
  – Operation of, development for
  – Documentation online
  – Free, open to faculty, grad, undergrad
  – by appointment
BREAK