Virginia Tech (VT): Ut Prosim

- A land-grant University serving the Public Good
- *Science* and the *Reproducibility* of Research is a core mission
- Investments in a broad spectrum of digital content and access:
  - Simulation
  - Analytics
  - Capture (i.e. scanning)
  - Design
  - Archival and sharing
- International Standards provide: interoperability, accessibility, and durability - the basis for a long-term strategy
VT Advanced Research Computing
VT Dept. of Computer Science

- [www.cs.vt.edu](http://www.cs.vt.edu)
Missions and Mandates

“... to develop qualitatively the Library's universal collections, which document the history and further the creativity of the American people and which record and contribute to the advancement of civilization and knowledge throughout the world, and to acquire, organize, provide access to, maintain, secure, and preserve these collections.”
Mandates

On the National Archives building:

“This X holds in trust the records of our national life and symbolizes our faith in the permanency of our national institutions. “

Smithsonian:

“The increase and diffusion of knowledge.”
Our Job:

• **The Public Record: Durability**

• **Public Money: Access**

• **Navigate technology trends and economics with the ‘long view’**
Something in Common?

Vis.arc.vt.edu
Instantreality.org
3dprint.nih.gov
Durability

Long-term Stewardship:

* The US and UK National Archives recommend the ISO-IEC X3D format!
VirtuWorlds™ Giza
(1998 ----> 2018!)

Early explorations into Web3D and Virtual Reality:

- Epistemology
- Metaphysics
- The Web
- Archival 3D
Open Standards

www.web3d.org

- Durability
- IP independence
- International recognition and support
- Portability
Web3D.org & WG introductions

**Enterprise 3D (X3D):**

ISO-IEC formats and API:

- Royalty-free, open X3D holds:
  - Volumes, meshes, appearances, text, metadata
  - Lights, cameras
  - Animation, interaction
The X3D ISO-IEC Standards

Demonstrated compatibility:

• Interactive 3D graphics
• Lossless metadata travels with the asset
• Data Assurance and Security with W3C’s XML Encryption and Authentication
• Semantic Web3D
Access... For all
The Web Is the Interface
3D Everywhere

- Workstations
- High-Resolution projection
- WWW
- Web3D
  - Mobile
  - WebVR (HMDs)
- Device-specific interaction
Lesson 1: Things Change

A lifetime of 3D ... ‘Mission-critical data’

- Requires durability longer than Silicon Valley cycles and market hype
- Requires IP and provenance for public records
- Emerging technologies and Access
  - VR
  - AR
  - ...
Industry Standards unify communities
ISO-IEC

Creates and ratifies specifications into International Standards through their National bodies:

• Experts around the world review and approve
• Proven process for global cooperation
• Proven value for governments, citizens, and industry
ISO-IEC Web3D Standards Evolution

Durability of 3D information across industry epochs:

- 1994: VRML 1.0
- **1997**: VRML 2.0
- 2002: VRML 2.1
- 2005: X3D 3.0
- 2006: X3D 3.1 ; H-Anim 1.0
- 2008: X3D 3.2
- 2013: X3D 3.3
- 2018: H-Anim 2.0

**Encodings:**
- XML,
- utf8,
- binary,
- JSON

**Bindings:**
- Javascript,
- Java,
- C#,
- C++, C,
- Python
The Way Forward

**Archival 3D: Fulfill the mandate**

- Procurements require ISO-IEC standards conformance and deliverables (e.g. X3D)
- Invest in extensible, open software platforms to guarantee application-specific needs
- Invest in improving the Standards themselves for increased capability
Web3D 2019

24th Annual ACM SIGGRAPH Conference

Los Angeles, USA

July 26-28: Co-Located w/ SIGGRAPH

In Cooperation with

Eurographics and the Web3D Consortium
Contact!

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Appendix

More info~!
ISO-IEC 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!
Web3D members are making this happen
Adoption
3D Information throughout the Web

– Websites (have) become Web applications

– Increasing interest in 3D for
  • Product presentation
  • Visualization of abstract information
  • Experiencing Cultural Heritage data
  • Supporting decision making, e.g. in Virtual Engineering

– Enhancing user experience with more sophisticated visualizations
  • Yesterday: Flash-based site with videos;
    Today: Immersive 3D inside Browsers
4D: a first-class citizen

What’s new?

- Networked 3D digital assets
  - Objects and components
  -Appearances & materials
  - Environments
- Animation and Timeseries databases
- Metadata & web-aware referencing
- Interaction semantics
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*
Source of Specs, Models, Links, Bulleting boards, Blogs, Mailing lists, ...

http://www.web3d.org

- http://www.web3d.org/getting-started-x3d
- http://www.web3d.org/hack-web3d-vr
X3D Book & Online Resources

- http://www.x3dgraphics.com/

From NPS grad class – slides, videos, examples all online!!!
X3DOM – Declarative (X)3D in HTML5

2D
(Final HTML5 spec)

Declarative
Scene-graph
Part of HTML document
DOM Integration
CSS / Events

3D
(No W3C spec)

Imperative
Procedural API
Drawing context
Flexible

<canvas>
3D Blacksburg

- n-D City model
- Enterprise scale GIS infrastructure
- International standards:
  - Web3D (X3D)
  - OGC (Sensor Web)
- Integrates sensor feeds and crowd-sourced content
3D Blacksburg Mirror World
Town & Building LODs

X3D
shared
multi-user
VT Campus

X3D Immersive
Abstracting Rendering Layer with Scene Graphs

**Extensible 3D (X3D)**

- Refactored VRML descendant - new features, multiple encodings (XML, binary, utf-8)
- Open ISO-Standard Scene graph

**X3DOM, x_ite**

- Profile of X3D integrating with W3C infrastructure (HTML5, CSS, DOM)
- Liberal Open Source (Javascript / WebGL)
OpenGL + GLSL on the Web: WebGL

- JavaScript Binding for OpenGL ES 2.0 in Web Browser
  - → Firefox, Chrome, Safari, Opera
- Only GLSL shader based, no fixed function pipeline
  - No variables from GL state
  - No Matrix stack, etc.
- HTML5 <canvas> element provides 3D rendering context
  - `gl = canvas.getContext('webgl');`
- API calls via GL object
  - X3D via X3DOM framework
  - http://www.x3dom.org

Overview of X3D

The eXtensible 3D Graphics and Visualization Markup Language, or X3D, is an open standard for 3D content delivery using XML. It is a language for authoring 3D scenes, 3D worlds, and 3D virtual environments. X3D is an active development project of the Virtual Reality Group at California State University, Northridge, and is maintained by the X3D Consortium, an international, non-profit organization.

X3D is designed for use in a variety of applications, including VR, simulation, animation, and rendering. It is a markup language that can be used to create 3D content, and can be viewed in a web browser with WebGL support.

X3D supports a wide range of 3D rendering techniques, including geometric modeling, rendering, and animation. It also supports a variety of data formats, including binary and XML.

X3D is an open standard, and is maintained by the X3D Consortium. The consortium is open to anyone who wishes to contribute to its development. X3D is available under an open-source license, and is free to use for both commercial and non-commercial purposes.

Advanced Research Computing

Invent the Future
X3DOM Example 1: Interactive Car Configurator

Interaction via standard Web technologies (e.g. JavaScript Events etc.)

Click on `<img>` element…

```html
document.getElementById('body_color').setAttribute("diffuseColor", '#000066');
```

…causes attribute change of `<texture>` url (i.e., other wheel rims appear)

Part of DOM/HTML document like every other HTML element (e.g. `<p>`, `<img>` etc.)
X3DOM Example 2: Painting Textures of 3D Objects

<x3d> element
Part of DOM/HTML document like every other HTML element

(JavaScript implementation based on new WebGL API of HTML5 <canvas> element)

HTML5 <canvas> element
Painted image used as texture on 3D object

jQuery UI (User Interface)
jQuery JavaScript library: http://jqueryui.com/
X3DOM Application (Large Data and Picking): 3D-Internet Design Review

Maximum Visualization
- Whole car incl. modules and parts (60%)
- Whole car incl. modules (20%)
- Modules with parts (20%)
- Only parts (42%)

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Invent the Future
X3DOM Application Integration: Virtual Engineering and Cultural Heritage on the Web
Other X3DOM rendering effects

- `<directionalLight direction='0 0 -1' intensity='1' shadowIntensity='0.7'></directionalLight>`

- `<fog visibilityRange='1000'></fog>`

- `<imageTexture url="myTextureMap.jpg"></imageTexture>`

  - Note: like `<material>` only as child node of `<appearance>` possible!
X3DOM Benefits

- **Development costs**: Web developer vs. graphics expert
- **Adaptability**: Declarative material abstraction allows shading adoption per client hardware (e.g. GLSL, ray-tracing...)
- **Efficiency**: UI events, culling, rendering can be implemented in native code, thus utilizes battery resources efficiently
- **Accessibility**: High level navigation and interaction styles allow very late adaptations for specific use cases
- **Metadata**: Allow indexing and searching content
- **Mash-ups**: Asset reuse in new context
- **Security**: No plugins or even direct GPU calls necessary