IEEE VR 2020
X3D Quick Start: Authoring

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X3D Tutorial Outline

Technology Overview

Ecosystem

Break

Applications: VT, Navy, NIH, 3DMD, ...

Authoring
X3D Scene graph

Resources & International Community

www.web3d.org


Book:

http://x3dgraphics.com/

Online Slides: http://x3dgraphics.com/slidesets/index.php

Online Examples: http://www.web3d.org/x3d/content/#Examples
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!

https://www.web3d.org/standards
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*
A Text Editor!

- Command line - some files may be zipped
- XML-enforcing editors can be handy
- Atom- has an http server extension for quick Web development
Scene Graph

- Lives above the rendering library
- Specifies object and environmental properties:
  - Lights
  - Camera
  - Transformation and Grouping of Shapes (parent - child)
  - Geometry and Appearance (materials, textures, shaders)
  - Environmental effects (e.g. Fog, Backgrounds)
- Manifests animation and interaction behaviors
- Is 'traversed' for drawing
Extensible 3D (X3D)

- Components and Profiles collect a structured nodeset (scene graphs)
  - Geometry, appearance, lighting
  - Animation, multimedia (sound, video)
  - Interaction and application logic
- File format with multiple encodings: XML, UTF8, Binary, JSON
- Runtime API for a Unified Object Model with multiple programming language bindings (JavaScript, Java, C#, C++, Python, ...)
- Widespread support through multiple commercial and open-source engines and VRML heritage
- ISO-IEC Standard
NIH - from PDB

COVID

https://3dprint.nih.gov/discover?terms=covid&field_model_category_tag_tid%5B%5D=94&uid=&field_model_license_nid=All&sort_by=created&sort_order=DESC&items_per_page=24

Corona

https://3dprint.nih.gov/discover?terms=corona&field_model_category_tag_tid%5B%5D=94&uid=&field_model_license_nid=All&sort_by=created&sort_order=DESC&items_per_page=24
Tons of Tools...

- Blender
- MeshLab
- 3DS Max
- Maya
- Rhino
- Paraview
- Agisoft
- ARCSene
- Creoform
- PointFuze
- ...

- Titania (Linux)
  http://create3000.de/
- X3D-Edit
  https://savage.nps.edu/X3D-Edit/
- AOPT (w/ InstantPlayer)
- XML & stylesheets
- ...

export me!

- 3DPrint Exchange
  https://postgis.net/
- POSTGIS
- ...
- Okino Polytrans
- Safe Software
- ...
- ...
Scientific Visualization Workflow

Digital simulation results: CFD, FEM, PDB Protein data bank

Post-processing Tool

other

X3D

X3D xml

HTML

X3D Browser

Web Server

3D Printing

ParaView

For GIS, PostGIS allows to export geometry as X3D files
Lots of tools export:

- Virtual Reality Modeling Language (VRML)
- Extensible 3D (X3D)

... lots of other proprietary formats; can be converted with commercial translation tools, open source tools, or your own Scripts!

**Target X3D Profiles and Components for different node sets**

*functionality*
X3D & VRML Scene Graph

- Transformation
  - Directed Acyclic Graph
- Worlds by URL#Viewpoint
- Bind-ables
  - NavigationInfo {} ... modes: WALK, FLY, EXAMINE, ...
  - Default to lexical order
  - Modifiable through Script and SAI / EAI
  - Background, Fog,
  - Viewpoint
Behavior Graph

- How events flow through the system
  - ROUTEs
- The 'Event Cascade' per timestep / frame
  - Animations (keyframe)
    - Interpolators
    - Sequencers
    - Timesensor
  - Interactions
    - ROUTE sensors to Event Utilities
    - Or write a Script {} to process events w logic
Lights

- Have attributes:
  - position, orientation/direction, on/off, intensity, color, range, attenuation, ...
- DirectionalLight
- PointLight
- Spotlight
- Scoping rules
  - Siblings
  - global
Cameras

- Binding Stack
  - Current at top
  - Forward and Back in the Stack (Pg-Up, Pg-Dn)
  - Listed in Browser
  - Scripted

- Viewpoint: perspective camera
- OrthoViewpoint: orthographic camera
Transformation & Grouping

- Transform
- Group
- LOD
- Switch
- Billboard
- Collision
- Anchor

(a 4x4 matrix multiply)

Scenegraph scopes lights and sensors
Shapes

Consist of geometry and appearance data:

- Material, ImageTexture, **Shaders**
- **Primitives** (Box, Cone, Cylinder, Sphere)
- ElevationGrid, Extrusion
- IndexedFaceSet, IndexedLineSet
- PointSet
- **Carries** Color, Normals, Coordinate, indices
- ‘ComposedGeometry’ component includes triangle fans and strips
Environment nodes

Bindables:
- BackGround
- TextureBackground
- Fog
- LocalFog
Shaders etc

X3D 4.0 PointProperties demo (las2x3d.py)
http://metagrid2.sv.vt.edu/~yansh93/catawba_pp.html

Volumetric Video
(category winner from VRHackathon 2018, Poznan)
http://metagrid2.sv.vt.edu/~npolys/WebVR_2018/example.html
Animation

- Keyframe or Scripts
- Keyframes:
  - Interpolators
  - Sequencers

ROUTE TimeSensor.fractionChanged to *Interpolator key

ROUTE *Interpolator keyValue to node’s field

For each field type you want to animate: position, orientation, scalar, integer, color, coordinate
Sensors

- Pointing & Dragging Sensors (Touch, Plane, Cylinder, Sphere)
- Environmental Sensors (Proximity, Visibility, Collision)

see:

https://www.web3d.org/x3d/content/examples/Vrml2Sourcebook/Chapter09SensingViewer/index.html

https://www.web3d.org/x3d/content/examples/ConformanceNist/
Scripts

- Add logic and processing for the runtime (uses the **Scene Access Interface (SAI)** binding inside the scene or externally)
  - [https://x3dgraphics.com/examples/X3dForWebAuthors/#Chapter09EventUtilitiesScripting](https://x3dgraphics.com/examples/X3dForWebAuthors/#Chapter09EventUtilitiesScripting)
  - [https://www.web3d.org/x3d/content/examples/Vrml2Sourcebook/#Chapter30Scripts](https://www.web3d.org/x3d/content/examples/Vrml2Sourcebook/#Chapter30Scripts)
  - [https://www.web3d.org/x3d/content/examples/ConformanceNist/Miscellaneous/Script/index.html](https://www.web3d.org/x3d/content/examples/ConformanceNist/Miscellaneous/Script/index.html)

- Process device streams and 3DUI Logic
Physics & HANIM in X3DOM


THANKS TO

http://www.medialab.teicrete.gr/
Typical VR Workflow

1. CAD
2. 3DS-Max
3. X3D
4. OpenCOVER

X3D Tutorial
CAVE2@CalIT²

- 70 4k TVs
- Running COVISE
- And CAL-VR

- PDB-Plugin
- PDB
- PyMOL
- VRML97
- OpenCOVER
Stuttgart21

- Reinforcement planning
- Constructability
- Safety

X3D Tutorial
Architecture BIM

Adidas

New office building at Herzogenaurach

Architect: Behnisch Architects
Construction: Ed. Züblin AG

X3D Tutorial
Thyssen Multi

New Cabin Design
• Lightweight
• Carbon fibre body
• User interface
Scripts can build X3D Scene Graphs

- Build an X3D file with scripts (perl, python, ...)
  - Read a CSV
  - Re-project GIS
  - Pointclouds
  - ...
- Build the scenegraph at runtime with Scripts
  - Java, Javascript
  - DOM
  - JSON
X3D from Python in Jupyter Notebooks
Volume Data
X3D Volume Rendering

Videos:

- DICOM, NRRD, TIFF:
  - [https://www.youtube.com/watch?v=ml7zfrH6A9U&t=37s](https://www.youtube.com/watch?v=ml7zfrH6A9U&t=37s)
- Segmentations and Interaction Mashup:
  - [https://www.youtube.com/watch?v=Z03jWjW9soE](https://www.youtube.com/watch?v=Z03jWjW9soE)
- Cell images with corresponding surfaces:
  - [https://www.youtube.com/watch?v=srpiEBvbG-Q&list=UUoQkIQuVbdKEBqgefLbhzw](https://www.youtube.com/watch?v=srpiEBvbG-Q&list=UUoQkIQuVbdKEBqgefLbhzw)
- Many publications
More

X3D Volume Rendering
Example Volume Rendering Styles

(Head MRI, XML encoding)

<Transform DEF='backdrop'>
  <VolumeData dimensions='751 1'>
    <ImageTexture3D containerField="voxels" url="./Segments/masked-vispart.nrrd"/>
    <OpacityMapVolumeStyle/>
  </VolumeData>
</Transform>
Example Volume Rendering Styles

(Head MRI, optic segment)
<ISOSurfaceVolumeData surfaceValues='1.15' dimensions='75 11' />
  <ImageTexture3D containerField="voxels" url="./Segments/masked-optic.nrrd"/>
  <CartoonVolumeStyle/>
</ISOSurfaceVolumeData>

(Head MRI, cerebrum segment)
<VolumeData dimensions='75 11'>
  <ImageTexture3D containerField="voxels" url="./Segments/masked-cerebrum.nrrd"/>
  <ComposedVolumeStyle>
    <CartoonVolumeStyle/>
    <EdgeEnhancementVolumeStyle gradientThreshold='0.8' edgeColor='0 0 0.5' />
  </ComposedVolumeStyle>
</VolumeData>
X3D Volume Rendering

- Composable Render Styles covering the state of the art
  - Formalizes parameters and transfer functions for 3D rendering & blending
    - BoundaryEnhancementVolumeStyle
    - CartoonVolumeStyle
    - ComposedVolumeStyle
    - EdgeEnhancementVolumeStyle
    - OpacityMapVolumeStyle
    - ProjectionVolumeStyle
    - ShadedVolumeStyle
    - SilhouetteEnhancementVolumeStyle
    - ToneMappedVolumeStyle
    - Greatest Common Denominator

- Assign different RenderStyles to different segments, blend two volumes
  - BlendedVolumeStyle
  - SegmentedVolumeData
  - IsoSurfaceVolumeData

- Clipping Planes are already specified in X3D 3.2 Rendering Component
Volume Rendering: X3D + HTML5 + WebGL

Web3D Member collaboration: Vicomtech

Python Scripts to produce ImageTextureAtlas for browser-based rendering

http://volumerc.org/demos.html

https://github.com/volumerc

... RAW, DICOM, NRRD, TIFF, PNG
Processing image stacks to ImageTextureAtlas

Required for WebGL volume rendering (with X3DOM)

Arguments:

```
python convertPNG.py <InputFolder> <OutputFileName> [width] [height]
```

Usage example:

```
python convertPNG.py ./data/slices/ ./output/atlas 512 512
```

*Can also generate a GradientAtlas and multiple output resolutions!!*

*See the project’s github Wiki for details and required Python packages*
Exercise

H-Anim 2.0 (ISO-IEC 19774 - 2) specifies the 3D graphics mappings for combining anatomy and Motion Data Animation (e.g. .bvh). These standards data structures are especially important in physical therapy and ergonomics.

Virginia Tech VR exercise mirror for stroke victims: we demonstrated real-time visual feedback for patients as avatars achieving progressive goals of muscular extension.

- EHR: “What happened there?”
Humanoid Animation v2


Level of articulation (LOA) represents the complexity and detail of joints for a humanoid skeletal hierarchy, and can be used for generating various motions based on the joints.

There are five levels of articulation:

- **LOA-0** represents only the humanoid_root Joint object without hierarchy.
- **LOA-1** represents the simplest organization and hierarchy of joints for a humanoid. 18 joints and 18 segments. Each segment has a joint in the hierarchy.
- **LOA-2** consists of 71 joints and 71 segments.
- **LOA-3** consists of 94 joints and 94 segments.
- **LOA-4** builds on LOA-3 by adding anatomical details of hands and feet, consisting of 148 joints and 148 segments.
H-Anim v2

Anatomies & Motions

ISO/IEC DIS 19774-2

(e.g. .BVH)
Point CloudS