X3D Authoring

Web3D Webinar 8/6/2020
Web3d.org

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Virginia Tech
Acknowledgements

Evolving material since 2018 with:

Johannes Behr
Timo Sturm
Uwe Woessner
Standards make the Web go round: 

**Ecosystem of Engines**

*Runtime approaches:*

1) Installed engines import, export, and render X3D and VRML with different node Profiles

2) Javascript Polyfills ('native' in browser):
   - X3DOM: [https://www.x3dom.org/](https://www.x3dom.org/)
   - X_ite: [http://create3000.de/x_ite/](http://create3000.de/x_ite/)
X3D Engines *(installed)* (July 2020)

- Instant Reality
- Covise/OpenCover
- V-slam.org (Unity, Hololense)
- Castle Game Engine
- FreeWRL
- H3D (Haptics, py)
- Octaga
- Xj3D
- BS Contact
- Coin3D
- ...

**HTML5 + WebGL Javascript Polyfills:**

- X3DOM
- X_ITE
- NIH 3D Viewer

...
Tons of Tools...

- **Blender**
- **MeshLab**
- 3DS Max
- Maya
- Rhino
- Paraview
- Agisoft
- ARCSene
- SketchUp
- Creoform
- PointFuze
- MatLab
- Mayavi
- ...

**export me!**

- **Titania (Linux)**
  [http://create3000.de/](http://create3000.de/)
- **X3D-Edit**
  [https://savage.nps.edu/X3D-Edit/](https://savage.nps.edu/X3D-Edit/)
- **Vivaty Studio (Win)**
  [https://www.web3d.org/projects/vivaty-studio](https://www.web3d.org/projects/vivaty-studio)
- **XML & stylesheets**
- **...**

- 3DPrint Exchange
- POSTGIS
  [https://postgis.net/](https://postgis.net/)

- **Converters:**
  - Okino Polytrans
  - Safe Software
  - AOPT (w/ InstantPlayer)
  - View3DScene
  - **...**
Molecules

- Chimera
- VMD
- *Mol
- CML

...
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
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!

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*

<table>
<thead>
<tr>
<th>Application</th>
</tr>
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<tbody>
<tr>
<td>VRML, X3D</td>
</tr>
<tr>
<td>Open GL, etc</td>
</tr>
<tr>
<td>Operating System</td>
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</tbody>
</table>
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
Scenegraph

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)
More Fundamentals

- Spatial Units assumed to be meters (unless otherwise declared)
- Rotational Units are in Radians
- Right-handed 3D coordinate system
1 Line upgrade to X3D!

‘Classic’ utf8 encoding:

A VRML.wrl file can become an X3D.x3dv file simply by changing the header line from:

VRML #2.0 to VRML #3.0
From VRML to X3D

- Introduced XML & Binary encoding
- Shaders
- Physics (Rigid Body)
- Volume rendering
- Distributed Interactive Simulation (DIS) [http://open-dis.org/](http://open-dis.org/)

From X3D 3.x to X3D4:

- New encodings: eg HTML5 encoding
- New Language Bindings: eg DOM API
- Physically-Based Rendering & glTF inlining

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

**Bindings:**
- Javascript,
- Java,
- C#,
- C++, C,
- Python
X3D: Encodings and Examples

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

<table>
<thead>
<tr>
<th>MIME Types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X3D Encoding</strong></td>
</tr>
<tr>
<td>XML</td>
</tr>
<tr>
<td>JSON</td>
</tr>
<tr>
<td>Classic VRML</td>
</tr>
<tr>
<td>Binary</td>
</tr>
<tr>
<td>VRML</td>
</tr>
</tbody>
</table>
Visit Web3D Example Archive

https://www.web3d.org/x3d/content/examples/X3dResources.html#Examples
YouTube
Web3D Consortium Channel
https://www.youtube.com/user/Web3DMaster/playlists

Twitter
https://twitter.com/Web3DConsortium
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Producing X3D content

- Exporters (MatLab, Paraview, VMD...)
- Authoring Tools (Blender, Modo, 3DSMax, ...)
- Converters (PolyTrans, CADExchanger, FME,...)
- Scripts to produce X3D documents and pages
- Text Editors to produce X3D documents and pages
- Runtime programs to feed X3D engines
Ecosystem of Authoring

Text editors, structured editors (eg any XML-tool, X3D Edit)

- Atom, Notepad++, BBEdit have syntax highlighting
- X3D-Edit 3.3 is stable and available for public use.
  https://savage.nps.edu/X3D-Edit

*Free & Open Source: Titania, Blender, MeshLab*

Free: Vivaty Studio  https://www.web3d.org/projects/vivaty-studio
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  - ...

...
Playing Well on the Web

No space in file names!

X3D 4.0 will support GLTF and PBR

https://www.web3d.org/blog-integrating-x3d-and-gltf
X3D Metadata

Travels with the 3D information and can be granular at any node when embedded in the scene graph. Scenes can be composed through the Inline node.

- UNITs & measures defined per scene
- **Metadata can be on any node in the scene**
  - Provenance and source of data
  - Document processing tool chains for derived data
  - Community vocabularies and annotations (FMA, SNOMED, CT, ...)
  - W3C encryption and authentication by element
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
Tutorials from Software

Have some helpful fundamentals about the X3D scene graph

X3DOM Tutorials: https://doc.x3dom.org/tutorials/index.html

X_ITE Tutorials: http://create3000.de/users-guide/tutorials/

NB: developing and testing HTML5 X3D locally usually needs a localhost server running (e.g. atom editor extension; python -m SimpleHTTPServer &)

Workflows
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
CAD/Computer aided Design Workflow

Any CAD Design Tool

- STEP ISO 10303-242
- VRML ISO/IEC 14772
- X3D xml ISO/IEC 19775

→ HTML

→ X3D Browser

→ Web Server

→ 3D Printing
Scientific Visualization Workflow

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

Post-processing Tool

X3D

other

ParaView

For GIS, PostGIS allows to export geometry as X3D files

X3D Browser

Web Server

HTML

3D Printing
Typical VR Workflow

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

X3D Tutorial
CAVE2@CallT²

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

- PDB-Plugin
- PDB
- PyMOL
- VRML97
- OpenCOVER
RECOM Services
Stadtwerke Augsburg

3D Scan
Surface Reconstruction
Mesh Generation
Simulation
OpenDX
3DS-Max
VRML/X3D

X3D Tutorial
Stuttgart21

- Reinforcement planning
- Constructability
- Safety
Architecture BIM

Adidas

New office building at Herzogenaurach

Architect: Behnisch Architects
Construction: Ed. Züblin AG

Arch
ELT
HVAC
MEP
Revit
3DS-Max
X3D
OpenCOVER

X3D Tutorial
Thyssen Multi

New Cabin Design
- Lightweight
- Carbon fibre body
- User interface

X3D Tutorial

SolidWorks
3DS-Max
X3D
OpenCOVER
Notes

Most work out of the box, but

Sometimes post-processing w/ a script or hand-editing will be necessary:

- To add metadata
- To change a url
- To fix an exporter bug
- ...

NB: Be vocal on mailing lists and support sites!

X3D!
MeshLab.net

Features

3D Acquisition: Aligning
The 3D data alignment phase (also known as registration) is a fundamental step in the pipeline for processing 3D scanned data. MeshLab provides a powerful tool for moving the different meshes into a common reference system, able to manage large set of range-maps. MeshLab implements a fine tuned ICP one-to-one alignment step, followed by a global bundle adjustment error-distribution step. The alignment can be performed on meshes and point clouds coming from several sources, including active (both short- and long-range) scanners and 3D-from-image tools.

3D Acquisition: Reconstruction
The process of transforming independent acquisitions, or point clouds, into a single-surface triangulated mesh can be fulfilled with different algorithmic approaches. MeshLab provides several solutions to reconstruct the shape of an object, ranging from volumetric (Marching Cube) to implicit surfaces (Screened Poisson).

Visualization and Presentation
The visualization features of MeshLab (including Decorators and Shaders) can help in graphically present the peculiar characteristics of a 3D model. It is possible to control the camera perspective/orthographic view parameters, and use predefined canonical views. MeshLab also offers a high-resolution screenshot feature, extremely useful in creating a graphical documentation of a survey.

Color Processing
MeshLab can manipulate the vertex and face colors using a series of Photoshop-like filters (gamma, saturation, brightness, contrast, levels, smoothing, sharpening). Automatic filters are available to calculate Ambient Occlusion and Volumetric Opacity and to map it to vertex or face color. It is also possible to explicitly write color functions, to highlight specific characteristics of the 3D model. MeshLab also offers a painting interface for vertex colors. Scalar values, possibly the result of a metric calculation on the 3D surface, may also be mapped on vertex/face color, to have a visual representation of that value.
Titania

- [http://create3000.de/](http://create3000.de/)

Outline Editor

**Have everything under control**

The swiss army knife of the editors is the Outline Editor. Fields can be directly edited, quick connect or delete routes between nodes and watch fields changes when in live mode. Nodes can be rearranged within the scene graph per drag & drop while preserving the location of the nodes in the scene. There is now full support to edit prototypes, they can be created, easily create instance of them and you can switch into a prototype for full control.

Route Graph Editor

**Easily edit your routing logics**

The upcoming release of Titania will include a new Route Graph Editor. It lets you manage and arrange different logics within a single scene. Routes can be connected between nodes and it suggests the right fields to connect. Existing logics can be easily imported via drag & drop into a page of the Route Graph Editor. Different logics are arranged in tabs for simple access.

Integrated Script Editor

**Directly run your scripts within Titania**

Work on different Script or Shaders at the same time. Scripts are checked for errors when they are saved.
Blender.org

Blender includes support for X3D out-of-the-box.

2.7 was decent; 2.8 broke a lot of things; 2.82 and 2.83 restores X3D import/export functions
3DS Max

Has built-in VRML exporter

The HLRS / U Stuttgart exporter supports many more X3D features!

https://www.hlrs.de/covise/support/
Functionality

Four file formats
- Inventor (VRML1.0)
- VRML97
- VRML97 with OpenCOVER extensions
- X3D

Many Bug Fixes
- Export selected
- Animations
- Instances
- Shell Materials
- Per Face Materials

Improved Speed (X50)
Compiling from source

Prerequisites
- CMake 3.9
- 3DS-Max API
- Cal3D
- VisualStudio 2017 Community Edition

Clone COVISE source from [https://github.com/hlrs-vis/covise.git](https://github.com/hlrs-vis/covise.git)
Exporter source is located in covise/src/tools/vrmlexp
Create a build directory
Grant write access to .../Autodesk/3ds Max 2018/stdlibs
Set 3DSMAXINSTALLDIR environment variable to your Max installation directory
Run cmake-gui for CMakeLists.txt in covise/src/tools/vrmlexp
set 3DSMAX_INCLUDE_DIR if not found automatically
set CAL3D_INCLUDE_DIR if not found automatically
Create a project file and compile it.
If 3DS-Max is not running it is automatically installed in stdplugins
Install binaries

Prerequisites

• Visual Studio 2017 runtime libraries

Download binaries from https://fs.hlrs.de/projects/covise/support/download/
Copy vrmlexp.dle to .../Autodesk/3ds Max 2018/stdplugs
Copy caI3d.dll to .../Autodesk/3ds Max 2018
Replace the original vrmlexp.dle, do not rename it.
The RawKee project developed Maya plugins to add X3D export, but their plugins are only for the older Maya versions (<= 2008).

Maya supports vrml exports through a plug-in. Load the vrml2Export.mll plug-in in the Plug-in Manager.

Starting with Maya 2016, the VRML Plug-in is retired and no longer available. The source code can be found in the Maya 2015 Devkit under obsolete: (/devkit/obsolete/games/vrml2Export).
Okino

Polytrans [https://www.okino.com/default.htm](https://www.okino.com/default.htm)

*Industrial Strength 3D format converter!*
FME

Safe Software https://www.safe.com/
X3D Reference
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 (a 4x4 matrix multiply)
- Group
- LOD
- Switch
- Billboard
- Collision
- Anchor

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

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

ROUTE TimeSensor.fractionChanged to *Interpolator key

ROUTE *Interpolator keyValue to node’s field
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.htm](https://www.web3d.org/x3d/content/examples/ConformanceNist/Miscellaneous/Script/index.htm)

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


THANKS TO

http://www.medialab.teicrete.gr/
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*
Engage!

- Standards make it work!
- Members drive features and Standards
- Expert Community
- Early Access to specifications
- Outreach opportunities

www.Web3D.org