

X3D Authoring

Web3D Webinar 8/6/2020
Web3d.org

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Virginia Tech



Acknowledgements

Evolving material since 2018 with :

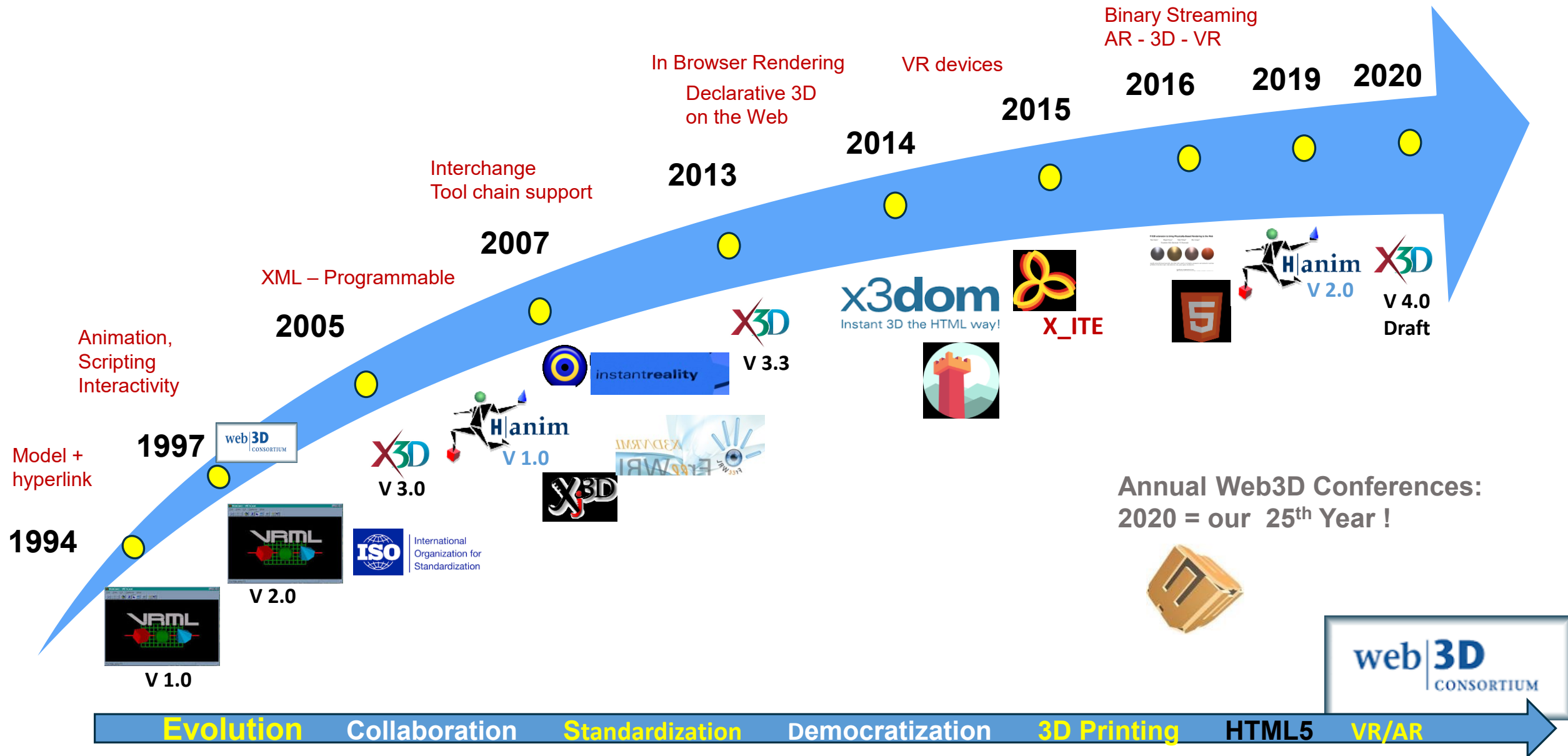
Johannes Behr

Timo Sturm

Uwe Woessner





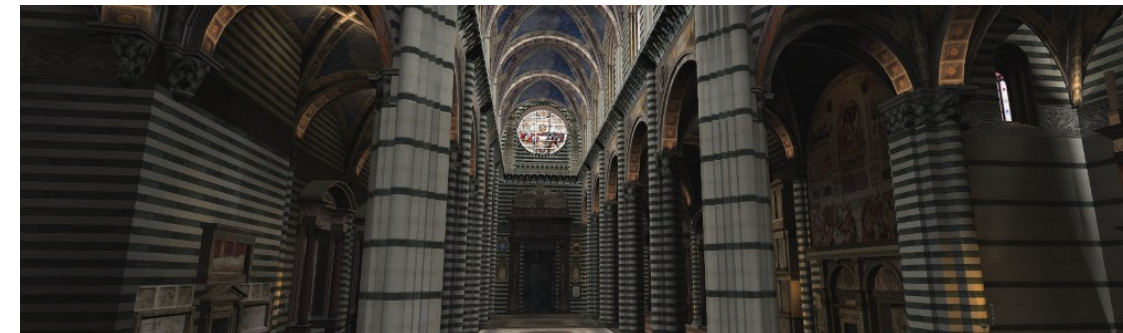
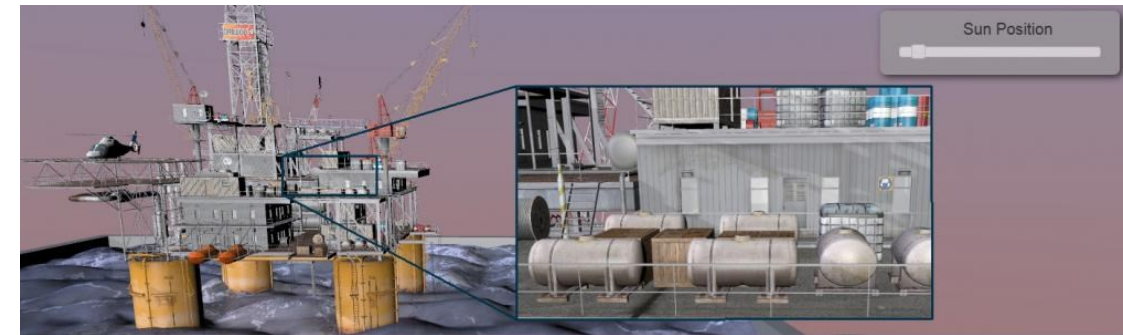


Standards make the Web go round: *Ecosystem of Engines*



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/>
 - 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...

export me!

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

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

- 3DPrint Exchange
- POSTGIS

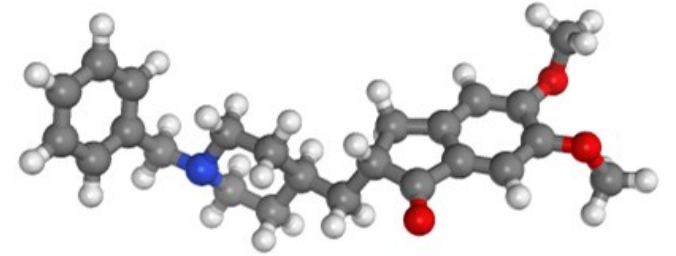
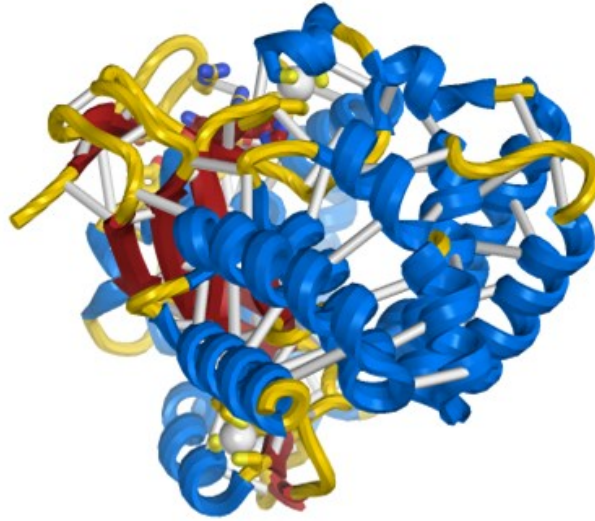
<https://postgis.net/>

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

Molecules

- Chimera
- VMD
- *Mol
- CML

...



X3D Scene graph

Resources & International Community

www.web3d.org



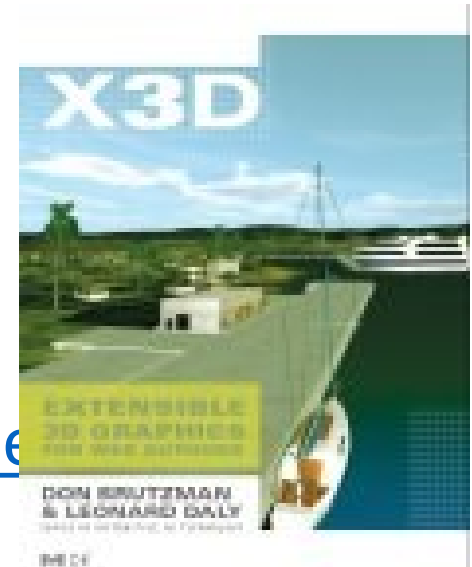
<http://www.web3d.org/documents/specifications/19775-1/V3.3/index.html>

Book:

<http://x3dgraphics.com/>

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

Online Examples: <http://www.web3d.org/x3d/content/#Example>





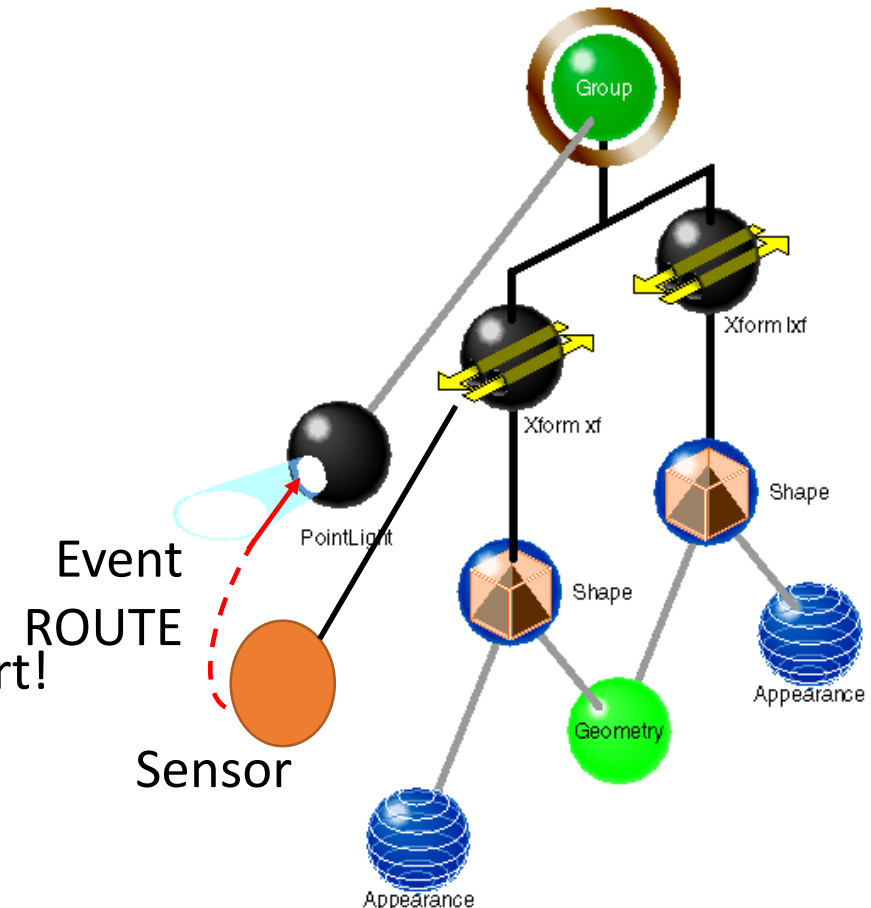
ISO-IEC Standard Scope

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

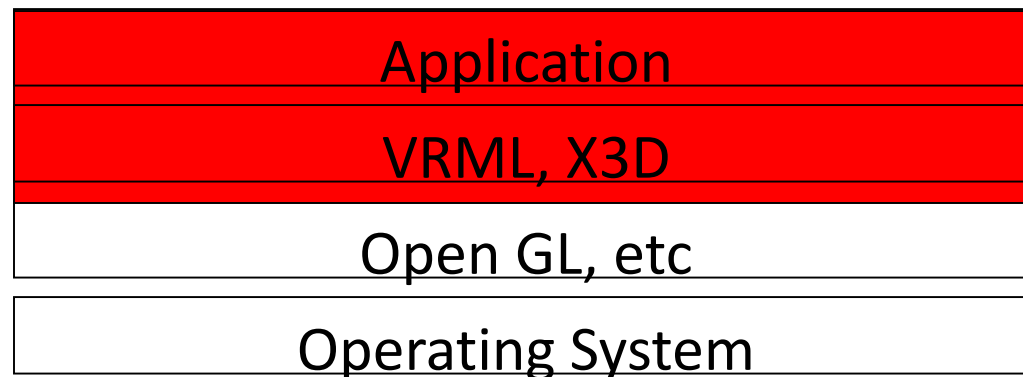
3.3 examples for Medical Imaging, CAD and Geospatial support!

<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*



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

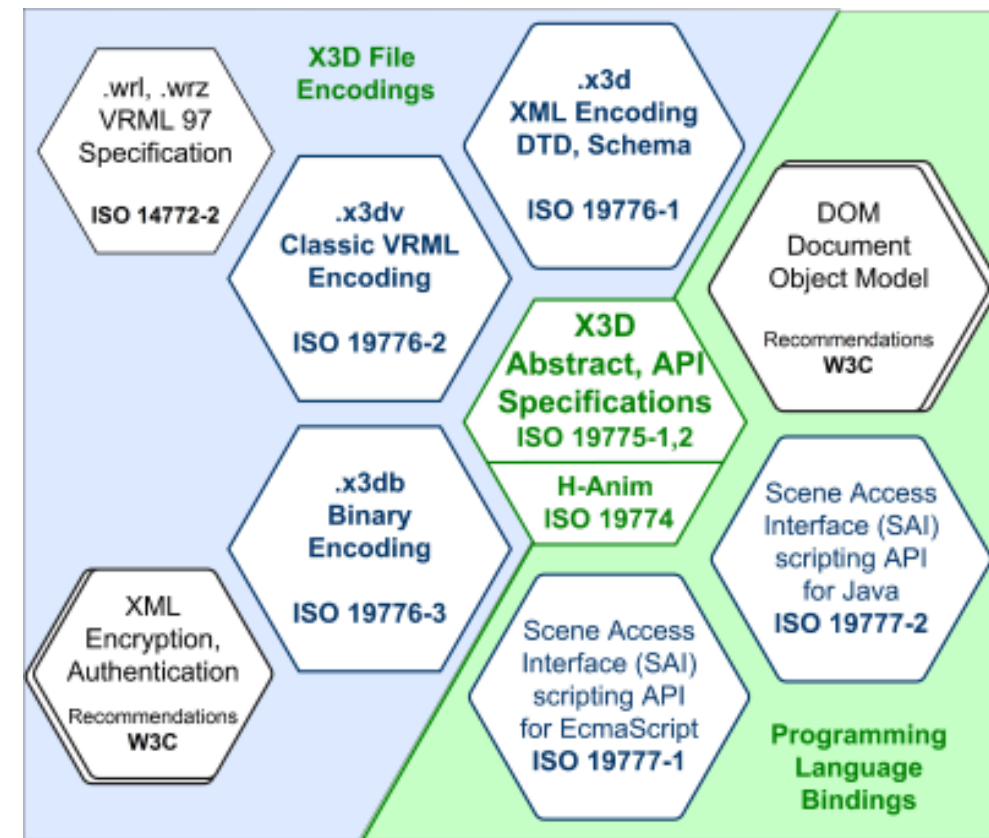
Lots of tools export:

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

... lots of other proprietary formats ;
can be converted with
commercial translation tools,
open source tools,

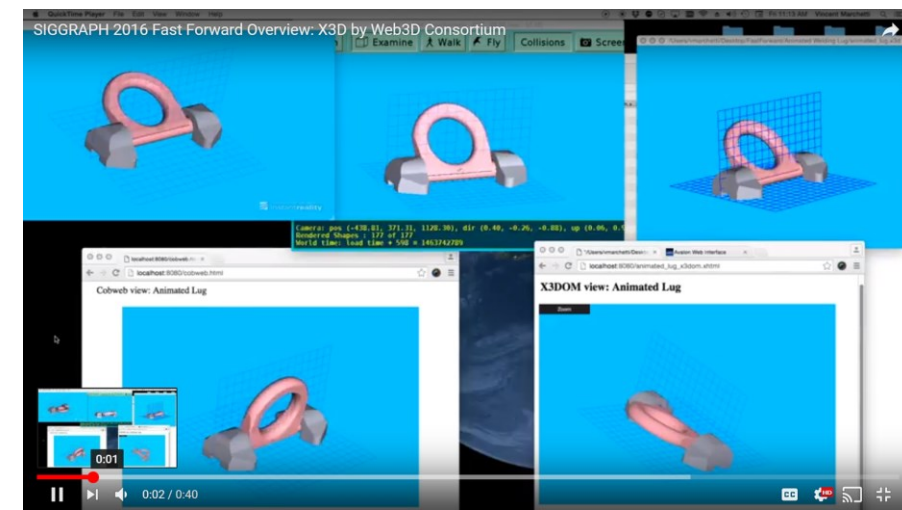
or your own Scripts !

***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

simply

an X3D.x3dv file

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/>

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*

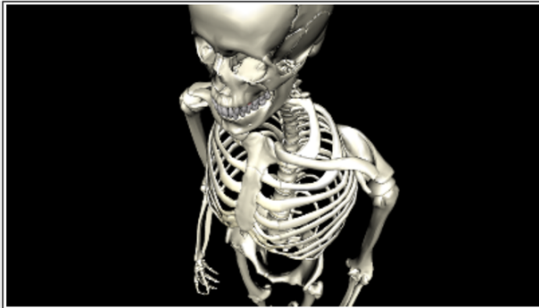
X3D: Encodings and Examples

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

Basic X3D Examples Archive, Medical, Skeleton Complete Normals

X3D Example Archives: Basic, Medical, Skeleton Complete Normals

Human skeleton reference example providing all bones, with polygonal normals precomputed and embedded. Scaled to normal size.



[X3D model](#) [X_ITE](#)
[ClassicVRML](#) [X3DOM](#)
[VRML97](#) [.json \(check\)](#)
[Canonical](#) [.x3db](#)
[annotated](#) [Binary](#)
[.x3d source](#) [Javadoc and .java source](#)

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.3//EN" "http://www.web3d.org/specifications/x3d-3.3.dtd">
<X3D profile="Immersive" version="3.3" xmlns:xsd="http://www.w3.org/2001/XMLSchema-instance" xsd:noNamespaceSchemaLocation="http://www.web3d.org/specifications/x3d-3.3.xsd">
  <head>
    <meta name="title" content="SkeletonCompleteNormals.x3d"/>
    <meta name="description" content="Human skeleton reference example providing all bones, with polygonal normals precomputed and embedded. Scaled to normal size."/>
    <meta name="created" content="TODO"/>
    <meta name="modified" content="22 December 2013"/>
    <meta name="creator" content="Damon Hernandez, Joe D. Williams, Don Brutzman"/>
  </head>
  <scene>
    <!-- ... (skeleton model content) ... -->
  </scene>
</X3D>
```

MIME Types

X3D Encoding	File Extension	MIME Type
XML	.x3d, .x3dz	model/x3d+xml
JSON	.x3dj	model/x3d+json
Classic VRML	.x3dv, .x3dvz	model/x3d+vrml
Binary	.x3db, .x3dbz	model/x3d+binary
VRML	.wrl, .wrz	model/vrml

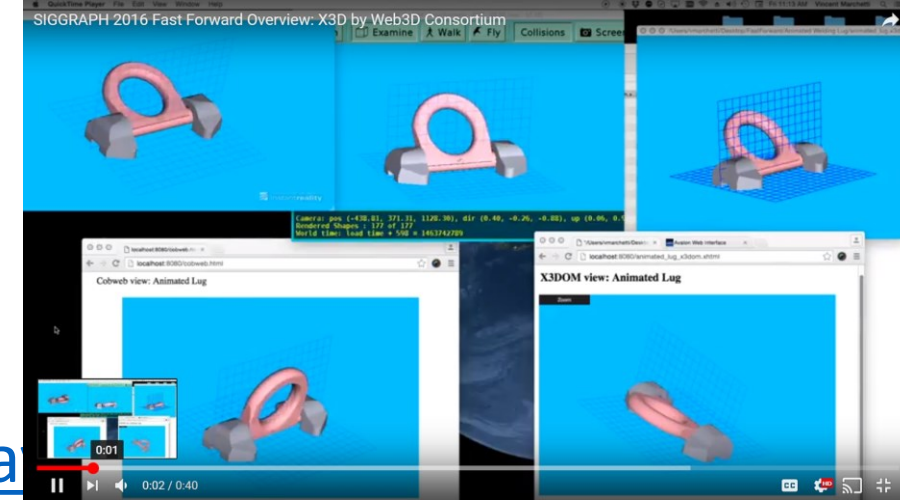
Visit Web3D Example Archive

<https://www.web3d.org/x3d/content/examples/X3dResources.html#Examples>

YouTube

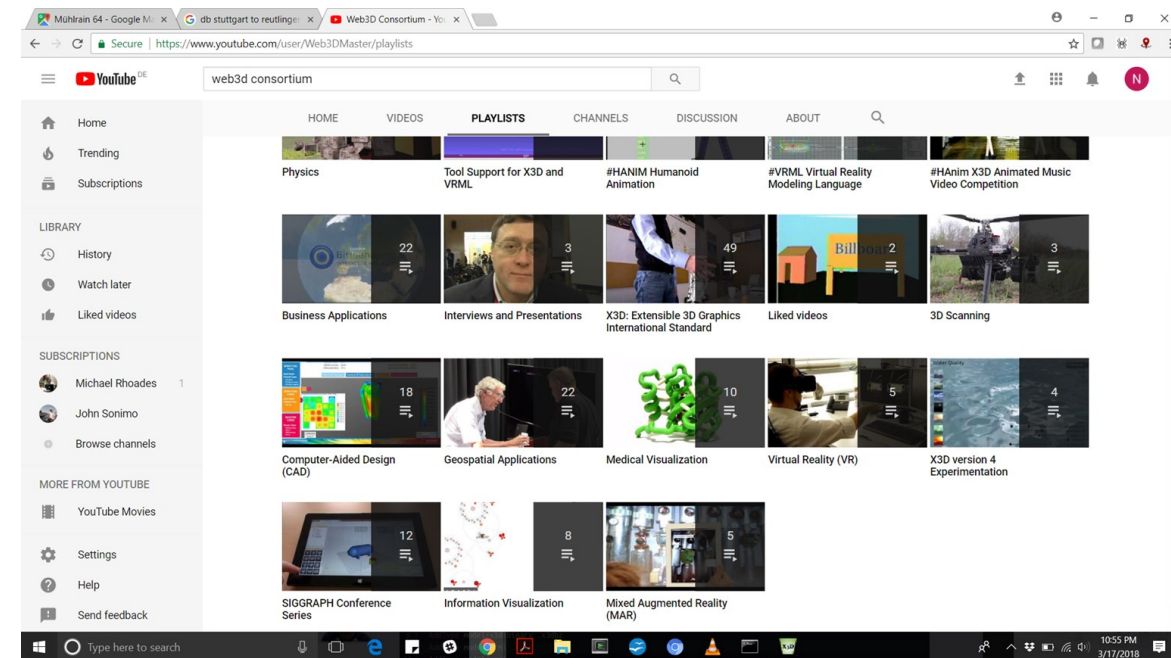
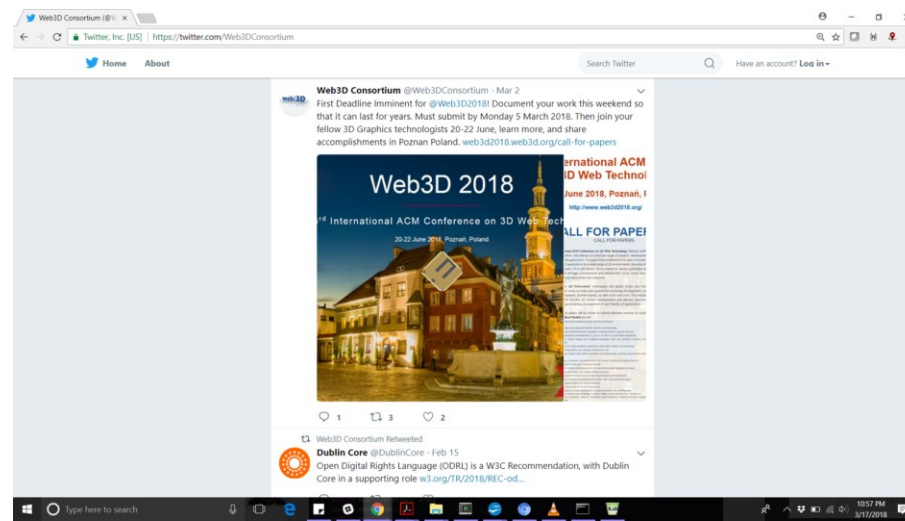
Web3D Consortium Channel

<https://www.youtube.com/user/Web3DMaster/play>



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>

Tons of Tools...

export me!

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- **MeshLab**
- 3DS Max
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- Agisoft
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- SketchUp
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- Mayavi
- ...

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<http://create3000.de/>
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- Vivaty Studio (Win)
<https://www.web3d.org/projects/vivaty-studio>
- XML & stylesheets
- ...

- 3DPrint Exchange
- POSTGIS
<https://postgis.net/>
- Converters:
 - Okino Polytrans
 - Safe Software
 - AOPT (w/ InstantPlayer)
 - View3DScene
 - ...

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/>

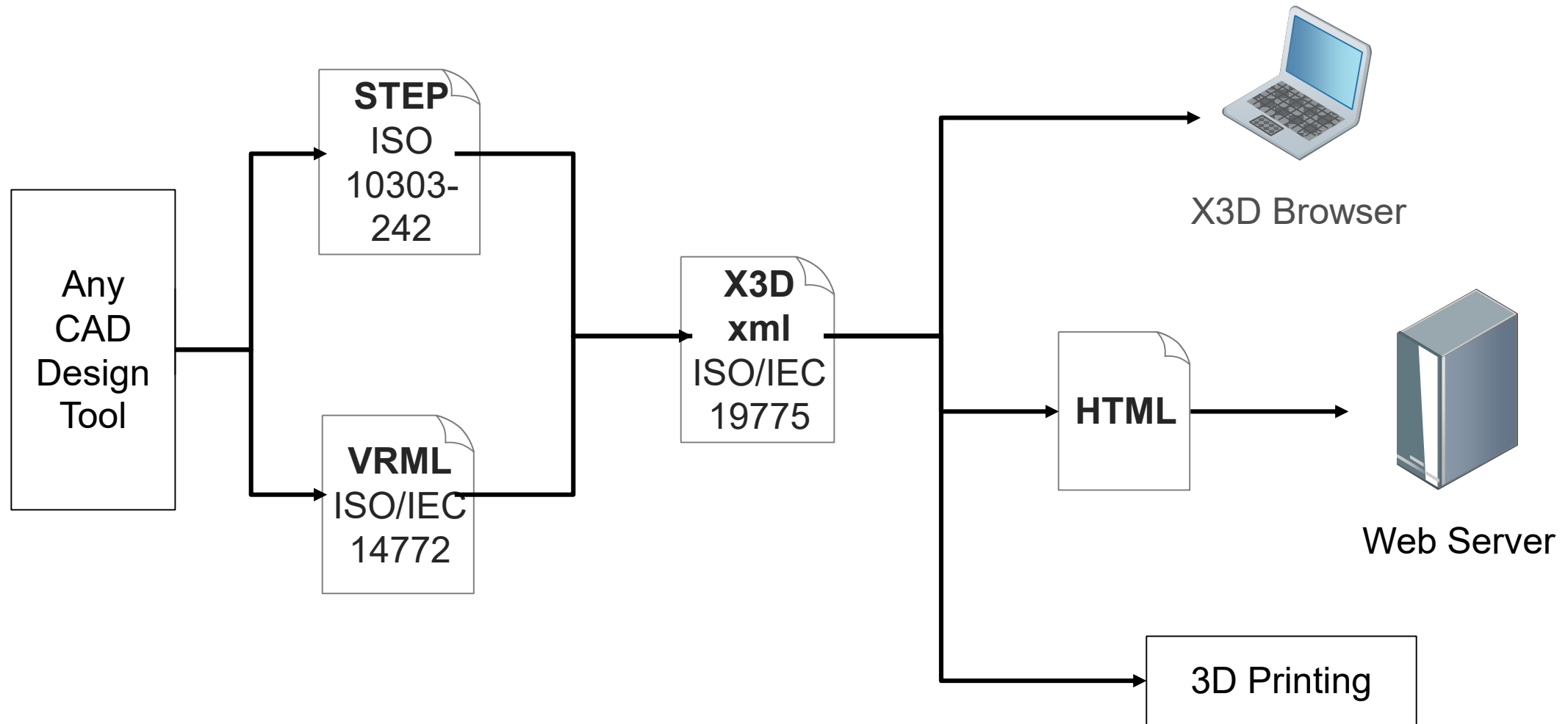
NB: developing and testing HTML5 X3D locally usually needs a localhost server running (e.g. atom editor extension; `python -m SimpleHTTPServer` &)

Workflows

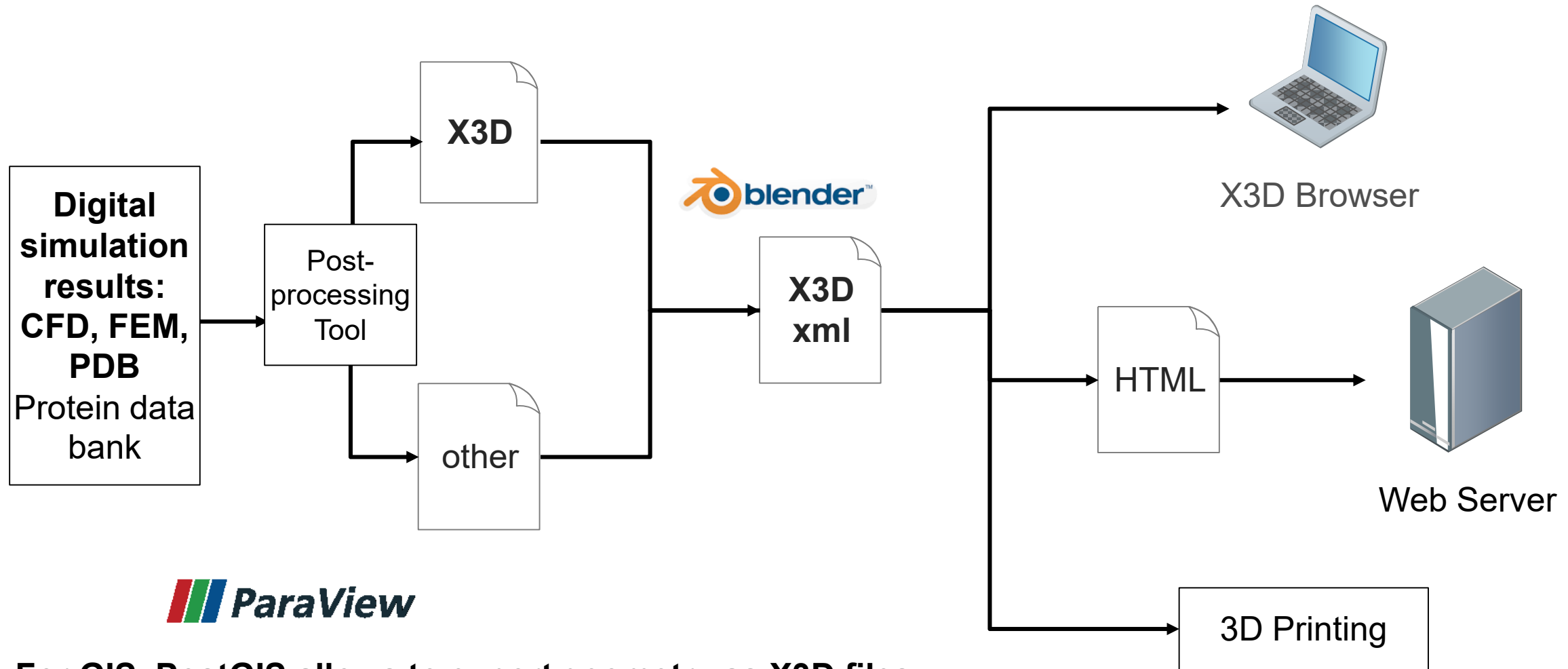
A Text Editor!

- 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

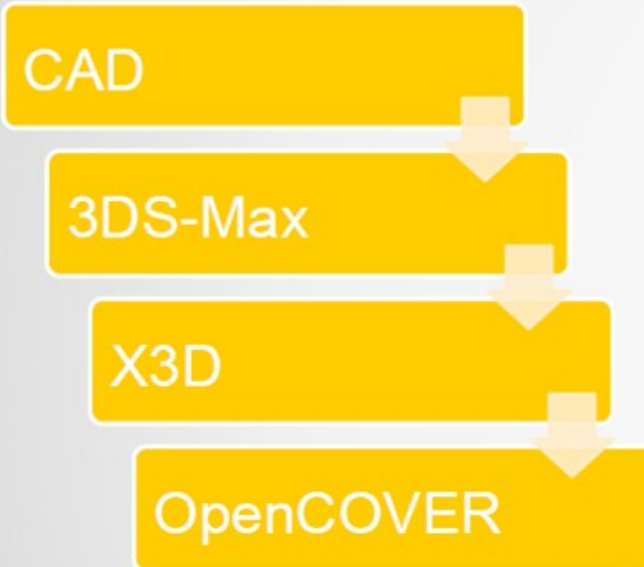


Scientific Visualization Workflow



For GIS, PostGIS allows to export geometry as X3D files

Typical VR Workflow



CAVE2@CalIT²

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

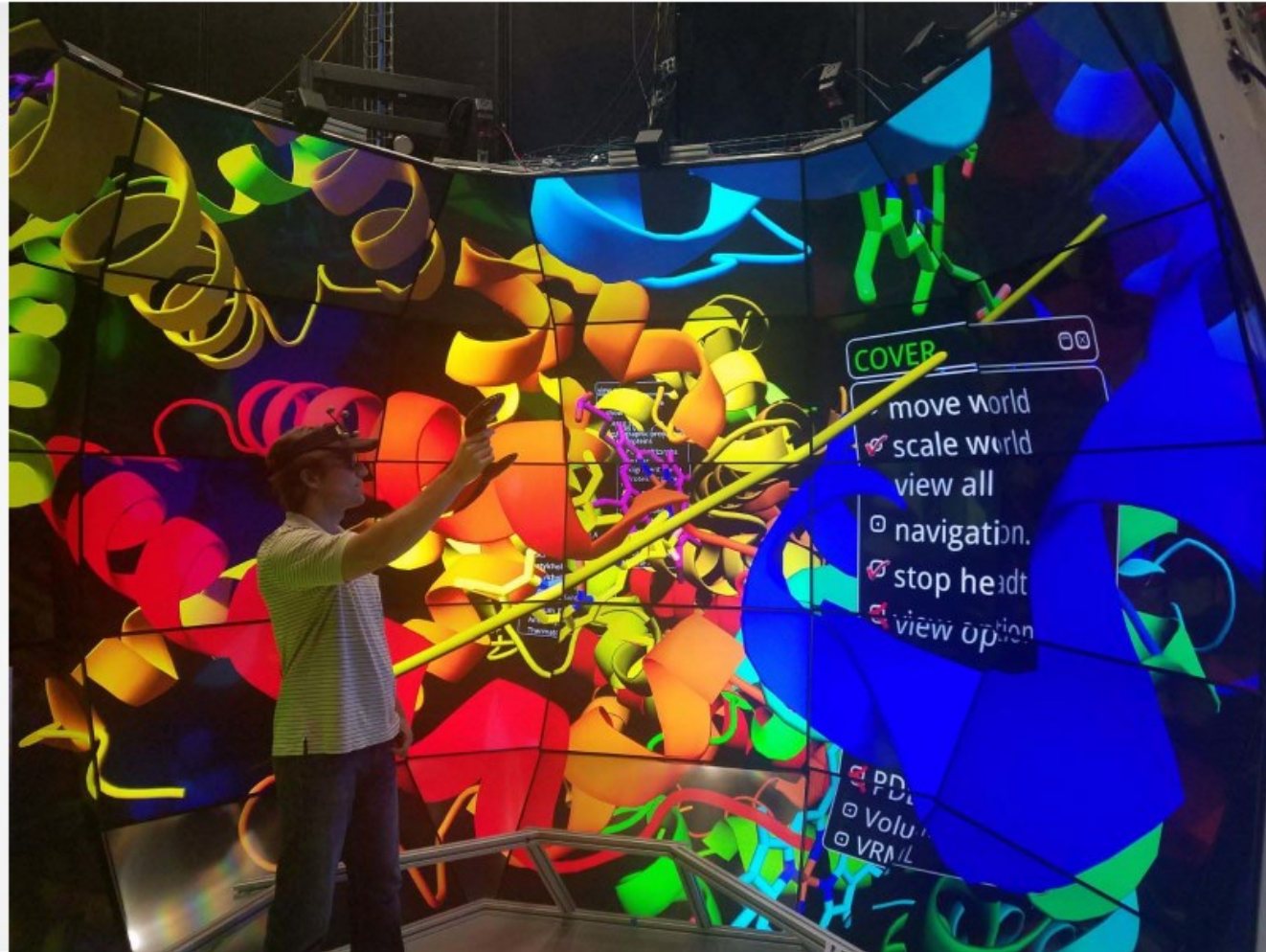
PDB-Plugin

PDB

PyMOL

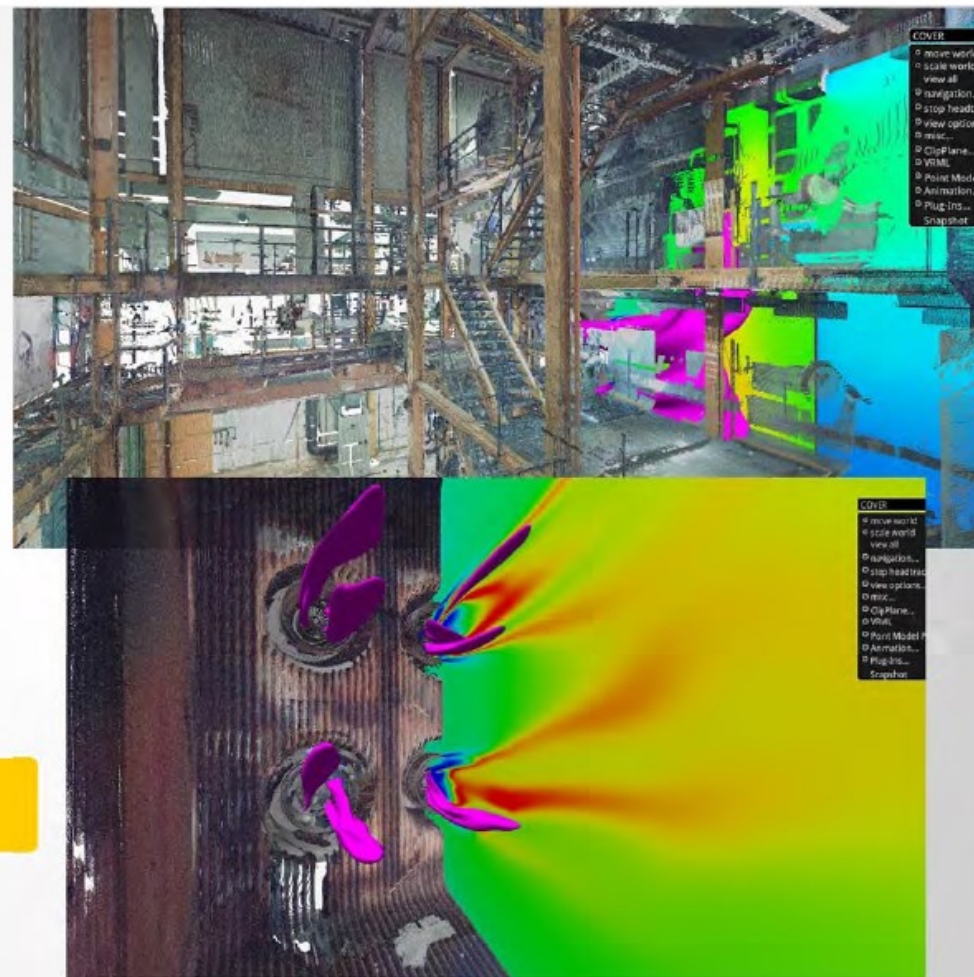
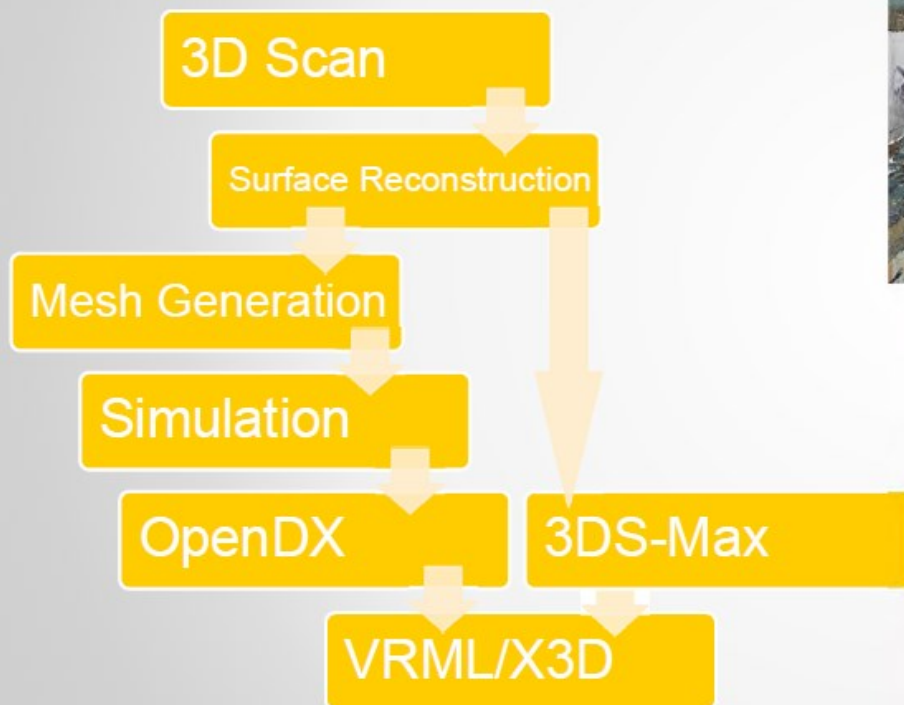
VRML97

OpenCOVER



RECOM Services

Stadtwerke Augsburg

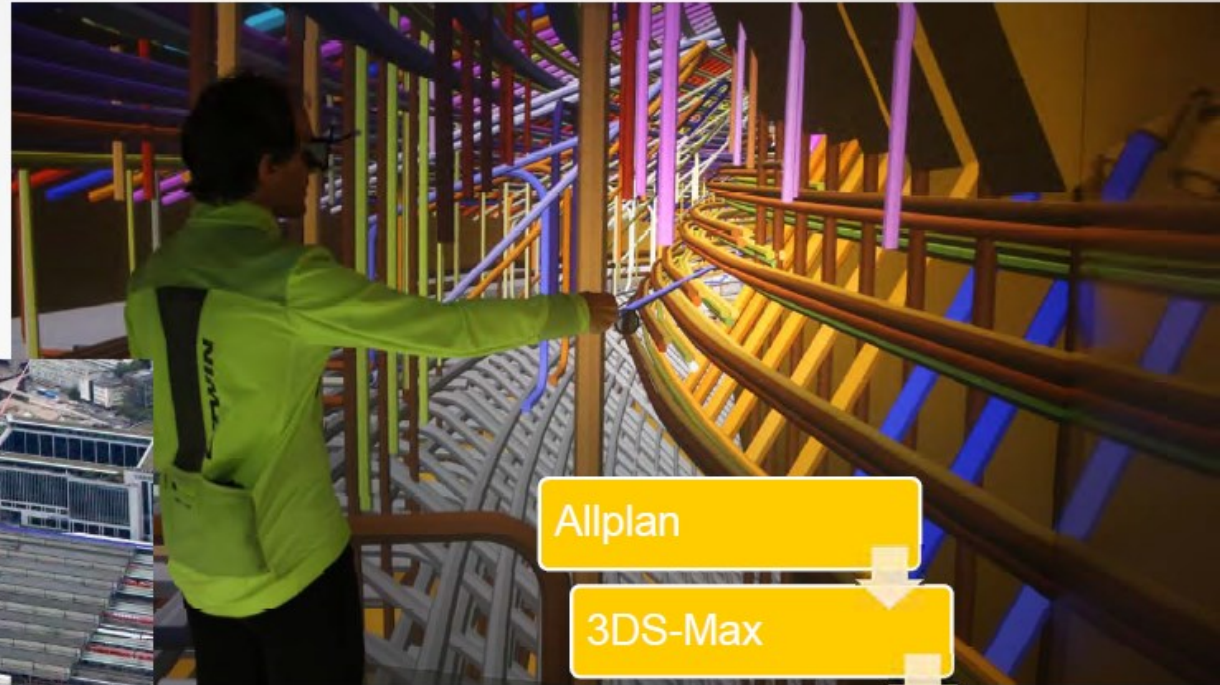


X3D Tutorial

H L R I S

Stuttgart21

- Reinforcement planning
- Constructability
- safety



Allplan

3DS-Max

X3D

OpenCOVER

X3D Tutorial

H L R I S

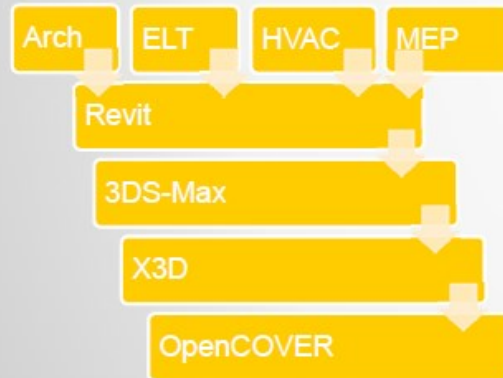
Architecture BIM

Adidas

New office building at Herzogenaurach

Architect: Behnisch Architects

Construction: Ed. Züblin AG



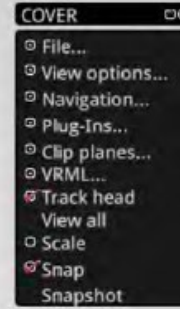
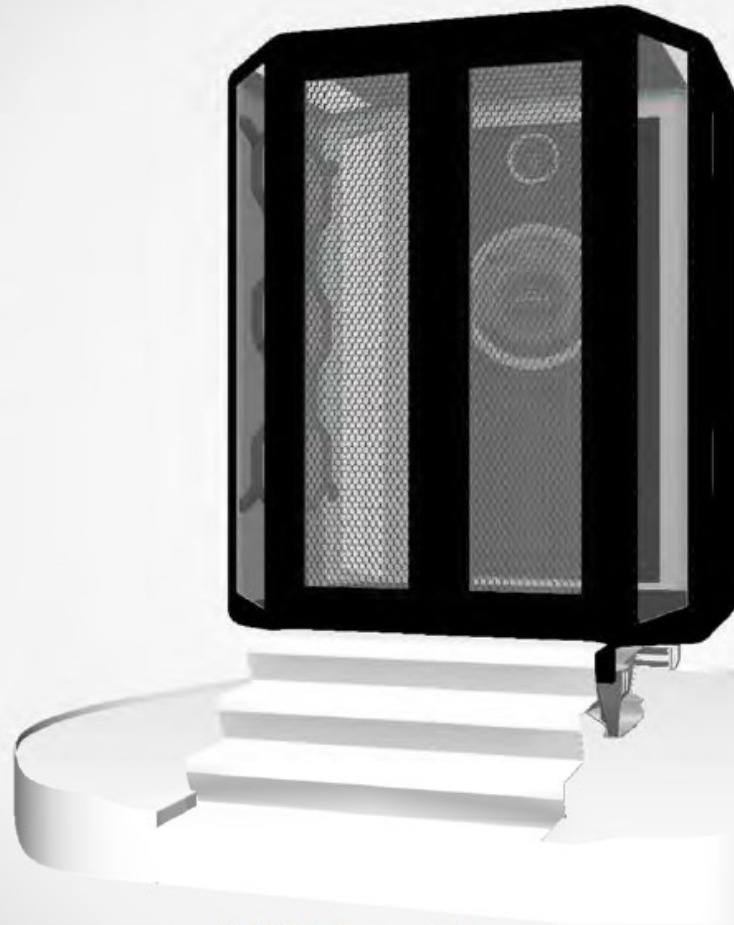
X3D Tutorial

H L R I S

Thyssen Multi

New Cabin Design

- Lightweight
- Carbon fibre body
- User interface



SolidWorks

3DS-Max

X3D

OpenCOVER

X3D Tutorial

H L R I S

Notes

Most work out of the box, but

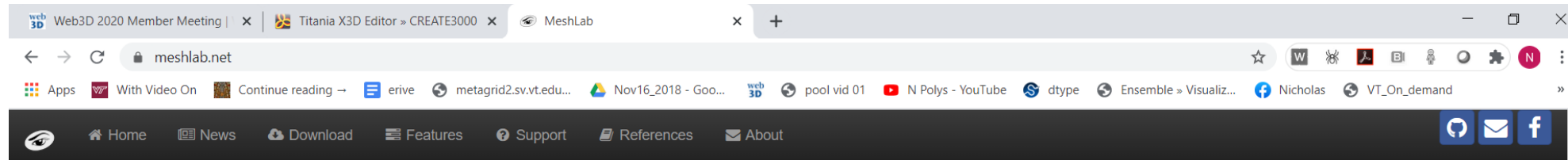
Sometimes post-processing w/ a script or hand-editing will be necessary :

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

NB: Be vocal on mailing lists and support sites!

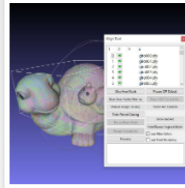
X3D!

MeshLab.net



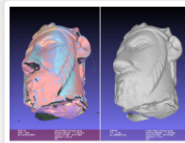
Features

3D Acquisition: Aligning



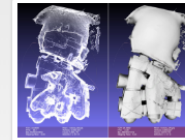
The 3D data alignment phase (also known as registration) is a fundamental step in the pipeline for processing 3D scanned data. MeshLab provides a powerful tool for moving the different meshes into a common reference system, able to manage large set of range-maps. MeshLab implements a fine tuned ICP one-to-one 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



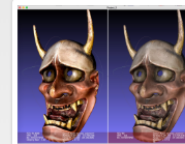
The process of transforming independent acquisitions, or point clouds, into a single-surface triangulated mesh can be fulfilled with different algorithmic approaches. MeshLab provides several solutions to reconstruct the shape of an object, ranging from volumetric (Marching Cube) to implicit surfaces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



Route Graph Editor

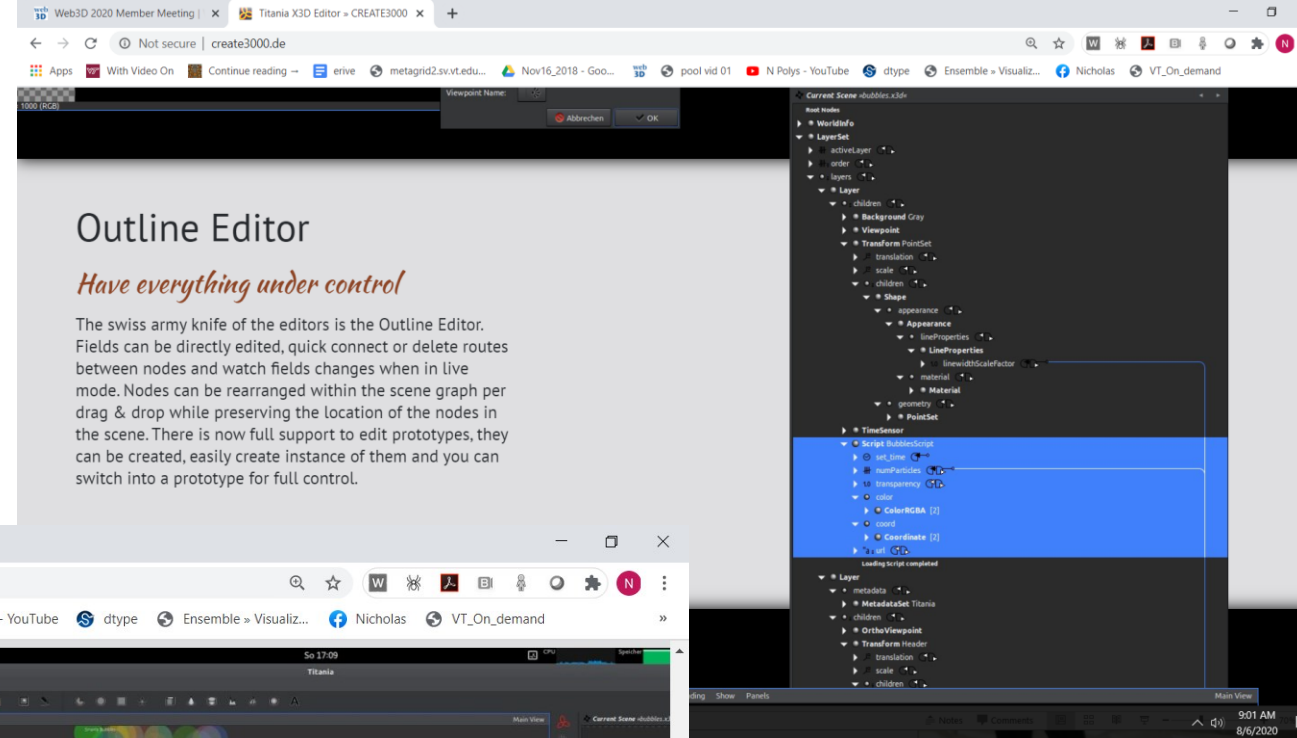
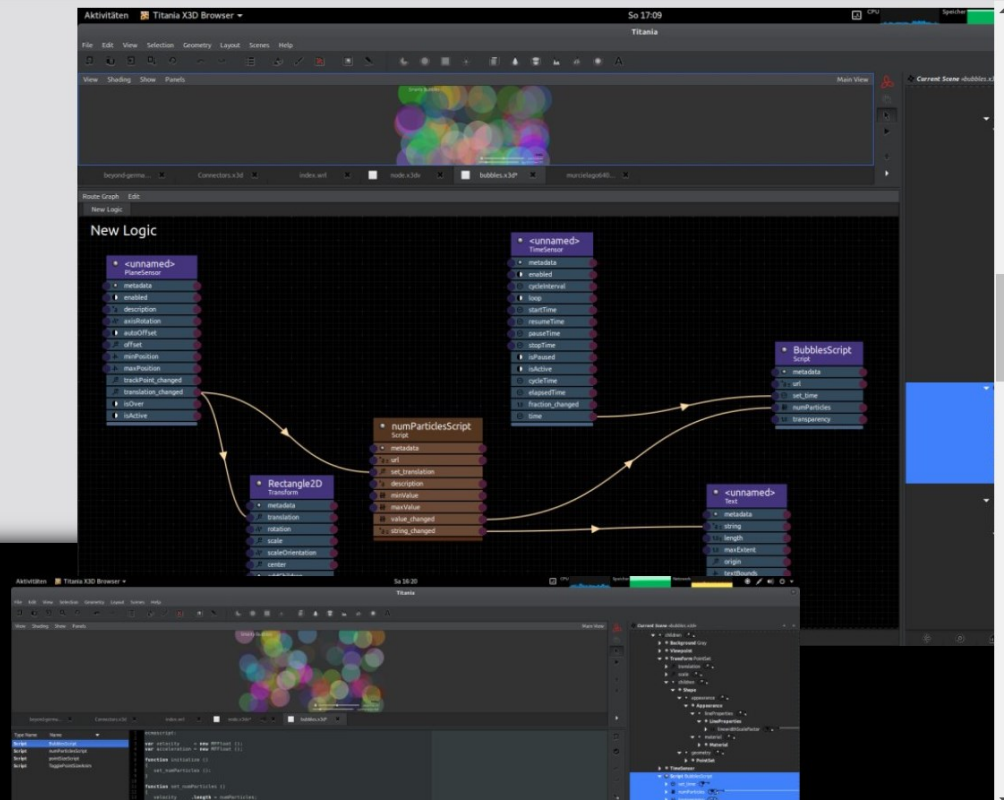
Easily edit your routing logics

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

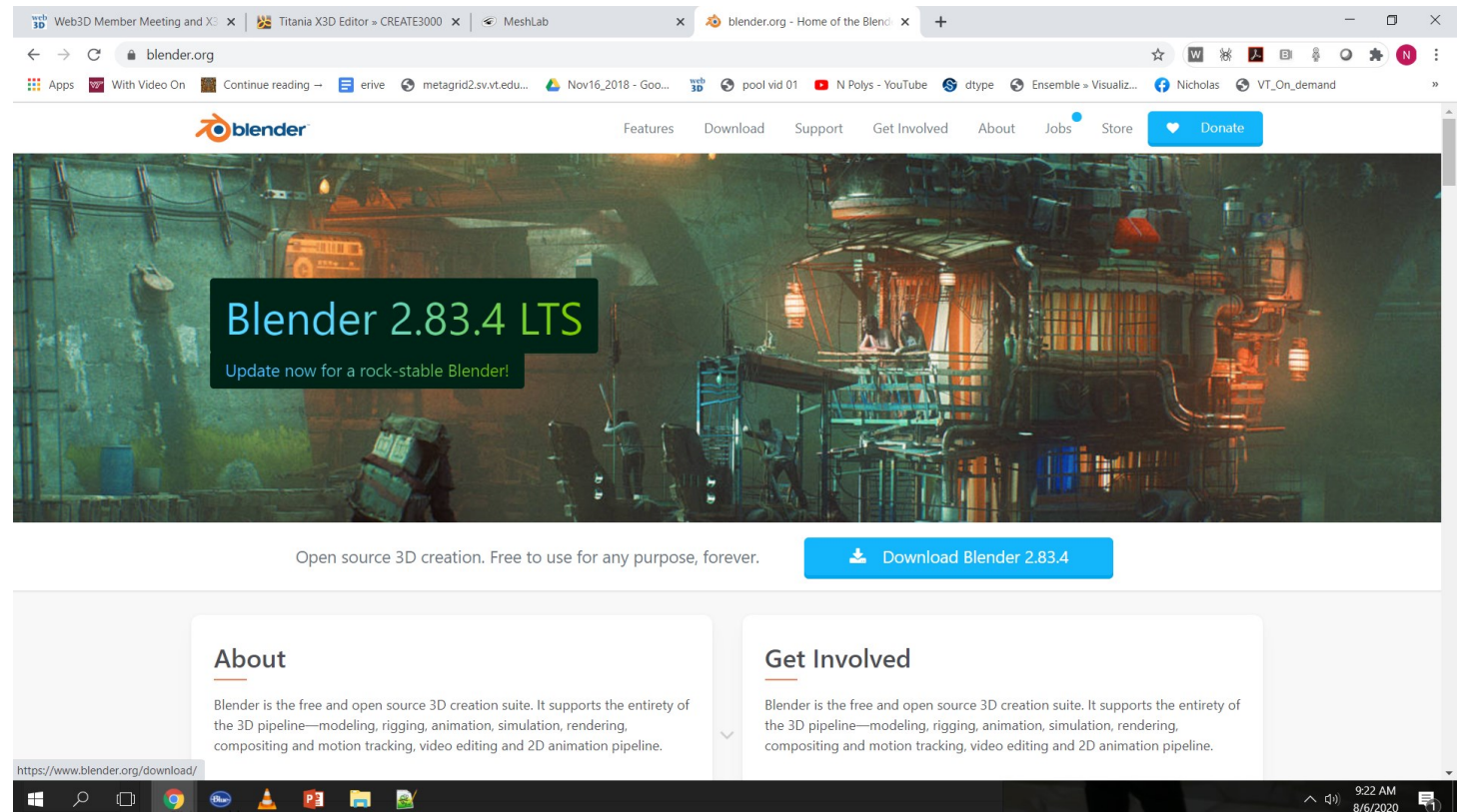
Work on different Script or Shaders at the same time. Scripts are checked for errors when they are saved. The ▶



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

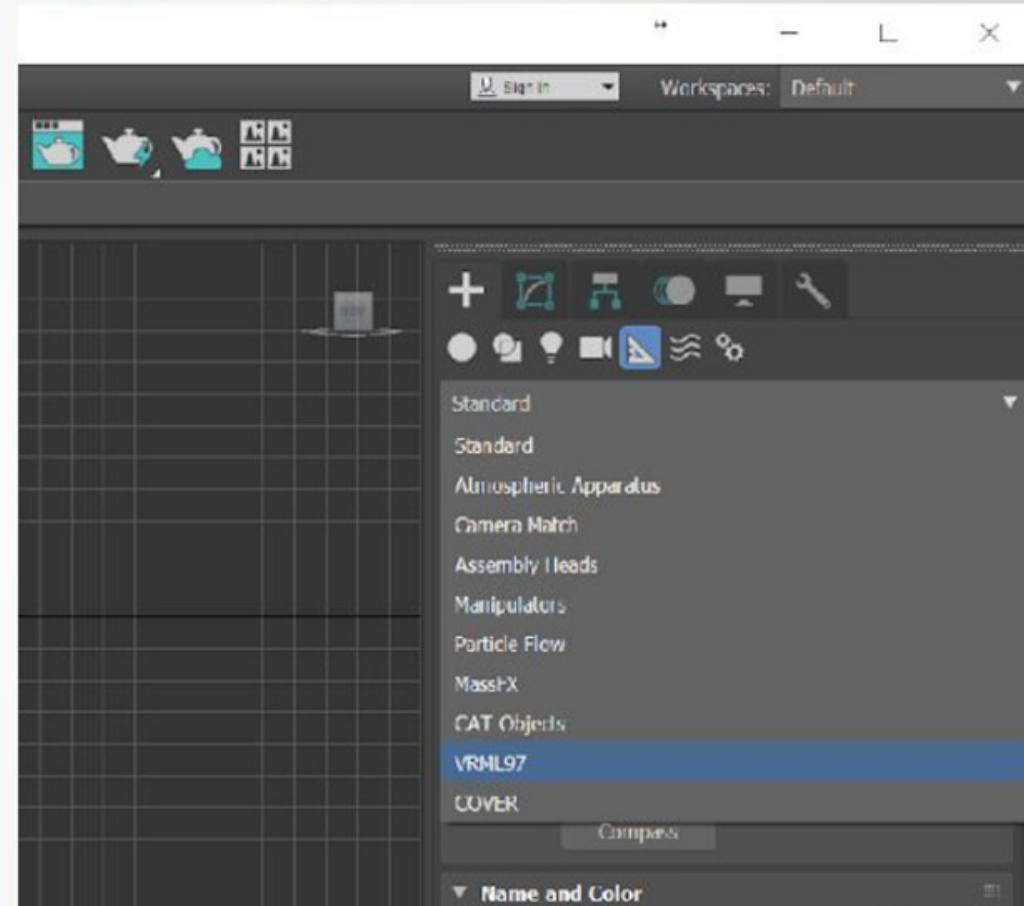
Four file formats

- 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>

Exporter source is located in covise/src/tools/vrmlexp

Create a build directory

Grant write access to .../Autodesk/3ds Max 2018/stdplugins

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 cal3d.dll to .../Autodesk/3ds Max 2018

Replace the original vrmlexp.dle, do not rename it.

Maya

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>

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

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

- Keyframe or Scripts
- Keyframes:
 - Interplators
 - Sequencers

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

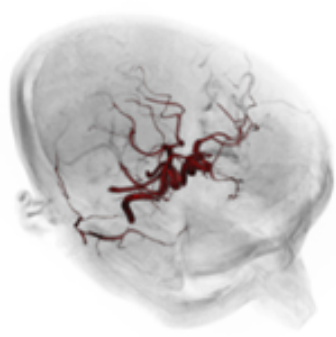
- Add logic and processing for the runtime
(uses the **Scene Access Interface (SAI)** binding inside the scene or externally)
 - <https://x3dgraphics.com/examples/X3dForWebAuthors/#Chapter09EventUtilitiesScripting>
 - <https://www.web3d.org/x3d/content/examples/Vrml2Sourcebook/#Chapter30Scripts>
 - <https://www.web3d.org/x3d/content/examples/ConformanceNist/Miscellaneous/Script/index.htm>
!
- Process device streams and 3DUI Logic
 - https://github.com/VT-Visionarium/garlic/tree/master/InstantReality_VTCAVE

Physics & HANIM in X3DOM

- <http://medialab.teicrete.gr/minipages/H-Anim/>
- http://medialab.teicrete.gr/minipages/H-Anim/X3DOM_Physics.pdf

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



Opacity Map



Silhouette



Cartoon

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/ ./ouput/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