The Semantic Web3D

**Semweb.pro 2019**
Paris, France
December 3, 2019

Towards comprehensive representation of 3D content on the semantic web

www.web3d.org

Don **Brutzman**, John **Carlson**, **Jakub Flotyński**, Felix **Hamza-Lup** , Athanasios **Malamos**, Christophe **Mouton**, Marc **Petit**, Nicholas **Polys**, Leslie **Sikos**, Krzysztof **Walczak**

Our Standards X3D **and** H|anim

web|3D
CONSORTIUM

Our Standards X3D and HAnim

Founded in 1997, Web3D is an open, non-profit, member-driven industry consortium developing royalty-free 3D ISO standards

Paving the Road to Interoperable 3D Graphics with Open Standards

Our Members
Academia
Industry
Research Institutes
Universities
Government
Professionals

We are based in
Mountain View, California

web|3D
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Objective:

- **Overview of Web3D Standards**

- **Web3D and the Semantic Web**

- **Example**

- **Conclusion and take-away**

Current State of 3D on the Web?
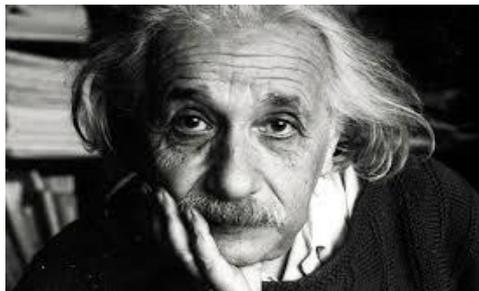
Factors Influencing 3D technology today

- **Growth of re-built 3D content**

- **Less hardware and network limitations**

- **Rendering high quality graphics in real-time**

- **Growth of VR devices**

- **Web is our platform**

Active Web3D Standards

eXtensible 3D Version 3.3

File Format and Rendering Engine

HAnim Version 2
Humanoid Animation

X3D standards and HANIM
Ratified by
ISO/IEC JTC 1/SC 24

**Delivering New
Dimensions on the Web**

X3D: Used in many Industry Verticals

Cultural Heritage
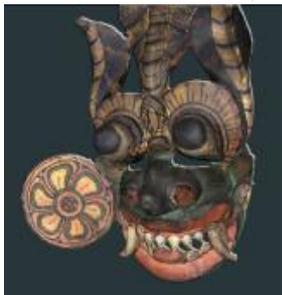
Geospatial

CAD

3D Printing

Mixed Augmented Reality

Medical

HAnim

3D Scanning
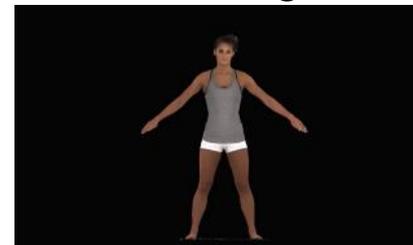
What is X3D?

Second Generation VRML
A complete Solution for 3D on the Web
* Enterprise 3D *

Real-Time * Web Based * Interactive * Animation * Extensible * Scriptable

+
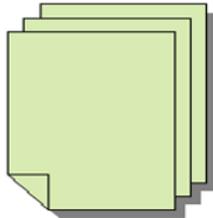
File Formats:
XML, ClassicVRML, Binary

Run-Time Engine:
Two Open source Implementations –
X_ITE and X3DOM

Meshes * Lights * Cameras * Materials * Textures * Shaders * Annotation * Volume *
Audio/Video * AR/VR * Security * Metadata

# Scene graph for real-time interactive 3D

Delivery of virtual environments over the web

Multiple encodings
XML (.x3d)
Classic VRML (.x3dv)
Compressed Binary (.x3db)
JSON

Multiple APIs

Javascript,

Java,

C#, C++, C,

Python

Event
ROUTE
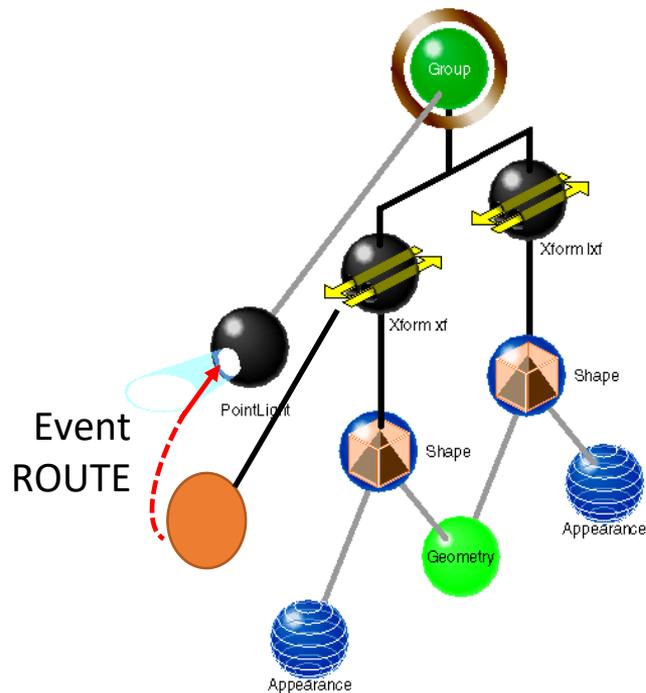
The X3D graphics stack

X3D Application	
⬍	X3DOM, X_ITE
	HTML Browser
X3D Browser (Standalone, Plug-in)	WebGL
DirectX/OpenGL	
Operating System	
Hardware	
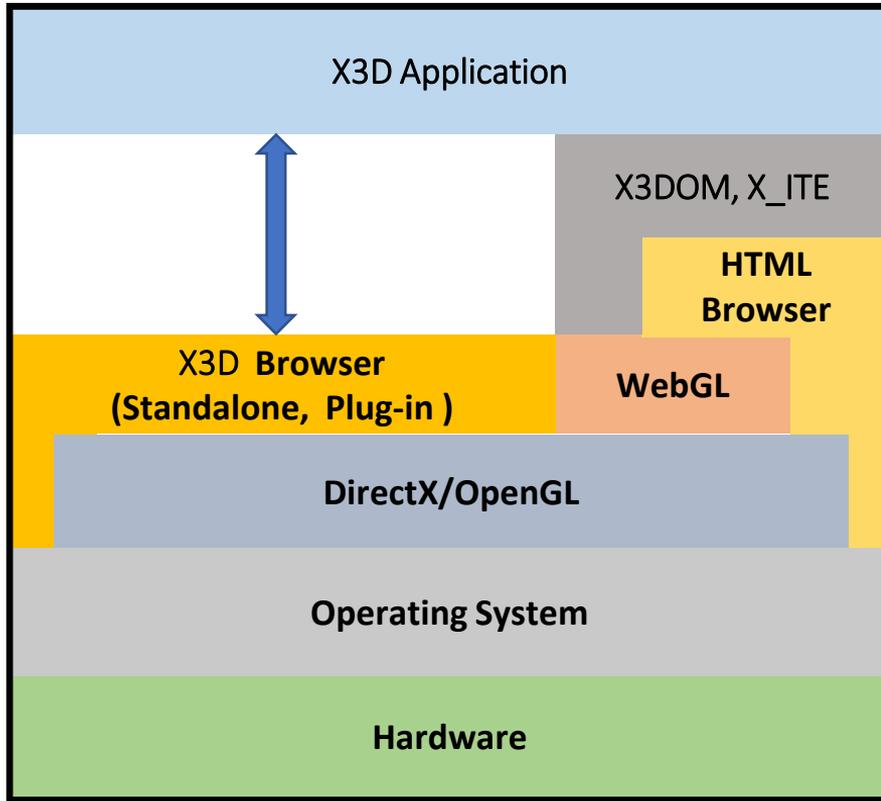
X3D for Web Authors Vs WebGL for 3D graphics application programmers

Open Source X3D Browsers

X3DOM http://www.x3dom.org

X_ITE http://create3000.de/x_ite

Standalone – Instant Reality

Two approaches of 3D in HTML

Completes graphics technologies

Web Programmers

2D	**3D HTML5**

Declarative
Scenegraph
Part of HTML-document
DOM Integration
CSS/ Events

X3D
open
source
solutions

X_ITE

Graphics Programmers

Imperative
Procedural API
Drawing context
Flexible

<canvas>

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Why is Declarative 3D important to Enterprise 3D

- **Interactive 3D objects in HTML5 web pages**

- **Allows easy creation and sharing of 3D graphics using HTML**

- **Bridges the gap between graphics programmers and Web programmers**

Declarative
Scenegraph
Part of HTML-document
DOM Integration
CSS/ Events

x3dom

X_ITE

X3D

xml3d

CAD/Computer aided Design Workflow

STEP
ISO 10303-242

VRML
ISO/IEC 14772

Any CAD Design Tool

X3D xml
ISO/IEC 19775

X3D Browser

HTML

Web Server

3D Printing
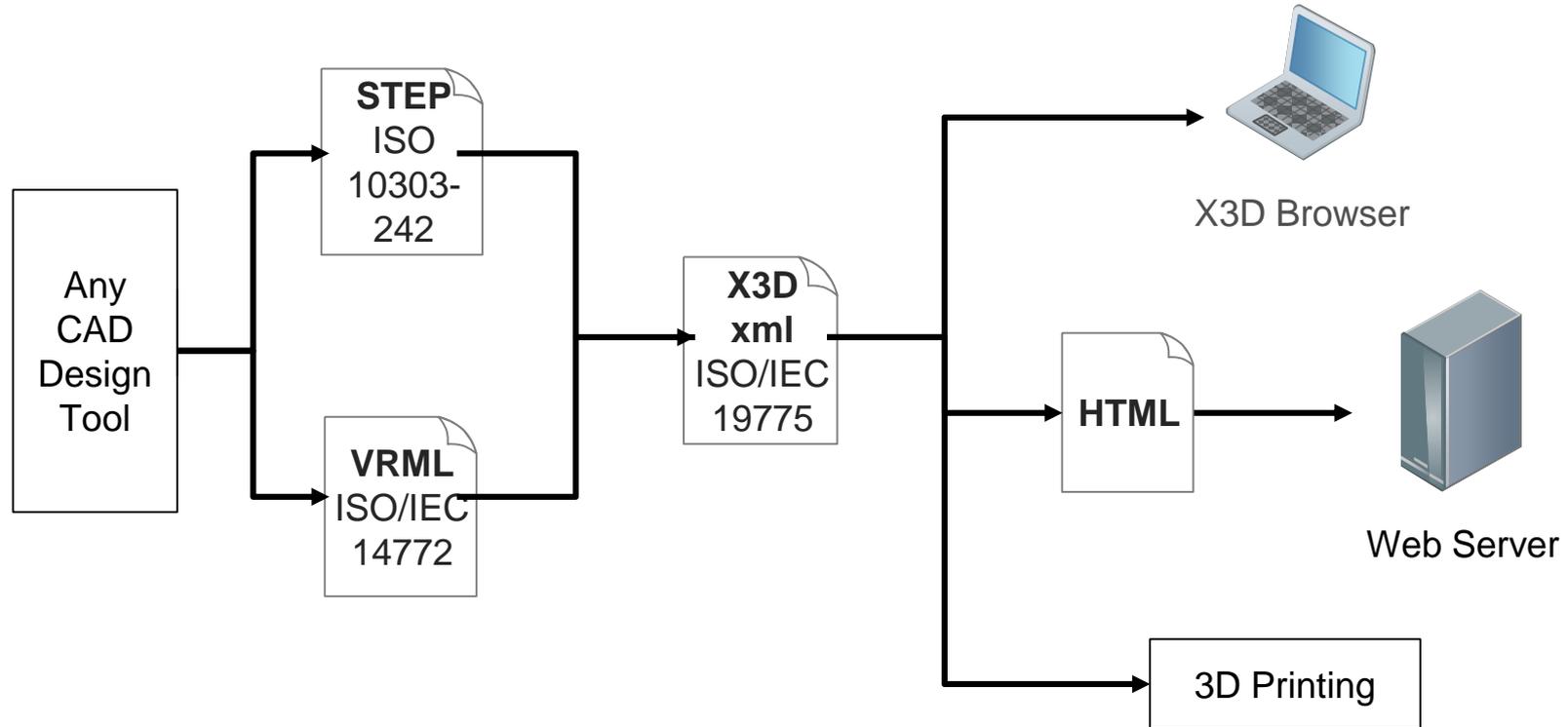
Scientific Visualization Workflow
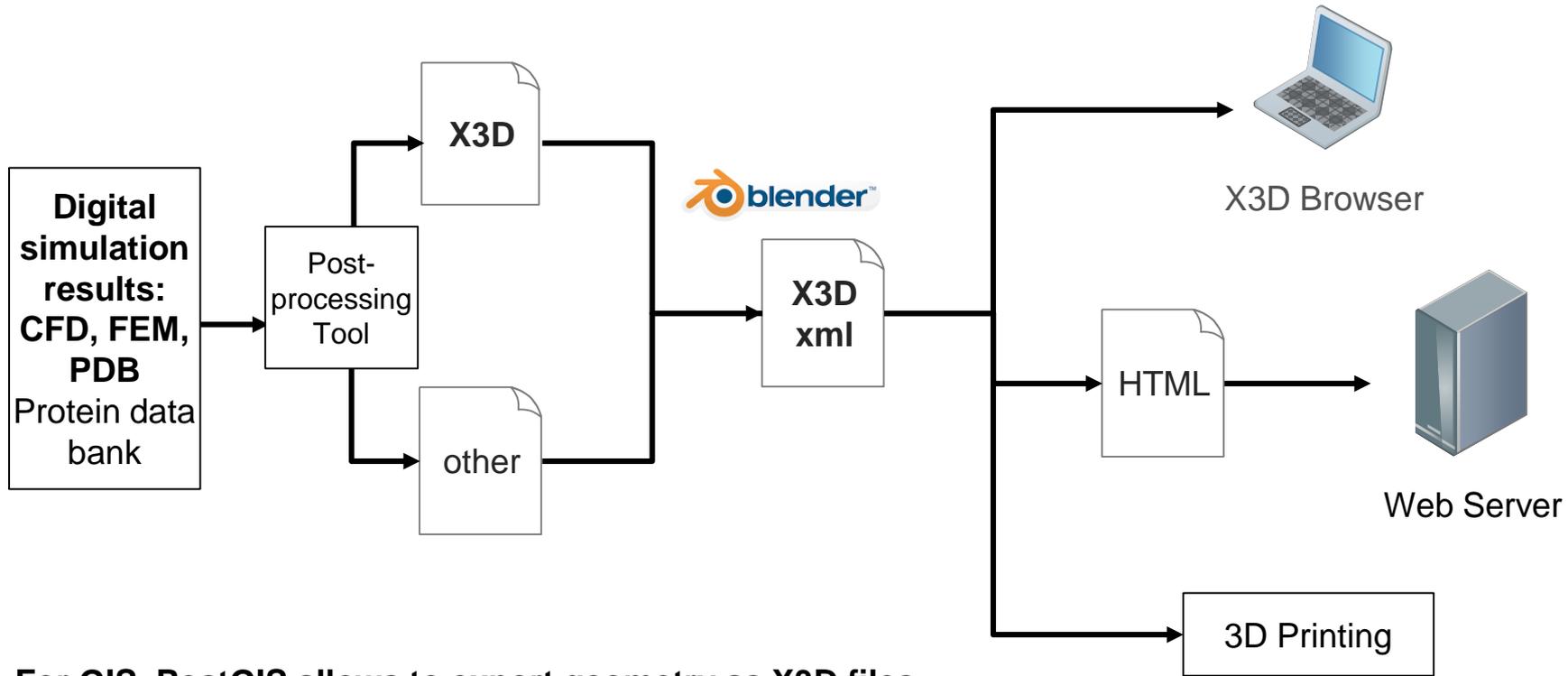
For GIS, PostGIS allows to export geometry as X3D files

X3D is Evolving - X3Dv4

Always backward compatible

X3Dv4 in Development
X3D Unified Object Model (X3DUOM)

X3Dv4
Native in all browsers

X3Dv4 Highlights
- **Improve the search-ability of 3D models**.
- 3D printing of models
- 3D scanning of objects, and toolchain workflow support for point clouds
- CAD interoperability includes model structure **complete metadata**.
- Volume visualization
- **Annotation**
- glTF inline Capabilities
- **Archival publishing of cultural and natural heritage**

Open-source implementations, X3DOM and X_ITE

Timeline - Dec 2019 – Feature set freeze
Draft Specification in 2020 followed by ISO Ratification

Available to members since 2018 in github
https://github.com/Web3dConsortium
Released public draft

Authors have the archival stability of a well-tested long-lasting specification to build upon

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Altar.wrl ×

```
28
29    NavigationInfo { type [ "EXAMINE" "ANY" ] } ###  Default X3D NavigationInfo
30
31    Background {
32      skyColor [ 1 1 1 ]
33    }
34    DEF Colonna1 Transform {
35      translation 0.7 0 -0.7
36      children [
37          Shape {
38            geometry Box {
39              size 0.4 1.2 0.4
40            }
41          appearance DEF WoodAppearance Appearance {
42            texture DEF Wood ImageTexture {
43              url [ "images/Wood.jpg" "http://X3dGraphics.com/examples/X3dForAdvancedModeling/SanCarlosCathedral/images/Wood.jpg" ]
44            }
45          }
46        }
47      ]
48    }
49    DEF Colonna2 Transform {
50      translation -0.7 0 -0.7
51      children [
52          Shape {
53            geometry Box {
54              size 0.4 1.2 0.4
55            }
56          appearance USE WoodAppearance
57        }
58      ]
59    }
60    DEF Colonna3 Transform {
61      translation 0.7 0 0.7
62      children [
63          Shape {
64            geometry Box {
65              size 0.4 1.2 0.4
66            }
67          appearance USE WoodAppearance
```

example

Line 11, Column 1

Spaces: 2   Plain Text

Web3D is so… semantic (web)!

- **Structural semantic info in 3D models, scene graphs…**

● Geometry	● Textures	● etc.
● Motion	● Viewpoints	
● Color	● Lighting	

- Examples: number of index values, curvature, velocity, color, Texture pattern, brightness…..

Ready for the machine-readable standards (SemWeb?)

Table 1. *Topological criteria for 3D R-tree structure*

	Disjoint	(RectA.xMax <= RectB.xMin || RectA.xMin >= RectB.xMax) ||
		(RectA.yMax <= RectB.yMin || RectA.yMin >= RectB.yMax) ||
	Touch	(RectA.zMax <= RectB.zMin || RectA.zMin >= RectB.zMax)
	Equal	(RectA.xMin == RectB.xMin && RectA.xMax == RectB.xMax) &&
		(RectA.yMin == RectB.yMin && RectA.yMax == RectB.yMax) &&
		("RectA.zMin == RectB.zMin && RectA.zMax == RectB.zMax)
	Within	(RectA.xMin >= RectB.xMin && RectA.xMax <= RectB.xMax) &&
		(RectA.yMin >= RectB.yMin && RectA.yMax <= RectB.yMax) &&
		(RectA.zMin >= RectB.zMin && RectA.zMax <= RectB.zMax)
		Complementary relation: *CoveredBy*
		Opposite MBB relations: *Contains, Covers*
	Contains	(RectA.xMin <= RectB.xMin && RectA.xMax >= RectB.xMax) &&
		(RectA.yMin <= RectB.yMin && RectA.yMax >= RectB.yMax) &&
		(RectA.zMin <= RectB.zMin && RectA.zMax >= RectB.zMax)
		Complementary relation: *Covers*
		Opposite MBB relations: *Within, CoveredBy*
	Overlap	(SearchRect.xMin < Rect.xMax && SearchRect.xMax > Rect.xMin) &&
		(SearchRect.yMin < Rect.yMax && SearchRect.yMax > Rect.yMin) &&
		(SearchRect.zMin < Rect.zMax && SearchRect.zMax > Rect.zMin)

Reference to paper: http://aetic.theiaer.org/archive/v2n4/p1.html

- **More and more references for VR, AR, MR, Digital Twin…**

- K. Kontakis, A. G. Malamos, M. Steiakaki, S. Panagiotakis and J. A. Ware,"Object Identification Based on the Automated Extraction of Spatial Semantics from Web3D Scenes," Annals of Emerging Technologies in Computing (AETiC) Vol. 2, No. 4, 2018

- Flotyński, J., K. Walczak, Ontology-based Representation and Modeling of Synthetic 3D Content: a State of the Art Review, in: Computer Graphics Forum, Wiley, ISSN: 0167-7055

Web3D 2011 ACM conference, Paris, France

A story of an initiative to extend the X3D Cadprofile adding BREP solid representation

An issue of semantic vs. structural expression

Henry Boccon-Gibod

Electricité de France, R&D Division

mailto:henry.boccon-gibod@edf.fr

https://web3d2011.web3d.org/p/WorkShop-CAD-Boccon-Gibod.pdf

A consistent populated model...
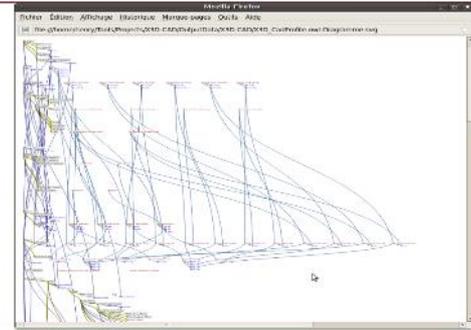
Questions

• Issues :
  • What are compared advantages/disadvantages of semantic (OWL) versus structural (XSD) expression ?
    – easier extensibility and consistancy of OWL expression ?
    – easy semantic extension of any kind ?
    – possible benefits of rule languages attached to owl ?
      • Model consistancy checking ?
    – Possible lack of efficiency issues due to OWL APIs ?
      • (Jena, OWLAPI etc.)
  • To change expression kind, would it be a revolution ?

What could we do with semantics for 3D contents? (the SemWeb-expert way)

- A semantic description of a 3D scene is an expression that can **answer to semantic reasoning and queries** about the scene

- Reasoning and queries may cover **geometrical, structural, presentational and behavioral** properties of 3D objects at the **3D-specific and domain-specific** levels of abstraction
  - Structural, e.g.,
    - How many polygons does a 3D model have?   (3D-specific)
    - What are components of a virtual car?   (domain-specific)
  - Presentational, e.g.,
    - Which objects in a scene use a common texture?   (3D-specific)
    - Which objects in a scene are made of wood?   (domain-specific)
  - Behavioral, e.g.,
    - What scripts describe the behavior of an object?   (3D-specific)
    - What is the exercise performed by an avatar?   (domain-specific)

- Different 3D- and domain-specific ontologies could be used together to describe 3D content, in particular through **mapping**, e.g., a virtual museum ontology mapped to a 3D ontology

© Web3D Consortium 2019
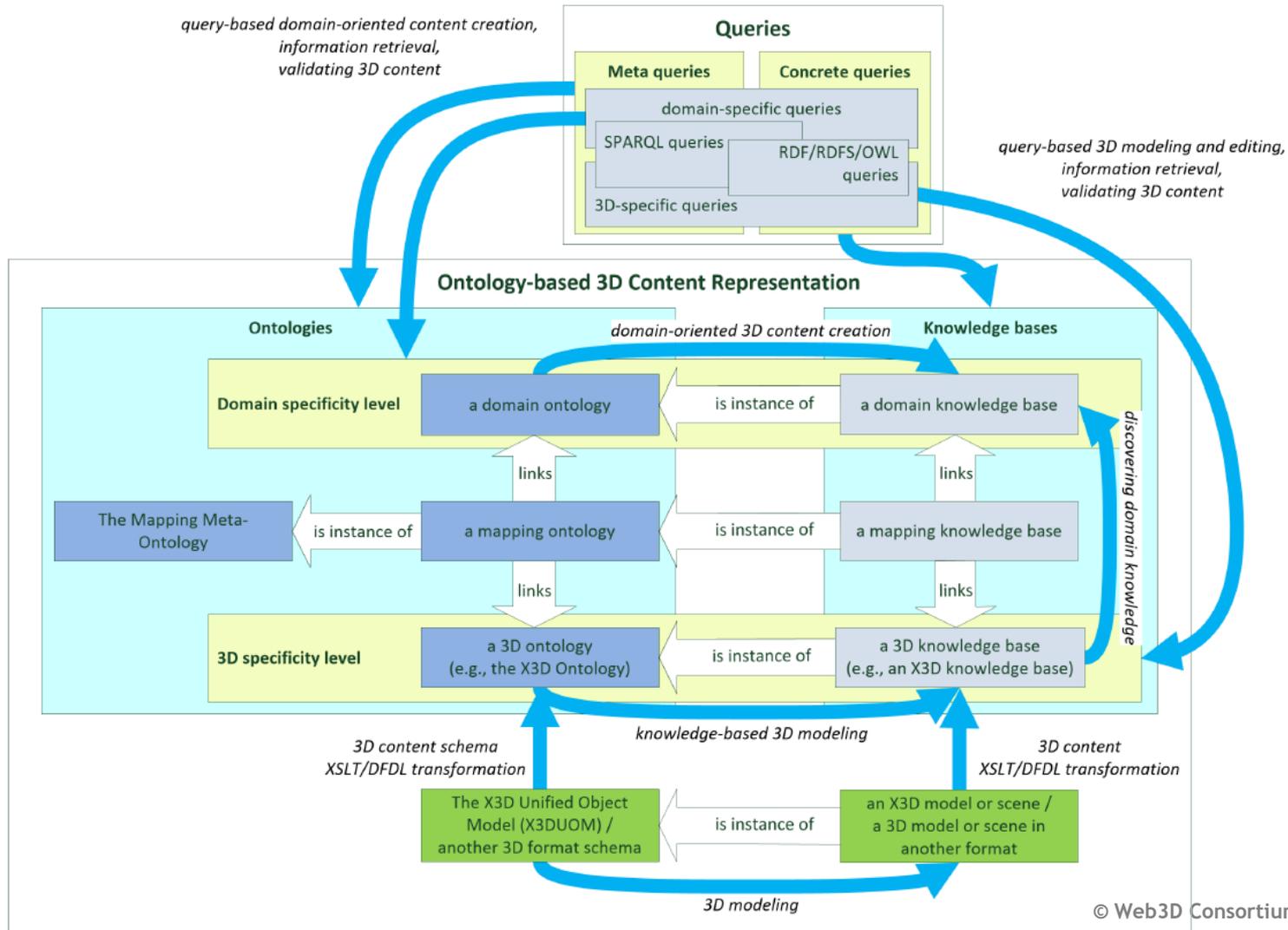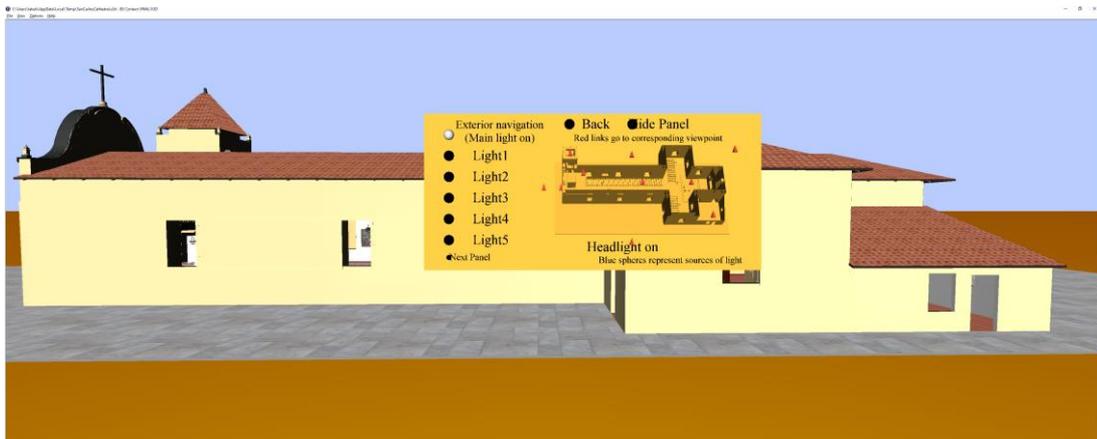
Example

Copyright © 2019 San Carlos Cathedral

X3D for Advanced Modeling E×

https://x3dgraphics.com/examples/X3dForAdvancedModeling/SanCarlosCathedral/SanCarlosCathedralInd

Rechercher

Les plus visités   Débuter avec Firefox   standards.iso.org/iso/t...

Main Menu

X3D model

ClassicVRML

VRML97

Canonical XML

annotated
documentation

.py python

X_ITE

X3DOM

.json (check)

.x3db Binary

.java source
(Javadoc)

.ttl Turtle
(query)
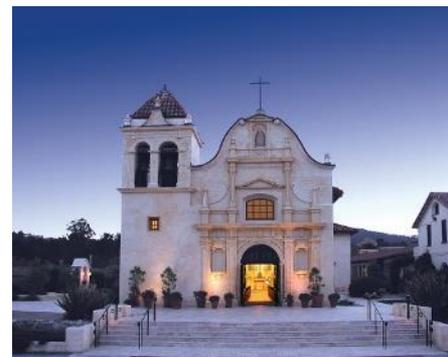
X3D Example Archives: X3D for Advanced Modeling, San Carlos Cathedral, San Carlos Cathedral

San Carlos Cathedral is the oldest continuously functioning church and the first stone building in the State of California.

```
<?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='SanCarlosCathedral.x3d'/>
        <meta name='description' content='San Carlos Cathedral is the oldest continuously functioning church and the first stone building in the State of California.'/>
        <meta name='creator' content='Michele Foti, Don Brutzman'/>
        <meta name='created' content='15 December 2011'/>
        <meta name='modified' content='5 December 2014'/>
        <meta name='reference' content='documentation/'/>
        <meta name='reference' content='tests/'/>
        <meta name='reference' content='TODO.html'/>
        <meta name='reference' content=' http://www.sancarloscathedral.net '/>
        <meta name='reference' content='RoyalPresidioChapelHistoricalReferences.pdf'/>
        <meta name='reference' content='originals/'/>
        <meta name='Image' content='SanCarlosCathedralFrontAbove.2012February.png'/>
        <meta name='reference' content='originals/ModelSanCarlosChurchFeb-3-2012.x3d'/>
        <meta name=' warning ' content=' under development '/>
        <meta name='identifier' content=' http://X3dGraphics.com/examples/X3dForAdvancedModeling/SanCarlosCathedral/SanCarlosCathedral.x3d '/>
        <meta name='generator' content='X3D-Edit 3.3, https://savage.nps.edu/X3D-Edit'/>
        <meta name='license' content=' ../license.html'/>
    </head>
```

The VRML encoding

```
28
29    NavigationInfo { type [ "EXAMINE" "ANY" ] } ###  Default X3D NavigationInfo
30
31    Background {
32      skyColor [ 1 1 1 ]
33    }
34    DEF Colonna1 Transform {
35      translation 0.7 0 -0.7
36      children [
37          Shape {
38            geometry Box {
39              size 0.4 1.2 0.4
40            }
41            appearance DEF WoodAppearance Appearance {
42              texture DEF Wood ImageTexture {
43                url [ "images/Wood.jpg" "http://X3dGraphics.com/examples/X3dForAdvancedModeling/SanCarlosCathedral/images/Wood.jpg" ]
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45            }
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65              size 0.4 1.2 0.4
66            }
67            appearance USE WoodAppearance
```

Altar.wrl

Line 11, Column 1   Spaces: 2   Plain Text

```
1   # Prefixes: 'x3do', ':', 'rdf' and 'owl' indicate: the X3D
        Ontology and knowledge base as well as RDF and OWL.
2
3   :scene rdf:type owl:NamedIndividual , x3do:Scene .
4   :scene x3do:hasBackground :background .
5   :background rdf:type owl:NamedIndividual, x3do:Background;
6     x3do:skyColor (0.7216 0.8 0.9922).
7   :scene x3do:hasTransform :Colonna1 .
8   :Colonna1 rdf:type owl:NamedIndividual , x3do:Transform ;
9     x3do:translation (0.7 0 -0.7) .
10  :Colonna1 x3do:hasShape :woodenElement1 .
11  :woodenElement1 rdf:type owl:NamedIndividual , x3do:Shape.
12  :woodenElement1 x3do:hasBox :woodenElement1Box .
13  :woodenElement1Box rdf:type owl:NamedIndividual, x3do:Box;
14    x3do:size (0.4 1.2 0.4) .
15  :woodenElement1 x3do:hasAppearance :WoodAppearance .
16  :WoodAppearance rdf:type owl:NamedIndividual , x3do:
        Appearance .
17  :WoodAppearance x3do:hasTexture :Wood .
18  :Wood rdf:type owl:NamedIndividual , x3do:ImageTexture ;
        x3do:url ".../Wood.jpg" .|
```


Where is the texture file?

```
SELECT ?textureUrl WHERE {                          1
  ?x x3do:hasTexture ?texture .                     2
  ?texture x3do:url ?textureUrl . }                 3
ORDER by ASC(?textureUrl)                           4
```

```
1  # Prefixes: 'x3do', ':', 'rdf' and 'owl' indicate: the X3D
        Ontology and knowledge base as well as RDF and OWL.
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3  :scene rdf:type owl:NamedIndividual , x3do:Scene .
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5  :background rdf:type owl:NamedIndividual, x3do:Background;
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7  :scene x3do:hasTransform :Colonna1 .
8  :Colonna1 rdf:type owl:NamedIndividual , x3do:Transform ;
9   x3do:translation (0.7 0 -0.7) .
10 :Colonna1 x3do:hasShape :woodenElement1 .
11 :woodenElement1 rdf:type owl:NamedIndividual , x3do:Shape.
12 :woodenElement1 x3do:hasBox :woodenElement1Box .
13 :woodenElement1Box rdf:type owl:NamedIndividual, x3do:Box;
14   x3do:size (0.4 1.2 0.4) .
15 :woodenElement1 x3do:hasAppearance :WoodAppearance .
16 :WoodAppearance rdf:type owl:NamedIndividual , x3do:
        Appearance .
17 :WoodAppearance x3do:hasTexture :Wood .
18 :Wood rdf:type owl:NamedIndividual , x3do:ImageTexture ;
        x3do:url ".../Wood.jpg" .|
```

Which RGB color is the sky?

```
SELECT ?skyColorListVal WHERE {                              1
  ?background rdf:type x3do:Background ;                     2
    x3do:skyColor/rdf:rest*/rdf:first ?skyColorListVal . }   3
```

```
 1  # Prefixes: 'x3do', ':', 'rdf' and 'owl' indicate: the X3D
        Ontology and knowledge base as well as RDF and OWL.
 2
 3  :scene rdf:type owl:NamedIndividual , x3do:Scene .
 4  :scene x3do:hasBackground :background .
 5  :background rdf:type owl:NamedIndividual, x3do:Background;
     x3do:skyColor (0.7216 0.8 0.9922).
 6
 7  :scene x3do:hasTransform :Colonna1 .
 8  :Colonna1 rdf:type owl:NamedIndividual , x3do:Transform ;
 9    x3do:translation (0.7 0 -0.7) .
10  :Colonna1 x3do:hasShape :woodenElement1 .
11  :woodenElement1 rdf:type owl:NamedIndividual , x3do:Shape.
12  :woodenElement1 x3do:hasBox :woodenElement1Box .
13  :woodenElement1Box rdf:type owl:NamedIndividual, x3do:Box;
14    x3do:size (0.4 1.2 0.4) .
15  :woodenElement1 x3do:hasAppearance :WoodAppearance .
16  :WoodAppearance rdf:type owl:NamedIndividual , x3do:
        Appearance .
17  :WoodAppearance x3do:hasTexture :Wood .
18  :Wood rdf:type owl:NamedIndividual , x3do:ImageTexture ;
        x3do:url ".../Wood.jpg" .|
```

How many shapes ?

```
SELECT (count(distinct ?shape) as ?num) WHERE {        1
    ?shape rdf:type x3do:Shape . }                     2
```

What could do semantics for 3D contents for me? (the industrial-final-user way)

- Knowledge-based 3D modeling,

- Domain-oriented 3D content creation,

- Query-based 3D modeling and editing,

- Generating mappings,

- Discovering domain knowledge,

- Information retrieval,

- Validating 3D content,

- Transforming available 3D content to semantic 3D content,

- Rendering ontology-based 3D scenes

The digital twin
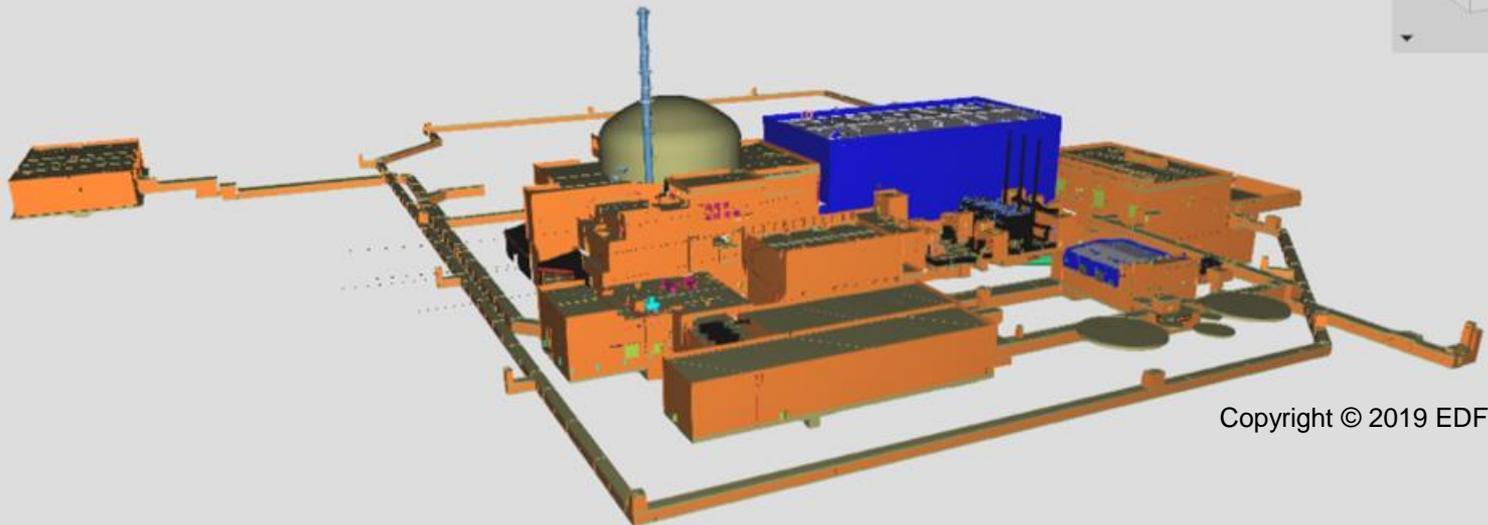
the semantic-web(3D) one!

Copyright © 2019 EDF

References: SemWeb.pro 2017 poster and « A plant engineering "digital rosetta stone": towards data-centric multidimensional CAD web portal", Web3D 2016 ACM conference: https://doi.org/10.1145/2945292.2945321

Resolution: "K"

Title: Establish PWI on ontology for geometry and topology
WG 12

ICS › 75 › 75.020

ISO/TS 15926-3:2009

Industrial automation systems and integration —
Integration of life-cycle data for process plants including
oil and gas production facilities — Part 3: Reference data
for geometry and topology

ICS › 25 › 25.040 › 25.040.40

ISO 10303-42:2019

Industrial automation systems and integration —
Product data representation and exchange — Part 42:
Integrated generic resource: Geometric and topological
representation

ICS › 25 › 25.040 › 25.040.40

ISO 16739-1:2018

Industry Foundation Classes (IFC) for data sharing in the
construction and facility management industries — Part
1: Data schema

Introduction:
Meetings took place between WG12 (T1), WG3, JWG 16 at the SC 4 meetings in Chicago and Toulouse to consider the way in which geometry and topology can be handled with a semantic web environment. Many industrial applications are now being developed for this environment, and many of these require a geometry and topology capability. The PWI will produce a technical report. The report will include a study that takes a part of ISO 10303-42 and provides an equivalent representation in OWL. Aspects to be reported on include: the ability of OWL profiles to represent the same information with equal precision; the effort required to create the OWL representation; the capability of having geometry and topology ontology to provide a capability for shape and location by being imported into any industrial ontology; the capability of the ontology to support both product and plant geometry and GIS applications; the practicality of the ontology for the representation of large data sets. An annex will list existing ontologies for geometry and topology ontologies and review the state of the art. The capability of the ontology may be illustrated by a simple use case with example instances.

Objective:
Establish a PWI to create a Technical Report

Resolution:
SC 4 establishes a PWI to create a Technical Report on Ontology for geometry and topology.

The report is to be delivered in May 2020 for review at the next SC 4 meeting.

SC4 nominates Ben Urick (US) as project leader with appreciation to serve in this capacity and requests member bodies and liaisons to nominate experts to this preliminary work.

Interested by the semantic web3D?

Public mailing-list : semantics-public@web3d.org

The WG: https://www.web3d.org/working-groups/x3d-semantic-web

The deliverables: https://www.web3d.org/x3d/content/semantics/semantics.html

X3D Ontology for Semantic Web

web|3D CONSORTIUM
Open Standards for
Real-Time 3D Communication

The X3D Ontology for Semantic Web provides terms of reference for semantic query of X3D models.

Motivation | Availability | Design and Design Patterns | OWLDoc | Queries | References | Tools | TODO | Contact

---

✏ Motivation

The X3D Semantic Web Working Group mission is to publish models to the Web using X3D in order to best gain Web interoperability and enable intelligent 3D applications, feature-based 3D model querying, and reasoning over 3D scenes.

Motivating insights:

"The answer to your question is the response to the query." Jim Hendler and Dean Allemang

"Trying to use the Semantic Web without SPARQL is like trying to use a relational database without SQL." Tim Berners-Lee

"The proof of the pudding is in the eating." Wiktionary

Some Take-away from X3D semantic web WG chairs

Don Brutzman, Naval Post-Graduate School, USA, brutzman[at]nps.edu
Jakub Flotyński, Poznan University, Ploand, flotynski[at]kti.ue.poznan.pl

« Much exciting activity to apply Semantic Web standards is occurring at Web3D Consortium.

We are steadily unlocking the entire media domain of 3D models for semantic query.

Slidesets and papers are provided for their continuing scrutiny, all insight and participation is welcome. »

https://www.web3d.org/working-groups/x3d-semantic-web

Looking for European and international collaborations and projects on semantic web(3D)?

Please contact the team:

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Web3D International Mobilization

- **Annual Outreach activates engage communities of interest**

- **SIGGRAPH/ Eurogaphics Web3D Conference (25 years)**

- **Workshops & exhibits at SIGGRAPH**

- **VR Hackathons worldwide**

- **Showcases & regional meetings**

- **X3D and members appear regularly at:**

  IEEE VR, Supercomputing, MMVR, IITSEC,

- **ISO/IEC JTC 1/SC 24 and ISO/TC 184/SC 4 Working Groups**

Web3D Resources

Membership: **www.Web3D.org/join**

Web3D Standards: **www.Web3D.org/standards**

Work Groups: **www.Web3d.org/working-groups**

Workshop: **www.Web3d.org/Web3d-quickstart**

Examples: **www.web3d.org/x3d/content/examples/Basic/**

Events: **www.Web3D.org/events**

Join and Participate

Participants always welcome

- http://www.web3d.org/join

Suggestions are always welcome

- x3d-public@web3d.org

Join us at:

- **Web3D 2020** June 24-26 – Seoul, South Korea
- **SIGGRAPH 2020** July 19-23 – Washington D.C.

Contact
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Web3D Consortium
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CFP in January 2020!

Semantic web is a major topic

Thank You for Considering Web3D Standards!

We look forward to the chance to work together

Resources and contacts
- Web3D Website
    - http://www.web3d.org
- Nicholas Polys, President
    - npolys@vt.edu
- Anita Havele, Executive Director
    - anita.havele@web3d.org

Thank you for your attention!

The Web3D Vision

An immersive world in which everyone can **securely** access and **share** 3D data **when and where** they need it.

The Web3D Mission

To provide standards that empower **efficient** and **secure** 3D Graphics that is **interoperable** and **archiveable**.

The backbone for the **new dimensions** of 3D!

www.web3d.org/join

medical   scanning   platforms   3D printing   geospatial

< X3D >

X3D Profiles

Full
Immersive
Interactive
Interchange
Core
CAD
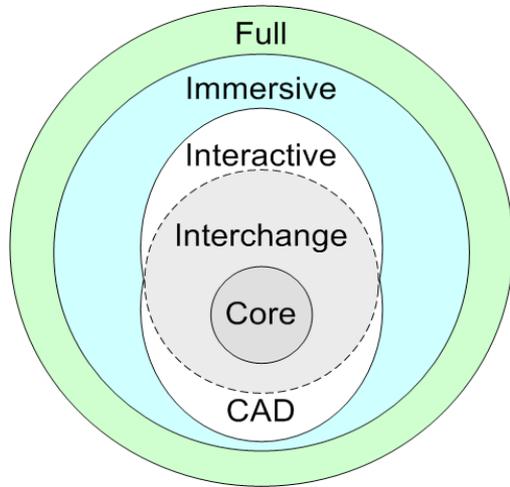
Profiles are X3D subsets

- Collection of X3D nodes for author's palette
- Interchange suitable for simple geometry conversion
- Interactive adds simple user interactivity (clicking etc.)
- Immersive matches VRML97, plus a bit more
- Full profile includes all nodes
- Components are collections of X3D nodes that perform similar operations, displays, or functions.

General Goal:

- A 3D visualization component for any runtime environment
- Reduced complexity and implementation effort

X3D Node Set
https://www.web3d.org/documents/specifications/19775-1/V3.3/Part01/nodeIndex.html

X3D Profile Relationships

Full: *H-Anim, Geospatial, NURBS, Texturing3D. Programmable Shaders*

Immersive: *Scripting, Prototypes, Networking*

CADInterchange

CADGeometry

Interactive: *Sensors*

Interchange: *Geometry, Rendering*

Core: *file definition, Metadata*

MedicalInterchange

Volume Rendering

Rev: April 4 2018

X3D Graphics Standards Relationships

Reference Standards

| Computer Graphics Reference Model (CGRM) 11072 | VRML97 with EAI 14772 | HTML5 and Document Object Model (DOM) | GL Transmission Format (glTF) 2.0 .gltf (json), .bin, .glb (combined) | 3D Printing Scanning ISO JTC1 | WebXR Device API OpenXR | Mixed Augmented Reality (MAR) Reference Model ISO/IEC 18038,39,40 series Multiple Individual MAR projects Open publication by ISO requested |

Web3D Consortium Architectures, File Encodings, Language Bindings

Humanoid Animation (H-Anim) 19774
- Part 1: Architecture, hands, feet
- Part 2: Motion animation
- Part 3: Facial model animation
- Part 4: Internal organ systems

X3D Graphics v4.0 Architecture 19775-1 | v4.0 HTML DOM | v4.1 MAR WebVR
X3D Unified Object Model (X3DUOM)
X3D Ontology for Semantic Web Technology

X3D Scene Access Interface (SAI) 19775-2
Standalone application functionality

Medical content and metadata for health records
HL7 FIHR | DICOM
IEEE 3D Body Processing

X3D XML Encoding 19776-1 — .x3d

X3D ECMAScript Language Binding 19777-1 — .js — ECMAScript (JavaScript) ISO/IEC 22275: 2018

ClassicVRML Encoding 19776-2 — .x3dv

X3D Java Language Binding 19777-2 — .java .jar — Java Language Specification version 12: 2019

XML Security: Authentication, Encryption, etc.

X3D CBE Compressed Binary Encoding 19776-3 — .x3db

X3D (SAI) C Language Binding 19777-3 — .c — C Language Specification ISO/IEC 9899:2018

Efficient XML Interchange (EXI) Compression

X3D EBE Efficient Binary Encoding 19776-4 — .exi

X3D (SAI) C++ Language Binding 19777-4 — .cpp — C++ Language Specification ISO/IEC 14882:2017

Fast Infoset (FI) Compression ISO 24824-1

X3D (SAI) C# Language Binding 19777-5 — .cs — C# Language Specifications ISO/IEC 23270:201x

JSON specifications: IETF RFC/schema, 22275:2018, etc.

X3D JSON Encoding 19776-5 — .json

X3D (SAI) Python Language Binding 19777-6 — .py — Python Language Reference python.org, PyPi

Legend
- ISO/IEC Web3D Standard
- ISO/IEC Standard
- W3C Recommendation
- Khronos Standard
- Other specifications
- refers to →
- Planned | Proposed

21 September 2019

Example Instances

| HTML5 pages containing X3D | X3D scenes, model files | Compressed glTF shapes | X3D scripts, applications | SAI libraries X3DUOM |

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Family of ISO Standards

X3D Specifications

X3D File Encodings

.wrl, .wrz
VRML 97
Specification

ISO 14772-2

.x3d
XML Encoding
DTD, Schema

ISO 19776-1

.x3dv
**ClassicVRML
Encoding**

ISO 19776-2

DOM
Document
Object Model

Recommendations
W3C

**X3D
Abstract, API
Specifications
ISO 19775-1,2**

**DICOM
HAnim**

.x3db
**Binary
Encoding**

ISO 19776-3

**Scene Access
Interface (SAI)
Java**

ISO 19777-2

XML
Encryption,
Authentication

**Recommendations
W3C**

**Scene Access
Interface (SAI)
ECMAScript**

ISO 19777-1

**Programming
Language
Bindings**

web|3D CONSORTIUM

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Fundamentals of X3D

Based on VRML, supports several APIs

- **Modular components, Extensible, Scriptable**

- **Efficient and Scalable Open Standards**

- **Open source and royalty-fee ISO standard**

- **Quality Assurance tools for conformance**

- **Interoperable with other standards**

- **Secure (Binary Encryption, Digital Signature, Compression)**

- **Platform Agnostic (All platforms all browsers)**

- **Stable that stands the test of time (Archiveable)**

IEEE 3DBP WG Feature Needs table (X3D offers most of the feature requests)

Web3D Standardization Process

Volunteers and Members work together on Standards

Development

Web3D Working Groups:

X3D

Medical

Geospatial

Mixed Reality

Heritage

Semantics

Design Printing & Scanning

Interoperability

SDO Partnerships:

Adoption Process

1. Identify Standard or Extension to existing standards
- Study Market Trends/Requirements
- Identify Consortium Members' Interest
- Identify if this requirement falls under an existing working group charter
- Form a new working group if this does not

2. Create Standard or Extension
- Follow Consortium's IP Policy, Ensure Open and Consensus based solution
- Identify at least two independent and interoperable
- Create conformance testing suites
- Announce member/public review of 30 days
- Review comments and incorporate or discard with cause.
- Complete standard or extension for submission

3. Submit Standard or Extension for Board approval and Member vote
- Web3D Consortium Board of Directors review
- Board determines if a Web3D Members vote is necessary
- Tabulate Member vote results
- Start ISO certification process after final Board approval

4. ISO Certification - Follows ISO policy for all standards

File Format

Rendering Engine

Who is using X3D?
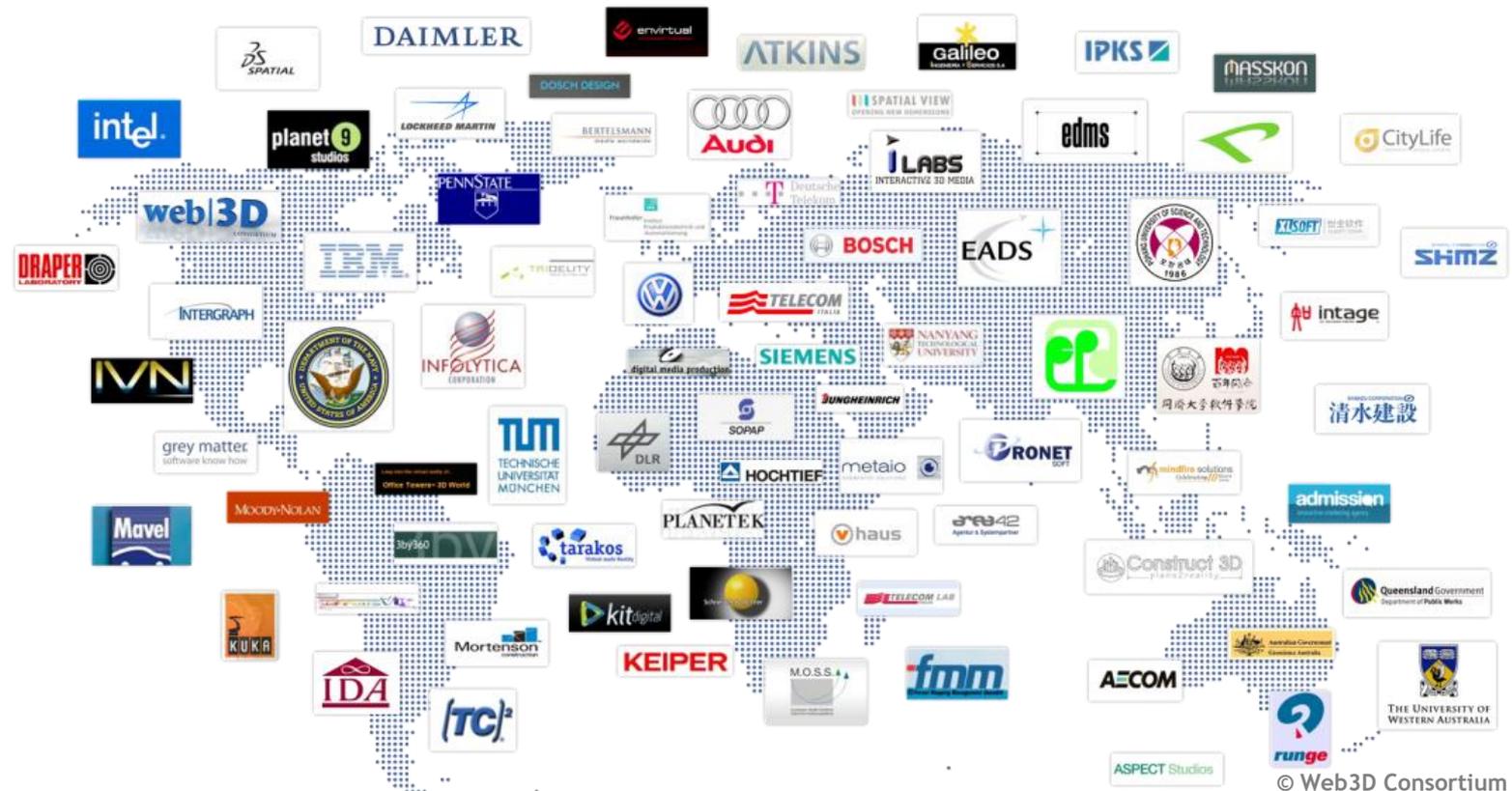
X3D ISO Standard High-Level Features
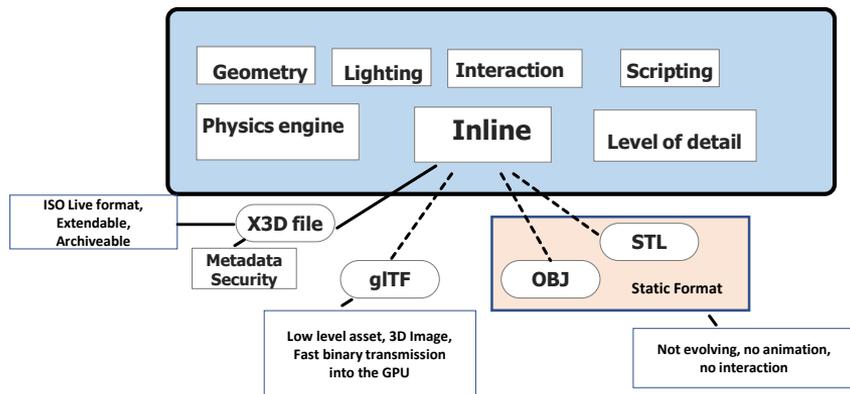
Illustration of the relation between high-level features of X3D enabling constructing dynamic, interactive, 3D scenes; and the ability to load contents, or assets, from external sources including other X3D files.

The ability to include other X3D content is a part of the current ISO standard X3D v 3.3; the inclusion of glTF is planned for the upcoming X3D v4.

Inclusion of glTF, OBJ, STL is already an extension offered by X3D viewers such as X3DOM and Castle Game Engine.

Web Volume Rendering

HTML5 + WebGL + X3D

- VICOMTech: Volumerc.org
- Online drag-and-drop service for DICOM:
  - To HTML5/WebGL/X3DOM
 - Mirror4All by VICOMTECH and Kshell
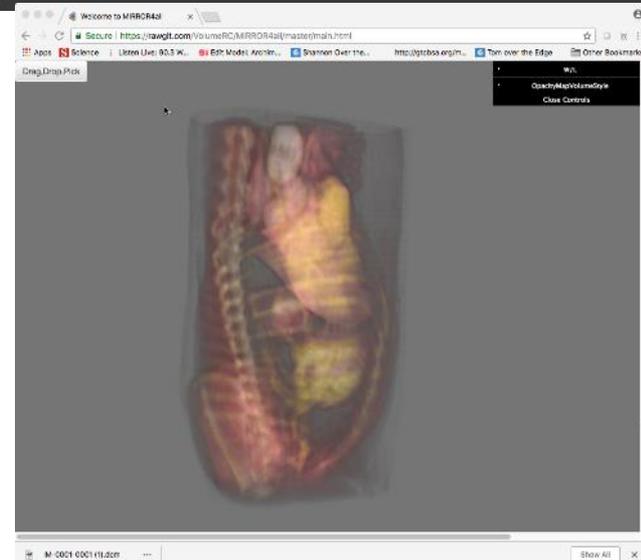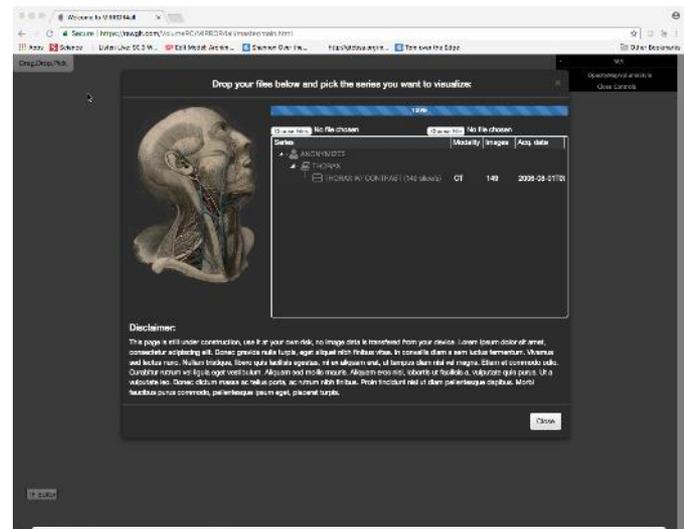
WWW and VR

- X3D: desktop, mobile, immersive VR/MR/AR
- Imaging
    - X3D Volume Rendering
    - TIFF stacks, DICOM, NRRD, PNG
    - Scripted automated conversions
- Molecular Visualization
- Immune Simulation
- Genomic alignment
- Polygons and volumes living together!
- VR and 3D printing !!!
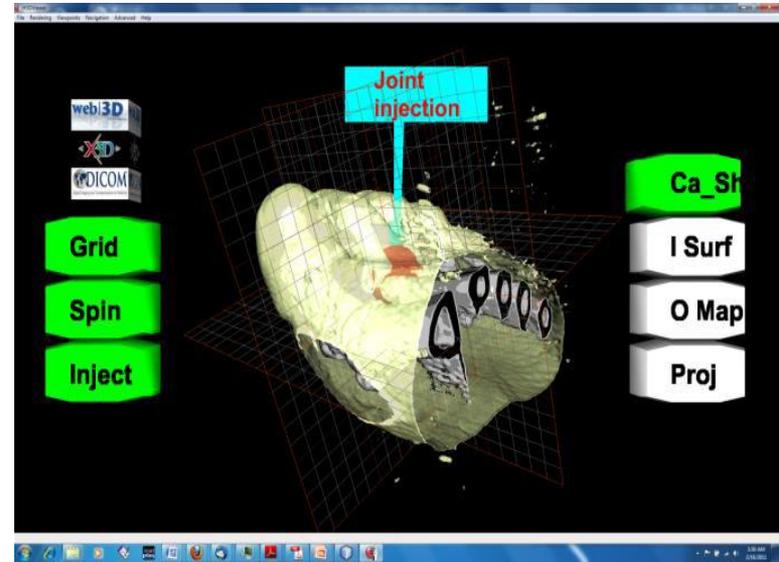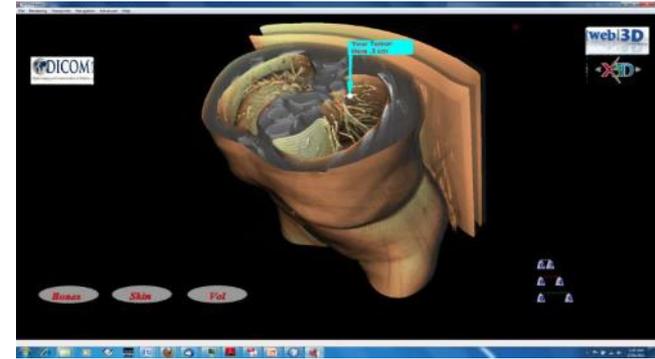
WebVR

X3D and HTML5 files Uses the browser as the platform

Many headsets

Support X3D

Samsung Gear

Oculus