X3D Semantic Web Working Group

Collected Concepts

Web3D and SIGGRAPH Conferences, Summer 2019

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

Web3D 2019 Workshop Information

Organizers: Don Brutzman, Jakub Flotyński, Athanasios Malamos

Workshop Description online

Working Group Overview

Concepts

Demonstration of X3D Ontology Autogeneration

Additional Speakers

Future Activities

Workshop Abstract

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

Semantic 3D/VR/AR is an emerging field of 3D graphics and animation. The Semantic Web, which has been derived from metadata and knowledge representation, aims at the evolutionary development of the current web towards a distributed database linking structured content described by ontologies. The Semantic Web is currently the main approach to building intelligent, explorable 3D applications in a variety of applications and domains, with content and animations described at different levels of abstraction.

Works related to various application domains, including e-commerce, education, cultural heritage, entertainment and infotainment, social media, tourism, medicine, military, industry and construction (and others) are welcome. The approaches will be considered in the context of building scalable, pervasive 3D/VR/AR systems using different semantic formats (e.g., RDF, RDFS and OWL), 3D formats and browsers. Finally, common fields of interest and opportunities of future collaboration are discussed.

Background

Semantic information is related to the human perception of the world.

From the early beginning of the graphics science there were introduced algorithms and descriptors of 3D scenes in a more human centric way

MPEG 7 was a multimedia annotation protocol introduced for expressing and annotating multimedia information with quantitative and qualitative characteristics extracted directly by the media themself

Among others, MPEG 7 included a set for visual descriptors about color, shape and texture for 3D models.

These MPEG7 descriptors, and many others presented in the literature, were used extensively for classification of 3D models and model searching in databases

….Background….

Classification and matching is still an interesting “open” problem but now scientists focus on point clouds and hybrid information gathered by scanners, depth sensors and cameras.

In our days, semantic information is essential for space segmentation and object identification in point clouds and modern machine vision

Of course semantic information is always essential for an efficient internet search

Semantic in the case of the WWW make use of Resource Description Framework (RDF), Web Ontology Language (OWL), and Extensible Markup Language (XML)

Prior Work

In P. Spala, A. G. Malamos, A. D. Doulamis, and G. Mamakis, "Extending MPEG-7 for efficient annotation of complex web 3D scenes." Multimedia Tools Appl, vol. 59, no. 2, pp. 463-504, 2012 we presented a set of descriptors and datatypes that may extend MPEG7 to include semantic information that is included in the X3D language. Thus to the existing descriptors we introduced also

BoundingBox3D: Specifies the position and size of a complex 3D object in a scene)

Geometry3D: Describes the types of primitive or complex geometries contained in the X3D scene)

Interactivity3D: Describes how an X3D object interacts with other objects in the scene or with the end user

MotionTrajectory: Describes the animation characteristics of a 3D moving object within an X3D Scene

Viewpoint3D: Describes each viewpoint nodes' position, orientation, animation and coordinates

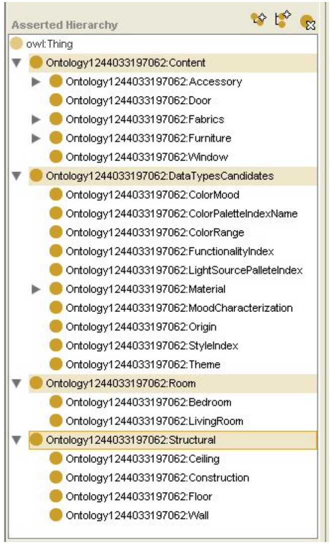
Lighting3D: Specifies the type of X3D Light nodes used within an X3D Scene

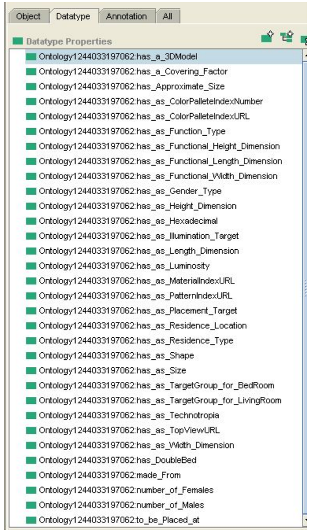
Profile3D: Describes the X3D profile in use

Script3D: Specifies the script class location and the scripting language used

Prior Work

In Kontakis, K., Steiakaki, M., Kalochristianakis, M., Kapetanakis, K., & Malamos, A. G. Applying Aesthetic Rules in Virtual Environments by Means of Semantic Web Technologies. Lecture Notes In Augmented and Virtual Reality (pp. 344-354). Springer International Publishing(2015) we present DECO ontology, an OWL description of interior designs. In this ontology we introduce a novel way to describe a room space with OWL objects and properties. DECO uses X3D for model presentation. In some way is built around X3D.





Prior work

In 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 we present the rules and the implementation of an X3D scene segmentation with a set of spatial semantic information that can be extracted by this segmentation. In http://www.medialab.hmu.gr/minipages/3DRtree/ there are many examples of the techniques introduced and the way to express spatial relations between objects like A is within B, A is in front of B, etc.

	Left	RectA.xMax <= RectB.xMin
		Opposite MBB relation: *Right*
	Right	RectA.xMin >= RectB.xMax
		Opposite MBB relation: *Left*
	Above	RectA.yMin > RectB.yMax
		Opposite MBB relation: *Below*
	Below	RectA.yMax < RectB.yMin
		Opposite MBB relation: *Above*
	Over	(RectA.yMin == RectB.yMax || RectA.yMax == RectB.yMin) && (!((RectA.xMax <= RectB.xMin) || (RectA.xMin >= RectB.xMax)) && (!((RectA.zMax <= RectB.zMin) || (RectA.zMin >= RectB.zMax)))
		Opposite MBB relation: *Below*
	*Front*	RectA.zMin >= RectB.zMax

Prior work

3D-specific semantics in RDF, RDFS and OWL

1) An ontology and algorithm for transformation of ontology-based 3D content to different 3D content formats, such as X3D, VRML and ActionScript with the Away3D library:

Flotyński, J., and K. Walczak, Semantic Representation of Multi-platform 3D Content, in: Computer Science and Information Systems, vol. 11, No 4, October 2014, issue Special Issue on Advances in Systems, Modeling, Languages and Agents, ComSIS Consortium, 2014, pp. 1555-1580, DOI 10.2298/CSIS131218073F, IF: 0,575 (2013), http://www.doiserbia.nb.rs/img/doi/1820-0214/2014/1820-02141400073F.pdf

Flotyński, J., and K. Walczak, Multi-platform Semantic Representation of Interactive 3D Content, in: Technological Innovation for Collective Awareness Systems, in: IFIP Advances in Information and Communication Technology, vol. 432, ed. Camarinha-Matos, L. M., N. S.Barrento, and R. Mendonça , Springer, Berlin, Heidelberg, 2014, pp. 63-72, ISBN 978-3-642-54733-1, DOI 10.1007/978-3-642-54734-8_8, http://semantic3d.org/wp-content/uploads/2017/02/DoCEIS-2014-Flotynski-W...

2) An ontology for 3D-specific semantics covering geometry, structure and appearance of 3D content:

Flotyński, J., and K. Walczak, Semantic Multi-layered Design of Interactive 3D Presentations, in: Proceedings of the 2013 Federated Conference on Computer Science and Information Systems Kraków, Poland, 8 - 11 September, 2013, vol. 1, ed. Ganzha, M., L. Maciaszek, and M. Paprzycki, Polskie Towarzystwo Informatyczne, Warszawa, 2013, pp. 541-548, ISBN 978-1-4673-4471-5, https://annals-csis.org/proceedings/2013/pliks/416.pdf

Prior work

Domain-specific semantics in RDF, RDFS and OWL

1) A state of the art report on both 3D- and domain-specific semantics of 3D content:

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, http://semantic3d.org/wp-content/uploads/2017/02/Ontology-based-Represen...

2) Using queries to build 3D scenes on the basis of generalized 3D meta-scenes represented by ontologies:

Flotyński, J., and K. Walczak, Customization of 3D content with semantic meta-scenes, in: Graphical Models, Elsevier, 2016,pp. in print, DOI http://dx.doi.org/10.1016/j.gmod.2016.07.001, https://ac.els-cdn.com/S1524070316300182/1-s2.0-S1524070316300182-main.p...

Walczak, K., and J. Flotyński, Semantic query-based generation of customized 3D scenes, in: Proceeding Web3D '15 Proceedings of the 20th International Conference on 3D Web Technology, Heraklion (Greece), June 18 - 21, 2015, ACM New York, 2015, pp. 123-131, ISBN 978-1-4503-3647-5, DOI 10.1145/2775292.2775311

Walczak, K., and J. Flotyński, On-Demand Generation of 3D Content Based on Semantic Meta-Scenes, in: Lecture Notes in Computer Science, vol. Augmented and Virtual Reality; First International Conference, AVR 2014, Lecce, Italy, September 17-20, 2014, ed. de Paolis, L T., and A. Mongelli, Springer International Publishing, 2014, pp. 313-332, ISBN 978-3-319-13968-5, DOI 10.1007/978-3-319-13969-2_24, http://semantic3d.org/wp-content/uploads/2017/02/AVR-2014-LNCS-8853-Walc...

Prior work

Conceptual semantics in RDF, RDFS and OWL

3) Modeling of 3D content with domain-specific ontologies by domain experts:

Flotyński, J., and K. Walczak, Conceptual knowledge-based modeling of interactive 3D content, in: The Visual Computer, vol. 31, issue 10, Springer Berlin Heidelberg, 2015, pp. 1287-1306, DOI 10.1007/s00371-014-1011-9, https://link.springer.com/content/pdf/10.1007%2Fs00371-014-1011-9.pdf

Walczak, K., and J. Flotyński, Ontology-Based Creation of 3D Content in a Service-Oriented Environment, in: Lecture Notes in Business Information Processing: Business Information Systems, vol. 208, ed. Abramowicz, W., Springer Verlag, Heidelberg, New York, London, 2015, pp. 77-89, ISBN 978-3-319-19026-6, DOI 10.1007/978-3-319-19027-3, http://semantic3d.org/wp-content/uploads/2017/02/BIS-2015-Flotynski-Walc...

Flotyński, J., Semantic Modelling of Interactive 3D Content with Domain-specific Ontologies, in: Procedia Computer Science, vol. 35, Elsevier, 2014, pp. 531-540, DOI 10.1016/j.procs.2014.08.134, https://ac.els-cdn.com/S1877050914010990/1-s2.0-S1877050914010990-main.p...

Flotyński, J., and K. Walczak, Conceptual Semantic Representation of 3D Content , in: Lecture Notes in Business Information Processing: International Conference on Business Information Systems, Poznań, Poland, 19 - 20 June, 2013 , vol. 160, ed. Wil van der Aalst, John Mylopoulos, Michael Rosemann, Michael J. Shaw, and C. Szyperski , Springer, 2013, pp. 244-257, ISBN 978-3-642-41686-6, DOI 10.1007/978-3-642-41687-3_23, http://semantic3d.org/wp-content/uploads/2017/03/BIS2013-Flotynski-Walcz...

Flotyński, J., and K. Walczak, Semantic Modelling of Interactive 3D Content, in: Proceedings "Virtual Environments 2013 - Joint Virtual Reality Conference of EGVE - 19th Eurographics Symposium on Virtual Environments EuroVR - 10th EuroVR Conference", Paris, France December 11th - 13th, 2013, Eurographics Association, 2013, pp. 41-48, ISBN ISBN 978-3-905674-47-7

Prior work

Conceptual semantics in RDF, RDFS and OWL

4) Explorable VR/AR environments:

Flotyński, J., A. Nowak, and K. Walczak, Explorable Representation of Interaction in VR/AR Environments , in: Augmented Reality, Virtual Reality, and Computer Graphics. 5th International Conference, AVR 2018; Otranto, Italy, June 24–27, 2018, Proceedings, Part II, vol. Lecture Notes in Computer Science (LNCS, volume 10851), ed. de Paolis, L T., and P. Bourdot , Springer, 2018, pp. 589-609

Flotyński, J., and P. Sobociński, Logging Interactions in Explorable Immersive VR/AR Applications , in: 2018 International Conference on 3D Immersion (IC3D), Brussels, 5-6 Dec. 2018 , IEEE, 2018, pp. 1-8, ISBN Electronic ISBN: 978-1-5386-7590-8, DOI 10.1109/IC3D.2018.8657830 .

Flotyński, J., M. Krzyszkowski, and K. Walczak, Query-based Composition of 3D Contents Animations for VR/AR Web Applications , in: Web3D '18; Proceedings of the 23rd International ACM Conference on 3D Web Technology Poznań, Poland — June 20 - 22, 2018 , ACM Digital Library, 2018, pp. Article No 15, ISBN 978-1-4503-5800-2, DOI 10.1145/3208806.3208828.

Is X3D capable to support semantic information?

In the case of X3D we may distinguish between…..

a. Semantic information is attached or embedded in a X3D scene in a way similar to metadata
b. Semantic information is interleaved or even hidden inside the X3D scene that can be extracted or calculated by some descriptors

These two categories of semantic information can be quite different, but at the same time can also be quite complementary.

In either case we may use one of the state of the art languages like RDF or OWL

Overview: Semantics for 3D Content

- 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

Goals of the Working Group

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. The exact goals are:

1. Enable more effective **indexing, querying, search, comparison, analysis, annotation and creation** of X3D models through the use of metadata and semantics
2. Create and autogenerate an **X3Dv4 RDF/RDFS/OWL Ontology** from the X3D Unified Object Model (X3DUOM) using best-practice design patterns, starting with those shown by prior published work
3. Select, extend and maintain a list of **domain-specific ontologies** to be used with the X3D Ontology
4. **Evaluate** the created ontologies by building 3D scenes and queries to the scenes (e.g., encoded in SPARQL)
5. Combine the Semantic X3D approach with the achievements of various **Web3D Working Groups**, including Computer-Aided Design (CAD), 3D printing/scanning, Medical, Cultural and Natural Heritage, Humanoid Animation (HAnim), Building Information Models (BIM), etc.
6. Create appropriate **specifications and recommended practices** for the Semantic X3D
7. Build suite of **tools** (ontologies and software) and **examples** exposed through various portals

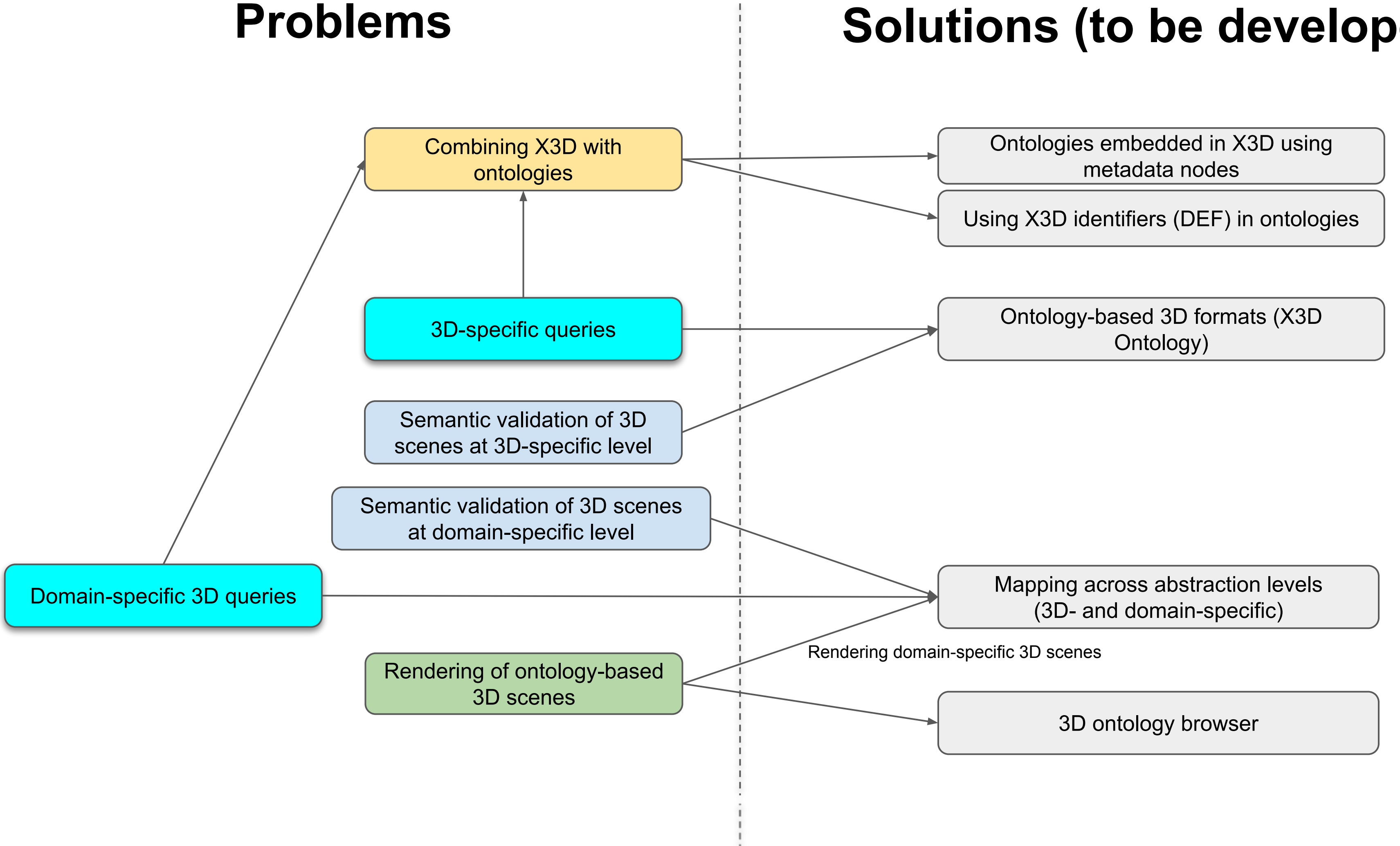
Semantics vs Metadata

Close cousins, but different breeds:

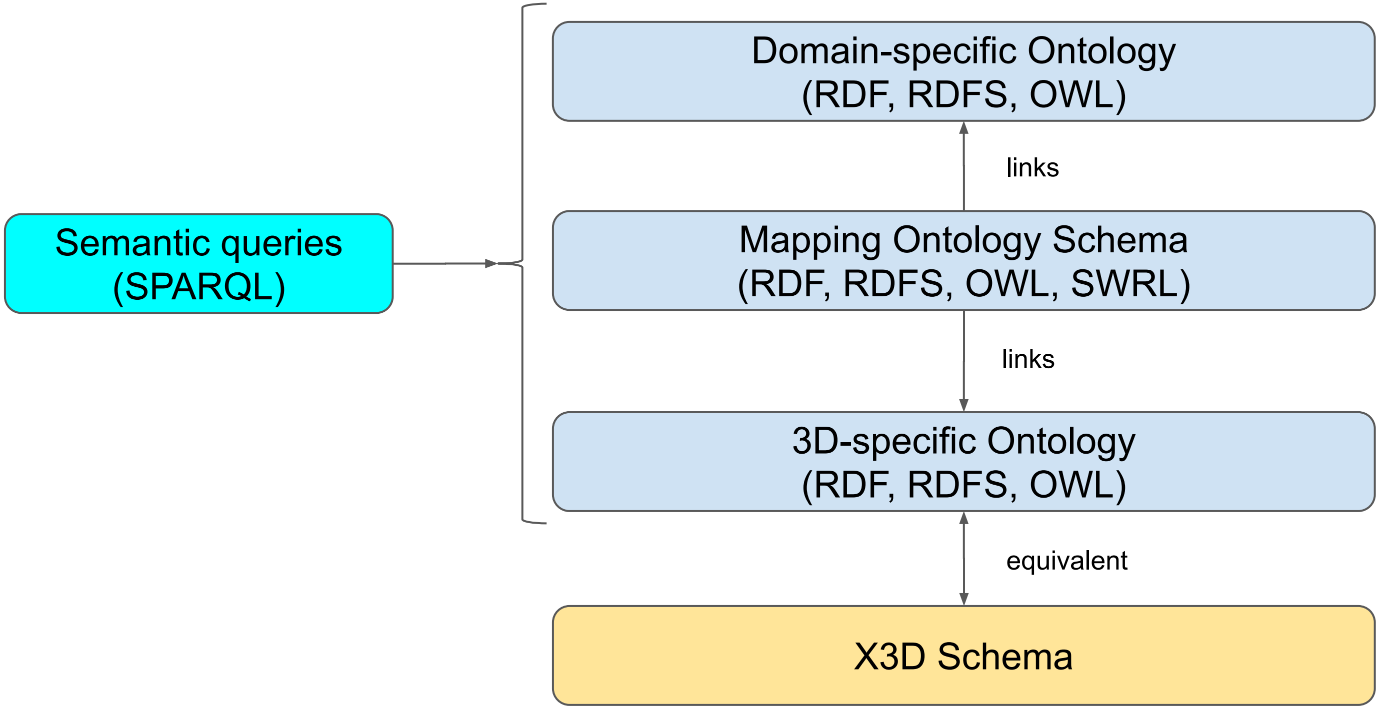
- Semantics are **more formal** and enable **more complex expressions**
  - Metadata - mainly keywords
  - Semantics - terminological and assertional statements on classes, properties and individuals
  - e.g., *a web page includes 3D models of virtual museum exhibitions: statuettes, armours, weapons* **vs** *a web page includes 3D models of virtual museum exhibitions: statuettes, armours, weapons, which are in different spatial relations and are described by different properties*
- More complex expressions enable **more complex queries**, e.g., *show web pages with 3D models of medieval weapons* vs *show web pages with only 3D models of medieval weapons that are from a given century and were produced in Europe*
- Semantics enables inference of **new information** through reasoning:
  - Deduction, e.g., *all 3D food models are in a particular region of a VR store. X is a 3D food model -> X is in the region*
  - Induction, e.g., *all 3D food models we saw in a VR store were in a particular region. X is a 3D food model -> X is also in the region of the store*
  - Abduction, e.g., *all 3D food models are in a particular region of a VR store. X is in the region -> X is a 3D food model*

Problems

Solutions (to be developed)

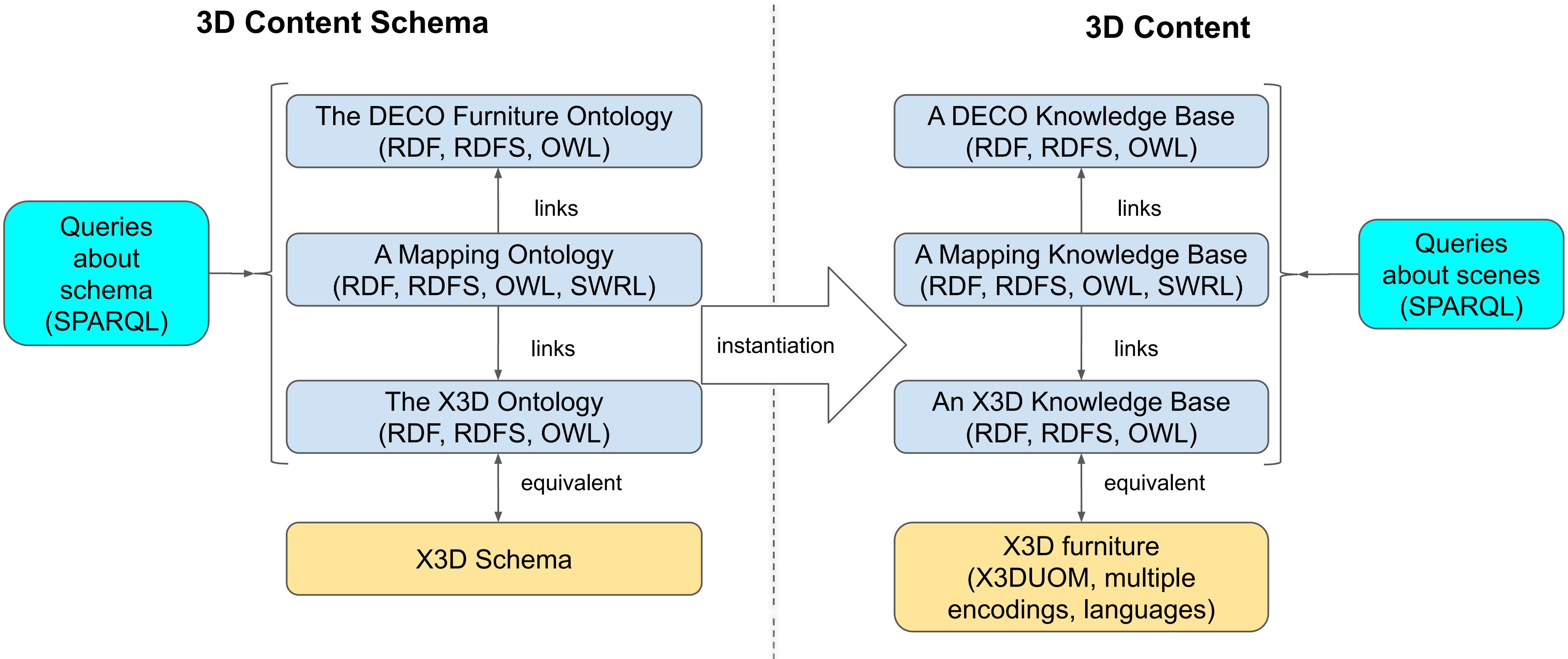


Semantic X3D: queryable semantic X3D content representation at different abstraction levels



Be careful about OWLcomputational profiles:
https://www.w3.org/TR/owl2-profiles/
We should use as simple OWL profiles as possible to express structural and conceptual representations as well as mappings.
SWRL rules are undecidable in general.
A well-defined ontology needs to be tractable.

Semantic X3D: example of domain-specific representation of X3D scenes



TODO list

Maps between numerous diverse 3D data models and X3D owl-based ontology

- With corresponding file parsers (both text-based and binary) to read data as either XML or JSON, using Data Format Description Language (DFDL) to decorate a correspondence XSD schema for each data model.

Render X3D owl ontology directly to browser for X3D visualization, exploration

- Virginia Tech O-Snap generates X3D visualization, enables VR/AR mode
- Numerous proprietary tools emerging

Semantic Queries

Finding information that is not explicitly declared in the knowledge base.

Examples:

- Klj
- kkjlk

Example: Heritage

CIDOC-CRM : http://www.cidoc-crm.org/collaborations

https://www.cultlab3d.de/

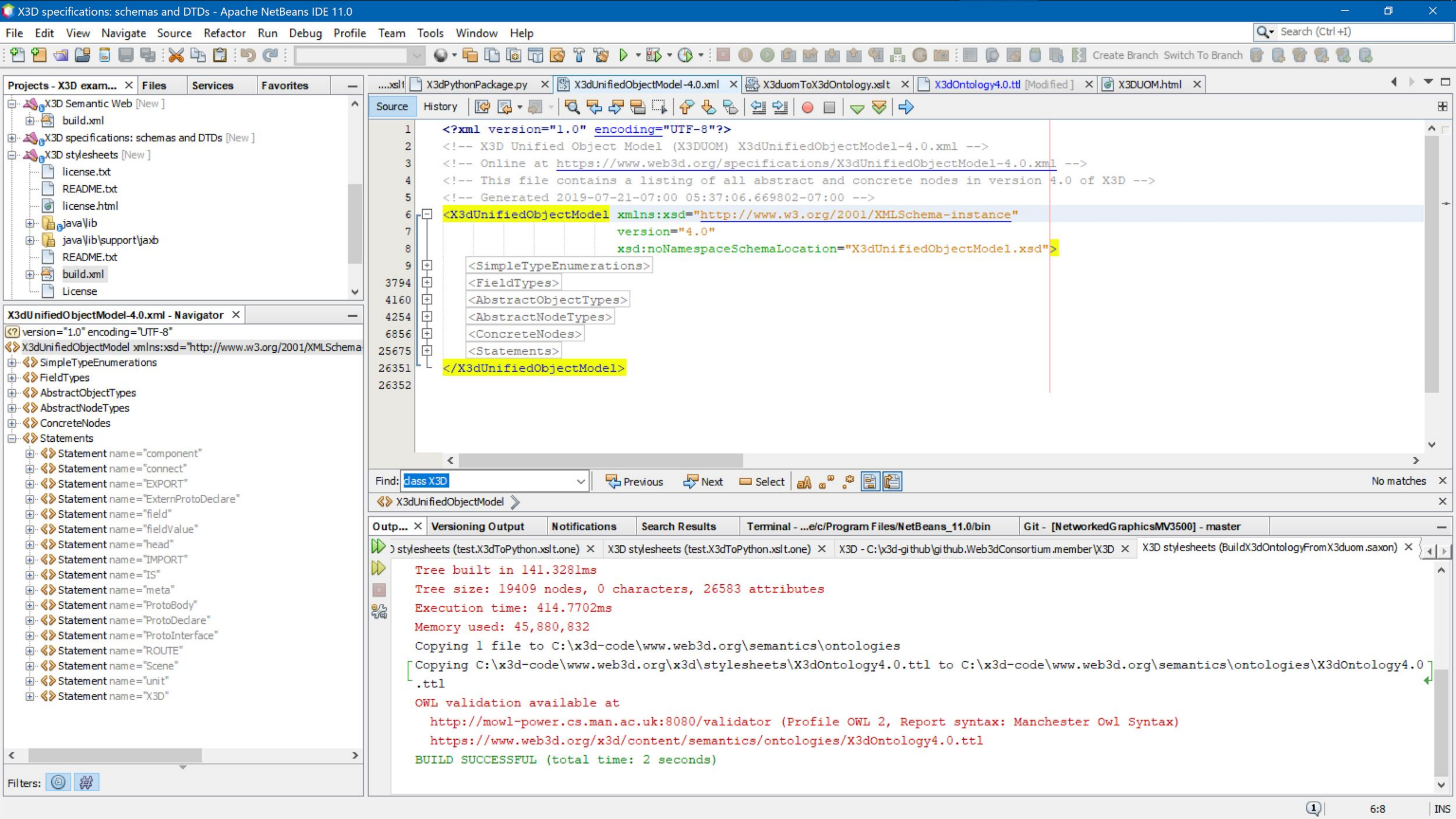
Demonstration of X3D Ontology Autogeneration

Current

1. X3D XML Schema leads to X3D Unified Object Model (X3DUOM)
2. XSLT stylesheet produces X3D Ontology in Terse Triple Language (Turtle)
3. SPARQL queries allow assertions, responses about a given scene graph
4. TODO: add many more properties, queries to demonstrate usefulness

Future

1. Add metadata norms, queries for various Web3D working group use cases
2. Add data models and correspondences for various 3D model formats


X3D specifications: schemas and DTDs - Apache NetBeans IDE 11.0
File Edit View Navigate Source Refactor Run Debug Profile Team Tools Window Help
Search (Ctrl+I)
Create Branch Switch To Branch
Projects - X3D exam... Files Services Favorites
X3D Semantic Web [New]
build.xml
X3D specifications: schemas and DTDs [New]
X3D stylesheets [New]
license.txt
README.txt
license.html
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java\lib\support\jaxb
README.txt
build.xml
License
X3dUnifiedObjectModel-4.0.xml - Navigator
version="1.0" encoding="UTF-8"
X3dUnifiedObjectModel xmlns:xsd="http://www.w3.org/2001/XMLSchema
SimpleTypeEnumerations
FieldTypes
AbstractObjectTypes
AbstractNodeTypes
ConcreteNodes
Statements
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Statement name="connect"
Statement name="EXPORT"
Statement name="ExternProtoDeclare"
Statement name="field"
Statement name="fieldValue"
Statement name="head"
Statement name="IMPORT"
Statement name="IS"
Statement name="meta"
Statement name="ProtoBody"
Statement name="ProtoDeclare"
Statement name="ProtoInterface"
Statement name="ROUTE"
Statement name="Scene"
Statement name="unit"
Statement name="X3D"
Filters:
...xslt X3dPythonPackage.py X3dUnifiedObjectModel-4.0.xml X3duomToX3dOntology.xslt X3dOntology4.0.ttl [Modified] X3DUOM.html
Source History
<?xml version="1.0" encoding="UTF-8"?>
<!-- X3D Unified Object Model (X3DUOM) X3dUnifiedObjectModel-4.0.xml -->
<!-- Online at https://www.web3d.org/specifications/X3dUnifiedObjectModel-4.0.xml -->
<!-- This file contains a listing of all abstract and concrete nodes in version 4.0 of X3D -->
<!-- Generated 2019-07-21-07:00 05:37:06.669802-07:00 -->
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<SimpleTypeEnumerations>
<FieldTypes>
<AbstractObjectTypes>
<AbstractNodeTypes>
<ConcreteNodes>
<Statements>
</X3dUnifiedObjectModel>
Find: class X3D
Previous Next Select
No matches
X3dUnifiedObjectModel
Outp... Versioning Output Notifications Search Results Terminal - ...e/c/Program Files/NetBeans_11.0/bin Git - [NetworkedGraphicsMV3500] - master
stylesheets (test.X3dToPython.xslt.one) X3D stylesheets (test.X3dToPython.xslt.one) X3D - C:\x3d-github\github.Web3dConsortium.member\X3D X3D stylesheets (BuildX3dOntologyFromX3duom.saxon)
Tree built in 141.3281ms
Tree size: 19409 nodes, 0 characters, 26583 attributes
Execution time: 414.7702ms
Memory used: 45,880,832
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OWL validation available at
http://mowl-power.cs.man.ac.uk:8080/validator (Profile OWL 2, Report syntax: Manchester Owl Syntax)
https://www.web3d.org/x3d/content/semantics/ontologies/X3dOntology4.0.ttl
BUILD SUCCESSFUL (total time: 2 seconds)
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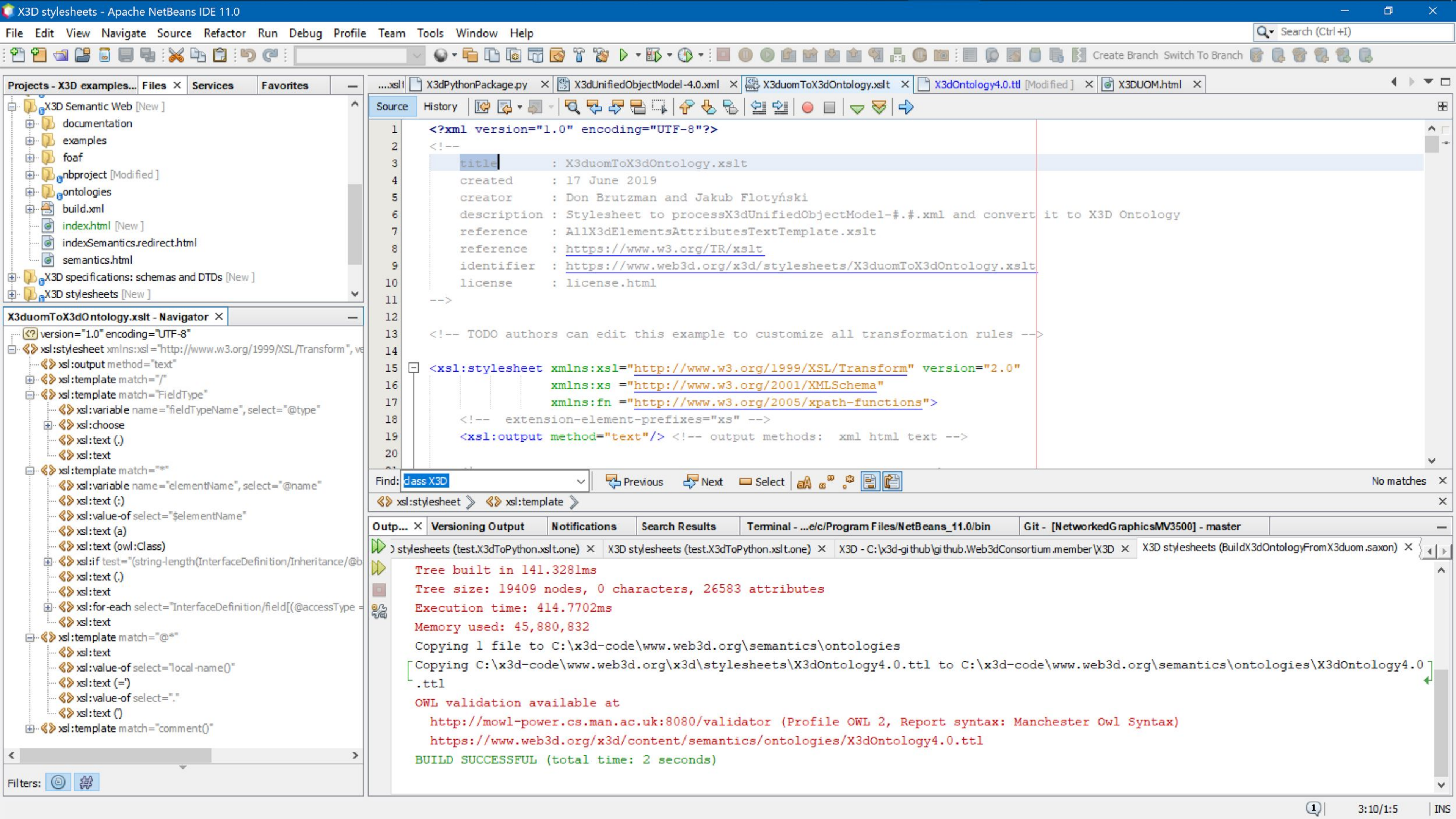

X3D stylesheets - Apache NetBeans IDE 11.0
File Edit View Navigate Source Refactor Run Debug Profile Team Tools Window Help
Search (Ctrl+I)
Create Branch Switch To Branch
Projects - X3D examples... Files Services Favorites
X3D Semantic Web [New]
documentation
examples
foaf
nbproject [Modified]
ontologies
build.xml
index.html [New]
indexSemantics.redirect.html
semantics.html
X3D specifications: schemas and DTDs [New]
X3D stylesheets [New]
X3duomToX3dOntology.xslt - Navigator
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xsl:variable name="fieldTypeName", select="@type"
xsl:choose
xsl:text (.)
xsl:text
xsl:template match="*"
xsl:variable name="elementName", select="@name"
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xsl:value-of select="$elementName"
xsl:text (a)
xsl:text (owl:Class)
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xsl:text (.)
xsl:text
xsl:for-each select="InterfaceDefinition/field[(@accessType =
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xsl:text
xsl:value-of select="local-name()"
xsl:text (=')
xsl:value-of select="."
xsl:text (')
xsl:template match="comment()"
Filters:
....xsl X3dPythonPackage.py X3dUnifiedObjectModel-4.0.xml X3duomToX3dOntology.xslt X3dOntology4.0.ttl [Modified] X3DUOM.html
Source History
<?xml version="1.0" encoding="UTF-8"?>
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title : X3duomToX3dOntology.xslt
created : 17 June 2019
creator : Don Brutzman and Jakub Flotyński
description : Stylesheet to processX3dUnifiedObjectModel-#.#.xml and convert it to X3D Ontology
reference : AllX3dElementsAttributesTextTemplate.xslt
reference : https://www.w3.org/TR/xslt
identifier : https://www.web3d.org/x3d/stylesheets/X3duomToX3dOntology.xslt
license : license.html
-->
<!-- TODO authors can edit this example to customize all transformation rules -->
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version="2.0"
xmlns:xs ="http://www.w3.org/2001/XMLSchema"
xmlns:fn ="http://www.w3.org/2005/xpath-functions">
<!-- extension-element-prefixes="xs" -->
<xsl:output method="text"/> <!-- output methods: xml html text -->
Find: class X3D
Previous Next Select
No matches
xsl:stylesheet xsl:template
Outp... Versioning Output Notifications Search Results Terminal - ...e/c/Program Files/NetBeans_11.0/bin Git - [NetworkedGraphicsMV3500] - master
stylesheets (test.X3dToPython.xslt.one) X3D stylesheets (test.X3dToPython.xslt.one) X3D - C:\x3d-github\github.Web3dConsortium.member\X3D X3D stylesheets (BuildX3dOntologyFromX3duom.saxon)
Tree built in 141.3281ms
Tree size: 19409 nodes, 0 characters, 26583 attributes
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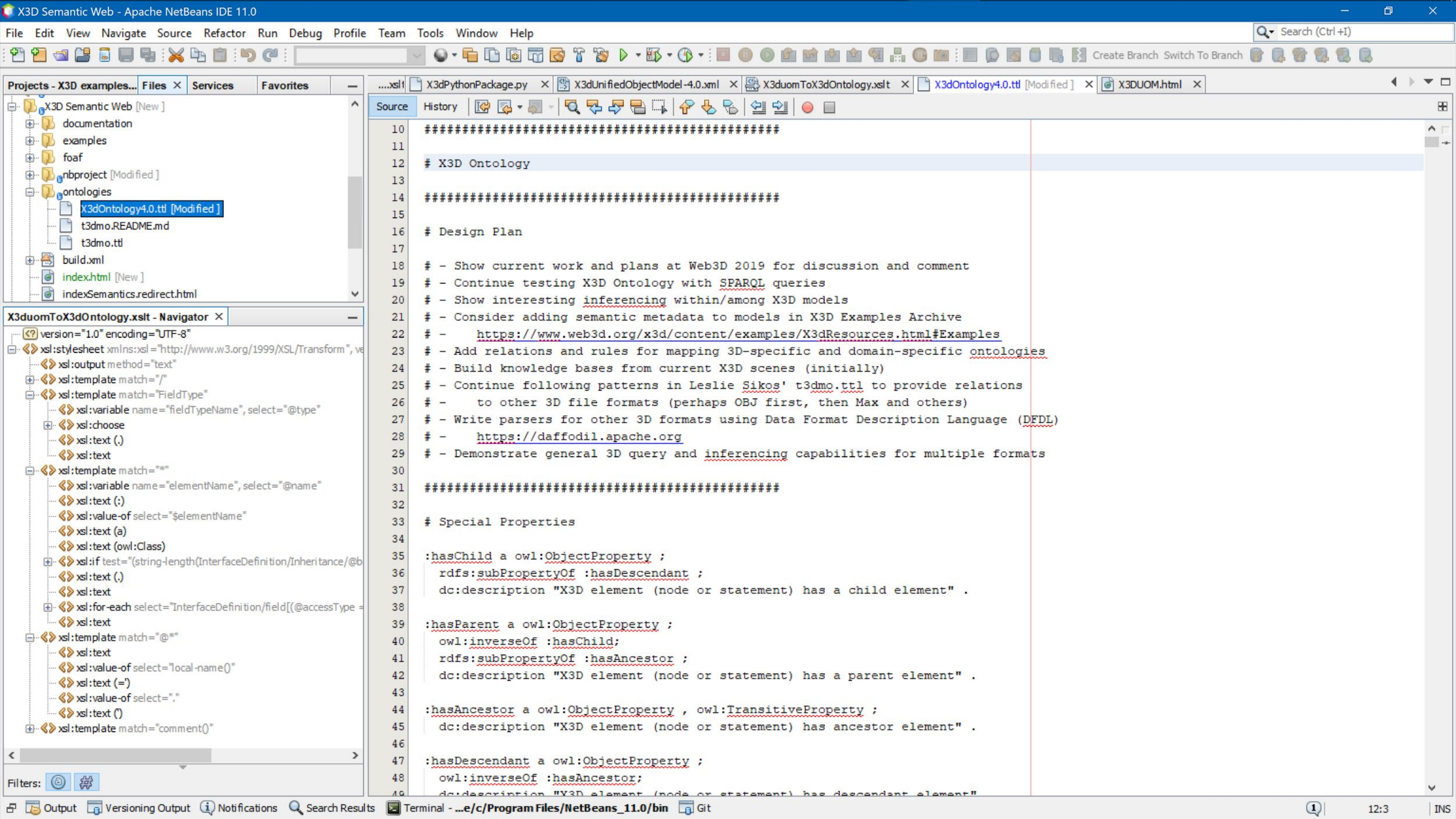
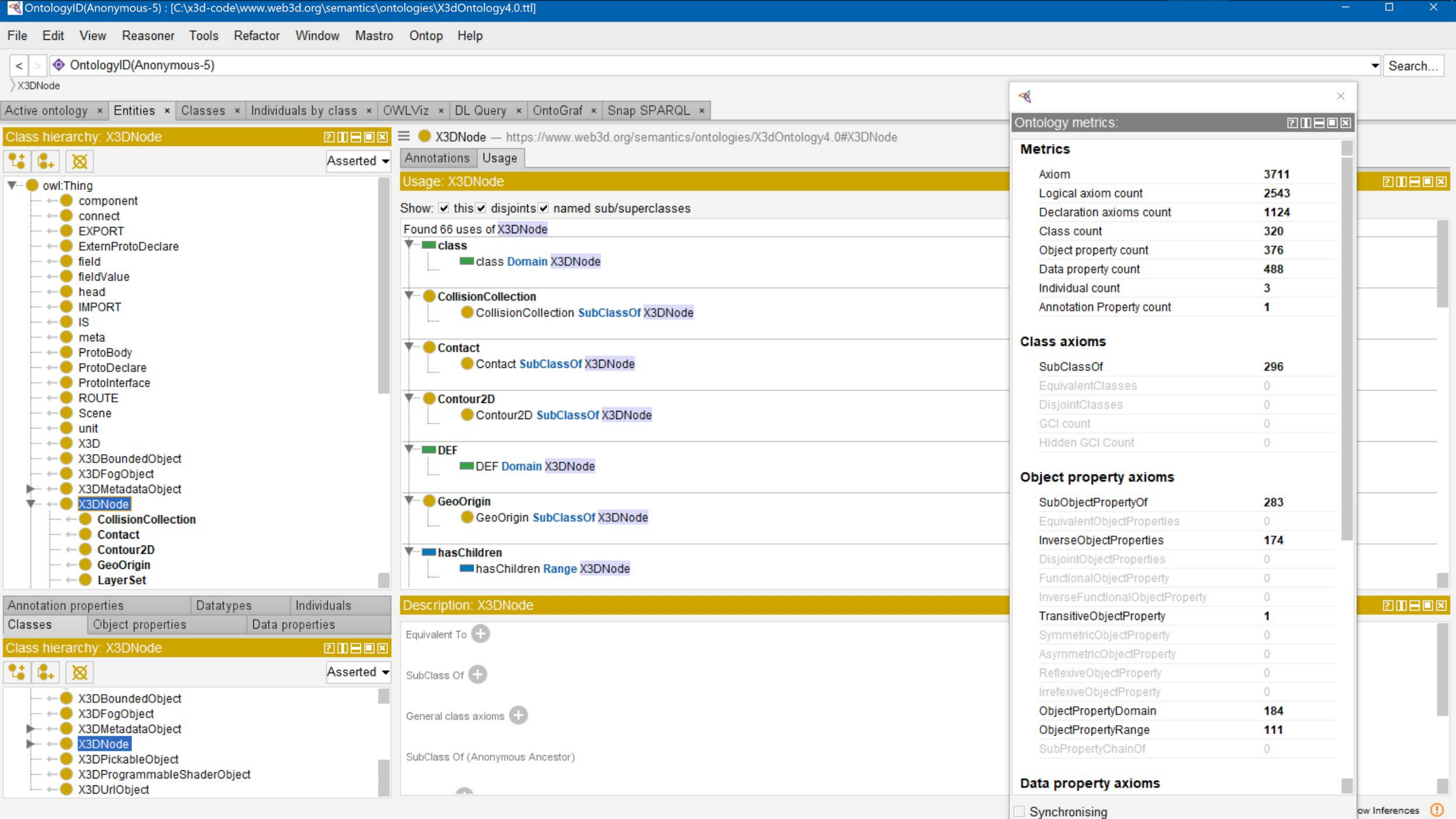
Copying 1 file to C:\x3d-code\www.web3d.org\semantics\ontologies
Copying C:\x3d-code\www.web3d.org\x3d\stylesheets\X3dOntology4.0.ttl to C:\x3d-code\www.web3d.org\semantics\ontologies\X3dOntology4.0.ttl
OWL validation available at
http://mowl-power.cs.man.ac.uk:8080/validator (Profile OWL 2, Report syntax: Manchester Owl Syntax)
https://www.web3d.org/x3d/content/semantics/ontologies/X3dOntology4.0.ttl
BUILD SUCCESSFUL (total time: 2 seconds)
3:10/1:5 INS



X3D Semantic Web - Apache NetBeans IDE 11.0
File Edit View Navigate Source Refactor Run Debug Profile Team Tools Window Help
Search (Ctrl+I)
Create Branch Switch To Branch
Projects - X3D examples... Files Services Favorites
X3D Semantic Web [New]
documentation
examples
foaf
nbproject [Modified]
ontologies
X3dOntology4.0.ttl [Modified]
t3dmo.README.md
t3dmo.ttl
build.xml
index.html [New]
indexSemantics.redirect.html
X3duomToX3dOntology.xslt - Navigator
version="1.0" encoding="UTF-8"
xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
xsl:output method="text"
xsl:template match="/"
xsl:template match="FieldType"
xsl:variable name="fieldTypeName", select="@type"
xsl:choose
xsl:text (.)
xsl:text
xsl:template match="*"
xsl:variable name="elementName", select="@name"
xsl:text (:)
xsl:value-of select="$elementName"
xsl:text (a)
xsl:text (owl:Class)
xsl:if test="(string-length(InterfaceDefinition/Inheritance/@b
xsl:text (.)
xsl:text
xsl:for-each select="InterfaceDefinition/field[(@accessType =
xsl:text
xsl:template match="@*"
xsl:text
xsl:value-of select="local-name()"
xsl:text (=')
xsl:value-of select="."
xsl:text (')
xsl:template match="comment()"
Filters:
....xsl X3dPythonPackage.py X3dUnifiedObjectModel-4.0.xml X3duomToX3dOntology.xslt X3dOntology4.0.ttl [Modified] X3DUOM.html
Source History
##
X3D Ontology
##
Design Plan
- Show current work and plans at Web3D 2019 for discussion and comment
- Continue testing X3D Ontology with SPARQL queries
- Show interesting inferencing within/among X3D models
- Consider adding semantic metadata to models in X3D Examples Archive
-   https://www.web3d.org/x3d/content/examples/X3dResources.html#Examples
- Add relations and rules for mapping 3D-specific and domain-specific ontologies
- Build knowledge bases from current X3D scenes (initially)
- Continue following patterns in Leslie Sikos' t3dmo.ttl to provide relations
-   to other 3D file formats (perhaps OBJ first, then Max and others)
- Write parsers for other 3D formats using Data Format Description Language (DFDL)
-   https://daffodil.apache.org
- Demonstrate general 3D query and inferencing capabilities for multiple formats
##
Special Properties
:hasChild a owl:ObjectProperty ;
rdfs:subPropertyOf :hasDescendant ;
dc:description "X3D element (node or statement) has a child element" .
:hasParent a owl:ObjectProperty ;
owl:inverseOf :hasChild;
rdfs:subPropertyOf :hasAncestor ;
dc:description "X3D element (node or statement) has a parent element" .
:hasAncestor a owl:ObjectProperty , owl:TransitiveProperty ;
dc:description "X3D element (node or statement) has ancestor element" .
:hasDescendant a owl:ObjectProperty ;
owl:inverseOf :hasAncestor;
Output Versioning Output Notifications Search Results Terminal - ...e/c/Program Files/NetBeans_11.0/bin Git
12:3 INS


OntologyID(Anonymous-5) : [C:\x3d-code\www.web3d.org\semantics\ontologies\X3dOntology4.0.ttl]
File Edit View Reasoner Tools Refactor Window Mastro Ontop Help
OntologyID(Anonymous-5)
Search...
X3DNode
Active ontology
Entities
Classes
Individuals by class
OWLViz
DL Query
OntoGraf
Snap SPARQL
Class hierarchy: X3DNode
Asserted
owl:Thing
component
connect
EXPORT
ExternProtoDeclare
field
fieldValue
head
IMPORT
IS
meta
ProtoBody
ProtoDeclare
ProtoInterface
ROUTE
Scene
unit
X3D
X3DBoundedObject
X3DFogObject
X3DMetadataObject
X3DNode
CollisionCollection
Contact
Contour2D
GeoOrigin
LayerSet
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: X3DNode
Asserted
X3DBoundedObject
X3DFogObject
X3DMetadataObject
X3DNode
X3DPickableObject
X3DProgrammableShaderObject
X3DUrlObject
X3DNode — https://www.web3d.org/semantics/ontologies/X3dOntology4.0#X3DNode
Annotations
Usage
Usage: X3DNode
Show: this disjoints named sub/superclasses
Found 66 uses of X3DNode
class
class Domain X3DNode
CollisionCollection
CollisionCollection SubClassOf X3DNode
Contact
Contact SubClassOf X3DNode
Contour2D
Contour2D SubClassOf X3DNode
DEF
DEF Domain X3DNode
GeoOrigin
GeoOrigin SubClassOf X3DNode
hasChildren
hasChildren Range X3DNode
Description: X3DNode
Equivalent To
SubClass Of
General class axioms
SubClass Of (Anonymous Ancestor)
Ontology metrics:
Metrics
Axiom 3711
Logical axiom count 2543
Declaration axioms count 1124
Class count 320
Object property count 376
Data property count 488
Individual count 3
Annotation Property count 1
Class axioms
SubClassOf 296
EquivalentClasses 0
DisjointClasses 0
GCI count 0
Hidden GCI Count 0
Object property axioms
SubObjectPropertyOf 283
EquivalentObjectProperties 0
InverseObjectProperties 174
DisjointObjectProperties 0
FunctionalObjectProperty 0
InverseFunctionalObjectProperty 0
TransitiveObjectProperty 1
SymmetricObjectProperty 0
AsymmetricObjectProperty 0
ReflexiveObjectProperty 0
IrrefexiveObjectProperty 0
ObjectPropertyDomain 184
ObjectPropertyRange 111
SubPropertyChainOf 0
Data property axioms
Synchronising
ow Inferences

Future Activites

cf. slide 17 - problems and solutions