Web3D 2019 Workshop Information

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Workshop Description [online]

Working Group Overview

Concepts

Demonstration of X3D Ontology Autogeneration

Additional Speakers

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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
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](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.
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:


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

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:


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


Prior work

Conceptual semantics in RDF, RDFS and OWL

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


Prior work

Conceptual semantics in RDF, RDFS and OWL

4) Explorable VR/AR environments:


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
3D ontology browser

Rendering of ontology-based 3D scenes

Problems

3D-specific queries

 Semantic validation of 3D scenes at 3D-specific level

 Semantic validation of 3D scenes at domain-specific level

 Domain-specific 3D queries

 Combining X3D with ontologies

 Solutions (to be developed)

 Ontologies embedded in X3D using metadata nodes

 Using X3D identifiers (DEF) in ontologies

 Ontology-based 3D formats (X3D Ontology)

 Mapping across abstraction levels (3D- and domain-specific)

 Rendering domain-specific 3D scenes

 3D ontology browser
Semantic X3D: queryable semantic X3D content representation at different abstraction levels

Be careful about OWL computational profiles: [https://www.w3.org/TR/owl2-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

3D Content Schema

- The DECO Furniture Ontology (RDF, RDFS, OWL)
- A Mapping Ontology (RDF, RDFS, OWL, SWRL)
- The X3D Ontology (RDF, RDFS, OWL)

X3D Schema

3D Content

- A DECO Knowledge Base (RDF, RDFS, OWL)
- A Mapping Knowledge Base (RDF, RDFS, OWL, SWRL)
- An X3D Knowledge Base (RDF, RDFS, OWL)

X3D furniture (X3DUOM, multiple encodings, languages)

Queries about schema (SPARQL)

Queries about scenes (SPARQL)

links

links

instantiation

equivalent

equivalent
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](http://www.cidoc-crm.org/collaborations)

[https://www.cultlab3d.de/](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 Ontology in Turtle Terse Triple Language .ttl

# Design Plan

# Special Properties

:hasChild a owl:ObjectProperty ;
  rdfs:subPropertyOf hasDescendant ;
  description "X3D element (node or statement) has a child element" .

:hasParent a owl:ObjectProperty ;
  owl:inverseOf hasChild ;
  rdfs:subPropertyOf hasAncestor ;
  description "X3D element (node or statement) has a parent element" .

:hasAncestor a owl:ObjectProperty , owl:TransitiveProperty ;
  description "X3D element (node or statement) has an ancestor element" .

:hasDescendant a owl:ObjectProperty ;
  owl:inverseOf hasAncestor ;
  rdfs:subPropertyOf hasDescendant ;
  description "X3D element (node or statement) has a descendant element" .
Future Activities

cf. slide 17 - problems and solutions