

Metadata and Semantics for Web3D

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CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Mixed / augmented reality**; • **Computing methodologies** → **Virtual reality**; **Mixed / augmented reality**; • **Information systems** → **Multimedia content creation**; **Semantic web description languages**; *Multimedia databases*;

KEYWORDS

Extensible 3D (X3D), Semantic Web, geometric query, graphics ontologies, metadata, QUDT, RDF, RDFS, OWL, SPARQL, SWRL, X3D Unified Object Model (X3DUOM)

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The mission of the X3D Semantic Web Working Group is to publish 3D scenes and objects to the Web using X3D in order to best gain Web interoperability that enables intelligent 3D applications and feature-based 3D models for describing, representing, querying, and reasoning across collections of 3D scenes [Web3D Consortium 2019]. Initial work has compared multiple assets for design leading to an X3D Ontology that can be broadly applied to facilitate both machine inference and human reasoning using Semantic Web standards [World Wide Web Consortium (W3C) 2019].

Activities include assembling all relevant work related to X3D metadata and ontologies, defining a comprehensive use cases corresponding to Web3D application domains, and showing autogeneration of RDF/OWL mappings via stylesheet adaptation of X3D Unified Object Model (X3DUOM). The group is defining triples and heuristics necessary for advanced 3D queries. The group expects to explore both low (3D-specific) and high (domain-specific) abstraction levels, thus determining appropriate mappings to other

metadata standards (e.g. MPEG-7). Applying O-SNAP [Nicholas Polys 2014] for 3D visualization of linked graph networks yields deep insight.

Multiple motivations drive this work. Establishing best practices for metadata, semantic information and model relationships enables many domains to utilize X3D as a Web-based presentation layer. Accepted conventions and best practices enable authors to utilize the power of X3Dv4 and HTML5/DOM together in any Web page utilizing a family of specifications provided by the Semantic Web, such as Microdata and Microformats, RDFa and JSON-LD, Linked Open Data, MPEG-7 structures, structured metadata vocabularies and taxonomies, plus numerous related references. Aligning a new ontology with the forthcoming X3Dv4 specification can further empower Digital Publishing industry and communities to utilize X3D as a first-class media type, enabling archival dissemination of any 3D model. Value propositions for utilizing semantic information in concert with archival export, publishing, visualization, and printing of any 3D model as X3D can lead to broad use and scalable query effectiveness.

A key principle guiding the working group is to maximize interoperability of X3D with Semantic Web standards for greatest possible reuse and integration with other Web assets.

Specific goals are also numerous [Dean Allemang and Jim Hendler 2011; Leslie F. Sikos 2015; Poznań University of Economics and Business (Poland) 2012]. A standardized X3D ontology enables more effective indexing, search, comparison, and analysis of X3D scenes and objects through the advanced use of metadata and ontologies for describing shape geometry, etc. Precision and evolution are together possible by creating and autogenerating an X3Dv4 OWL ontology from the X3D Unified Object Model (X3DUOM) using best-practice design patterns, starting with those shown by prior published work. Supporting explorations are underway for various Web3D Working Groups including Computer-Aided Design (CAD), 3D Printing and Scanning, Medical, Cultural and Natural Heritage, and Humanoid Animation (HAnim). Future design work may consider other structured domains such as Building Information Models (BIM), cultural heritage, etc. Towards those diverse objectives inherent in digital stewardship [Library of Congress, Washington DC 2018], the group is building lists and exemplars of domain-specific controlled vocabularies, taxonomies, thesauri, properties, ontologies and queries that are suitable for use in concert with the X3D Ontology.

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Workshop discussions include roadmap consideration of specific follow-on activities:

- Problems, solutions and use cases for combining X3D with Semantic Web standards, in particular RDF, RDFa, RDFS, OWL, SWRL and SPARQL.
- Support for Semantic Web standards and JSON-LD across multiple X3D file formats and programming languages.
- Dimensional analysis and correspondences between X3D UNIT statements and Quantity Units Dimensions Types (QUDT) ontology.
- Metadata framework for describing the semantics of X3D scenes and objects in HTML.
- General shape and animation properties common to all 3D graphics model formats.
- Mappings between X3D ontology and domain-specific ontologies: CAD, medical, etc.
- Building compatible 3D-geometric and domain-specific queries for X3D scenes to enable Linked Open Data (LOD) reasoning over X3D scenes at low and high abstraction levels
- Archival model preservation, publication, annotation and digital stewardship.
- Simple Knowledge Organization System (SKOS) and use within knowledge repositories.
- Checking logical consistency of X3D scenes across multiple abstraction levels.
- Automatically generating X3D model documents from ontologies and vice versa.

- Potential for unlocking any binary 3D graphics file format through definition of custom schemas using Data Format Description Language (DFDL) and Daffodil applications, creating XML/JSON representations that can then be mapped semantically to X3D.
- Cooperation with standards development organizations and Web3D working groups.

This workshop presents active work to date, describes next-step challenges and explores next-step activities. These are big topics with many aspects and great potential. Elaborating domain-relevant use cases can steer collaborative work in fruitful directions for widespread future use.

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