A New Tool for Linked Data Visualization and Exploration in 3D/VR Space

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A New Tool for Linked Data Visualization and Exploration in 3D/VR Space

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Abstract. Linked data and knowledge graphs have become widely used in the last years. As the interest in linked data and ontologies grows, so does the interest in means of studying, presenting, developing and storing ontologies. Here, we introduce a first version of novel tool for presenting and studying ontologies and linked data which visualizes the semantic graph structure in the natural form for humans – in form of 3D objects in space. The use of 3D space provides additional means to visualize and annotate objects, and for the user to explore. The presented tool builds on an existing ontology visualization system (Ontodia), and extends it with the ability to display ontologies in 3D and virtual reality space.

Keywords: semantic data visualization, visual data exploration, knowledge graphs, 3D graph, virtual reality

1 Introduction

Ontologies and linked data, as a means of knowledge representation, are typically hard to understand for lay users if serialized in RDF or similar formats. Visualization tools can make the semantic data more easily accessible. In visual data consumption, different users will prefer different representations. Depending on the use case, some find it convenient to work with a table views, others prefer flat trees, others again graph views, etc. Therefore, visualization tools often take the complex approach of multi-faceted graph visualization by implementing several representations of the same data at once with the possibility of seamless switching between representations [2].

In this work, we build on a semantic graph visualization platform called *Ontodia*[3] [4, 5]. *Ontodia3D* is an extension of the Ontodia in order to visualize ontologies and linked data in 3D and VR space. We chose Ontodia as underlying framework, as it is a) published under an open license (GNU LGPL), b) it is build on a modern technology stack and under active development, c) offers a wide range of functionalities and potential use cases [1].

Figure 1 shows an example of a simple visualization within the Ontodia interface, which is inherited by Ontodia3D. The interface includes the ontology

[3] `ontodia.org`

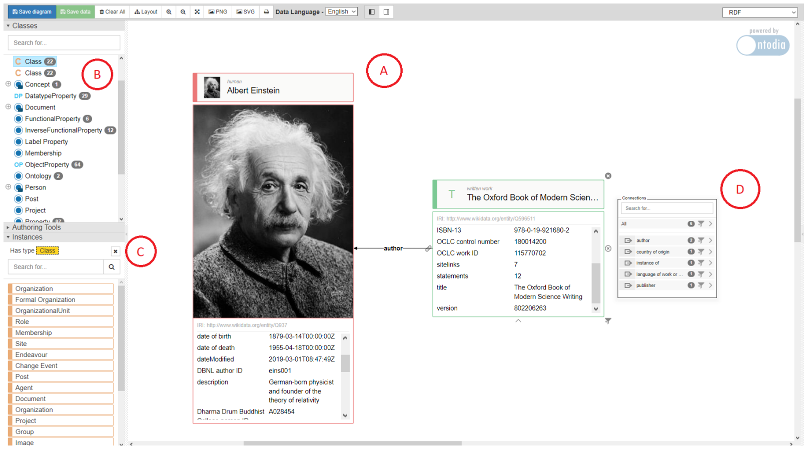

Fig. 1. Ontodia - visualization example from the DBPedia dataset

panel (Class panel, Fig. 1 B) and the data panel (Instances panel, Fig. 1 C), as well as the Connections panel, (Fig. 1 D), which allows users to add elements to a graph by searching them by types and by direction of relations.

To the best of our knowledge, there has been little work in 3D visualization of ontologies and linked data – restricted to visualization plugins for the desktop versions of Protege and Eclipse (see Section 2). In contrast, Ontodia3D[4] is a scalable Web-based tool built on a recent technology stack. In the demo track at ESWC we plan to present the latest version of the Ontodia3D prototype, including its main features of visual customization of various graph components by their type (see Section 3), and the 3D exploration of small but also large graph structures. We aim to use the potential offered by the addition dimension to improve semantic graph exploration and understanding. A short video presenting the prototype is available here: `https://cl.ly/bdb3919f4fac`

2 Related work

In contrast to 2D visualization of ontologies and linked data, there has been little work on 3D visualization and making use of VR technologies. VR systems become a mass product only recently, and interactive 3D visualization of large graphs poses very high demands on the available hardware. Existing work on 3D visualization of ontologies includes OntoSphere3D [6] and Harmony information landscape (HIL) [3]. Originally designed for hypertext document, HIL provides landscapes with color-encoded documents on a 3D plane with relations between them. OntoSphere3D can be used as plugin for either the Protege[5] environment or for Eclipse[6]. The tool uses a multi-faceted approach to ontology visualization

[4] Prototype demo available at: `https://ontodia3d.herokuapp.com/wikidata.html`

[5] `protege.stanford.edu`

[6] `www.eclipse.org`

and supports four types of diagrams: taxonomy view, concept detailing view, instances view and a main view for smoother navigation.

In contrast to existing work, the tool presented here is Web-based and uses a modern technology stack. While OntoSphere3D is restricted to the 3D visualization of specific parts of ontologies with a limited number of nodes, Ontodia3D is limited only by the amount of memory available on the machine, and can potentially render graphs with thousands of nodes – depending on a complexity of shapes which are representing elements. Finally, the current technology stack (three.js/WebGL) allows Ontodia3D to implement VR support with little extra effort.

3 Ontodia3D

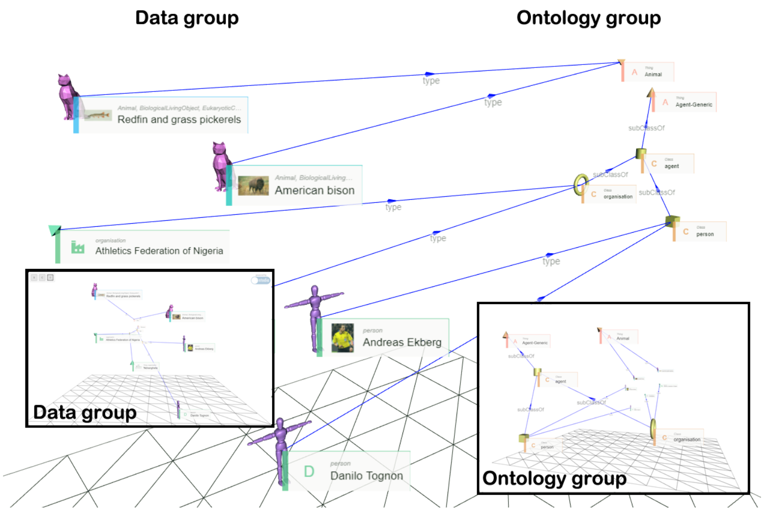

Fig. 2. Ontodia3D - an example of grouping elements via the 3rd dimension

Ontodia3D currently is a fork of the original Ontodia repository. We support seamless switching between React/SVG and Three.js/WebGL/CSS3D stacks within the UI. With "seamless" we mean that elements from the 2D-graph can occupy the corresponding position in the 3D-graph, which prevents a user from losing the display context. Ontodia provides *Element Templates* for flexible annotation of elements and for embedding of content into a graph scene. Ontodia3D element templates in turn expand the basic Ontodia templates allowing to define the 3D-shapes that represent the selected elements. 3D-shapes can be loaded from files or as one of the predefined primitives, incl. sphere, cube, ring, pyramid, octahedron, and dodecahedron (see Fig. 2).

Additionally to the customization of shapes, Ontodia3D supports setting object colors, and templates selected by annotation type. The user of the library can determine the rules to select certain element styles. For example, all the vertices of the graph that are instances of the `http://dbpedia.org/ontology/Agent` class can be rendered in a shape of a 3D person, and the annotations to this vertex can be represented as a page from a social network (see e.g. Figure 3). The annotation templates are based on the original templates from Ontodia, which allow setting the color and style of annotations, as well as to integrate almost any content that can be rendered on a Web page, from SVG-images to videos from YouTube.

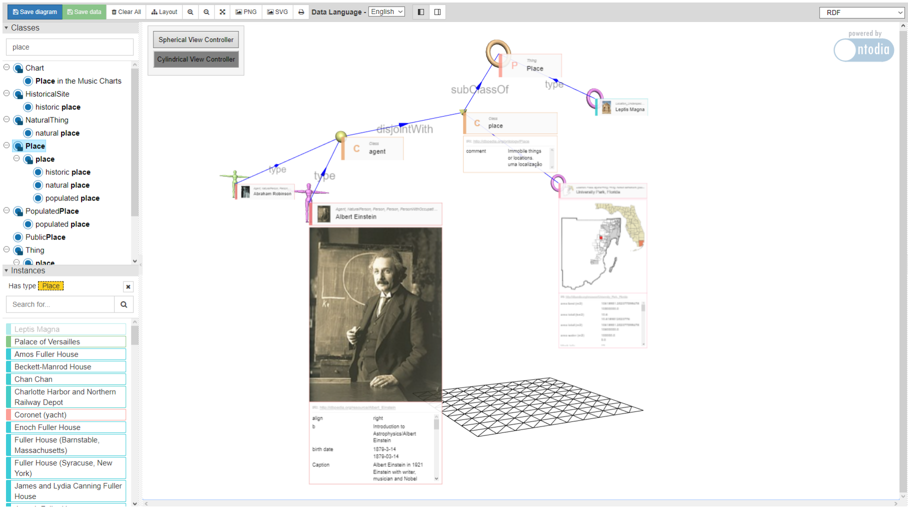

Fig. 3. Ontodia3D - an example from the DBPedia dataset

The 3D representation of graphs provides multiple benefits and opportunities as compared to 2D. Firstly, we have another spacial dimension for expressing and grouping data. In 2D space we can differentiate elements of an ontology by color, text, template design (annotations), as well as by the shape and size of an object – in order to express certain properties. In 3D space the depth of space allows for a more meaningful placement and grouping of objects, and for 3D object shapes and textures.

A frequent challenge faced by graph visualization tools is the difficulty to draw links between nodes so that links do not overlap with each other. This problem is mitigated in 3D space, esp. when using stereo vision (VR helmet). In addition, the 3rd dimension gives the ability to group elements more effectively. For example, all elements of one data set can be placed farther from the user, elements from another dataset closer. While using the Ontodia3D navigation tools, a user can change the position of the viewpoint when switching between data sets. Moreover, links between two data sets will be easily noticed by turning the view-port in a position perpendicular to the data placement planes (see Figure 2).

Finally, as a more concrete use case, it is possible e.g. to make an ontology of kitchen furniture and, at the same time, place real 3D models of kitchen furniture in 3D space, so that the ontological graph will look like a 3D scene equipped with annotations that provide important characteristics of each class or instance.

4 Conclusion

We introduce a prototype of a new tool for 3D linked data visualization. Ontodia3D is a Web-based application with a modern technology stack that extends an existing ontology visualization framework. The tool aims to make use of the additional visual dimension in order to improve semantic graph exploration by providing new features to customize object and link shapes and annotations, to allow visual distinctions for example by object type, navigation in 3D space, and supports flexible integration of different types of content into the visualization. In contrast to existing work, Ontodia3D aims to display large graphs.

Future work will improve the prototype in various directions: a) Tighten the integration with the Ontodia base platform, esp. regarding UI interaction, b) import and export of 3D scenes in various formats, c) extend the number of supported layout-algorithms for 3D-graphs, d) align and group nodes using 3D shapes in space (layers, etc), e) enhance the support for VR devices, f) 3D features such as camera movement animation, scene customization, lighting configuration, and the ability to use textures on objects. After the implementation of these and other features, we plan a user study to empirically study the benefits and drawbacks of 3D visualization in semantic graph exploration.

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