VOWLMap: Graph-based Ontology Alignment Visualization and Editing *

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Abstract. Manual validation of automated ontology alignments remains essential to produce high quality ontology alignments. However, few alignment systems feature user interfaces for alignment visualization, validation and editing, and those that do, support a limited number of requirements.
We developed VOWLMap — an extension for the web application, WebVOWL — for visualizing, editing, and validating ontology alignments. VOWLMap employs modularization techniques to facilitate the visualization of large alignments while maintaining the context of each mapping and supports direct interaction with and editing of graph representations.

Keywords: Ontology Alignment · Ontology Visualization · Alignment Visualization

1 Introduction

Ontology matching techniques can be applied to establish semantic relations between entities of two ontologies, and various have been developed to tackle the semantic heterogeneity problem. In most cases, matching systems employ automated approaches without human intervention but, due to the complexity of the alignment process, the alignments produced can contain erroneous, incoherent, or missing mappings. For this reason, manual validation remains an essential part of the process of producing high quality ontology alignments. Comprehensive and interactive visualizations are key features in user involvement in the validation process. Nevertheless, few alignment systems provide a user interface that supports alignment visualization, editing, and navigation strategies, and even fewer provide the functionalities needed to make the task seamless for the user, such as interaction with the visualization or contextual information about the mappings. Moreover, the available interfaces are coupled with automated ontology alignment systems, which theoretically can support more sophisticated types of interaction that may happen during the alignment process, but in practice, can make them less versatile by tying visualizations to specific implementation technologies [4].

We present VOWLMap [4], a tool for visualizing, validating, and editing ontology alignments. VOWLMap extends the web application, WebVOWL [3] and its underlying visual notation (VOWL) [2] to the context of ontology alignment. VOWLMap employs modularization techniques to facilitate the visualization of large alignments while maintaining the context of each individual mapping and supports diverse interaction mechanisms, including direct interaction with and editing of graph representations.

2   VOWLMap

To develop VOWLMap, we analyzed the requirements described in [1], selected target requirements, and considered existing development and visualization options. The success of javascript-based visualization for complex data afforded by D3.js made us consider a browser-based architecture, which enables easier use by domain experts since no specific software needs to be installed. We investigated existing browser-based ontology visualization systems, and WebVOWL matched our functional and technical requirements.

Extending VOWL — To represent ontologies with different colors, we assigned the *light blue* to the source ontology and the *dark blue* to the target ontology. Each mapping is treated as a property between two mapped nodes, represented by a solid line with arrowheads at both ends and a label rectangle indicating the confidence score. Four different colors have been added to color the mapping representations according to its status: dark green for *correct*, dark red for *incorrect*, medium yellow for *unsure* and medium grey for *unreviewed*.

Loading ontologies and alignments — Like WebVOWL, VOWLMap receives as input a JSON representation of two ontologies and an alignment between them. To produce a file that can be loaded in VOWLMap, we developed a small Python-based tool, that receives as input two JSON files of ontologies, previously converted using OWL2VOWL [3], and an alignment RDF file. This tool merges the three files into one single JSON file containing all the information about the ontologies and the respective alignment between them.

Alignment views — The interface is divided into two views: an alignment panel and a graph visualization (Figure 1). The alignment panel is composed of a list of mappings, their confidence score, and status, and allows to validate and create new mappings. By selecting a mapping from the list, a graph visualization for that mapping is generated, where both ontologies are represented in the same graph with different colors, and the mappings are represented as double-edges arrows colored according to their status and labeled with their score.

Visual information seeking — Users can interact with the visualization by zooming in/out, panning the background and adapting the force-directed layout. It is possible to change the characteristics of the graph (e.g., apply filters), and adjust the neighborhood (from zero to a maximum of three edges of distance). Besides searching for ontology entities, VOWLMap allows searching for a mapping in the search bar, located across both views.

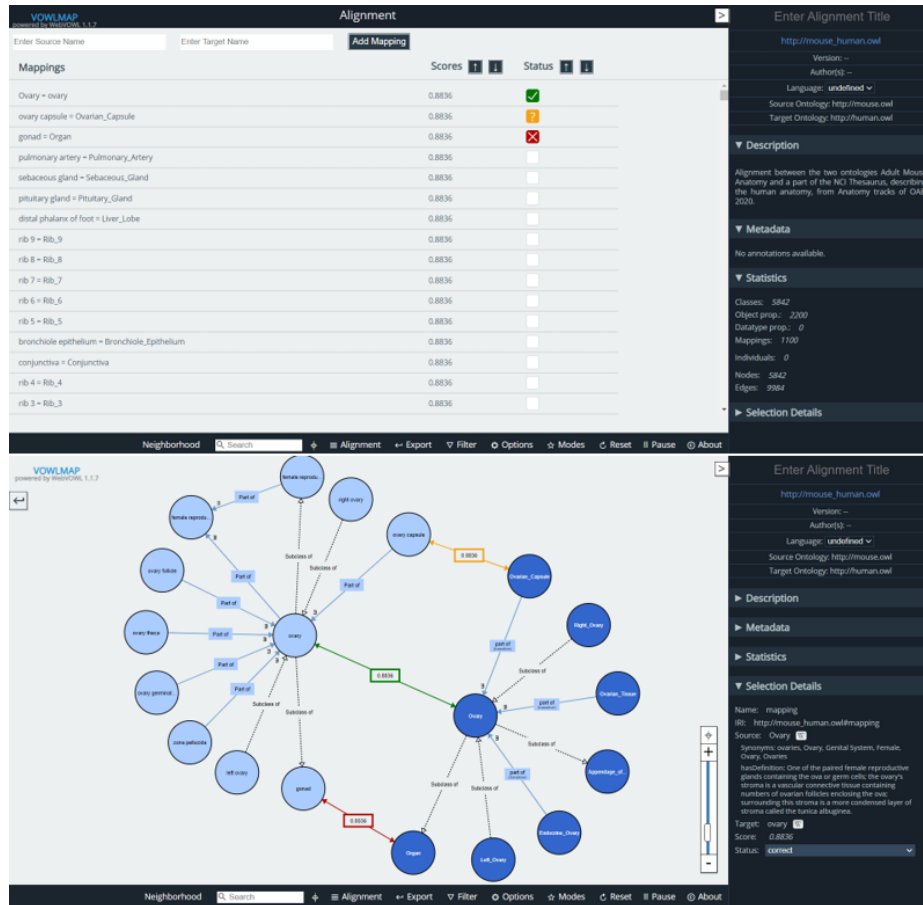[4] Available at https://github.com/liseda-lab/VOWLMap

Fig. 1. User Interface of VOWLMap: an alignment panel (above) and a graph visualization of the mapping *Ovary-ovary* with neighbourhood at a distance of one (bellow).

Visualize and edit mapping status — VOWLMap supports 4 values for a mapping status - *unreviewed*, *correct*, *incorrect* and *unsure*. Users can visualize and edit a mapping status in both views. In the graph, when users select a mapping, the sidebar contains a dropdown that allows users to select one of the four available options. In the alignment panel, users can change the status of a mapping in the status checkbox by clicking on it. Each status has an associated color and icon to distinguish them.

Visualize metadata and mapping context — The sidebar gives information about the mapped classes (e.g., synonyms, definitions), and generates an automatic link to Wikipedia for each class, which can help users to get extra information. Moreover, VOWLMap allows to visualize an individual mapping and its local context, including nearby mappings. By default, the neighborhood

is displayed at a distance of one, but it is possible to change it from 0 to a maximum of 3 edges.

Create and refine mappings — Users can refine mappings by dragging the ends of the source or target nodes to another one, manually remove the mapping or add new mappings to the alignment in the graph. When a mapping is added, the maximum score and the status value *correct* are assigned to that mapping. In the list, users can also add mappings by entering the label of the source and target classes, and a graph visualization for that mapping is created.

Session support and exporting alignments — the changes made are saved in a cached version and, as long as VOWLMap is open in the browser, this version is always loaded, supporting interruptions in the validation process. The reload button allows to discard these alterations and load the original alignment. Moreover, VOWLMap allows to export the validated alignment in many formats (e.g., RDF) or the complete/filtered visualization of a mapping in SVG format.

3   Results

We performed a preliminary user study with 4 users presenting different backgrounds (life sciences, health sciences, computer science and engineering) and levels of expertise in alignment validation. Users were asked to validate two different alignments derived from the Conference and Anatomy tracks of OAEI 2020[5], and rate the features of VOWLMap in a Likert scale, ranging from "Not useful" (score 1) to "Very useful" (score 5).
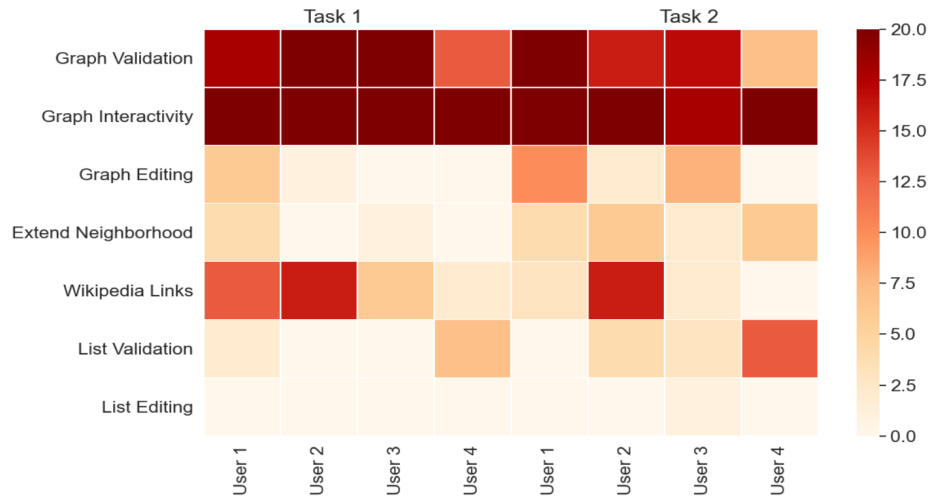

Fig. 2. Frequency of mappings where users used each feature. Task 1 and 2 consist of validating an alignment from the *Conference* and *Anatomy* domains, respectively.

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[5] http://oaei.ontologymatching.org/2020/

The correctness of each validation action was assessed with a reference alignment. Users accurately validated both alignments, with accuracy ranging from 80% to 95% the two tasks.

With regard to VOWLMap's features, users made use of most of VOWLMap's features, and generally considered them useful in the feedback they provided. *Graph Visualization* and *Graph Interactivity* were consistently the highest rated features and the most used by users in both tasks (Figure 2), indicating that users highly benefited from these new functionalities in both tasks. *Wikipedia Links* was rated with score 4 by all users, likely due to the fact that these links are automatically generated from the entities' labels, and sometimes there is no Wikipedia page available for that specific term. *Graph Editing* was the only feature scored with 3, by user 4. As Figure 2 shows, this user was the only user that attempted neither to add nor to refine any mapping, making the least use of this functionality among all users.

Overall, users used more features when validating the alignment from the Anatomy domains (Task 2), suggesting that VOWLMap can be more suitable for the validation of alignments from the biomedical domain.

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