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IOPE: Interactive Ontology Population and Enrichment ^{*}

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Abstract. We demonstrate IOPE, a framework for the automatic construction of a Graphical User Interface (GUI) from the ontological constraints of an input ontology. The resulting GUI functions as a guidance for the experts with no knowledge of OWL/RDFS which enables them to easily explore and update their ontologies. The GUI also helps the experts to easily curate their own knowledge, and share it with peers. We illustrate the functionality of IOPE on an ontology for simulation-based medical workshops called ONTOSAMSEI, and demonstrate two key scenarios on the GUI: *semester planning*, where an instructor in Medicine department uses the GUI to populate the ontology with information about target groups for different training workshops, and *robotic surgery evaluation*, where a laboratory director employs the GUI to enrich the ontology with new assessment techniques to evaluate surgical skills.

1 Introduction

Ontologies are the backbone of many information systems that require access to structured knowledge. By their very nature, real world ontologies are dynamic artifacts that evolve both in their structure (the data model) and their content (instances). Keeping them up-to-date is a critical operation for most applications which rely on semantic Web technologies. Ontology updates encompass both *enrichment* and *population*. Ontology enrichment is the task of extending an existing data model of an ontology with additional concepts and semantic relations, while ontology population is the task of adding new instances of concepts to the ontology, through domain documentations. Ontology updates are often performed manually, as the non-documented knowledge of the domain expert is required to be taken into consideration. However, this manual updates put burden on the experts and render the whole ontological ecosystem inefficient. In this demo paper, we advocate for an alternative and more effective approach, and propose to handle updates automatically through a few interactions with the expert, using a Graphical User Interface (GUI).

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The challenges associated to interaction-based automatic updates are two-fold: (i) While ontologies are typically represented in the form of graphs, it is inherently difficult and counter-intuitive to provide a graphical graph-based representation of ontologies for the consumption of experts. While there exist several methods to visualize a graph structure [4, 5], the outcome is often hard to digest by domain experts. (ii) It is unclear how experts should perform ontology updates through the interactions, without the prior knowledge of the formal syntax and the semantics of ontology languages.

In this paper, we demonstrate IOPE (Interactive Ontology Population and Enrichment), a framework for the automatic construction of a GUI using *pre-filled Web forms*. We leverage Web forms as a natural interaction means to tackle the challenge of counter-intuitive ontology representations. IOPE generates the Web forms from *ontological constraints*, which support the controlled update process of a given ontology, and prefills the generated forms. While IOPE is generic and can be applied to ontologies from a variety of domains, we employ an ontology called ONTOSAMSEI [2] for demonstration purposes, whose content helps the domain experts design teaching units for learning skills in simulation-based Medicine. ONTOSAMSEI is a hierarchy of classes and properties enriched by ontological constraints on those classes and properties, that convey the constraints that will have to be fulfilled by their future sub-classes, sub-properties or instances. We show how to exploit such ontological constraints as a source of guidance for (possibly less experienced) educators willing to design their own simulation sessions, hence addressing the challenge of expert noviceship. ONTOSAMSEI's IOPE GUI is accessible via the following link: <http://iope.tabasi.info> (in French).

In the literature, ontological updates are often performed using ontology editing tools, such as PROTÉGÉ⁴, TOPBRAID⁵, and ONTODIA⁶. However, these systems require a basic understanding of the RDF notation and of the OWL semantics to edit the ontology consistently. Graph-based editing approaches alleviate this limitation by leveraging shapes graphs in the form of SHACL standard⁷ [8, 7]. While shapes graphs are well adapted for editing complex data, they require the definition of such graphs for each ontology. In contrast, IOPE abstracts all RDF/OWL technicalities and seamlessly enforces the ontological constraints as a strong guidance for the experts to update the ontology, using the pre-filled forms. Forms are also used in [6] in a nested structure to capture relational aspects of knowledge graphs and update RDF data. However, the nested structure introduces increasing complexity and hence lacks intuitiveness. Moreover, the focus in [6] is solely on the population part and the approach does not extend to OWL constraints. In [3], Web forms are generated from ontologies (using a User Interface ontology, called RaUL) by interpreting ontology assertions as rules. While the approach only incorporates individual assertions

⁴ <https://protege.stanford.edu>

⁵ <https://www.topquadrant.com/products/topbraid-composer/>

⁶ <https://metaphacts.com/ontodia>

⁷ *Shapes Constraint Language (SHACL)*: <https://www.w3.org/TR/shacl/>

(ontology population), IOPE serves both ontology enrichment and population, through interactions with the experts. IOPE stresses on ontological constraints as first-class citizens and renders pre-filled Web forms to provide a more aggregated view for the experts, which is, to the best of our knowledge, nonexistent in the literature.

2 System Architecture

Our approach consists of transposing the RDF data and the ontological constraints of a given domain ontology into a GUI named IOPE GUI. It functions as a guidance for domain experts to easily explore the ontology and update it through interactive graphical widgets. The input entered by domain experts through the IOPE GUI is transformed into RDF triples that must be verified by an ontology engineer before being added effectively in the domain ontology. Figure 1 is an overview of our interactive IOPE system.

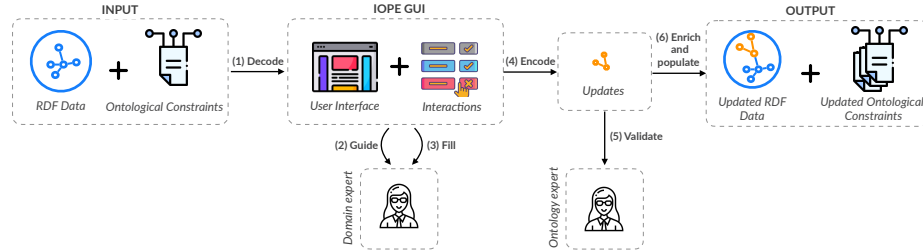


Fig. 1: Overview of IOPE workflow

In the following, we describe the components of IOPE workflow.

Input: A domain ontology is the input for GUI construction. The ontological constraints of the input ontology have been automatically saturated by a reasoning algorithm, detailed in [1].

IOPE GUI: The GUI consists of automatically generated pre-filled Web pages which represent domain ontological constraints. We specify a set of 16 *mapping rules* to generate pre-filled Web pages [1]. The domain expert is guided using the generated pages, where she interacts with the GUI to explore and update the ontology through interactive graphical widgets. Those interactions must be bound to RDF data corresponding to new instances or new constraints submitted for populating or enriching the domain ontology. We specify a set of 9 *binding rules* to generate RDF graphs from user entries [1]. The resulting RDF graphs should be verified by an ontology engineer before adding to the domain ontology.

Output: The output is the updated RDF data and the updated ontological constraints.

3 Interface

We present IOPE GUI features using an example in simulation-based medical domain. A medical educator aims to design a simulation workshop, i.e., a task which lacks referential and is often performed in an entirely manual fashion. IOPE, equipped with an ontology for simulation-based medical workshops called ONTO SAMSEI [2], will first guide the educator to select the type of her workshop through a comprehensive list. A list of pre-filled Web pages will then

be provided as “content guidance” for the selected workshop type, where the educator can interact with the pages to gain insights from the pre-filled values and add her own knowledge wherever she needs more specialization. These interactions include the enrichment and population of the underlying ontology. This knowledge source encompasses the educator’s curated workshop, which is ready to use and easy to share among peers.

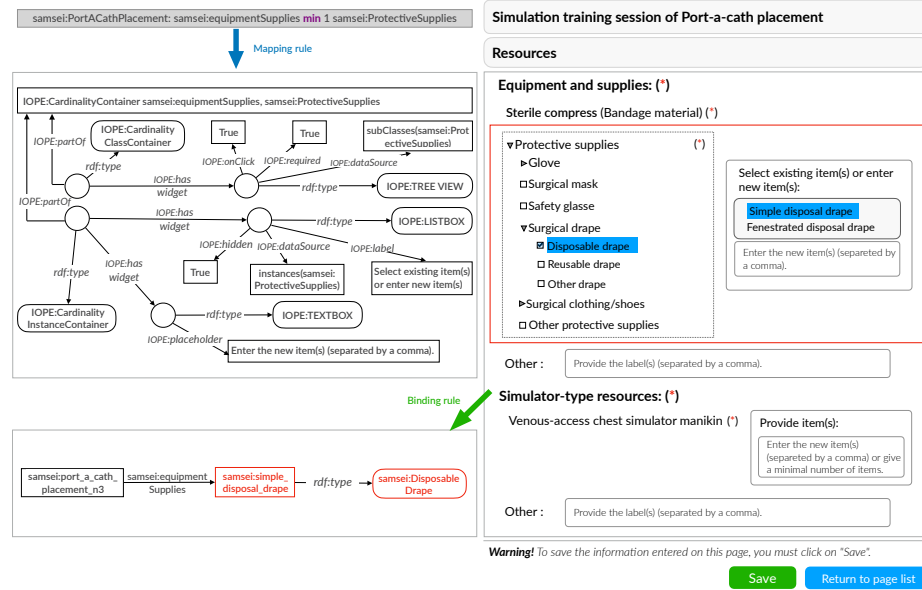


Fig. 2: An instance of a pre-filled Web page generated by applying the mapping rules to ontological constraints, and the transformation of interactions with the binding rules.

Figure 2-right illustrates one of the resulting pre-filled Web pages generated by applying the mapping rules to ONTOSAMSEI’s ontological constraints, to represent information about the workshop required resources, e.g., equipment and supplies, and simulator-type resources. At the top-left of the figure, an ontological constraint is mentioned in Turtle format⁸, conveying that at least one equipment of type “protective supply” is mandatory for this workshop. Obviously, the Turtle format is difficult to be comprehended by users without OWL/RDFS knowledge. The graph-based result of a mapping rule applied on the constraint is shown in the middle-left part of the figure, whose HTML implementation is highlighted with a red-border square on the right side. The user interactions with the pre-filled Web page are highlighted in blue, where the educator selects a sub-class Disposable Drape from the Protective Supplies hierarchy, and picks the instance Simple disposable drape from the provided list of instances. The interactions are transformed into RDF graphs using the binding rule shown in the bottom-left part of the figure. This transformation results in two RDF triples which declare relations between an instance of the workshop and the selected instance, and between the selected instance and its class.

⁸ <https://www.w3.org/TR/turtle/>

4 Demonstration Scenarios

We describe two scenarios that demo attendees can perform on IOPE.

Semester planning. We consider a scenario focused on ontology population. The demo attendees can act as an instructor in Medicine department whose aim is to plan her workload for the upcoming semester. She seeks to define the target audience for her different simulation-based training workshops. She employs IOPE GUI to inspire from previous audience-workshop assignments, and choose a subset of interest, by scanning different widgets provided by the GUI, such as lists and checkboxes. In case the instructor doesn't reach ample insights about targeted audience, she populates the ontology by specifying training groups which are not among the prior assignments.

Robotic surgery evaluation. We consider a scenario focused on ontology enrichment. The demo attendees can act as a director in a robotic surgery laboratory, whose aim is to evaluate surgical skills when students operate in collaboration with robots. The director employs the IOPE GUI to access the workshops dedicated to robotic surgery. This is where she can select a target group of students, define the objective of her own workshop, specify the number of participants, etc. She observes the list of possible assessment techniques, and finds OSATS (Objective Structured Assessment of Technical Skill) as an appropriate approach for evaluation. However, due to the rising complexity of robotic surgical skills, she seeks a more specialized technique. This is why she selects "other" in the assessment list, and adds a new one called GEARS (Global Evaluative Assessment of Robotic Skills). This results in the enrichment of the ontology with a new assessment technique. She will then use the textbox in the GUI to provide the URL to her own instance of GEARS assessment.

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