Visualization of a Domain Knowledge (A Case Study of Crops Ontology)

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Abstract

With the huge volume of data in the cloud and on our storage devices, getting the relevant knowledge from the stored data is a challenge. The semantic web, through data visualization and ontology is currently being used in overcoming this challenge. Also, effective comprehension and utilization of domain knowledge are critical for informed decision-making. This study explores the concept of visualizing domain knowledge, using crop ontology as a case study, as a powerful means to enhance understanding and decision-making processes. The study outlines the creation and structuring of crop ontology, designed to capture and formalize knowledge related to crops, farmer, harvesting and post-harvesting, origin of crops and pests and diseases associated with the crops. An ontograph, a feature in an ontology editor was used to visualize the concepts and relationships in the ontology. This visualization technique offers a transformative approach to represent complex data, enabling stakeholders to grasp intricate relationships, patterns, and insights within the agricultural sector. Leveraging on semantic web technologies, the ontology serves as a structured, machine-readable resource that facilitates interoperability and knowledge sharing across diverse agricultural data sources.

Keywords
Visualization, Domain ontology, Crops, Ontograph, Protege

1. Introduction

In today's digital age, the amount of information available on the World Wide Web is vast and constantly growing. This abundance of data presents both opportunities and challenges. While it is easier than ever to access information, finding and making sense of relevant data remains a complex task. To address this challenge, two powerful concepts have emerged: the Semantic Web and the Knowledge Graph [1,2]. These concepts, rooted in the principles of linked data and semantic technology, are revolutionizing the way we organize, access, and understand information. The Semantic Web envisions a web where data is not just stored as unstructured documents but is also structured in a way that machines can understand and process it [3]. This vision is underpinned by several key principles like the Resource Description Framework (RDF), Ontology and Linked Data.

RDF is a fundamental framework for representing data and resources on the web [4]. It uses subject-predicate-object triples to express relationships, and it is the building block of semantic data while Ontologies define the relationships between entities and concepts on the Semantic Web. These formal, machine-readable definitions enable a common understanding of data. Linked Data is the practice of linking data sets on the web, creating a vast interconnected web of

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knowledge. Each data point or resource is assigned a unique URL, making it to be referenced and linked to related resources [5].

Ontology is one of the structures on which the Semantic Web is built because of its formal framework for understanding and representing data [6]. The use of ontologies allows for shared, machine-readable knowledge, which, in turn, supports the vision of a more intelligent and interconnected web [7]. As the Semantic Web continues to evolve, the role of ontology in fostering a common understanding of data will become increasingly important, driving innovation across various industries and domains. Ontologies enable semantic interoperability, which means that data from various sources can be integrated and processed together because they share a common understanding of terms and relationships [8]. This facilitates seamless data exchange and processing. Search engines and applications can use ontologies to understand user queries and provide more relevant and context-aware search results. This leads to more precise and helpful search experiences. Also, ontologies support automated reasoning. They enable computers to infer new information based on the existing knowledge, making it possible to answer complex questions and make decisions based on structured data.

An Ontograph, or Ontological Graph, is a graphical representation of a domain's knowledge using ontological concepts, relationships, and entities. It is a way to visually depict and model the semantics of a particular domain or subject area. Ontographs focus on creating a graphical model of the semantics of a specific domain. They define the key concepts, their relationships, and how they interact. Ontographs rely on ontologies to define the terms, concepts, and relationships used in the graph. Ontologies provide a formal, structured way to describe knowledge in a machine-readable format [9] and as intelligent knowledge management tool [10]. They are used for knowledge representation, enabling machines to understand and reason about information within a particular domain. This is especially valuable in fields such as artificial intelligence, where clear semantics are essential. Ontographs are often presented as visual graphs, with nodes representing concepts or entities and edges indicating relationships between them. This visual representation helps in understanding complex relationships. In an agricultural sector, an ontograph could represent agricultural knowledge of a crop or animal, including concepts like types and diseases associated with them among others.

According to [11], crops are plants' products grown to provide food, fuel and clothing among others. They basically have six categories which are: food crops, feed crops, fiber crops, oil crops, ornamental crops, and industrial crops. This study deals only with food crops. Pests are insects or small animals which damage crops or food supplies and different pests are associated with different crops. Hence, this study presents a visualization of crops ontology using ontographs. Five major concepts are described which are: crops, farmer, harvesting and post-harvesting, origin of the crops and pests and diseases associated with them.

2. Related Works

In [12], it was shown that some information visualization tasks can be simplified by the semantic web. Also, the semantic annotation can be utilized for semantic visualization. The authors mentioned that these two fields differ from their philosophical groundings to tactical approaches to individual problems such as knowledge modeling and representation. They suggested that a lot of theoretical and practical work will be done in order to harmonize the two fields.

In [13], it was observed that knowledge elicitation, formalization and management need to be supported by usable tools. In order to provide this need, this article describes fully integrated semantic web framework experiences, where users can represent and manage their data in a visual way. With this, semantic web experts will not be needed as intermediaries. The framework for the study consists of an ontology editor, a resource editor, reasoning capabilities and intuitive interaction and visualization facilities. Investigation was performed on the use of effective visualization techniques to graphically represent ontologies. This produces the EasyOnto prototype.

According to [5], the semantic web and its integration with other domains has a good future. Linked open data was emphasized as one that has a large amount of repository of knowledge graphs in RDF or OWL formats. But these formats are difficult to analyze. Since data visualization is required for better clarity, their study gives a brief summary of various tools and platforms used for visualizing semantic web data along with the snapshots of most widely used tools.

3. Methodology

The major five concepts (crops, farmer, harvesting and post-harvesting, origin of the crops and pests and diseases) described in this ontology have their sub-classes as shown in Figure 1.

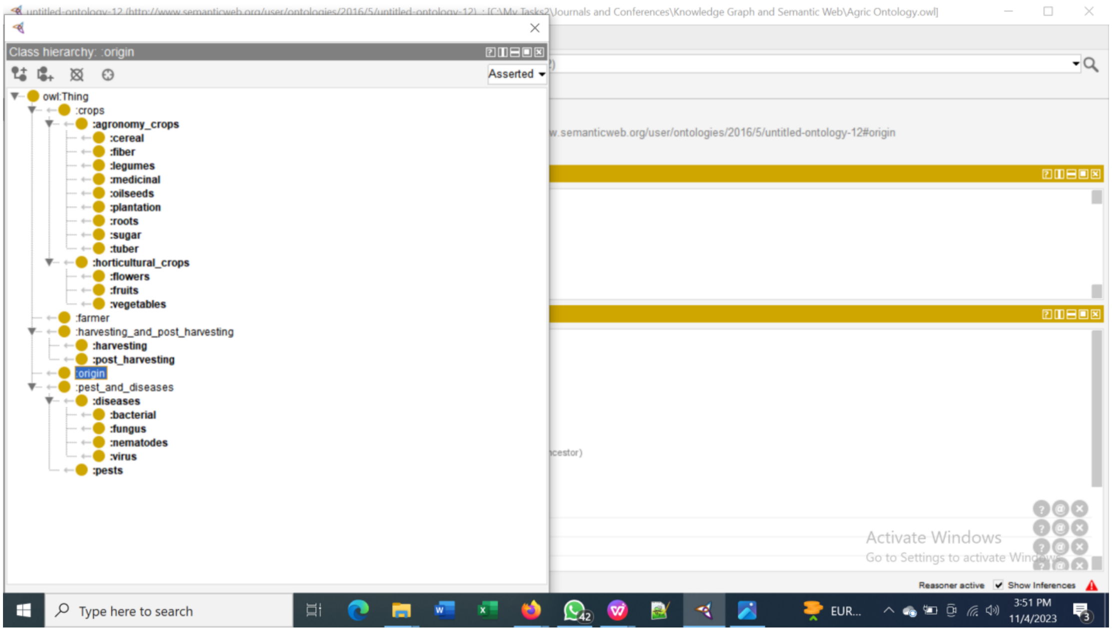

Figure 1: Class Hierarchy of the Crops Ontology

The object properties are shown in Figure 2 while Figure 3 shows the Data properties

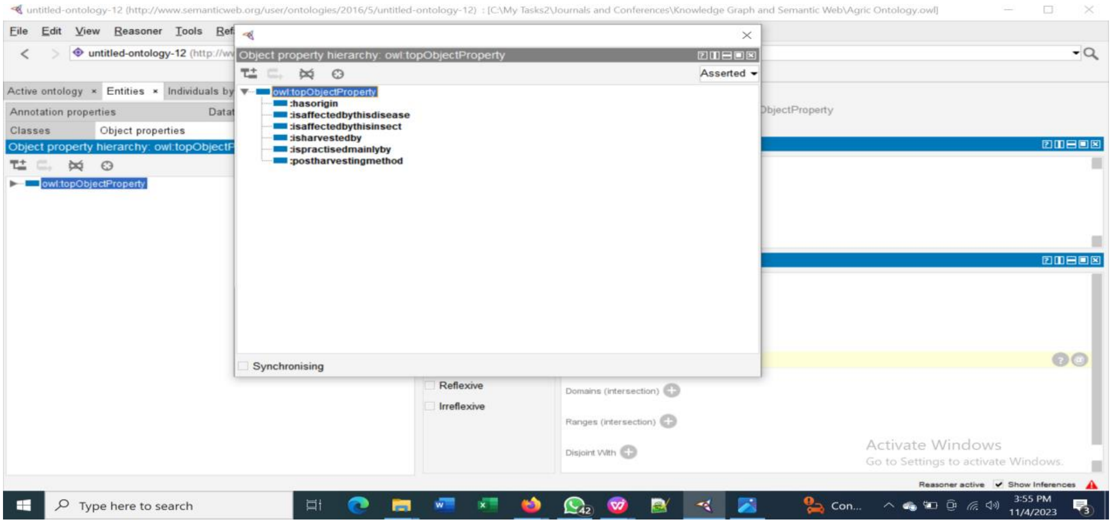

Figure 2: Object Properties of the Crops Ontology

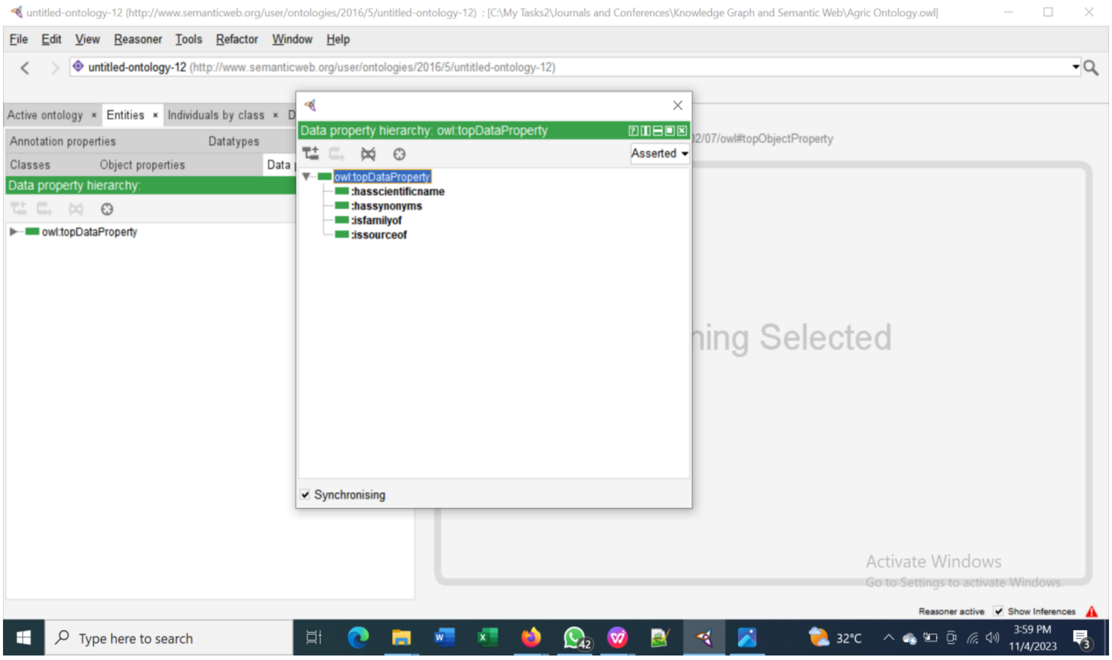

Figure 3: Data Properties of the Crops Ontology

The object properties connect two individuals (a subject and object) with a predicate while the data property provides a relation to attach an entity instance to some literal datatype value.

4. Implementation and Discussion of Results

The crops ontology examined in this study is implemented with Protege, an ontology editor with Hermit Reasoner. Ontographs are generated to show the relationship between the various concepts while DL Query was used to answer some competency questions.

4.1 Ontographs

Figure 4 shows the two major sub-classes of crops as Horticultural and Agronomy Crops. Each of these is further sub-divided again. Under the Horticultural crops, we have flowers, fruits and vegetables while under the Agronomy crops, we have medicinal, fibre, cereal, legumes, tuber, sugar, plantation, roots and oilseeds.

This visualization helps to see the classifications at a glance. It also shows the relationships of the crops with other concepts like farmer, harvesting and post-harvesting, origin, pests and diseases.

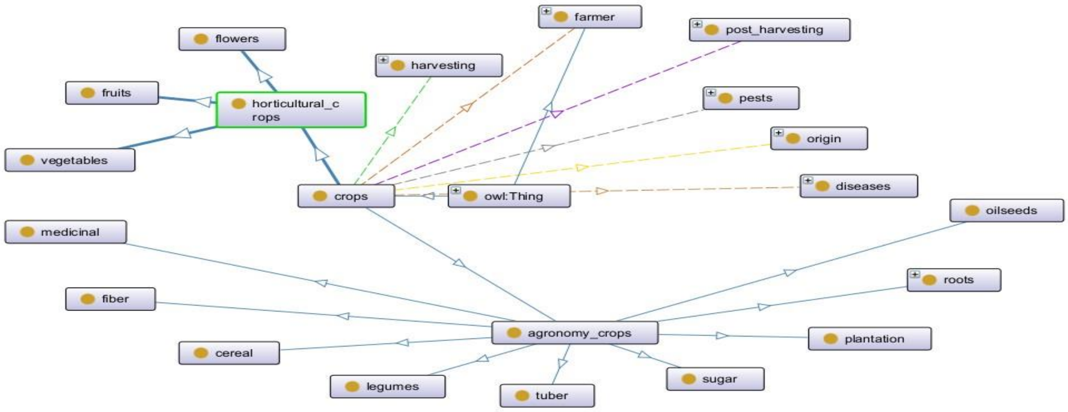

Figure 4: Ontograph of the Super Class Crops and Its Sub-Classes

Figure 5 shows the Agronomy Crops sub-classes while Figure 6 shows the ontograph of pests and diseases and their relationships with the crops.

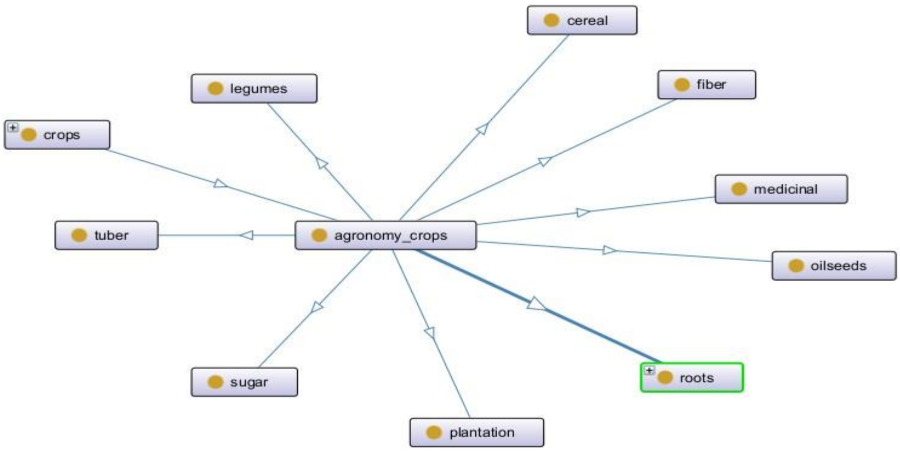

Figure 5: Ontograph of Agronomy Crops

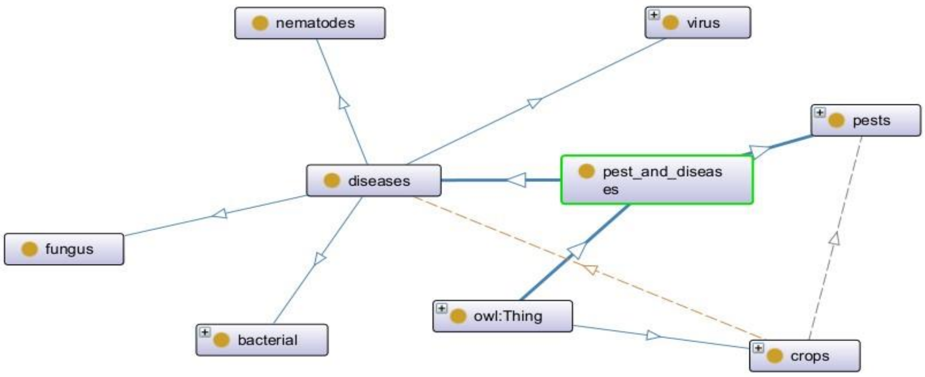

Figure 6: Ontograph of Pests and Diseases

4.2 Answer to DL Queries

The use of DL Queries is another way to test the competency of the ontology. This section shows the answers to some of the DL Queries of the crops ontology.

4.2.1 Answer to the Query: Which crops are classified under Agronomy?

Figure 7 shows the various crops that are classified as agronomy crops

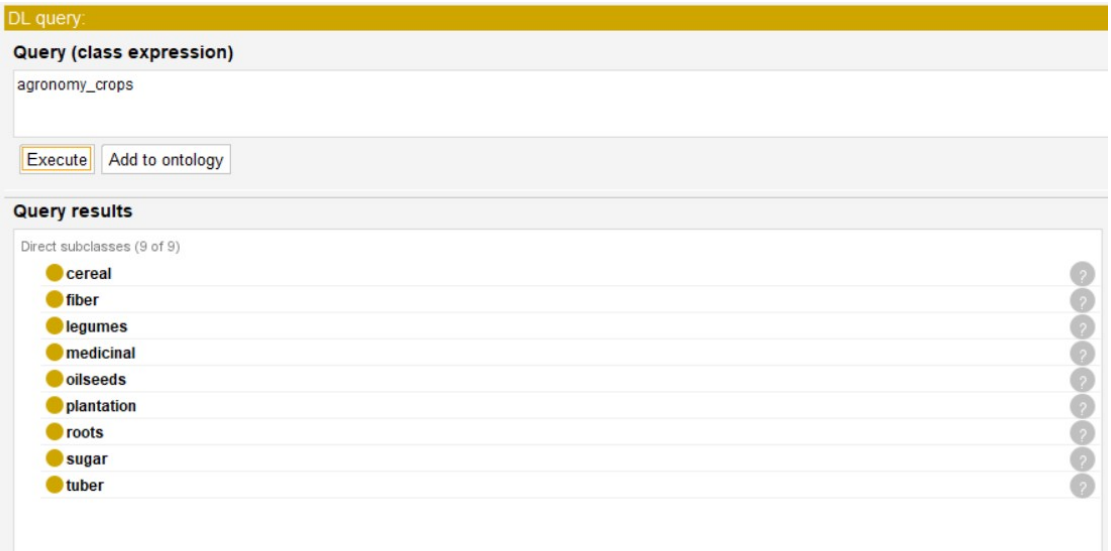

Figure 7: Agronomy Crops

4.2.2 Answer to the Query: What type of diseases affect the crops?

Figure 8 shows the categories of diseases that affect the crops. They are bacterial, fungus, nematodes and virus.

Figure 8: Classification of The Crop's Diseases

4.2.3 Answer to the Query: Give Instances of Bacterial Diseases

Figure 9 gives the instances of the various diseases that fall under bacterial diseases which affects the crops.

Figure 9: Instances of Bacterial Diseases

4.2.4 Answer to the Query: What are the activities performed during post-harvesting?

Figure 10 shows the post-harvesting activities.

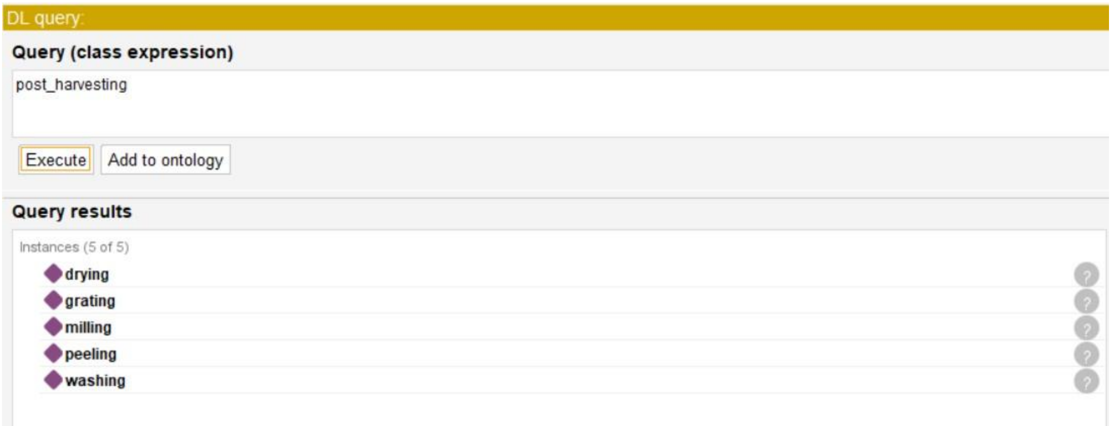

Figure 10: Post-Harvesting Activities

5. Conclusion

This study has presented a visualization technique that offers a transformative approach to represent complex data, enabling stakeholders to grasp intricate relationships, patterns, and insights within the agricultural sector. With the semantic web technologies, the ontology serves as a structured, machine-readable resource that facilitates interoperability and knowledge sharing across diverse agricultural data sources. It can be used as both information retrieval system and a brief tutorial on crops and the type of diseases that affect them.

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