Divergent Exploration of an Ontology

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ABSTRACT
This paper discusses an ontology exploration tool which allows the users to explore an ontology according to their own perspectives. It extracts concepts from an ontology and visualizes them in a user-friendly form, i.e. conceptual map, in which the user is interested. It helps users to understand the extracted knowledge from the ontology, and contribute to integrated understanding of ontologies and domain dependent knowledge.

Keywords
ontology exploration, view point, conceptual map

1. INTRODUCTION
Ontologies are designed to provide systematized knowledge and machine readable vocabulary of domains for Semantic Web applications. It is important that the ontology captures the essential conceptual structure of the target world as generally as possible. However, such ontologies are sometimes regarded as verbose and divergent descriptions by domain experts because they often want to understand the target world from the domain-specific viewpoints in which they are interested. In many cases their interests are different, even if they are experts in the same domain. Therefore, it is highly desirable to have not only knowledge structuring from the general perspective but also from the domain-specific and multi-perspective so that concepts are structured for appropriate understanding from the multiple domains. To satisfy the requirement, we developed an ontology exploration tool which allows the users to explore and understand ontology from multiple perspectives according to their interest.

2. DIVERGENT EXPLORATION OF AN ONTOLGIY
Ontology is defined as an "explicit specification of conceptualization" by Gruber [1]. In other words, a target world is captured (conceptualized) by the author of the ontology. Construction of a well-designed ontology presents an explicit understanding of the target world that can be shared among people. That is, the essential conceptual structure of the target world is understood through its ontology. Based on ontology engineering, a variety of knowledge can be organized in terms of general, highly versatile concepts and relationships. Because an ontology systematizes generalized concepts and relationships in a domain-neutral way at the primitive level, domain-specific knowledge viewed from a specific viewpoint can be represented by combining them. The viewpoint-dependent knowledge can also be generated from ontology thanks to the machine readable format of the ontology. We propose divergent exploration of an ontology to generate the viewpoint- specific knowledge from it.

The divergent exploration in "the ocean of concepts" enables researchers to search for interesting concepts/relationships that have been hidden in the conventional unstructured world guided by divergent thinking across domains. The divergent exploration of an ontology can be performed by choosing arbitrary concepts according to the explorer's intention to obtain what we call "multi-perspective conceptual chains." There should be many ways of tracing the conceptual chains geared for various aspects of the ontology. The multi-perspective conceptual chains represent the explorer's understanding of ontology from the specific viewpoint. The visualization of them in a user-friendly form, i.e., a conceptual map, contributes to integrated understanding of the ontology and its target world from multiple perspectives across domains. It bridges the gap between ontology and domain experts (Fig.1). On the basis of this observation, we developed an ontology exploration tool which supports the divergent exploration of an ontology and the generation of a conceptual map.

3. DEVELOPMENT OF AN ONTOLOGY EXPLORATION TOOL
The ontology exploration tool have two main functions: 1) exploration of multi-perspective conceptual chains depending on viewpoints and 2) visualization of them. In this section, we summarize these functions with an example.

We define the viewpoint for exploring an ontology as the combination of a focal point and an aspect. The focal point indicates a concept to which the user pays attention as a starting point of the exploration. The aspect is the manner in which the user explores the ontology. Because an ontology consists of concepts and the relationships among them, the aspect can be represented by a set of methods for extracting concepts according to its relationships. We classify the relationships into *four types*

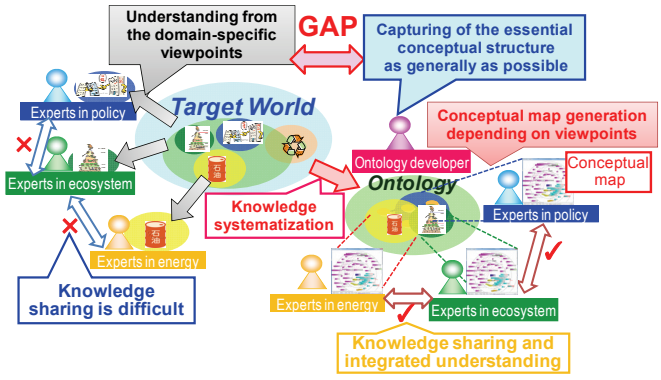

Fig.1. Understanding of an ontology and its target world systematically across domains using multiple conceptual maps.

Table.1. Aspects for exploring concepts

	Related relationships		Kinds of extraction	
	in Hozo	in OWL		
(A)	*is-a relationship*	*rdfs:subClassOf*	*(1*	*Extraction of sub concepts*
			(2	*Extraction of super concepts*
(B)	*part-of/attribute-of relationship*	*properties which are referred in*	*(3*	*Extraction of concepts referring*
			(4	*Extraction of concepts referred to*
(C)	*Depending on relationship*		*(5*	*Extraction of contexts*
			(6	*Extraction of role concepts*
(D)	*play(playing) relationship*		*(7*	*Extraction of player (class constraint)*
			(8	*Extraction of role concepts*

and define two methods in each relationship according to the direction to follow it (upward or downward) (See Table 1). While they are relationships in ontology model in Hozo [2], some of them correspond to relationships (i.e. properties) in OWL.

Here, we suppose an example of exploration of a sustainable science ontology [3] as follows. If we set *Problem* in Fig. 2 as the focal point and extract its sub concepts, then concepts such as *Destruction of regional environment*, *Global environmental problem*, and so on are extracted. Next, if we trace the concepts referred to by them while focusing on *target*, then the extracted concepts include *Water*, *Soil*, etc. Finally, if we explore all the paths to the selected concepts, (Sub concepts of) *Countermeasure* in this example, from any concept traced thus far, then concepts such as *Automobile catalyst* and *Green Chemistry* are extracted. The user can choose preferred aspects using a GUI.

As a result of the concept extraction based on the viewpoint, the system obtains conceptual chains that fit in with the user's interest. The conceptual chains are visualized as a conceptual map. In the conceptual map, the focal point is located in its center and the conceptual chains are represented as a divergent network (Fig. 3). It expresses the result of the exploration from the viewpoint of "What kinds of problems are defined in the SS ontology? What are their targets? And, what countermeasures are considered? In such a way, the system can explore the ontology divergently and generate conceptual maps based on any viewpoint and helps users understand the extracted knowledge embedded in the ontology.

Our tool has the following supplementary functions for supporting users when exploring an ontology:

-A highlighting of the focused conceptual chain.

-Control of the range of exploration.

-Linking conceptual map with other ontology-based systems.

Through these functions, multiple conceptual maps generated

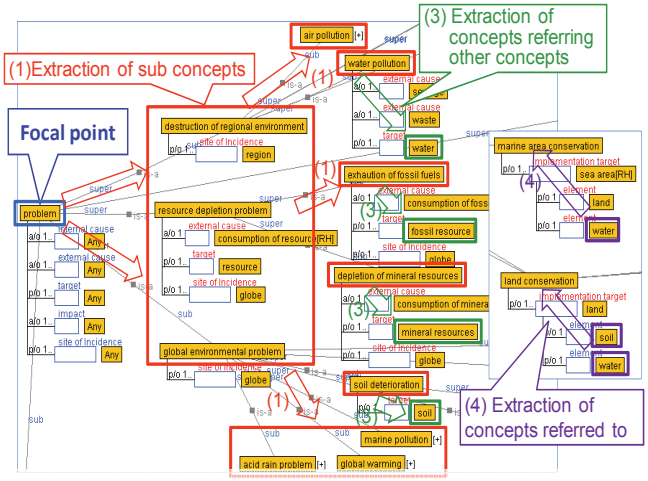

Fig.2. An example of exploration of a Sustainability Science Ontology (partly.).

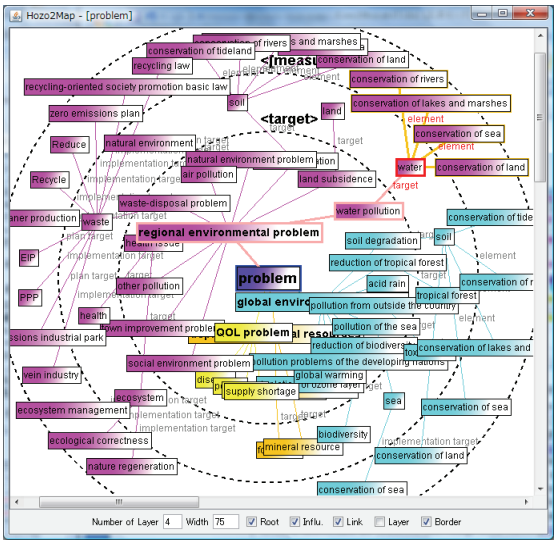

Fig.3. An Example of Conceptual Map.

from an ontology based on various viewpoints support users' understanding of the knowledge systematically across domains. Because these maps are generated exhaustively by the computer, it is supposed that they would contribute to a discovery of unexpected causal chains that are not noticed by the explorers.

4. Conclusion and Future Work

The conceptual map generation tool has been used by domain experts of sustainability science for structuring knowledge. Because sustainability science consists of various domains, it is important for experts in each domain to understand it comprehensively. Our tool contributes to help them explorer the sustainability ontology from several focal points to eventually obtain integrated understanding of ontologies and it is being well received by them.

Future work includes evaluating and improving the system through feedback from the experts. One of the important topics is a function for convergent thinking after collecting collecting multi-perspective such conceptual chains divergently, the explorer would move on to a convergent thinking stage, which we consider as Layer 3. In the task, the task of this layer is named "context-based convergent thinking." It is at this layer that the explorer can set a specific context of a problem that he or she actually treats and obtains "multiple convergent conceptual chains" which represents important concepts/relations in the context." For example, it is needed to discover a trade-off between the focal concept and others in conceptual chains.

The ontology exploration tool is developed as an extended function of Hozo and available at http://www.hozo.jp/. We are developing new version which support OWL.

5. REFERENCES

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