An Ontology Explorer for Biomimetics Database

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Abstract. Biomimetics contributes to innovative engineering by imitating the models, systems, and elements of nature. For biomimetics research, it is important to develop biomimetics database including widely varied knowledge across different domains such as biology and engineering. Interoperability of knowledge among those domains is necessary to create such a database. For this purpose, the authors are developing a biomimetics ontology which bridge gaps between biology and engineering. In this demo, the authors shows an ontology exploration tool for biomimetics database. It is based on linked data techniques and allows the users to find important keywords so that they can search meaningful knowledge from various databases.

Keywords: ontology, linked data, biomietics, database, semantic search

1 Introduction

Learning from nature aids development of technologies. Awareness of this fact has been increasing, and biomimetics[1] [1], innovative engineering through imitation of the models, systems, and elements of nature, has caught the attention of many people. Well-known examples of biomimetics include, paint and cleaning technologies that imitate the water repellency of the lotus, adhesive tapes that imitate the adhesiveness of gecko feet, and high-speed swimsuits that imitate the low resistance of a shark's skin. These results integrate studies on the biological mechanisms of organisms with engineering technologies to develop new materials. Facilitating such biomimetics-based innovations requires integrating knowledge, data, requirements, and viewpoints across different domains. Researchers and engineers need to develop a biomimetics database to assist them in achieving this goal.

Because ontologies clarify concepts that appear in target domains [2], we assume that it is important to develop a biomimetics ontology that contributes to improvement of knowledge interoperability between the biology and engineering domains. Furthermore, linked data technologies are very effective for integrating a database with existing biological diversity databases. On the basis of these observations, we developed a

[1] http://www.cbid.gatech.edu/

biomimetics ontology and ontology exploration system based on linked data techniques. The tool allows users to find important keywords for retrieving meaningful knowledge from viewpoints of biomimetics through various databases. This demo shows how the ontology explorer for biomimetics database works on the web.

2 A Biomimetics Ontology

Before we began developing a biomimetics ontology, we conducted interviews with engineers working with biomimetics regarding their requirements for biomimetics database search. When we asked, "What do you want to search for in a biomimetic database?" they said they wanted to search for organisms or organs that perform functions that they were trying to develop in their new products. In fact, most successful examples are imitations of capabilities that organisms possess, such as the water repellency of a lotus and the adhesiveness of a gecko's feet. Therefore, we proposed that it is important to search the biomimetic database for functions or goals that they want to achieve.

On the other hand, someone engaged in cooperative research with engineers and biologists reported that engineers do not have knowledge that is very familiar to biologists. For instance, when an engineer had a question about functions of projections shown in an electron microscopy image of an insect, a biologist (entomologist) suggested that it could have an anti-slip capability, because the insect often clings to slippery surfaces. This suggests that a biomimetic ontology must bridge knowledge gaps between engineers and biologists.

Considering the requirements discussed in the above, we set the first requirement for biomimetics ontology as to be able to search for related organisms by the function the user wants to perform. At the same time, we propose that it should support various viewpoints to bridge gaps among domains. As a result, we built a biomimetics ontology that includes 379 concepts (classes) and 314 relationships (properties), except for the *is-a (sub-class-of)* relation. For example, *Organism* may have relationships such as *Ecological environment*, *Characteristic behavior*, *Characteristic structure*, *Characteristic function*, *Region Part*, and *Goal* may have relationships such as *Structure on which to base* and *Related function*. Other top level concepts includes *Behavior*, *Act, Function*, *Process*, *Structure*, *Living environment*, and so on.

3 An Ontology Explorer for Biomimetics Database

We developed the ontology explorer for biomimetics database based on an ontology exploration techniques proposed in our previous work [3]. The framework enables users to freely explore a sea of concepts in the ontology from a variety of perspectives according to their own motives. Exploration stimulates their way of thinking and contributes to deeper understanding of the ontology and hence its target world. As a result, users can discover what interests them. This could include new findings that are new to them, because they might find unexpected conceptual chains from the ontology exploration that they would otherwise never have thought of.

Exploration of an ontology can be performed by choosing arbitrary concepts from which *multi-perspective conceptual chains* can be traced, according to the explorer's

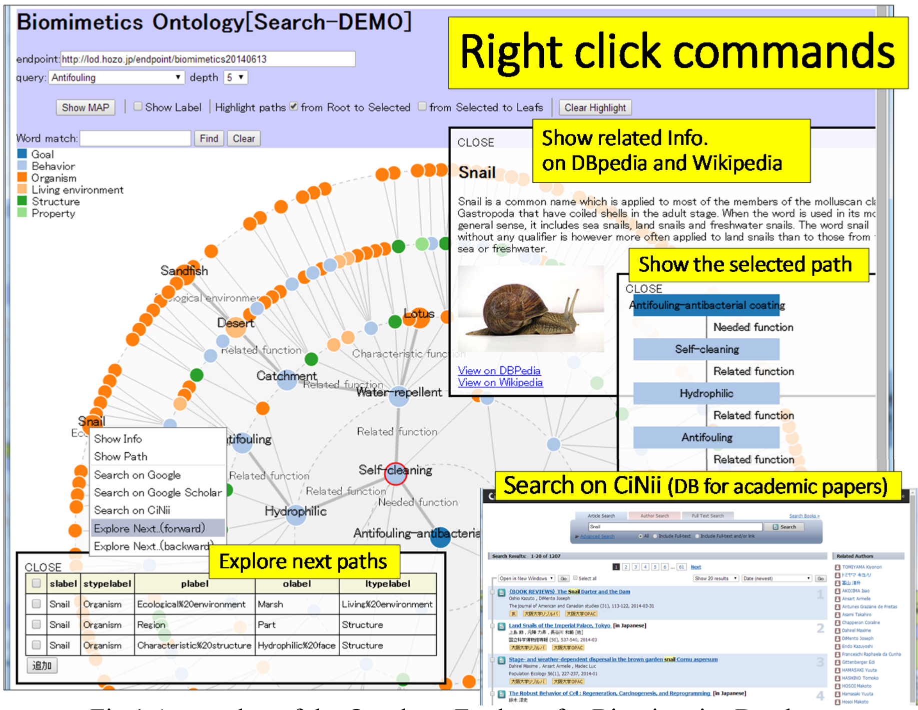

Fig.1 A snapshot of the Ontology Explorer for Biomimetics Database.

intention. We define the viewpoint for exploring an ontology and obtaining multi-perspective conceptual chains as the combination of a *focal point* and *aspects*. A 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. The multi-perspective conceptual chains are visualized in a user-friendly form, i.e., in a conceptual map. Based on these techniques, we developed the ontology explorer for retrieving information from biomimetics database as a web application to assist the user in using the results easily for searching other databases, while the previously described system was developed as a Java client application. We implemented the ontology exploration tool using HTML5 and Java Script to enable it to work on web browsers on many platforms, including not only PCs but also tablets and smartphones. We implemented the exploration methods based on Simple Protocol and RDF Query Language (SPARQL) queries.

Fig.1 shows one result of ontology exploration using the system. In this example, the user selected *Antifouling* as the focal point (starting point) and obtained conceptual chains to some *Organism* as the end point. In this case, the system searches all combination of aspects (relationships) to generate conceptual chains from a concept selected as starting point to those specified by the user. As a result, the system shows all conceptual chains between the selected concepts as a conceptual map. By clicking the nodes on the map, the user can detailed information about each paths. Furthermore, the user can use the selected information to search other Linked Data such as DBpedia and databases. Though the current version supports only a few LODs and databases, it can be easily extended to others.

4 Conclusion and Future work

This article outlined an ontology explorer for biomimetics database. Since the current version of the system is a prototype, it uses only a small ontology and has limits on the conditions of exploration. However, it was well received by researchers on biomimetics. In fact, one of them said that the resulting path from *Antifouling* to *Sandfish* shown in Fig.1 was unexpected one for him. This suggests that the proposed system could contribute innovations in biomimetics. The researchers also plan to use the biomimetics ontology and system as an interactive index for a biomimetics textbook.

Future work includes extensions of the biomimetics ontology and the exploration system. For the former, we plan to use documents on biomimetics and existing linked data related to biology and considering some methods for semi-automatic ontology building using them. For later, we are exploring potentially useful patterns through discussion with biomimetics researchers and ontology engineers.

There are many approaches to Semantic Search using SPARQL. For example, Ferré proposes QFS (Query-based Faceted Search) for support in navigating faceted search using LISQL (Logical Information System Query Language) [4] and implement it based on SPARQL endpoints to scale to large datasets [5]. Popov proposes an exploratory search called Multi-Pivot [6] which extracts concepts and relationships from ontologies according to a user's interest. These are visualized and used for semantic searches among instances (data). The authors took the same approach as Popov. Considering how to use these techniques in our system is an important future work.

The current version of the proposed system is available at the URL;
http://biomimetics.hozo.jp/ontology_db.html .

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