Universal Networking Language (UNL) is an artificial language for computers that represents human languages using graphs. The UNL system consists of UNL Ontology, which provides the semantic background for all Universal Words (UWs) or concepts. UNL Ontology includes all possible relations between UWs, definition of UWs, and the UW system. In addition, it stores such information in a lattice structure, where the UWs are interconnected through several relations including hierarchical relations such as icl (a-kind-of) and iof (an-instance-of). However, it is difficult for users to visualize UNL Ontology. Therefore, we have developed a web system that helps them with such a visualization process.

Keywords: Ontology Visualization, UNL, Data Visualization

1. Introduction

Ontology visualization is an active research area. In fact, ontologies such as WordNet and Universal Networking Language (UNL) have several visualization techniques [4][6][7]. In addition, as the structures of WordNet and UNL Ontology are different, we cannot use the same visualization technique for both of them. Moreover, it is difficult for users to visualize UNL ontology from a text such as triples described using UNL relations. Thus, it would be helpful for ontology users to have a web-based system with a graphical interface. For this purpose, to visualize UNL Ontology online, Khan et al. [3] proposed a system using circle visualization. However, this technique had a limitation: in case there were more than 100 UWs, it was not possible for the users to read all the UWs. To solve this problem, we have developed circle-step visualization and tree visualization for UNL Ontology. Thus, in this study, we have described a new and updated web-based system for visualizing UNL Ontology.

The end users of such a system are researchers and linguists who work with UNL Ontology. The system provides the end users a visual representation of UNL Ontology for a better understanding. In addition, they no longer have to go through raw data for getting information. They can access this web-based system online using any of the popular web browsers. We found that Tree visualization is better choice for UNL Ontology visualization.

2. Background

2.1. Universal Networking Language (UNL)

Universal Networking Language (UNL) is an artificial language for computers to represent human languages using graphs. UNL has all the required components to represent knowledge described in natural languages.

The UNL system consists of UNL Ontology, which provides the semantic background for all Universal Words (UWs) or concepts. UNL Ontology includes possible relations between UWs, definition of UWs, and the UW system. It stores such information in a lattice structure, where the UWs are interconnected through several relations including hierarchical relations such as icl (a-kind-of) and iof (an-instance-of).
UNL initiative was originally launched in 1996 as a project of the Institute of Advanced Studies of the United Nations University (UNU/IAS)\(^1\). UNL was first introduced in 1999 \(^2\). In 2001, the UNU set up the UNDL (Universal Networking Digital Language) Foundation\(^2\) for the development and management of the UNL project. In 2005, a new technical manual of UNL was published \(^1\), which defined UNL as an information and knowledge representation language for computers. UNL has all the components to represent knowledge described by natural languages. UWs constitute the vocabulary of UNL, and each concept described by natural languages has a unique UW. In UNL, a UW is defined in the following format: `<uw> =:: <headword>[<constraint list>]`. The UWs are interlinked with each other through the UW System in UNL Ontology. Master definitions for UWs describe all relations that a UW can hold. In `<constraint list>`, a minimum set of relations is used as constraints, in order to make a UW distinguishable from sibling UWs. For example, `dog(icl>mammal)` is a UW where the headword is “dog” and “icl>mammal” is the constraint that differentiates this concept with other dog concepts.

In the aforementioned example, the headword of a UW is an English expression, which could have been a word, compound word, phrase, or sentence. UWs are the basic elements for constructing a UNL expression for a sentence or a compound concept. Therefore, keys to information in the UNL database are UWs. Each UW is interlinked with other UWs using “relations” to form UNL expressions. These relations specify the role of each word in a sentence. Using “attributes,” the UW can express the subjectivity of an author. Currently, UWs are available for many languages such as Arabic, Bengali, Chinese, English, French, Indonesian, Italian, Japanese, Mongolian, Russian, and Spanish.

### 2.2. UNL Ontology

UNL Ontology is a lattice structure where UWs are interconnected through several relations including hierarchical relations such as icl (a-kind-of) and iof (an-instance-of). UNL Ontology includes all possible relations between UWs, definitions of UWs, and the UW system. In UNL Ontology, all possible semantic co-occurrence relations, such as “agt” and “obj,” between the UWs are defined based on the UW System. Using the property inheritance characteristic of the UW System, possible relations between lower UWs are deductively inferred from upper UWs, and this inference mechanism reduces the number of binary relation descriptions of the UNL Ontology. In the topmost level, UWs are divided into four categories: adverbial concept, attributive concept, nominal concept, and predicative concept.

Figure 1 shows the topmost level of partial UNL Ontology, where the black directed lines represent the “icl” relations, and dotted directed lines represent the “agt” relations. In Figure 1, we only expanded the partial “nominal concept” until “dog(icl>mammal)” to give a brief overview of the UNL Ontology. In UNL Ontology, each UW can have incoming and outgoing relations. For example, in Figure 1, “animal(icl>living thing)” has two incoming relations: “agt” from “eat(agt>animal,obj>food)” and “icl” from “volitional thing,” “animal(icl>living thing)” has only one outgoing relation: “icl” to “mammal(icl>animal).” As possible relations between lower UWs are deductively inferred from upper UWs, we can infer that “mammal(icl>animal),” “canine(icl>mammal),” and “dog (icl>mammal)” have an incoming relation: “agt” from “eat(agt>animal,obj>food).”

\(^1\)http://www.ias.unu.edu/
\(^2\)http://www.undl.org/
2.3. UNL Explorer

UNL Explorer\(^3\) is a web-based application, which allows all the components of the UNL system to be accessible online. UNL Explorer can translate documents into various languages such as UNL, English, Japanese, and Arabic. UNL Society members and dictionary editors can add or edit information using the UNL Explorer.

3. Editing Process for UNL Ontology

Previously users cannot update the UNL Ontology online. Our developed visualization tools allow users to update the UWs in UNL Ontology online. Figure 2 shows the new workflow that the dictionary editors follow to update the definitions of the UWs. For this purpose, an editor first chooses a UW, which already exist in UNL Ontology by the basic editing process. Second, the editor uses this visualization system to evaluate the quality of the UW and its relations with other UWs. Based on the editor’s understanding and requirement, he or she can add the required relations to the UW’s master definition. Finally, the editor edits the updated UW’s definition in UNL Ontology. In this way, editors can easily update the UWs using a new system with a graphical interface.

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\(^3\)http://www.undl.org/unlexp/
4. UNL Ontology Visualization

UNL Ontology contains millions of UWs and the various relations between them. Therefore, it is almost impossible to display the complete UNL Ontology using one single map. To retrieve semantic background information, a system needs to navigate the various UW relations. It is often difficult for the users to browse UNL Ontology, rendering it possible to lose track of UW relations in the raw data format. To address such problems, we have designed an interactive web-based system for UNL Ontology visualization. Instead of leaving the users to manually browse UNL Ontology, our updated system allows users to visualize the information they require. The interactive ontology visualization encodes a number of properties that help users to see the UWs relations they require, and get the semantic background. Moreover, users can easily orient themselves while navigating through the whole range of ontology visualizations. The system can be accessed online via any popular web browser such as Internet Explorer and Mozilla Firefox. The system also requires the browser to support JavaScript.

Let us now consider an example. Suppose a user wants to know about the semantic relations for the UW: “dog(icl>mammal).” In this case, the user only needs to know the semantic relations, which include the relations related to the given UW “dog(icl>mammal),” as shown in Figure 1. For this purpose, this new, updated system retrieves all the deductively inferred relations for the UW “dog(icl>mammal),” and visualizes using a graph.

For such a visualization, the system first discovers a concept map for a given UW. (A concept map contains all direct and deductively inferred relations for every specific UW from UNL Ontology.) The arcs of this graph are the relations of UNL Ontology. In UNL Ontology, each relation is connected from “fromUW” to “toUW.” Starting from a given UW, the system discovers the concept map graph, which includes deductively inferred relationships. A maximum search depth is established to limit the size of the graph on the screen.

To discover the concept map graph from UNL Ontology, the user provides a particular UW. First the algorithm adds that particular UW to the concept map graph. For each outgoing relation from that UW, it adds “toUW” to the concept map, and then recursively the concept map (toUW) discovers the relations from “toUW.” Second, for each incoming relationship, it adds “fromUW” with the relation to the concept map graph. The algorithm keeps discovering the graph until it reaches maximum search depth, which has already been defined in the system settings, or if it reaches the topmost UW. Finally, it returns the concept map graph, which contains the required relations for the given UW. Moreover, users can customize the limits to redraw the graph according to their own requirements.

4.1. Circle Visualization
Circle visualization [3] shows the input UW in the center of a circle, and the related UWs around circle. Figure 4 shows a sample screenshot of the Circle visualization for UNL Ontology, illustrating the partial relations for the UW: “dog(icl>mammal).” Each red node denotes a UW, and each arc denotes a relation between the UWs.

![Figure 4. Screenshot of the Web-based UNL Ontology Viewer](image)

Figure 5 shows the limitation of this approach: it displays a large number of UWs, thus making it difficult for users to read the partial UWs in this visualization technique.

![Figure 5. Screenshot of the Web-based UNL Ontology Viewer](image)

4.2. Tree Visualization

Figure 6 shows a sample screenshot of the Tree visualization of UNL Ontology, illustrating the partial relations for the UW: “dog(icl>mammal).” Each box denotes a UW, and each arc denotes a relation between the UWs. This visualization technique only expands the selected UWs, and hides the remaining UWs, which makes the visualization much simpler and easily accessible than Circle visualization.

![Figure 6. Screenshot of the Tree Visualization for UNL Ontology](image)
4.3. Circle-Step Visualization

Figure 7 shows a sample screenshot of the Circle-Step visualization, illustrating the partial relations for the UW: “dog(icl>mammal).” Each node denotes a UW, and each arc denotes a relation between the UWs. As shown in Figure 7, the UWs are in level stepwise; therefore, it is easier for users to quickly understand the relations between the UWs.

![Circle-Step Visualization](image_url)

Figure 7. Screenshot of the Circle-Step Visualization for UNL Ontology

4.4. Discussion

In Figure 8 we compared all these three visualization techniques. From our comparison we found that each of them has advantages and disadvantages, as described earlier. Nevertheless, we argue that Tree visualization is the only visualization technique that allows the users to navigate through UWs in an interactive mode; thus, making it the most effective for displaying a large number of UWs.

<table>
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<tr>
<th>Visualization</th>
<th>Easily accessible</th>
<th>Handle many UWs</th>
<th>Easily understandable</th>
<th>Easily Interactive Operations</th>
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</tr>
<tr>
<td>Tree</td>
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<td>Circle-Step</td>
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</tbody>
</table>

Figure 8. Comparison of Visualization for UNL Ontology

5. Conclusion

It is difficult for humans to visualize the UNL ontology from a text, such as triples, described using UNL relations. Thus, it would be helpful for ontology users to have a web-based system with a graphical interface. This study described such a web system to visualize UNL Ontology. It aims to help the users of UNL ontology by providing an interactive web interface so as to easily understand the various relations between UWs. We have developed the Tree visualization and Circle-Step visualization techniques for UNL ontology. In future, we would like to experiment with newer interactive visualization techniques for editing UNL Ontology.

6. References


