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Building/Visualizing an Individualized English Vocabulary Ontology

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Abstract: This paper proposes a way to bring a synergy in education through an analysis of co-relationships and each advantage between ontology and concept map. Specifically this paper shows on how a concept map agent translates an individualized English vocabulary ontology into a customized concept map effectively. In the proposed system, the translation is processed by the concept map agent, which uses an ontology to reconstruct English vocabulary properties, extracts the learning contents from the ontology, and then displays the analyzed results directly through the user interface in a graphical form of concept map. In addition, the agent automatically links previously learned English vocabularies systematically and helps learners learn English vocabularies by making relations among them based on constructivism so that learners escape from memorizing each word separately without knowing relations among words.

Key-Words: - e-Learning, ontology, concept map, visualization, English vocabulary

1 Introduction

Presently, prefix 'e-' is being so popular in society. One of areas which has the prefix is e-learning, which typically means learning based on the web. e-Learning, started from the emergence of the Internet, is based on the concept of hypertext that combines multimedia with varieties of new technologies that can overcome time and space restriction of existing classroom lectures. However, there still have a few problems in education based on e-learning. First, the current e-learning system's reusability and interoperability are not high because implementing them requires not only a research on improving learning effectiveness, but also acquisition and production of learning contents. Second, existing searching mechanisms without consideration of semantics make learners to re-filter learning contents. Third, it's not easy to provide the contents to be studied through searching that are commensurate with learners' learning levels. To overcome such problems, this paper suggests an e-learning system based on semantic description tools such as the ontology and the concept map. The ontology raises content's reusability and interoperability. As well, it supports a semantic search for constructed learning contents. The concept map promotes effective learning by visualizing the relationships between concepts to be learnt in the form of graph. It is notable that in case there could be developed an e-learning system that links a concept map with an ontology, the system would be much more effective than the conventional web-based e-learning system. The primary reason is based on the fact that learners can use effectively the outstanding features of the two during learning. In other words, the main role of a transformation agent is to map between both of them effectively and then enables learners to take advantages of both in the new e-learning system.

In the constructivism, the emphasis is made on learners rather than instructors. Learners interact with objects and events, and thus get the understandings of the features of such objects or events. Learners, therefore, perform their own conceptualizations and construct solutions to the problems. When using the concept map in e-learning, learners are encouraged to invent their own solutions and to try out ideas and hypotheses. They are given an opportunity to build on prior knowledge. Thus, the use of a concept map in e-learning fits well with the constructivism approach where learners construct their own typical understanding of knowledge [1]. In addition, while adding, deleting, and modifying the relationships between concepts and labeled links which connect concepts, learners can develop their own knowledge systematically.

The rest of the paper is organized as follows. Section 2 briefly summarizes the theoretical background of the ontology and the concept map, and makes the comparison between them. Section 3 details the structure of the overall system. Section 4 describes the user interface. Section 5 makes conclusion of the paper.

2 Theoretical Background

2.1 Ontology

The Tom Gruber defines an ontology as “a shared conceptualization of formal and explicit specification” [2]. This means that reusability and interoperability between heterogeneous systems through networks are available using ontology engineering. An ontology in computer science evolved from semantic networks and was proven to be quite useful in representing and facilitating the sharing of the knowledge about a domain by human and automatic agents [5]. An ontology has definitions of taxonomy and inference rules. The former defines relations between super-classes and sub-classes, and the latter shows and extends domain-related terms in taxonomical hierarchy. Also, an ontology shares a common set of characteristics to make knowledge representation and inference task possible.

- Classes: Classes are the description of the common features that a set of individuals has. A class can represent whatever it can be stated. It can be physical or digital objects.

-Properties: Properties contribute to identify concepts by characterizing them. They can be used in intentional definitions of concepts, to relate individuals or to give attribute values. Properties are the way to represent the existent relations among concepts into a domain.

-Axioms: Axioms contribute to specify the definition of the ontology elements constraining their interpretation. Structural axioms constrain the structure of the ontology. Non-structural axioms are local to a concept and constrain its interpretation stating conditions about its attributes.

-Instances: Instances are individuals holding definitions and facts representing relations between individuals.

2.2 Concept Map

Concept mapping is a technique for representing knowledge in graphs. The technique was developed by Prof. Joseph D. Novak at Cornell University in the 1960s. Concept mapping – the process of organizing concepts in a hierarchical manner and forming meaningful relationships between the concepts – has grown out of Ausubel’s theory of meaningful verse rote learning. The theoretical framework that supports the use of concept mapping is consistent with constructivism epistemology and cognitive psychology [7]. Also, concept map’s graphical representations of learning contents and relationships among concepts are used to help with learner’s text comprehension and reflection [6]. Therefore, by applying concept mapping technique to e-learning, learners will finally break from the rote learning and result in a meaningful learning. When e-learning system takes both merits of the concept map and the ontology, learners are able to elicit necessary learning contents displayed by a concept map from huge amount of the constructed ontologies and study what they want to, while constructing a concept map.

Gouli, Gogoulou, and Grgoriadou announced their experimental results of their research on applying concept mapping technique to an educational assessment activity [7]. They found the context of the assessment activity and the use of the concept map enabled the draw of inferences about the students’ understanding, the identification of differences in the students’ abilities and the determination of key-points that may be used in order to differentiate the students’ knowledge level concerning the subject matter. Through the concept mapping task, they were able to easily and precisely detect changes in the students’ conceptual understanding in comparison to their initial and intermediate conceptions.

Chen and Ine-Dai tested the learning effects of a concept-mapping strategy [4]. They designed three concept mapping approaches-map correction, scaffold fading, and map generation to determine their effects on students’ text comprehension and summarization ability. The experimental results from 126 fifth graders showed that the map-correction method enhanced text comprehension and summarization ability and that the scaffold-fading method facilitated summarization ability. In addition to these, there are many other researches which indicate that the concept map is an effective tool for e-learning.

2.3 Ontology vs. Concept Map

From the viewpoint of e-learning, we can see that there are pros of an ontology and a concept map respectively. The key advantage of an ontology is that learners are able to get the exact knowledge that they

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want to study by using the function of the semantic-based searching. The key advantage of a concept map is that learners can naturally escape from rote learning. Therefore, it would be desirable to develop an e-learning system to take advantage of them, respectively. For the reason, we compared the two in order to apply both advantages to our e-learning system.

Table. 1. Comparison between Ontology and Concept Map

	Ontology	**Concept Map**
Main purpose	-Machine processing	-Human understanding
Components	-Super-class -Sub-class -Property	-General concept -Specific concept -Labeled link
Language	-RDF/S, DAML-OIL, OWL, etc.	-None
Search	-Possible	-Impossible
Inference	-Possible	-Impossible
Hierarchy	-Possible	-Possible
Domain	-Large-scaled knowledge construction	-Small-scaled knowledge representation
Practical use	-Intellectual searching, sharing -Semantic-based search	-Learning tool -Knowledge representation tool

Above Table 1 shows some differences and similarities between the ontology and the concept map. The main differences between them are that an ontology is proper for search and inference that can be processed by a machine agent and can be described by languages such as RDFS, DAML-OIL, OWL, etc. Also, it often uses for semantic-based search or resource sharing from the large-scaled ontology. On the other hand, a concept map is mainly for human understanding of knowledge expression used mostly for a learning tool at school or a knowledge representation tool in business world. Also, its construction size is relatively small. However, both have some similarities, one of which is to be presented in a hierarchical view. Additionally, both components can be roughly equivalent to each other as super-class to general concept, subclass to specific concept and property to labeled link respectively, as shown in Table 1.

3 The Overall System Architecture

Below figure 1 shows the whole structure of our English vocabulary learning System. A typical scenario of the system will be demonstrated by a learner's point of view. When a learner types and requests an English word that wants to learn, the concept map agent looks up learner's own OWL ontology to see if the matching word exists in it. If the word is found in the OWL ontology as an instance of class, the concept map agent converts both instances of word class and properties according to the learner's interests into a graphical form of concept map to help learners study English vocabulary visually. If the word searched by a learner cannot be found in the OWL ontology, the concept map agent searches the word in an English dictionary database, which had been already built and maintained. Then, the concept map agent finds the word from the English dictionary; it gathers the necessary information to write it into the OWL ontology as instances of the word class and properties. The classified information is saved as instances in the OWL ontology; the concept map agent translates the information such as sentence, idiom, meaning, synonym, antonym, etc. chosen by a learner into the graphical form of concept map to visualize and utilize them for learners to study effectively. Furthermore, ontology built like this can be useful learning contents in educational games. For instance, we can develop associated quiz games using several words extracted from the OWL ontology, which ask learners to infer a correct word. Therefore, when a learner learns English vocabularies using our system, they can study English vocabularies visually. In addition, they can play a game which eventually helps them memorize words in more interesting way. By doing this, finding the matching word from the English dictionary will be decreased little by little and searching will be faster because the concept map agent doesn't need to look up the English dictionary. Also, the ontology raises content's reusability and interoperability so that our individualized building ontology can solve one of main problems of the existing database.

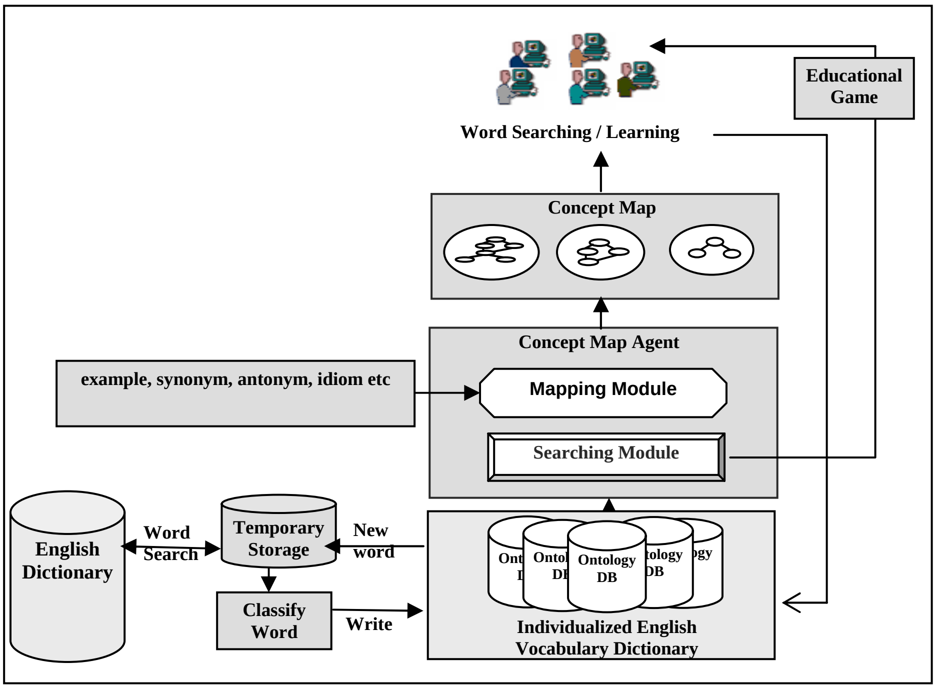

Fig. 1. The Structure of the English Vocabulary Learning System

3.1 System Developing Environment

Our system-developing environment is given in Table 2. In our system, OWL has been used to develop as an ontology building language. Edit Plus programming edit tool is used to develop both ontology and java programming such as Servlet, JSP, Swing, and so on.

Table. 2. System Construction Environment

Ontology Language	OWL (Web Ontology Language)	
Programming Edit Tool	Edit Plus	
Programming Tool Kit	J2SDK (Java 2 Software Developer's Kit)	
System Components	Web Server	Apache
	JSP Container	Jakarta-Tomcat
	Hardware	Pentium®4CPU 3.00 GHz
Programming Language	Searching Module	Jena 2 API, Servlet, JSP
	Mapping Module	Java Graphic API, Servlet, JSP

We chose Jakarta-Tomcat as a JSP container, which it is free, very power, and stable. Also to speed up the requested results in the Web environment, we connected Jakarta-Tomcat with Apache, which is also free, very powerful and commonly used.

3.2 Creating an Ontology

Before building our ontology, we designed it according to "Ontology Development 101: A Guide to Creating Your First Ontology" written by Noy and McGuineness [11] We chose OWL as ontology building language since it has been recently standardized by W3C and has powerful expression. Specific building techniques and methods were referenced by W3C OWL Guide [12]. In this subsection, we also illustrate how ontology is translated into a concept map as shown in Table 2. Class that is one of ontology main elements is translated into a circle and a label of property is changed into a lozenge. We divided property value into three categories: object type property, data type property and functional type property. The object type properties are translated into circles like a class instance. The data type properties are translated into squares. The functional type properties are translated into lozenges. The object type property value is like a instance of class so it will be translated into a circle like a instance of class. When we design and build our ontology, we mainly target to extract word instances such as love, people, father, etc. and word properties such as 'hasSynonym', 'hasAntonym', etc. but not class 'word' itself. So we don't try to convert or map a class into a graphical form of a concept map. For the reason we only map ontology instances and properties to concept map like Table 3.

Table. 3. Mapping between Ontology Elements and Concept Map Elements

Ontology Elements		Concept Map Elements
Instance of class		○
Property	Label of Property	◇
	Object Type Property Value	○
	Data Type Property Value	□
	Functional Type Property Value	⬡
Relation		—

3.3 Concept Map Agent

The main purpose of concept map agent is searching and mapping between ontology and concept map. In the searching module, we used query facilities in extracting certain relevant parts of our ontology. There are several ways of storing an ontology in the repository that also supports query facilities such as Sesame RDF storage and query facility [12], KAON server [9], or Jena API [8], etc. In our paper, we use Jena API to develop the searching module because Jena is an open source and written in Java. We not only search word instances but also word properties.

The mapping module links between an ontology and a concept map and then generates the various kinds of concept map-based learning according to sentence, idiom, synonym, antonym, and meaning as illustrated in Table 3. Figure 2 visualizes the domain and the range of object type property 'hasSynonym'. The domain of 'hasSynonym' property is 'word' class; the range of its property limits to 'synonym' class.

```
<owl:ObjectPropertyrdf:ID="hasSynonym">
<rdfs:domain rdf:resource="#Word"/>
<rdfs:range rdf:resource="#Synonym"/>
</owl:ObjectProperty>
```

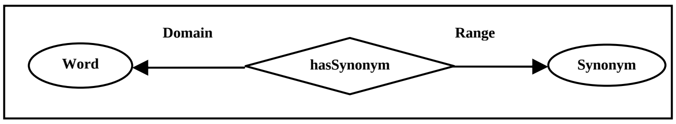

Fig. 2. The Domain and the Range of Object Type Property 'hasSynonym'

4 System User Interface

4.1 Searching by Word Relations

'Word Relation Menu' will display certain word relations with other words such as synonym, antonym, etc. as a graphical form of a concept map like Figure 5. When a learner wants to know word relations in their ontology dictionary, they just need to type in the text box and then press a search button. Then the concept map agent will generate the result like Figure 4.

It shows the relations of 'love' with other words like 'hate', 'adore', 'dislike', etc. When a learner keys in 'love' word in the system, the agent will display all object type property values: 'hasSynonym', 'hasAntonym' related to 'love' but some data type property values like 'hasMeaning' and 'hasPartOfSpeech' will be displayed because this search is mainly focused on the word relations. The advantage of this search is that a learner can see the relation among words, which he/she has searched.

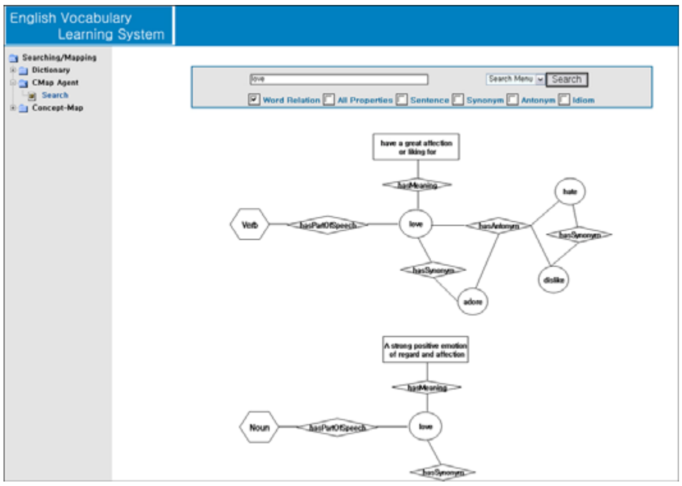

Fig. 3. The result of the 'love' Word by Relation Search

4.2 Searching by All Property Values

'All properties Menu' displays all property values of a word such as 'hasSentence', 'hasIdiom', 'hasAntonym', 'hasSynonym', 'hasMeaning', 'hasPartOfSpeech', etc., as shown in Figure 3. As we mentioned earlier, each individual belongs to a part of speech. So each individual will have the same number of concept maps as the number of parts of speech. Figure 5 shows all property values of word 'love'.

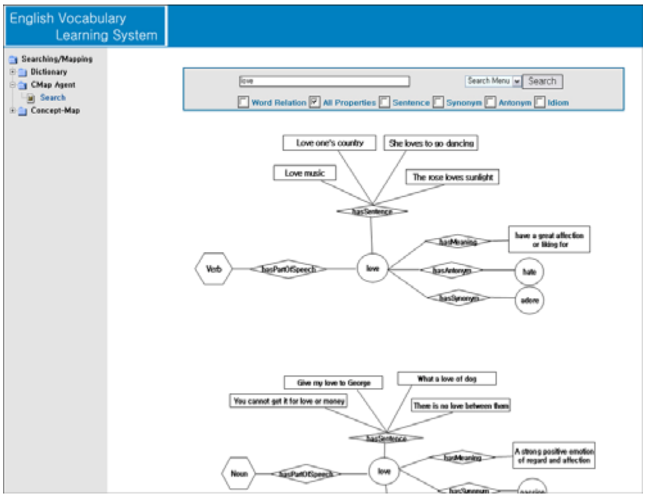

Fig. 4 The result of the 'love' Word by All Property Values Search

Also, in additional menus of Figure 4, 'Sentence Menu' will display only word's example sentences. 'Synonym menu' will display only word synonyms. 'Antonym Menu' will display only word antonyms. 'Idiom Menu' will display only word idioms. 'Multi-property Menu' means that the choice of properties is set by a learner so that learners can select as many properties as they want.

5 Conclusion

Our paper shows a way to build an individualized English vocabulary ontology and to visualize it using concept map. Our system has several merits. First, our proposed system will help learners break from the convention of the rote learning and engage in a meaningful learning. Especially, learners are able to take advantages of both ontology and concept map through agent as mapping, eliciting and displaying tool. Second, learners are able to study what they want at the level of their conceptual understanding of the certain knowledge. Third, while learners search and study words, their own individualized English vocabulary ontology will grow bigger by making inter-relationships. It raises content's reusability and interoperability. In such case, we don't need to rebuild the ontology from the scratch.

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