Supporting Cooperative Consensus Formation via Ontologies

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Abstract. In this paper, we propose the Discussion Board system to support the nebulous communication between the users who do not clearly express the concepts intended. The method proposed in this paper aims to enable the user to understand each other and/or reach a mutual consent and create new ideas. This is achieved by indicating the conceptual differences between the users through the users' direct creation of the concepts as ontologies and by showing other concepts obtained from World Wide Web.

1 Introduction

When people communicate with each other, reaching a mutual understanding is often difficult. This can be caused by the misunderstanding of words, lack of knowledge, difference of viewpoints, and so on. For the participants, however, the cause of the misunderstanding is not clear. Even worse, people do not always have an explicit conceptualization of the world which might contribute to a resolution of a such misunderstanding. Under such circumstances, rather than resolving the problem, continuing the communication can cause more confusion. In such a blurred situation, people need help. We believe a conceptual representation of the participants' topic of interest can help, since such information can provide an understanding of the conceptual structure of the topic and the cause of the misunderstanding.

An ontology, which is "an explicit specification of conceptualization" [1], is the backbone of the knowledge structure of a target world. One of the problems of ontology research is the difficulty of its development. How to design an ontology has been a key issue of ontological engineering [1]. One of the promising approaches to this problem is the use of Human-Computer Interaction (HCI) technology, which makes the interaction between the system and the developer, and the interaction between developers in collaborative development cases, more efficient.

In ontology research, a unification between ontology and HCI is anticipated hopefully expected because of the limited ability of users to describe conceptual

[1] A Step Towards Ontological Engineering (Translation of the paper presented at the 12th National Conference on AI of JSAI, pp.24-31, June, 1998) http://www.ei.sanken.osaka-u.ac.jp/english/step-onteng.html

structure [2] [3]. Ogino et al. reported on the activities of sharing ontologies, aiming at controlling the multilingual information between EDR dictionary and WordNet [4]. Aligning the ontologies without tools can be an extremely tedious and time-consuming process. Noy and Musen proposed a semi-automatic approach to ontology merging and alignment[2]. These efforts used already-made ontologies. Our aim is articulation of the tacit knowledge in the nebulous mental world. When a person creates something new, his or her mental world has many components of new ideas that are not yet articulated, especially in the early stages of creation. This is the nebulous world [5].

Many creativity support systems have been researched and it has been reported that visual computer displays of concepts enhances human creativity. However, what process of discussion changes the condition of conceptual difference to the condition of understanding or mutual consent, and how to support that has not been established.

Building a very good ontology is not an easy task, but we exploited an excellent ontology characteristic for our problem. That is that building an ontology makes the developer aware of the conceptual structure of the target world. This is a very interesting phenomena which can be used for resolving misunderstanding through a better and deeper understanding of the world of interest. When people find difficulty in mutual understanding, the system will ask each of them to build an ontology of the common target world, with some help functions, and then compares the ontologies built, and facilitating the discussion on the similarity and/or differences between them. This in turn should lead to a consensus or, at least, to a better understanding of why they cannot come to an agreement.

A beneficial aspect of our endeavor is that the use of an ontology does not require very rigorous definitions of concepts. What is mainly needed is a hierarchical structure of the key concepts and viewpoints associated with it. Using ontologies as a mediation tool has an implicit side effect, that is, we can expect a rough ontology on which the participants can agree when they happily come to a consensus.

We have researched the personalization of information using the model of conceptual structure according to each user's viewpoint by observing the user's behavior [6]. Information personalization by this method deepens the user's understanding of the domain. We also have developed the system which can compare the conceptual difference between a user and an expert [7].

The proposed method described in this paper is support for users to consent or understand each other, and to create new ideas by indicating conceptual differences between the users through the users' direct creation of the concepts, displaying the another concepts obtained from the Web.

Our long-term goal includes building a support environment for the resolution of misunderstanding, for facilitating creative thinking and for building an agreeable ontology using an ontology as a mediation tool.

2 Cooperative consensus formation system via ontologies

With the proposed system, the Discussion Board, the scenario of the users' discussion will proceed as follows: proposed system,

1. Having difficulty understanding each other.
2. Discussing the conceptual differences using the Discussion Board.
3. Discovering the conceptual differences.
4. Understanding each other and/or having mutual consent.
5. (Creating a new idea.)

We propose that the cause of conceptual differences encountered when people communicate are as follows:

1. Misunderstanding of same objects.
2. Viewpoint-differences of same objects.
3. Similar concepts of different objects.
4. Same term for different objects.

The Discussion Board displays an explanation of the conceptual differences between the users and visualizes the difference independently and relatively, allowing the users to discover the differences and understand each other and/or achieve mutual consent in the "Discovering the conceptual difference" step and the "Understanding each other and/or having mutual consent" step.

By showing the concepts of the others from the World Wide Web (WWW) in the "Creating new idea" step, users can be expected to obtain new knowledge and create a new idea. The others' conceptual structures are represented by the Document Object Model (DOM) tree structure of eXtensible Markup Language (XML) on WWW.

Figure 1 shows the relation between ontologies and the viewpoints that are examined. An object has some common concepts, but, at the same time, there are different concepts according to individual viewpoints, thus some conceptual differences present. This is the individual concept. Individual concepts have different elements, or structures, and weights. We treated the individual concept as an ontology, just as the common concept was treated as an ontology, because it is common within a field or generation. The Discussion Board supports blurred conditions caused by the difference between individual concepts.

Figure 2 is the framework of the Discussion Board. The users enter into a discussion by editing their own individual concept using the Discussion Board. The Discussion Board shows the individual viewpoint by explaining each viewpoint and visualizing the difference. The system uses the ontology editor system (OE) [8], an ontology editing tool, to store common concepts and individual concepts. The Discussion Board shows the individual concepts of others by searching for the similar or dissimilar concepts on the WWW according to similarity, and visualizing the differences of the concepts for comparison. The function of the Discussion Board system is as follows:

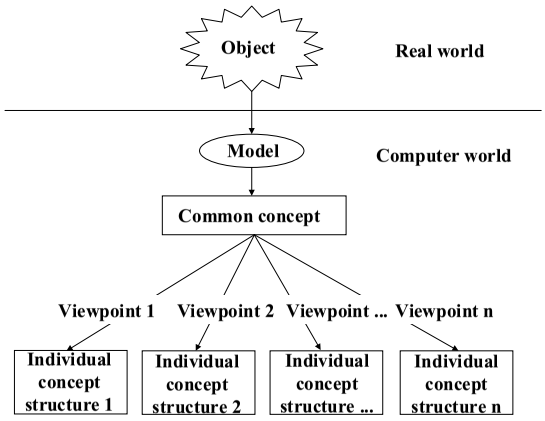

Fig. 1. Ontologies and viewpoints

1. Storing common and individual concepts.
   This function can be used for searching the WWW and for operation histories.
2. Searching similar or dissimilar concepts according to similarity.
   This function illustrates whether the individual concept held by a majority or minority in the world, stimulate interest or knowledge [6] and prompt the user to create a new idea.
3. Explanation and visualization of the concept differences relatively or independently.
   For system explanation and independent visualization using each concept of the users, can be understood, at first site, the helping increase domain understanding. For relative visualization using WWW data, the difference of several others' concepts can be understood, at first site, the helping increase domain understanding.

2.1 Comparing users' concepts

The concepts are expressed as a tree structure with nodes and links, and can be compared in terms of concepts and structures. The system has a thesaurus so that all synonyms have the same node. For comparing concepts, the system defines a similarity. The similarity considers conceptual differences located at a higher level in the hierarchy to be greater than those found at a lower level.

When we compare concept tree α rooted by concept α to another concept tree, the system proceeds according to the following steps:

1. Finding the same concept as α in another concept tree. If concept tree β is found, the levels lower than β are counted as the similarity.

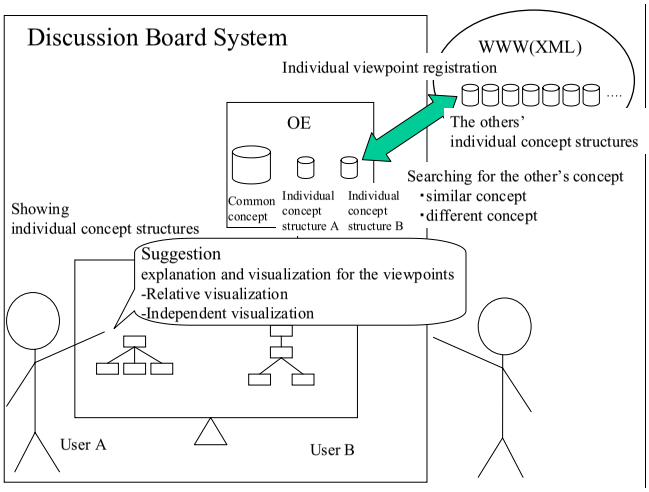

Fig. 2. System framework for Discussion Board

2. In the lower level of the tree β, if the same node rooted by concept α is found, any position of the tree will be treated as the same.
3. When it compares between links, only the existence of a link will be made applicable to comparison. The label of a link is not made applicable to comparison.

The steps for comparing concept are defined simply because we use data on the WWW, and the value of similarity is define simply for visualization of the concepts' relation.

The value of similarity S, which varies between 0 and 1, is calculated by the following equation:

$$S = 1/2n \sum_{i=1}^{n-1} i \cdot F_i + 1/2l \sum_{i=1}^{l-1} i \cdot F_i$$

In this equation, l is the number of links and n is the number of nodes. i is the index of where nodes or links are located. F is a factor which indicates the consistency of the nodes or links descriptions. When these two nodes (links) are consistent, the value is 1. When these two nodes (links) have no consistency, the value is 0.

2.2 Comparing the user's concepts with the others

The system can not only use the concepts of the users currently in discussion but also the concepts of the others by searching on the WWW. The system

searches for similar or dissimilar concepts on the WWW. The similar or dissimilar concepts are judged by using the value of similarity. Transformed XML's DOM tree structures are used as concept tree structures. For simplification and efficiency, because WWW data is used, we use a thesaurus for comparing nodes of concepts' trees and we do not count on a label of the link for comparing links of concepts' trees.

2.3 Visualizing the concepts

The system prepares two kinds of visualizations of the concept. One is independent visualization, which visualizes the tree structures of the viewpoints and is useful for comparing a small number of trees. The other is relative visualization, which visualizes the similarities of a number of the viewpoints and is useful for comparing many other viewpoints on the WWW. The system displays in a two-dimensional space by matching the similarity of a pair of viewpoints to the distance in the space by means of the multidimensional scaling method. By simply glancing at these spaces, a user can easily understand the similarity of the viewpoints.

3 Examples

3.1 The concept differences of Internet

In Japan, we often encounter difficulties in communication caused by the difference of concepts.

```
A: Internet can't boot from my PC!
B: It is impossible that Internet can't boot as you said.
A: ??
A: But, this can't boot by clicking...
B: We have several PC softwares supported by Internet.
Which software do you mean? WWW browsers, e-mail softwares...?
A: When we say Internet, we mean that we can browse homepages.
B: Oh, you mean WWW browsers.
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With the help desk company for some computer's for instance, customers call in similar requests and annoyed when the operators can not understand their needs exactly. The operator will speak with the user patiently, by way of repeated question-answering, until s/he understands her/his requirement. In the example above, when A said *Internet*, A may mean some application supported by the Internet, but B does not understand which application A means. A assumes that the *Internet* is a WWW browser, but s/he can't explain this using a word that B will understand. Using the Discussion Board, A describes the concept of *Internet* as in Figure 4. Then, B will explains the concept of Internet as in Figure 3.

After the discussion, A comes to an agreement with B and revises her/his concept.

The Discussion Board system searches and shows similar concepts from the WWW according to the similarity, if the user requests it. It determines whether some other may have a similar concept, that is, that the Internet is a WWW browser, and whether that concept held by the majority or minority of others.

Recently, we have often seen applications on palm type PCs, for example, where if we click on an icon of "*Internet*", the Web browser or e-mail software is invoked. This concept assumes that the *Internet* is a browser or e-mail on the same level of the tree (Figure 5)(Figure 6).

3.2 The concept difference of PC

This is a case where B does not understand that we can not use all the applications if we version-up an operating system like Microsoft Windows.

```
A: We must version-down this PC's operating system, Windows.
Are you O.K. with that?
B: I don't mind if I can use this PC the same as before.
A: Please be aware that you may not be able to
use all of the applications.
B: Can I use this word processor software?
A: I don't know but there is some possibility of that.
B: But there was no application which we couldn't use
when we versioned-up before.
Are there any differences?
A: I must explain the basics of the computer structures to you...
There are a lot of levels in the structures, and there is
a level of operating system, and there is a level of application that
is the lower level of this level, and...
B: ???
```

It is difficult for a novice to understand the concept of computers, and explaining orally is also difficult for the explainer. This kind of system's structures, when related to ontology, can be explained much easier visually than orally, and can then be discussed using the Discussion Board.

By describing concepts with the Discussion Board, B may explain that s/he has been assuming that the PC means a hard disk(Figure 7). Then A explains that a memory, a hard disk and a CPU are all parts of the PC(Figure 8), and data and software are stored on the hard disk (Figure 9).

If they continue discussing software, B may explain that s/he has been assuming that an operating system, word processor software and a WWW browser were all software (Figure 10). A will agree with this. Then, B may explain that s/he has also assuming that an operating system, a word processor and a WWW browser are all supported by a hard disk (Figure 11). B has been taking for granted for that the OS and other applications stand in a line. A explains that a word processor software and a WWW browser, which we call application software, are all supported by the operating system (Figure 12).

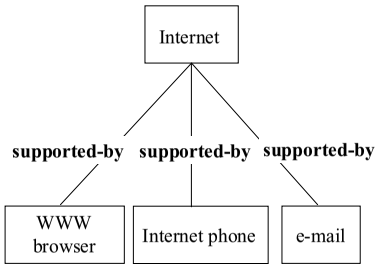

Fig. 3. A correct conceptualization of Internet

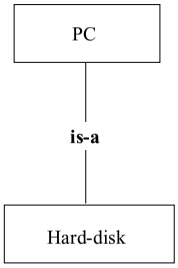

Fig. 7. An incorrect conceptualization of PC

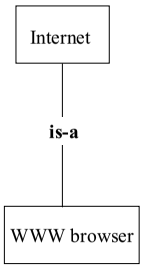

Fig. 4. An incorrect conceptualization of Internet(1)

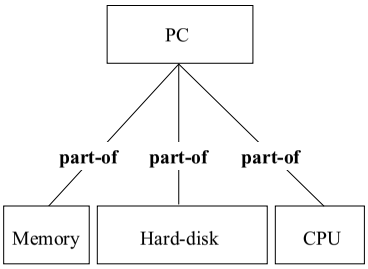

Fig. 8. A correct conceptualization of PC

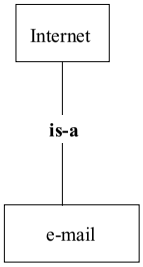

Fig. 5. An incorrect conceptualization of Internet(2)

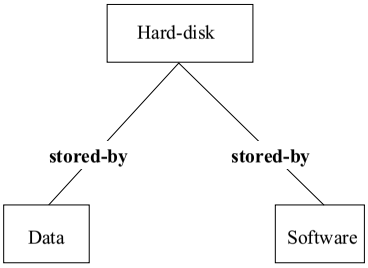

Fig. 9. A correct conceptualization hard-disk

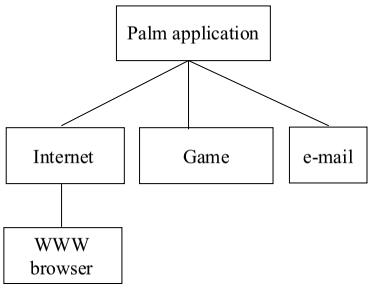

Fig. 6. An incorrect conceptualization of Internet(3)

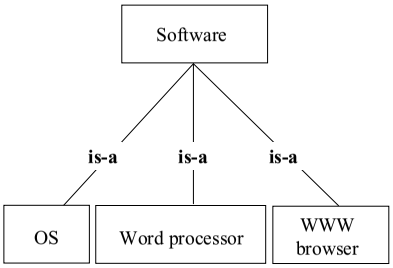

Fig. 10. A correct conceptualization of software

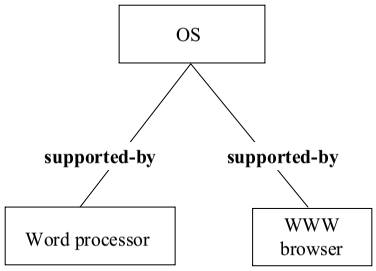

Fig. 12. A correct conceptualization of operating system

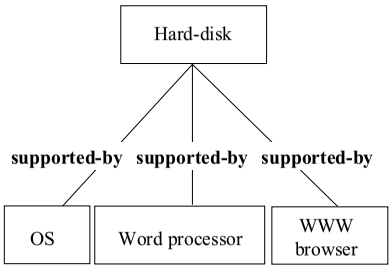

Fig. 11. An incorrect conceptualization of hard-disk

Then, after the discussion, B comes to an agreement with A and revises her/his concept. By searching and showing similar concepts from the WWW, they can recognize that B's concept is a minority. B also recognizes that the concept is obviously wrong in this case. Thus the Discussion Board may contribute to truthfully defining a concept.

4 Discussion

The Discussion Board system is effective for the articulation of concept that we can not express completely of which, but, we have some information. We can clarify our knowledge and recognize what we need to know by using this system. It may also contribute to a clarification of our unconsciousness.

We believe that we consider Discussion Board can be widely applied for several viewpoint differences such as (1) one's sense of values, (2) fixed ideological notions, (3) new concept creation.

The beneficial aspects of using ontology is that a better and deeper understanding of the world of interest by clarified of the concept and Discovering the conceptual differences.

The use of an ontology does not require very rigorous definitions of concepts. In the case of comparing an ontology which user described with an ontology which construct using Transformed XML's DOM tree structures on the WWW, the label of a link is not made applicable to comparison. What is mainly needed is a hierarchical structure of the key concepts and viewpoints associated with it.

Expression using the Discussion Board clarifies our concept, and the visualization simplifies our understanding of other viewpoints of the concept and it's expression. We will view several concepts by searching the concepts of the others on the WWW. By comparing our viewpoint of a concept and with others, we determine whether we have the right or wrong answer, or a major or minor notion. This system may lead to pioneering a new business or market.

5 Conclusion

In this paper, we proposed the Discussion Board system for supporting the nebulous communication between who do not clearly express the concepts they intend. We aims the user to be able to understand each other's viewpoints and/or reach a mutual consent, and create new ideas by understanding the viewpoints of the others.

We described the fundamental view of the Discussion Board system in this paper. We believe it will be a novel approach for articulation of the tacit knowledge in the nebulous mental world using a unification between ontology and HCI.

We will verify some prototypes which is corresponding to several problems of communication difficulties.

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