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Keywords
Framework, Ontology, Revision, Semantic, Web, Belief, Revision, Approach

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A FRAMEWORK OF ONTOLOGY REVISION ON THE SEMANTIC WEB: A BELIEF REVISION APPROACH

Seung Hwan Kang[1], Sim Kim Lau[1]

Abstract

The focus of the research in ontologies shifts from ontology representation to ontology evolution perspectives that become an important field of ontology research. Even though ontology refers to specification of conceptualisation that provides a useful way to represent the semantics of the Web resources, there is a still need for maintaining and handling ontologies. Because ontologies may change as a result of accepting new information, when this occurs, ontology needs to be revised. However the new information may contradict what was initially defined in the ontology when ontology revision is performed. To discuss this revision perspective, this research proposes an approach based on the belief revision theory to revise ontologies. Three operators of expansion, revision and contraction are proposed to revise ontology to ensure that consistency of ontologies is maintained.

1. Introduction

In the context of the Semantic Web, ontology refers to forming comprehensible specifications of conceptualisation [6]. Thus it allows agreements to be made so that shared concepts and relationships can be used in a coherent and consistent manner within the community of practice. However, one of the problems identified in the literature of ontology is the difficulty in maintaining ontology when there is a change in knowledge or perhaps a change in the perception about things within the community of practice [2, 3, 9]. In the literature, it refers to ontology revision that handles a change in the components of ontology [9]. When this happens, the ontology may need to be revised to reflect the changes. The above issue is related to changes in conceptualisation that are due to changes in domain, and changes in the explicit specification of the concept [12]. To address this issue, this research proposes a way of revising ontologies. It ensures that consistency is maintained during the revision process using the concept of the belief revision theory. A positivist research model is used to derive a conceptual framework that provides a mechanism to process ontology revision in a consistent manner using three operators of expansion, contraction and revision. The rest of the paper is organised as follows. Section 2 discusses ontology in general and the motivation associated with ontology revision. Section 3 discusses the theory of belief revision. Section 4 presents the proposed ontology revision approach. Section 5 concludes the paper.

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2. Ontology

In general, ontology deals with describing, distinguishing, descriptive analysis and classification of the concepts and relations [6, 9, 11]. Recently, the term ontology was introduced as knowledge representation in the field of the Semantic Web. The Semantic Web is an extension of the current web in which information is given well-defined meaning to better enable computers and people to work together [1]. Hendler envisions that a large number of ontologies in the web will consist of small components and are interconnected to allow sharing and reusing of ontological information [1]. Thus the first step towards this vision is its *use* to create web pages with ontological information. When one or more small and decentralised ontologies are linked to each other, it provides an opportunity for different ontologies to be *re-used* and *shared*. When this occurs, information is exchanged and definitions of web services in machine-readable form can be achieved through agreement of terms and constraints in the ontology. Then agents can be deployed to communicate with each other using ontologies, as well as be able to exchange and merge ontologies of other agents. Thus a mechanism in support of changes in ontologies is essential.

Several researchers have attempted to address the interoperability issue to track the changes in ontologies [2, 3, 9]. Ontology Library [2], Ontology Versioning [9] and ONIONS methodology [3] are some examples of research in this area. The changes are tracked using a kind of library or versioning system. For example, the ontology library system is used to manage, adapt and standardise collections of ontologies, whereas the ontology versioning system allows comparability issues to be taken into consideration when new knowledge is added to the system over time. On the other hand, the ONIONS methodology proposes to integrate a large-scale ontology to address the problem of conceptual heterogeneity. Recently, an approach that manages ontological changes from the aspect of taxonomy of ontological changes and their impact of the class has been proposed [7, 12]. These approaches have been generally used to address changes in ontology from the ontology maintenance perspectives. In this paper, thus focusses on a consistency perspective of changes in ontologies. That is, a result of ontology changes should not contradict existing concepts and relations presently defined in ontologies.

3. Belief Revision

From the historical viewpoint of belief revision, the idea of modelling the dynamics of epistemic states are formulated by keeping track of the justifications for one's beliefs and the logical structure of the beliefs [4]. The coherence theory of belief revision highlights the logical structure of the things in a "world" which are semantics in a form of logically consistent structure [5]. It is an idea where all justification of beliefs relies on coherence within a belief system. It is a holistic view that the basis of the justifications in a systematic network of beliefs can be justified via coherence that offers an idea for other justified beliefs. For example, a sentence p is true if only if p is a member of coherent set. An idea of truth here is that it is a relation or coherence between propositions or beliefs. Firstly, logical entailment relations are considered as kinds of coherence relations that are essential to a justification. It implies that one belief logically entails another if the truth of the first one is assured the truth of the second one. Explanatory relations are also considered as kinds of coherence relations because these relations explain why some other beliefs are true. Secondly, the coherent belief system that requires an

attained explanatory set, "*the more a set can explain, the more coherent it is*", defines coherence relation. This relation makes a worthy explanation when some beliefs explain why some other beliefs are true. In particular, this research follows the AGM (Alchourrón, Gärdenfors and Makinson) model of the coherence theory that is based on the idea where all justification of beliefs relies on coherence within a belief system [4, 5]. Therefore, a belief set is used as a model of belief state in the AGM model. To model a belief set, a construction of a logically consistent structure is also necessary. In order to determine which set of sentences make up a belief set, ideally, the set of accepted sentences should be logically consistent so that it is possible to draw the consequences of what is accepted.

4. Illustrations

We use a scenario buying items online to illustrate applied ontology revision. The concept hierarchy is used to illustrate conceptual relationships in which the relationships of different concepts are shown using parent-child relationship. We apply the belief revision concept to illustrate the updates of ontology of the online shop M as a result of encountering new information from the ontology of the online shop N. *Figure 1* shows the concepts related to the electronics such as "all MP3 players are electronics", "Apple is a manufacturer of electronic products" and others. *Figure 2* describes a brief concept of a MP3 player and others. However the shop N defines the concept of MP3 player differently from that of the shop M.

Figure 1 The partial ontology of the shop M

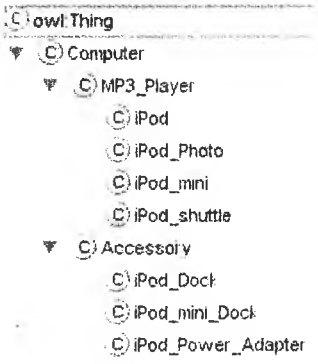

Figure 2 The partial ontology of the shop N

Firstly, the expansion occurs when the system learns something new such as the concept c. Let $O_e(m, c)$ denotes the expansion of an ontology M by a concept c, where m is the model of ontology M. When new concept is to be expanded by the expansion operator, the concept is tested for logical consistency with the current concepts. Then the expansion is accepted if and only if it is consistent with existing ones, otherwise it is rejected. Furthermore, a new expression p can also be expanded in the following notation of expansion: $O_e(m, p)$ where p is an expression that includes a concept, a relation and an URI. *Figure 3* shows the result of a series of expansion that includes the concepts "iPod_Photo" and "iPod_shuttle".

Secondly, the contraction occurs when incorrect semantic classification is introduced to ontologies. Let $O_c(m, c)$ denotes the contraction of an ontology M by a concept c, where m is the

model of ontology *M*. When a concept *c* is no longer established with the valid definition in the model of ontology *M*, the concept *c* is contracted by the contraction operator. If there is any existing sub-concept that logically entails to the precedent concept then it is also tested for logical consistency with the current concept. Thus the contraction is accepted if and only if it is consistent in ontology *M*, otherwise it is rejected. For instance, if the owner of the online shop *M* decides not to sell cameras in the future, the semantic classification of the Camera is no longer consistent. In this case, an expression that includes a concept Camera, its relation and URI needs to be given up to ensure consistency. *Figure 4* shows the result of the contraction.

Finally, the revision occurs when conflicting information lodges to ontologies, few concepts might be given up so that a change is in some sense consistent. Let $O_r(m, c)$ denotes the revision of an ontology *M* by revising a concept *c*, where *c* is no longer consistent in the model of ontology *M*. The revision can be performed by the expansion follows by the contraction. For instance, consider a MP3 player is no longer categorised as electronics (p_1). That is, it is an expansion of negation p_1 in the ontology *M* so that conflicting expressions need to be given up. As a result, *Figure 5* shows the result of the revision in ontology *M*. Importantly, the revision should not give up entire expressions to accept one in particular because it does not meet the minimality requirement [10].

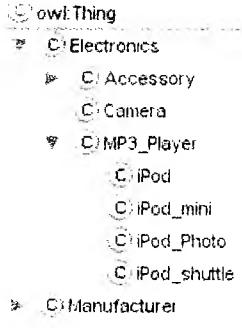

Figure 3 Illustrated expansion

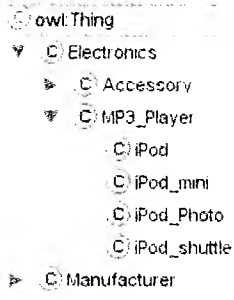

Figure 4 Illustrated contraction

Figure 5 Illustrated revision

5. Conclusion

In this paper, we pointed out that there is a shift from an ontology representation to ontology evolution perspectives. In order to meet the comprehensive requirement, it becomes necessary to merge one or more ontologies. As a result, an issue of handing interoperability among ontologies expands and is important. Moreover, to achieve the Semantic Web vision, it is becoming increasingly difficult to ensure consistencies in ontologies. This is because any new changes made may contradict what was initially agreed or defined in the ontology. When this happens, the ontology needs to be revised to reflect the changes. To address this issue, the concept of the belief revision theory is applied to ensure that new changes do not cause inconsistent beliefs and contradict the existing ontology. Further study concerning handling of comparability issues in ontologies as a result of ontology revision will be conducted.

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