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Ontology based semantic conflicts resolution in collaborative editing of design documents

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Abstract

Semantic conflicts happen frequently during collaborative editing of design documents. The problem of semantic consistency of words and the maintenance of users' editing intentions are the two major challenges when resolving those semantic conflicts. Based on WordNet this paper presents an ontology description language—FLoDL and introduces it to describe the global ontology library (GOL) and the individual ontology library (IOL) in collaborative editing. By this means, we reconstruct the architecture of collaborative editing and propose a mixed peer-to-peer structured semantic collaborative editing architecture. Then a new algorithm for inserting operations, from which semantic conflicts are often caused, is designed to solve the problem of semantic consistency of words. Moreover, by adding users' individualized semantic information into their IOL, we provide the users with individualized services and successfully maintain users' editing intensions. Finally, through some detailed experiments, we perform a compared analysis to show that semantic collaborative editing not only keeps smaller clients (less storage space) but also localizes many editing operations and thereby improves the performance of collaborative editing.

Keywords: Collaborative design; Collaborative editing; Ontology; Ontology description language; Semantic conflicts; WordNet

1. Introduction

In collaborative design designers often insert, delete and update design documents collaboratively [12]. That is, designers often edit design documents collaboratively through network. There are two types of collaborative editing: synchronous and asynchronous. In this paper, we mainly discuss synchronous case. Concurrence control is essential in synchronous collaborative editing. It consists of the operation consistency control and the semantic consistency control [1,5]. Now there are many solutions to concurrence control in collaborative editing, such as locks. There are different types of locks: the pessimistic lock, the semi-optimistic lock, the optimistic lock and etc. The more optimistic the lock is, the more cost the system undo has to spend, which leads to low system efficiency; on the other hand, the more pessimistic the lock is, the weaker the system's response ability is [15]. Therefore, locks fail to meet the strict response requirement in synchronous collaborative editing. Besides locks, serialization, operation transformation [2], Reduce [3,4] have also been suggested to solve concurrence control in synchronous collaborative editing. However, all these methods only solve the syntax problems. There are also many semantic problems in synchronous collaborative editing such as semantic consistency of words, which belongs to the semantic conflict problem [5]. If the semantic consistency of words is not maintained, design documents completed by multi-users using collaborative editing will be full of semantic errors. So far, there is little achievement on solving the semantic consistency of words in synchronous collaborative editing except for the user-centered model which is proposed by Xue [6]. In this model, when dealing with the problem of semantic consistency of words in collaborative editing, according to different users' operations, many different document versions are generated. After that users will discuss these versions to get one which is agreed on by most users. This model needs users to discuss many times in order to solve the semantic consistency problem of one word. Since there might be plenty of words which have semantic consistency problems in synchronous [7] collaborative editing of design documents, this model has a poor efficiency. Moreover, because many sentences and phrases of design documents are produced through users' discussions, the writing style of

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the documents may not comply with every single user's own. This is called the maintenance of users' editing intentions problem which is another kind of semantic conflicts. Users will feel uncomfortable due to the strange writing style of documents when they are synchronously collaboratively editing design documents. This will have a bad effect on the quality of documents. Therefore the maintenance of users' editing intentions is also of great importance in synchronous collaborative editing. In this paper, we use ontology in synchronous collaborative editing to solve the above two semantic problems. Ontology is an explicit specification of conceptualization [13,16]. It has powerful syntax description ability. With the appearance of the ontology description languages such as OIL, SHOE, XOL [9,11], ontology can be used in WEB, which further improves syntax description ability of ontology [10,13,14]. Based on ontology, this paper reconstructs the architecture of collaborative editing. We not only solve the semantic consistency of words efficiently in synchronous collaborative editing of design documents but also provide users with individualized services and resolve the maintenance of users' editing intention problems successfully. As a result, the performance of collaborative editing is fundamentally improved.

This paper first introduces the semantic problems in the collaborative editing of design documents. Then we discuss the ontology description and use ontology library to reconstruct the architecture of collaborative editing. After that, by making some detailed experiments, we perform a compared analysis to show that semantic collaborative editing not only keeps smaller clients (less storage space) but also localizes many editing operations and thereby improves the performance of collaborative editing. Finally, we discuss the future development of collaborative editing.

2. Semantic conflicts in collaborative editing of design documents

2.1. The semantic consistency problem of words

Here is an example: suppose there is a sentence 'Tom will buy a' in the initial design document. Two users are editing this document using the traditional collaborative editing. User S_1 adds 'bike' after 'a' in this sentence and user S_2 adds 'bicycle' at the same position. If these operations are performed by traditional algorithms, this sentence will be 'Tom will buy a bike bicycle' which is a wrong sentence. However, user S_1 and S_2 both want to write the sentence 'Tom will buy a bike (bicycle)'. This is a semantic consistency problem of words [5], which is quite common in collaborative editing of design documents.

2.2. The maintenance of user's editing intention

After solving the semantic consistency of words, the writing style of the design documents completed by collaborative editing may not comply with writers' own expression styles, that is, users' editing intentions may not be maintained. For example, while user S_2 adds 'bicycle' but the sentence is changed into 'Tom will buy a bike'. Only when he knows that 'bicycle' and 'bike' are synonyms and does not care such replacement will he accept this sentence. However, if he prefers to use 'bicycle' or he does not know the word 'bike', he will not accept this modification. So we should provide users with individualized semantic services to meet the need of different users' editing intentions. We call these individualized semantic services the maintenance of users' editing intentions, which is also of great importance in collaborative design editing.

3. Semantic collaborative editing

3.1. The ontology description in semantic collaborative editing

In semantic collaborative editing, we use WordNet to resolve the semantic conflicts. WordNet is a semantic network of concepts organized as taxonomy. It can describe the connotations and relations of concepts in conceptualization and is a huge ontology resource [17]. Originally, it was designed on the grounds of psycho-linguistic, trying to simulate the way concepts are organized in human brain. However, its broad applications in the field of Natural Language Processing have led to the opening of its ports in the official languages in the European Union, and in many other languages such as Catalan and Basque. In order to satisfy the needs of different fields, WordNet has been developed very intricately [18]. To meet the strict requirement on response time in semantic collaborative editing, we improve WordNet by designing a Four-Layered ontology Description Language, FLoDL. In this paper, we use FLoDL to describe the ontology in WordNet. Compared with WordNet, FLoDL is a concise ontology description language. It adopts the knowledge description method of framework theory and conforms to XML syntax, which makes it easy for computers to process and for users to understand.

FLoDL has four layers: object layer, attribute layer, definition layer and relation layer. Object layer describes the relation between the connotation concepts of objects and their different representations. Attribute layer describes objects' attributes, each of which includes an attribute name and its corresponding value. Definition layer defines objects in informal natural language. Relation layer describes the relation among different objects in ontology. This paper mainly discusses the object layer. But relation layer is also covered so as to give a comprehensive description of ontology. Object layer description is based on concepts, connecting different names and representations that belong to the same connotation concepts together. One concept may have different terms and representations. In this paper,