Demand-driven knowledge acquisition method for enhancing domain ontology integrity

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ARTICLE INFO

ABSTRACT

Knowledge, as the most important resource for the knowledge economy in the 21st century, is fundamental to enterprise competitive strength. Therefore, how to effectively integrate internal and external knowledge and provide correct knowledge to the right users in a timely fashion have become key success factors in business operation.

This study attempts to develop a demand-driven knowledge acquisition method to enhance the integrity of domain ontology. Based on the demand of the user request, the developed method can dynamically discover the insufficient knowledge concepts in the domain ontology, acquire such knowledge concepts from knowledge documents available on the Internet, and integrate the acquired knowledge concepts into the domain ontology to make it more correct and complete, thus enhancing its reuse value. This objective can be achieved by performing the following tasks: (i) design of a demand-driven knowledge acquisition process to enhance domain ontology integrity, (ii) development of techniques related to demand-driven knowledge acquisition to enhance domain ontology integrity, and (iii) implementation of a demand-driven knowledge acquisition mechanism to enhance domain ontology integrity. Developing techniques associated with demand-driven knowledge acquisition involves demand preprocessing, knowledge retrieval and searching, ontology construction, and ontology integration.

1. Introduction

Modern economic systems consider knowledge the most crucial resource for enhancing the competitive strengths of enterprises. Effective knowledge management therefore is one of the keys to continuous enterprise development. Successful knowledge management depends on effective construction, application, and maintenance of domain ontology, for use as knowledge formation and description in a specific domain to enable enterprises to effectively manage and apply domain knowledge [15,18,30,32,33].

Recently, various methods of domain ontology construction, usage, and maintenance have been developed. For example, Maedche and Staab [19] focused on semantic web to propose a semi-automatic ontology learning process to complete target ontology by integrating existing knowledge structures or webpage documents. Missikoff et al. [21] developed an integrated method for web ontology learning and construction to link related websites

efficiently. Navigli and Velardi [23] proposed an ontology construction tool "OntoLearn", to extract a concept and construct the ontology from document warehouses and dedicated web sites. Valarakos et al. [35] proposed a machine learning-based method and used specific domain corpuses and evaluation mechanisms to effectively update domain ontology. Furthermore, Plessers et al. [27] proposed a framework for ontology evolution and a method for ontology change detection to help ontological engineers propose ontology change requirements or implement changes in ontology. Following each change, an associated record automatically generated to ensure ontology consistency. Stanojević and Vraneš [32] developed an algorithm for space of universal links to accurately present the semantic knowledge and reinforce the relation among knowledge. Ahmed et al. [2] proposed a six-phase methodology for constructing engineering design ontology and developed evaluation methods for each phase. Additionally, Ribes and Bowker [28] completed the practical processes surrounding ontology design and deployment within the infrastructure project GEON (the geosciences network) and traced the emergence of an organizational routine for their production. Chen et al. [6] developed a mechanism for concept feature-based ontology construction and maintenance to help enterprise knowledge

engineers construct and classify knowledge more accurately to increase knowledge maintenance efficiency. However, these recent studies did not construct and use domain ontology according to user knowledge requirements. Meanwhile, the domain ontology was generally constructed using the one-time static model or the artificial acquisition and adjustment method. This situation incurs not only increased development costs of domain ontology, but also does not allow the knowledge concepts of domain ontology to be automatically updated for the growth of domain ontology. Such domain ontology frequently cannot satisfy user knowledge requirements and further reduces its reuse value.

This study develops a demand-driven knowledge acquisition method to effectively enhance the integrity of domain ontology. Based on the demand of the user request, this method can dynamically identify the insufficient knowledge concepts in the domain ontology, acquire such knowledge concepts from knowledge documents on the Internet, and integrate these knowledge concepts into the domain ontology to make the domain ontology more correct and complete, and thus increase its reuse value. This objective can be achieved by performing the following tasks: (i) design of a demand-driven knowledge acquisition process to enhance domain ontology integrity, (ii) development of techniques related to demand-driven knowledge acquisition to enhance domain ontology integrity, and (iii) implementation and evaluation of a demand-driven knowledge acquisition mechanism to enhance domain ontology integrity. Developing techniques associated with the demand-driven knowledge acquisition involves demand preprocessing, knowledge retrieval and searching, ontology construction, and ontology integration. For developing and using the proposed approach, some limits are identified as follows. First, system users must be experts with professional domain knowledge. Second, this study only deals with knowledge concepts and relationships between knowledge concepts. Attributes of knowledge concepts are not included in the research scope. Third, the demand-driven knowledge acquire from English documents, this work does not consider Chinese-based knowledge documents.

The remainder of this paper is organized as follows. Section 2 designs the demand-driven knowledge acquisition process intended to enhance domain ontology integrity. Section 3 then develops the techniques involved in demand-driven knowledge acquisition for domain ontology enhancement. Next, Section 4 presents results of the implementation of a prototype demand-driven knowledge acquisition mechanism and experiment with an application example. Finally, Section 5 concludes the paper with some perspectives.

2. Design of a demand-driven knowledge acquisition process for enhancing domain ontology integrity

This section first proposes the demand-driven knowledge acquisition model. The model is used to design a detailed process of demand-driven knowledge acquisition for enhancing the integrity of domain ontology integrity. This process involves demand preprocessing, knowledge retrieval and searching, ontology construction, and ontology integration, as described below.

2.1. Demand-driven domain ontology acquisition model

Domain ontology acquisition aims to establish domain ontology contents, including knowledge concepts and relations [17,19]. To effectively acquire domain ontology, the demand-driven domain ontology acquisition model is proposed, as shown in Fig. 1. In the model, the user query is first analyzed to determine the user knowledge requirements. According to the user knowledge requirements, knowledge retrieval is processed in the domain ontology and knowledge concepts are judged to determine the
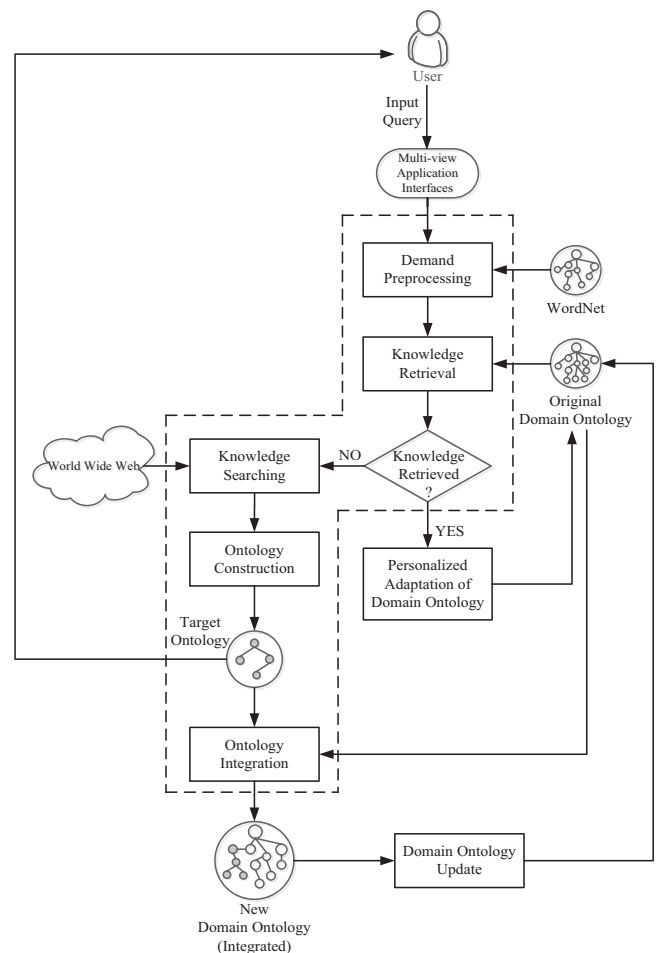

Fig. 1. Demand-driven domain ontology acquisition model.

suitability of the knowledge concepts for user knowledge requirements. If the knowledge concepts are suitable, a suitable domain ontology is adapted accordingly. The adaptive domain ontology can satisfy future user knowledge requirements, and thus enhance the reusability of domain ontology. Conversely, if the original domain ontology is unsuitable for user knowledge requirements, the insufficient knowledge concepts in the original domain ontology are first identified. Based on these knowledge concepts, relevant knowledge documents on the Internet are then searched to construct a target ontology. Finally, the constructed target ontology is integrated into the original domain ontology to satisfy the user knowledge requirements. This study primarily focuses on the latter, which are displayed as the shaded portion and bounded by the broken line, as illustrated in Fig. 1.

2.2. Demand-driven knowledge acquisition process for enhancing domain ontology integrity

The demand-driven knowledge acquisition process for enhancing domain ontology integrity is designed based on the demand-driven domain ontology acquisition model. The detailed process includes four phases, namely demand preprocessing, knowledge retrieval and searching, ontology construction, and ontology integration, as shown in Fig. 2. These phases are briefly explained as follows.

2.2.1. Demand preprocessing

Users of the information system constructed by domain ontology often use natural languages to describe the queried