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Establishing formalized representation of standards for construction cost estimation by using ontology learning

Zhe Liu[a], Zhiliang Ma[a]*

[a]*Tsinghua University, Haidian District, Beijing, 100084, China*

Abstract

Construction cost estimation for tendering is important for both tenders and bidders in construction projects and needs to be strictly complied with corresponding standards so that quantities and prices from different bidders are comparable. In the view of flexibility and extensibility, ontology is regarded as a promising technology for formalized representation of the standards for construction cost estimation (cost standards for short hereafter) in computer programs. In order to automate the processes of construction cost estimation for estimators. However, the manual establishment of ontology for construction cost estimation (cost ontology for short hereafter) is labor-intensive and time-consuming for software developers, not to mention that there are numbers of standards for different types of construction projects in different regions. In order to solve this problem, a semi-automatic approach based on the framework of cost ontology that authors established previously is proposed to establish the cost ontology by using ontology learning technology. Firstly, the data sources, i.e. the cost standards are analyzed and the corresponding relations between information in cost standards and the elements in the framework are summarized. Then based on the corresponding relations, the approach is designed, in which concepts, relations and rules are extracted by natural language processing and domain lexical analysis to fill the framework. The approach lays a foundation for the practical use of ontology for automating construction cost estimation.

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Keywords: construction cost estimation; formalized representation; ontology learning

1. Introduction

Construction cost estimation for tendering is important for both tenders and bidders in construction projects and needs to be strictly complied with corresponding standards so that quantities and prices from different bidders are

* Corresponding author. Tel.: +86-10-6277-3543
E-mail address: mazl@tsinghua.edu.cn

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comparable. In order to improve the efficiency and accuracy of the estimation, standards for construction cost estimation (cost standards for short hereafter) are manually translated into formalized representation such as hard coding, parametric table, decision tree, etc. in computer programs to semi-automate the processes [1]. However, it is difficult to extend, share and reuse these formalized representations for other applications. In recent years, ontology has been regarded as a promising technology to represent concepts, relations and rules for both human and program on account of its flexibility and extensibility. Additionally, it can be used for automatic decision processes with the support of existing reasoning machines and has been adopted in researches on knowledge representation [2,3,4], information query [5,6], rule checking [7,8], etc. in the AEC (Architecture, Engineering, and Construction) industry.

In the domain of construction cost estimation, Staub-French et al. [9] proposed a feature-based ontology for estimators to generate and maintain complete, consistent and expeditious estimates. But limited to the ontology technology at that time, this ontology was not sharable. Lee et al [10] suggested a BIM (Building Information Modeling) and ontology-based approach for construction cost estimation which utilized reasoning machines to infer work items and unit costs automatically. The authors [11] made a preliminary discussion on adopting ontology as a new formalized representation of cost standards, and [12] established a framework of ontology for construction cost estimation (cost ontology for short hereafter) to discriminate building products into corresponding cost items. Although cost ontologies are sharable and reusable and can be utilized to improve the efficiency and accuracy of construction cost estimation for estimators, the manual establishment of ontology is labor-intensive and time-consuming for software developers. Since there are numbers of standards for different types of construction projects (e.g. civil buildings and industrial buildings) in different regions (e.g. provinces in China), cost ontologies are still hampered from practical use.

Ontology learning is a technology to create ontology semi-automatically based on techniques such as natural language processing, machine learning, data mining, etc., and has been implemented in web search successfully [14]. According to the types of data sources, ontology learning can be classified into three groups, i.e., ontology learning from structured data (e.g. database schemas), that from semi-structured data (e.g. web pages), and that from unstructured data (e.g. text documents). For each type of data sources, there have been several existing methods and tools to extract concepts and relations to create ontologies [13,14]. A few researches have focused on ontology learning from data sources in Chinese [15,16,17]. Nevertheless, for the full extraction of information from the semi-structured Chinese cost standards to establish cost ontologies, the existing ontology learning tools are still insufficient.

In order to solve this problem, a semi-automatic approach based on the framework that authors established previously is proposed to establishing the cost ontology by using ontology learning technology. Firstly, the data sources, i.e. the cost standards are analyzed and the corresponding relations between information in cost standards and the elements in the framework of cost ontology are summarized. Then based on the corresponding relations, the approach is designed, in which concepts, relations and rules are extracted by using natural language processing and domain lexical analysis to fill the framework of cost ontology. Finally, the approach is implemented and tested with typical Chinese cost standards.

2. Analysis of two typical cost standards

2.1. Cost standards for construction cost estimation

The bill-of-quantity (BQ for short hereafter) method is well-accepted for tendering in practice in many countries and regions all over the world. According to the BQ method, buildings are broken into building products and classified into groups with similar features and construction works. For each construction work, several construction conditions are specified with different unit costs of labor, material, and equipment etc., i.e. quota items. In each BQ item, once all related quota items are identified, the comprehensive unit cost of BQ item can be calculated, and the total quantities of building products are classified into the same BQ item can be summed up. Then the budget cost of buildings is obtained by summarizing the product of the comprehensive unit cost and the total quantity of each BQ item.