

Chapter 63

A New Method for Building Probabilistic Ontology (Prob–Ont)

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ABSTRACT

During the past years, ontologies are widely used for representing knowledge of complex domains. Despite that the ontologies (classical ontologies) have become standard for representing knowledge; however, they are not able to represent and reason with uncertainty which is one of the characteristics of the world that must be handled. Probabilistic Ontologies have come to remedy this defect. This paper is part of this framework in which the authors have proposed a new method of probabilistic ontology construction, named Prob-Ont, by integrating uncertainty to elements of OWL ontology (especially to instances and/or relations). As a case study, the authors have constructed a probabilistic ontology for the domain of scientific documentation system (dblp).

1. INTRODUCTION

The Semantic Web, an extension of the World Wide Web, allows to express the semantics of data. Ontology, which is the foundation of the semantic web, is an abstract model that is defined by a machine-interpretable language. Despite that the ontologies have become standard for representing knowledge in many applications; however, they are not able to represent and reason with uncertainty that may arise from the incorrect or incomplete understanding of domains (Santos & Jurmain, 2011). The uncertainty is a ubiquitous aspect of most real world problems. It exists in almost every aspect of ontology engineering

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(Ding et al., 2005). Today, there is a very interesting requirement to develop formalisms of knowledge representation allowing to deal with uncertainty. Various researchers address the need to model the probabilistic and uncertain information in the semantic web. The authors of (Predoiu & Stuckenschmidt, 2010) describe five areas where probabilistic information plays a role in the context of the Semantic Web: Ontology Learning, Ontology Mapping Usage for Information Integration, Representing inherently uncertain Information, Ontology Matching and Document Classification.

On the other hand, modeling uncertainty is a big challenge. Several methods for modeling uncertainty in ontologies have recently started emerging. Generally, these methods are based on mathematical techniques of uncertainty: the Probabilistic theory, the Fuzzy logic approach and the Dempster-Shafer theory (Bellenger & Gatepaille, 2010; Dennis, 1987; Zadeh, 1965). The Probability theory has been proven to be one of the most powerful approaches to deal with uncertainty and it is a natural choice for representing the uncertain and probabilistic knowledge (Ding, 2005). Moreover, it has been widely applied with success in various fields; for example, in artificial intelligence, many researchers have used probabilistic methods for dealing with uncertainty in knowledge-based systems (Duda et al., 1990). According to (Dennis, 1987), the only satisfactory description of uncertainty is probability. In this work, we restrict our attention to approaches based on the Probabilistic theory for representing uncertain and probabilistic knowledge and more specifically on the Bayesian Network. The latter is one of the best probabilistic models for representing the knowledge on a formal theoretical basis (Finn, 1996; Ben Mrad et al., 2015). We have chosen the Bayesian Network to model the uncertainty for many reasons. Firstly, this model is one of the best models for representing the uncertainty on a formal theoretical basis. It has the excellent ability to represent uncertain and probabilistic knowledge in a sound mathematical way (Yang, 2007). A powerful technique of this model is Bayesian inference. The latter consists to propagate one or more certain information (values established by certain variables) to deduce how this intervenes on the probabilities of other Bayesian Network variables. In addition, the Bayesian Network is widely used with success in a wide range of activities (as engineering, medicine, etc.) for representing and reasoning with uncertainty.

In practical cases, the schema of ontology is assumed to be deterministic (precise) however the ontology population (instantiation of ontology) is not (Salvatore, 2015). This means that the classes, their hierarchies and the individuals of ontology are deterministic. However, the association of an individual with a concept is valid with a probability. In the same way, the relation between two individuals or between an individual and data types is valid with a probability. In this paper, focusing on this assumption we have proposed a new method of construction of probabilistic ontology by integrating uncertainty to element(s) of OWL ontology (especially to instances and/or relations between them). Indeed, this paper aims to represent uncertainty in the semantic web with the help of Bayesian Network. As a case study, we have constructed a PO for the domain of scientific documentation system (dblp¹).

The remainder of this paper is organized as follows. Sections 2 and 3 present the Bayesian Networks and the major existing works for representing uncertainty with the help of Bayesian Networks in semantic web. In section 4, we propose a new method for building a probabilistic ontology. In section 5, we present a case study for constructing probabilistic ontology for dblp. Section 6 presents the discussions and the obtained results of this work. Finally, we conclude by summarizing our work and listing points for future work.

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