Reasoning with Vague Concepts in Description Logics

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ABSTRACT

The open world assumption in ontologies representing knowledge may assign deficient (imprecise) meaning for ontology concepts which are language adjectives referring the meaning of classes of objects (individuals). The interpretation of an imprecise (vague) concept is by three subsets of individuals. The first subset of individuals surely belongs to the vague concept, the second subset of individuals surely doesn't belong the vague concept and the third subset is in the borderline. In this paper, the authors will show that is possible to describe ontology vague concepts using well-defined formal languages. The authors will propose also an extension of the Tableau algorithm for reasoning over vague ontologies.

KEYWORDS

Automatic Reasoning, Description Logics, Ontologies, Tableau Algorithm, Vagueness

1. INTRODUCTION

The Semantic Web is an extension of the Web where data are given explicit meaning. This allows the data to be integrated, processed, shared, and filtered with much greater easily than before. It relies heavily on the formal ontologies that structure underlying data for the purpose of comprehensive and transportable machine understanding. Therefore, the success of the Semantic Web Is highly dependent on the proliferation of ontologies, which requires fast and easy engineering of ontologies and avoidance of a knowledge acquisition bottleneck. (Baader et al, 2007; Horrocks et al, 2006). This language and these ontologies enabled the computing agents to understand the diverse annotations and to communicate between them, by making reasoning on the concepts. But the real world has several uncertainties and imperfections that we cannot conceive using traditional ontologies. Formally, ontology is a logical theory taking into account the sense expected from a formal vocabulary (Krötzsch, 2012). It described generally in classic description logic which shows its limits for all facts that are not expressed with "true" or "false" values.

Typically, in most applications of description logics that we are aware of, except (Straccia, 1998, Tresp 1998, Straccia 2001), concepts are crisp unary relations, i.e., an object may or may not be an element of a particular. However, there are many vague concepts in reality. These vague concepts have

no clear boundaries. For example, temperature in the human Respiratory frequency. For this vague concept, there is not a clear and precise boundary. Description logics and the ontologies based on DLs cannot handle this fuzzy concept. In this example the linguistic label could be associated with one of the following terms {Bradypnea, Eupnea, Tachypnea}. Note that the human Respiratory frequency can have a vagueness extension, average frequency between brady and normal pnea or between normal and tachy pnea. The source of this indecision is the imprecise definition (representation) of concepts that is caused by lack of rigorous knowledge.

Recently great deal of work has been devoted to dealing with this phenomenon of vague description logic and most of them express it as a concept property as those based on fuzzy logics (Bobillo and Straccia, 2011; Straccia, 2013; Lukasiewicz and Straccia, 2007). Other works counts on an additional degree to choose how to interpret concepts or the logical constructors. A standard approach inherited from mathematical fuzzy logic (Hajèk, 2001; Cintula, 2011), based on triangular norm (t-norm) (Klement P and all, 2000) to interpret conjunction. Fuzzy DLs generalize crisp DL by annotating each axiom with a fuzzy value that specifies the degree to which the axiom holds ex: $\exists$tallPerson$\geq$0.7. For recent work, research on fuzzy DLs has covered many different logics, from the inexpressive EL to the expressive SROIQ(D), from simple fuzzy semantics to ones covering all continuous t-norms, from acyclic terminologies to GCIs. Fuzzy reasoning algorithms have been implemented and the use of fuzziness in practical applications has been studied (Borgwardta, 2014). (Natalia and all, 2014) propose a fuzzy KB for human activity representation, which allows us to model and reason about vague, incomplete, and uncertain knowledge. They demonstrate that the inclusion of fuzzy concepts and relations in the ontology provide benefits during the recognition process with respect to crisp approaches.

The most recent works in this domain based on fuzzy functions to assign a membership degree to concepts instances. We believe that the concepts should be treated as having a fixed meaning (not a balanced meaning), shared by all users of the ontology; we think that the best solution is to benefit from the ontology evolution by a learning, which allows vague concepts to define their precise regions and thus to arrive at every evolution to more less fuzzy concepts until that arrived to no vague concepts. This idea is the basis of our vagueness approach that we will use for reasoning about the vague description logic.

In this paper, vague concepts depend on individual assertion, where pre-processing phase was proposed to treat vague concept, the result of this phase is new TBox without ambiguity and vagueness, also give a simpler and more organized representation, which allow us in a second stage to apply an effective vague reasoning. The second phase product new ABox with new assertion that will help us during the standard reasoning. This paper is organized as follows. A fuzzy logic membership function is proposed in section 2. A fuzzy linguistic description in section 3, to show how to express vague concepts and to describe the characteristics of vague ontologies. Section 4 and 5 presents added reasoning rules to extend the Tableau algorithm, for fuzzy reasoning of vague concept. Section 6 present related work. Section 7 discusses our approach compared to previous works. At the end, conclusions and perspectives are given.

2. FUZZY LOGIC MEMBERSHIP FUNCTION

A fuzzy set is completely characterized by its membership function (MF). Since most fuzzy sets in use have a universe of discourse X consisting of the real line R, it would be impractical to list all the pair defining a membership function. A more convenient and concise way to define an MF is to express it as a mathematical formula5 Jyh-Shing R.J 1996).

2.1. Triangular MFs

A triangular MF is specified by three parameters {a, b, c} as follows:

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