A Fuzzy Extension of SWRL

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1 Introduction

Experience in using ontologies and rules in applications has shown that in many cases we would like to extend their representational and reasoning capabilities to deal with vague or imprecise knowledge. For example, multimedia applications have highlighted the need to extend representation languages with capabilities which allow for the treatment of the inherent imprecision in multimedia object representation, matching, detection and retrieval. Unfortunately, neither OWL nor SWRL provides such capabilities.

In order to capture imprecision in rules, we propose fuzzy extensions of SWRL (SWRL is proposed by the Joint US/EU ad hoc Agent Markup Language Committee.[3], the reader is referred to [HPSB$^+$04] for full details of the model-theoretic semantics and abstract syntax of SWRL.). In this extension OWL facts (axioms relating to individuals) can include a specification of the "degree" (a truth value between 0 and 1) of confidence with which we assert that an individual (resp. pair of individuals) is an instance of a given class (resp. property); and SWRL atoms can include a "weight" (a truth value between 0 and 1) that represents the "importance" of the atom in a rule.The syntax extends the existing abstract syntax for SWRL, while the semantics is based on the theory of fuzzy sets [Zad65].

For example, the following fuzzy rule asserts that if one has a parent that is happy, then one is likely (with the weight 0.8) to be happy:

$$\mathsf{parent}(?x, ?p) \wedge \mathsf{Happy}(?p) \rightarrow \mathsf{Happy}(?x) * 0.8,$$

where parent is an object property, Happy is a class. and 0.8 is the weight for the atom $\mathsf{Happy}(?x)$. A detailed motivating use case for fuzzy rules can be found in [TS04].

2 Fuzzy SWRL

Fuzzy rules are of the form antecedent $\rightarrow$ consequent, where atoms in both the antecedent and consequent can have weights, i.e., numbers between 0 and 1.

[3] See `http://www.daml.org/committee/` for the members of the Joint Committee.

More specifically, atoms can be of the forms C(x)$*w$, P(x,y)$*w$, sameAs(x,y)$*w$ or differentFrom(x,y)$*w$, where $w \in [0, 1]$ is the weight of an atom,[4] and omitting a weight is equivalent to specifying a value of 1. For instance, the following fuzzy rule axiom asserts that if a man has his eyebrows raised enough and his mouth open then he is happy, and that the condition that he has his eyebrows raised is a bit more important than the condition that he has his mouth open.

$$\mathsf{EyebrowsRaised}(?a) * 0.9 \wedge \mathsf{MouthOpen}(?a) * 0.8 \rightarrow \mathsf{Happy}(?a), \tag{1}$$

In this example, EyebrowsRaised, MouthOpen and Happy are classes, ?a is a *individual-valued* variable, and 0.9 and 0.8 are the weights of the atoms EyebrowsRaised(?a) and MouthOpen(?a), respectively.

Consider, as another example, the following two fuzzy rules:

$$\mathsf{parent}(?x, ?p) \wedge \mathsf{Happy}(?p) \rightarrow \mathsf{Happy}(?x) * 0.8 \tag{2}$$

$$\mathsf{brother}(?x, ?b) \wedge \mathsf{Happy}(?b) \rightarrow \mathsf{Happy}(?x) * 0.4, \tag{3}$$

which share Happy($?x$) in the consequent. Since $0.8 > 0.4$, more weight is given to rule (2) than to rule (3) when determining the degree to which an individual is Happy.

3 Conclusions

In an attempt to extend existing knowledge representation systems to deal with the imperfect nature of real world information, the AI community has devoted considerable attention to the representation and management of uncertainty, imprecision and vague knowledge. Moreover, a lot of work have been carried out on the development of reasoning engines that can interpret imprecise knowledge. The need to deal with imperfect and imprecise information is likely to be common in the context of the (Semantic) Web. In anticipation of such a requirement, this paper presents a proposal for fuzzy extensions SWRL, a proposed rule language extension to OWL DL.

References

[HPSB+04] Ian Horrocks, Peter F. Patel-Schneider, Harold Boley, Said Tabet, Benjamin Grosof, and Mike Dean. SWRL: A Semantic Web Rule Language — Combining OWL and RuleML. W3C Member Submission, `http://www.w3.org/Submission/SWRL/`, May 2004.

[TS04] Vassilis Tzouvaras and Giorgos Stamou. A use case of fuzzy swrl. Technical report, 2004. http://image.ntua.gr/ tzouvaras/usecase.pdf.

[Zad65] L. A. Zadeh. Fuzzy sets. *Information and Control*, 8:338–353, 1965.

[4] To simplify the presentation, we will not cover datatype property atoms in this paper.