Annotating Ontologies with Descriptions of Vagueness

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Abstract. Vagueness is a common linguistic phenomenon manifested by predicates that lack clear applicability conditions and boundaries such as *High*, *Expert* or *Bad*. The usage of vague terminology in ontology entities can hamper the latter's quality, primarily in terms of shareability and meaning explicitness. In this paper we present the Vagueness Ontology, a metaontology that enables the explicit identification and description of vague entities and their vagueness-related characteristics in ontologies, so as to make the latter's meaning more explicit.

1 Introduction

Ontologies are formal shareable conceptualizations of domains, describing the meaning of domain aspects in a common, machine-processable form by means of concepts and their interrelations [2]. As such, their role in the Semantic Web is very important as they enable the production and sharing of structured data that can be commonly understood among human and software agents. On the other hand, vagueness is a natural language phenomenon, demonstrated by concepts with blurred boundaries, like *tall*, *expert* etc., whose extensions is difficult to precisely determine (e.g. some people are borderline tall: neither clearly "*tall*" nor "*not tall*") [3]. When building ontologies, engineers and domain experts often use predicates that are vague. These, in turn, influence in a negative way the comprehension of these ontologies by other parties and limits their value as a reusable source of knowledge [1]. The reason is the subjective interpretation of vague definitions that can cause **disagreements** among the people who develop, maintain or use an ontology.

To reduce these disagreements we have put forward the notion of **vagueness-aware ontologies** [1], informally defined as *"ontologies whose vague elements are accompanied by comprehensive metainformation that describes the nature*

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and characteristics of their vagueness". An example of such metainformation is whether an ontology entity is vague or not; this is important as many ontology users may not immediately realize this. In this paper we show how vagueness-aware ontologies may be represented by means of the **Vagueness Ontology (VO)**, a metaontology that defines the necessary concepts, relations and attributes for creating explicit descriptions of vague ontology entities. VO is meant to be used by both producers and consumers of ontologies; the former will utilize it to **annotate** the vague part of their produced ontologies with relevant vagueness metainformation while the latter will **query** this metainformation and use it to make a better use of the vague ontologies.

2 The Vagueness Ontology

The Vagueness Ontology[1] enables the annotation of an ontological entity (class, relation or datatype) with a description of the nature and characteristic of its vagueness. A class is vague if, in the given domain, context or application scenario, it admits borderline cases, namely if there are (or could be) individuals for which it is indeterminate whether they instantiate the class (e.g., *"TallPerson"*, *"ExperiencedResearcher"*, etc.). Similarly, an object property (relation) is vague if there are (or could be) pairs of individuals for which it is indeterminate whether they stand in the relation (e.g., *"hasGenre"*, *"hasIdeology"*, etc.). The same applies for datatype properties and pairs of individuals and literal values. Finally, a vague datatype consists of a set of vague terms (e.g., *"RestaurantPriceRange"* with the terms *"cheap"*, *"moderate"* and *"expensive"*).

A vagueness description explicitly states whether the entity is vague or not. For example, the class *"StrategicClient"* defined as *"A client that has a high value for the company"* is vague while *"AmericanCompany"* as *"A company that has legal status in the Unites States"* is not. Moreover, it can often be the case that a seemingly vague entity can have a non-vague definition (e.g. *"TallPerson"* when defined as *"A person whose height is at least 180 cm"*). Then this element is not vague in the given ontology and that is something that needs to be explicitly stated. Also, vagueness can be quantitative or qualitative [3]. A predicate has quantitative vagueness if the existence of borderline cases stems from the lack of precise boundaries for the predicate along one or more dimensions (e.g. "*bald*" lacks sharp boundaries along the dimension of hair), and qualitative if there is a variety of conditions pertaining to the predicate, but it is not possible to make any crisp identification of those combinations which are sufficient for application (e.g., "*religion*", "*strategic*", etc.). Knowing the type of vagueness is important as elements with an intended (but not explicitly stated) quantitative vagueness can be considered by others as having qualitative one and vice versa. Also, when the entity has quantitative vagueness it is important to state explicitly its intended dimensions (e.g. the amount of R&D budget for the term "*strategic*". Therefore, VO makes explicit the type of the entity's vagueness and the dimensions of the term's quantitative vagueness.

[1] Available at http://www.essepuntato.it/2013/10/vagueness.

Furthermore, vagueness is **subjective** and **context dependent**. The first has to do with the same vague entity being interpreted differently by different users. For example, two company executives might have different criteria for the entity "*StrategicClient*", the one the amount of revenue this client has generated and the other the market in which it operates. Similarly, context dependence has to do with the same vague entity being interpreted differently in different contexts even by the same user; hiring a researcher in industry is different to hiring one in academia when it comes to judging his/her expertise and experience. Therefore, VO explicitly represents the **creator** of a vagueness annotation of a certain entity as well as the **applicability context** for which the entity is defined. Context-dependent can be (i) the description of vagueness of an entity (i.e. the same entity can be vague in one context and non-vague in another) and (ii) the dimensions related to a description of vagueness having quantitative type (i.e. the same entity can be vague in dimension A in one context and in dimension B in another).

Figure 1 depicts VO. To show how to use VO let us assume a scenario where the relation *ex:isExpertInResearchArea* is considered vague by John Doe in the context of researcher hiring and its vagueness is quantitative in the dimensions of the number of publications and the number of projects. The first dimension is related to the context of Academia while the second to the one of Industry. To represent this scenario we create an instance of the *VaguenessAnnotation* class and link it to its creator, the entity and a description of the entity's vagueness or non-vagueness:

```
ex:annotation a :VaguenessAnnotation ;
prov:wasAttributedTo ex:john-doe ;
  oa:hasBody ex:description-of-vagueness ;
  oa:hasTarget ex:isExpertInResearchArea .
ex:isExpertInResearchArea a owl:ObjectProperty .
ex:john-doe a prov:Agent .
```

Such a description is an instance of the class *DescriptionOfVagueness* or *DescriptionOfNonVagueness* respectively. Vagueness descriptions must specify a type and must provide at least one justification for considering the target ontological entity vague. Non-vagueness descriptions, instead, require only a justification and are used for entities that would typically be considered vague but which in the particular ontology are not (e.g. the *"TallPerson"* example mentioned above). Also, vagueness dimensions always refer to descriptions of quantitative vagueness and indicate some measurable characteristic of the annotated entity. Given this, the scenario's description of vagueness is represented as follows:

```
ex:description-of-vagueness a :DescriptionOfVagueness ;
  :hasJustification ex:justification ;
  :hasVaguenessType :quantitative-vagueness .
ex:justification a :Justification ;
  :hasNaturalLanguageText "It is not possible to define the exact minimum
       number of relevant publications and projects that make a researcher
       expert in a given area." ;
  :hasDimension ex:dimension-publications , ex:dimension-projects .
ex:dimension-publications a :Dimension ;
  :hasNaturalLanguageText "The number of relevant publications." .
ex:dimension-projects a :Dimension ;
  :hasNaturalLanguageText "The number of relevant projects." .
```

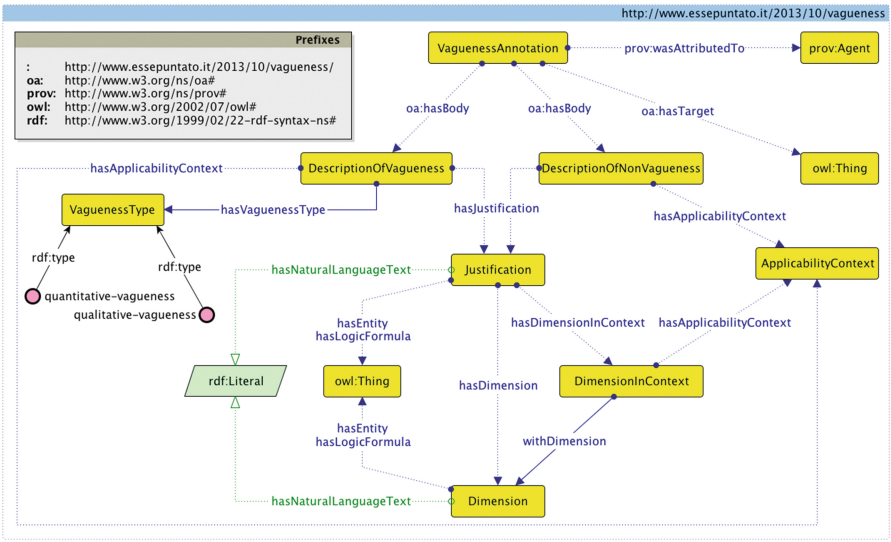

Fig. 1. Vagueness ontology structure.

Also, descriptions of vagueness/non-vagueness and related dimensions can be characterised by particular applicability contexts. This is facilitated by an assertion between the description and the related context through the object property *hasApplicabilityContext*. In the case of dimensions the context-dependent object is the *relation* between justifications and dimensions, therefore a reification of this relation is employed:

```
ex:description-of-vagueness
  :hasApplicabilityContext ex:researcher-hiring-context .
ex:researcher-hiring-context a :ApplicabilityContext .
ex:justification :hasDimensionInContext
  ex:dimension-publications-in-context , ex:dimension-projects-in-context .
ex:dimension-publications-in-context a :DimensionInContext ;
  :withDimension ex:dimension-publications ;
  :hasApplicabilityContext ex:academia-context .
ex:dimension-projects-in-context a :DimensionInContext ;
  :withDimension ex:dimension-projects ;
  :hasApplicabilityContext ex:industry-context .
ex:academia-context a :ApplicabilityContext .
ex:industry-context a :ApplicabilityContext .
```

3 Conclusions and Future Work

The Vagueness Ontology (VO) is a metaontology for annotating vague ontology entities with descriptions that describe the nature and characteristics of their vagueness in an explicit way. The idea is that even though the availability of the metainformation will not eliminate vagueness, it can help reduce the potentially high level of disagreement and low level of comprehensibility it may cause

and achieve better shareability of vague semantic information. We are currently working towards facilitating the easier and more intuitive usage of VO for the production of vagueness-aware ontologies.

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