EXTENSION OF A CRISP ONTOLOGY TO FUZZY ONTOLOGY

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Abstract:
Ever since its inception, web has remained a huge repository for information and with each passing day it is growing at a rapid pace. It has become increasingly important for the computer programs to handle the information on web autonomously and intelligently and hence the vision of semantic web has emerged. Some domains have an inherent vagueness and in order to exploit knowledge from these sources traditional structures are not self sufficient. In order to adapt uncertainty or ambiguity in domain knowledge, Linguistic variables in fuzzy logic should be included. This paper discusses the extension of a crisp ontology to fuzzy ontology.

Keywords: crisp ontology, fuzzy logic, fuzzy ontology, linguistic variables, semantic web, uncertainty, vagueness.

1. Introduction
World Wide Web today is dependent on the keyword based search process. The search results entirely depend on the maximum keyword based matching in a document. The user requirements may not be satisfied or fully realized as irrelevant pages may be retrieved. This is mainly because of the way in which the world wide web is designed as it relies on the design, presentation and layout of the web pages and documents using the markup languages like Hypertext Markup Languages.The semantic web is a vision that aims to solve the problem faced by the world wide web users by utilizing smart and bright web agents that retrieve useful, meaningful and relevant results. In order to obtain precise and high quality information from the search engines, ontologies that form an important component of the semantic web are used for communication among the web agents [18]. The conventional ontologies do not acknowledge the human perception in the desired way. Hence, a need was felt to introduce fuzziness in the ontologies. This paper extends a crisp ontology to fuzzy ontology.

2. Preliminaries
2.1. Extensible Markup Language (XML)
XML is an extensible markup language used for the description of marked-up electronic text. XML is also known as a metalanguage that means to describe a language formally [3].
The characteristics of XML that distinguish it from rest of the markup languages are [3]:
- descriptive markup is emphasized over the procedural markup.
- document type concept.
- independent of any one hardware or software system.
- XML is extensible. Custom tags can be created as per user requirement and data can be expressed logically [3] [7].
- XML documents are well formed and may be validated.
- XML focuses on the meaning and content of the data.

The above characteristics of XML make it appropriate and convenient for representing the contents of the semantic web.XML can be efficiently utilized to add information to the web pages such that it can be processed meaningfully by the computers [1].

2.2. Ontology
Ontology is a formal explicit specification of a shared conceptualization where, conceptualization is an abstract, simplified view of the world that describes the objects, concepts and other entities, existing in a domain along with their relationships [1][5]. Gonzales [15] analyzes the terminologies in the definition and expresses that formal is an abstract model of portion of the world; explicit specification signifies that the constructed ontology must be machine readable and understandable; shared implies consensus of the community towards the ontology that have been built and conceptualization is expressed in terms of the concepts and the properties of the ontology. It is also formally expressed

as knowledge representation of concepts and relationships of those concepts [14].Ontology provides a common understanding of specific domains that can be communicated between people and application systems. Ontologies can be used to [10]:

- Share a common understanding of the structure of information.
- Enable reuse of already existing domain knowledge instead of creating a new one.
- Make domain assumptions unambiguous
- Examine domain knowledge.

Ontology consists of four main components to represent a domain [14]. They are:

- Concept represents a set of entities within a domain.
- Relation specifies the interaction among concepts
- Instance indicates the concrete example of concepts within the domain
- Axioms denote a statement that is always true.

Ontologies allow the semantics of a domain to be expressed in a language understood by computers, enabling automatic processing of the meaning of shared information [17]. Ontologies are a key element in the Semantic Web, an effort to make information on the Internet more accessible to agents and other software.

2.2. Fuzzy Logic

Fuzzy logic is a logic that emulates the human thinking, cognition and inference and it is designed in a way such that it can be processed by a computer [13]. Fuzzy logic is the theory of fuzzy sets, sets that express uncertainty. Fuzzy logic is based on the concept of membership degrees. Fuzzy set theory mimics the human perception in its application of vagueness and impreciseness to make decisions. It was designed to mathematically represent uncertainty for dealing with the inbuilt vagueness in some domains. Fuzzy logic is based on the mathematical concepts for depicting knowledge based on degrees of membership. The classical logic is comprised of only two values i.e. true and false and has its constraints in dealing with problems related to the real world domain. Fuzzy logic uses a continuum of logical values between 0 and 1. It rests on the idea that things can be partly true and partly false at the same time.

2.2.1. Fuzzy set theory

In the fuzzy theory, fuzzy set A of universe X is defined by a membership function. It is denoted by $\mu_A(x)$ such that

$$\mu_A(x): X \rightarrow [0, 1]$$

$$\mu_A(x) = \begin{cases} 1 \text{ if } x \text{ is totally in } A \\ 0 \text{ if } x \text{ is not in } A \\ 0 < \mu_A(x) < 1 \end{cases}$$

This definition of set allows a continuum of possible choices. For any element x of universe X, membership function $\mu_A(x)$ equals the degree to which x is an element of set A. This degree, a value between 0 and 1, represents the degree of membership, also called membership value, of element x in set A.

2.2.2. Linguistic Variables and Hedges

In everyday life, natural human language comprises of the terms such as "fast", "old" and "ugly". Such terms are known as the linguistic variables in the Fuzzy set theory. The values of linguistic variables are words and not numerals. The objective of using linguistic variable is to supply means of approximate description of occurrences that are not defined accurately and precisely [19]. Such basic terms in language are frequently changed using adverbs and adjectives such as slow, lightly, moderately, fairly, very etc. Such words are known as linguistic hedges. The linguistic hedges impact and modify the membership function for the linguistic variables.

2.3. Crisp Ontology

A crisp ontology is a precise (i.e., binary) specification of a conceptualization. In other words, it is an enumeration of the accurate concepts and exact relationships that prevail for any information assemblage. In crisp ontology, the domain knowledge [6] is organized in terms of

- concepts (O)
- properties (P)
- relations (R)
- axioms (A)It is formally defined as a 4 – tuple O = (C, P, R, A) where:

- C is a set of concepts defined for the domain. A concept corresponds to a class.
- P is a set of concepts properties
- R is a set of twofold semantic relations defined between the concepts in C.
- A is a set of axioms and it is a real fact or a reasoning rule.

2.4. Fuzzy Ontology

Fuzzy ontologies are an extension of crisp ontologies of a particular domain for resolving the uncertainty or inaccuracy problems. Impreciseness and inaccuracies are often encountered in the present systems [6]. Fuzzy ontology aims to:

- encapsulate the vagueness in itself. adapt the uncertainties and bring forth a view which is machine processable and interpretable. A fuzzy ontology is a 7-tuple $O_F = (C, P, C_F, P_F, R, R_F, As, As_F, A)$ where:
- C is a set of crisp concepts defined for the domain.
- P is a set of crisp concept properties.
- C_F is a set of fuzzy concepts
- P_F is a set of fuzzy concept properties
- R is a set of crisp binary semantic relations defined between concepts in C or fuzzy concepts in C_F.
- R_F is a set of fuzzy binary semantic relations defined between crisp concepts in C or fuzzy concepts in C_F
- As is a set of crisp binary associations defined between concepts in C or fuzzy concepts in C_F.
- As_F is a set of fuzzy binary associations defined between crisp concepts in C or fuzzy concepts in C_F.
- A is a set of axioms. An axiom is a real fact or reasoning rule.

3. Review of Literature

Protiti Majumdar describes in his paper a general idea about www and search engines and how the semantic web help in information retrieval which is otherwise not possible from other search engines [12].Tim Berners-Lee et al. in their paper coined the idea of the semantic web and described the need of expressing meaning; ontologies; knowledge representation, agents [18].B.Chandrasekaran et al. studied the definition and the need of ontologies. Ontology forms the heart of any system of knowledge representation for that domain [2].Petr Musilek et al. propose a new approach to apply concepts of fuzziness and approximate reasoning to ontologies. The concept of ontology with fuzziness is proposed to represent preferences and acceptance of semantic web services from the perspective of human users [11].Silvia Calegari et al. in their paper illustrate how to insert fuzzy logic during ontology creation using KAON (Karlsruhe Ontology). KAON is an ontology editor. It provides a framework for building ontology-based applications [16].Muhammad Abulaish proposed an ontology enhancement framework to accommodate imprecise concepts. Framework is modeled as a fuzzy ontology structure to represent concept descriptor as a fuzzy relation which encodes the degree of a property value using a fuzzy membership function [9].Maryam Hourali et al. proposed a method for ontology creation based on fuzzy theory with two degrees of uncertainty. Combination of uncertain models and two uncertainty degrees in concept expression and relation expression is the main contribution of this work [8].

Aarti Singh et al. proposed a Fuzzy Integrated Ontology Model which can handle the uncertain information presented by the user in the Web Exploitation [1].Comfort T. Akinribido et al. proposed a Fuzzy-Ontology Information retrieval system (FOIRS) that measures the relevance of documents to users' query based on meaning of dominant words in each document. Fuzzy techniques were applied to rank relevant document. The author emphasizes that user's preference is made easy through the use of fuzzy techniques for efficient ranking [4].

There is still not a standard method to encode or incorporate fuzziness in ontologies. Hence it is an area of active research. The following section presents extension of crisp student ontology to fuzzy student ontology.

4. Implementation

In the present work, a crisp ontology belonging to the student domain has been fuzzified based on the marks obtained by a student in six semesters. The need for fuzzification of marks arises in order to introduce a fair judgment and the result which is based on the fuzzy sets approach could provide better information which portrays the performance of the students and at the same time an alternative way of evaluating performance is introduced. It has been implemented using swings in java for creating the graphical user interface.The input student ontology is taken in the form of an XML document which contains the student attributes such as name, roll no, marks in six semesters and marks in five different extracurricular activities. This XML file is parsed using the DOM Parser in Java. The crisp values are converted to uzzy values, the membership degrees of the various categories and the fuzzy values of the

student's performance are displayed depending upon the marks obtained by the students and the final result sheet is saved in an excel file.
Depending on the marks attained by the student, students are assigned various linguistic variables which determine and indicate the performance level of the student. The linguistic variables chosen provide an accurate judgment of the overall performance of the student in the semester examination. The linguistic terms that are assigned to the students according to the marks obtained and their performance are as given in Table 1.

Table 1. Linguistic variables

Linguistic Variable	Range
Exceptional	90-100
Excellent	80-90
Very Good	75-80
Fairly Good	70-75
Marginally Good	65-70
Competent	60-65
Fairly Competent	55-60
Marginally Competent	50-55
Bad	45-50
Fairly Bad	40-45
Marginally Bad	35-40
Fail	0-35

5. Results and Discussion

The results of fuzzification of a crisp ontology have been tested on student ontology. Result that is based on the fuzzy sets approach could provide better information which depicts the student performance and at the same time an alternative way of evaluating performance is introduced. The results of fuzzification of a crisp ontology have been tested on student ontology. Result that is based on the fuzzy sets approach could provide better information which depicts the student performance and at the same time an alternative way of evaluating performance is introduced. Student marks in the input ontology are taken and are evaluated for performance using the traditional approach. Table 2 illustrates categories to which student belongs according to the marks obtained by students in crisp logic.

Table 2. Student categories in the crisp logic

Average marks of all the semesters	Category of Performance	Performance in the crisp logic
68.3	Marginally	0.68
73.5	Fairly Good	0.74
68.5	Marginally	0.69
94.16	Exceptional	0.94
97.5	Exceptional	0.97

Fuzzification is done at four different levels. In the first level, degree of membership to the various categories of the student in which his marks lie are assigned, thus giving a student a better idea about his performance. Table 3 describes the degrees of membership of students in Category 1.

Table 3. Membership values in Category 1

Average marks obtained in Academics	Category 1	Degree of Membership Value
68.3	Marginally Good	0.66
73.5	Fairly Good	0.7
68.5	Marginally Good	0.7
94.16	Exceptional	0.42
97.5	Exceptional	0.75

At the second level, we assign the degree of membership to the lower category of the student in which his marks lie as depicted in Table 4.

Table 4. Membership values in Category 2

Average Marks Obtained in Academics	Category 1	Membership Value	Category 2	Membership value
68.3	Marginally Good	0.66	Excellent	0.34
73.5	Fairly Good	0.7	Competent	0.3
68.5	Marginally Good	0.7	Marginally Good	0.3
94.16	Exceptional	0.42	Fairly Bad	0.58
97.5	Exceptional	0.75	Marginally Bad	0.25

The third level describes the performance of the student in Academics alone as shown in table 5.

Table 5. Academic Performance

Name	Average Marks	Average difference in performance of all semesters	Final Performance in Academics
Rohan	68.3	8.5	0.65
Rahim	73.5	-10.5	0.713
Rakesh	68.5	17	0.718
Ram	94.16	-.5	0.94
Ravan	97.5	2.5	0.98

At the fourth level, the overall performance of the student including extracurricular activities is described. At this level, marks of the students in both academics as well as extracurricular activities are taken. Performance of the student in both the aspects is calculated and weight age to both the conditions is assigned. Weight age improves the overall performance as a student who is not very good in studies or academics but is good in sports and other extracurricular activities gets a chance to improve his score because a quarter weight age to the marks of a student in extracurricular activities is assigned and 3 quarter weight age to marks of the student in academics is given.

Table 6. Overall Performances

Average Marks in Academics	Extra Curricular Activities average marks	Overall Performance in academics and extracurricular Activities
68.3	52.8	0.65
73.5	62.6	0.69
68.5	36.6	0.62
94.16	52.8	0.84
97.5	44.4	0.84

Figure 1 shows the membership value display and the performance of the student in academics alone and performance including the extracurricular activities.

Student	Category	Membership	Category2	Membership2	PerformanceBasedOnSubjectiveStudy	PerformanceIncludingextraCurricularActivities
Rohan	Marginally Good	0.67	Competent	0.33	0.697	0.655
Rahim	Marginally Good	0.7	Competent	0.3	0.713	0.626
Rakesh	Fairly Good	0.7	Marginally Good	0.3	0.718	0.695
Ram	Exceptional	0.42	Excellent	0.58	0.942	0.838
Ravan	Exceptional	0.75	Excellent	0.25	0.978	0.845

Figure 1. Membership value and Performance

5. Conclusion And Future Work

The vagueness and uncertainty in the human search processes cropped the need of introducing fuzziness and incorporation of the same using fuzzy logic in the ontologies that comprise of one of the most important components of the semantic web. We have designed a system that extends a traditional crisp ontology to fuzzy ontology. Application of fuzzy logic to the student domain has been carried out in this study to introduce better performance measurement criteria. Linguistic variables and hedges have been applied that tries to deliver a fair judgment and lets a student better understand the areas in which he needs to improve depending upon the extent of his performance as evaluated in the given work. By applying the fuzzy logic, students' performance can be better approximated and judged and different aspects can be included which is not possible in crisp logic.

This study determines the performance of a student in a more absolute way. And thus adding fuzziness improvises the present systems of information. Different varieties of domain ontologies can be considered for reuse and extension to fuzzy ontologies in the future.

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