Building a Fuzzy Ontology of Edutainment Using OWL

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Abstract. OWL Web Ontology Language is a W3C recommended Language for representing machine-readable knowledge with more facilities than other knowledge representation languages. In this paper, we present a Use-Case based Fuzzy Ontology Constructing (UFOC) methodology for the building of edutainment ontology, which is encoded with OWL. Besides, a solution of representing fuzzy relation in OWL is also provided. In the edutainment ontology, two fuzzy relations, DE and AE are discovered, both playing vital roles in property calculation among online computer game.

Keywords: Fuzzy Ontology; Edutainment; OWL; Ontology Building.

1 Introduction

Computer games have gained great popularity in recent years, especially within teenagers. Along with prevalence of games, some intelligent scholars realized the significant influence of games on teenagers, and hoped for the combination of game and education. Under such situation, the project "Educational Game for Middle & Primary School Students" (EGMPSS) was carried out, aiming at making students "Learning in playing".

As a widely accepted knowledge representation model, ontology has been used and taken a key role in many software applications. An increasing number of researchers realized, however, the difficulty of describing uncertainty knowledge in ontology. To approach this problem, some pioneers incorporated fuzzy logic into ontology in some domains [1] [2].

Although there are already some papers concerning Ontology building [3], no paper describes how to build Fuzzy Ontology so far. And as a way of representation of knowledge, Ontology has not been applied to game domain yet, not to speak of edutainment. So, the main goal of this paper is providing not only a methodology of building Fuzzy Ontology, but also the Fuzzy Ontology of edutainment itself.

The rest of this paper is organized as following. Section 2 presents some related definitions of Edutainment Fuzzy Ontology. Section 3 gives the way of representing Fuzzy Relation in OWL. Section 4 introduces the UFOC methodology. Section 5 provides a simplified case study. Finally, section 6 concludes this paper and discusses some future work.

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2 Fuzzy Ontology of Edutainment

Firstly, we give some formal definitions related to Edutainment Fuzzy Ontology based on Fuzzy Set theory [4] and our research before going ahead.

Definition 1: Fuzzy Relation. A Fuzzy Relation R is a set of triples {<x, y, $\mu_R(x,y)$> | $x \in X$, $y \in Y$ }. The $\mu_R(x,y)$ is a membership function mapping from universe of discourse X×Y to real number region [0,1]. For every $x \in X$, $y \in Y$, $\mu_R(x,y)$ denotes the membership degree of relation R between x and y.

Definition 2: Damage Effectiveness. Damage Effectiveness (DE) is a Fuzzy Relation between Intelligence and Strength, which means the degree of fitness of the proportion among them. In EGMPSS, the damage to monster is affected by the player's Intelligence and Strength, and vice versa.

Definition 3: Armor Effectiveness. Armor Effectiveness (AE) is a Fuzzy Relation between Intelligence and Dexterity, which means the degree of fitness of the proportion among them. In EGMPSS, the defense against attack is affected by the player's Intelligence and Dexterity, and so does Monster.

Definition 4: Fuzzy Ontology. Fuzzy Ontology in EGMPSS is an extended Domain Ontology, denoted as $\{C, I, R_{ex}\}$. Here, $C = \{C_1, C_2, \ldots, C_m\}$. I is a set of instances of the concepts in C. $R_{ex} = R_n \cup \{DE, AE\}$ where R_n is a set of binary relations among C and I of the domain.

3 Representation of Fuzzy Relation in OWL

According to the above definition, Fuzzy Ontology is an extension of domain ontology. Then, how to represent the membership degree in OWL (or other representation languages) will be an urgent problem to be solved before Fuzzy Ontology could be put to use.

First thought is to extend owl:DatatypeProperty to allow for two domains at the same time. It, however, is impractical. A feasible solution is to build a concept of Fuzzy Relation, which includes two owl:ObjectPropertys: "domain-1" and "domain-2", and one owl:DatatypeProperty: "hasFuzzy_Degree". The two domains denote two universes of discourse in Fuzzy Relation, and "hasFuzzy_Degree" means the corresponding membership degree. Whenever there is a need of an element of Fuzzy Relation, create an instance of this concept and assign specific values for each property.

4 Use-Case Based Fuzzy Ontology Constructing Methodology

There are many suggestions for building domain ontology [5]. Fuzzy Ontology, however, is an extended domain ontology, which involves Fuzzy Information processing. For this purpose, we present a Use-Case based constructing methodology.

The main processes of this methodology are explained as follows.

(1) Use-Case: the basis for guiding ontology construction.
(2) Objects Enumeration: enumerating all objects that may occur in domain.
(3) Categorization: categorizing objects into different concepts.
(4) Concept Tree: reorganizing concepts with "is-a" relation.
(5) Attributes Discovery: discovering appropriate attributes for each concept.
(6) Pruning: eliminating those unnecessary concepts and attributes.
(7) Relations Discovery: finding other right relations among concepts.
(8) Instances Creating: creating necessary individuals for ontology.
(9) DE, AE: building elements of DE and AE from relative individuals.

5 Case Study: The EGMPSS Ontology

In this section, we just give the Use-Case diagram and the hierarchy of core concepts in the EGMPSS due to the restriction of page in length. Both of them may cooperate to present a full picture of the EGMPSS ontology.

5.1 Use-Case Diagram of EGMPSS

In EGMPSS, there are three actors: PC, NPC and Monster. According to the requirements of EGMPSS, we present a Use-Case diagram in Fig. 1.

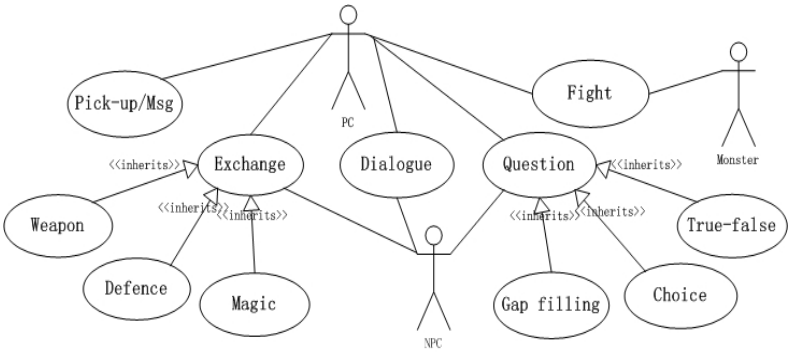

Fig. 1. The Use-Case diagram of EGMPSS

From this diagram, we know that (1) PC can talk to NPC by dialogue to learn knowledge, (2) PC may pick up treasures and read some messages (some knowledge points), and (3) NPC may ask questions in the form of gap-filling, choice and true-false. Questions, dialogues and messages provide full knowledge appeared in the textbooks of middle and primary school, and etc.

5.2 Core Concepts Hierarchy

As EGMPSS is an educational game, naturally, there should be two main series of concepts, one for game, and the other for education. Reflected in concept tree, there are two branches from the top concept, as shown in Fig. 2.

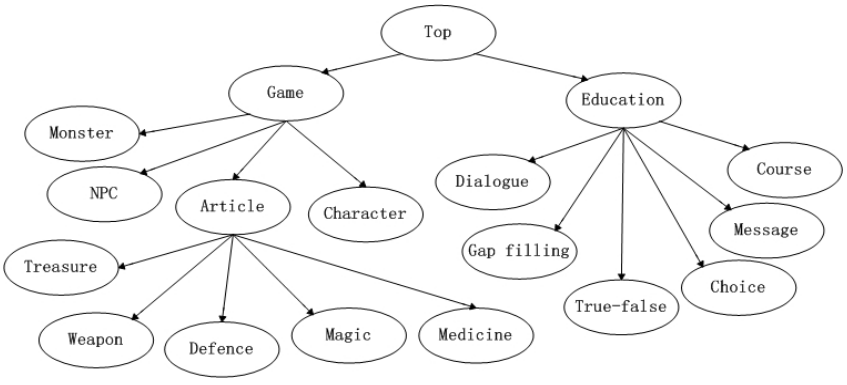

Fig. 2. The hierarchy of Core concepts in EGMPSS Ontology

In the Game branch, all leaves are not the ends of concept tree. They all should be derived out more special concepts. For instance, there are certainly some kinds of monsters, each kind being a concept. And so do other leaves. While in the education branch, each concept leaf means one mode for providing knowledge. There is no need to be further subdivided.

6 Conclusions

In this paper, we have proposed a Use-Case based methodology for constructing Fuzzy Ontology, and provided a Fuzzy Ontology that has come into use in EGMPSS. Besides, representation Fuzzy Relation in OWL is also introduced. All these work would be much useful for guiding Fuzzy Ontology building to engineers.

However, there are still some problems to be solved. For example, establishing inference rules on Fuzzy Ontology to enable intelligent query and making the Fuzzy Ontology well accepted are all important and beneficial work.

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