An Ontology Approach To Represent User Profiles In E-Learning

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Abstract

E-Learning is a process in which electronic medium is used to access the defined set of applications and processes. In E-Learning environment, studies of the behaviors of the learner are essential to provide an adaptive E-Learning system. Ontology has the potential to play an important role in representing an area of knowledge. This paper proposes ontology to classify learner profile based on their activities and personal information. Two specific examples were designed to show the automatic classification of learner profile. Experiments were performed using the OWL reasoner Pellet and editor Protégé 4.2 beta version. The results of our performance evaluation show that the ontology is able to classify and locate learner profile, according to the desired area, age, interest, profession etc.

1. Introduction

E-Learning refers to online learning or distance learning which allows users to access electronic learning contents delivered over internet or intranet [1]. It uses technology to enable people to learn anytime and anywhere. The challenge in an information-rich world is not only to make information available to people at any time, at any place, and in any form, but to offer the right thing to the right person in the right way. The rapid increase of learning content on the Web will be time-consuming for learners to find contents they really want to and need to study [2].

The success of any E-Learning system depends on the retrieval of relevant learning materials according to the requirement of the learner. Without knowing anything about the learner, a system would perform in exactly the same way for all learners. The basic requirements of the learner can be obtained by analyzing the learner profile.

A learner profile describes the ways in which a student learns best. A comprehensive learner profile includes information on student interests, learning preferences and styles, and differences related to gender, culture and personality. It also might include information on student learning strengths, needs and types of supports that have been successful in the past. A learner profile needs to be dynamic, as individual learners are constantly growing and changing [3]. An extensive learner profile must contain information about the learner's domain knowledge, the learner's progress, preferences, goals, interests and other information about the learner, which is important for the used systems.

User profiling is commonly employed nowadays to enhance usability as well as to support personalization, adaptivity and other user-centric features. This leads to the development of the adaptive E-Learning system to provide learning materials considering the requirements and understanding capability of the learner [4].

The adaptive E-Learning system focuses on how the profile data is learned by the learner and pays attention to learning activities, cognitive structures and the context of the learning material [2].

In this context, ontologies have the potential to play an important role in defining the terms used to describe and represent the knowledge in learner profile thus providing a common shared understanding of the structure of information among individuals or organizations, to enable reuse of domain knowledge, make domain assumption explicit, to separate domain knowledge from the operational knowledge and to analyze domain knowledge. It includes machine-interpretable definitions of basic concepts in the domain and relations among them [5].

Through ontologies, hierarchical structures of themes related to the learner profile can be defined and also it is possible to add reasoning to this structure in order to help the automatic classification of learner profile within the defined hierarchy.

The remainder sections of this paper are organized as follows: Section 2 presents the related work; Section 3 describes the details of the proposed ontology and its integration with the ontology for the classification of learner profile in E-Learning environment. Section 4 discusses some case studies and Section 5 concludes the paper.

2. Related Work

Some of the research papers which discuss the learner profile are listed as follows:

User profile ontology [6] is created which incorporates concepts and properties used to model the user profile.

Ontologies related to the domain have been used to create this ontology model. This ontology model is available in two different areas, personal information management and adaptive visualization.

User profile modeling method [7] is designed by combining the keywords and the ontology concepts. This model takes into account short-term interest and long-term interest of user profile and verified that this model improve the efficiency of information retrieval.

A new method [8] is proposed to develop user profile in music domain by analyzing user's web access behavior. Items that are high relevance to user interests are identified by proposing ontology based similarity measure.

A fuzzy clustering method [9] combined with optimization techniques are used to construct ontology-based user profiles. This method allows some information to belong to several user profiles simultaneously with different degrees of accuracy.

A fuzzy ontology based user profile [10] is created in E-Learning environments. An algorithm that allows automatic construction of ontology is introduced which shows good representation of the users' preferences.

3. Proposed Ontology

The proposed ontology is developed for learner profile in an adaptive learning support. There is no discipline approach to assign learner activities using relationships among concepts or precise properties. Learner profile is used as a reference in this paper to define the hierarchical structure of ontology. This learner profile includes personal information of a learner such as name, gender, age, contact, education, character etc and learner activities such as ability, activity, interest, preference, profession, style etc. This ontology can be used in the adaptive learning content based on the learner's activities such as learner interest and learner style.

In this proposed ontology development, widely available ontology editor Protégé 4.2 beta is used as a development tools. Many widely available tools used for ontology development includes Ontolingua, Ontosaurus, WebOnto, Protégé, OILEd, OntoEdit etc.

3.1 Development of Ontology

There is no one "correct" way or methodology for developing ontologies. The method for development of ontologies proposed by [5] is followed in this paper. According to the proposed approach, ontology development involves the following six basic steps. The general stages in the design and development of ontology are as follows:

- Step 1 - ENUMERATE IMPORTANT TERMS IN ONTOLOGY

To build learner profile, terms related to learner profile are collected.

- Step 2 - DEFINE THE CLASSES AND THE CLASS HIERARCHY

The main goal of this step is the creation of a set of preliminary concepts and the categorization of those terms into concepts. Using the top-down strategy terms and concepts are tried to fit into the metaconcept.

- Steps 3 & 4 - DEFINE THE PROPERTIES OF CLASSES – SLOTS, DEFINE THE FACETS OF THE SLOTS

This step is used to create relationships between the concepts.

- Step 5: GENERATION OF INSTANCE

3.2 LnPRF: Ontology Representation of Learner profile

This section presents a brief description of the user profile ontology. The ontology may be extended through inheritance and the addition of more classes, as well as concept instantiation according to the needs of a specific application [6].

The general proposed hierarchy is presented in Figure 1. The hierarchy groups the learner profile such as name, gender, age, interest, preference, profession, style etc.

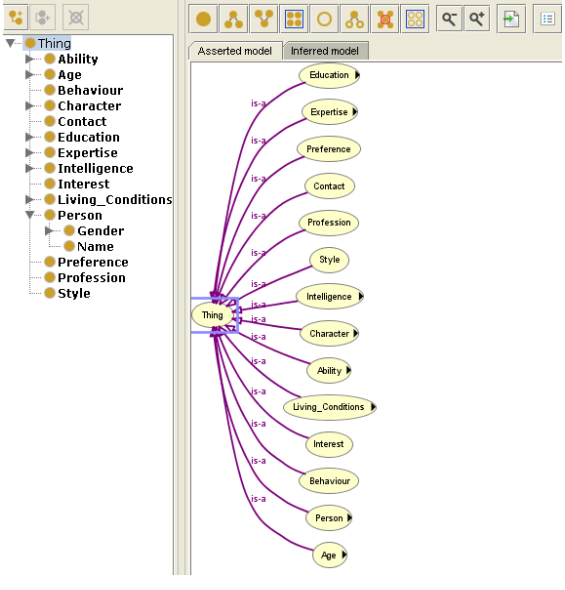

Figure 1. LnPRF general hierarchy

LnPRF was developed with learner and its relationship to the key concepts Behaviour, interest, preference etc.

Some of the relationships and their properties created for these concepts are shown in Table 1.

Table 1. Classes and properties from LnPRF

Domain Class	Range Class	Property	Special Property (inverse)
Name	Age	Has_Age	is_Age_Of
Name	Gender	has_Gender	is_Gender_Of
Name	Interest	has_Interest	is_Interest_Of
Name	Profession	has_Profession	is_Profession_Of
Name	Behaviour	has_Behaviour	is_Behaviour_Of
Name	Style	has_Style	is_Style_Of

The Name class is related to other classes such as Age and Gender using the relation "has Age" and "has_Gender" as shown in Figure 2. Similarly, classes Age and Gender were related to the Name class using "is_Age_Of" and "is_Gender_Of" property.

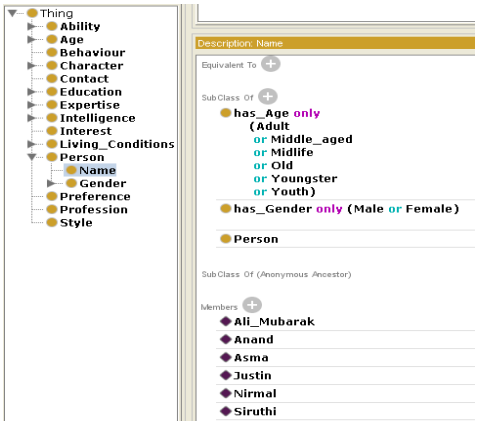

Figure 2: Name class

The Name class is related to other classes such as Interest, Age, Behavior and Style. Furthermore, instance of each names are related to the instance of classes Interest, Age and Behaviour using relationships "has_Interest", "has_Age" and "has_Behaviour" as shown in Figure 3.

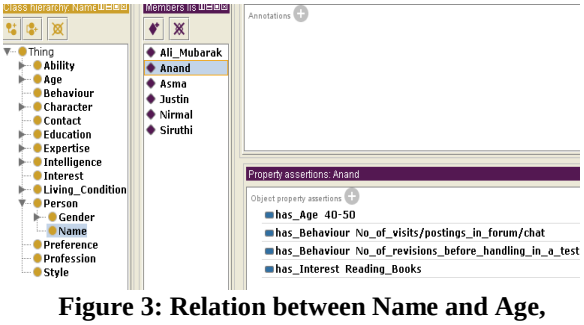

Figure 3: Relation between Name and Age, Behaviour and Interest

The style of the learner can be obtained by analyzing the learner's behavior while utilizing the system. Learning styles typically refer to how a student tends to use senses to learn. Felder-Silverman's learning style categories are classified based on the perception, input processing and understanding is shown in Table 2 [2].

Table 2. Relationship between Learner Behaviour and (FSLSM) category

Parameter	Value	FSLSM Category
No. of visits/postings in forum/chat	High	Active, Verbal
No. of visits and time spent on exercises	High	Active, Intuitive
Amount of time dealt with reading material	High	Reflective
Performance on questions regarding theories	High	Intuitive
Performance on questions regarding facts	High	Sensing
Amount of time spent on a Test	High	Sensing
No. of revisions before handing in a test	High	Sensing
No. of performed tests	High	Sensing
No. of visits and time spent on examples	High	Sensing
Amount of time spent on contents with graphics	High	Visual
Performance in questions related to graphics	High	Visual
Performance on questions related to overview of concepts and connections between concepts	High	Global

The Behaviour class was created to represent the behaviour of the learner. The Behaviour class has direct relationship with the Style class through the "has_Style property as shown in Figure 4.

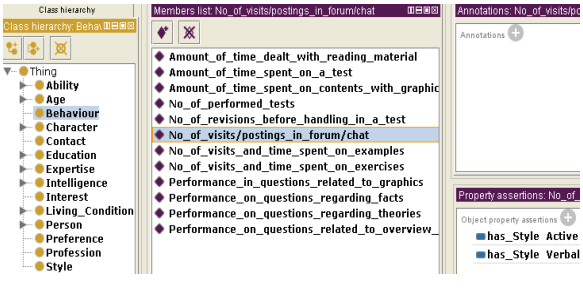

Figure 4: Relation between Behaviour and Style

4. RESULTS

The proposed ontology could be used in the E-Learning environment to classify the learner profile based on their interest, age etc. This ontology will help the researchers in two areas. First, it will help to classify the learning profile based on the personal information. Second, it will assist to find the learner style based on the learner behavior in utilizing the system. These two cases have been explained with help of proposed ontology in the following sections. The simulations were created using the Protégé 4.2 beta tool. The Pellet reasoner was used to classify the learner profile.

Case 1 – Learner Profile Classification

Below table 3 shows the values assigned to the name class for each of the learner information such as Age, Interest, Behavior and Profession.

Table 3. Values assigned to the name class

Name	Age Group	Interest	Behavior	Profession
Ali Mubarak	11-16	Playing Music, Reading Books	No of performed tests	Student
Anand	40-50	Reading Books	No of visits/postings in forum/chat, No of revision before handling in a test.	Network Analyst
Asma	17-21	Reading Books	No of visits and time spent on examples, Performance on questions regarding theories.	Student
Justin	30-40	Playing Music	No of visits and time spent on examples, Performance in questions related to graphics, Performance on questions regarding theories.	Student
Nirmal	30-40	Swimming	Performance on questions related to overview of concepts, Performance on questions regarding facts, No of visits/postings in forum/chat.	Student
Siruthi	8-10	Sports	Performance on questions regarding theories, Performance in questions related to graphics, Performance on questions regarding facts, No of visits and time spent on exercises.	Student

SPARQL was used to simulate a sample of these cases possibilities. The SPARQL is an RDF query language, that is, a query language for databases, able to retrieve and manipulate data stored in Resource Description Framework format [11]. Figure 5 shows the result obtained using SPARQL query which retrieves learner name, age group and interest.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ont: <http://www.semanticweb.org/justin/ontologies/2013/1/untitled-ontology-11#>
SELECT ?Name ?LearnerAgeGroup ?LearnerInterest
        WHERE {
            ?Name ont:has_Age ?LearnerAgeGroup.
            ?LearnerAgeGroup rdf:type ?Group.
            ?Group  rdfs:subClassOf ont:Age.
            ?Name ont:has_Interest ?LearnerInterest.
            ?LearnerInterest rdf:type ont:Interest.
            }
```

Name	LearnerAgeGroup	LearnerInterest
Ali_Mubarak	11-16	Playing_Music
Ali_Mubarak	11-16	Reading_Books
Nirmal	30-40	Swimming
Siruthi	8-10	Sports
Asma	17-21	Reading_Books
Justin	30-40	Playing_Music
Anand	40-50	Reading_Books

Figure 5: Query using SPARQL by Name, Age Group and Interest

Case 2 – Learning Style

Case 2 allows the users to find learner style based on the learner behavior. Figure 6 shows the result obtained using SPARQL query which retrieves learner style based on learner behavior.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ont: <http://www.semanticweb.org/justin/ontologies/2013/1/untitled-ontology-11#>
SELECT ?LearnerName ?LearnerBehaviour ?LearnerStyle
        WHERE {
            ?LearnerName rdf:type ont:Name.}
            ?LearnerName ont:has_Behaviour ?LearnerBehaviour.
            ?LearnerBehaviour ont:has_Style ?LearnerStyle.
            ?LearnerStyle rdf:type ont:Style.
            }
```

LearnerName	LearnerBehaviour	LearnerStyle
Justin	No_of_visits_and_time_spent_on_examples	Sensing
Asma	No_of_visits_and_time_spent_on_examples	Sensing
Anand	No_of_revisions_before_handling_in_a_test	Sensing
Ali_Mubarak	No_of_performed_tests	Sensing
Siruthi	No_of_visits_and_time_spent_on_exercises	Active
Siruthi	Performance_on_questions_regarding_facts	Sensing
Nirmal	Performance_on_questions_regarding_facts	Sensing
Nirmal	No_of_visits/postings_in_forum/chat	Active
Anand	No_of_visits/postings_in_forum/chat	Active
Justin	Performance_in_questions_related_to_graphics	Visual
Siruthi	Performance_in_questions_related_to_graphics	Visual
Siruthi	No_of_visits_and_time_spent_on_exercises	Intuitive
Siruthi	Performance_on_questions_related_to_overview_Global	
Nirmal	Performance_on_questions_related_to_overview_Global	

Figure 6: Query using SPARQL by Name, Behavior and Style

Below Figure 7 shows the result obtained by filtering learner style "Sensing" using the statement "Filter" in SPARQL.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ont: <http://www.semanticweb.org/justin/ontologies/2013/1/untitled-ontology-11#>
SELECT ?LearnerName ?LearnerBehaviour ?LearnerStyle
        WHERE {
            ?LearnerName rdf:type ont:Name.
            ?LearnerName ont:has_Behaviour ?LearnerBehaviour.
            ?LearnerBehaviour ont:has_Style ?LearnerStyle.
            ?LearnerStyle rdf:type ont:Style.
            FILTER regex(str(?LearnerStyle), "Sensing") }
```

LearnerName	LearnerBehaviour	LearnerStyle
Justin	No_of_visits_and_time_spent_on_examples	Sensing
Asma	No_of_visits_and_time_spent_on_examples	Sensing
Anand	No_of_revisions_before_handling_in_a_test	Sensing
Ali_Mubarak	No_of_performed_tests	Sensing
Siruthi	Performance_on_questions_regarding_facts	Sensing
Nirmal	Performance_on_questions_regarding_facts	Sensing

Figure 7: Query using SPARQL using Filter

5. Conclusion

This paper proposed ontology to automatically classify learner profile related to the E-Learning environment. Main structure of learner profile was used to define the ontology. Also, concept and relationships among the classes such as Age, Interest, Profession, and Behavior etc are defined.

Some experiments were performed to automatically classify the learner profile in the E-Learning environment. Furthermore, the ontology provides views of the learner style based on the behavior of the learner.

This ontology can be used in adaptive learning system to provide learning materials based on the learner activities. This ontology can be extended using fuzzy logic by adding membership values to each terms and also fuzzy relation between those terms.

6. References

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