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Semantic retrieval based on SPARQL and SWRL for learner profile

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Abstract- E-Learning is the use of electronic media to access a wide set of applications and processes. Information retrieval is the important work for learner profile in e-learning environment. Ontology-based semantic retrieval is a hotspot of current research. Ontologies have the potential to play an important role to represent an area of knowledge. This paper proposes an ontology based semantic retrieval using Resource Description Framework (RDF). First, we apply RDF/RDFS data model to represent learner profile information on the Semantic Web. Then, apply semantic query expansion in SPARQL (Simple Protocol and RDF Query Language) query language and rule using SRWL (Semantic Web Rule Language). The experiments were achieved using the editor Protégé 4.2 beta and the OWL reasoner Pellet. The result shows that the retrieval of learner profile information can be achieved from the created ontology on the Semantic Web.

Keywords- Learner Profile, SPARQL, OWL2, SWRL, Protégé 4.2 beta, Semantic Web

1. INTRODUCTION

With the development of World Wide Web (WWW), technology based technology has been widely used in learning environments such as universities and companies. Technology based technology includes Internet, satellite broadcasts, video and audio conferencing, chat rooms, Internet conferencing, e-bulletin boards, computer-based instruction etc. This technology provides easy content access, virtual classroom participation, self paced training, full scalability, and timely dissemination of up-to-date detailed knowledge and information and streamlined and effective online delivery [1].

The main challenge faced by this technology is waste of time in searching the learning content compatible with knowledge background, accepting individuals with disabilities, technology incompatibility, lack of credibility and high development costs [1].

The success of any technology based learning system depends on the retrieval of appropriate learning contents according to the requirements and understanding ability of the Learner. 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 [2].

In order to satisfy the requirements of the learner, learner profile is required to reflect on his or her learner needs. Learner profile acts as a most desirable and effective method of selecting information and services that fit users' needs and requirements. It also helps in the process of matching users' profiles against information retrieved from the web.

A user profile plays a significant role in a process of identifying users' points of view for the purposes of access and retrieval to information.

One of the main issues to take into account in the process of constructing learner profiles is the notions of the Semantic Web. 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 [2]. Ontology based semantic retrieval is a hotspot of current research.

Ontologies have proved to be successful in expressing information in machine-processable representation. Ontology is described as a specification of conceptualization, the conceptual specification of a particular domain of interest.

The ontological representation of the user profile enhances the performance of variety of tasks such as filtering, information retrieval, classification, information management etc.

The remainder sections of this paper are organized as follows: Section 2 presents the related work; Section 3 gives learner profile information model; Section 4 studies the semantic retrieval using SPARQL query language and SWRL rule language and Section 5 concludes the paper.

2. RELATED WORK

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

A user profile ontology model [3] is created using concepts and properties and applied to two different areas, personal information management and adaptive visualization. A new method [4] of ontology based similarity measure is proposed to identify the terms that are relevant to user interest. This user profile is developed in music domain by analyzing the user's web access behavior. A user profile modeling method [5] is designed by taking into account short-term and long term interest of the user. This model combines the keywords and the ontology concepts which was verified that this model improve the efficiency of information retrieval. An ontology based user profile [6] is created using fuzzy clustering method and optimization techniques. This method clusters some information of user to belong to different profile simultaneously with different degrees of accuracy. An automatic construction of fuzzy ontology based user profile [7] is created in E-Learning environment which proves as a good representation of the users' preferences. A fuzzy semantic retrieval for Electronic Commerce [8] is proposed using RDF and fuzzy ontology.

The next section discusses the proposal of a learner profile information model.

3. LEARNER PROFILE INFORMATION MODEL

The idea of Semantic Web came from Tim Bemers- Lee in his vision to move the web into a new generation, where the web resources are annotated with meaning in a form that machines can understand [8]. The Semantic Web is the extension of the World Wide Web that enables people to share content beyond the boundaries of applications and websites [9].

A. Ontology

Ontologies allow the semantics of a domain to be expressed in a language understood by computers thereby enabling automatic processing of the meaning of shared information. It is the key element in the Semantic Web, an effort to make information on the Internet more accessible to agents and other software [2]. It can be considered a central structure that can reduce some conceptual confusion (due to the high level of formalization) and it may be useful to share information with people (or agents) from different points of view.

B. Ontology Languages

The Semantic Web is to be realized through a shared infrastructure consisting of languages and tools for knowledge representation and processing [8]. Semantic Web relies heavily on formal ontologies to structure data for comprehensive and transportable machine understanding [10]. There are several knowledge representation format proposed to develop ontology.

a) *RDF(S)*

It uses Uniform Resource Identifier (URI) for expressing relationship between objects (triples). It allows for the mixing, exposing, and sharing of structured and semi structured data across different applications. It allows the definition of classes, the relations between them and semantic constraints on RDF. In a graphical representation of an RDF statement [8], the source of the relationship is called the subject, the labeled arc is the predicate (also called property), and the relationship's destination is the object.

b) *OWL*

The OWL Web Ontology Language [11] is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics. OWL has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Full.

OWL builds on RDF and RDFS, and like them, it is constructed from XML tags. The OWL tags that correspond to data modeling constructs include the following [12]:

Entity Class: <owl: class rdf: id=" " >

Attribute: <owl: data type Property rdf: id="….">

Relationship: <owl: object Property rdf: id="….">

c) *OWL2*

It is the logical extension of OWL. It deals with weaknesses in OWL expression and integrates features requested by users. It has 3 variations: EL, QL, RL. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents. OWL 2 ontologies can be used along with information written in RDF, and OWL 2 ontologies themselves are primarily exchanged as RDF documents.

The OWL 2 tags that correspond to data modeling constructs include the following:

```
<Class Assertion>
<Class IRI="Person"/>
<Named Individual IRI="Anand"/>
</Class Assertion>
<Object Property Assertion>
 <Object Property IRI="#has_ Interest"/>
 <Named Individual IRI="#Anand"/>
 <Named Individual IRI="#Reading_ Books"/>
 </Object Property Assertion>
 <Data Property Assertion>
 <Data Property IRI="#has_ Weight"/>
 <Named Individual IRI="#Asma"/>
 <Literal data type IRI="& rdf; Plain Literal">70</Literal>
 </Data Property Assertion>
 <Data Property Assertion>
 <Data Property IRI="#has_ Height"/>
 <Named Individual IRI="#Justin"/>
 <Literal data type IRI="& rdf; Plain Literal">6 feet
</Literal>
 </Data Property Assertion>
 <Data Property Assertion>
s
```

d) *Query Languages*

Query languages have been proposed for retrieving information from ontology repositories. Eg., SPARQL, SeRQL, RDQL. Most have similarities with SQL.

This paper proposes SPARQL technology to operate with ontologies. It is a language and a protocol, to perform queries and treatment which results in semantic documents. These documents not necessarily are ontologies. Many file formats can be used as database-level knowledge. Despite the semantic differences, the original idea is to have a SQL language of relational databases to semantic and for this purpose, SPARQL has contributed to the ontologists.

e) Rule Languages

Rule language adds expressive extensions to ontology languages. Eg., E.g: SandArea(?x), SeaArea(?y), is Adjacent(?x, ?y)-> Beach(?x). Standard languages such as Rule ML, SWRL have been defined. Other rule languages are offered by reasoning engines Such as Jena, OWLIM, Pellet, Hermit etc.

This paper proposes SWRL as rule language and the reasoning engine as Pellet. The Semantic Web Rule Language (SWRL) [13] is an expressive OWL-based rule language. It provides more powerful deductive reasoning capabilities than OWL alone. It is built on the same description logic foundation as OWL. It provides similar strong formal guarantees when performing inference.

Protégé 4 [14] offers a number of reasoning engines in its standard distribution. The Pellet Reasoner Plug-in, version 1.0, makes Pellet 2 available in Protégé 4, including Pellet's unique capabilities: data type reasoning, SWRL support, etc. Pellet (incremental) option is available which will then automatically check the consistency of the ontology each time a entity change is made to the ontology.

C. Web Protégé

Web Protégé [15] is a free, open source collaborative ontology development environment for the Web. It provides the following features such as support for editing OWL 2 ontologies, a default simple editing interface used to access commonly used OWL constructs, full change tracking and revision history, collaboration tools such as, sharing, permissions and customizable user interface. It provides multiple formats for upload and download of ontologies (supported formats: RDF/XML, Turtle, OWL/XML, OBO, and others). Protégé is the leading OWL ontology development environment for both commercial and academic uses.

Some of the widely used ontology development tools include Ontolingua, Ontosaurus, Web Onto, Protégé, OntoEdit etc. In this area of ontology development, ontology editor Protégé 4.2 beta is used as an appropriate language and development tools as it is widely available.

D. Ontology Representation of Learner Profile

Ontology is used to define a set of representational primitives which model a domain of knowledge. It consists of four main components to represent a domain. They are:

- Classes: which represent a set of objects within a domain
- Properties: which express attributes and relations between classes and objects
- Constraints: for expressing logical consistency
- Individuals: atoms (objects) which are members of a class

This specification is structured between a set of objects, relationships and instances. The objects, or classes, describe the existing concepts, while the relationships suggest and formalize the inter-relationships between concepts. There are properties that can be types of relationships between concepts or, in the case of concepts, internal features (object properties). Instances, or also called as individuals, are the elements of each class. Therefore, the ontology can sort and organize the existing knowledge about a given area in a structure that can be readable both by machines and by people.

To develop it, we used the Protégé tool. In this project, the editor used is based on frames, i.e., the development ontology is a concept hierarchy form, where each term is a class, where we have: classes, instances and relationships between these objects.

The general proposed hierarchy is presented in Fig 1. The hierarchy groups the learner profile as static and dynamic. Static data includes name, gender, age, contact, education, height, weight, preference, profession etc and dynamic data includes behavior, interest and style.

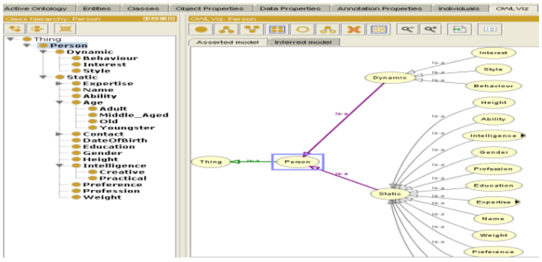


Fig 1: Protégé view of the model concepts

Interrelationship between classes and instances can be created using object properties and data properties.

Each network node is a concept. These nodes are related with each other through arcs that describe their meanings (predicates, which compose the semantics). These arcs are called technically as "object properties". Some of the relationships and their properties created for these concepts are shown in Table 1.

TABLE 1: CLASSES AND PROPERTIES

Domain Class	**Range Class**	**Property**	**Special Property (inverse)**
Name	Ability	Has_ Ability	is_ Ability_ Of
Name	Gender	has_ Gender	is_ Gender_ Of
Name	Education	has_ Interest	is_ Interest_ Of
Name	Profession	has_ Profession	is_ Profession_ Of
Name	Behaviour	has_ Behaviour	is_ Behaviour_ Of
Behaviour	Style	has_ Style	is_ Style_ Of
Name	Intelligence	Has_ Intelligence	Is_ Intelligence_ Of

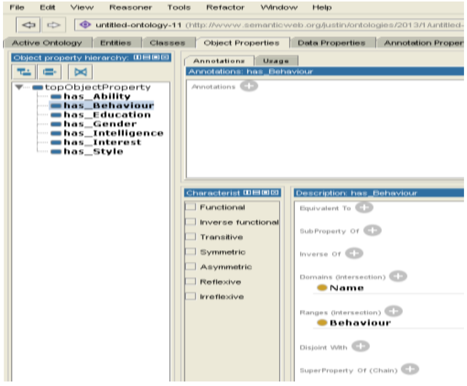


Fig 2: Object Properties

Data Properties displays the hierarchy of data properties based on subPropertyOf assertions. Data properties created for the concepts are shown in the below Fig 3.

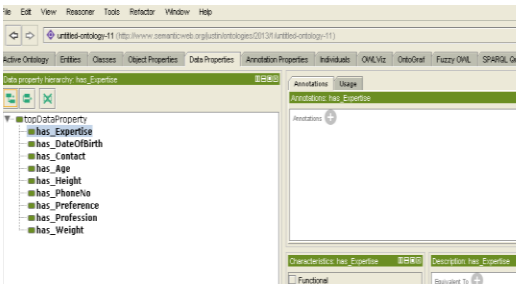


Fig 3: Data Properties

Instance of each Name class is related to the instance of classes Ability, Behaviour, Gender, Interest using Object Property assertions. Similarly, Weight, Profession, Age and Height are related using data property assertions as shown in Fig 4.

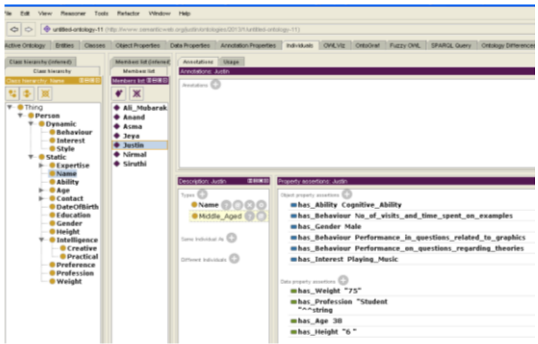


Fig 4: Relation between Name and object property and data property assertions

Learning styles typically refer to how a student tends to use senses to learn. The style of the learner can be obtained by analyzing the learner's behavior while utilizing the system. The model of Felder-Silverman's learning style categories are classified based on the perception, input processing and understanding is shown in Table 2 [16].

The Behaviour class is created under Dynamic class to represent the behaviour of the learner. The parameter mentioned in the above table is created and has mapped with style using the property "has_Style" as shown in Fig 5.

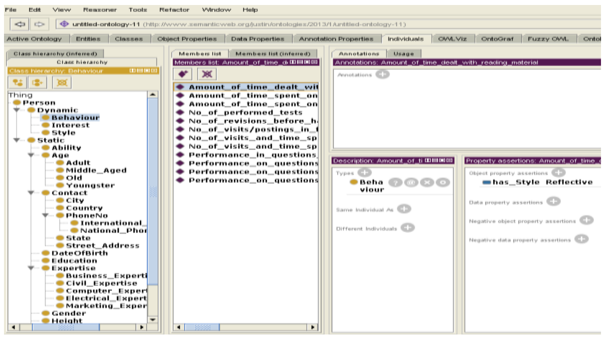


Fig 5: Relation between "Parameter" and "Style"

4. SEMANTIC RETRIEVAL OF LEARNER PROFILE INFORMATION USING SPARQL AND SWRL

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

A. SPARQL

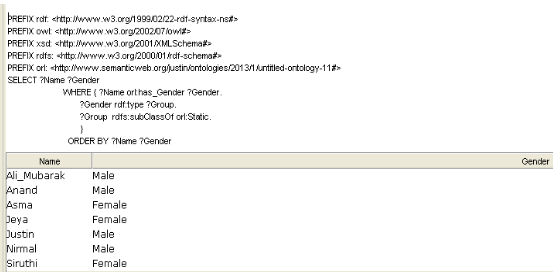
Semantic retrieval or conceptual search, i.e., search based on meaning rather than just character strings, has been a hotspot in the information retrieval (IR) field along with the Semantic Web [8]. One way to view a semantic search engine is as a tool which allows formal ontology-based queries (e.g., in SPARQL, RDQL, RQL etc.) from a client. This query is executed against the knowledge base (KB), which returns a list of tuples of ontology values that satisfy the query [8].

The SPARQL query language for RDF provides Semantic Web developers with a powerful tool to provide access to large scale storage. It is able to retrieve and manipulate data stored in Resource Description Framework format The SPARQL has been proposed by the World Wide Web Consortium (W3C) and has recently achieved the candidate recommendation status. SPARQL is a language designed to query data for RDF graphs which is a finite set of triples of the form (subject, predicate, object).

The overall structure of the language, from a syntactic point of view resembles the syntax of Structured Query Language (SQL). It consists of three main blocks:

- A WHERE clause, to define graph patterns to find a match for in the query data set.
- A FROM clause, which specifies the sources or datasets to be queried.
- A SELECT clause, used to select data from the query data set to determine which subset of the selected data is returned.

SPARQL was used to simulate a sample of these cases possibilities. Fig 6 shows the result obtained using SPARQL query which retrieves Name and Gender.

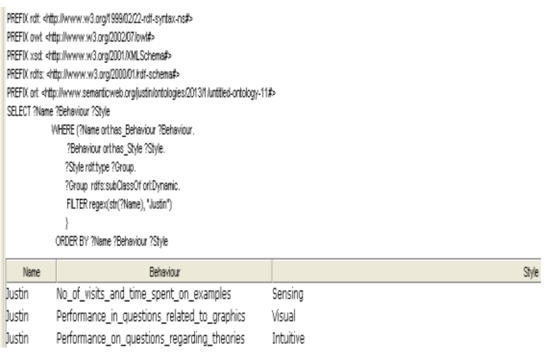


```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX orl: <http://www.semanticweb.org/justin/ontologies/2013/1/untitled-ontology-11#>
SELECT ?Name ?Gender
        WHERE { ?Name orl:has_Gender ?Gender.
            ?Gender rdf:type ?Group.
            ?Group  rdfs:subClassOf orl:Static.
            }
        ORDER BY ?Name ?Gender
```

Name	Gender
Ali_Mubarak	Male
Anand	Male
Asma	Female
Jeya	Female
Justin	Male
Nirmal	Male
Siruthi	Female

Fig 6: Query using SPARQL by Gender

Fig 7 shows the result obtained using SPARQL query which retrieves learner style based on learner behaviour.



```
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 orl: <http://www.semanticweb.org/justin/ontologies/2013/1/untitled-ontology-11#>
SELECT ?Name ?Behaviour ?Style
        WHERE {?Name orl:has_Behaviour ?Behaviour.
          ?Behaviour orl:has_Style ?Style.
          ?Style rdf:type ?Group.
          ?Group  rdfs:subClassOf orl:Dynamic.
          FILTER regex(str(?Name), "Justin")
          }
        ORDER BY ?Name ?Behaviour ?Style
```

Name	Behaviour	Style
Justin	No_of_visits_and_time_spent_on_examples	Sensing
Justin	Performance_in_questions_related_to_graphics	Visual
Justin	Performance_on_questions_regarding_theories	Intuitive

Fig 7: Query using SPARQL by Behaviour and Style

B. SWRL (Semantic Web Rule Language)

The OWL 2 language is not able to express all relations. The expressivity of OWL can be extended by adding SWRL rules to ontology. Protege OWL editor supports SWRL rules, and the reasoners Pellet and Hermit also support SWRL rules. Pellet reasoner can only allow own SWRL built-ins [17]. Below Fig 8 shows the SWRL rules applied to the constructed ontology.

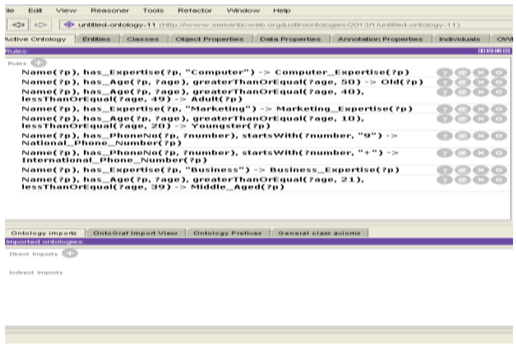


Fig 8: SWRL Rules

The search engine completes semantic matching of retrieval conditions through ontology reasoning for the user's search request, then finds out the eligible data set. Fig 9 &10 shows the results after applying the SWRL Rules. Eg., Age of the person is automatically classified in to “Adult”, “Middle Aged”, “Old” and “Youngster”. Phone Number is classified into “International Phone Number” and “National Phone Number”.

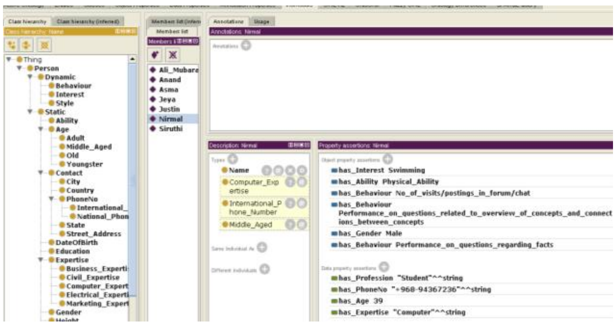


Fig 9: SWRL Rule for Expertise, Phone No and Age

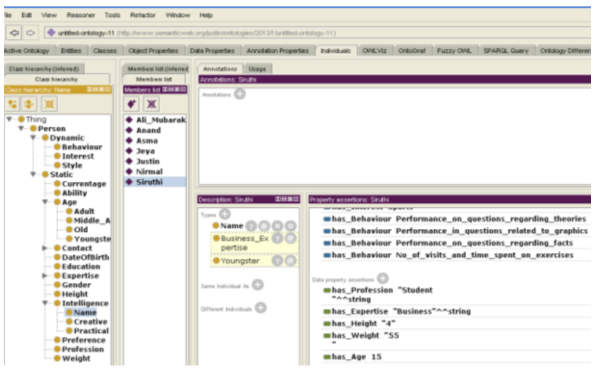


Fig 10: SWRL Rule for Expertise and Age

Below Fig 11shows the result of the SWRL rule applied to the members “Anand” and “Nirmal” of the concept “International Phone Number”.

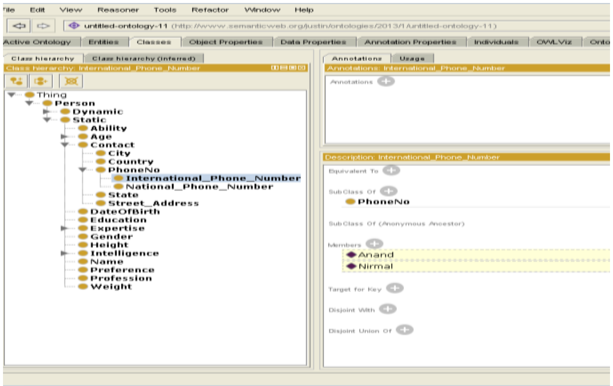


Fig 11: SPARQL Rule for “International Phone Number”

5. CONCLUSION

The Semantic Web extends current web to recognize the meaning of information in web documents. This paper proposes ontology to automatically classify learner profile based on the static and dynamic data of the learner. Main concepts and their relationship have been defined using object and data properties. Moreover, proper instances also defined for the created concepts. Furthermore, the ontology provides views of the learner style based on the behavior of the learner.

Some experiments were performed for the semantic retrieval of learner profile data from the constructed ontology using SPARQL. In addition SWRL rule is used to express all relations that cannot be expressed by the OWL.

Future enhancement includes incorporating the fuzzy concepts, fuzzy relations, and fuzzy linguistic variable ontology in order to represent uncertainty information found in the typical ontology.

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