

BUILDING RULES BASED SOIL CLASSIFICATION ONTOLOGY

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Abstract—Soil classification for engineering purpose based on ASTM D2487-06 has many levels of hierarchy and there is distinct possibility of increase in hierarchy levels in future. Soil classification for engineering purpose inevitably requires evaluation of mathematical expressions. Ontology is formal explicit description of knowledge in form of concepts and their relationships [1]. It enables to share the common understanding of the domain knowledge. It also enables humans and machines to interpret the meaning and collaborate with other entities in a meaning manner depending upon the context. In this paper a step by step procedure is explained for building rules based engineering classification of soils using Protégé knowledge acquisition system and swrl. Query interface for fetching data relevant data in the ontology is explored.

Keywords-owl;swrl;rdf;sparql;protege;ontology[3]

I. INTRODUCTION

Engineering soil classification as per ASTM-STANDARD PRACTICE FOR CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSE (UNIFIED CLASSIFICATION SYSTEM) D2487-06 [2] there are many levels in the classification hierarchy. In future also the possibility of increase in the levels of taxonomy is distinct. To classify and to know the approximate engineering behavior of soils is a daunting task for a geotechnical engineer who is in the field.

Ontology is a model of any bounded region of interest expressed as concepts, relationships, and rules about constructs and associations of interest to a modeller [5]. Ontology provides the shared understanding of the domain. With the advent of semantic web technologies (OWL, RDF, SPARQL, SWRL) it is possible for machines and humans to interpret and collaborate with other entities in a meaningful manner.

More over the tools are now available for modeling of the domain knowledge. The domain experts can now use these tools for solving different problems

Geotechnical engineers can make use of these tools to encode their knowledge by developing ontology in form of concepts and their relationships using simple to use tools like Protégé.

Development of ontology for engineering purpose inevitably involves evaluation of mathematical expressions, hence there is a need for developing a rule based ontology.

A step by step process involved in development of the rules based ontology for classification and verification of the result

is put forward in this paper using protégé tool which is widely used by researchers.

II. BUILDING RULE BASED ONTOLOGY

Building of rule based ontology comprises of the following steps

- A. The details in the problem space are described using mind map
- B. Configuration of ontology design tool
- C. Classes and subclasses of the design are enumerated in the ontology design tool.
- D. Creation of properties
 - a. Object Properties
 - b. Data Properties
 - c. Annotation Properties
- E. Giving meaning to concepts
- F. Adding annotations to concepts
- G. Creation of rules
- H. Individual instances are created and data type properties are assigned.
- I. Classification
- J. Queries issued in the ontology for fetching relevant data.

A. Creation Of Mind Map

Before creation of ontology a mind map having concepts and their relationships involved in the ontology to be build is first created. The mind map can be created on a piece of paper or by the use of mind map creation tool.

For example unified soil classification classifies soil samples broadly as coarse grained, fine grained and highly organic. The above example can be illustrated as a mind map as shown in the figure below.

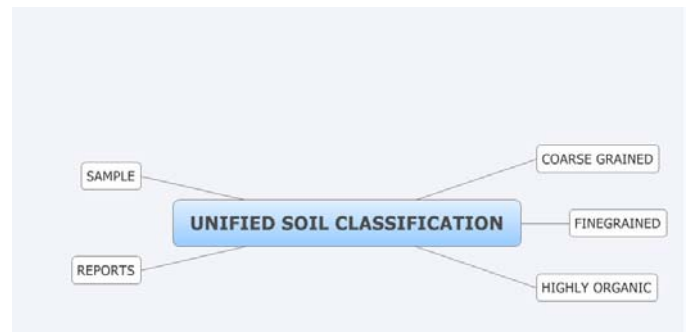


Figure 1 Mind Map showing basic concepts of domain

B. Configuration Of Tool

Latest version of the ontology design tool is downloaded and configured [7]. Following prerequisites can be considered for configuration.

1) Installation of Reasoner

The ontology design tool need to be configured with a reasoner which supports SWRL rules fully. For example in protégé the configuration can be done by using File → Check for plugins and select Pellet Reasoner plug-in.

2) Installation Of Annotation Template:

If there is tool support for annotation template it can be installed. For example protégé has a support for installation of annotation template.

C. Creation of classes and sub classes

The concepts which are mentioned in the mind map are converted into classes and sub classes under Thing super class. If there is tool support for creation of classes and subclasses it can be used. For example in protégé Tools → Create class hierarchy [8] can be used for creation of classes and subclasses

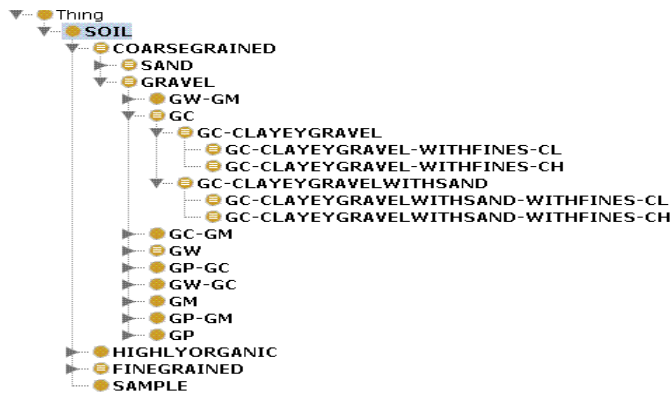


Figure 2 Creation of class hierarchy of soil classification ontology in protégé

In engineering soil classification the hierarchy can be given as SOIL → COARSEGRAINED → GRAVEL → GC → GC-CLAYEYGRAVEL → GC-CLAYEYGRAVELS-WITHFINES-CH

D. Creation of properties

In owl there are three types of properties [8]. They are

1. Object Properties
2. Data type properties
3. Annotation properties

1. Object Properties:

Object provides the relationship between two individuals. For example if some relationship exists between two soil samples then object property is considered. Since such relationship is normally not required, the object property is not considered for engineering soil classification

2. Data Properties:

Data type properties provide the relationship between one individual and data values. For example sample instance “SAMPLE1” can have data property hasPercentageWeightRetainedOnNo200Sieve with value as double.

The Data properties tab in Protégé can used for its creation.[8]

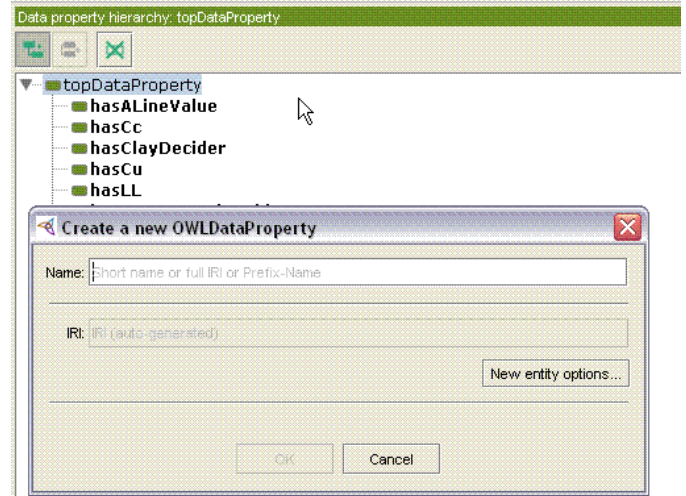


Figure 3 Creation of owl data type property

TABLE I

Some data properties in soil classification

Sr No	DATA PROPERTIES IN SOIL CLASSIFICATION	
	Data Property	Datatype & Description
1	hasPercentageRetainedOnNo200Sieve	Double & User input
2	hasPercentageRetainedOnNo4Sieve	Double & User input
3	hasCc	Double & User input
4	hasCu	Double & User input
5	hasLL	Double & User input
6	hasPL	Double & User input
7	hasPI	Double & Calculated by rule
8	hasPercentageWeightPassingOnNo200Seive	Double & calculated by rule
9	hasALineValue	Double & calculated by rule
10	hasClayDecider	Double & calculated by rule

3. Annotation Properties

Annotation is data about data i.e. Meta data. For example once the engineering classification is done the user may be interested in the engineering properties of the classification. Approximate engineering properties

of the classification can be provided using annotation properties of the class[8].

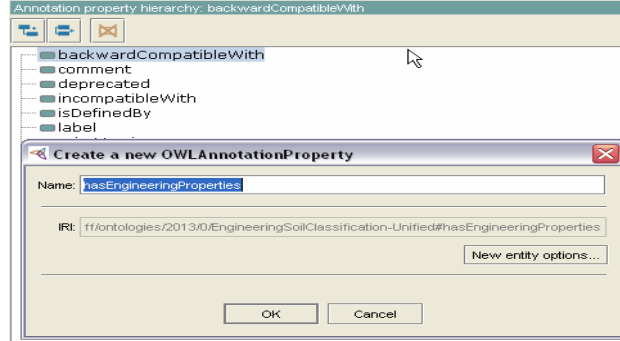


Figure 4 Creation of annotation property

E. Giving meaning to the concepts

Semantic web is all about giving meaning to concepts. In owl one such provision to give meaning is “Equivalent tag[8]. For example it is accessible through “Equivalent To” item of class description of protégé and also the meaning of GW classification of soil can be given in the class expression editor of GW class as

“GRAVEL and (hasCu some double[>= 4.0]) and (hasCc some double[>= 1.0]) and (hasCc some double[<= 3.0]) and (hasPercentageWeightPassingOnNo200Sieve some double[< 5.0])”

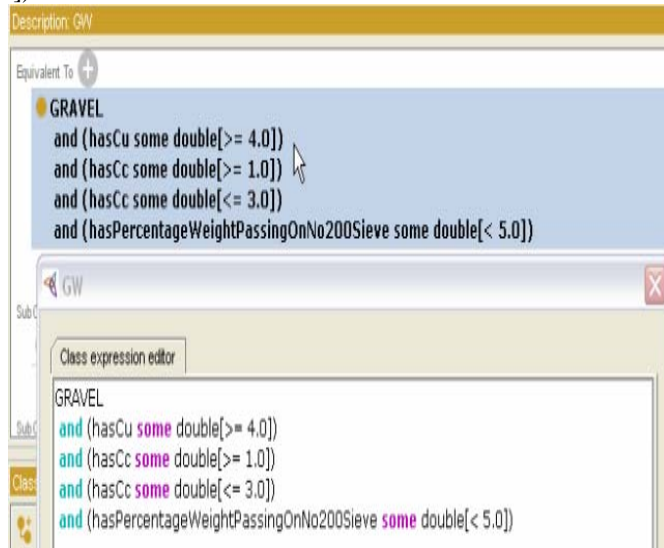


Figure 5 Giving meaning to concepts

F. Adding annotations to concepts

Tools provide the provision to describe the data about data(Meta data)(For eg in protégé ClassDescriptionView (Windows->Views->ClassViews->Description)[8] the annotation in the form of engineering properties can be assigned to GW by using ‘@’ symbol.

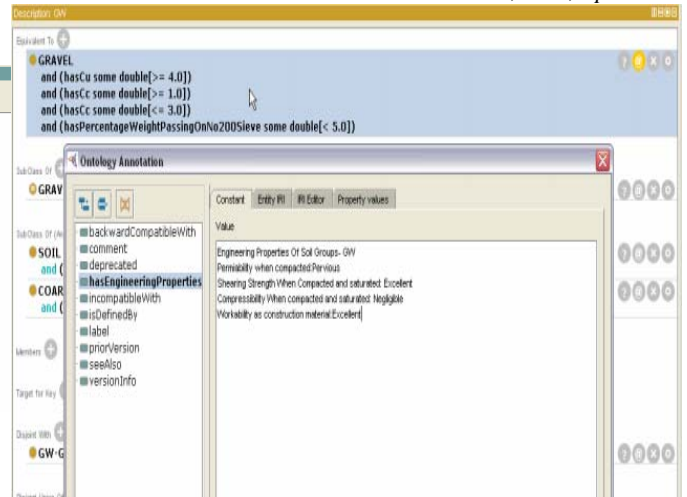


Figure 6 Adding annotation properties to concepts

G. Creation of rules

SWRL is the language used for creating rules[6]. The rules window in protégé can be accessed through Window->Views->Ontology Views->Rules. For example rule for calculating the A- Line value can be obtained by providing the following in the rules tab.

Following are some of the rules used in soil classification

TABLE III Some rules in soil classification

Sr No	SOME RULES IN SOIL CLASSIFICATION	
	RULE	Description
1	SAMPLE(?S), hasLL(?S, ?LL), hasPL(?S, ?PL), subtract(?PI, ?LL, ?PL) -> hasPI(?S, ?PI)	Calculates plasticity index
2	SAMPLE(?S), hasPercentageWeightRetainedOnNo200Sieve(?S, ?PR), subtract(?PP, 100.0, ?PR) -> hasPercentageWeightPassingOnNo200Sieve(?S, ?PP)	Calculates percentage weight retained on No200 Sieve
3	SAMPLE(?S), hasLL(?S, ?LL), multiply(?IP, ?ALV1, 0.73), subtract(?ALV1, ?LL, 20) -> hasALineValue(?S, ?IP)	Calculates A-Line Value[4]

H. Creation of individuals

Under Sample class, instances of it(SAMPLE-1,SAMPLE-2) are created. Tools provide the provision for it[8].(For e.g. using Protégé the instances SAMPLE-1 can be created and assigned to SOIL class using Windows->Views->Individual View->Description And Windows->Views->Individual View->Description

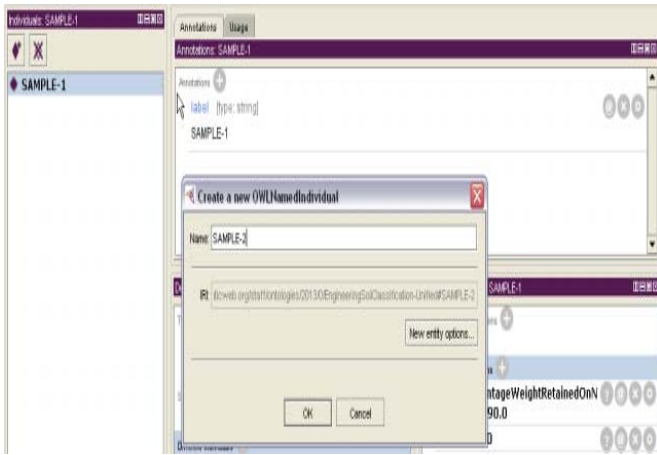


Figure 7 Creation of instances

Using the property assertion view, the values for the data type properties can be provided to the sample (Windows->Views->Individual View->Property assertions)

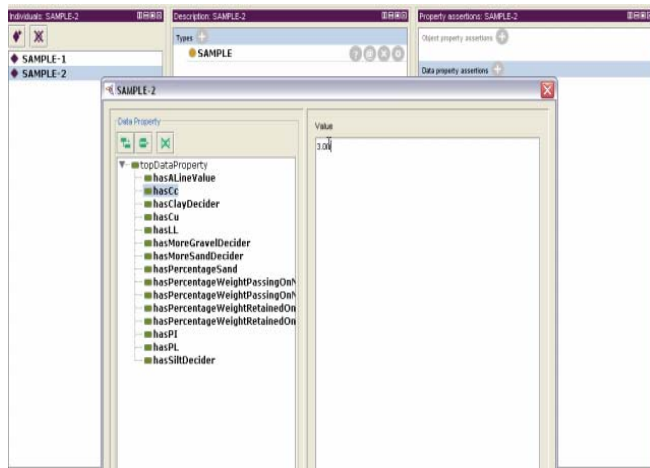


Figure 8 Creation of data property assertions

I. Classification

At the time of writing this paper it is observed that not all reasoners support rules. Some reasoners support rules partially. Some reasoners support rules fully (For example Pallet). Using plug-in facility (for example Files->Plugin in protégé) the reasoner plug in is installed in the tool. Invoke the reasoner for classification (for e.g. Reasoner->Start Reasoner)[8].

If there is any anomaly in the ontology then reasoner gives the reason for inconsistency. If there is no anomaly then the ontology is consistent and the classification of the soil sample takes place based on the rules and meaning provided in the equivalent section of the class.

On classification in individual view the soil classification will be displayed and the in class view the individual (SAMPLE-1) is displayed.

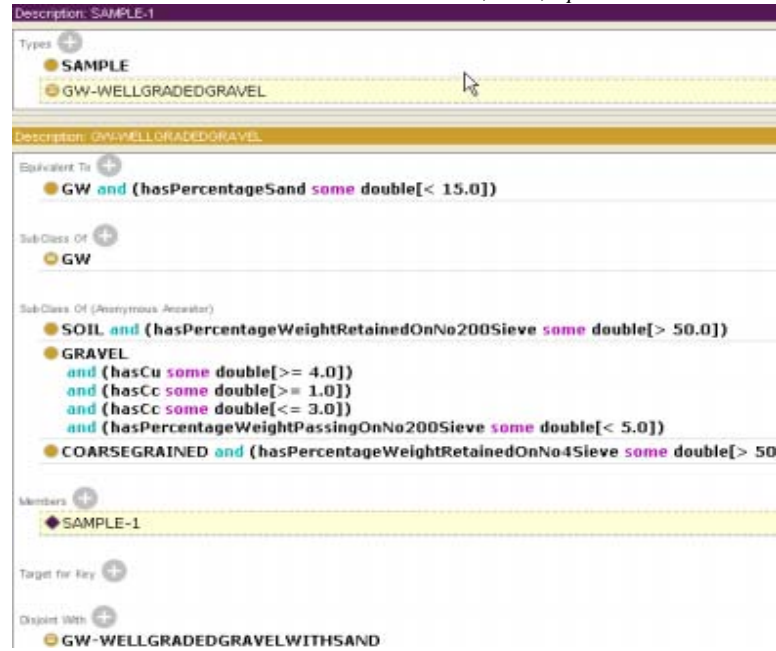


Figure 9 Classification

J. Querying Ontology

Using SPARQL language the queries can be issued to the ontology and the required information can be obtained using the query language.

For example following is the simple query issued for finding out all sub categories present in GRAVEL classification.

```
SELECT ?C WHERE {
?C rdfs:subClassOf sch-ont:GRAVEL.
}
```

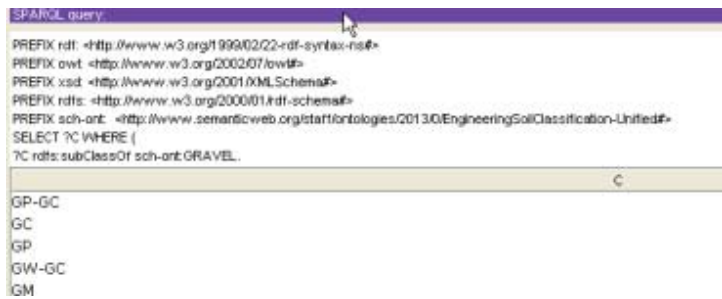


Figure 12 SPARQL query interface with query to find out all classification categories of GRAVEL

III. CONCLUSIONS

Information as available in the web today is in very much unstructured and not suitable for collaboration between different entities involved in collaboration. Collaboration happens effectively when the meaning of the shared knowledge of domain is agreed upon among the entities which are collaborating. This gains importance when collaboration needs to happen between humans and machines. Semantic web technologies which are evolving and which are available today make this collaboration possible.

Engineering soil classification is the basic knowledge which every geotechnical engineer needs to have in order to have an approximate judgement of engineering behaviour of soils. Engineer who is at site can benefit in using semantic web technologies as he can quickly and accurately arrive at the classification results, approximate engineering behaviour of soils and also helps to collaborate with either humans or software agents.

Knowledge acquisition system like protégé which are simple to use helps like geotechnical engineer (domain expert) to represent knowledge in the form of ontology which helps to infer and adaptively take correct judgement in the light of new information emerging from the field conditions at work.

Towards this direction engineering soil classification based on rules based ontology is a small step forward.

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