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Semantic Image Annotation using Ontology And SPARQL

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Abstract: ***Based on user's interest or requirements, the search and retrieve images from large scale the databases, the content-based image retrieval (CBIR) technique has become the primary emerging area in research for digital image processing which makes the visual contents to use. Most promising tools for image searching are Google Images and Yahoo Image search. They are used for annotations based on textual of the images. In this, the images are annotated manually with the help of keywords and then the retrieval is carried by using various search methods based on text. Due to this method, the system performance is too low. Therefore, CBIR goal is to construct Image Ontology. The Ontology extracts the relevant images from the database by using low-level features like texture, shape and color. In multimedia technology, the challenging task is to retrieve the relevant images from an image database. For representation, organization and retrieving of images, the searching approaches based on semantic provide effective and efficient results by using image ontology. In this paper, protege software shows us how to create ontology and SPARQL query language provides semantic annotation for images. In addition to this, OntoViz and OntoGraph were used to generate Ontology in a graphical form for the relevant application.***

Keywords - Image Annotation, Ontology, OntoGraph, OntoViz, OWL, Protégé Semantic, and SPARQL.

I. INTRODUCTION

In the universe, Web (WWW) is huge database. This discovers files, documents, images etc. for the human. The current search is based on keyword where the machines are lacking in understanding the meaning and relationships among the data. It lacks in semantic structure, where the components scalability and interdependency is maintained . In turn, returns the results for the input query using the hyperlinks among resources and may also retrieve irrelevant information to the user.

With the help of hyperlinks, the resources are accessed, where the content is available on the web and here the disadvantage is, the information is in machine readable form which fails in making the machine understand. Therefore, effective search or retrieval of information has becomes highly crucial. In context of given query, the process of extracting relevant results is defined as information retrieval explicitly. We can extract keywords by using various information retrieval techniques. Therefore new search strategies are to be adopted.

Semantic based search provides appropriate and relevant results than that of traditional keyword based search. The efficiency of semantic based search depends on the ontology [1]. The process of representation by making use of the properties and relationships among the images are termed as ontology and it is constructed by considering the level of human understanding. Ontology is constructed by making use of the low-level features like texture, color and shape of images which replicates human understanding. Therefore ontology is considered as more useful for retrieval of images that are semantic based.

If the feature count varies from high to low, then the ontology construction tends to be inefficient. The, Resource Description Framework (RDF) framework is used to describe and interchange metadata which provide intelligent access among heterogeneous and distributed information and also to construct domain ontology, Web Ontology Language (OWL), is widely used. The two main search approaches for image are:

1. Annotation Based
2. Content Based

Annotation based approach is based on keywords or image metadata. [2]-[3]. Images Google Search is one of the examples for this approach.

In this the search engine relies on the properties or content of the image. The properties of the image include name/title, creation date, format of the image, resolution, copyright information and so on. Whereas, content based metadata match with the properties of the entities depicted like person, object, etc. The Semantic Web (SW) provides framework which allows data to share and reuse for various applications, enterprises etc and this termed as Resource Description Framework (RDF).

- To represent the knowledge resources, RDF is used and to identify the resources, Uniform Resource Identifier (URI) is used.
- To represent the resources based on web and SPARQL (Standard Protocol for RDF Query language), RDF Schema is used, to obtain information or data from RDF graphs. These graphs in-turn represented in machine understandable form.
- Semantic Search engines and browsers are used for semantic traversal where the agents act as programs for transferring the meaningful data.

The paper covers the keyword based annotation structure, and ontology guided reasoning methods for the retrieval of images. Our proposed approach has been implemented using protégé for retrieval using. Images are retrieved using the content description of the images by SPARQL query.

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II. VISION OF SEMANTIC WEB

The idea of Semantic Web (SW) is proposed by Tim Berners Lee in 1996.

The vision of Semantic Web is to access data from the Web in a well structured form and to provide the linkage for machines to interpret automation process , Reusability and integration work for the purpose of data reuse across various applications along with display.

For the domain of knowledge representation, Ontology is used. The objective of ontology construction is, "to classify the different forms of things ". The main idea is to create a common vocabulary of keywords to describe about the particular domain knowledge in detail and also to subdivide into a logical class hierarchy, leading to generate the shared knowledge representation language. It can be defined as a framework of expressing information as it acts as a platform to develop various languages and approaches for efficiency improval of Image Retrieval. The Semantic Web (SW) is designed using Semantic Web documents (SWD's) with the integration of SW languages like OWL, DAML+OIL [4].

III. ARCHITECTURE

Tim Berners Lee who proposed the concept of Web, HTTP, & HTML states that thenext generation of web & IT revoulution will be semantic web.

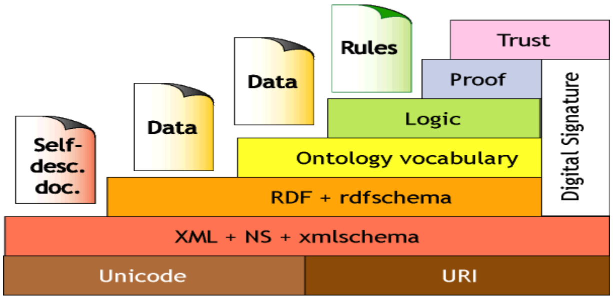

Fig. 1: Semantic Web layered Architecture.

The layered architecture of semantic web is shown in Fig.1. The purpose of these layers is described as follows:

1. The XML Layer is appropriate for sending documents across the web and it is the bottom layer in the architecture.
2. For writing simple statements about web objects (resources) RDF layer is considered as a basic data model. It has three components: Resource, Property and Statement.
3. RDF Schema is RDF vocabulary description language. Groups of resource are represented to show the relationships.
4. Logic layer is intended in developing ontology and producing the representation of knowledge document in the form of knowledgeable representation document written in either RDF or XML.
5. The Proof layer deals with deductive process notations as well as the Proof representations in web languages (from bottom layers) and performs proof validation [7].
6. Final layer referred as the Trust layer will focus on the usage of digital signatures and various forms of knowledge, based on recommendations.

A. Ontology

The term "ontology" can be defined as an explicit specification of conceptualization. Ontology is simply a knowledge representation method. Ontology layer represents hierarchical distribution of Ontology concepts description and domain knowledge, constraints and relationships. Fig. 2 displays the Ontology and its associated components.

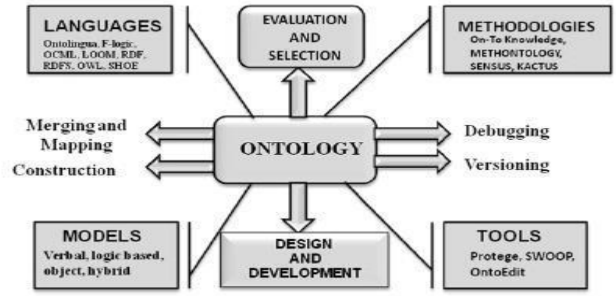

Fig. 2: Ontology and its associated components

Ontologies broadly divided into two main categories:

1. Lightweight Ontologies: It includes class hierarchy or taxonomy of classes, subclasses, values and attributes.
2. Heavyweight Ontologies: It represent the domains in depth-wise manner by including axioms and constraints [11].

B. Building Ontology Using Protégé

The image retrieval technique named Content-based image retrieval is said to be efficient as it considers low-level features of the image than the entire image. The other alternative for the image retrieval process is performed using ontology based representations named as Ontology based image retrieval which used the knowledge representations that integrates the context of content based image retrieval with the text based image retrieval features. The key idea of ontology is to present the image in semantic notations which is interpretable for the machine leading to the efficient retrieval of results. The ontology provides the representation of knowledge using the entities specifying the OWL with construction of classes, relations, attribute and events among domain individuals which is supported logically in the form of Rules.

The advancement of semantic web [12] is facing the issues in terms of rules. The Semantic web needs more powerful notations than ontology languages like RDF, XML, XMLS (XML schema), RDFS (RDF Schema), OWL (Ontology Web language) describing the semantics and reasoning of metadata/resources and identifying the relationships among the entities that are available on the web.

The platform named protégé[13] supports two ways of modeling ontologies using its own user interfaces[14][15] like frame-based and OWL. The semantic web adapts the well-known vocabulary named Friend of a Friend (or FOAF), to specify or represent the relationships among people and the surrounding "things".

The Resource Description Framework (RDF) portrays FOAF as an intelligent agent which is used to create the intellect of huge social network, providing the interrelation among each other ie, among people, their jobs and things related to them in their lives.

The social network is the huge or large network from which from which the information retrieval is the major challenge and thus the human interpretation is not the better idea for analyzing the network.

The semantic web attempts to establish relationships in a social context using FOAF. The term "ontology" is extracted from Greek philosophy to describe "the study on the nature of being". The challenge lies in providing the framework for defining the syntax(like XML) and semantics representations for all the languages in uniform and coherent manner.

A. Motivation for Ontology Development:

- Share similar understanding about information structure among people or software agents
- Enabling the domain knowledge reuse.
- Construct explicit domain assumptions.
- Distinguish between operational knowledge and domain knowledge
- Evaluate domain knowledge.

B. Language Support for Ontology:

The OWL notations are used to share and publish ontologies supporting web search, knowledge management and software agents. The OWL is designed as the top layer of RDF, used to process information on the web. It is also designed for the computer interpretation as an alternative of human interpretation.

C. Steps in constructing Ontology

1: Identify the domain and scope.
2: Enumerate important terms.
3: Specify class and class hierarchies
4: Characterize Object properties, Annotation properties and Data properties.
5: Describe restriction on properties (cardinality, value type)

Fig.3 shows the OWL implementation for Nature ontology with the classes such as Flowers, Fruits and Wonders. The classes are subdivided into subclasses of Flowers such as rose, jasmine and lilly, whereas subclass of Fruits consists mango, apple and grape and Wonders subclass consists tajmahal, pisa, chinawall, colosseum, instanbul, picchu and pyramid.

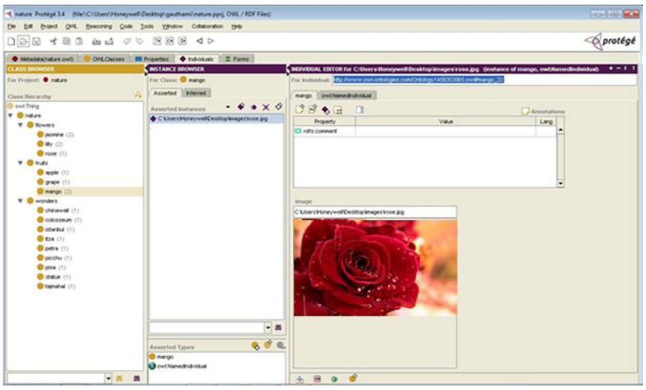

Fig.3: Nature Ontology

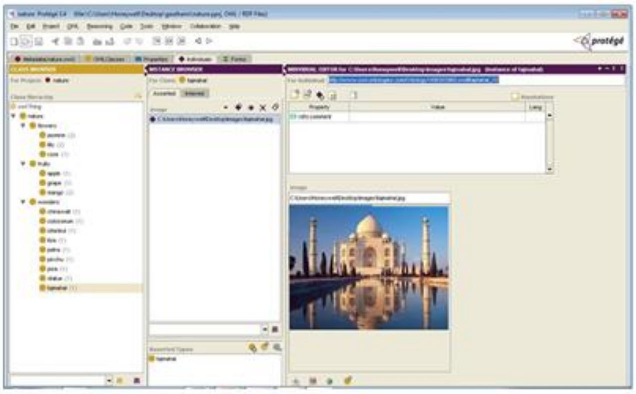

Fig.4: Ontology Annotating Image of Rose

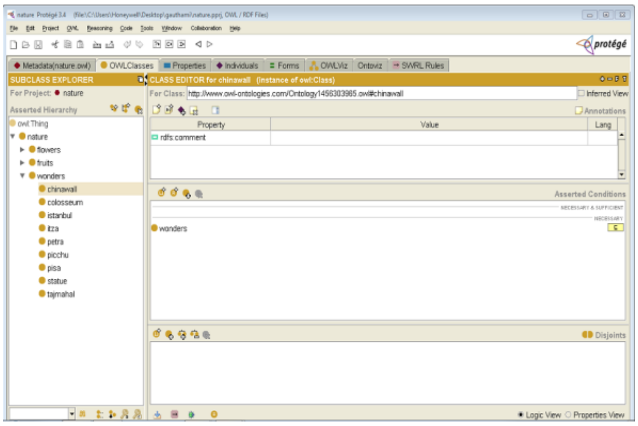

Fig. 5: Illustration of Subclass of Wonders with Annotation of Tajmahal Image.

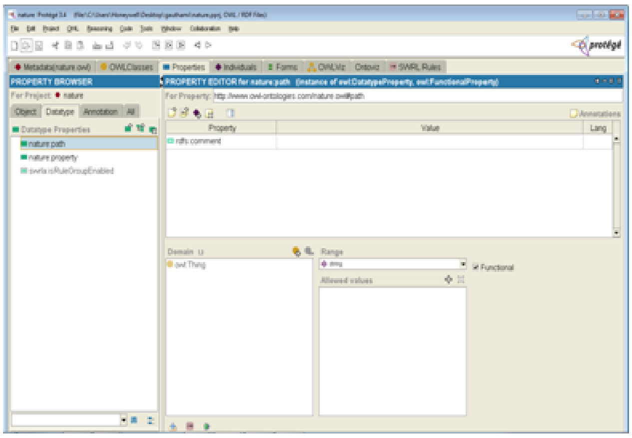

Fig. 6: Illustration of Properties for nature Ontology

Fig.4 shows the annotation of rose from the subclass of flowers. The rose flower is classified based on color, size etc, Fig.5 shows the annotation of wonders based on the object properties such as country, century, history etc. Fig.6 presents the properties like object, data and its annotations on nature class and its subclass.

IV. IMAGE ANNOTATION USING SPARQL

The querying of RDF graphs are performed using a query language named SPARQL represented as "Simple protocol and RDF query Language[16] or SPARQL Protocol.

In general, it is an RDF query language - a standard query language and a data access protocol for handling of RDF data model. SPARQL is a query language is similar to that of SQL and that of open source tools like TWINKLE 2.0, Apache Jena Framework with ARQ Processor where SPARQL is tested and validated and works for any RDF mapped data source. The data is retrieved from RDF and OWL using SPARQL. The Ontology tool named Protégé includes: Query Processing, Query Optimization and Query Execution discussed as follows:

Query Processing refers to the internal processing performed in a query engine to evaluate and transform the query for execution and use rewriting methodologies if required for executing without distracting the query outcome.

Query Optimization presents the rules for query rewriting by transforming the structure of execution of a query.

Query Execution step includes evaluation of the SPARQL query by generating Query Execution plan (QEP) in the query engine [17][18].

The query language SPARQL has been intended to collect data from multiple sources and to fasten up the implementation of web 2.0 applications, providing the web standards. The entity that belongs to a particular class is expressed by predicate, defined from the standard namespace RDF and the subclass of the class is defined by the subclass of the predicate. Other entities are represented using the default namespace ":".

The SPARQL language majorly presents four query variations that perform the different operations.

The raw values from the SPARQL endpoint are extracted and after returning, it is represented in a tabular form using SELECT query.

(1) The process of extracting the information and the transformation of the results into valid RDF are performed using CONSTRUCT query.

(2) The results in terms of Boolean results i.e True/ False is generated using ASK Query.

(3) The RDF graph is generated or extracted using DESCRIBE query stating that the contents towards left to endpoint decides the useful information from which the hierarchy has to be generated.

The SPARQL representation on subclass of wonders, chinawall, tajmahal , statue etc are presented in Fig.7.

1 .Identify the subclass of wonders.

SPARQL Syntax:

Find Subject, Predicate and Object nodes.

```
SELECT ?Sub? Pr? Ob
WHERE { ?Sub? Pr ?Ob }
LIMIT 5
```

SPARQL Query:

```
SELECT ?x1
WHERE { ?x1 rdfs:subClassOf :wonders

}
```

Table 1: SPARQL Query Results Illustrating Subclass of Wonders

Wonders subclass
Tajmahal
Pisa
Chinawall
Colosseum
Instanbul
Picchu
Pyramid

V. ONTOLOGY VIZUALIZATION USING OWLVIZ AND ONTOGRAF

The two widely used ontology viewing tools OWLViz and OntoGraf are supported by protégé 5.0 and GraphViz. The OWLViz represents the classes hierarchy and does not reveal any properties and relationships. OntoGraf demonstrate classes with relationships and hierarchy. It does not print/labels any relationship names on the graph. The tool is flexible and can be customized or configured. The Taxonomy plays an important role in most of the conceptual models where the taxonomies which are structured properly provides extensive order of elements in a model presenting the inadequate views of a model for the efficient human interpretation tasks with a key role in integration and reuse tasks. The proper taxonomy generation focus on the semantics of a relationships like class inclusion, is-a [19] along with relations like generalization, subset hierarchy, specialization with respect to constraints that included in multiple taxonomic relationships along with the general framework of data abstractions and structural similarities between the descriptions.

Table.2: Taxonomical relationship of nature class with its Subclasses

Nature class											
Fruits			Flowers			Wonder class					
Mango	Apple	Grape	Rose	Jasmine	Lilly	Tajmahal	Pisa	Chinawall	Colosseum	Instanbul	Picchu and Pyramid

The Tables. 1 to 2 presents the nature class visualization with its subclass fruits, flowers along with wonder class subdivided into respective domain.

Taxonomical relationship of nature's class and subclasses are displayed using OWLVIZ and ONTOGRAF as shown in figures 7 and 8.

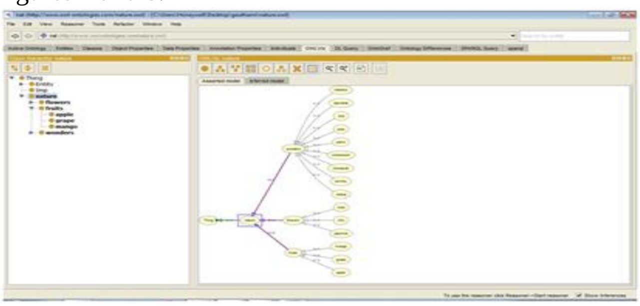

Fig.7: Taxonomical relationship of nature class with its subclasses using OWLVIZ.

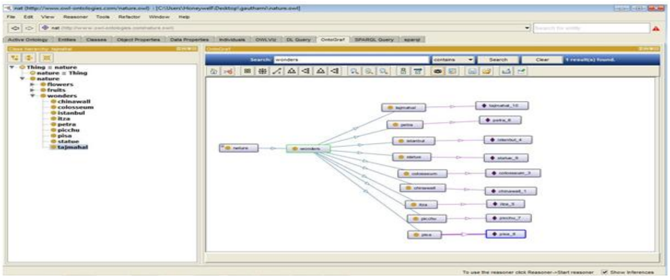

Fig 8: Illustration of OntoGraf for nature Ontology

VI. VISUALIZING ONTOLOGY USING RDF

The description of objects or entities like plants, animals ,people, communities, document definitions, countries, blog posts or wiki pages etc using RDF framework. The RDF modeling [20] is used to implement the ontology an object definition system. The RDF notations helps to represent information and exchange of knowledge in web. Sometimes the web based search depends upon the uncertainty, misinterpretation and complexity of linked data among semantic web communities. The linked data is easy to tamper and grab as it is a concept with the ability to investigate, observe the objects with related things in the network of a real world. The objects in the linked data are in distributed fashion with a uniform style of identifier.

The concept of Hyper Text Transfer Protocol (HTTP) can be considered as an example of linked data and Internationalized Resource Identifier (IRI) is considered as a uniform style of identifier[20] . The changes recommended are the separation of web based data from semantic web data, i.e, the RDF should be separated from RDF/XML and to increase the understanding of internationalized and distributed data using the frameworks , technologies and ontologies.

The ontology acts as the source for precisely defining the web resources by providing the knowledge base for annotating the multimedia information or contents semantically for machine processing.

The representation syntax of an RDF is explained in the preceding example , in which the notations of an RDF and ontology is followed for the representation of the concept using the name spaces like <owl:Class> </ owl:Class> and < rdfs:subclass> . The example presents the ontological description of flowers, with the main concept of Nature.

A. Sample RDF for Flowers Class:

```
<!-- http://www.owl-ontologies.com/Ontology1456303965.owl#flowers
-->
<owl:Class rdf:about="http://www.owl-
ontologies.com/Ontology1456303965.owl#flowers">
<rdfs:subClassOf rdf:resource="http://www.owl-
ontologies.com/Ontology1456303965.owl#nature"/>
</owl:Class>
<!-- http://www.owl-ontologies.com/Ontology1456303965.owl#jasmine --
>
<owl: Class rdf:about="http://www.owl-
ontologies.com/Ontology1456303965.owl#jasmine">
<rdfs:subClassOfrdfresource="http://www.owl-
ontologies.com/Ontology1456303965.owl#flowers"/>
<rdfs:comment rdf:resource="&xsd;string"/>
</owl:Class>
<!-- http://www.owl-ontologies.com/Ontology1456303965.owl#lilly -->
<owl:Class rdf:about="http://www.owl-
ontologies.com/Ontology1456303965.owl#lilly">
<rdfs:subClassOfrdfresource="http://www.owl-
ontologies.com/Ontology1456303965.owl#flowers"/>
</owl:Class>
```

VII. EVALUATION OF PERFORMANCE FOR PROPOSED SBIR SYSTEM BASED ON ANNOTATIONS

The retrieval performance is a challenging task in a Semantic Based Image Retrieval (SBIR) system where we retrieve the images based on the annotations. There are different methods for measuring and evaluating the performance of a system has been implemented and used.

To evaluate the system accuracy we used Precision and Recall. The formulae for finding Precision and Recall values are given as follows:

Precision measures the ratio of the total similar mages retrieved relevant to the query from the total set of image retrieved from the database.

$$\text{Precision} = \frac{\text{Total Number of relevant OR similar images}}{\text{Number of relevant images retrieved.}}$$

Recall measure is defined as the fraction of the all relevant images.

$$\text{Recall} = \frac{\text{Number of similar images retrieved}}{\text{Total number of images retrieved.}}$$

High precision means more relevant images are obtained whereas the high recall value indicates that some relevant images were missed.

VII. CONCLUSION

In this paper, the work has been implemented on creating ontology for the collection of images and established a relationship among them. The proposed work performed faster retrieval process compared to the ordinary retrieval process. The protégé interface has been used, as it is provides the RDF/XML code for annotating images and their respective relationships. The SPARQL query is used for the efficient retrieval process of images and text basing on the subject, predicate and object using domain ontology. The visualizing tools like OWLViz and OntoGraf were used to display the relationship among the classes and subclasses for the specific domain of application selected for implementation. In this work, we considered the domain as nature and its classes and subclasses are presented with object properties, data properties along with the properties considered for the image annotation. The efficiency of the image search can be improved by integrating ontology and SPARQL.

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