

ENHANCING IMAGE SEARCH ACCURACY USING SEMANTIC ANNOTATION

Thesis submitted in partial fulfillment of the requirements for the award
of degree of

**Master of Engineering
in
Computer Science & Engineering**

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Certificate

I hereby certify that the work which is being presented in the thesis entitled, "Enhancing Image Search Accuracy using Semantic Annotation", in partial fulfillment of the requirements for the award of degree of Master of Engineering in Computer Science and Engineering submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Shalini Batra* and refers other researcher's works which are duly listed in the reference section.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.

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Abstract

With the advent of the Internet as a medium of sharing resources like text, images, audio, video, documents *etc.*, the Web users made it a way to interchange the knowledge as well. This behavior of the Web users over the Internet phenomenally turned the WWW into a huge repository of unstructured data inducing a need of the standard based representation of the data over the Internet. This need made itself more demanding because the searching or extraction of the knowledge from the unorganized data was becoming impossible, giving rise to the concept of Semantic Web. The use of XML for representing the data made the situation at the rest in the meanwhile. But, only the syntactical exploitation of the data could not help the situation because the process like searching of the images on the Web demanded the inclusion of the supplement of semantic structures into the list of standards. The Resource Description Framework (RDF) standard, a base technology of the Semantic Web, appeared as an intuitive solution of this problem as it employs the concept of annotation to describe the images and keeps all pieces of information pertaining to the images in the RDF documents, making the search process semantic rather than the traditional.

In this thesis, the intent is to generate annotated RDF model for semantic retrieval of images using RDF editor for annotation. This RDF model is validated through online W3C RDF validation service. SPARQL, RDF query engine, is used to query the validated RDF model to check the efficiency of image search.

Table of Contents

Certificate	i
Acknowledgement	ii
Abstract	iii
Table of Contents	iv
List of Figures	vi
List of Tables	vii
Chapter 1:Introduction	1
1.1 Images search in search engine.....	1
1.1.1 Problems encountered in searching images on WWW.....	2
1.2 Semantic Web	3
1.2.2 Definition of Semantic Web	3
1.2.2 Structure of Semantic Web	4
1.3 Resource description framework (RDF).....	6
1.4 Role of Annotation in Semantic Web	8
1.5 Semantic Annotation in Images	10
1.6 Structure of the Thesis	11
Chapter 2: Literature Review	13
Chapter 3: Problem Statement	17
3.2 Problem Definition.....	17
3.2 Methodology	17
Chapter 4: Resource Description Framework (RDF)	19
4.1 Resource description framework	19
4.1.1 RDF Triples	20

4.1.2 RDF Specifications	21
4.1.3 Basic RDF Model	21
4.1.4 Advantage of using RDF	25
4.2 Annotating Images using RDF	25
4.3 Tools and Browsers.....	30
4.3.1 RDF Editor.....	30
4.3.1 Twinkle: Sparql Tools.....	31
Chapter 5: Implementation and Results.....	33
5.1 RDF document creation	33
5.2 Query Results.....	36
5.2.1 Query 1.....	36
5.2.1 Query 2.....	37
5.2.1 Query 3.....	38
5.2.1 Query 4.....	39
5.2.1 Query 5.....	40
5.2.1 Query 6.....	41
Chapter 6: Conclusion and Future Scope.....	42
6.1 Conclusion	42
6.2 Future Scope	42
References.....	43
List of Publications	46
Appendix-A.....	47

List of Figures

Figure 1.1: Image return by google Image Search for eclipse keyword	3
Figure 1.2: Berners-Lee's Original semantic Web Architecture	4
Figure 1.3: RDF triples	7
Figure 1.4: Honda white car.....	11
Figure 4.1: A simple RDF assertion	20
Figure 4.2: Simple node and arc diagram	23
Figure 4.3: Property with structured value	23
Figure 4.4: Cars images with different brand, model and color	26
Figure 4.5: Indian cricket player Sachin Tendulkar.....	28
Figure 4.6: Images search result for eclipse keyword.....	29
Figure 5.1: Creating RDF using RDF Editor	33
Figure 5.2: Validation of RDF using W3C RDF Validation Service	34
Figure 5.3: Graph of Two Entities of RDF Document	35
Figure 5.4: Query and output for all type of cars.....	36
Figure 5.5: Query and output for cars of Maruti Suzuki brand	37
Figure 5.6: Query and output for cars of 'Honda' brand, color is 'red' and kerbweight=1250 kg.	38
Figure 5.7: Query and output for all cars those have 'red' color.....	39
Figure 5.8: Query and output for all cars those have 'Honda' brand	40
Figure 5.9: Query and output for all cars those have kerbweight < 1275 kg.....	41

List of Tables

Table 4.1: RDF Format	23
Table 4.2: RDF elements description	25

Chapter 1

Introduction

The Internet revolutionised the way in which our society disseminates and uses information. The popularity of the Internet resulted in an exponential growth of information available on the Internet and the associated Web. A consequence of this popularity is an overload of information available on almost any topic which in turn has created several new problems for users. How to find required information in such a short time has become the key constraint to the process of human society progress while facing the vast ocean of information. For example, it is increasingly difficult to find applicable information or to verify the origin of information. In addition, it is difficult to verify that the information, or even the source of the information, is trustworthy.

With the growth of multimedia the huge amount of images are increasing daily on the internet. In simple search user gets many irrelevant images and to retrieve the accurate images from the Web according to user query is a challenging task. To find the proper result from the Web need is to enrich the annotation process as much as possible and move toward the semantic image search.

1.1 Image Search in Search Engine

Although Internet has contributed a lot for human society, the explosive growth of multimedia data transmission has generated a critical need for efficient, high-capacity image databases, as well as powerful search engines to retrieve image desired from them. At present, main search engines have developed a series of feasible solutions for text search as text is a kind of structural information, which also have already been taken into commercial use phrase. Google PageRank or Baidu's own ranking algorithm [1], has reached satisfactory result on text information search area, helping users find useful information in relatively short time, but with the pluralism of internet media, unique text search service cannot meet customers' current requirement. As one of the most important media for presentation, images have become significant as text information recently, but the performance of images search engine is still less than satisfactory.

An image search is a systematic process that includes browsing, searching and retrieving images from a large database of digital images. Various image search options available today on World Wide Web are:

Google Image Search - Google Image Search is the most frequently used image search engine in the world. It produces thousands of image results in response to users query – which are syntactically related to the words given by the user but may or may not be semantically related to the user’s request and thus it requires some serious filtering to get desired results. Major limitation of this engine is that at every click full page source is retrieved and user needs to click each individual thumbnail to open every image.

Yahoo! Image Search - Yahoo Image Search (<http://images.search.yahoo.com>) finds images that appear as a framed interface on a source page and it has a wide range of options which can be applied to searches.

Flickr - Flickr Images is presently very popularly used and subscribed image sharing data base on the Web. Powered through Yahoo, it acts as a community space for storing photos and images. Copyrighted photos can be found in unique range, but it is rather rare. It has search options such as ‘most relevant’ and ‘most recent’ which makes searching easier.

In all these search engines, traditional and common methods of adding metadata such as captioning, keywords, or descriptions are used for image retrieval.

1.1.1 Problems encountered in searching images on WWW

Search engines are based on simple keyword matching process so many a times they return the unexpected results for searched images.

For example, if user gives query for keyword ‘eclipse’ in Google Image Search it will return the following images:



(a) Eclipse-5exposures



(b) Solar Eclipse



(c) Mitsubishi Eclipse



(d) Integrated with Eclipse SDK

Figure 1.1: Image return by Google Image Search for eclipse keyword

But these results of the keyword ‘eclipse’ may not comply with the need of the users because if the user is interested in word ‘eclipse’ related to astronomy, search for the word ‘eclipse’ gives images for eclipse car, eclipse software, etc.

To present more precise result to each user with different occupations, hobbies, and some other background profiles; there is a need to modify search method and involve some factors of user’s background information. To solve this problem, images should be annotated so that image retrieval is semantic in nature. In addition to the classic “Web of documents”, W3C is building a technology stack to support a “Web of data,” the sort of data found in databases. The ultimate goal is to enable computers to do more useful work and to develop systems that can support trusted interactions over the network.

1.2 Semantic Web

1.2.1 Definition of Semantic Web

According to Tim Berners-Lee “The Semantic Web is an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation” [2, 27].

"The Semantic Web is a vision: the idea of having data on the Web defined and linked in such a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications" [3].

Semantic means adding meaning of data to be discovered by computers. It is a vision of a new architecture for the World Wide Web, characterized by the association of machine-accessible formal semantics with more traditional Web

content. The core idea is to create the meta data describing the data, which will enable computers to process the meaning of things.

The ultimate goal of the Semantic Web [25, 26] is to transform the Web into a medium through which data can be shared, understood and processed by automated tools. Semantic Web techniques, which consist of applying knowledge representation techniques in a distributed environment (potentially on a Web-wide scale) have proven useful in providing richer descriptions of Web resources [4].

The Semantic Web extends the Web through the use of standards, markup languages and related processing tools. Semantic Web technologies enable people to create data stores on the Web, build vocabularies, and write rules for handling data. Linked data are empowered by technologies such as RDF, SPARQL, and OWL.

The vision of the Semantic Web is an extension of the existing Web through which machines are able to interoperate and work on our behalf. It promises to infuse the Internet with a combination of metadata, structure, and various technologies so that machines can derive meaning from information, make more intelligent choices, and complete tasks with reduced human intervention. Semantic web vision is oriented toward machine-readable resources rather than human-readable. It requires resource description so that machines know what they mean (metadata) [5].

1.2.2 Structure of Semantic Web

Currently, the World Wide Web consists of documents written in HTML. This makes the Web readable for humans, but since HTML has limited ability to classify the blocks of text apart from the roles they play, the Web in its current form is very hard to understand. The purpose of the Semantic Web is to add a layer of descriptive technologies to Web pages so that become readable [6].

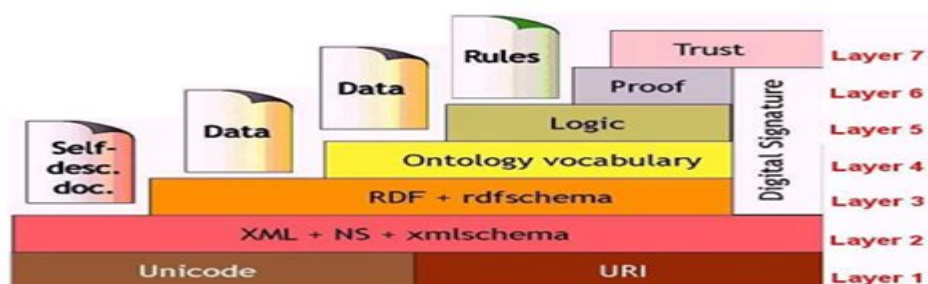


Figure 1.2: Berners-Lee's Original Semantic Web Architecture [4]

The Semantic Web is implemented in the layers of Web technologies and standards.

The layers are presented in Figure 1.2 and described as follows:

- The Unicode and Uniform Resource Identifier (URI) layers make sure that international characters sets are used and provide means for identifying the objects in the Semantic Web. The most popular URI's on the World Wide Web are Uniform Resource Locaters (URLs).
- The XML layer with namespace and schema definitions make sure the Semantic Web definitions can integrate with the other XML based standards. XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents. XML Schema is a language for restricting the structure of XML documents [7].

XML Schemas provide greater flexibility in the definition of an XML application, even allowing the definition of complex data types. Furthermore, XML Schemas use the same syntactic style as other XML documents. However, XML Schema only gives XML an advanced grammar specification and data typing capability, and still suffers from the same semantic drawbacks as DTDs. The lack of semantics in XML DTDs and XML Schemas makes it difficult to integrate XML documents.

- The Resource Description Framework (RDF) [28] is a W3C recommendation that attempts to address XML's semantic limitations. It presents a simple model that can be used to represent any kind of data. This data model consists of nodes connected by labeled arcs, where the nodes represent Web resources and the arcs represent properties of these resources.

RDF Schema is a simple type modeling language for describing classes of resources and properties between them in the basic RDF model. It provides a simple reasoning framework for inferring types of resources.

- The ontology layer supports the evolution of vocabularies as it can define relations between the different concepts. In this layer knowledge is expressed as descriptive statements, stating some relationship exists between one thing and another.
- A digital signature is an electronic signature that can be used to authenticate the identity of the sender of a message or the signer of a document.

The Digital Signature layer ensures that the original content of the message or document is unaltered.

- The top layers Logic, Proof and Trust, are currently being researched and simple application demonstrations are being constructed. The Logic layer enables the writing of rules while the Proof layer executes the rules and evaluates together with the Trust layer mechanism for applications whether to trust the given proof or not.

The Semantic Web comprises the standards and tools of XML, XML Schema, RDF, RDF Schema and OWL.

1.3 Resource Description Framework (RDF)

The Resource Description Framework (RDF) is a W3C standard for describing Web resources, such as the title, author, modification date, content, and copyright information of a Web page [8].

- RDF is designed to be read and understood by computers and it is not designed for being displayed to people.
- It is written in XML and it is a part of the W3C's Semantic Web Activity.

Resource Description Framework Define metadata vocabularies and use them to make statements. Resource can be anything identifiable with a URI, Description is a statement about properties of resources and Framework means a common model for statements using diverse vocabularies.

RDF is a model and XML syntax for representing information in a way that allows programs to understand the intended meaning. It's built on the concept of a statement, a triple of the form {predicate, subject, object}. The interpretation of a triple is that <subject> has a property <predicate> whose value is <object>. In RDF a <subject> is always a resource named by a URI with an optional anchor id, <predicate> is a property of the resource, and the <object> is the value of the property for the resource [9]. Consider the following triples (figure 1.3):

```
{dc:Publisher, http://www.w3.org, "World Wide Web Consortium"}  
{dc:Title, http://www.w3.org, "W3C Home Page"}
```

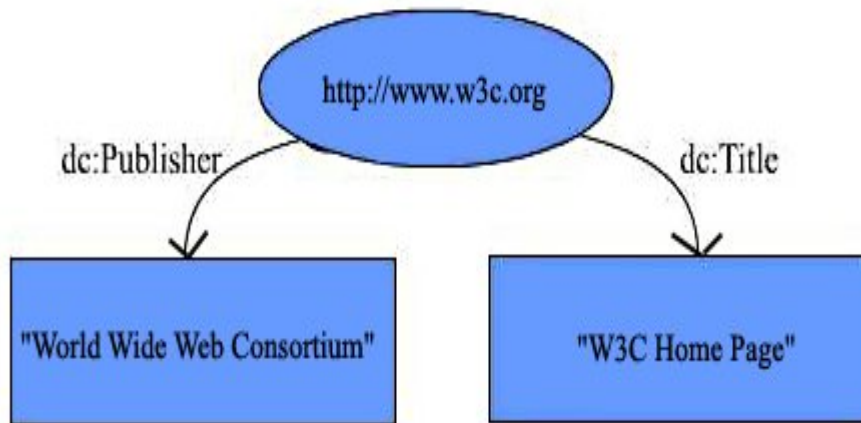


Figure 1.3: RDF triples

RDF syntax:

```

<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:cd="http://www.recshop.fake/cd#">
  <rdf:Description
rdf:about="http://www.recshop.fake/cd/Empire Burlesque">
    <cd:artist>Bob Dylan</cd:artist>
    <cd:country>USA</cd:country>
    <cd:company>Columbia</cd:company>
    <cd:price>10.90</cd:price>
    <cd:year>1985</cd:year>
  </rdf:Description>
</rdf:RDF>

```

The first line of the RDF document is an XML declaration. The XML declaration is followed by the root element of RDF documents: `<rdf:RDF>`. The `xmlns:rdf` namespace specifies that elements with the `rdf` prefix are from the namespace `"http://www.w3.org/1999/02/22-rdf-syntax-ns#"`. The `xmlns:cd` namespace specifies that elements with `cd` prefix are from the namespace `"http://www.recshop.fake/cd#"`. The `<rdf:Description>` element contains the description of the resource identified by the `rdf:about` attribute. The elements: `<cd:artist>`, `<cd:country>`, `<cd:company>`, etc. are properties of the resource. RDF has the following features [10]:

- **Reification:** An important feature of RDF is its representation of a collection of resources. In addition to making assertions about resources, RDF can be used to make assertions about other RDF statements. This means that an RDF statement can be used in place of an object or property value in an RDF triple, which is known as reification.
- **Collection of Resources:** For representing a list of resources, RDF uses the type “Container” and reified statements are represented using the type “Statement”. A Container object is used to represent a collection of resources in RDF.

The three different types of container objects defined by the RDF specification are Bag, Sequence and Alternative. A Bag represents an unordered list of resources or literals; a Sequence represents an ordered list of resources or literals. Unlike the Bag container type, the order of resources or literals is important. Both Bag and Sequence are not sets, i.e., duplicate values are permitted in both container types.

1.4 Role of Annotations in Semantic Web

Meaningful use of any data requires knowledge about its organization and content. Contextual information that establishes relationships between the data and the real world aspects it applies to is called metadata. In other words, metadata is data that describes information about a piece of data, thereby creating a context in terms of the content and functionality of that data. Domain conceptualizations, ontologies or world models provide agreed upon and unambiguous models for capturing data and metadata to which applications, data providers and consumers can refer. Broadly speaking, there are two kinds of metadata - structural and syntactic metadata [11].

Structural metadata provides information about the organization and structure of some data, e.g. format of the document. Semantic metadata on the other hand, provides information 'about' the data for example the meaning or what the data is about and the available semantic relationships from a domain model in which the data is defined. The key aspect behind the realization of the Semantic Web vision is the provision of metadata and the association of metadata with web resources.

The process of associating metadata with resources (audio, video, structured text, unstructured text, web pages, images etc) is called annotation and **semantic**

annotation is the process of annotating resources with semantic metadata. Semantic annotations can be coarsely classified as being formal or informal. Formal semantic annotations, unlike informal semantic annotations follow representation mechanisms, drawing on conceptual models represented using well-defined knowledge representation languages. Such machine processable formal annotations on web resources can result in vastly improved and automated search capabilities, unambiguous resource discoveries, information analytics etc. The annotation of Web based resources like text files or digital content is very different from the annotation of Web services [11].

Annotation is about attaching names, attributes, comments, descriptions, etc. to a document or to a selected part in a text. It provides additional information (metadata) about an existing piece of data. Tagging is a sequence of characters used to provide some basic information to a document or images.

Compared to tagging, annotation speeds up searching and helps you find relevant and precise information; Semantic Annotation goes one level deeper:

- It enriches the unstructured or semi-structured data with a context that is further linked to the structured knowledge of a domain.
- It allows results that are not explicitly related to the original search.

So, if tagging is about promptly finding the most relevant result, semantic annotation adds diversity and richness to the process [12].

Thus an annotation is a form of meta-data attached to a particular section of document content. The section may be a single word, a sentence or even a series of paragraphs. An annotation must have a type (or a name) which is used to create classes of similar annotations, usually linked together by their semantics.

Semantic Annotation helps to bridge the ambiguity of the natural language when expressing notions and their computational representation in a formal language. By telling a computer how data items are related and how these relations can be evaluated automatically, it becomes possible to process complex filter and search operations.

1.5 Semantic Annotation in Images

In general, manual annotation can provide image descriptions at the right level of abstraction. It is, however, time consuming and thus expensive. In addition, it proves to be highly subjective: different human annotators tend to "see" different things in the same image. On the other hand, annotation based on automatic feature extraction is relatively fast and cheap, and can be more systematic.

In the process of image annotation, we may find values for attributes or relationships that are not previously present in the knowledge base. The process of enhancing the existing metadata could be as simple as entering values for attributes; in that case they could be automated. Moreover this process could be as complex as modifying the underlying schema, in that case some user involvement might be required [11].

To annotate the images, RDF data model can be used. It is based upon the idea of making statements about Web resources in the form of subject-predicate-object expressions, called triples in RDF terminology. This mechanism for describing resources is a major component in what is proposed by the W3C's Semantic Web activity: an evolutionary stage of the World Wide Web in which automated software can store, exchange, and use machine-readable information distributed throughout the Web, in turn enabling users to deal with the information with greater efficiency and certainty. RDF's simple data model and ability to model disparate, abstract concepts has also led to its increasing use in knowledge management applications unrelated to Semantic Web activity [13].

To extract text content information by image pattern recognition technology would be a cost way to get semantic information of one picture as it requires complicated and optimized algorithm to realize it. To solve these challenges, RDF documents can be used as one of the alternates for image content storage because:

RDF supports self-defined tags that allows user to setup new defined semantic description tags and make further modification. RDF as a mechanism for resource description would contribute to the semantic inference based on the ontology theory. Its resource/property/value triples character helps to make inference based on the description documents. For example, any image can be described in several aspects

like brand, and color etc. Below is given an example of image of car annotated in RDF format as shown in figure 1.4.



Figure 1.4: Honda White Car

```
<image>
  <pic: contain>
    <rdf: Description rdf: about="http://www.rdf.com/car">
      <car: brand>Honda</car: brand>
      <car: color>White</car: color>
    </rdf: car>
  </pic: contain>
</image>
```

Now when user types Honda 'White' car, the search engine would make inference based on the RDF document and finally show image in figure 1.4, which contain the description of car with 'Honda' brand and 'white' color that user is actually looking for.

1.6 Structure of the Thesis

The rest of the thesis is organized in the following order:

Chapter 2 - Provides a review of all the work done in the area of semantic annotation for image searching.

Chapter 3 - Gives the problem statement and methodology used to solve it.

- Chapter 4 -** Gives a detailed introduction about RDF, semantic image retrieval through RDF and provides an idea of a making some self defined tags in RDF files.
- Chapter 5 -** Explains the experiments performed and evaluates the results achieved.
- Chapter 6 -** Presents the conclusion of this thesis and suggestions for future work. Thesis concludes with references.

Chapter 2

Literature Review

In the present day scenario, anyone with a server can publish documents for the rest of the world to see, and one can hyperlink any document to any other document. More amazingly, it does not matter if the page you are browsing is being served up by someone in Delhi (India) from a UNIX server or whether your Web browser is in fact running on a Macintosh machine in London (England) — if you can browse the page, you can link to it.

Search, integration, and Web mining are the three main uses of the Internet. Web browsers, Web servers, and even search engines do not actually distinguish weather forecasts being provided by any weather forecast site from a scientific papers providing information about weather forecast. The search engines, for example, are therefore forced to do keyword matching only; as long as a given document contains the keyword, it will be included in the candidate set which is presented to the user as the search result [5].

The Internet is constructed in such a way that its documents only contain enough information for the computers to present them, not to understand them. Requirement is to reconstruct the Web by adding some information into the documents stored on the Internet so that the computers can process this extra information and understand what a given document is really about.

The real reason for difficulty is that the current Internet is not constructed well; computers can only present users with information, but they cannot “understand” the information well enough to display the data as per user’s requirement. Another difficulty is integration, there is too much manual work involved and more automation is required. There is a need for improvement especially for searching activity so that the results are more relevant.

One of the promising solutions to all these problems is Semantic Web. Tim Berners-Lee [5], who presented the idea of Semantic Web, describes it as “an extension of the current Web in which information is given well-defined meaning, better enabling

computers and people to work in cooperation". The concept behind Berners-Lee's idea was to use hypertext as a means of organizing a distributed document system [5].

Presently, the Hypertext Transport Protocol (HTTP) is used to request documents, which are received by programs and a Web server uses a URL provided in the request to determine which file to deliver. Despite its popularity, HTML suffered from two problems. First, whenever someone felt that HTML was insufficient for their needs, they would simply add additional tags to their documents, resulting in a number of non-standard variants. Second, because HTML was mostly designed for presentation to humans, it was difficult for machines to extract content and perform automated processing on the documents [24].

To solve these problems, the World Wide Web Consortium (W3C) developed the Extensible Markup Language (XML) [24]. XML (Extensible Markup Language) is an industry-standard, system-independent way of representing data. XML was designed to transport and store data, with focus on what data is whereas, HTML was designed to display data, with focus on how data looks. In other words, it can be said that HTML is about displaying information; while XML is about carrying information.

XML too could not provide machine understandable construct as the XML schema provides a syntactic description of data and it does not provide semantics to the data and these Schemas use a restricted tag set to describe the structure of an XML document and are syntactically constrained to form a balanced tree (i.e., every starting tag must have a corresponding closing tag). Although, XML provides many different possibilities to encode domain of discourse, but this leads to difficulties when understanding of foreign documents is required.

The Resource Description Framework (RDF) is a language designed to support the Semantic Web. It is a W3C recommendation that attempts to address XML's semantic limitations. It presents a simple model that can be used to represent any kind of data. It consists of nodes connected by labeled arcs, where the nodes represent Web resources and the arcs represent properties of these resources.

RDF supports self-defined tags that allow user to define semantic description tags and hence, it serves as a mechanism for resource description, contributing to the semantic

inference based on the ontology theory. Its resource/property/value triples character helps to make inferences based on the description documents. By using these characteristics, RDF has been successfully applied for image search and results of image search through RDF are much faster and precise [14].

To enhance the semantic interpretability of images semantic annotation can be added for describing the basic characteristics of images in RDF. Semantic annotations can be coarsely classified as being formal or informal. Formal semantic annotations follow representation mechanisms, drawn on conceptual models, represented using well-defined knowledge representation languages [5].

Since the starting of this decade lot of research has been focus on semantic annotation of image collections. In [15] a tool for semantic annotation and search in a collection of art images has been discussed. Multiple existing ontologies are being used to support this process, including the Art and Architecture Thesaurus, WordNet, ULAN and Icon-class. Knowledge-engineering aspect such as the annotation structure and links between the ontologies has been discussed and some ideas have been proposed on how a semantic Web for images might work. Semantic annotation allows us to make use of concept search instead of keyword search. It paves also the way for more advanced search strategies. For example, users can specialize or generalize a query with the help of the concept hierarchy when too many or too few hits are found.

Oge Marques and Nitish Barman [16] proposed semi-automatic semantic annotation of images using machine learning techniques. It was suggested that the success of the Semantic Web hinges on ability to produce semantic mark-ups on Web pages and their components, in a way that is cost-effective and consistent with adopted schemas and ontologies. Since images are an essential component of the Web, their work focused on an intelligent approach to semantic annotation of images. Three-layer architecture was proposed, in which the bottom layer organizes visual information extracted from the raw image contents, which was mapped to semantically meaningful keywords in the middle layer, which were further connected to schemas and ontologies on the top layer. The key contribution was the use of machine learning algorithms for user-assisted and semi-automatic image annotation in such a way that the knowledge of previously annotated images - both at metadata and visual levels -

was used to speed up the annotation of subsequent images within the same domain as well as to improve future query and retrieval of annotated images.

According to Osman, T. et al. [17] most image search engines rely on free-text search that often returns inaccurate sets of results based on the recurrence of the search keywords in the text accompanying the images. They suggested that, to maximize the benefit of the colossal repository of digital images available both publicly and in private collections, intelligent matchmaking tools are required. In their paper, a semantically-enabled image annotation and retrieval engine that relies on methodically structured ontologies for image annotation allowing for more intelligent reasoning about the image content and subsequently obtaining a more accurate set of results and a richer set of alternatives matchmaking the original query .

Elahi, N., Karlsen, R., and Akselsen, S. [18] proposed to improve the quality of image retrieval and image management with the help of context information over the Web. Their hypothesis was that leveraging the semantic annotated contextual metadata of the image would yield the relevant search results and facilitate building a consistent, unambiguous image knowledge base. According to the authors, inference capability of semantic technology is very useful to deduce the new metadata from the existing metadata about images.

After going through various proposal presented for semantic annotations of images it has been realized that precision of image retrieval can be improved, by using textual annotation to the images available on WWW. RDF which serves as a basic language for realizing the dream of Semantic Web can be used as mean to describe all the resources based on some predefined rules. This helps the searching process more systematic because the search engine directly approach to RDF documents for getting the reliable information related to search and returns more relevant results.

Here we propose a semantic annotation method for image retrieval using RDF and accuracy of the search results has been validated with the use of SPARQL query engine which takes RDF as input.

Chapter 3

Problem Statement

3.1 Problem definition

During the literature survey, it was analyzed that the Semantic Search targets to make the process of image search on the Internet more compliant, according to the need of the user, by making search operation based on the image annotation and not on the keyword matching only. Earlier, the algorithms related to searching, inherently approached to keyword matching for searching the textual content but, whenever these algorithms were applied for searching non-text content, it resulted into a non-semantic search. Most of the search results were not correlating themselves to the actual need of the user because the algorithms did not possessed any meaning to know what context a user is searching for. So, these algorithms kept on the evolving over a long period of time by incorporating advance concepts on existing technologies like HTML. New concepts like XML, RDF, OWL were introduced which facilitate the semantic search on the Web. Finally, keyword searching is being replaced by the semantic searching based on the RDF documents of the resources (like images). In these RDF documents, resources are annotated by adding all the required pieces of information for making the search more intuitive and relevant.

The main objective is to create a resource repository of images related to a concept like car, airplane *etc.* A repository of RDF document will be created to annotate the images where the RDF document serves as a data model. Data model developed needs to be validated, which can be done using online W3C RDF validation service RDF model developed will be queried using SPARQL query engine.

3.2 Methodology

The step-by-step methodology to be followed in enabling Semantic Search on resource repository of images is given below:

- Study of the semantic Web technologies like RDF, OWL *etc.*
- Review of all image search engine methods used for text and non-text search.
- Create a RDF documents for important concepts and annotate these documents using RDF editor tool.

- Validate the RDF document through W3C RDF validation service.
- Run the SPARQL queries on developed RDF documents with the use of Twinkle SPARQL Tool.

Resource Description Framework (RDF)

Now a day's, information is the most important resource available. Information has diverse and overlapping groups of producers and consumers, which needs several media for communication between them. Internet represents the latest evolution of such communication channels. The success of Internet is greatly attributed to two application layer protocols HTTP and HTML. Hyper Text Transfer Protocol (HTTP) and Hyper Text Markup Language (HTML) provide a reliable, communication channel. HTML is essentially a presentation layer language for formatting web pages.

Since HTML has no inherent semantics, i.e., it does not provide a description of the Web page, a major shift in this paradigm is required. The World Wide Web Consortium, recognizing this need, introduced standardized protocols such as XML, RDF and OWL to address the semantics issue. In the present scenario a search application that can understand the semantics of a Web search will provide a better-refined search than conventional text based searches.

4.1 Resource Description Framework (RDF)

Resource Description Framework was proposed by the World Wide Web Consortium to overcome the semantic limitations of XML. It is a foundation for processing metadata; it provides interoperability between applications that exchange machine-understandable information on the Web and emphasizes facilities to enable automated processing of Web resources.

The Resource Description Framework (RDF) is an extremely flexible technology, capable of addressing a wide variety of problems as it is a language designed to support the Semantic Web, in much the same way that HTML is the language that helped initiate the original Web. RDF is a framework for supporting resource description, or metadata (data about data), for the Web and it provides common structures that can be used for interoperable XML data exchange.

As a result of many communities coming together and agreeing on basic principles of metadata representation and transport, RDF has drawn influence from several

different sources. The main influences have come from the Web standardization community itself in the form of HTML metadata and PICS, the library community, the structured document community in the form of SGML and more importantly XML, and also the knowledge representation (KR) community. There are also other areas of technology that contributed to its design; these include object-oriented programming and modeling languages, as well as databases. Although RDF draws from the KR community, it does not specify a mechanism for reasoning [19].

4.1.1 RDF Triples

- A simple model for “statements”
 - Subject: what the statement is about
 - Predicate: a property of the subject
 - Object: the value of the property
- A natural way to describe the vast majority of the data processed by machines. In figure 4.1, the subject is `http://doc`, predicate is `dc:creator` and the object is Joe Smith.



Figure 4.1: A simple RDF assertion

RDF is a general method to decompose information into pieces. The emphasis is on general here because the same method can be used for any type of information. In RDF information is expressed as a list of statements in the form SUBJECT, PREDICATE, OBJECT. The subject and object are names for two things in the world, and the predicate is the name of a relation between the two. In short, predicates can be considered as verbs.

Consider an example where information about an apartment is break down into RDF statements:

SUBJECT	PREDICATE	OBJECT
I	own	my apartment

my apartment	has	my computer
my apartment	has	my bed
my apartment	is in	hiladelphia

These four lines express four facts. Each line is called a statement or triple. The subjects, predicates, and objects in RDF are always simple names for things: concrete things, like an apartment, or abstract concepts, like has. These names don't have internal structure or significance of their own. They're like proper names or variables.

4.1.2 RDF Specifications

- The RDF specification was originally released as one document, the RDF Model and Syntax, or RDF. However realizing some problems in the initial release, updated specification released six new documents: RDF Concepts and Abstract Syntax, RDF Semantics, RDF/XML Syntax Specification, RDF Vocabulary Description Language 1.0: RDF Schema, the RDF Primer, and the RDF Test Cases.
- The RDF Concepts and Abstract Syntax and the RDF Semantics documents provide the fundamental framework behind RDF: the underlying assumptions and structures that makes RDF unique from other metadata models (such as the relational data model). These documents provide both validity and consistency to RDF - a way of verifying that data structured in a certain way will always be compatible with other data using the same structures. The RDF model exists independent of any representation of RDF, including RDF/XML [20].

The broad goal of RDF is to define a mechanism for describing resources that makes no assumptions about a particular application domain, nor defines (a priori) the semantics of any application domain [21].

4.1.3 Basic RDF Model

RDF is model and XML syntax for representing information in a way that allows programs to understand the intended meaning. It represents information about resources on the Web, i.e., metadata about resources. A resource in RDF is mapped to a Uniform Resource Identifier (URI) and is described in terms of its

properties. The purpose is to make statements about resources, which can be viewed as labeled edge (property) between two nodes (object and property value).

The foundation of RDF is a model for representing named properties and property values. Its properties may be thought of as attributes of resources hence correspond to traditional attribute-value pairs. Its properties represent relationships between resources and an RDF model can therefore resemble an entity-relationship diagram. In object-oriented design terminology, resources correspond to objects and properties correspond to instance variables [22].

The RDF data model is a syntax-neutral way of representing RDF expressions. Two RDF expressions are equivalent if and only if their data model representations are the same. The basic data model consists of three object types:

- **Resource**

All things being described by RDF expressions are called resources. A resource may be an entire Web page; such as the HTML document "http://www.w3.org/Overview.html" for example. A resource may be a part of a Web page; e.g. a specific HTML or XML element within the document source. A resource may also be a whole collection of pages; e.g. an entire Web site.

- **Property**

A property is a specific aspect, characteristic, attribute, or relation used to describe a resource. Each property has a specific meaning, defines its permitted values, the types of resources it can describe, and its relationship with other properties. This object type does not address how the characteristics of properties are expressed.

- **Statement**

A specific resource together with a named property plus the value of that property for that resource is an RDF statement. As mentioned earlier, these three individual parts of a statement are called, the subject, the predicate, and the object respectively.

Example:

In RDF resources are identified by a resource identifier. A resource identifier is a URI plus an optional anchor id. Consider as a simple example the sentence: Ora Lassila is the creator of the resource <http://www.w3.org/Home/Lassila>.

{Creator, <http://www.w3.org/Home/Lassila>, Ora Lassila}

This sentence has the following parts:

Subject (Resource)	http://www.w3.org/Home/Lassila
Predicate (Property)	Creator
Object (literal)	"Ora Lassila"

Table 4.1: RDF Format [19]

Figure 4.2 shows the diagram of this RDF statement using directed labeled graphs (also called "nodes and arcs diagrams"). In this diagram, the nodes (drawn as ovals) represent resources and arcs represent named properties. Nodes that represent string literals are drawn as rectangles.

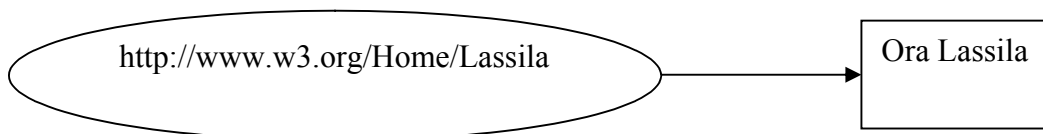


Figure 4.2: Simple node and arc diagram [19]

Thus, such a sentence would be: The individual whose name is Ora Lassila, email <lassila@w3.org> is the creator of <http://www.w3.org/Home/Lassila>.

The intention of this sentence is to make the value of the Creator property a structured entity. In RDF such an entity is represented as another resource. The sentence above does not give a name to that resource; it is anonymous, so in the diagram below we represent it with an empty oval:

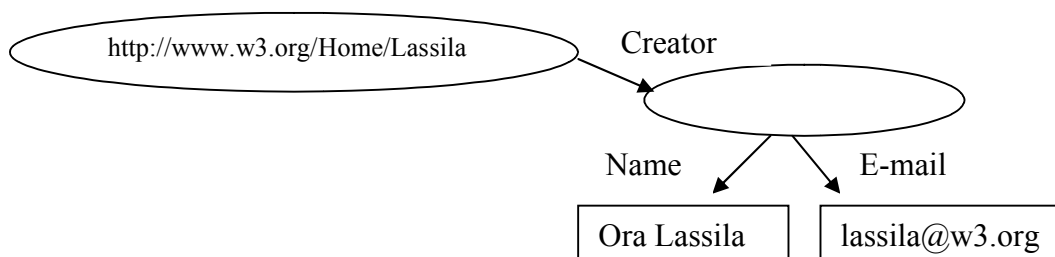


Figure 4.3: Property with structured value [19]

RDF general format:

```
<?xml version="1.0"?>  
<Class rdf:ID="Resource"  
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"  
xmlns="uri">  
  <property>value</property>  
  <property>value</property>  
  ...  
</Class>
```

Element description:

rdf:ID	RDF provides an ID attribute for identifying the resources being described. The value of rdf:ID is a "relative URI". The "complete URI" is obtained by concatenating the URL of the XML document with "#" and then the value of rdf:ID.
resource	Identifies the resource being described.
xmlns:rdf	The ID attribute is in the RDF namespace.
Class	Identifies the type (class) of the resource being described.
property	These are properties, or attributes, of the type (class).
value	Values of the properties.

Some other elements rdf:about	Instead of identifying a resource with a relative URI (which then requires a base URI to be attached before relative URI), we can give the complete identity of a resource. However, we use rdf:about, rather than rdf:ID.
-------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Table 4.2: RDF elements description [19]

4.1.4 Advantages of using RDF:

1. The RDF format, if widely used, will help to make XML more interoperable:
 - Tools can instantly characterize the structure, "this element is a type (class), and here are its properties".
 - RDF promotes the use of standardized vocabularies, standardized types (classes) and standardized properties.
2. The RDF format gives a structured approach to design XML documents. The RDF format is a regular, recurring pattern.
3. It enables quick identification of weaknesses and inconsistencies of non-RDF-compliant XML designs, providing better understanding of the data.
4. RDFS gives the benefits of both worlds:
 - Standard XML editors and validators to create, edit, and validate XML file.
 - Use the RDF tools to apply inferencing to the data.
5. It positions the data for the Semantic Web.

4.2 Annotating Images Using RDF

Images are not structured documents like text information; at the same time, the current mechanism is too rigid to make some modification and always ineffectively use information provided by users except keywords. Before the emergence of the RDF, the keywords for the image search were based on the filename of the image, the link text pointing to the image, and text adjacent to the image. To enhance and optimize search results, RDF standard is used now to describe the image resource with attributes as its weight for such content descriptive phrase, which would help user in providing new content description to images by adding new self-defined tags into resource description.

Consider images of cars with all the possible specifications i.e. brand, model, color, wheelbase, kerbweight *etc.* If user's query is for car of brand 'Honda' or 'Maruti, all the images of car will be displayed, irrespective of the brand mentioned by the user.

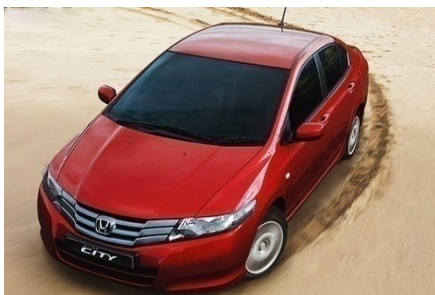
A simple RDF for figure 4.4 (a)

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:car="http://www.flickr.com/search/?q=honda+city+car#">
<rdf:Description
rdf:about="http://www.flickr.com/photos/marcusvieira/3839909947/">
<car:brand>Honda</car:brand>
</rdf:Description>
</rdf:RDF>
```

When the user searches Honda City car with 'red' color and/or wheelbase=2300 and/or kerbweight=1350, the search engine will not be able to provide the desired result as there is no annotation for these attributes in the above RDF; instead, the information returned is of all 'Honda' cars regardless of its 'color', 'wheelbase' and 'kerbweight'.

To make the image retrieval more accurate and precise and to make machine more understandable RDF document are augmented with self defined tags. The image annotation process will be improved by using such tags. In RDF document, we can give as much as possible information about any image.

Examples:



(a) Honda City 'red' Car



(b) Maruti Suzuki SX4 White Car

Figure 4.4: Cars Images with different brand, model and color

Resource description framework for Figure 4.4 (a) with semantic annotations

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:car="http://www.flickr.com/search/?q=honda+city+car#">
<rdf:Description
rdf:about="http://www.flickr.com/photos/marcusvieira/3839909947/">
<car:brand>Honda</car:brand>
<car:model>Honda City</car:model>
<car:color>red</car:color>
<car:wheelbase>2300</car:wheelbase>
<car:kerbweight>1350</car:kerbweight>
<car:weight>10</car:weight>
</rdf:Description>
</rdf:RDF>
```

Resource description framework for Figure 4.4 (b) with semantic annotations

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:car="http://www.flickr.com/search/?q=maruti suzuki+sx4+car#">
<rdf:Description rdf:about="http://www.flickr.com/photos/labeeb-
xaman/2528477801/">
<car:brand>Maruti Suzuki</car:brand>
<car:model>SX4</car:model>
<car:color>white</car:color>
<car:wheelbase>2250</car:wheelbase>
<car:kerbweight>1100</car:kerbweight>
<car:weight>9</car:weight>
</rdf:Description>
</rdf:RDF>
```

When user searches Honda City ‘red’ car or car with wheelbase=2300 or kerbweight=1350, the search engine will make inference based on the corresponding RDF document and finally provide the set of images (given in figure 4.4 (a)) fulfilling the user demand. Similarly, when the user searches Maruti Suzuki SX4 white car with

wheelbase=2250 and kerbweight=1100, the search engine will make inference based on the respective RDF document and finally provide the desired image (given in figure 4.4 (b)).

Hence, by creating the RDF document for any image or resource and providing maximum content description to that image or resource, we have enhanced the searching process and the images retrieved are more semantic in comparison to traditional search.

Second enhancement proposed in this thesis for semantic retrieval is to add weight tag in RDF document. As the number of users of any image increases, the weight corresponding to the searched keyword will increase and therefore increasing the ranking of that image with respect to that searched keyword.

By injecting the Web 2.0 features we can obtain more semantic image content description in the following ways:



Figure: 4.5: Indian cricket player Sachin Tendulkar

Consider the XML for figure 4.5

```
(i) <?xml version="1.0"?>
    <sample>
        <keyword att = "Sachin Tendulkar">1</keyword>
        <link>http://www.flickr.com/photos/Sachin Tendulkar/
    </sample>
```

In figure 4.5 - Initial description of an image regarding a famous Indian cricket player Sachin Tendulkar. “att” provides the keyword description for the image while the value ‘1’ describes the initial weight for the keyword of “Sachin Tendulkar”.

The users searches images using such keywords and get various images as the result. Further, when the user just selects one of these images, it means the content description is confirmed by user’s selection. The value of <weight> tag, which performs a very important role in the ranking of the result, will be increased by 1 for the keyword “Sachin Tendulkar” in RDF document of the image shown in figure 4.5.

The **third** idea [23] proposed for increasing the semantic image search is to add category tag which can further increase the accuracy and precision of search.

While performing search operation, the user’s background information is added in the related RDF document as additional semantic information for keywords to overcome from the situation where that keyword has several various meaning in different contexts.

To present more precise result to the users with different occupations, hobbies, and some other background profiles, we need to modify ranking algorithm for accommodating the factor of user interaction in order to present individual ranked result for various individuals even they use the same keyword to perform search operation. New evaluation method is:

For each image, except content description, add category description:

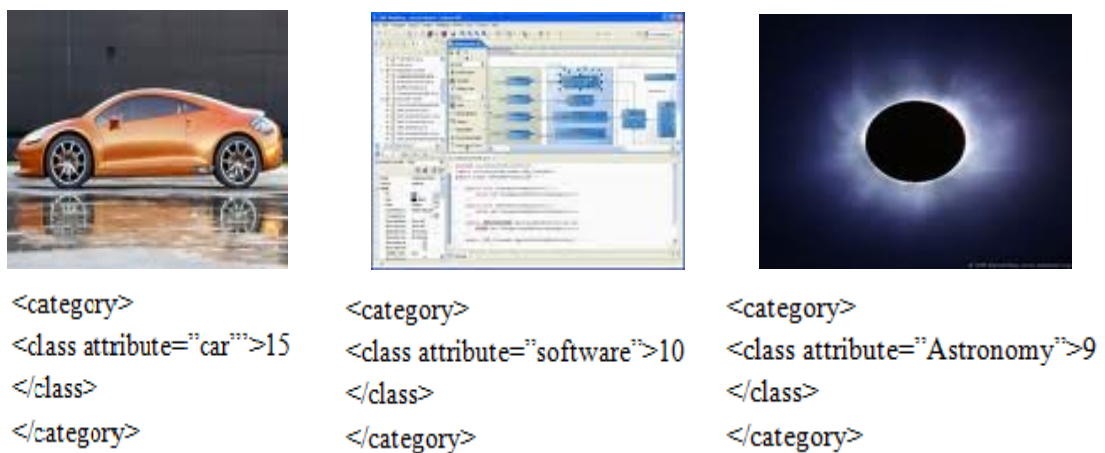


Figure 4.6 Image search result for eclipse keyword

RDF for adding category tag

```

<category>
  <class attribute=' ' >weight</class>
  ...
  <class attribute=' ' >weight</class>

```

</category>

<class> tag's attribute corresponds to users' background info description terms like occupation: 'software engineer', hobby: 'cars', 'astronomy', etc.

Figure 4.6 shows the example of using user background information for describing the category of images. As some people searching for images of cars would probably choose the first image. As soon as, the car fans choose the first image as the result for the search after keyword of 'eclipse', this image would add value car to the attribute 'attribute' of <class> tag to the category description section and with other car fans' confirmations, the value of weight for <class> tag will be increased for that particular value of 'attribute' attribute. The similar procedure will be followed in case of software and astronomy.

Rank Grade = Class Weight + keyword Weight

The Rank Grade will decide the search result of images. If one image has highest Rank Grade, it will come on the top level of the result and other images with the lowest Rank Grade will come in the last page. The Rank Grade totally depends upon appropriate semantic annotation of images and semantically searches of those images.

4.3 Tools and Browsers

The following tools have been used in solving the problem stated in problem statement section.

4.3.1 RDF Editor

RDF Editor is used to write and edit RDF documents. It generates and saves N-Triple reports on any platform.

RDF Editor Interface:

Available Menus

File Menu

- File -> New - Creates a New RDF File.
- File -> Open - Opens a current existing RDF File.

File -> Save - Saves the currently open RDF File.

File -> Save Report - Saves the report that you have generated. (Report area is the text area in the bottom half. Whatever you see there will be saved).

File -> Exit - Exit the application.

Edit Menu

Edit -> Copy All - Copy the whole RDF document that is currently open and put it in clipboard.

Edit -> Undo - 1-level down implementation of undo. If someone accidentally add or remove any component from the file, you can use undo to undo the previous action. Pressing undo twice will bring back the change done.

Tools Menu

Tools -> Generate N-Triple report - Generate N-Triple report from the currently open RDF file and show it in the Report area (bottom half).

4.3.2 Twinkle: Sparql Tools

Twinkle is a simple GUI interface that wraps the ARQ SPARQL query engine. The tool should be useful both for people wanting to learn the SPARQL query language, as well as those doing Semantic Web development.

Features:

- Load, edit and save SPARQL queries.
- Insert PREFIX statements into queries.
- Configure custom namespaces so they can be quickly inserted into queries.
- Cancel long running queries.
- Save results to file.
- Query local files and remote RDF documents.
- Query RDF data held in relational databases.
- Query online SPARQL endpoints, such as DBpedia, reylvu.com and GovTrack.
- Query using standard SPARQL, or the ARQ extended syntax which supports COUNT, etc.

- Use ARQ extension functions and property functions.
- Apply inferencing (e.g. Jena rules, RDF Schema, OWL ontology) when running queries.
- Configure commonly used data sources for quick access.

5.1 RDF document creation

RDF Editor is used to make the RDF document for cars image repository. Self defined tags are used to annotate the images. Figure 5.1 shows RDF document created using RDF Editor.

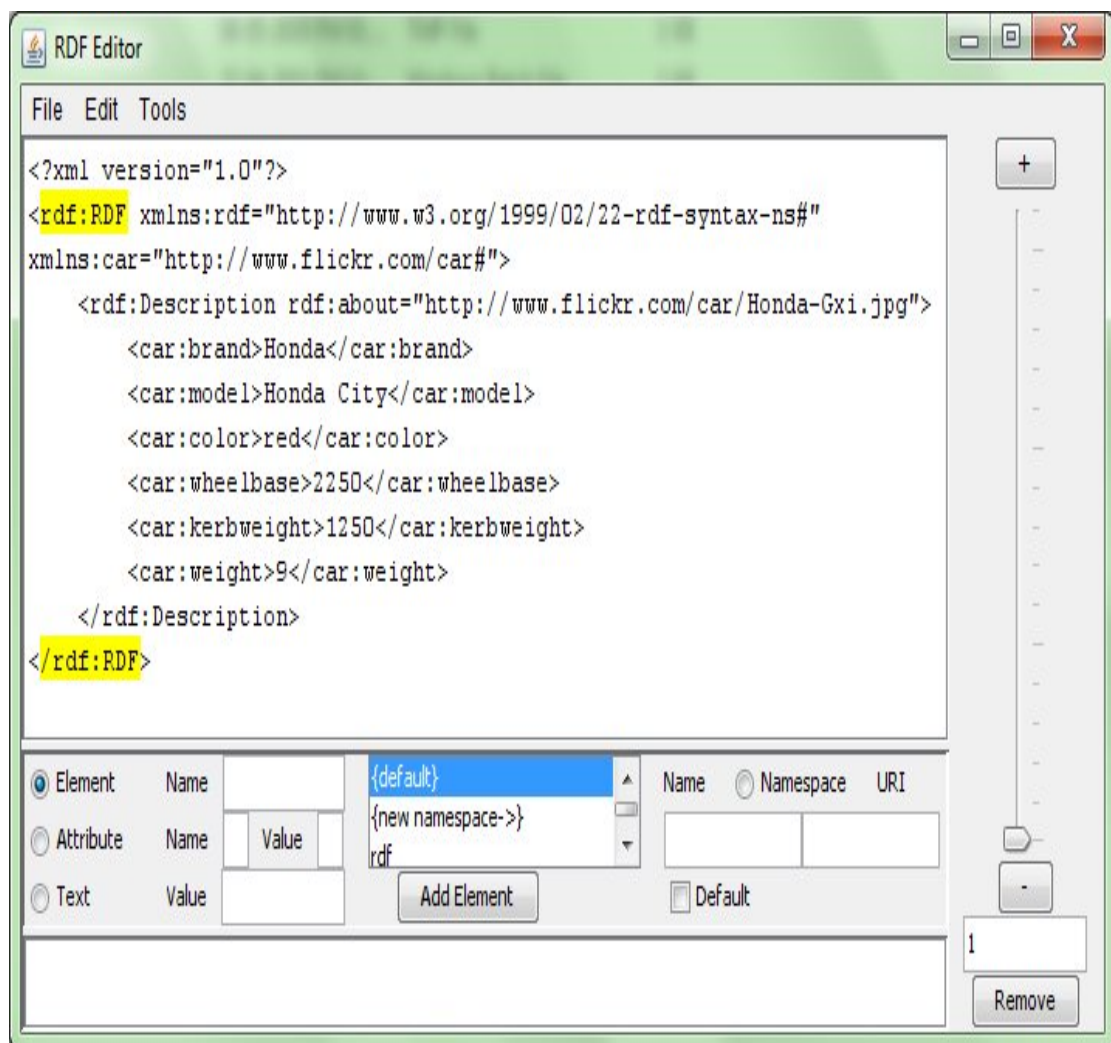


Figure 5.1: Creating RDF document using RDF Editor

The RDF document has been validated through online W3C RDF validation Service. This validation process generates the triples (subject, predicate, and object) for the RDF document (Data Model). The validation process is shown in figure 5.2:

The screenshot shows the W3C RDF Validation Service interface. At the top, there is a navigation bar with 'Home', 'Documentation', and 'Feedback' links. The main heading is 'Validation Results', followed by the message 'Your RDF document validated successfully.' Below this, a section titled 'Triples of the Data Model' contains a table with 12 rows of validation results.

Number	Subject	Predicate	Object
1	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#brand	"Honda"
2	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#model	"Honda City"
3	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#color	"red"
4	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#wheelbase	"2250"
5	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#kerbweight	"1250"
6	http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#weight	"9"
7	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#brand	"Honda"
8	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#model	"Honda City"
9	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#color	"red"
10	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#wheelbase	"2300"
11	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#kerbweight	"1350"
12	http://www.flickr.com/car/Honda-Dxi.jpg	http://www.flickr.com/car#weight	"10"

Figure 5.2: Validation of RDF using W3C RDF Validation Service

Figure 5.3 shows the graph generated for our data model showing the subject, predicate and object (triples) of few entities of RDF document.



Figure 5.3: Graph of Two Entities of RDF Document

5.2 Query Results

SPARQL tool is used to query the RDF document from different perspectives. The SPARQL, a RDF Query Language, has been used to write queries.

5.2.1 Query 1

Query 1 (as shown in figure 5.4) retrieves all the information for concept cars from the RDF document generated in figure 5.1. Results are generated in the form of triples (path, attribute, value).

The screenshot shows the Twinkle: SPARQL Tools application window. The interface includes a menu bar (File, Edit, Query), a toolbar with 'Save', 'Run', and 'Cancel' buttons, and a sidebar with 'Select Query Task' options: General, In Memory, Inferencing, and Persistent Stores. The main area contains a query editor with the following text:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?path ?attribute ?value
WHERE
{
?path ?attribute ?value
}
```

Below the query editor is a table displaying the results of the query. The table has three columns: path, attribute, and value. The results are as follows:

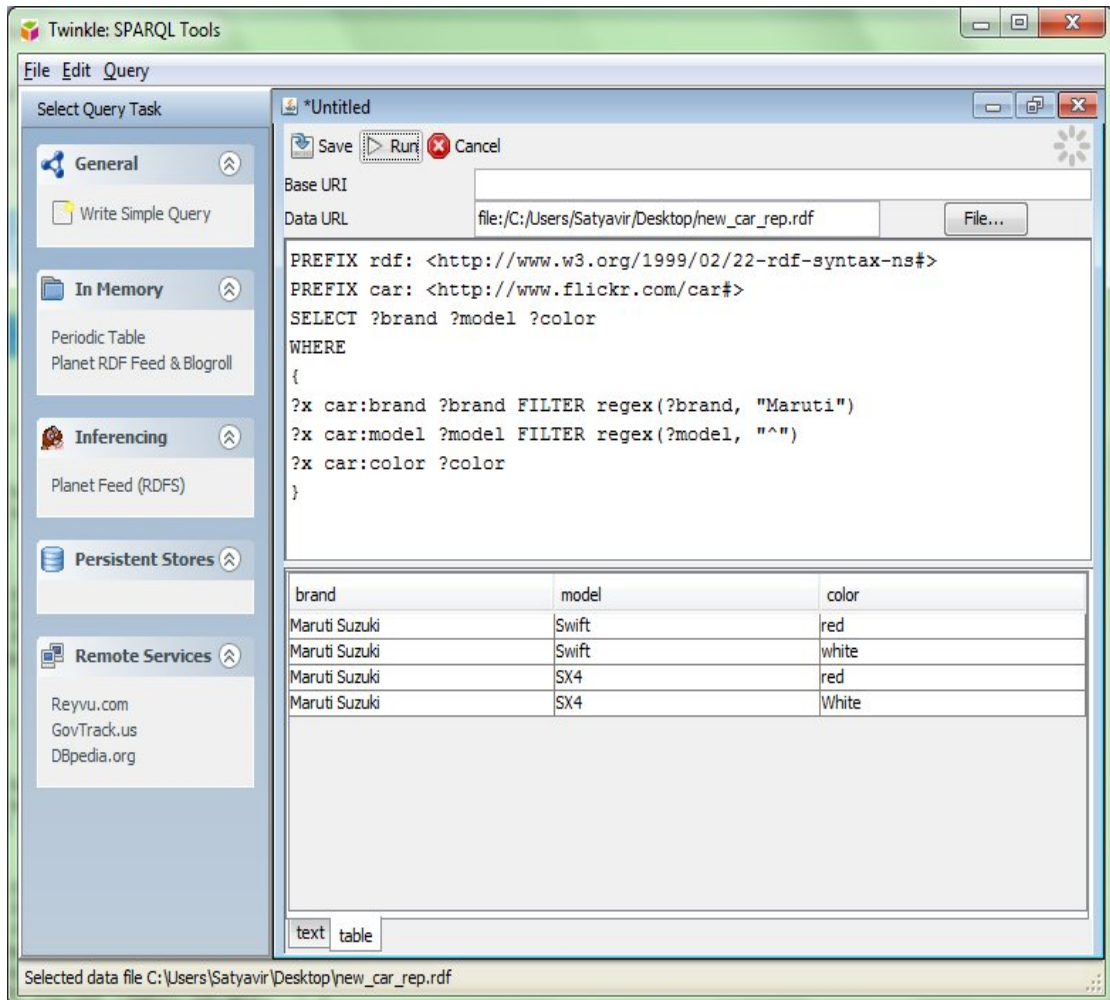
path	attribute	value
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#weight	8
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#kerbweight	1400
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#wheelbase	2500
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#color	red
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#model	Honda Accord
http://www.flickr.com/car/1404285524.jpg	http://www.flickr.com/car#brand	Honda
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#weight	9
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#kerbweight	1250
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#wheelbase	2250
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#color	red
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#model	Honda City
http://www.flickr.com/car/Honda-Gxi.jpg	http://www.flickr.com/car#brand	Honda
http://www.flickr.com/car/Honda-Gxi1.jpg	http://www.flickr.com/car#weight	7
http://www.flickr.com/car/Honda-Gxi1.jpg	http://www.flickr.com/car#kerbweight	1275
http://www.flickr.com/car/Honda-Gxi1.jpg	http://www.flickr.com/car#wheelbase	2400

At the bottom of the window, it says 'Selected data file C:\Users\Satyavir\Desktop\new_car_rep.rdf'. The status bar at the bottom shows 'text table'.

Figure 5.4: Query and output for all type of cars

5.2.2 Query 2

Figure 5.5 shows output for query on “all cars of Maruti Suzuki brand” irrespective of any model and any color.



The screenshot shows the Twinkle: SPARQL Tools interface. The main window displays a SPARQL query in a text editor. The query is as follows:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX car: <http://www.flickr.com/car#>
SELECT ?brand ?model ?color
WHERE
{
  ?x car:brand ?brand FILTER regex(?brand, "Maruti")
  ?x car:model ?model FILTER regex(?model, "^")
  ?x car:color ?color
}
```

Below the query, the output is displayed as a table with three columns: brand, model, and color. The table contains four rows of data:

brand	model	color
Maruti Suzuki	Swift	red
Maruti Suzuki	Swift	white
Maruti Suzuki	SX4	red
Maruti Suzuki	SX4	White

The interface also shows a left sidebar with navigation options like 'General', 'In Memory', 'Inferencing', 'Persistent Stores', and 'Remote Services'. The status bar at the bottom indicates the selected data file is C:\Users\Satyavir\Desktop\new_car_rep.rdf.

Figure 5.5: Query and output for cars of Maruti Suzuki brand

5.2.3 Query 3

Figure 5.6 shows output for query on “cars with model name ‘Honda’, color ‘red’ and kerbweight = 1250 kg.

The screenshot shows the Twinkle: SPARQL Tools interface. The main window displays a SPARQL query in a text editor. The query is as follows:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX car: <http://www.flickr.com/car#>
SELECT ?brand ?model ?color ?kerbweight
WHERE
{
  ?x car:brand ?brand FILTER regex(?brand, "^")
  ?x car:model ?model FILTER regex(?model, "^Honda")
  ?x car:color ?color FILTER regex(?color, "red")
  ?x car:kerbweight ?kerbweight FILTER regex(?kerbweight, "1250")
}
```

Below the query, the output is displayed in a table format:

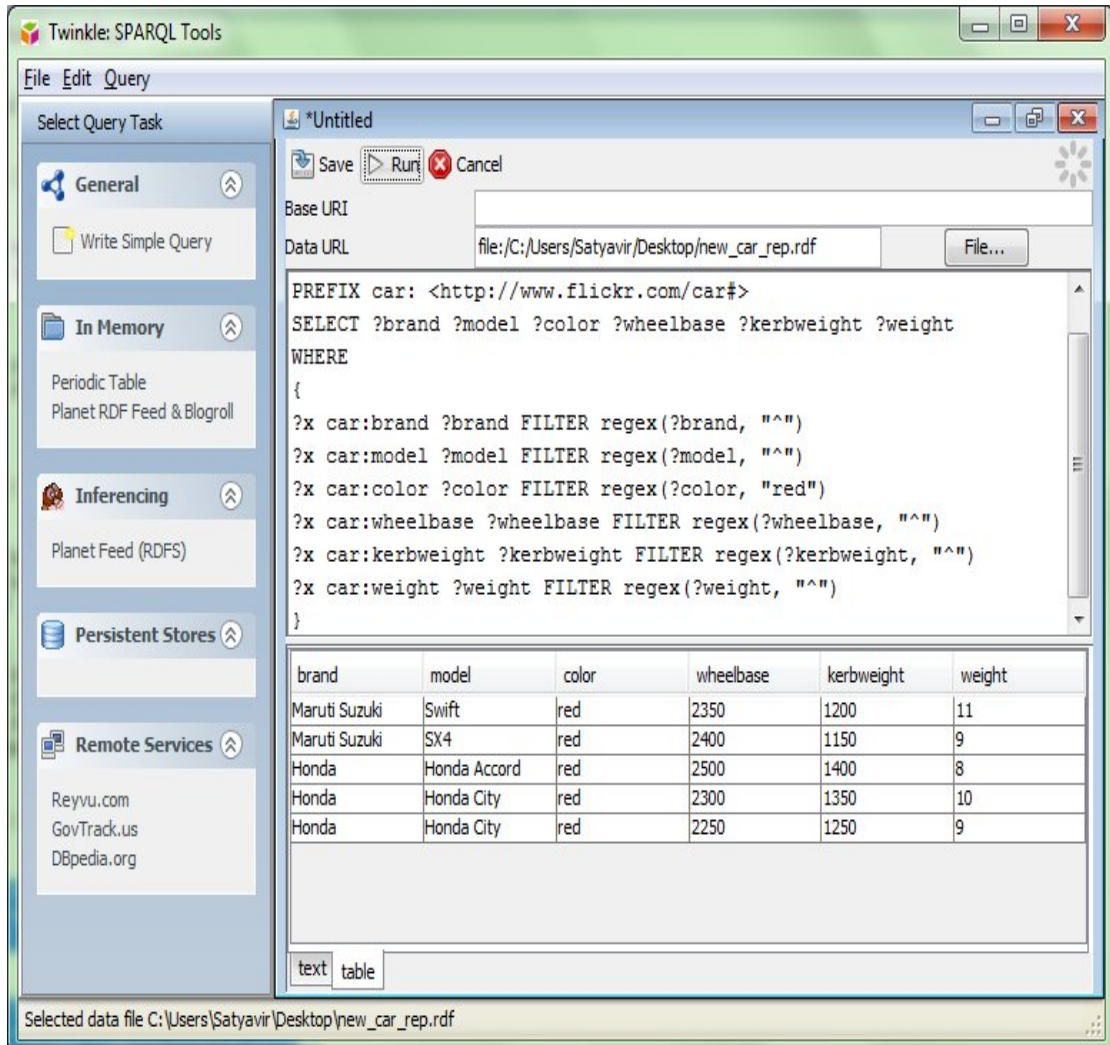
brand	model	color	kerbweight
Honda	Honda City	red	1250

The interface also shows a sidebar with various query tasks and a bottom status bar indicating the selected data file: C:\Users\Satyavir\Desktop\new_car_rep.rdf.

Figure 5.6: Query and output for cars of ‘Honda’ brand, color is ‘red’ and kerbweight=1250 kg.

5.2.4 Query 4

Figure 5.7 retrieves the information regarding cars which have 'red' color whether they are 'Honda' cars or Maruti cars.



The screenshot shows the Twinkle: SPARQL Tools application window. The main area displays a SPARQL query and its results. The query is as follows:

```
PREFIX car: <http://www.flickr.com/car#>
SELECT ?brand ?model ?color ?wheelbase ?kerbweight ?weight
WHERE
{
  ?x car:brand ?brand FILTER regex(?brand, "^")
  ?x car:model ?model FILTER regex(?model, "^")
  ?x car:color ?color FILTER regex(?color, "red")
  ?x car:wheelbase ?wheelbase FILTER regex(?wheelbase, "^")
  ?x car:kerbweight ?kerbweight FILTER regex(?kerbweight, "^")
  ?x car:weight ?weight FILTER regex(?weight, "^")
}
```

The output is a table with the following data:

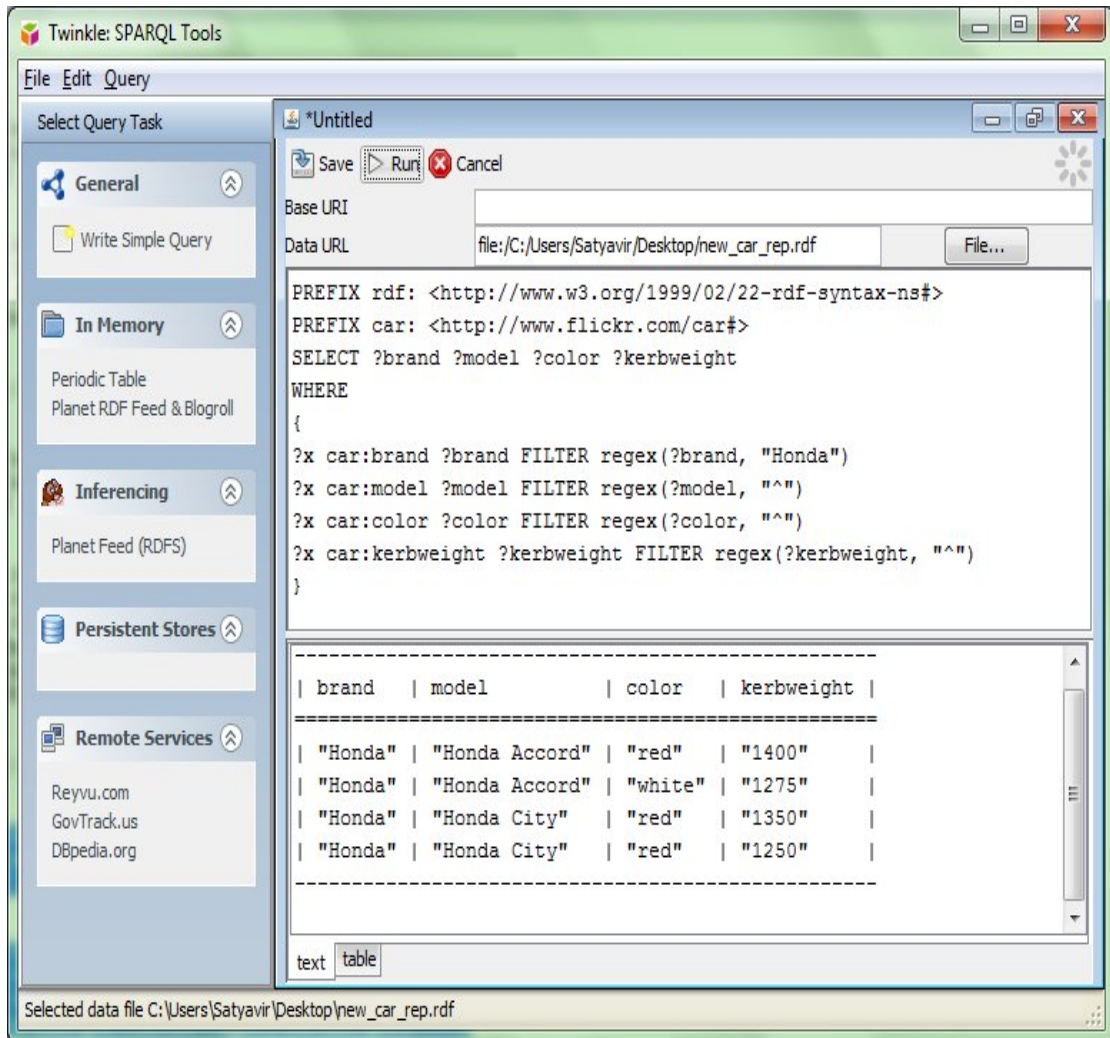
brand	model	color	wheelbase	kerbweight	weight
Maruti Suzuki	Swift	red	2350	1200	11
Maruti Suzuki	SX4	red	2400	1150	9
Honda	Honda Accord	red	2500	1400	8
Honda	Honda City	red	2300	1350	10
Honda	Honda City	red	2250	1250	9

The interface also shows a left sidebar with 'Select Query Task' options: General (Write Simple Query), In Memory (Periodic Table, Planet RDF Feed & Blogroll), Inferencing (Planet Feed (RDFS)), Persistent Stores, and Remote Services (Reyvu.com, GovTrack.us, DBpedia.org). The bottom status bar indicates the selected data file is C:\Users\Satyavir\Desktop\new_car_rep.rdf.

Figure 5.7: Query and output for all cars those have 'red' color

5.2.5 Query 5

As shown in figure 5.8, query targets to retrieve the information of cars of any model, any color and any kerbweight for 'Honda' brand.



The screenshot shows the Twinkle: SPARQL Tools interface. The main window is titled '*Untitled' and contains a SPARQL query. The query is as follows:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX car: <http://www.flickr.com/car#>
SELECT ?brand ?model ?color ?kerbweight
WHERE
{
  ?x car:brand ?brand FILTER regex(?brand, "Honda")
  ?x car:model ?model FILTER regex(?model, "^")
  ?x car:color ?color FILTER regex(?color, "^")
  ?x car:kerbweight ?kerbweight FILTER regex(?kerbweight, "^")
}
```

The output of the query is displayed in a table format below the query editor:

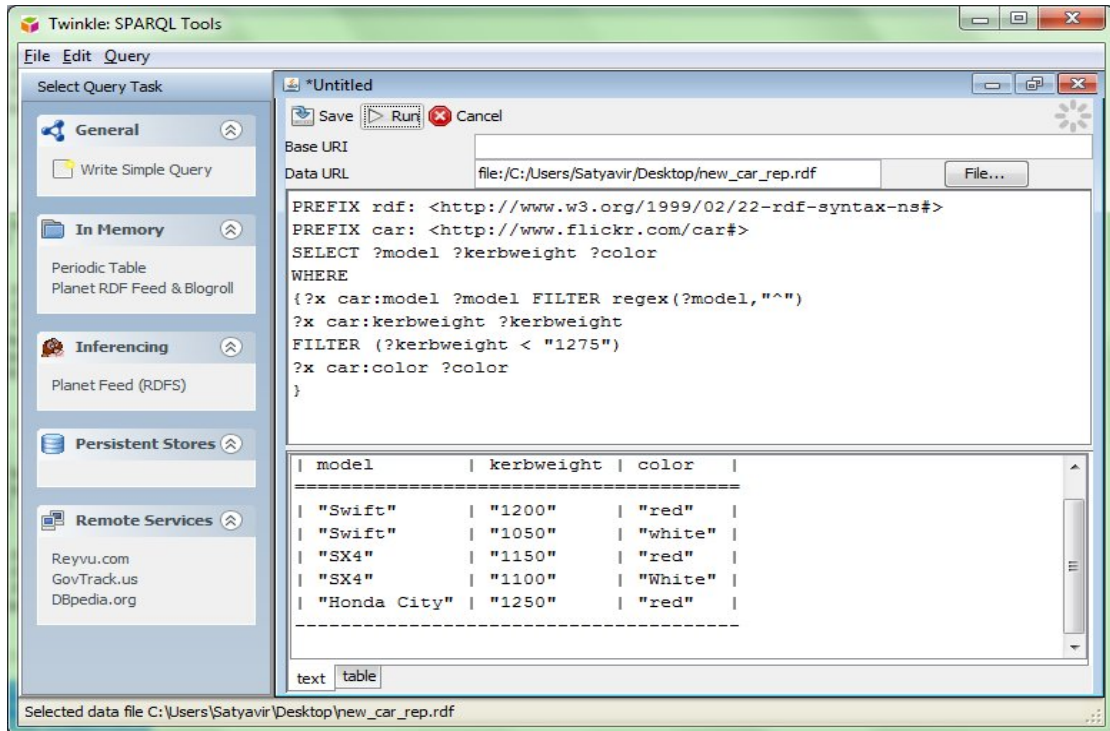
brand	model	color	kerbweight
"Honda"	"Honda Accord"	"red"	"1400"
"Honda"	"Honda Accord"	"white"	"1275"
"Honda"	"Honda City"	"red"	"1350"
"Honda"	"Honda City"	"red"	"1250"

The interface also shows a sidebar with 'Select Query Task' options: General (Write Simple Query), In Memory (Periodic Table, Planet RDF Feed & Blogroll), Inferencing (Planet Feed (RDFS)), Persistent Stores, and Remote Services (Reyvu.com, GovTrack.us, DBpedia.org). The bottom status bar indicates the selected data file is 'C:\Users\Satyavir\Desktop\new_car_rep.rdf'.

Figure 5.8: Query and output for all cars those have 'Honda' brand

5.2.6 Query 6

Figure 5.9 shows query and output for information of cars which have kerbweight < 1275 kg.



The screenshot shows the Twinkle: SPARQL Tools interface. The main window displays a SPARQL query and its output. The query is as follows:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX car: <http://www.flickr.com/car#>
SELECT ?model ?kerbweight ?color
WHERE
{
  ?x car:model ?model FILTER regex(?model,"^")
  ?x car:kerbweight ?kerbweight
  FILTER (?kerbweight < "1275")
  ?x car:color ?color
}
```

The output is displayed as a table with the following data:

model	kerbweight	color
"Swift"	"1200"	"red"
"Swift"	"1050"	"white"
"SX4"	"1150"	"red"
"SX4"	"1100"	"White"
"Honda City"	"1250"	"red"

The interface also shows a sidebar with navigation options: General (Write Simple Query), In Memory (Periodic Table, Planet RDF Feed & Blogroll), Inferencing (Planet Feed (RDFS)), Persistent Stores, and Remote Services (Reyvu.com, GovTrack.us, DBpedia.org). The status bar at the bottom indicates the selected data file is C:\Users\Satyavir\Desktop\new_car_rep.rdf.

Figure 5.9: Query and output for all cars those have kerbweight < 1275 kg.

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

This thesis work concludes that the RDF is a very powerful tool to annotate images and create data models for the repositories of the different types of resources. The predefined tags used in RDF capture all the targeted information about the resources (images in our case) and put ahead a way to make all the searches over the defined repository more relevant and accurate.

The SPARQL, a query language as well as a data access protocol, armed with all features that any general purpose query language can possess solves the purpose of making RDF a true machine understandable language. It has been confirmed that the query results exactly match with what the user desires.

Both, the RDF and the SPARQL combined together can serve as a platform to fulfill the vision of Semantic Web, as proposed by Tim Berners Lee. As the amount of images are growing exponentially on the WWW, using self defined tags and annotations will always increase the efficiency and precision of image retrieval.

6.2 Future Scope of Work

There is scope for extending this thesis work on the following aspects:

- The RDF document of car repository can be modified by adding new tags to it which can bring additional information to data model of cars and therefore enhancing the users' capability to search more meaningful contents or making a way to enhanced semantic search over the Internet.
- More profound SPARQL queries can be written in order to provide other related contents (those contents which are semantically linked to the exact content) to the users in response to their search on the Internet.

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List of Publications

Published:

- [1] Satyavir Singh, Shalini Batra, “Measures Of Semantic Relatedness And Emergence Of Flickr Distance ”, National Conference on Emerging Trends in Information Technology & Computing (ETIC-2010), Gurgaon Institute of Technology and Management, Gurgaon, Haryana, March 27, 2010.
- [2] Satyavir Singh, Shalini Batra, “Flickr Distance: An Emerging Cognitive Approach for Semantic Relatedness”, All India Seminar on Advanced Computing – 2010 (AC-10), Doaba Institute of Engineering & Technology, Mohali, Punjab, 11th-12th March 2010.

The original RDF/XML document developed for various models of cars.

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:car="http://www.flickr.com/car#">

<rdf:Description rdf:about="http://www.flickr.com/car/Honda-Gxi.jpg">
  <car:brand>Honda</car:brand>
  <car:model>Honda City</car:model>
  <car:color>red</car:color>
  <car:wheelbase>2250</car:wheelbase>
  <car:kerbweight>1250</car:kerbweight>
  <car:weight>9</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/Honda-Dxi.jpg">
  <car:brand>Honda</car:brand>
  <car:model>Honda City</car:model>
  <car:color>red</car:color>
  <car:wheelbase>2300</car:wheelbase>
  <car:kerbweight>1350</car:kerbweight>
  <car:weight>10</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/Honda-Gxi1.jpg">
  <car:brand>Honda</car:brand>
  <car:model>Honda Accord</car:model>
  <car:color>white</car:color>
  <car:wheelbase>2400</car:wheelbase>
  <car:kerbweight>1275</car:kerbweight>
  <car:weight>7</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/1404285524.jpg">
  <car:brand>Honda</car:brand>
  <car:model>Honda Accord</car:model>
  <car:color>red</car:color>
  <car:wheelbase>2500</car:wheelbase>
  <car:kerbweight>1400</car:kerbweight>
```

```

        <car:weight>8</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/maruti-suzuki-sx4-extf.jpg">
    <car:brand>Maruti Suzuki</car:brand>
    <car:model>SX4</car:model>
    <car:color>White</car:color>
    <car:wheelbase>2550</car:wheelbase>
    <car:kerbweight>1100</car:kerbweight>
    <car:weight>10</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/maruti-suzuki-sx4-extf1.jpg">
    <car:brand>Maruti Suzuki</car:brand>
    <car:model>SX4</car:model>
    <car:color>red</car:color>
    <car:wheelbase>2400</car:wheelbase>
    <car:kerbweight>1150</car:kerbweight>
    <car:weight>9</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/maruti-suzuki-swift-
dzire.jpg">
    <car:brand>Maruti Suzuki</car:brand>
    <car:model>Swift</car:model>
    <car:color>white</car:color>
    <car:wheelbase>2300</car:wheelbase>
    <car:kerbweight>1050</car:kerbweight>
    <car:weight>10</car:weight>
</rdf:Description>

<rdf:Description rdf:about="http://www.flickr.com/car/maruti-suzuki-swift-
dzire1.jpg">
    <car:brand>Maruti Suzuki</car:brand>
    <car:model>Swift</car:model>
    <car:color>red</car:color>
    <car:wheelbase>2350</car:wheelbase>
    <car:kerbweight>1200</car:kerbweight>
    <car:weight>11</car:weight>
</rdf:Description>
</rdf:RDF>

```