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Semantic-based Recommendation Tool for Library Management System using Domain Specific Ontology

Priya. P, P. Velmurugan

Abstract*: Semantic search plays a vital role for improving the output of information retrieval in today's scenario. Users those who want to find the necessary information always feel comfortable to submit queries based on related keywords to the search engine. But, the major drawback of submitting keyword query is ambiguity. So, we are moving to semantic based search. Many traditional approaches like semantic search depending on ontology encourages user to type a formal language query. Most of the novice users are not aware of formal query languages. To resolve the above drawback and enhance the retrieval effectiveness, a semantic based recommendation tool using domain specific ontology is proposed. And also to solve the limitations of usability, a query interface has to be provided to the users in which the users can enter the natural language query. To implement this semantic based recommendation tool, a domain-specific ontology is used through which accurate search results can be achieved. This Query Recommendation tool is proposed for Library Management System which uses Library Ontology for Query Recommendation. This tool compares the input query given by the user related to Library with the Library ontology and other possible queries which are related to the user query are generated from the ontology based on different entities and relationship. The queries which are extracted from the ontology using entities and properties along with query log are recommended alternative to the user's initial query. Since, the queries are extracted based on the semantics by which the concepts related to the user query are revealed, more relevant information is retrieved which leads to user satisfaction.

***Keywords:** Domain ontology, Knowledgebase, Query Augmentation, Semantic web, SPARQL.*

I. INTRODUCTION

The keyword based search engines are more popular among the users who search for information. The main disadvantage of such traditional search engines is that the synonyms of present web information sources are not processed by them. The possibilities to transcribe web information and bring out necessary information are very slight. An unconventional approach is to express the content of the web in the form of ontology which is a hierarchical structure that can be easily processed by any of the Information Retrieval tools or search engines. In this paper, the information related to library domain is collected and that information is represented in the form of hierarchical structure by developing a domain specific Library ontology. Then, the domain specific library ontology is used as a knowledgebase for developing a semantic based recommendation tool for the library domain.

A. Query Expansion

The important motivation for query expansion is to enhance the queries submitted by the user to the search engine by adding additional terms and phrases which are more closely related to the meaning of the user's original query. Such automatic query framing can be performed with the support of system which provides suggestions without the user's intervention. Since the natural language query results in high ambiguous state and a query with only one word cannot represent the actual concept of the information required by the user, query expansion is required to reformulate the queries to obtain the better results. The query expansion can also be renamed as query augmentation because the initial query is augmented with new meaningful terms.

Semantic Web is a collection of different techniques which allows the tools or search engines to understand the synonyms or information semantics on the internet. Guha et al [1] suggested Search over the semantic web which tends to upgrade the search outcomes' accuracy and effectiveness. The search based on ontology is one of the approaches for semantic web to achieve retrieval effectiveness.

B. Query Recommendation

The main aim of query recommendation technique is to upgrade the effectiveness of user's information search by recommending other possible queries to the users' initial query. The users can specify their information necessity by entering alternative queries by using the query recommendation as one of the tool. The auto completion is also a popular methodology which automatically completes the queries entered by the users in the search engine. Generally, most of the queries which are encouraged alternative to the user's query are extracted from the query log which stores the huge collection of queries framed by the users previously. The query recommendation in the process of information searching is expressed in fig. 1.

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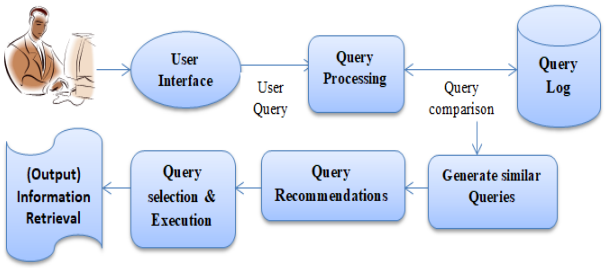

Fig. 1. Query Recommendation in search process

Even though the additional queries are provided to the users, some unwanted information may be retrieved and also the relevant documents may not be retrieved. This may be due to ambiguity problem because the document may contain words different from the term specified by the user. So, to overcome the pitfall of ambiguity, semantic-based query recommendation tool is proposed for the library domain with the goal of satisfying the user who searches for the information related to any books, journals, authors, magazines etc...

C. Semantic Query Recommendation

A semantic query suggestion [10] is a notable type of query transformation which is based on finding out the semantic concepts which are present in user queries. This technique suggests queries which reveals the concepts related to the user's query rather than suggesting the similar keywords. Semantic query Recommendation can be achieved using ontology for retrieving the required information.

When a query is entered by the user in the User Interface, the search engine searches the Knowledgebase (KB) which consists of ontologies for the required concepts, usually called as semantic search. Thus, more related information is provided by this semantic search based on the synonym and the results of this search are displayed to the user. As a result, the search time is saved for the users since the intended data is retrieved and displayed to them instead of retrieving a lot of web pages.

One of the drawbacks in semantic information retrieval is that many semantic retrieval systems do not provide natural language query interface. So, the user has to frame the query using formal query language called ontology based query language (for example, SPARQL). But, many users are not aware of ontology based query language. So, to increase the usability, semantic retrieval system has to provide a natural language query interface that eases the users to enter their own query.

In this paper, we propose a framework to make the semantic search easier. This framework provides entities present in the query as query recommendations. Our proposed work includes three steps: 1) entities are extracted from the query, 2) those entities are used to find out the new and related entities from the ontology, and 3) finally, discovered entities are suggested as alternative and relevant queries to the user.

The rest of our paper is organized as follows. In section 2, related works are reviewed. Section 3 describes how to build an ontology specific to library domain. Section 4 describes the entity-based query recommendation framework to resolve the problem in keyword based query suggestion and query expansion. The experimental results are described in section 5. Section 6 concludes the paper.

II. RELATED WORK

Semantic Search always aims to improve the effectiveness of the information retrieval. Noel Nuo Wi Tay, Sheng-Chi Yang, Chang-Shing Lee and N. Kubota [1] suggested to add intelligence into information retrieval tools which includes construction of knowledge graph for eBook material with little overhead and information retrieval through typed similarity query via random walk.

An approach called 'Semantic Search' was designed by Guha et al [2] to improve traditional web searching. This application performs the following steps: As a first step, the query is mapped to one or more nodes in semantic web. Once nodes corresponding to search term are identified, the next step is to determine data to be retrieved from semantic web and order in which it should be displayed. The node which is selected as denotation of query term is called "Anchor Node". A sub graph around this node is chosen and shown. A simple approach to obtain this sub graph is to walk through the graph in breadth first order and collect the triples in vicinity of each node. The intuition behind this approach is that proximity in graph reflects mutual relevance between nodes. A set of templates is used to display the triples in search results page.

Zhiwen Yu et al [3] proposed an approach based on ontology which takes information about the learner, information about content, and information about the domain for providing semantic content recommendation for context-aware e-learning. Such kinds of knowledge are represented using ontology. This recommendation technique consists of four steps: semantic relevance calculation, refining the recommendation, learning path generation, and augmentation of recommendation.

In area of Semantic Web, semantic search system specifies different mechanisms for information searching in the Knowledge base which varies from traditional Information Retrieval (IR) model that supports document searching. Hence, there is more concentration on improving new mechanisms that observes user queries and translates them into a query which follows the formal query representation.

A semantic search system designed by Fernandez et al [6] furnishes Natural Language Query Interface (NLI) for users to get the outcomes by passing queries over the web of semantics.

GINO (Guided Input Natural language Ontology editor) was introduced by Bernstein et al [4] based on ontology by which users can edit and query the ontologies in English. This approach depends on small grammar rules to provide query suggestions. Once a query is entered by the user, it is used to search the ontology by converting the query into Simple Protocol and RDF (Resource Description Framework) Query Language (SPARQL) query. A retrieval system designed by Fernandez et al [9] follows the approach of ontology based semantic search. Several steps are followed by the overall retrieval process of the system. The first step is to take the natural language query given by the user as input and the query processing module has to convert the query into semantic entities.

In the second step, the documents relevant to the user's query are retrieved and ranked. For this, the documents are annotated using annotation algorithm which is built inside the indexing module. Then, the annotated documents are indexed for retrieval purpose using indexing module. A list of relevant documents which are ranked based on semantics and a set of elements extracted from the ontology that provides answers to the user's queries is the final output of the system.

Bhogal et al [5] examines the ontology based query expansion and explains different types of query expansion approaches. The feedback based on the relevance, knowledge models which are dependent on corpus and knowledge models which are corpus independent are the various query expansion approaches. This paper also includes case studies describing query expansion based on ontology which is specific to one particular domain and also based on ontology which is independent of domain.

An approach called 'concept search' based on computation of semantic relation between concepts was presented by Giunchiglia et al [7]. Instead of developing new retrieval model, this approach reuses syntactic search retrieval model and data structures but the only difference is that syntactic matching of words is extended to semantic matching of concepts i.e., words are replaced with concepts.

Lopez et al [8] designed a system named 'PowerAqua' which takes natural language query as input and retrieve the answers from the ontology found anywhere on semantic web. Most of the query answering systems uses ontology as the important semantic resource.

Zhipeng Huang et al [10] proposed an approach which uses two information sources: (1) a knowledge base (or KB), such as YAGO and Freebase; and (2) a click log, which contains the URLs accessed by a query user. Using those sources, new entities are found which are useful for query recommendation. This approach also uses a hybrid framework which combines different query recommendation methods for long-tail queries effectively. This solution is applicable for providing online query recommendation services for search engines.

Jike Ge et al [12] presented an ontology-based method for personalized recommendation of knowledge in the heterogeneous environment. This approach provides an autonomous tool to the users which help to minimize the repetition and more difficult retrieved information. This approach builds domain ontology by combining data from multiple and heterogeneous resources. Then, the proper information is suggested by the recommender system to the user by matching the results which are retrieved from the domain ontology based on user's query requests and interest ontology.

Amil Rohani Dar et al [11] depicts how to build the Ontology for representing the information related to Library using Dewey Decimal Classification Scheme which represents all kind of books in the form of list of classes and subclasses.

III. BUILDING AN ONTOLOGY SPECIFIC TO LIBRARY DOMAIN

Ontology is a representation of all the relevant concepts and their relationships in a hierarchical structure. This hierarchical structure may be generic or domain specific. The main purpose of ontology is to make the semantic retrieval process easy and to retrieve most accurate information.

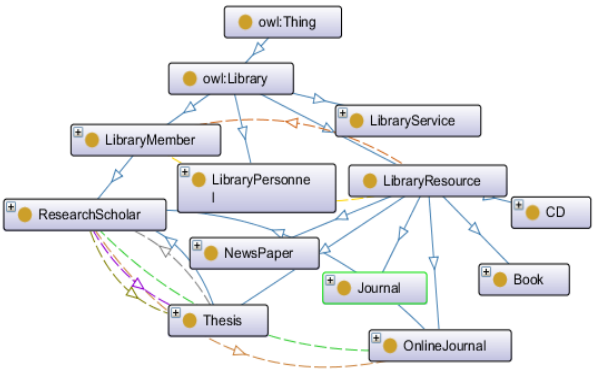

Fig. 2. Sample Library Ontology

Ontology which is specific to library domain is selected for building the information retrieval system. It incorporates classes, subclasses and relationships between the classes are revealed in terms of properties. This ontology which is used as a Knowledge Base is stored in a repository, usually called ontology repository. Ontology files are having a popular extension called .owl format. The sample hierarchical structure containing concepts or classes and sub classes of library ontology is depicted in Fig. 2.

A. Hierarchy of ontology classes

Library ontology consists of different classes such as Library member, Library personnel, Library Resource and Library Service. It is possible to create Subclasses of any of the above mentioned classes. Subclasses of class 'Library member' are Admin staff, Faculty, Guest User, Research Scholar and Student which are directly mapped to the library ontology concepts. All the classes and subclasses are represented in a hierarchical form which is shown in fig. 3.

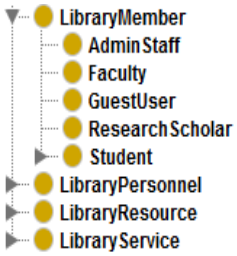

Fig. 3. Hierarchical form of classes and subclasses of Library Ontology

B. Ontology properties

The class characteristics are specified by a set of properties. Those properties of classes are also called as attributes which behaves as data values or link to other instances. The transitive, symmetric, inverse and functional properties are the various types of properties which specify the characteristics of each and every class in the ontology. The domains and ranges are also possessed by the properties. There are two major categories of properties. They are:

- Individuals to individuals are linked by Object properties
- Individuals to data values are linked by Data type properties

"Book" is a subclass of "LibraryResource" class. All the book attributes like book title, author, ISBN, edition, price, publisher, etc. provide the properties. For example; a book has an author which gives the object property 'has author'. Book has title which gives object property 'has title'. The Book has ISBN which is called as the data type property 'has ISBN'. The hierarchy of Library Ontology's object properties is shown in fig. 4.

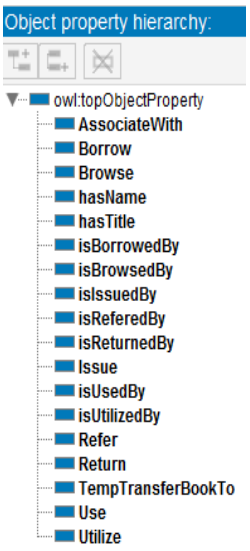

Fig. 4. Sample Object properties of Library Ontology

C. Ontology individuals

All book attributes in the library ontology consist of values. These values are called as the individuals. Suppose a book has title 'Database Management Systems'. 'Database Management Systems' is the individual for class 'Book' which has object property "has a title". Book has the author 'Ramakrishnan Gehrke' which is another individual of object property "has the author". The Book has ISBN '0-07-246563-8'. ISBN is an integer type which is called as the data type property.

Thus, a simple hierarchy of steps involving in developing the library ontology is shown below.

- Install Protégé and Build the library ontology
- Choose the storage directory in which the ontology has to be stored.
- Build ontology by considering "Thing" as the main class.
- Specify the classes' and subclasses' names under main class.
- For each class, add the respective individuals.
- Add object properties and data type properties.
- Finally add annotation properties.

D. Research Methodology

For developing ontology for the library, an approach is used in which the ontology is divided into class and subclass relation. Protégé Editor is used for the building the ontology. 'Thing' is considered as the main class of ontology which adds other classes of Library Domain whose OntoGraph is shown in fig. 5.

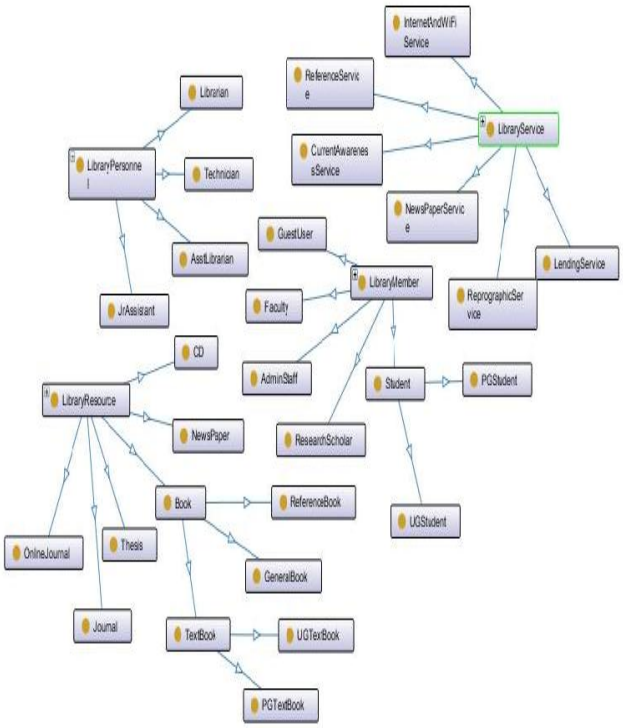

Fig. 5: OntoGraph of Library ontology

IV. QUERY RECOMMENDATION FRAMEWORK BASED ON ENTITY FOR LIBRARY DOMAIN

In this paper, a query recommendation framework is proposed in which the entities within a query are provided as query recommendations. There are three steps in this recommendation framework: 1) entities are extracted from the given user query, 2) the novel and matching entities are found with the support of other sources of information, and 3) alternative and relevant queries are recommended to the user based on the extracted entities,.

Let us examine the query which is given below.

q1: Database Management Systems written by Ramakrishnan Gehrke

In the initial step, Database Management Systems and Ramakrishnan Gehrke are the entities present in the query and those entities are related through the process of entity-linking. Then, the other conceptually related entities are identified using the other sources of information and knowledgebase.

A framework for Semantic-based Recommendation Tool for Library Management System Using Domain specific Ontology is shown in Fig. 6.

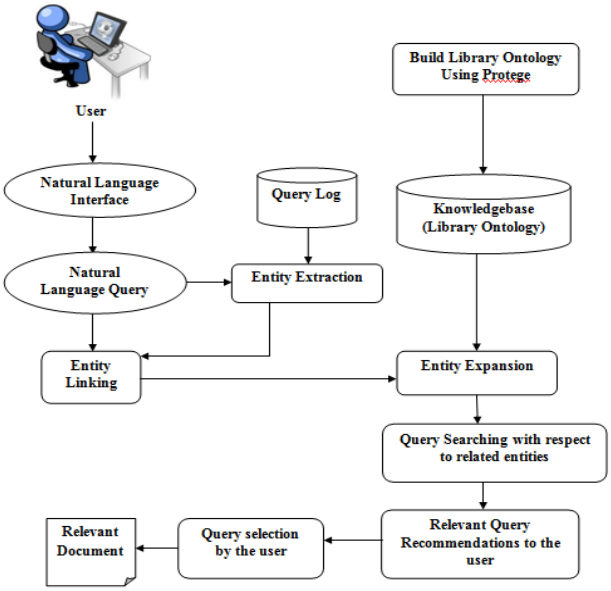

Fig. 6. Ontology based Query Recommendation Framework

In this framework, the first step is to create library ontology using protégé editor which is described in the previous section. Then, the ontology is stored in a repository which will be used as a knowledge base for query recommendation.
This Query Recommendation framework based on domain specific ontology involves three main steps for the given query q which is described below:

Step 1 – Entity linking:

Consider the query q1=”Database Management System by Ramakrishnan Gehrke’” given by the user. To extract entities from the input query q1, the entity linking has been done on q1 using query log and the set of related entities has been generated.

Step 2 – Entity expansion:

Once the related entities are identified by comparing input query with the query log, the next step is to expand the query by finding other related entities using the properties extracted from the knowledgebase.

Library ontology consists of number of classes and subclasses. They are related by number of properties. Library ontology can be queried using the SPARQL query language. The properties of each class are retrieved from the library ontology using SPARQL. Some of the properties of library domain are hasName, hasTitle, isBorrowedBy etc.. Using these properties, the other related entities are retrieved from the knowledgebase and are used to expand the entities which are found using the query log.

Step 3 – Query searching:

In keyword-based retrieval, the information that contains the given keyword is retrieved. The related concepts are not retrieved since only the keyword queries are suggested. If relationships present in the knowledgebase are used, more relevant entities are retrieved. To achieve this entity-based retrieval, both entities and properties are retrieved from the library ontology and new queries are framed and suggested to the user. Then, the user selects the required query. Finally, the information about the selected query is retrieved from the knowledgebase and the result is shown to the user.

V. EXPERIMENTAL RESULTS

A. Domain ontology

The hierarchical structure of Library Ontology developed using Protégé is shown in fig. 7.

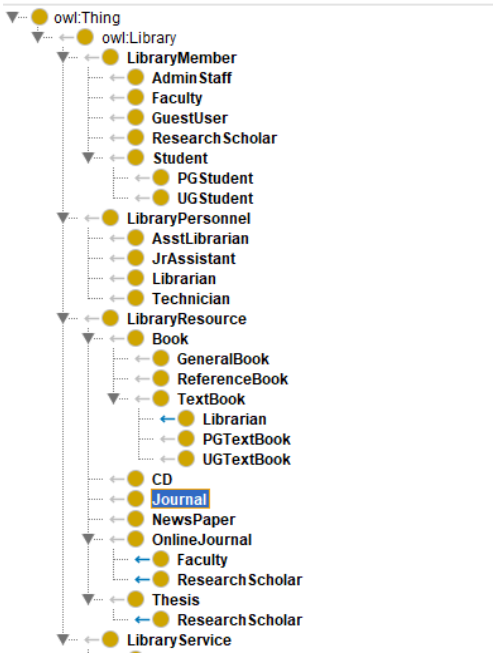

Fig. 7: Hierarchical structure of Library Ontology developed using rotégé

B. Parameters for Evaluation

- **Precision** is the percentage of relevant items out of those items selected by the query which is given by,

Precision= (Relevant_Items_Recommended in top-*k*) / (*k*_Items_Recommended) **(1)**

- **Recall** is the percentage of relevant items selected out of all the relevant items in the repository which is given by,

Recall= (Relevant_Items_Recommended in top-*k*) / (Relevant_Items) **(2)**

C. Result Analysis

To evaluate the proposed model of Semantic-based Recommendation Tool for Library Management System and its performance, precision and recall is measured in ranking results based systems. Since, in library, we usually have a huge number of resources such as books, journals, magazines, e-books etc... rather than a single one, the recall and precision retrieval evaluation method is applied to assess the functionality of the recommendation tool in picking the correct resource from the list. Depending on the number of differential resources recommended by system, the system’s precision and recall were calculated. Table- I shows the average of precision and recall based on the number of retrieved results.

Table- I: Average of precision and recall based on the number of retrieved results

Number of results	1	2	3	4	5	6	7	8
Precision	0.0667	0.0567	0.064	0.065	0.0712	0.0787	0.0819	0.1
Recall	0.75	0.85	0.85	0.7	0.7	0.75	0.65	0.5

The Recall graph depends on the number of retrieved results is depicted in Fig. 8.

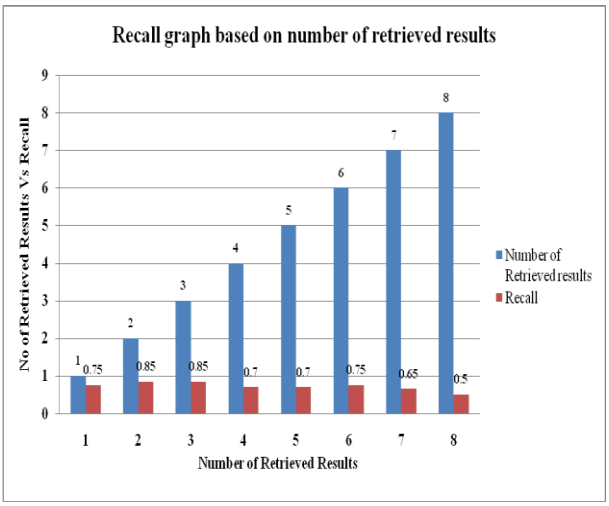

Fig. 8. Recall graph based on the number of retrieved results

The Precision/Recall graph depends on the number of retrieved results is depicted in Fig. 9.

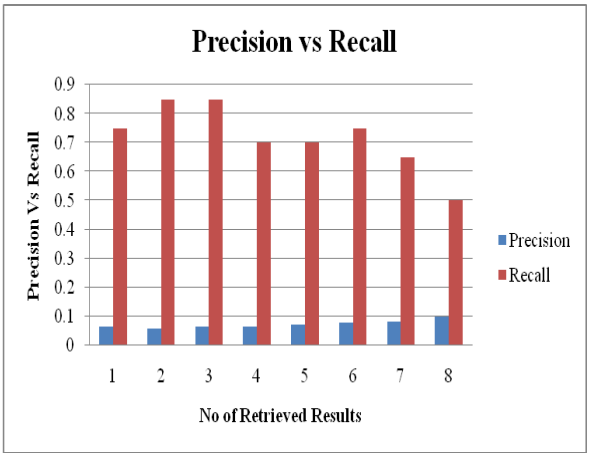

Fig. 9. Precision/Recall graph based on the number of retrieved results

VI. CONCLUSION

In this paper, building a domain specific ontology and query recommendation framework for library domain has been discussed. Retrieving information from knowledgebase using keyword-based query expansion is not effective and the user intention is not achieved. To overcome this drawback, an approach for entity-based query recommendation for library domain has been proposed. The performance of query recommendation has been improved by this approach by recommending entities based queries to the initial query framed by the user. This provides semantic based recommendations using various properties in the ontology. So, the user can retrieve the required information.

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