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A Review of Ontology based information retrieval

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Abstract: Information retrieval from unstructured contents using ontology has become an activity now a day. We attempt to review some of such activities. Unstructured content typically includes text, speech, music, video, or still images. Vocabulary mismatch and fuzzy search goals are the common problems encounters in the traditional information retrieval (IR) systems. The prime reason is the way the search concepts are expressed. The quality of search result and the usage of the system has mainly affected the keyword-based retrieval in multimedia documents. Perception and the representation of the user information needs affect the personalized search results. We propose to capture the user information needs using ontology using a world knowledge base and the user's local instance repository. A care should be taken that irrelevant concepts are not getting associated and matched and that relevant concepts will not be discarded. This can be achieved by using ontology. Many researchers have been proposed with regard to information retrieval using ontologies.

Keywords: Information Retrieval, Knowledge Representation, Domain of knowledge, Ontology.

I. INTRODUCTION

Information retrieval is a wide, often loosely-defined term. Unfortunately the word information can be very misleading. In the context of information retrieval (IR), information, in the technical meaning it is not readily measured. In fact, in many cases one can adequately describe the kind of retrieval by simply substituting 'document' for 'information'. Nevertheless, 'information retrieval' has become accepted as a description of the kind of work. This discusses the basic concepts and methods of information retrieval including capturing, representing, storing, organizing, and retrieving unstructured or loosely structured information. The most well-known aspect of information retrieval is document retrieval: the process of indexing and retrieving text documents. However, the field of information retrieval includes almost any type of unstructured or semi-structured data, including newswire stories, transcribed speech, email, blogs, images, or video. Therefore, information retrieval is a critical aspect of Web search engines. The shortcomings of keyword based techniques we have opted to employ a concept based technique utilizing ontology. Ontology is a collection of concepts and their interrelationships which can collectively provide an abstract view of an application domain.

In general, ontology is the study or concern about what kinds of things exist, what entities there are in the universe. It derives from the Greek onto (being) and logia (written or spoken discourse). It is a branch of metaphysics, the study of first principles or the essence of things. "The specification of conceptualizations, used to help programs and humans share knowledge." In this usage, an ontology is a set of concepts - such as things, events, and relations - that are specified in some way (such as specific natural language) in order to create an agreed-upon vocabulary for exchanging information. In computer science and information science, ontology formally represents knowledge as a set of concepts within a domain, using a shared vocabulary to denote the types, properties and interrelationships of those concepts.

Ontologies are the structural frameworks for organizing information and are used in artificial intelligence, the Semantic Web, systems engineering, software engineering, biomedical informatics, library science, enterprise bookmarking, and information architecture as a form of knowledge representation about the world or some part of it. The creation of domain ontologies is also fundamental to the definition and use of an enterprise architecture framework. The search keys and query formulation are the typical problems users face in information retrieval. It is known that users' queries typically contain only a few keys which might not match the vocabulary of relevant documents. Also the formulation of queries poses problems if operators should be used to connect search keys. In [1] authors have presented an ontology-based system assisting users in information retrieval.

II. Information Retrieval

Over the years, the volume of information available through World Wide Web has been increasing continuously, and never has so much information been so readily available and shared among so many people. The role of searching applications has therefore changed radically from systems designed for special purposes with a well defined target group to general systems for almost everyone. Unfortunately the unstructured nature and huge volume of information accessible over networks have made it increasingly difficult for users to shift through and find relevant information. Numerous information retrieval techniques have been developed to help to deal with this problem.

The information retrieval systems commonly used are based on keyword-based techniques. Users frequently have problems expressing their information needs and translating those needs into requests. This is because information needs cannot be expressed appropriately in the terms used by the system and partly because it is not unusual for users to apply search terms that are different from the keywords information systems use. Various methods have been proposed to help users chose search terms and formulate requests.

Using conceptual knowledge to help users formulate their requests is just one method of introducing conceptual knowledge to information retrieval. Another is to use conceptual knowledge as an intrinsic feature of the system in the process of retrieving the information. Obviously such methods are not mutually exclusive and would complement one another well.

III. Ontology based knowledge domain

In a view of semantic information retrieval, a knowledge base has been built and associated to the information sources (the document base), by using one or several domain ontologies that describe concepts appearing in the document text. The concepts and instances in the KB are linked to the documents by means of explicit, non-embedded annotations to the documents.

Domain ontology is used to describe the area designated as a specialized ontology. It gives the entity concept, mutual relation of the concepts in the area of activities as well as the formal description of features and rules. Domain ontology is essential terms and correlative forms in the specific areas which can be identified by the computer.

Domain ontologies describe a given domain e.g., medicine, agriculture, politics, etc. They are normally attached to top level ontologies which are the most general ontologies, if needed, and thus do not include common knowledge. Different domains can be overlapping, but they are generally reusable in a given domain. The ontological knowledge base of a particular domain is a knowledge frame describing and specifying the background knowledge possessed by humans forming the world knowledge base (WKB)for a domain. The primitive knowledge units in WKB are used as a subject which are linked by semantic relations.

Knowledge domain enables provision of sufficient information on data resources, and facilitates data discovery, use and exchange of data among systems. A domain model comprises the following domain elements; data identification, content, quality, extent, discovery, distribution, and others.

IV. ONTOLOGIES AND KNOWLEDGE

Exactly what the knowledge representation is? This question can be answered as:

1) A Knowledge representation is a surrogate. Most of the things that we want to represent cannot be stored in a computer e.g., bicycle, birthdays, motherhood, etc., so instead, symbols are used as a surrogate for the actual objects or concepts.

2) A knowledge representation is a set of ontological commitments. Representations are imperfect approximations of the world, each attending to some things and ignoring others. A selection representation is therefore also a decision about how and what to see in the world. This selection is called the ontological commitment.

3) A knowledge representation is a fragmentary theory of intelligent reasoning.

To be able to reason about the things represented, the representation should also describe their behaviour and intentions. While the ontological commitment defines how to see, the recommended inferences suggest how to reason.

4) A knowledge representation is a medium for efficient computing. Besides, guidelines on how to view the world and how to reason, some remarks on useful ways to organize information are given.

5) A knowledge representation is a medium for human expression. The knowledge representation language should facilitate communication.

Over the past few years, many ontology development and query languages have been developed and this is still a continuing effort. As a branch of symbolic Artificial Intelligence, *knowledge representation and reasoning* aims at designing computer systems that reason about a machine-interpretable representation of the world, similar to human reasoning. *Knowledge-based systems* have a computational model of some domain of interest in which symbols serve as surrogates for real world domain artefacts, such as physical objects, events, relationships, etc.[2]

V. MEANS OF ONTOLOGICAL KNOWLEDGE REPRESENTATION

If the knowledge in the KB is incomplete the semantic ranking algorithm performs very poorly: RDQL queries will return fewer results than expected, and the relevant documents will not be retrieved, or will get a much lower similarity value than they should. As limited as that might be, keyword-based search will likely perform better in these cases. To cope with this, our ranking model combines the semantic similarity measure with the similarity measure of a keyword-based algorithm. [3]

On-to-Knowledge uses the general-purpose Resource Description Framework to represent metadata. The tool suite uses RDF Schema, a simple, Web-based RDF Vocabulary Description Language (http://www.w3.org/TR/rdf-schema/) to describe application-specific attributes and their corresponding semantics—for example, class hierarchies and domains and ranges of properties. [4]

OIL is particularly effective as a development, delivery, and exchange language for ontology such as the Tao, which is complex and evolves with the current understanding of biology. Specifically, OIL inherits the best of both the frame and the description logic worlds. The frame-based modelling style and the range of epistemological constructs offered by OIL's syntax is comfortable and intuitive for most ontologists. [5]

The RDFS produced by Protégé conforms to the W3C standard, except for the range definition of properties. RDFS only allows a single type for a range constraint; this is too limited for Protégé. This inconsistency can be handled by simply allowing multiple range constraints. The RDFS specification document indicates that we should specify a superclass for multiple range classes, but this syntactic solution is not desirable from an ontological-engineering perspective because ranges can be disjunctive. [6]

GeoShare lets users integrate heterogeneous information by resolving structural, syntactical, and Semantic heterogeneities. In the GeoShare spatial data infrastructure, we use the BUSTER search module as the core component of an Open GIS Consortium- compatible catalog service. The knowledge is represented in ontologies formalized in SHIQ description logic which can be migrated to OWL in the near future. [7]

IHO S-100 Marine Data Model of the international Hydrographic Organization recently introduced new paradigm for integration and usage of various data on marine safety and the marine environment also includes a metadata model defined in Uniformed Modelling Language(UML).[8] This model describes main concepts and conceptual structures which provides syntactic interoperability between systems.

Orymold is desktop software for the contextual management of gene expression data. The technical aspects of the implementation and the features of Orymold can be described by building a semantic model of the model organism *Oryza sativa*. This model can be used to include macro and microscopic pictures of organs, tissues, and cell types and to integrate gene expression data. [9]

The ontology will be used to facilitate salivaomics data retrieval and integration across multiple fields of research together with data analysis and data mining. The ontology will be tested through its ability to serve the annotation ('tagging') of a representative corpus of salivaomics research literature that is to be incorporated into the SKB. [10]

User profiles are semantically enriched using association rules, Bayesian networks and ontological knowledge in order to improve an agent’s performance. Herein, the user profile is enhanced by enriching it with the semantics of ontology. [11]

FAQ system on the Personal Computer (PC) domain, which employs ontology as the key technique to pre-process FAQs and process user query. It is also equipped with an enhanced ranking technique to present retrieved, query-relevant results. Specifically, the system uses the wrapper technique to help clean, retrieve, and transform FAQ information collected from a heterogeneous environment, such as the Web, and stores it in an ontological database. During retrieval of FAQs, the system trims irrelevant query keywords, employs either full keywords match or partial keywords match to retrieve FAQs, and removes conflicting FAQs before turning the final results to the user. [12]

Search activities are performed by analyzing the *subtopic correlation* degrees with the user profile using *Kendall*, *WebJaccard* and *cosine* measures along the *training subtopic sequence*, measuring the session boundary recognition accuracy to identify the best threshold value. [13]

High precision and high recall are preserved during concept selection for documents or user requests. For this an automatic mechanism is proposed for the selection of these concepts from the description of documents / user requests by using Scalable disambiguation Algorithm for concept selection from documents using domain specific ontology is presented. Document indexing is done using vector space model of concepts or a richer and more precise model that will employ ontology. [14]

A generic scheme combining ontology based evidential framework and high level multimodal fusion aimed at recognizing the semantic concepts in videos works in two stages:

1. Neural Network based on evidence theory (NNET) provides two information for decision making belief degree and system ignorance.

2. Perplexity based Evidential Neural Network (PENN)

And TRECVid dataset to support effectiveness of scheme using MPEG-7 description tool. [15]

NKRL (Narrative Knowledge Representation Language) inference engine techniques are applied on ‘terrorism in southern Phillipines’ that can be of some interest in an ‘Ontological Modelling of Legal Events and Legal Reasoning’ context. [16]

Baysian networks (BN) are used to update the ontology repository with user selection results. An ontology mapping-based search method (OntSE) works in three phases: 1) ontology building: defining the ontology of user's keyword; (2) ontology mapping: ontology-based mapping between user keyword and terms (concepts) stored in an ontology repository; and (3) ontology updating: updating the ontology repository. [17]

OnAIR (Ontology-Aided Information Retrieval), an ontology-based video retrieval system that can be used to allow users to look for information in video fragments through queries in natural language. [18]

Case-Based Reasoning (CBR) has been largely implemented using centralized storage systems. In such systems, when the cases contain both numeric and free-text attributes, similarity-based retrieval cannot exploit standard speedup techniques based on multi-dimensional indexing, and the retrieval is implemented by an exhaustive comparison of the case to be solved with the whole set of stored cases.[19]

The Variation Reduction Adviser (VRA) system used within General Motors (GM) is a database containing problems encountered in this process and their possible solutions. The VRA acts as an electronic logbook that shares information across shifts within a plant as well as across multiple plants. The VRA also serves as a problem-solving tool by which solutions to problems encountered may be retrieved and reused. [20]

Using various visual query mechanisms, such as the query by- example (QBE) paradigm, the user presents a sample image, image region of interest (ROI), or pattern to the system, which responds with images. [21]

A Markov Logic Network (MLN) is a first order logic knowledge base with weights that can be either positive or negative, associated to each formula which combines the expressive power of knowledge representation formalisms with probabilistic learning thus enabling one to represent syntactic dependencies between words and capturing statistical information of words in text. [22]

The Vector Space Model (VSM) is adapted in order to transform these shoot context words into document-vector terms. [23]

VI. KNOWLEDGE USED FOR INFORMATION RETRIEVAL AND PERFORMANCE MEASURES USED

Tao Zang Nayak[24] used ontology-based knowledge IR framework which captures user's background knowledge to improve IR performance. Here the ontology is personalized by using the user's local instance repository. The semantic relations of hypernym/hyponym, holonym/meronym and synonym are specified in the ontology model. The performance of the experimental models are measured by three methods: the precision averages at eleven standard recall levels (11SPR), the mean average precision (MAP), and the F1 Measure.

Sugato Chakrabarty & Rahul Chougule & Ronald M. Lesperance[20] have built an ontology which is a simple version of thesaurus for the information retrieval and they claim that the ontology-guided approach gives better search results than the exact match mechanism. The results are shown in the context of real searches (in the domain of information of automobile industry) The performace measure is by means of the quantities precision and recall, where

Precision = number of retrieved relevant records/number of retrieved records

Recall = number of retrieved relevant records /number of relevant records

They have defined a metric precision_order, which determines how well ordered the retrieved set of records is in terms of relevance. If the retrieved set has more relevant records in the top n records, then its precision_order value is higher than if it has fewer relevant records in n.

Shlomo Berkovsky · Tsvi Kuflik · Francesco Ricci[19] have worked on similarity-based retrieval of structured data, such as Case-Based Reasoning (CBR). It has been found that in such systems, when the cases contain both numeric and free-text attributes, similarity-based retrieval cannot exploit standard speedup techniques based on multi-dimensional indexing. They have proposed a novel approach for storage of the case-base in a decentralized Peer-to-Peer environment using the notion of Unspecified Ontology to improve the performance of the case retrieval stage and build CBR systems that can scale up to large case-bases. They have developed a distributed an algorithm with distributed nature for the retrieval of approximated most-similar cases, which exploits inherent characteristics of the unspecified ontology in order to improve the performance of the case retrieval stage in the CBR problem solving cycle.

DaeWon Park [8] has given the S-100 of the International Hydrographic Organization (IHO), recently introduced new paradigm for integration and usage of various data on marine safety and the marine environment and also includes a metadata model defined in uniformed modeling language (UML). But people encounter difficulties in semantic heterogeneities as well as in automatic semantic-based processing. DaeWon Park introducee new metadata ontology. They have presented an ontology as a semantic base for support of the semantic understanding of marine metadata, focusing on the resolution of semantic ambiguity and the removal of redundancy.

It has been found that metadata ontology enables systems to automatically understand marine metadata, thereby enhancing semantic interoperability between systems. Moreover this ontology can be used as a semantic base for adjusting the heterogeneity of different metadata models.

Jaume Mercadé [9] has developed software named Orymold, which is a flexible and customizable software application for the integrative exploration of heterogeneous experimental data sources in a biologically meaningful context. Its architecture allows both individual and collaborative initiatives and research groups to rapidly and easily integrate experimental data in their own semantic model describing an organism, or part of an organism.Once experimental data is integrated, it is straightforward to perform semantic queries and point out relevant trends on gene expression data based on both spatial and temporal expression patterns.

Sheng-Yuan Yang & Fang-Chen Chuang & Cheng-Seen Ho [12] describes an FAQ system on the Personal Computer (PC) domain, which employs ontology as the key technique to pre-process FAQs and process user query. It uses an enhanced ranking technique to present retrieved, query-relevant results. This work uses ontology in the activities of retrieval process like trimming irrelevant query keywords, full or partial keyword matching, and removing conflicting FAQs. For the fine refinement of the output of the search, the system employs an enhanced ranking technique, which includes Appearance Probability, Satisfaction Value, Compatibility Value, and Statistic Similarity Value as four measures properly weighted to rank the FAQs.

They have defined ranking sequence from the system and the ranking sequence from the expert. To measure how consistent the two ranking sequences are they definee ranking gain G. A higher G implies better ranking consistency between the domain expert and the system. This calculation is a special form of vector similarity and reflects the degree of similarity between the two ranking sequences. The normalized raning gain is defined based on the best ranking gain Gmax and worst ranking gain Gmin. The best ranking gain occurs when the system ranking sequence conforms to that of the expert sequence.

Latifur Khan, Dennis Mcleod [14] has created a domain-specific ontology to improve the accuracy in terms of precision and recall of an audio information retrieval system. Through the use of a domain-specific ontology appropriate concepts can be identified during metadata generation (description of audio) or query generation, thus improving precision. In conjunction with the use of a domain specific ontology we have thus proposed a novel, automatic pruning algorithm which prunes as many irrelevant concepts as possible during any case of description and identification of documents, and query generation. To improve recall, A controlled and correct query expansion mechanism is proposed for the improvement of recall, thus guaranteeing that precision will not be lost. The performance measures are precision and recall and F score.

GIAN PIERO ZARRI [16] gives an application of Narrative Knowledge Representation Language (NKRL) techniques on (declassified) ‘terrorism in Southern Philippines’ documents has been carried out in the context of the IST Parmenides project.

This paper describes some aspects of this work: it is our belief, in fact, that the Knowledge Representation techniques and the Intelligent Information Retrieval tools used in this experiment can be of some interest also in an 'Ontological Modelling of Legal Events and Legal Reasoning' context.

Min Jung & Hong-Bae Jun & Kyun-Woo Kim & Hyo-Won Suh [17] says that users in enterprise information systems want to efficiently search the information that they need. Although several searching approaches have been proposed so far, they still have the limitation in finding the semantically similar information that users need. To overcome the limitation, it is essential to consider the semantics of user keyword and terms (concepts) stored in the ontology repository and continuously update the ontology repository for information searching. To this end, in this study, an ontology mapping-based search methodology (OntSE) is proposed. The OntSE consists of three phases: ontology building, ontology mapping, and ontology updating. Its objective is to find the terms which have the same semantics with user's keywords, based on multidimensional similarity and Bayesian network. To show the benefits of the proposed methodology, a case study has been carried out.

VII. Conclusion and Future Work

One of the important milestones before building an ontology driven query formulation system is to decide on the ontology development language to be used. It has been reviewed in this paper that the ontology models, and in particular, is suitable for capturing the relational schema structure, data semantics and knowledge representation of a particular domain. However, there exist structural and conceptual differences between an ontology model and a relational model. Moreover, there are limited structured and generic architectural methods or frameworks which can assist in defining queries in terms of ontology statements so that they can be translated to relational queries.

Thus, this raises the need for the development of structured and generic ontology-relational query translation methods, where users can be assisted in formulating domain specific queries without the knowledge of the associated information structure and access mechanisms. To achieve this, it is proposed that the link between ontology statements constructs and relational query statement constructs can be used to generate relational queries. Furthermore, an ontology guided relational query formulation process needs to take into consideration aspects of ontology modelling, processing and integration of domain knowledge based on the underlying relational models and mapping of ontological concepts to a relational schema.

The performance measures in information retrieval using ontology are in majority cases found to be the precision and recall or depending on the context these parameters are modified.

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