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Emerging Trends in Reducing Semantic Gap towards Multimedia Access: A Comprehensive Survey

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Abstract

Objectives: The exponential growth of web has increased the volume of the documents. Data does not carry any meaning, but it should be interpreted efficiently for execution of query. Semantic web is combined with statistical and machine learning techniques to increase the efficiency of an information retrieval system. Semantic web supports reasoning of uncertain and vague knowledge for applications like multimedia processing, ubiquitous contexts, etc. **Method:** Resource Description Framework and Ontology Web Language are standard formats for sharing and integrating knowledge. This paper includes the recent trends in accessing the information in semantic web and reducing semantic gap. **Findings:** This paper provides an overview of contemporary challenges and open research issues in reducing the Semantic gap. **Application/Improvement:** Use of Description logics increases the efficiency of semantic retrieval.

Keywords: Ontology, Semantic Gap, Annotation

1. Introduction

The World Wide Web is a storehouse of multimedia information that can be available to a user with an internet connection. Due to the distributed design of web, each file can point to other file, either on the same or different computer. Understanding and interpretation of natural language expression by a machine is difficult. The Semantic Web provides meaningful information for machine interpretation[1]. A search engine navigates the web looking for original or changed pages. Some search engines use link analysis to find the web pages to process a query. To illustrate an example for present-day web search, consider a query to find the "chair of Stanford electrical science department". Initially search engine maps the word "Stanford" and relates it to the United States department of any university. Also a person completing electrical science degree from Stanford is returned.

The problem is that the search engine is not aware of the relationship between the keywords of the query. Semantic web provides a model for sharing and reusing of data by various user communities. The Semantic Web is an evolving research area which builds on the fundamentals of providing understanding to the web and represents the knowledge. The semantic gap is the deviation of description between the low level and high level characteristics of an entity. Multimedia analysis and reasoning is a field where the semantic gap directly affects the user. If an image is to be understood by the content, then the only available information is the low level feature. The recent trend in multimedia research is to reduce the semantic gap for efficient access.

2. Related Approaches to reduce Semantic Gap

The primary objective of an information retrieval system across web is to reduce semantic gap. Ontologies support model driven software engineering techniques. In[1-2-3] introduced a framework for classification of ocean images using ontologies. The dataset is preprocessed, segmented and then annotated. Decision tree algorithm is used as a classifier and represented in web ontology language.

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Semantic web rule language is a rule based classifier. The Geospatial information is retrieved by using fuzzy logic.[2] provide an overview of computational system that combines annotation with image classification. The steps involved in retrieval system include cloud masking, histogram equalization, segmentation, deleting regions over a threshold and extraction of various descriptors. A fuzzy database is created and Neurofuzzy classifiers are applied to classify the regions of the images. Fuzzy structured query language is used. Also the accuracy rate is evaluated.

To build a machine understandable language to structure the information is challenging task. The proposed work[4-6] introduces Description Logic (DL) as a logical formalism to reason over concepts. The proposed approach combines feature based similarity methods with logic for multimedia retrieval. An ontology layer is built using fuzzy description logic to define the concepts and relations of the domain. Description Logic based Multimedia content management system consists of metadata models represented in XML. When a user enters a query, results are ranked in a list and displayed after evaluation module processes the query. Also DL-media uses an extension of DLR-lite (D). Web ontology language is presently World Wide Web standard for expressing information in semantic web. Fuzzy Logic is extended to enumerations, axioms and ontology to handle vague and imprecise knowledge. Automatic image annotation of images is a thought provoking problem. The proposed approach introduces a system to associate textual description of an image by classifying them into semantic classes based on their visual features to reduce semantic gap. Also it provides an overview of multimedia ontology for image annotation.

An annotated image database is considered for training. Then fuzzy logic component is added to multimedia ontology to obtain spatial, conceptual and contextual knowledge. Two major steps involved in the approach are performing hierarchical image categorization and multistage reasoning to obtain logical coherence over the knowledge base.

Statistical and machine learning techniques are applied to build intelligent computational model for handling human behavior based on features. Ontologies are useful in recognizing and modeling human activities. Knowledge assisted techniques increase interoperability of the computing system. Also ontologies are widely used to design crisp and fuzzy knowledge base and then fuzzification procedure is applied. Neon ontology engineering methodology is used as a standard. The proposed approach[6] provides a framework to draw inference on crisp human behavior ontology consisting of user's environment, behavioral activity, relationships, activity duration and concurrency. Managing huge amount of multimedia requires designing a minimalistic ontology structure and reasoning algorithm to increase the performance and scalability. The proposed approach[7-8] provides a mathematical descriptive scheme to build a semantic video ontology. Concept lexicon, concept properties and relations are factors considered to design a formal ontology. In the proposed approach, concept detection towards multi-modality fusion is done by weighting scheme. Pair wise correlations among concepts are established. Bayesian network is built to establish hierarchical relation among concepts. Also as an extension, fuzzy interrelationships among the shots of video are introduced and similarity is computed over the large annotated data set.

The proposed work[9] explains a generic scheme to combine a domain based ontology with a multimodality fusion technique to recognize semantic concepts. The proposed framework adopts neural network based evidence theory to build relationship between multimedia descriptors and concepts based on entropy and perplexity. Perplexity based evidential neural network is also introduced in combination with classifiers. Concepts associated with ontologies are subjected to readjustment of confidence values to find semantic similarities. The metrics used in evaluation are error rate, F- measure and classification rate.

News related content is accessed by many users for everyday applications. The proposed framework[10] associates temporal segment of the video to the relevant semantic concept. A domain based multimedia ontology is built. Multimodal analysis is carried by tools to perform audio event detection, video classification and linguistic analysis of speech transcripts. The visual information is analyzed by key frame and region level classification techniques. The support vector machine classifier computes visual information on set of images. A performance analysis is carried between multimodal methods. Imprecision is taken into account to model vague information. Spatial relation between the objects is calculated for image interpretation in computer vision.

Description logics support reasoning on quantitative characteristics of real world objects. The proposed approach[11-12] combines fuzzy description logics and mathematical morphology to represent concepts. This spatial relation representation combines features, morphological operators and fuzzy sets. A spatial relation ontology structure is built for cerebral image representation and reasoning is performed.

The role of decision making is necessary for phenomenal growth of digital image and video collection. In order to improve the human computer communication interface, understanding semantic concepts of images based on linguistic descriptions is necessary.

Ontology are interoperable description schemes to represent, share and reason on knowledge. Ontology matching and Ontology alignment is performed. The proposed approach[13] provides an overview on ontology matching and extraction of image features. To address the interoperability problem, MPEG-7 descriptors called as baseline detectors build image signature efficiently to differentiate among concepts. The Semantic content can be categorized into various levels. The proposed work[14] represents video as a temporal sequence of frames by relating it to the semantic content. Also Meta ontology is constructed and fuzzy relation is introduced between concepts of the domain. Initially objects are extracted and classified from video key frames. Then semiautomatic genetic algorithm is applied over temporal and spatial relations that are extracted. Precision and Recall parameters are calculated.

The proposed approach[15] introduces multilevel model for information retrieval. A probabilistic relation between terms of documents is established to enhance the value of precision and recall. Also a ranking algorithm is proposed to rank the documents based on the degree of relevance. Collection of documents, Query processor and a ranking entity are the modules considered. Based on the weighting scheme, matching degree is calculated for documents.

3. Comparison of Selected Approaches

Table 1. Summary of related work

Reference	Approach	Data Set	Tool
Jesus M. et al.	Representing ontologies in OWL using semantic web rule language	NOAA Images	Protege
Jose A. et al.	Neurofuzzy classification using fuzzy structured query language	NOAA Images	Neurofuzzy classifier
Stoilos et al.	Fuzzy extensions for description logics	Concept	Protege
Bannour et al.	Hierarchical Image Classification and annotation	Pascal VOC'10	Protege
Umberto Straccia	Logic and feature based similarity Retrieval	Flicker Images	DL-Media
Natalia D R et al.	Reasoning on fuzzy human Behavior	Sensor Readings	Protege
Jun Zha et al.	Video semantic ontology for concept Detection	TRECVID 2005	Columbia374
Zarka et al.	Fuzzy ontology based video annotation	Flicker Images	KAON
Benmokhtar et al.	Multimedia fusion and indexing using ontology	TRECVID 2007	LSCOM-lite
Mezaris et al.	Multimodal analysis and annotation	Deustche Welle	OntoEdit
Hudelot et al.	Spatial Relation ontology	Medical Images	Protege
Nicolas James et al.	Generic instance based ontology matching	LSCOM Images	Protege
Nicolas James etal.	Interoperability among heterogeneous ontology models	TRECVID 2005	Wordnet and LSCOM
Yildirim et al.	Fuzzy video metaontology	Office Surveillance videos	Protege
Todorov et al.	Collaborative framework for sharing Ontologies	TRECVID 2005	LSCOM-lite
Zeinab E. et al.	Ranking of documents based on relevance	Documents	OntoEdit
Wallace et al.	Subjective classification of multimedia using fuzzy algebra	Video data sets	Onto mat annotizer

4. Research Challenges in Reducing Semantic Gap

The following are the open research challenges[16] in the area of semantic web -

- An open platform to address the issue of interoperability: The knowledge representation and reasoning can be extended to heterogeneous systems. A fault-tolerant and reliable system can be built using Grid structure.
- Large scale distributed information management and query accuracy: Querying over large database requires efficient mining, updating and sharing algorithms to retrieve the information from multiple sources.
- Adaptive Personalization: Intelligent web personalization techniques in semantic can be developed for communicating information to machine and perform content- aware search over the resources. Some of the techniques include collaborative filtering and subject based filtering.
- Semantic Mining and Relevance Feedback: Exploration and understanding of user's search history across web requires taxonomical organization of concepts. Relevance feedback can be applied to improve ranking over the information. Low precision and high recall are the parameters to increase performance measure of search.
- Trust based systems: Trust is an essential component of Semantic Web and refers to authenticating the source of information. User's intention and identification are essential to build an intelligent and secured search model. Advanced security algorithms can be integrated in the architecture.
- Collaborative resource sharing: Resources should be dynamically and transparently available to the user by an optimal computational model.

5. Conclusion

With the phenomenal growth in information, it is necessary to improve the human computer interaction. The objective of semantic web search is to intelligently exploit web information and resources for better results. Ontologies are supplemented with spatial and correlated information to improve reasoning and provide efficient retrieval.

Fuzzy description logics deal with uncertain conceptual relationships. Further research can be extended to scale the information and apply efficient algorithms. This paper provides an overview of various approaches to retrieve multimedia knowledge in semantic web and challenges related to reducing the semantic gap.

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