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New-Fangled Alignment of Ontologies for Content Based Semantic Image Retrieval

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Abstract

This paper highlights content based image retrieval system using alignment of ontologies. The traditional contents-based image retrieval systems using single ontology retrieve imprecise images. To overcome this weakness, proposed image retrieval system designed using core semantic multiple ontology which merges feature ontology, semantic feature ontology, user ontology and metadata ontology. Proposed content based image retrieval system reduce semantic gap and provides highly accurate, efficient and effective image retrieval result.

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1. Introduction

Ontology is a body of knowledge describing some domain, usually knowledge domain. In other words, an

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ontology is an inner body of knowledge, it not a way to describe the knowledge. Ontology enfold representations and descriptions of types of objects found in the domain. In computer science and information science, ontology is a formal representation of knowledge as a set of concepts within a domain, and the relationships between those concepts. Ontology provides a shared vocabulary, which can be used to model a domain [1]. There are many computer fields where ontologies are used typically in artificial intelligence, Semantic Web, image retrieval systems, 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.

1.1. Fundamental of ontology

In Computer Science, ontology is an explicit specification of the conceptualisation of the domain. Ontology makes things explicit; without ontology many design assumptions may be implicit in the executable representation, ontology is supposed to formal; the notions it captures are thus precise and unambiguous. Ontology concerns some specific domain and ontology represents a conceptualisation. Different people will conceptualise a domain differently according to experience, temperament and their tasks in the domain. As mention earlier, ontology is a description of the concepts and relationships that can formally exist for a domain. Ontologies are often equated with taxonomic hierarchies of classes, class definitions, and the subsumption relation. Generally, the majority of ontology describes individuals, classes, attributes, and relations. General components of ontologies include individual, classes, attributes, relations, restrictions, rules and axioms [1].

- Individuals: instances or objects or ground level objects
- Classes: sets, collections, concepts, classes in programming, types of objects, or kinds of things
- Attributes: aspects, properties, features, characteristics, or parameters that objects (and classes) can have
- Relations: ways in which classes and individuals can be related to one another
- Restrictions: formally stated descriptions of what must be true in order for some assertion to be accepted as input
- Rules: statements in the form of an if-then sentence that describe the logical inferences that can be drawn from an assertion in a particular form
- Axioms: assertions in a logical form that ontology describes in its domain of application.

1.2. Types of ontology

On the basic of scope of the ontology, ontology may be classified into four type’s generic ontology, domain ontology, task ontology and application ontology. Sometime, it is found that an application ontology as the bottom of a hierarchy in which an upper ontology is developed into a domain ontology which is further developed into the application ontology. All such ontologies typically contain the detail of attributes, values and axioms not found in lightweight ontologies.

- Generic ontology is top-level ontology. It describing general knowledge, such as what time is and what is space. Basically, this ontology describes fundamental categories applicable to all domains.
- Domain or Core ontology describes a domain, such as medical domain or electrical engineering domain, or narrower domains, such as personal computers domain. Domain ontology clear the concepts fundamental to some particular domain.
- Task ontology is suitable for a specific task, such as assembling parts together.
- Application based ontology developed for a specific application, such as assembling personal computers. Application ontology contains the appallingly detailed and specific concepts required to perform a particular task on a particular part of rule.

2. Related work

Content Based Image Retrieval system provide accurate feature-based similarity measures in a multi-ontology setting using simple terminological and/or partial matchings [1]. In content based image retrieval, ontology estimate semantic similarity between images. Latest crisp and fuzzy ontology model is developed for reducing the Semantic gap between the user requirements and the System model [2]. The approach is based on building ontology
of natural scenes using Protégé for querying in more natural way and then integrating fuzzy logic to improve the image retrieval. Content based image retrieval is performed using automatic ontology based annotation [3]. The ontology used by the annotation process was created in an original manner starting from the information content provided by the Medical Subject Headings. Ontology - based web image retrieval method is developed for CBIR by utilizing content and model annotations [4]. A technique to construct Image Ontology using low-level features like colour, texture and shape is proposed in used for content based image retrieval [5]. The resulting ontology extracts the relevant images from the image database. To address semantic gap problem, CBIR is proposed using integrated multi-level image features in ontology fusion construction by a fusion framework, which based on the latent semantic analysis [6]. Generic instance-based ontology matching approach for image retrieval is developed and a methodology to extract a minimal ontology is defined for common reference between different heterogeneous ontologies [9]. Content based image retrieval with background ontology is developed to handle manual semantic mapping process problem [11]. Modern efficient content based image retrieval CBIR systems use integration of subsequence kernel function based on ontology [13]. The kernel methodology improves retrieval result both in functional similarity and in sequence/words similarity by gap-weighted subsequence kernels. A new application of domain ontology is to generate personalized user interfaces for transportation interactive systems [15]. In this system, the transportation ontology is used to provide the content, concepts, relationships and axioms of transportation ontology are exploited during the semi-automatic generation of personalized user interfaces.

3. Significance of semantic image retrieval

Semantic image retrieval can reduce semantic gap between low level image feature and high level concept in human mind. There are many ways and techniques of semantic image retrieval such as ontology, machine learning, fuzzy logic techniques etc. Content based image retrieval systems are critically suffer from semantic gap between the low-level visual features such as colour, texture and shape and the higher-level abstract properties like emotion, filling, expression and other high level concept in human mind. To improve performance and accuracy of content based image retrieval system, semantic gap should be reduced. Higher-level abstract properties are always more indicative for the expression of art images. However, such higher-level abstract properties are not like the object-based concepts e.g. flower, dog in image, and the abstract properties in image are somewhat vague. These high level properties cannot be directly obtained from image content. There are many techniques like ontology, machine learning, fuzzy logic techniques are describe and extract such higher-level properties for image retrieval. Semantics retrieval from images can be performed by using many techniques like annotating the images, ontology, designing semantic code book. In annotating image techniques, monotonic tree is used as a hierarchical representation of image structures [8]. Microstructure called structural elements is classified and clustered using methods based on minimum spanning tree. The images are rendered with semantic annotation keywords. Another novel approach for semantics image retrieval is based on the content and context of image regions [7]. This method consists of three levels. At pixel level, colour-texture classification forms the semantic codebook. At region level, the semantic codebook is used to segment the images into regions. At image level, the content and context of image regions are defined and represented to support the semantics retrieval from images.

4. Implementation core semantic multiple ontology in CBIR

This section introduces Core semantic multiple ontology and its implementation in content based image retrieval system as shown in fig.1. Proposed core semantic multiple ontology can provide a more efficient basis for image extraction or content clustering.

4.1. Core semantic multiple ontology

Core semantic multiple ontology is a multiple-ontology approach which combine ontologies such as feature ontology, semantic feature ontology, user ontology and metadata ontology for improving accuracy of feature matching. In single global ontology, it is very difficult to combine different domain information. With single
ontology, similarity measure is inaccurate and doesn’t give relevant retrieval result. Hence, to improve accuracy and precision of image retrieval, we design multilevel ontology for image retrieval system. In principle, core semantic ontology combines several other ontologies. A standard ontology language, OWL is used for ontology mapping.

- **User ontology**
  User input is one of the vital sources of information related to image. User ontology is based user model involve both concepts and semantic relations to signify users’ interests. Automatic ontology mapping utilize some user interaction which consist of seeding the mapping algorithm with primary set of matching pairs, validate the matches, or configuring the precise matchers used

- **Metadata ontology**
  Metadata ontology deals with associated with image. Meta data associated with image is rich source of knowledge about image.

- **Feature ontology**
  Feature ontology build on low level image feature database. In content based image retrieval system, low level features are extracted from image stored in feature database in the form of feature vector.

- **Semantic feature ontology**
  This ontology is used for the explicit description of the image semantics. High level semantic features are mapped from low level feature database by using machine learning techniques using machine learning.

- **Domain ontology**
  Based on domain knowledge related to image, domain ontology is designed. Domain ontology provides formal descriptions concepts and their relationships that depict an application area.

![Fig.1. (a) proposed image retrieval system with Core semantic multiple ontology; (b) Core semantic multiple ontology.](image)

### 4.2. Proposed system working mechanism

Proposed core semantic multiple ontology data structure and inverted indexing are used by the retrieval process. Proposed system take image query as input via ontology language interface which implement to reduce semantic gap and then features are extracted and mapped the ontology by proposed ontology. From internet, images are crawling in image database, feature of images in the database are extracted and mapped using proposed ontology strategy. Then, multilevel indexing is designed which is off-line processing that unaffected the response time to queries. The inverted index is generated from multilevel indexing and core semantic multiple ontology. An inverted index is an index structure that stores the frequency and the occurrences of the term in image DB and its weight to evade computing it in the retrieval phase. In retrieval phase, the query image features are compared with the image contents and the system retrieves those which most excellent answer the query. We employed the vector space model for retrieval. Proposed core semantic ontology combines the use of the class hierarchy in the ontology, the terms frequency in the collection and the relationships in the ontology to compute the similarity. Similarity matching
algorithm compare the similarity of each term in the index with the query is computed, represented by the weighted average of the similarity with all query terms. The similarity between two terms in the ontology is computed via the algorithm and retrieved most relevant images to query image.

5. Result evaluation

Semantic image retrieval incorporates user ontology, metadata ontology, feature ontology, semantic feature ontology and domain ontology. We experiment with the proposed image retrieval engine; first we use individual ontology in retrieval process and check performance with the test queries. The performance of the retrieval system is evaluated in terms of the average precision of the top 15 images retrieved as Fig.3. Finally, we experiment with the image retrieval system based on core semantic multilevel ontology as shown in fig.3 (b). The proposed make use of query image as input and retrieved set of relevant images as output as shown fig.2.

![Fig.2. (a) proposed system input; (b) set of relevant image as output.](image)

![Fig.3. Average precision of the image retrieval (a) with individual ontology; (b) with core semantic ontology.](image)

The core semantic multiple ontology is mapped using OWL, which is composed of metadata, feature, semantic feature, user and domain ontology. The detail of proposed ontology is explained with example as shown in fig.4.
Performance of proposed system is evaluated using average precision as shown in Table 1 by using user test query images from standard database. Experimental result shows that proposed ontology based retrieval system illustrate conspicuous improvement in retrieval result as compared to single ontology based retrieval.

6. Conclusion

Proposed ontology-based content based image retrieval system try to reduce semantic gap, limitation of traditional image retrieval system. Proposed ontology improves semantic retrieval of image by bridging semantic gap and addresses the main weakness of traditional content based image retrieval system. Experimental evaluation noticeably show that proposed core semantic ontology for content based image retrieval system improve semantic image retrieval with high accuracy, precision, recall and efficiency.

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