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Image Retrieval: Techniques, Challenge, and Trend

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***Abstract*—**This paper attempts to discuss the evolution of the retrieval techniques focusing on development, challenges and trends of the image retrieval. It highlights both the already addressed and outstanding issues. The explosive growth of image data leads to the need of research and development of Image Retrieval. However, Image retrieval researches are moving from keyword, to low level features and to semantic features. Drive towards semantic features is due to the problem of the keywords which can be very subjective and time consuming while low level features cannot always describe high level concepts in the users' mind.

***Keywords*—**content based image retrieval, keyword based image retrieval, semantic gap, semantic image retrieval.

I. Introduction

IMAGE retrieval is the field of study concerned with searching and retrieving digital images from a collection of database. This research has been explored since the 1970s [1, 2] Image retrieval attracts interest among researchers in the fields of image processing, multimedia, digital libraries, remote sensing, astronomy, database applications and others related area. An effective image retrieval system is able to operate on the collection of images to retrieve the relevant images based on the query image which conforms as closely as possible to human perception.

Two major research communities (database management and computer vision) study image retrieval from different perspectives, one being text-based and the other visual based [3]. Text-based image retrieval techniques employ text to describe the content of the image while visual based or content-based image retrieval (CBIR) used visual features to describe the content of images.

II. Conventional Image Retrieval

In conventional image retrieval system, keywords are used as descriptors to index an image however the content of an image is much richer than what any set of keywords can express.

Text-based image retrieval techniques employ text to describe the content of the image which often causes ambiguity and inadequacy in performing an image database search and query processing. This problem is due to the difficulty in specifying exact terms and phrases in describing the content of images as the content of an image is much richer than what any set of keywords can express. Since the textual annotations are based on language, variations in annotation will pose challenges to image retrieval.

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III. Content Based Image Retrieval

Content-based image retrieval (CBIR) then has been used as an alternative to text based image retrieval. IBM was the first, who take an initiative by proposing query-by image content (QBIC). QBIC developed at the IBM Almaden Research Center is an open framework and development technology. Unlike keywords-based system, visual features for contents-based system are extracted from the image itself. CBIR can be categorized based on the type of features used for retrieval which could be either low level or high level features. At early years, low level features include colour, texture, shape and spatial relations were used.

The CBIR researches were done in retrieving the image on the basis of their visual content as shown in table I.

TABLE I
RESEARCH WORKS ON CONTENT BASED IMAGE RETRIEVAL BASED ON VISUAL CONTENTS

Low level features	***Researches***	***Approaches***
Color	W. Niblack et al [4]	Histogram and color moments
	Chad Carson et al [5]	Region Histogram
	Wang [6]	Dominant color
	J. Sawhney & Hafner [7]	Color Histogram
	Stricker & Orengo [8]	Color Moment
	Kankanhalli et. al [9]	Color Cluster
	Wang [10]	Bit Signature
Shape	MichaelOrtega et al [11]	Fourier Transform
	F. Mokhtarian et al [12]	Curvature scale Space
	Sougata Mukherjea [13]	Template Matching
	Fumikazu Kanehara [14]	Convex parts
Texture	J. R. Smith [15]	Wavelet transform
	S. Michel[16]	Edge statistic
	B. S. Manjunath [17]	Gabor filters
	George Tzagkarakis & Panagiotis Tsakalides [18]	Statistical

Although there are many sophisticated algorithms to describe color, shape and texture features approaches, these algorithms do not satisfied and comfort to human perception This is mainly due to the unavailability of low level image features in describing high level concepts in the users' mind. For an example finding an image of a little girl is playing a ball near the sea. The only way a machine is able to do is

automatic extraction for the low level features that represented in low level features from images with a good degree of efficiency.

Since the low level image features cannot always describe the high level concepts in the users' mind such as find an image of a little girl is playing a ball. The only way a machine is able to perform automatic extraction is by extracting the low level features that represented by the color, texture, shape and spatial from images with a good degree of efficiency.

The semantic gap which is the lack of correlation between the semantic categories that a user requires and the low-level features that CBIR systems offer has been explored. This is due to the fact that the visual image feature descriptors extracted from an image cannot (as yet) be automatically translated reliably into high-level semantics [4].

IV. Semantic Based Image Retrieval

Neither a single features nor a combination of multiple visual features could fully capture high level concept of images. Besides, due to the performance of Image retrieval based on low level features are not satisfactory, there is a need for the mainstream of the research converges to retrieval based on semantic meaning by trying to extract the cognitive concept of a human to map the low level image features to high level concept (semantic gap). In addition, representing image content with semantic terms allows users to access images through text query which is more intuitive, easier and preferred by the front end users to express their mind compare with using images. For example, users' queries may be 'Find an image of sunset rather than 'find me an image contains red and yellow colors'.

The semantic extraction and representation of images are shown in Fig. I. Semantic representation of images can be done through the process as shown in Fig 1. Firstly, the image extraction process will get the low level features of images either by color, shape, textures and spatial. Next, these low level features can be clustered or segmented based on the similar characteristics of the visual features to form some regions representation and next to form objects representation in the images. The regions/objects representation will be annotated with keyword by image annotation process. This annotation process can be done either manually, semi-automatically or automatically.

The image then will be represented using semantics and image retrieval can be queried based on high level concept. Semantic content representation has been identified as an important issue to bridge the semantic gap in visual information access. It has been addressed as a good description and representation of an image and is able to capture meaningful contents of the image. Spatial relationship among these objects/regions can be used to further increase the confidence in image understanding.

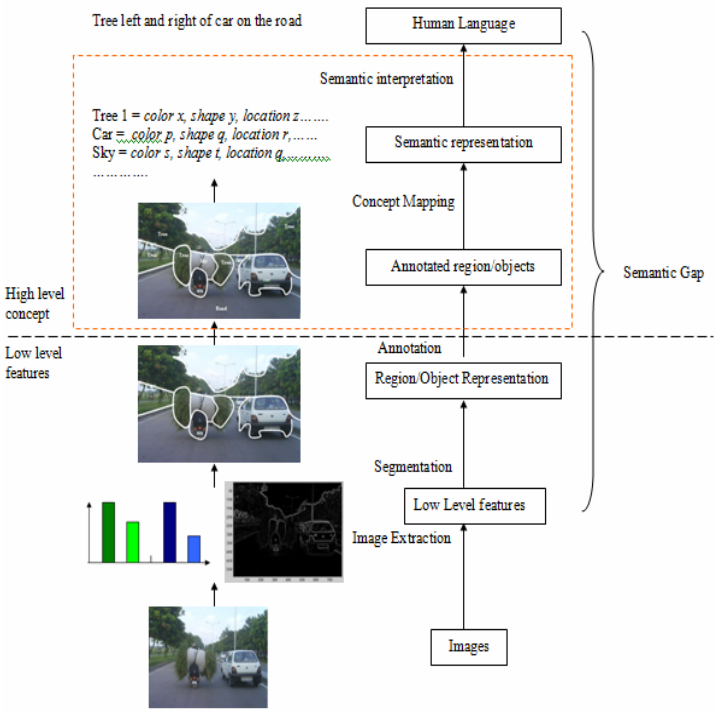

Fig. 1. Bridging the gap: the semantic extraction and representation of images

Table II shows the common techniques used in bridging the semantic gap in image retrieval or in other words, mapping from low level to high level concepts.

Even though the image retrieval is moving towards semantic concept however, much initial research in semantic image retrieval are focusing just on the simple semantic retrieval such as retrieval of objects of a given type but pays little attention on the retrieval by abstract attributes, involving a significant amount of high-level reasoning about the meaning and purpose of the objects or scenes depicted. In other words, the retrieval by abstract attributes was still not satisfied to human perception.

Moreover, the retrieval involved human interference and is time consuming besides inconsistency. There is a need to further increase the confidence in image understanding and to effectively retrieve similar images that are conform to human perception and without human interference.

The semantic gap is harder to overcome in broad domains database rather than narrow domains because images in broad domains can be described using various concepts that are very challenging to detect [5] Besides, broad domains contains images of various scenes, themes, objects and people gathered from the web or from a stock image collection with high visual granularity [6] while narrow domains describe little or limit concepts that are much more easy to detect since the scenes, themes, objects and people having low visual granularity. The researchers are moving to reduce the semantic gap in broad domains.

The summary of image retrieval research is shown as below.

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TABLE II
RESEARCH WORKS ON BRIDGING THE SEMANTIC GAP IN IMAGE RETRIEVAL

Techniques		Researchers	Approaches
Anno-tation	Manual	Wikipedia image collection[20],	User annotated
		google image labeler [21]	User annotated
	Semi-Autom atic	Bradshaw [22]	Bayer probability
		Ghoshal *et al* [23]	Co-Occurrence model
		Ilaria Bartolini and Paolo Ciaccia[24]	Graph based link
	Autom atic	Huang *et al*.[25]	Decision Trees
		Feng and Chua [26]	Bootstrapping
		Gao et al. [27]	Latent Semantic Analysis
		Mori et al. [28]	hidden Markov model
Relevance feedback		Yang et al. [29]	Semantic feedback mechanism
		Rege et al. [30]	multi-user relevance feedback(user-centered semantic hierarchy)
Object Ontology		P.L.Standchey et al [31]	Color representation ontology
		V. Mezaris [32]	High level concept ontology
		Huan Wang [33]	multi-modality ontology
Semantic template		S.-F. Chang [34]	Semantic visual template

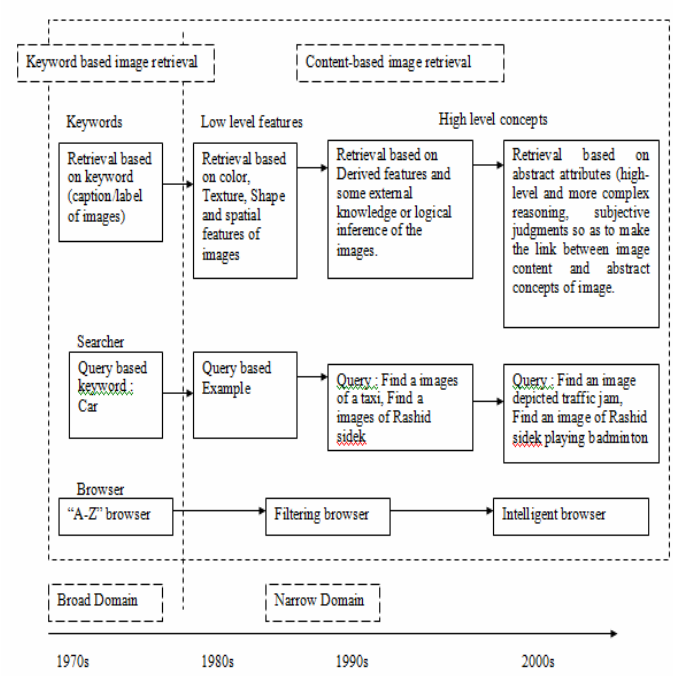

Fig. 2. Summary of image retrieval research

In image retrieval research, researchers are moving from keyword based, content based then towards semantic based image retrieval. More abstract and high level concept user query can be supported now compared with 1970s where keyword that based on image caption is used and next, user query by sample image is used. Besides, image browser are moving from "A-Z" browser (browsing one image by image) to filtering image browse (browsing based on certain categories) and toward an intelligent browser. However for the domain of dataset, researchers are moving from broad domain to narrow domain due to narrow domain can used for knowledge representation and images share and having limited concept.

V. TOWARD INTELLIGENT IMAGE RETRIEVAL

Bridging the semantic gap for image retrieval is a very challenging problem yet to be solved. Even though there are a lot of significant efforts and works on image retrieval research, there are still some spaces which need to be improved besides the challenges that is associated with mapping low level to high level concepts. Researchers are moving towards to intelligent image retrieval that are also support more abstract in concept by understanding the image content in terms of high level concepts, which is closely related to the problem of computer vision and object recognition besides more intelligent system. The domain should be not specific but broad where all the extracted semantic features are applicable for any kind of images collection.

VI. CONCLUSION

This paper provides a study of image retrieval work towards narrowing down the 'semantic gap'. Recent works are mostly lack of semantic features extraction and user behavior consideration. Therefore, there is a need of image retrieval system that is capable to interpret the user query and automatically extract the semantic feature that can make the retrieval more efficient and accurate.

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