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A Survey on Methodologies in Image Retrieval for Reducing Semantic Gap

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Abstract - *Image retrieval, is a technique which uses visual contents to search images from large image databases in keeping with user's interests. Content-Based Image Retrieval (CBIR) is one of the important subfields of Image Retrieval field. This paper presents an overview on research activities in the field of image retrieval for reducing semantic gap. The most crucial processes in image retrieval are feature extraction, classification, segmentation.*

Key Words: **CBIR, Feature extraction, Classification**

1. INTRODUCTION

Content-based image retrieval (CBIR) is a process in which for a given query image, similar images are retrieved from a large image database based on their content similarity. Any technique that helps to organize digital images by their visual content can be regarded as CBIR system. The goal of a CBIR algorithm is to work on image information and retrieve semantically similar images in response to a query image submitted by the end user.

In these systems the visual contents of the images in the database are extracted and represented by feature vectors. The feature vectors of the images in the database form a feature database. To retrieve images, users provide the retrieval system with query images. The system then changes these queries into its feature vectors. The similarities between the feature vectors of the query example and those of the images in the database are then calculated and retrieval is performed. The most crucial processes in image retrieval are feature extraction, classification, segmentation.

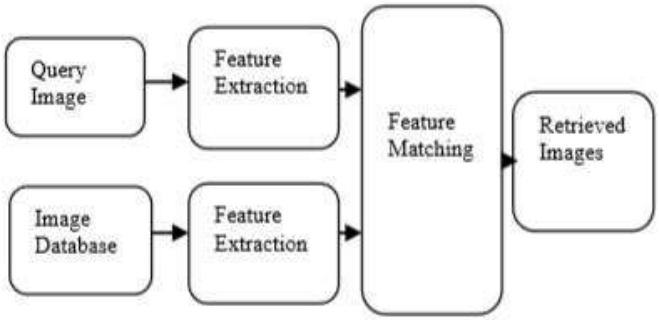

Fig -1: CBIR Image retrieval [1]

2. Feature extraction

The visual feature selection and extraction is very important in designing an efficient image retrieval system because the features that are used for discrimination directly influence the effectiveness of the entire image retrieval system. Low-level features such as colour, texture, shape and edge may be extracted directly from the image while not having external information. These features are extracted without human intervention. Low-level features can be categorized into global or local. Extraction of global features is performed at image level, whereas local feature extraction is performed at region level. In content-based image retrieval techniques, the low-level features like color, texture, shape, and spatial location are used for retrieval.

Initially, CBIR techniques were developed based on any one of the low-level features such as colour, texture, shape alone. Colour is one of the important features in the field of content-based image retrieval.[2]present colour histogram based image retrieval. Colour coherence based image retrieval is explained in [3]. Texture is an important characteristic of an image, which is widely used in CBIR systems. Various algorithms have been designed for texture analysis. In [4] features are extracted through applying Gabor filters. Image texture feature extraction method based on Discrete Cosine Transform (DCT) is proposed in [5]. Many models to extract the shape features using the contour and area of the region have been proposed. Fourier descriptors and curvature scale space descriptors are proposed in [6].

The Fourier descriptors are obtained through Fourier transform on a complex vector derived from shape boundary coordinates and The CSS descriptors are obtained after scale normalization on a complex vector derived from shape boundary.

It is found that usage of single type feature is not sufficient in order to achieve high retrieval rate. Hence, the researchers have focused on investigating techniques based on combination of low-level features such as colour, texture and shape. In [7] a unique approach for content based image retrieval based on low-level features such as color texture and shape is proposed. The DBC, Haar wavelet and HOG techniques are utilized sequentially so as to extract color texture and shape features from the image. The combinations of low-level features such as provide accurate illustration of content of an image that helps to achieve high retrieval rate. However, the performance of these CBIR approaches is still far from users' expectation. The problem is due to it is not unusual that targets, for which users search through an image retrieval system, is not images but the visual objects in images. Also global features extracted from the images cannot represent the characteristics of objects in these images.

RBIR is an image retrieval approach which focuses on contents from regions of images, not the content from the entire image in early CBIR. For RBIR, it first segments images into a number of regions and then extracts a set of features from segmented regions. A similarity measure between target regions in the query and a set of segmented regions from other images is utilized to determine relevant images to the query based on local regional features. The motivation of RBIR approaches are based on the fact that high-level semantic understanding of images can be better reflected by local features of images, rather than global features. An step prior to constructing local features of images is to segment images into several regions, which may possibly retain their own semantic meaning.[8] Proposes a new RBIR approach using low-level features .In this image is represented by segmented regions, each of which is associated with a feature vector derived from DCT and SA-DCT coefficients. Users can select any region as the main theme of the query image. [9] Presents another segmentation method based on low-level visual features including colour and texture of image. On the basis of segmented image, the paper creates binary signature to describe location, colour, and shape of interest objects. The paper presents a similarity measure between the images. Such precise segmentation of images into semantic regions is often difficult to attain and semantically meaningful segmentation is still an open issue. [10] States that accurate region segmentation method to be developed to get better representation of images using low-level features.

It's apparent that low-level contents often don't describe the high-level semantic concepts in users' minds. This gap between the richness of high-level human's perception and low-level machine's descriptions is known as the 'semantic gap' .This is one of the major burdens in implementing a CBIR system for practical image retrieval applications. To overcome this burden, unify text based retrieval with content-based retrieval [11] in which low level features of images and keyword annotations are used. A gap still exists between the two because keywords have more direct mapping toward high-level semantics than low-level visual features.

Use machine learning tools to associate low-level image features with high-level semantics increase retrieval rate is proposed in [12].Decision trees are often used for image semantic learning, One important breakthrough technique is known as deep learning, which includes a family of machine learning algorithms that attempt to model high-level abstractions in data by employing deep architectures. CNN is such an algorithm. [13] use CNNs to generate feature representations and uses linear support vector machine (SVM) for classification.

Table -1: Accuracy Comparison based on features

Author	features	database	Retrieval Accuracy%
Amina Belalia et.al	Global low-level features	Wang	84
Thanh Van et.al	Local low level features	Wang	83.2874
Ying Liu et.al	Low level features+ decision tree learning	Corel	82
O. Mohamed et al.	Deep learning features	Caltech256	98.5

3. SEGMENTATION

Segmentation is one of the most widely applied preprocessing approaches where image pixels are subdivided into some constituent regions or objects that represented by many regions. Image segmentation is one of the difficult tasks in CBIR systems.

1) Graph-based segmentation:

These methods are used for image segmentation by constructing a weighed graph for describing relationships between pixels. Specifically, each pixel is regarded as a vertex, two adjacent pixels are connected with an edge, and the dissimilarity between such two pixels is computed as the weight of the edge [14].

2) Thresholding based

Thresholding is considered as one of the simplest and most commonly used methods for image segmentation. Basically, the image objects, edges, shapes, and backgrounds can be separated by detecting the discontinuities based on a predefined thresholding value. This method possesses the advantages of smaller storage space, fast processing speed and ease in manipulation [15].

3) Region-based segmentation

This method works on the principle of homogeneity by considering the fact that the neighboring pixels inside a region possess similar characteristics and are dissimilar to the pixels in other regions. The objective of region based segmentation is to produce a homogeneous region which is bigger in size and results in very few regions in the image [16].

4. CLASSIFICATION

The classification step allows grouping similar images into some class, for each class a descriptor vector is computed. It depends much on descriptor vectors of the constituent images in the same classes. Image classification is also an active sub domain in the field of machine learning, in which it uses algorithms that map images of input, to set of labeled classes. These algorithms are called classifiers.

1) Support Vector Machines

Support vector machines are a set of supervised learning methods used for classification and regression. The goal of SVM classifier is to find the best hyper plane separating classes. The best hyper plane has the maximum distances to the nearest data points from the classes to be separated [17].

2) K-nearest neighbor

The KNN classification is based on a majority vote of k-nearest neighbor classes. First a point is defined which represents feature vectors of an image in a feature space. Then, determine the distance between the point and the points in training data set. Finally, KNN classifier takes only k-nearest neighbor classes. So that majority vote is then taken to predict the best-fit class for a point [18].

3) Naive Bayes

Naive Bayes is a simple probabilistic learning algorithm based on applying Bayes' theorem with the following"Naive" assumption: distributions of input features are assumed to be independent. In order to perform multi-class classification of an input, Naive Bayes algorithm computes a posterior probability that the input belongs to a class for every class in the system. The result of the classification is the class with the highest posterior probability. An advantage of the Naive Bayes classifier is that it requires a small amount of training data to estimate the parameters necessary for classification [19].

4) Decision tree (DT)

DT classifiers are non-parametric classifiers that do not require any a priori statistical assumptions regarding distribution of data. The structure of a decision tree consists of a root node, some non-terminal nodes, and a set of terminal nodes [20].

Table -1: Accuracy Comparison based on Classifier

Author	Classifier	Database	Accuracy%
M.A. Ansari et.al	SVM	Wang database	85
M.A. Ansari et.al	SVM	Caltech	90
M.A. Ansari et.al	SVM	Corel	78
Pragati et.al	KNN	500 images	86
Dong-Chul Park	Naïve bayes	Caltech images	77.2
Arun Kulkarni et,al	Decision trees	Wang database	70
Dayanand Jamkhandikar	KNN	Caltech	76.42

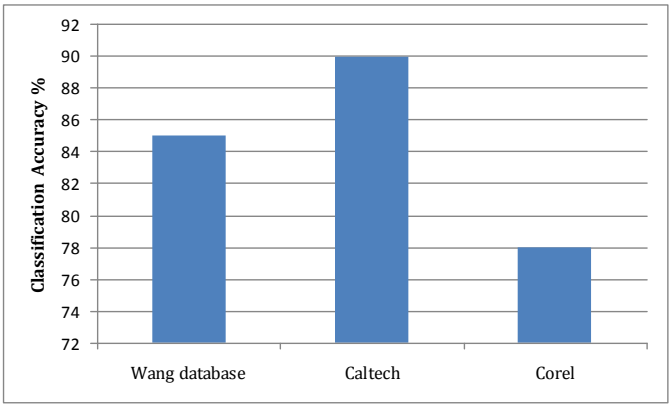

Chart -1: Classification accuracy using SVM on different databases

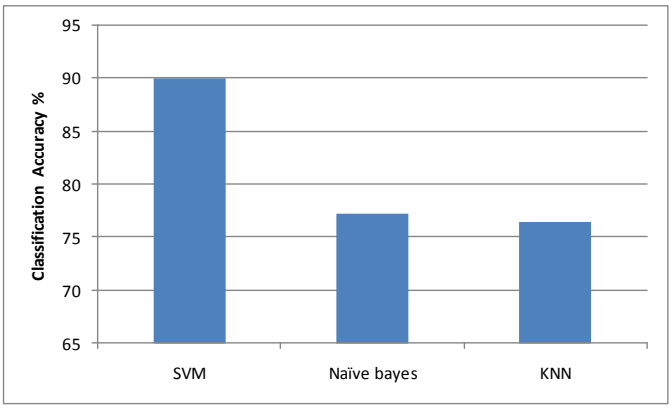

Chart -2: Classification accuracy of different Classifiers on Caltech database

5. CONCLUSIONS

The gap between high-level human's perception and low-level machine's descriptions is known as the 'semantic gap', is one of the main problems in CBIR.In this paper, we have discussed about the different methodologies used in content based image retrieval for reducing semantic gap. The techniques include segmentation, feature extraction, classification. Recent advances that contribute in reducing the semantic gap includes use of deep learning for extracting the feature and region based segmentation. This study has identified that classification accuracy depends on the classifier and database.

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