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Understanding the Fundamentals of Content Based Image Retrieval System

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Abstract: Image retrieval system is used for browsing, searching and retrieving images from a large database of digital images. Content-based means that the search analyzes the contents of the image rather than the metadata such as keywords, tags, or descriptions associated with the image. The term content might refer to colors, shapes, textures, or any other information that can be derived from the image itself. Content Based Image Retrieval (CBIR) is desirable because searches that rely purely on metadata are dependent on annotation quality and completeness. To develop better content based image retrieval system, it is important to improve various processes involved in retrieval like feature extraction, image segmentation, image decomposition and similarity matching techniques. In this paper we discuss the fundamental aspects, visual features and techniques for fast searching and retrieval of images from the database.

Keywords: feature extraction, multidimensional indexing, retrieval design, image decomposition, matching techniques.

I. INTRODUCTION

The term content-based image retrieval seems to have originated in 1992 when it was used by T. Kato to describe experiments into automatic retrieval of images from a database, based on the colors and shapes present [1]. Since then, the term has been used to describe the process of retrieving desired images from a large collection on the basis of syntactical image features. The techniques, tools, and algorithms that are used originate from fields such as statistics, pattern recognition, signal processing, and computer vision.

The earliest commercial CBIR system was developed by IBM and was called QBIC (Query by Image Content). Recent network and graph based approaches have presented a simple and attractive alternative to existing methods. Image retrieval techniques are split into two categories text and content-based categories. The text-based algorithm comprises some special words like keywords. Keywords and annotations should be dispensed to each image, when the images are stored in a database. The annotation operation is time consuming and tedious [4].

In addition, it is subjective. Content-based image retrieval is the modern image retrieval system. The Content based image retrieval systems are used to extract image features, index those using appropriate structures and efficiently process user queries providing the required answers. The query processing includes segments and features extraction and search in the feature space for similar images. In Content based image retrieval system various techniques are brought together effectively for the same purpose as image processing, information retrieval and database communities. It is also called query-by-image content and content-based visual information retrieval.

II. FUNDAMENTAL ASPECTS OF CBIR

The typical CBIR system performs two major tasks. The first one is feature extraction (FE), where a set of features, called image signature or feature vector, is generated to accurately represent the content of each image in the database.

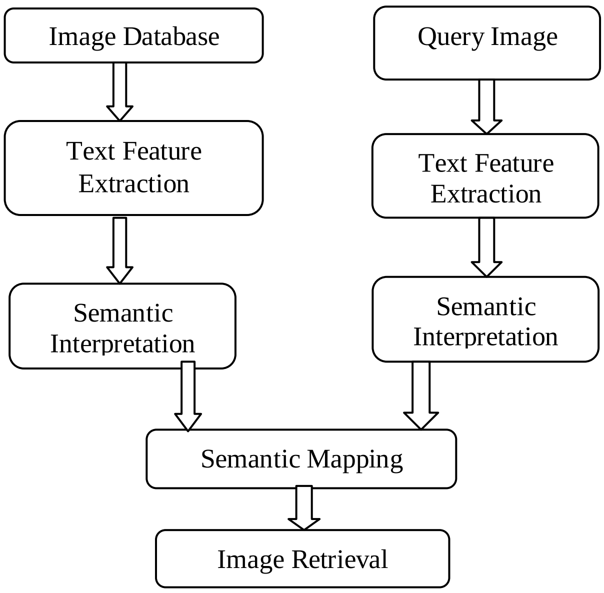

Fig 1. Block Diagram of Semantic Image Retrieval

A feature vector is much smaller in size than the original image, typically of the order of hundreds of elements (rather than millions). The second task is similarity measurement (SM), where a distance between the query image and each image in the database using their signatures is computed so that the top “closest” images can be retrieved, searched by the system for components that match classes in alphabet[7].

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III. FEATURE REPRESENTATIONS

Feature extraction and representation is the fundamental process behind CBIR systems. As mentioned, features are properties of the image extracted with image processing algorithms, such as color, texture, shape, and edge information. Our discussion will focus on three general features representations that have been extensively studied in the literature: color, texture, and shape. However, there is no single "best" feature that gives accurate results in any general settings [3]. Usually, a combination of features is minimally needed to provide adequate retrieval results since perceptual subjectivity permeates throughout this problem.

A. Color Feature

The first and most straightforward feature for indexing and retrieving images is color, the basic constituent of images (we consider grayscale a color). All other information computed by image processing algorithms start with the color information contained in an image. Color moments have been successfully used in much retrieval, especially when the image contains just the object. The first order (mean), the second (variance) and the third order (skewness) color moments have been proved to be efficient and effective in representing color distributions of images. Each image added to the collection is analyzed to compute a color histogram which shows the proportion of pixels of each color within the image. The color histogram for each image is then stored in the database. The color histogram of an image is a description of the colors present in an image and in what quantities. They are computationally efficient to compute and insensitive to small perturbations in camera position. At search time, the user can either specify the desired proportion of each color (75% olive green and 25% red, for example), or submit an example image from which a color histogram is calculated.

Either way, the matching process then retrieves those images whose color histograms match those of the query most closely. When an image database contains a large number of images, histogram comparison will saturate the discrimination. To solve this problem, the joint histogram technique is introduced. However, it is possible that two images have the same color histogram even though they have completely different appearances, because a single color histogram extracted from an image, which is used in most of histogram-based image retrieval systems, lacks spatial information of colors in the image [2]. To overcome this problem, Yamamoto proposed content based image retrieval system which takes account of the spatial information of colors by using multiple histograms. The proposed system roughly captures spatial information of colors by dividing an image into two rectangular sub-images recursively. The proposed method divides an image into dominant two regions using a straight line, vertically or horizontally, even when the image has three or more color regions and the shape of each region is not rectangular. In each sub-image, the division process continues recursively until each region has a homogeneous color distribution or the size of each region becomes smaller than a given threshold value. As a result, a binary tree which roughly represents the color distribution of the image is derived. The tree structure facilitates the evaluation of similarity among images. Another technique in which the position of each color also plays an important role in the retrieval of images is proposed by Zhang Lei, A fast algorithm is proposed which could include several spatial features of color in an image for retrieval. These features are area and position, which mean the zero-order and the first order moments, respectively. By computing the moments of each color region, one can evaluate the similarity of two images according to the weight of each factor.

B. Texture

Texture measures look for visual patterns in images and how they are spatially defined. Textures are represented by texts which are then placed into a number of sets, depending on how many textures are detected in the image. These sets not only define the texture, but also where in the image the texture is located. Texture is a difficult concept to represent. The identification of specific textures in an image is achieved primarily by modeling texture as a two-dimensional gray level variation. The relative brightness of pairs of pixels is computed such that degree of contrast, regularity, coarseness and directionality may be estimated [8]. The problem is in identifying patterns of co-pixel variation and associating them with particular classes of textures such as silky, or rough. In computer vision, texture is defined as all what is left after color and local shape have been considered or it is defined by such terms as structure and randomness. The ability to retrieve images on the basis of texture similarity may not seem very useful. But the ability to match on texture similarity can often be useful in distinguishing between areas of images with similar color (such as sky and sea, or leaves and grass). Basically, texture representation methods can be classified into two categories: structural and statistical. Structural methods, including morphological operator and adjacency graph, describe texture by identifying structural primitives and their placement rules [11]. They tend to be the most effective when applied to textures that are very regular. Statistical methods, including Fourier power spectra, co-occurrence matrices, shift-invariant principal component analysis (SPCA), Tamura feature, Markov random field, fractal model, and multi-resolution filtering techniques such as Gabor and wavelet transform, characterize texture by the statistical distribution of the image intensity.

C. Shape

The ability to retrieve by shape is perhaps the most obvious requirement at the primitive level. Unlike texture, shape is a fairly well-defined concept – and there is considerable evidence that natural objects are primarily recognized by their shape. A number of features characteristic of object shape (but independent of size or orientation) are computed for every object identified within each stored image. Queries are then answered by computing the same set of features for the query image, and retrieving those stored images whose features most

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closely match those of the query [11]. Two main types of shape feature are commonly used – global features such as aspect ratio, circularity and moment invariants and local features such as sets of consecutive boundary segments. Alternative methods proposed for shape matching have included elastic deformation of templates, comparison of directional histograms of edges extracted from the image. Queries to shape retrieval systems are formulated either by identifying an example image to act as the query, or as a user-drawn sketch.

IV. MULTIDIMENSIONAL INDEXING

To make the content-based image retrieval truly scalable to large size image collections, efficient multidimensional indexing techniques need to be explored. Main challenge in such an exploration for image retrieval is high dimensionality. The best way to index is to reduce the dimensionality and then indexing the images. Clustering is a powerful tool in performing dimension reduction. The clustering technique is used in various disciplines such as pattern recognition, speech analysis and information retrieval [5]. Normally it is used to cluster similar objects (patterns, signals, and documents) together to perform recognition or grouping. This type of clustering is called row-wise clustering. However, clustering can also be used column-wise to reduce the dimensionality of the feature space. But blind dimension reduction can be dangerous, since information can be lost if the reduction is below the embedded dimension. To avoid blind dimension reduction, a post-verification stage is needed. The Figure 2 shows the process of indexing of images. When a query is posed in the high level phrase, the data is retrieved from the database. Image indexing is done to improve the retrieval mechanism. The indexing helps retrieving the images when a query is posed by the user.

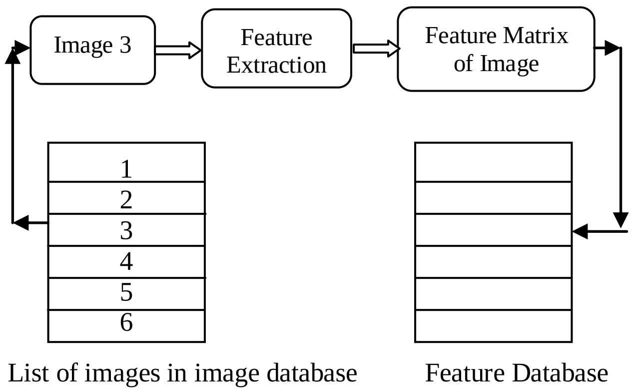

Fig 2. Image indexing process

V. RETRIEVAL SYSTEM DESIGN AND SIMILARITY MATCHING

After extracting the image features, the images are indexed. After indexing, similarity is measured. The similarity measures in the Retrieval of images are essentially the determination of similarity between the features of the query image and the features of the target images in the database. Similarity measure is the distance between feature vectors representing the images [12].

The similarity measure is a function which computes the degree of similarity between a pair of images. Similar images should have smaller distance between them and different images should have larger distances. The similarity measure gives good result if the retrieval is accurate. Most image retrieval systems support one or more ways for retrieval of images such as random browsing, search by example, search by sketch, search by text (including key word or speech), and navigation with customized image categories.

VI. RELATED WORK

There are various method has been proposed to extract the features of images from very large database. In this paper various algorithms are discussed to retrieve the image:

Jisha. K. P, Thusnavis Bella Mary. I, Dr. A. Vasuki [7]: proposed the semantic based image retrieval system using Gray Level Co-occurrence Matrix (GLCM) for texture attribute extraction. On the basis of texture features, semantic explanation is given to the extracted textures. The images are regained according to user contentment and thereby lessen the semantic gap between low level features and high level features.

Heng Chen and Zhicheng Zhao [5]: authors described relevance feedback method for image retrieval. Relevance feedback (RF) is an efficient method for content-based image retrieval (CBIR), and it is also a realistic step to shorten the semantic gap between low-level visual feature and high-level perception. SVM-based RF algorithm is proposed to advances the performance of image retrieval. In classifier training, a model expanding method is adopted to stability the proportion of positive samples and negative samples. After that a fusion method for multiple classifiers based on adaptive weighting is proposed to vote the final query results. SVM-based RF scheme is proposed to improve performance of image retrieval. In classifier training, a sample intensifying scheme is accepted to balance the proportion of positive and negative samples and then fusion scheme for multiple classifiers based on adaptive weighting is anticipated to vote the final query results.

Monika Daga, Kamlesh Lakhwani [9]: Proposed a new CBIR classification was being developed using the negative selection algorithm (NSA) of ais. Matrix laboratory functionalities are being used to extend a fresh CBIR system which has reduced complexity and an effectiveness of retrieval is increasing in percentage depending upon the image type.

Swati Agarwal, A. K. Verma, Preetvanti Singh [13]: The proposed algorithm is enlightened for image retrieval based on shape and texture features not only on the basis of color information. Firstly the input image is decomposed into wavelet coefficients these wavelet coefficients give generally horizontal, vertical and diagonal features in the image. Subsequent to wavelet transform (WT) and Edge Histogram Descriptor (EHD) is then used on preferred wavelet coefficients to gather the information of foremost edge orientations. The grouping of DWT and EHD methods increases the performance of

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image retrieval system for shape and texture based retrieve. The performance of diverse wavelets is also compared to find the appropriateness of meticulous wavelet function for image retrieval. The proposed algorithm is skilled and examined for large image database. The results of retrieval are conveyed in terms of exactitude and recall and compared with different other proposed schemes to show the supremacy of our scheme.

Xiang-Yang Wang, Hong-Ying Yang, Dong-Ming Li [14]: proposed a new content-based image retrieval technique using color and texture information, which achieves higher retrieval effectiveness. Initially, the image is altered from RGB space to adversary chromaticity space and the individuality of the color contents of an image is incarcerated by using Zernike chromaticity distribution moments from the chromaticity space. In next, the texture attributes are extracted using a rotation-invariant and scale-invariant image descriptor in contour-let domain, which presents the proficient and flexible estimation of early processing in the human visual system. Lastly, the amalgamation of the color and texture information provides a vigorous feature set for color image retrieval. The experimental results reveal that the proposed color image retrieval is more accurate and efficient in retrieving the user interested images.

S. Manoharan, S. Sathappan [14]: They Implemented the high level filtering wherever they are using the Anisotropic Morphological Filters, hierarchical Kaman filter and particle filter proceeding with feature extraction method based on color and gray level feature and subsequent to this the results were normalized.

S. Nandagopalan, Dr. B. S. Adiga, and N. Deepak [12]: They proposed a novel technique for generalized image retrieval based on semantic contents is offered. The grouping of three feature extraction methods specifically color, texture, and edge histogram descriptor. There is a prerequisite to include new features in future for better retrieval efficiency. Any combination of these techniques, which is more suitable for the application, can be used for retrieval. This is presented through User Interface (UI) in the form of relevance feedback. The image properties analyzed in this work are by using computer vision and image processing algorithms. Anticipated for color the histogram of images are calculated, for texture co-occurrence matrix based entropy, energy etc are calculated and for edge density it is Edge Histogram Descriptor (EHD) that is found. To retrieval of images, a new idea is developed based on greedy approach to lessen the computational complexity.

VII. EXISTING TECHNIQUES

There are various techniques have been proposed to retrieve the image effectively and efficiently from the large set of image data in which some of the methods are described below:

A. Relevance Feedback: Every user need will be different and time varying. A typical scenario for relevance feedback in content-based image retrieval is as follows:

Step 1: Machine provides early retrieval results

Step 2: User provides opinion on the currently exhibited images based on the degree whether they are relevant or irrelevant to her/his request

Step 3: Machine learns the judgment of the user and again search for the images according to user query. Go to step 2.

B. Semantic template: This technique is not so widely used. Semantic templates are generated to support high-level image retrieval. Semantic template is usually defined as the "representative" feature of concept calculated from a collection of sample images

C. Wavelet Transform: Wavelet transforms are based on diminutive waves, called wavelets, of varying frequency & limited duration. Discrete wavelet transform renovate the image in four different parts higher frequency part (HH), high low frequency part (HL), Low high frequency part(LH), lower part (LL) vertical parts is 1-level image decompositions then compute moments of all frequency part than store and use it as feature to obtain the images. Texture entropy and contrast, clumsiness are the mostly used properties. Statistical features of grey levels were one of the efficient methods to classify texture [13]. The Grey Level Co-occurrence Matrix (GLCM) is used to extract second order statistics from an image. GLCMs have been used very profitably for texture calculations. From Grey Level Co-occurrence Matrix all the features are deliberated and stored into the database. The use of Grey Level Co-occurrence Matrix provides good result but it is in spatial domain so it is more error pron. CCH (Contrast Context Histogram) to find out the feature of the query image and other images stored in the database. CCH is in spatial domain and it presents global distribution. The MPEG Descriptors has been used like Edge Histogram Descriptor for texture. The Edge histogram differentiates edges according to their direction.

D. Gabor filter: They are widely used for texture analysis because it's similar characteristics with human perception. A two dimensional Gabor function g(x, y) consists of a sinusoidal plane wave of some frequency and orientation (carrier), modulated by a two dimensional translated Gaussian envelope [12]. Gabor Filter have one mother filter using that other filter banks are generated and their features are calculated and stored in database. Structure of different types of Edges is as shown in Fig. 3

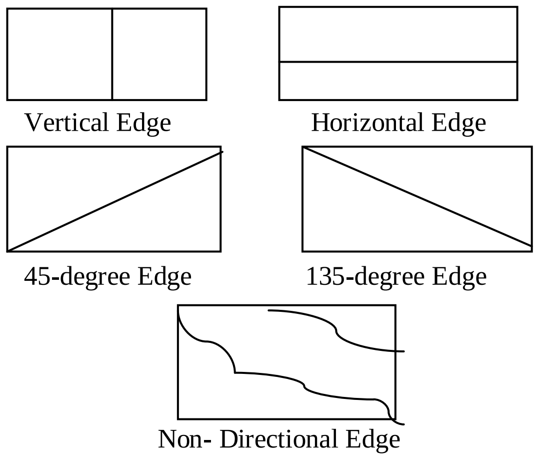

Fig. 3: Different types of Edges

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E. Support Vector Machine: Support vector machine is a supervised learning technique that analyzes data and identify pattern used for classification. It takes a set of input, read it and for each input desired output form such type of process is known as classification, when if output is continuous than regression performed. For constructing maximum separating hyper planes SVM maps input vector to a higher dimension feature space. Feature space refers to an input space which is reserved for measuring similarity with the help of kernel function. It is high dimension space where linear separation becomes very easier than input space. In this, raw data is transformed into a fixed length sample vectors [9]. Here are two terms which are used in feature space i.e. called feature values and feature vectors. The features of image is called feature values and these feature values presented the machine in a vectors is known as feature vectors. Kernel function used in the kernel method performing some operation such as classification, clustering upon different categories of data like text document, progression, vectors, group of points, image and graphs etc. it maps the input data into a higher dimension feature space because in this data could be easily separated or better structured. There are some points in the feature space which are separated by some distance is called support vectors. It is the point between origin and that point and demonstrates the location of the separator. The detachment from the decision surface to the closet data point concludes the margin the classifier.

VIII. CONCLUSION

Content based image retrieval system is an emerging way of image retrieval from a large database. Although this area has been explored for decades, there is still a very large scope for achieving the accuracy of human visual perception in distinguishing images. The CBIR system can be improved by improving the indexing, retrieval design and feature extraction mechanism and to reduce the time better clustering approach with image decomposition and feature extraction can be used. To achieve more accurate and fast results better methods of image decomposition can be applied. Other techniques of clustering can be used with the system. At last in this paper we studied the basic Content based image retrieval system and the use as well as the evolution of wavelets in the field of CBIR systems.

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