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A Comprehensive Survey of Image Search Based on Visual Similarity

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Abstract: Image search based on visual similarity is the widely applicable image processing method, which is used extensively. One of the important stage in content based image retrieval system is Feature Extraction, where low level features are extracted from image, then The features vector is formed by the extracted features. Feature Extraction is used for indexing images and interpretation of image. Effective storage, ranking and organizing a large image database is a critical issue in computer systems. To overcome these problems many methods has proposed. However, the accuracy and speed of image retrieval is still an interesting topic of research. This paper presents a survey of various states-of-the-art- image search techniques such as color edge detection, Discrete Wavelet Transform and Singular value decomposition etc. that allows faster and effective visual similarity search.

Keywords: Feature Extraction, Similarity Matching, Canny Edge Detection, Color Edge Detection, Haar Wavelet Transform, singular value decomposition.

I. INTRODUCTION

Rapid evolution of multimedia and web technology is the main reason for the growth of images on the internet. Images are the media which is used widely in web pages and hence it created need for wide range of images. There is strong need to retrieve more relevant images from such large image databases. In the past decade content based image retrieval has taken substantial attention over the widely used text based image search engines. A content based image retrieval (CBIR) system has more advantages over traditional image search system, based on image tags, to retrieve images efficiently and effectively. This system helps the user to retrieve relevant images based on visual properties such as color, texture and the shape of an object in the image. In the Place of taking text keyword as input, CBIR systems directly take image query and try to retrieve relevant images from the database based on pre-specified feature space and distance measure.

The traditional search methods based on annotations of the images which is very difficult to describe each image with all the possible words, require large amount of space and although not giving satisfactory results. Thus the researches migrated toward CBIR. CBIR does not depend on image annotations or image names. It analyses the content of the image and the search is based on this content. Hence CBIR is a more direct method of image search, giving more satisfactory results, but it is a complex process.

The working of the typical CBIR system divided into two major parts. Feature extraction (FE) is the first part, where a set of features are called feature vector, which accurately represent the content of each image in the database. The second part is similarity measurement (SM), where calculate distance between the query image feature vectors and feature vectors of each image in the database and images are ranked based on smaller distance.

Effective representation of image features and an efficient search mechanism are two key factors which affect the efficiency of large scale image retrieval system. It is known that the quality of image search results heavily depends on the representation power of image features (vectors).The latter, it is very difficult to develop an efficient search mechanism because existing image features not describe image properly (not give semantic information) and we retrieve similar from huge image database.

This paper focus on those techniques which is able to search the very similar images from a huge and possibly distributed image databases. Moreover, search techniques must be memory efficient, able to store billions of images and also do fast similarity search.

The remaining paper is organized as follows. System frameworks of Image Search based on visual similarity describe in Section II and Techniques used for similarity image search discussed in Section III. Finally, Section IV concludes this paper.

II. SYSTEM FRAMEWORK

The flow of image search using its content is shown in Fig. 1. It only needs the user to enter query image with less effort and accordingly retrieve its most relevant images from a given database using smaller distance ranking. The system works in two steps as following:

1) First, visual features are extracted from individual images from database. The features vector is formed by the extracted features. These feature vectors are then stored in feature database.
2) In second, the user has to enter query image for finding relevant images from database. Similarly, it extract features vector of given query image.

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The comparison between the feature vector of query image and already stored feature vectors of all images in the feature database is called similarity matching. And it is depends on distance calculation between the query image features vector and features vectors of all the images in the database. Finally, relevant images are retrieved based on smaller distance between images.

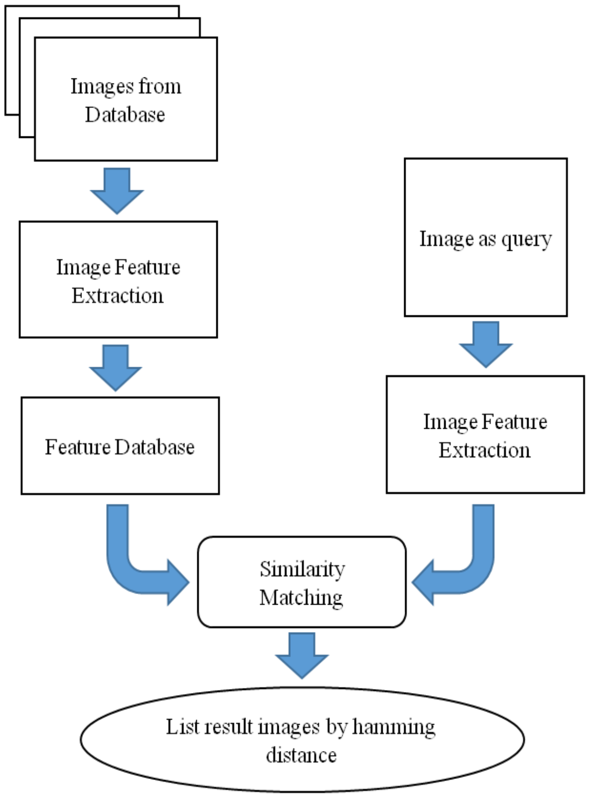

Fig. 1 : Content Based Image Search System

III.TECHNIQUES USED FOR VISUAL SIMILARITY SEARCH

We will start the discussion of the image retrieval based on content schemes with the most popular and simple yet effective technique called Color Edge Detection that color and edges information images for finding feature.

Later, we will proceed to discuss the discrete wavelet transforms (DWT) which is widely used for multi-scale image retrieval. Finally, we describe the Singular Value Decomposition (SVD) method.

A. Color Edge Detection

Color is one of the most important low-level features used in image retrieval and mostly all content-based image retrievals (CBIR) systems use color as an image features. Due to its easy and fast computation, the color feature is one of the most effective element of image search [5]. Color is also an instinctive feature and perform an important role in image searching. The theory of color and its representation in digital images plays important role at the time of extraction of color feature from digital images. The color histogram (CH) is one of the most commonly used color feature representations for image search.

First, Swain and Ballard use the CH for image Search [5], who observed that the power to recognize an object, using color is much greater than that of a grey-valued image. The advantages of CH are low complexity of computation and the approximate invariance of translation, rotation and scale [6], but it does not concern with the spatial information of pixels of images. Therefore two images can have similar color distribution but great difference in visual sense. The general idea in using CH is to divide an image into sub-block and calculate a histogram for each of these sub-blocks [7]. Increasing the number of sub-areas leads to increase the usage of memory and computational time. These problems are exacerbated forvery large databases even further. However, only color features often not give satisfactory results for image retrieval because many times it is found that, images with similar colors do not posses similar content. Color Edge Detection is the solution to this problem.

For extraction of Color features, YCbCr and RGB color spaces are used. Bitmap images use the RGB planes directly to represent color images. But it is found in medical research that the human eyes have different sensitivity to brightness and color. The human eyes quickly identify the changes in brightness than changes in color. Thus there is need of transformation of RGB color space to YCbCr color space [8]. In YCbCr color space Y denotes the luminance component and the chrominance components represented by Cb and Cr. The YCbCr color space represents color as brightness and two color difference signals whereas in RGB color space represents color as red, green and blue format. We mostly used YCbCr space because the luminance component is not depends on color and solve the color variation problem [9].

Canny edge detector is used for extracting edges from image, because it is an optimal detector. The detector ensures only one response to a single edge and it provides shape that is optimal at any scale. Canny edge detector is also able to cope up with noise in the image [13].When the query image comes, a combined feature vector iscomputed for color and edge features.

B. Discrete wavelet transforms (DWT)

The wavelet transform has been taking more attention in image searching. It decomposes a signal into a set of basis functions. These basis functions are called wavelets. Wavelets transform convert the image into a series of wavelets. And these wavelets may be stored more efficiently than pixel blocks of image. Due to rough edges, wavelets are able to represent images better by eliminating the “blockiness”.

Discrete wavelet transforms is very acceptable transformation method used for image retrieval. The DWT is introduced because decomposition of signals into sub band as it is highly flexible and efficient method. DWT decomposes an image into four sub-bands: an approximated image (A) and horizontal (H), vertical (V), and diagonal (D) detailed images. The detailed images measure variations along the columns (horizontal edges),

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rows (vertical edges), and diagonals (diagonal edges) respectively.

For image search, we can use more than one decomposition level to give less but meaningful information representing query image. Again the approximated image is decomposed into wavelet sub-bands. Two or three decomposition levels may be used. The final resultant approximated image is used to generate the feature vector. It can decompose the image into three levels i.e. level one, level two, and level three.

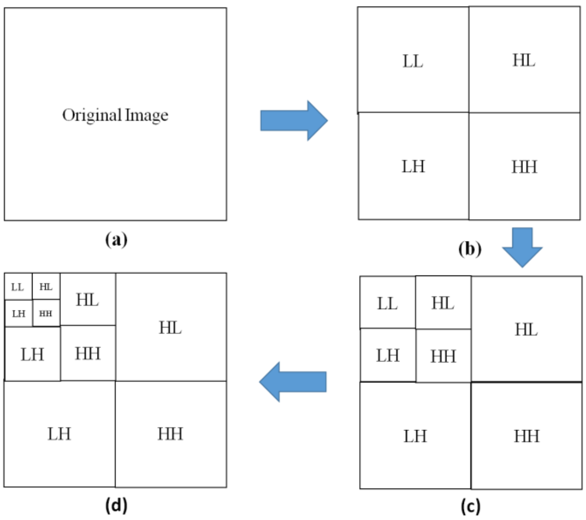

Fig. 2 : 2D-DWT decomposition: (a) Original image (b) Level one decomposition (c) Level two decomposition (d) Level three decomposition

Nowadays the 2D-DWT is known for content based image search. It is multi resolution analysis that decomposes the images into scaling functions and wavelet coefficients. A 2D DWT generally is seen as a 1D wavelet transform along the rows and a 1D wavelet transform along the columns. The operation of the 2D DWT is in a very straight forward manner. It inserts an array transposition between the two 1D DWT. At first only one level decomposition is processed on the rows of the array. Hence the array is vertically halved; the first half stores the average coefficients whereas the second half stores the detailed coefficients. Same process is repeated on the columns. This process results in four sub bands (see Fig. 2) within the array defines by filter output. Fig. 2 shows 2-D DWT decomposition of the image.

C. Singular Value Decomposition (SVD)

Beltrami has independently discovered Singular Value Decomposition (SVD) for square matrix in 1973and Jordan in 1874 and Eckart and Young it's extended for rectangular matrix in 1930. Singular Value Decomposition (SVD) is a feature transformation method which decomposed the high dimensional matrix into small dimensional matrices. The matrix A is decomposed into small three matrices based on singular value decomposition in the form:

$$A = UDV^T \qquad (1)$$

(See the fig. 3 for illustration)

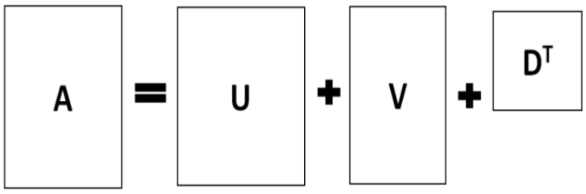

Fig. 3 : Illustration of Factoring A to USV^T

Where A is matrix having m rows and n columns, with rank r and $r \le n \le m$. Matrix U is an $m \times m$ orthogonal matrix, matrix V is an $n \times n$ orthogonal matrix and D is an $m \times n$ diagonal matrix with singular values (SV) on the diagonal. The main diagonal of matrix D represents singular values $\sigma_1 \ge \sigma_2, \ldots\ldots\ldots\ldots \ge \sigma_n \ge 0$ which is always in descending order. The singular values are calculated by taking the square root of eigen value of AA^T and $A^T A$. Equation (1) can be written as

$$A = UDV^T$$

$$A = [u_1, u_2, \ldots\ldots\ldots u_n] \begin{bmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & .. & 0 \\ 0 & 0 & 0 & \sigma_n \end{bmatrix} \begin{bmatrix} v_1^T \\ | \\ | \\ v_n^T \end{bmatrix}$$

The following equation gives the relation between SVD and eigen values

$$A = UDV^T$$

Now

$$AA^T = UDV^T(UDV^T) = UDV^T VDU^T = UD^2U^T$$

Also

$$A^T A = (UDV^T)^T UDV^T = VDV^T UDV^T = VD^2V^T$$

Thus U and V are known to be a eigen vector of AA^T and $A^T A$ respectively. The singular values are always real number and orthogonal matrix U and V are also real, if and only if the matrix A is real.

There are many properties of SVD but here we only present some of them, which is useful in image search project:

1. The matrix and are not unique, although the singular values are unique $\sigma_1 \ge \sigma_2, \ldots\ldots\ldots\ldots \ge \sigma_n \ge 0$.
2. The Eigen vector of AA^T is used to compute the matrix U.
3. The number of its non-zero singular value is equal to the rank of matrix A.

Singular value decomposition (SVD) has following application in image processing:

1. For image compression SVD approach is used.
2. SVD used for face recognition and image retrieval.
3. SVD also used for the texture classification.

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IV. CONCLUSION

In this paper, we have represented our semantic literature review on various recent states-of-the-art techniques used for visual similar image search. These techniques were presented in a way highlighting their advantages and limitations in terms of efficiency and time-taken.

The review of this paper will support our future research on improving image search quality using Singular Value Decomposition, which provide fine grained ranking on return images.

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BIOGRAPHY

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