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Content Based Image Retrieval in Multimedia Database

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Abstract - Multimedia is a combination of text, graphics animations, audio and videos converted from different formats into digital media. With rapid advancement in the field of computer technology, the amount of digital image data on the Internet and in the digital library has seen immense growth. Therefore there is a requirement of an accurate and fast method to retrieve digital images from large databases. Over the years, several content based image retrieval techniques have been developed but still they lag behind the existing text search engines. This term paper briefly describes some of the existing content based image retrieval techniques and suggests modification on one of these techniques in order to achieve efficiency.

Keywords - CBIR, Multimedia, HSV, texture.

I. INTRODUCTION

Due to the rapid advancements in the field of computer technology, computation power as well as storage capacity has increased immensely mainly due to its cost reduction. Also due to Internet, the requirement as well as the availability of digital image information has accelerated manifold. Therefore there is a requirement of accurate and fast techniques to retrieve digital images from the underlying large databases. Image retrieval systems attempt to search through a database to find images that are perpetually similar to query image. There is several image retrieval techniques are existing in the environment and one of them is CBIR (content-based image retrieval). CBIR is a process used to find images similar in visual attributes to a given query from an image database. It is usually performed in two phases: indexing and searching. In the indexing phase, each image of the database is represented by a set of image attributes, such as color, shape and texture. Features extracted are stored in a visual feature database. In the searching phase, when a user makes a query, a feature vector for that query is computed. Using a similarity criterion, this vector is compared to the vectors in the feature database. The images most similar to the query are returned to the user.

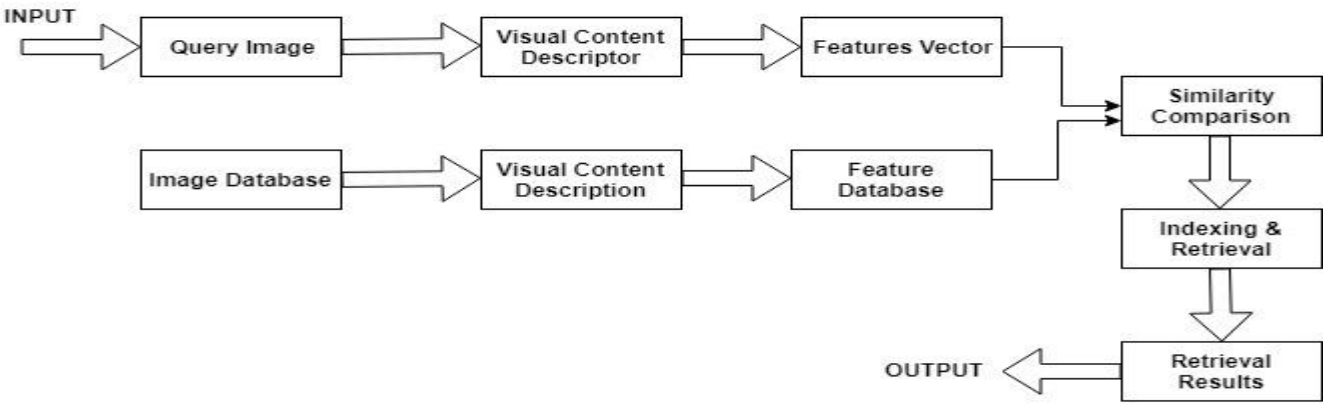

Figure 1: Content Based Image Retrieval

II. PROBLEM DEFINITION

In Content based image retrieval problem, a query image is retrieved from an image database according to some notion of similarity. The main issue in CBIR is how to encode the database images and how to locate query images effectively and efficiently. Content based image retrieval uses the visual features of an image such as color, shape and texture to represent and index the image. These visual features of images in the database are extracted and described by multidimensional feature vector. To retrieve image user provides the retrieval system with query image. The system then changes this query image into its internal representation of feature vectors. The similarities /distances between the feature vectors of the query image and those of the images in the database are then calculated and retrieval is performed with the aid of an indexing and searching or matching scheme. The key issues are:

(a) Selection of an appropriate feature for feature extraction from an image.
(b) Selection of an indexing scheme for fast and efficient image retrieval.
(c) Selection of an optimal searching / matching mechanism.

III. EXISTING SOLUTIONS

Image retrieval from multimedia database is a popular research area and there exist several methods for its retrieval in the environment. Some of these existing solutions or techniques for image retrieval are as:

3.1 Image Retrieval Based on Visual Feature Matching Methods

These methods are based on matching visual features i.e. Color, texture, shape or spatial relationship of a query image with a database image. These methods differ in terms of feature selection which can be either a single feature or a combination of different features. The basic principle of these methods is as:

1 Query image is first analyzed based on feature/features selected and its value is stored in a quantized histogram.
2 Feature differences and histogram differences between a query image and a database images is calculated.
3 Images with minimum difference from the database are retrieved.

3.2 Image Retrieval Based on Indexing Schemes

A number of approaches have been proposed for this purpose which include R-tree, R*-tree, linear quad-trees, K-d-B tree and grid files. Most of these multi-dimensional indexing methods have reasonable performance for a small number of dimensions (up to 20), but explore exponentially with the increasing of the dimensionality and eventually reduce to sequential searching.

3.3 We have selected one of the approach for image retrieval named "**Content Based Sub Image Retrieval via Hierarchical Tree Matching**" proposed by Jie luo and Mario A. Nascimento. This approach consist of -

3.3.1 Hierarchical partition and tree structure

Image is hierarchical partitioned into three levels, the highest level is the image itself, for the second level the image is decomposed into 3*3 rectangles with each side having half the length of the whole image, yielding 9 overlapping tiles. In third level each region of the second level is partitioned into 4 non-overlapping sub regions thus yielding a total of 36 sub regions.

3.3.2 Feature Extraction

Only color visual feature is used and the average color of the image tiles in the RGB color space is used for image indexing.

3.3.3 Index Sequence

An index sequence representing the predefined parent child relationship for the tree structure stored in the secondary storage and used for fast retrieval.

3.3.4 Search strategy

The searching process is accomplished by 'floating' the tree structure of the query image over the full tree structure of the candidate database image, shrinking the query's tree structure so that it is comparable with the candidate database image's trees at each level of the hierarchical structure. The minimum distance from tree comparisons at all hierarchical levels, indicating the best matching tile from a database image, is used as the distance between the database image and the query image. The average of distance values among the corresponding leaf nodes is taken for the distance between the tree structures of query image and a certain tile of the database image at any hierarchical level.

IV. IMPLEMENTATION DETAILS

The suggested approach comprises of following steps:

a. First the visual features color and texture are extracted using HSV color histogram and edge histogram.
b. In order to rank the images three distance measures used are L2 distance, cosine distance and mainly histogram intersection.
c. Finally the best ranked image is selected by using minimum of weighted sum of the two feature distances among database images.

4.1 Color Histogram

I. Input image of RGB color space is converted into HSV color space by using following formulas:
Hue, $H = \text{Cos}^{-1} \{ [½ [(R-G)+(R-B)]] / [\sqrt{(R\_G)^2 + (R-B)(G-B)}] \}$

Saturation, $S = 1- 3 [\min(R,G,B)] / (R+G+B)]$

Value, $V = 1/3(R+G+B)$

II. Then each color component is uniformly quantized into H: 16 bins, S: 4 bins, V: 4bins.
III. Finally this 16 x 4 x 4 histogram is concatenated resulting in a 256 - dimensional vector.

4.2 Edge Histogram

I. A 4-bin edge histogram is used to represent the strength of edge in 0, π/4, π /2, 3π /4 directions.

II. Image gradients G_x and G_y are calculated using sobel operator -

Sobel_y = [1 0 -1; 2 0 -2; 1 0 -1]
Sobel_x = [1 2 1 ; 0 0 0; -1 -2 -1]

III. Edge direction is computed for each edge pixel using the following formula:
$\Theta = \tan^{-1} (G_y/G_x)$

And edge direction Θ is then uniformly quantized into 4 bins 0, +/- 45, 90 degrees using decision values +/- 22.5, +/- 67.5 degrees.

IV. Edge histogram is normalized with respect to image size.

4.3 Histogram Distance Measures

Three different histogram distance measures used are as -

I. L-2 Distance : to find the Euclidean distance between vectors in feature space by using formula:

$$d(q,i) = [{}_{m=1}{}^{N}\sum(h_q(m) - h_i(m))^2]^{1/2}$$

II. Cosine Distance: The cosine similarity coefficient which uses the angle between vectors is used for comparing feature vector of a query image with feature vector of database image. The following formula used as:

$$d(q,i) = 2/\pi \cos\text{-}1\{ [m=1 {}^{N}\sum h_q(m)\, h_i(m)] / [\min(||h_q||,||h_i||)] \}$$

III. Histogram Intersection distance: The intersection of histograms $h_q(m)$ and $h_t(m)$ is computed by:

$$d(q,i) =\{[{}_{m=0}\sum^{M-1} \min(h_q(m), h_i(m))] / [\min(|h_q|, |h_i|)] \}$$

4.4 Image Selection Decision Algorithm

In this part the different features extracted are combined in order to select a best matching image from a image database with respect to query image. The combination of different features is carried out by finding the weights of different features distances and by using decision algorithm.
Decision Algorithm: This algorithm has following steps -

I. For a query image q and images in the database i, the distances with respect to two features i.e. Color and texture features is

$d_k (q,i)$, where k = 2 (color and texture features) and i= 1….N

II. Combining them as a weighted sum of all the distances, the distance for a image in the database is given as -

$$D(q,i) = {}_{k=1}\sum^{2} w_k\, d_k(q,i)$$

III. Search for a vector w that satisfies a equation:

$$\sum_{k=1}^{2} w_k = 1,\ w_k >= 0$$

IV. Database image that minimizes the maximum distance over all valid set of weights is declared as the best match to a query image.

V. RESULTS

The performance of content based image retrieval (CBIR) can be evaluated in terms of its recall and precision. Recall measures the ability of the system to retrieve all images that are relevant where as precision measures the ability of the system that retrieves only images that are relevant. It has already been proved in [2] On the basis of experimental results on a general purpose image database, it has been proved in [2] that:

i. The retrieval performance of histogram intersection distance measure is superior to the performance of cosine distance and L 2 distance (or Euclidean distance) in measures.
ii. Performance of image retrieval using both color and texture features in terms of recall and precision is more promising than using only a single feature.

VI. CONCLUSION

"Content Based Sub Image Retrieval via Hierarchical Tree Matching" proposed by Jie luo and Mario A. Nascimento used only a single color (RGB) feature for feature extraction from the image database. However results have shown that the performance of image retrieval using more than one visual feature for feature extraction is better than the system using only a single feature. Thus using both color (HSV) and texture features for feature extraction from the query image and database images, the performance of Content Based Sub Image Retrieval via Hierarchical Tree Matching in terms of recall and precision can be enhanced.

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