Content-Based Image Retrieval Using Color, Texture and Shape Features

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Abstract. Nowadays CBIR is getting more and more attention from organizations and researchers due to advances in digital imaging techniques. A lot of interest is getting paid to search images from large databases, as it is not only difficult and time-consuming task but sometimes frustrating for the users. This paper proposes the CBIR system based on color, texture and shape features. The proposed method employs the use of DCT and DWT along with Hierarchical k-means algorithm for faster retrieval of images. The efficiency of the given method is demonstrated by the results in the paper.

Introduction

With the proliferation of digitization techniques and equipment in the last few decades, big archives of multimedia information such as videos, images, satellite pictures, books, newspapers, magazines, etc. have been digitized. Due to increased usage of computers with greater memory and communication capacities, digital images have become an important class of data contributing to large digital storage databases. Due to advancement of the Internet and availability of cheap handheld devices it is possible to access a huge amount of images through various multimedia services. Initially a text-based retrieval technique was proposed to locate accurate and relevant image from databases.

In this technique, images are assigned by keywords to convey their contents. The keywords stored as an attribute associated with the image in the database. During the image retrieval, the system accepts one or many words as a string combining the search criteria to retrieve images having keywords corresponding to the input search string.

The main issue with the text-based image retrieval system is that the keywords used for describing an image are not clear and rather inappropriate for efficient performance of search methods. The textual annotations are language based, variations in these annotations pose a severe challenge to image retrieval [1]. This makes the text-based retrieval techniques more error-prone.

To overcome the difficulties of the text-based image retrieval system the content-based image retrieval system came has been an important area of research. CBIR uses the visual content of the images, i.e. properties of images to process, search and retrieve. CBIR techniques make use of image processing algorithms to extract feature vectors from the image representing the image properties such as color, texture, shape, etc. [2] making CBIR more descriptive for the image retrieval and less subjective than the text-based image retrieval.

The CBIR systems can be categorized on the basis of the type of features used for the image retrieval such as: low level features, i.e. color, texture, shape, spatial relations, etc. or high level features including refinement of low level features, e.g. use of fuzzy logic rules to determine similarity between searched shape and given object shape.

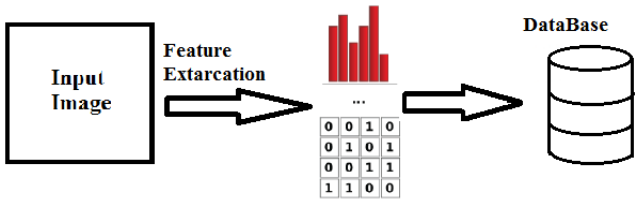


Fig. 1 Database creation of CBIR systems

Figure 1 above shows the general procedure used by the CBIR systems to build database. Some features of the input image are first calculated using feature extraction techniques such as color histogram, Gabor filter, Fourier descriptors, spatial orientation graphs, energy, and etc. These extracted features are then stored in the database along with the image as attributes.

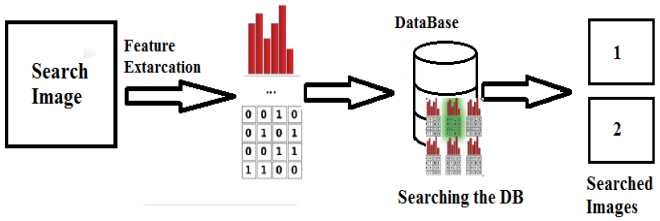


Fig. 2 Querying database for image retrieval

Figure 2 shows the image retrieval process, where the user inputs a query image to be searched in databases. The system evaluates the features of this query image, and searches for the images with similar features, and displays the matched images. The complete CBIR system framework is represented in Figure 3 [3].

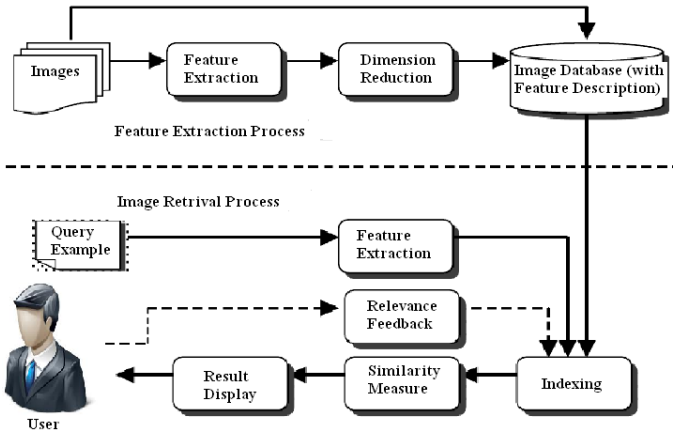


Fig. 3 CIBR system framework

Due to recent enhancement in the CBIR techniques the image retrieval process can be made more effectively by recognizing the image class prior to any kind of processing. This technique helps to successfully categorize images to enhance the performance of the system by sorting out extraneous images, requiring similarity matching step to be performed between query and images in the filtered set only.

Proposed CBIR System

The proposed content-based image retrieval system using color, texture and shape features applies Hierarchical k-means algorithm for faster image and hierarchical image retrieval. For color, texture

and shape feature extraction, the proposed system uses color histogram, text on co-occurrence matrix and range filtering respectively.

The proposed system can be categorized into:

Database creation. The input image is pre-processed and saved into the database (DB) with these pre-processed parameters. The input image is first applied with DWT. This application of DWT on the input image gives approximation, horizontal, diagonal and vertical components of the image. The components of the image are used to calculate the texture, color and shape of the image. Finally, the input image is saved with its color, texture and shape features into the database. The color features are obtained from the color histogram of the image. The color histograms are used to find the color distribution in the image frame, i.e. count the number of occurrences of each unique color on a sample image. The shape features are obtained after applying range filtering.

The same can be achieved using DCT on the input image. By using DCT the color, texture and shape features of the image are calculated and saved with the input image into the database. The complete DB creation process is shown in Figure 4.

Database evaluation. This is where the image retrieval process takes place based on the input query image. DCT or DWT is first applied to the input query image to calculate the color, shape and texture of the query image. These features are then compared with the values in the DB using Hierarchical k-means algorithm. The algorithm evaluates the images in the database that differs less in the feature values with the input query image to find possible best-matched images. Finally, these images with the best-matched features are displayed in a hierarchical fashion, with the best-matched image at the top. Figure 5 shows the block diagram for the DB evaluation process of the proposed CBIR image retrieval system. [4,5]

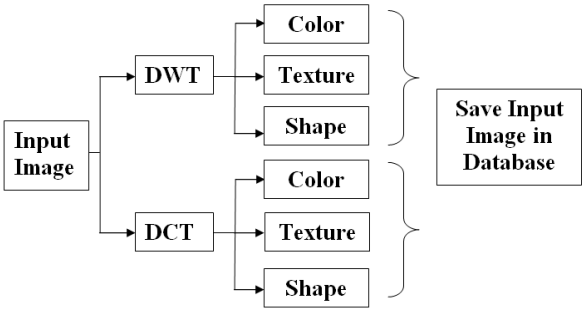


Fig. 4 DB creation step of proposed BIR system

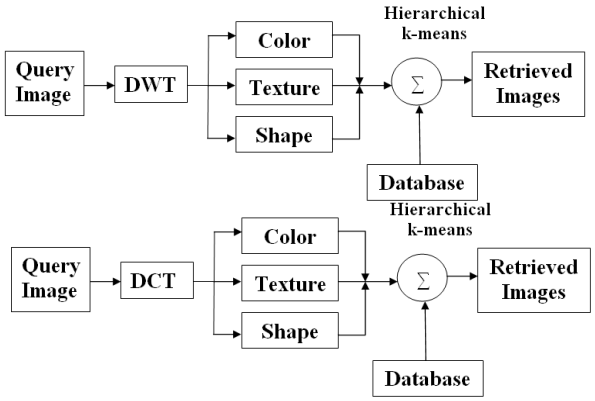


Fig. 5 DB evaluation of proposed BIR system

Hierarchical k-means algorithm essentially divides the data set recursively into clusters. First, the k-means algorithm is used to divide the dataset into two subsets by setting k to 2 in order. Then these two subsets are further divided into two subsets by setting k to 2, as shown in Figure 6. The recursion terminates when a stop criterion is reached or when the dataset is divided into single data points. Hierarchical k-means has O(n) run time. Traversing a tree is always performed via a depth- first-search or breadth-first-search.

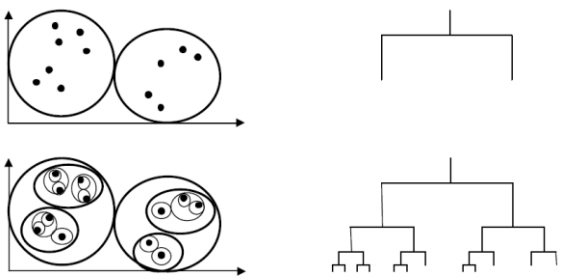


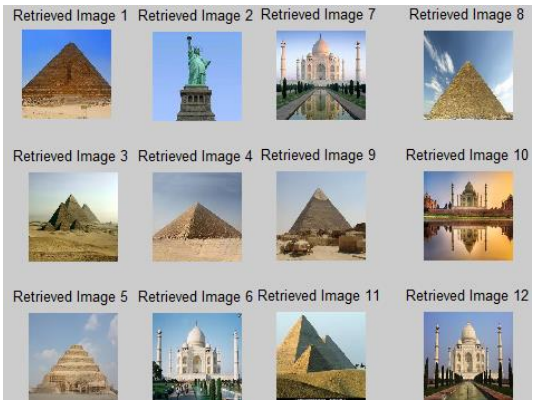
Fig. 6 Hierarchical k-means algorithm

Proposed System Results

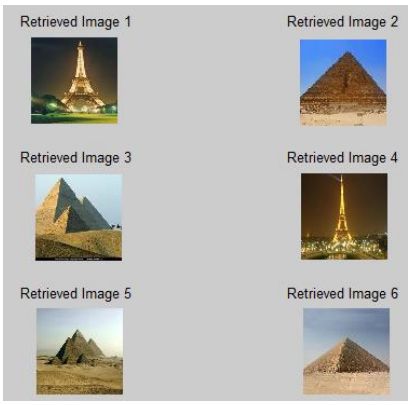
The proposed system has been implemented using MATLAB. For evaluating the proposed system database of more than 1000 images has been created. The created database has been used to save images to the database by processing the images and calculating the color, texture and shape features by color histogram, range filtering and text on co-occurrence matrix respectively.

To evaluate the performance of the algorithm implemented, we consider the input image as shown in Figure 7. Figure 8.a depicts the output of the proposed CBIR system for the input image using DWT, whereas Figure 8.b represents some of the retrieved images for the considered input image using DCT.

Fig. 7 Input image



a) Image retrieval using DWT



b) Image retrieval using DCT

Fig. 8 Retrieved images for input image

Table 1 below outlines the results for evaluation of the proposed system for some of the images. The table uses percentage of the successful retrieval of image criteria, which is basically the ratio of the successful retrieved images to the actual number of images in the database related to the input image.

Table 1. Comparison of image retrieval using DCT and DWT techniques

Input Image	**Percentage of Successful Retrieval of Images (%)**		**Input Image**	**Percentage of Successful Retrieval of Images (%)**	
	DCT	**DWT**		**DCT**	**DWT**
Eiffel Tower	31.25	38.65	Golden Gate Bridge	59.58	58.6
Koala	61.33	66.85	London	45.69	56.25
Pyramid	48.64	54.05	Statue of Liberty	47.5	58.65
Sachin Tendulkar	51.29	58.68	Red Fort	46.88	52.66
Taj Mahal	48.05	48.71	Himalayas	53.99	61.28
Tree	49.52	56.24	Garden	40.56	44.9
Apple	38.56	48.93	Toyota Car	55.47	62.15
Penguin	55.12	62.44	Football	54.65	59.8
Alps	57.5	62.59	Cake	49.56	63.05

Considering the example shown in Figure 7 and its outputs in Figures 8.a and 8.b, the percentage of successful retrievals of the pyramid image obtained is 54.05% and 48.64% for DWT and DCT respectively.

Conclusion

In this paper, the content-based image retrieval system using color, texture and shape features has been proposed and implemented using MATLAB. The proposed system takes into account the usage of both DWT- and DCT-based image retrieval techniques. The system uses Hierarchical k-means

algorithm for faster and hierarchical image retrieval. For color, shape and texture features extraction, the proposed system has used color histogram, range filtering and text on co-occurrence matrix respectively. The proposed system has been tested successfully with the database of more than 1000 images and it has been found that the average percentage of retrieval of images is about 57%. It has also been observed that the DWT-based technique offers a better image retrieval as compared to DCT and may exceed the other by more than 5-8% in some cases.

References

[1] David G. Lowe, Distinctive image features from scale-invariant keypoints, International Journal of Computer Vision, 60/2(2004) 91-110.

[2] C. A. Z. Barcelos, M. J. R. Ferreira, and M. L. Rodrigues, Retrieval of textured images through the use of quantization and modal analysis pattern recognition, 40/4(2007) 1195–1206.

[3] Hui Hui Wang, Dzulkifli Mohamad, N.A. Ismail, Approaches, challenges and future direction of image retrieval, Journal of Computing, 2/6 (2010).

[4] T. Kato, Database architecture for content-based image retrieval, Proceedings of SPIE Image Storage and Retrieval Systems USA, 1662 (1992) 112–123.

[5] A.Smeulders, M.Worring, S.Santini, A.Gupta, R.Jain, Content-based image retrieval at the end of the early years, IEEE Trans Pattern Rec. & Machine Intel, 22(2000) 1349-1380.

[6] Herve Jegou, Matthijs Douze, Cordelia Schmid, Hamming embedding and weak geometric consistency for large scale image search, ECCV '08: Proceedings of the 10th European Conference on Computer Vision, (2008) 304-317.

[7] A. Ponomarev, E.Merker. I. Korneva, Use of OPEN UMS format for document flow formalization in medicine, The doctor and Information Technology, (2015) 17-23.