Indian Journal of Science and Technology, *Vol 8(28), DOI:10.17485/ijst/2015/v8i28/75065, October 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Performance Enhancement of Content based Image Retrieval System by Integration of Suitable Image Features

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Abstract

Background/Objectives: Retrieving visually similar images from image database needs high speed and accuracy. Various text and content based image retrieval techniques are being investigated by the researchers in order to exactly match the image features. **Methods/Statistical analysis:** The proposed technique deals with Content Based Image Retrieval (CBIR) system by applying various image feature detection and matching techniques to investigate the retrieving efficiency of the image. The newness in the proposed research is that it extracts image features like texture, color and shape by combining various angular rotation and image segmentation techniques. With the output of the rotation and segmentation algorithm, color histograms, straight line and outline features including vertical, angled and horizontal lines are extracted. **Findings:** The accuracy and performance related issues listed in the previous works are overcome while the database images grow. The results obtained by the proposed system obviously confirm that Partitioning and rotating of image objects helps in retrieving many numbers of similar images from the database. **Conclusion/Improvements:** The proposed CBIR method is compared with our previously existed methodologies and found better in the retrieval accuracy. The retrieval time and accuracy are comparatively good than previous works proposed in CBIR system.

Keywords: CBIR, Image Features, Outline Color Histogram, Rotation Mechanism, Segmentation, Straight Line

1. Introduction

Content Based Image Retrieval (CBIR) system is arrived due to the problems associated with the Text Image Retrieval (TBIR)[1]. Retrieving visually similar images from image database needs high speed and accuracy. Various text and content based image retrieval techniques are being investigated by the researchers in order to exactly match the image features[2]. A perfect CBIR system should retrieve the image from database without indexing of the human activities. Having color, shape and texture features of an image, we cannot increase the exactness of retrieving. Thus there arrived many researches including various algorithms and methodologies. Color based CBIR is not fit for all database images where different kinds of images are associated.

Unlike the usual features of image such as color, texture and shape, different method of features extraction is investigated and proposed. They are straight line features, outline/edge detection features, segmentation features and features after angular rotation of the images[3]. Typical content based image retrieval system block diagram shown in Figure 1.

2. Survey on CBIR System

In the first generation of image retrieval system, text annotations were used to pick the similar images from

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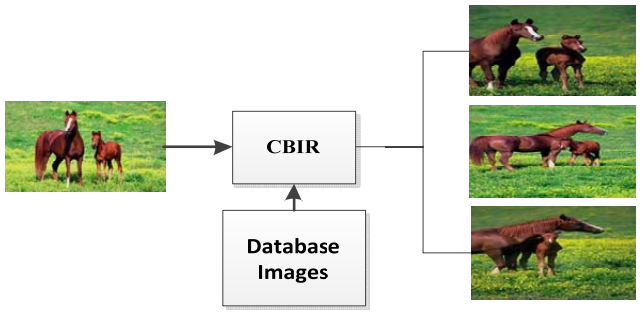

Figure 1. Typical CBIR system.

the database[4]. Content based image retrieval system was proposed to overcome the difficulties encountered in TBIR. Color, texture and shape based CBIR was proposed at the last years of 19th century[5]. Segmentation of texture and extraction of texture feature was concentrated in 1989 by Sagi and Fogel. Rose J, Orlando has implemented Content-based image retrieval using gradient projections in 1998 where gradient can be computed at each pixel. And then the CBIR system was utilized for identification of fingerprints by Hammamoto in 1999, iris detection and recognition by Daugman, 1998, recognizing the face by Wechsler, 2001 and for the Edge detection based image similarity detection by Wang, 2003.

Huang et al.[9] has implemented a CBIR system using texture similarity. Sub band gradient vector (CSG) and the Energy Distribution Pattern (EDP) string are the two features extracted in his retrieval work.

Chuen Horng Lin et al. combined three image features to make easy the image retrieval process. First two features are useful for describing the relationship between colors and textures in an image. And they are called Color Co-occurrence Matrix (CCM).

The CBIR was used in medical image, museums, galleries, satellite images and institutional database images by applying various distance measurement techniques such as Chi-Square Distance and Euclidean Distance method[6]. But all were using the 3 common feature content (color, shape and texture) of image without applying any mechanism before extracting the features of an image. But in this paper we focus on retrieving many number of similar images with high retrieving accuracy by introducing angle based image rotation, top, middle, bottom region based image segmentation and various line features extraction.

3. Proposed Image Feature Reduction and Extraction Technique

In this proposed research, we use two methodologies to extract the image features. The image features or image signatures we extract is Color, Various Lines present in the image (horizontal, vertical, angled) and outline/edges of the image. And the two proposed methodologies are image segmentation and angular rotation of detected object.

4. Segmentation and Scaling Method

The given image is segmented in to different blocks in size with uniform rows and columns[7]. Image signatures are extracted by means of these segmented blocks in future. In this experiment we segment the image as 3x3 sized blocks which produces horizontally segmented blocks (Top, Middle and Bottom), vertically segmented blocks and central block of the image[8]. To find the 9 region of the image the following rule is used.

X1 = img_width/3, & Y1 = img_height/3
X2 = 2 * img_width/3, & Y2 = img_height/3
X3 = img_width/3, & Y3 = 2 * img_height/3
X4 = 2 * img_width/3, & Y4 = 2 * img_height/3

In our previous research we focused only on Top, Middle and Bottom blocks of the image. After the process of getting all segmented blocks we apply edge detection algorithm to find the image edges in all blocks. Importantly unlike other segmentation based retrieval method we don't concentrate on all the partitioned sub blocks[9,10]. Instead it only passes the sub block in which the white pixel intensity is much greater to the feature extraction method. In partition, horizontal blocks are named as H1, H2 and H3. The vertical blocks are named as V1, V2, and V3. The centered block of the query image is named as C as in the Figure 2.

5. Angular Rotation Normalization of Image Object

Previously existed CBIRs might be high in accuracy while retrieving the similar images from the large database[11,12]. Even though they could fail in retrieving some similar

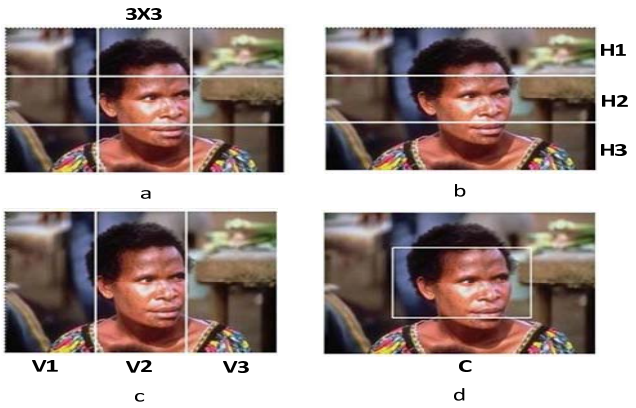

Figure 2. **(a)** 3x3 partitions of query image. **(b)** Horizontal blocks. **(c)** Vertical blocks. **(d)** Center blocks.

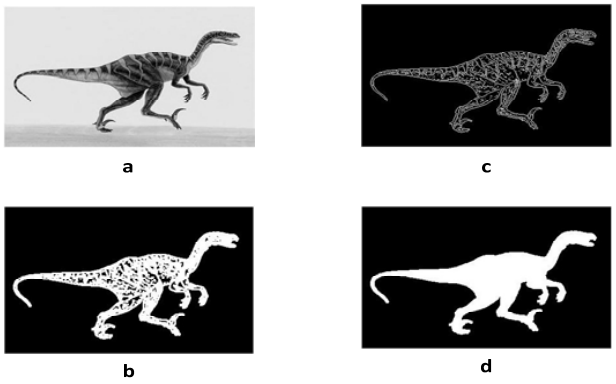

Figure 3. **(a)** Gray scale image. **(b)** Edge detection and thinning stages of image. **(c)** Edge detection and thinning stages of image. **(d)** Edge detection and thinning stages of image.

images if there found angled or mirror objects in the image. Taking all into account proposed method first extracts the major object present in the processing image using particle analysis which includes boundary tracings and edge detection.

Edges are measured by detecting the places where the intensity levels changes rapidly[13,14]. Let us consider the Dinosaurs in an image that has to be extracted using edge and boundary extraction method[15]. Figure 3 shows extraction of Dinosaurs from the query image with the same background. Then it focuses on rotating the objects with various angles in order to match all the images which are having angled and mirrored objects as in Figure 4.

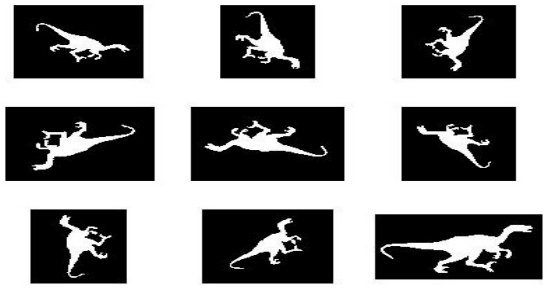

Figure 4. Rotation of the shape region.

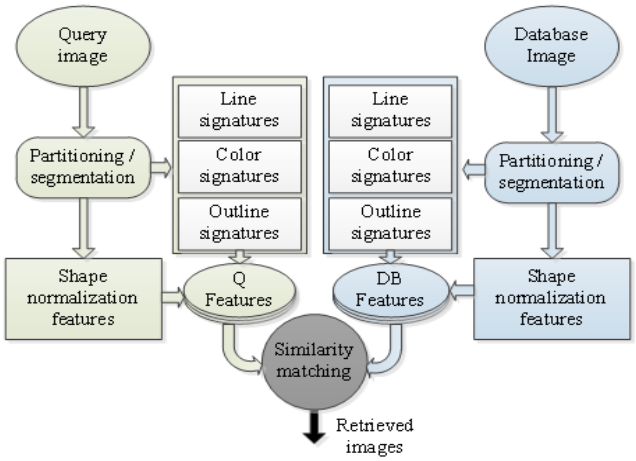

Figure 5. Proposed CBIR architecture.

6. Proposed Image Feature Extraction Algorithm

The proposed algorithm implements a modified Euclidean Distance matching technique based CBIR using Color, Straight line and Outline features of the query Image. All the features are being extracted after the segmentation and image object rotation based methods. The block diagram of the proposed combined feature detection, reduction and extraction methodology is shown in Figure 5.

The flow of proposed algorithm is described as follows.

Flow of algorithm:

Get the query image of size m x n (I_Q).

Sub-blocks segmentation and histogram

Divide I_Q into 3x3 blocks.

Sub-Blocks = H1, H2, H3, V1, V2, V3, C.

I_H = combined 3 region color histogram of the H1, H2, H3 blocks.

I_V = combined 3 region color histogram of the V1, V2, V3 blocks.

I_C = color histogram of the center block.
S1= $I_{hist} = I_H * I_V * I_C$.

Image Rotation and Scaling
Read Image I_Q.
Resize and Rotate the Image [0–360].
Find Matching Features between I_Q with database Images.
S2=Extract the matched features of I_Q with each database Images.

Straight line features extraction
Find long straight line feature as
Horizontal lines L_H
Vertical lines L_V
45° lines L_{45}
Strore all feature as $L_{straight}$ in database

Outline features extraction
Detect the outlines of the input image.
Take FFT of the binary outline Image store outline signature as L_{out}.

- Integrate all straight line outline and color histogram feature of the input query image I_Q.
- Compute Euclidean Distance between the I_Q signatures and database signatures.
- Sort the Euclidean Distance D in ascending order.
- Find the index of Top N ranked minimum distances of D and find the average image signature.
- By using average image signature as virtual query image do repeat search.
- After finding Euclidean Distance D1 and index of the Top N ranked display the Top N ranked Images from the image database using the index for retrieving all similar images.

7. Signature/Feature Extraction of Proposed Technique

The three signatures extracted from the image are color histogram, straight line and outline features[16–20]. In this the color signature is used to find different colors present in the query image in various places as it is partitioned above. Figure 6 shows the color histogram signature of the horizontal planes of the query image as 3 regions (Region1, Region2 and Region3).

The color histogram of the query image with L maximum possible intensity level [0, G] is estimated as follows,

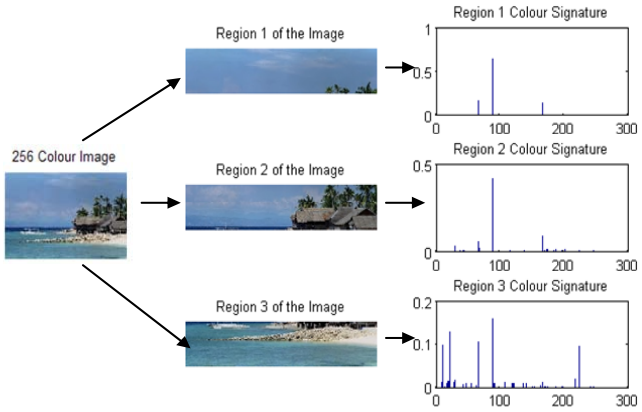

Figure 6. Color histogram feature extraction of image.

Figure 7. Straight line (horizontal, vertical, 45 degree) feature extraction of image.

$$h(l_k) = n_k$$

Where l_k is the $\mathbf{k}^{th}$ intensity level in [0, G] and n_k is the no. of pixel in image with l_k

G is 255 for 8bit image and 65535 for 16 bit image.

$$p(l_k) = \frac{h(l_k)}{n}$$

$$p(l_k) = \frac{(n_k)}{n}$$

Where n is the total no. of pixels.

8. Straight Line Feature Extraction

Unlike our previous straight line features, to extract the various line features of the image, the proposed line

signature extractor integrates horizontal, vertical and angles straight lines present in the input query image. The extracted three line features are depicted in the Figure 7. The general equation of a line in the image can be denoted with two variables (r, θ) in polar coordinate system and its line equation can be expressed as,

$$y = \left(-\frac{\cos\theta}{\sin\theta}\right)x + \left(\frac{r}{\sin\theta}\right)$$

$$r = x\cos\theta + y\sin\theta$$

9. Outline Features Extraction

The query image is converted into gray scale image and SNR is increased by Pseudo Matching Filter. Then the image is divided into sub-blocks and Fourier transform is applied to generate orientation, angular bandwidth, and frequency. Each block is filtered using frequency selective filters and converted into binary by adaptive algorithms. Finally the outer contours and edges are traced and the outline features are extracted. The outline feature extraction of an image is shown in the Figure 8.

Figure 8. Outline feature extraction of image.

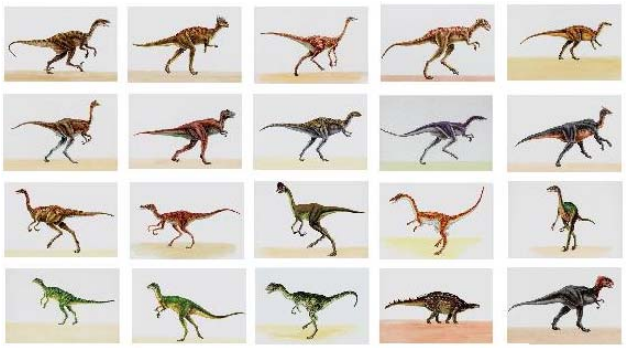

Figure 9. CBIR- experimented output images.

10. Results and Analysis

The proposed content based image retrieval technique uses portioning and rotation methods in order to increase the accuracy of retrieval process and increase the number of similar images. Our experiment is tested with 1000 images of Simplicity database which consists of African, Bus, buildings, Ocean, Elephant, Mountain, Food, Horses images. The tests are taken to retrieve more similar images from database and the test results with its precision comparison are shown in Figure 9 and Table 1. The whole CBIR system is developed in MATLAB.

Table 1. Precision comparison of proposed methods with various works

Class	IRM	FIRM	CSP	RT and F-RFM	3RCS	CSLS	CSLOS	ICSLOS	Proposed Segmentation and Rotation method with CSLOS
Africans	0.48	0.47	0.48	0.49	0.66	0.63	0.63	0.66	0.75548
Beach	0.32	0.35	0.34	0.40	0.37	0.40	0.40	0.38	0.49727
Buildings	0.35	0.35	0.33	0.39	0.48	0.47	0.47	0.48	0.62260
Buses	0.36	0.60	0.52	0.58	0.67	0.70	0.70	0.74	0.82056
Dinosaur	0.95	0.95	0.95	0.96	0.98	0.99	0.99	0.99	0.99080
Elephant	0.38	0.25	0.40	0.50	0.43	0.43	0.43	0.42	0.61368
Flower	0.42	0.65	0.60	0.75	0.68	0.76	0.76	0.77	0.88369
Horse	0.72	0.65	0.70	0.80	0.90	0.88	0.88	0.91	0.96252
Mountain	0.35	0.30	0.36	0.40	0.44	0.48	0.48	0.48	0.60306
Food	0.38	0.48	0.46	0.51	0.64	0.59	0.59	0.60	0.72020
Average Precision	0.47	0.51	0.51	0.58	0.63	0.63	0.63	0.64	0.74699

This CBIR system searches the database to retrieve the similarity images of query image. It also recalls the search by extracting the main shape present in the object to find similar and angled images to increase the retrieval of more images.

11. Conclusion

In literature, there are several approaches existing for content based image retrieval. Conventional and recently proposed techniques extract the features from the whole images and retrieve most similar images from the database. Whereas the methods based on segmentation and portioning segments both the query and database images in its first stage in order to increase the accuracy of the image retrieval. Also rotation of the main object in image improves the image retrieval process in matching more similarity images from the database. The image color, straight line and outline features are extracted after the portioning and rotation process. The final experimental results improve the performances of the CBIR in achieving accuracy and retrieving more similar images significantly.

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