ISSN:0975-9646

Image Retrieval using Shape Texture Content as Row Mean of Transformed Columns of Morphological Edge Images

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Abstract. **The paper discusses novel image retrieval methods based on edge texture of images extracted using morphological edge extraction techniques [21]. Twenty one variations of proposed image retrieval techniques using seven image transforms have been discussed. The proposed image retrieval techniques are tested on generic image database with 1000 images spread across 11 categories. In all 55 queries (5 from each category) are fired on the image database. The average precision and recall of all queries are computed and considered for performance analysis.**

***Keywords*: CBIR, Edge Texture, Top-Hat, Bottom-Hat, Transforms, Cosine, Sine, Haar, Hartley, Kekre, Slant, Walsh.**

I. INTRODUCTION

Information retrieval (IR) is the science of searching for documents, for information within documents, and for metadata about documents, as well as that of searching relational databases and the World Wide Web. There is overlap in the usage of the terms data retrieval, document retrieval, information retrieval, and text retrieval, but each also has its own body of literature, theory and technologies. IR is interdisciplinary, based on computer science, mathematics, cognitive psychology, linguistics, statistics, and physics. Web search engines are the most visible IR applications. Images do have giant share in this information being stored and retrieved, making image retrieval one of the key research field in IR. Content Based image retrieval (CBIR) is the area where searching is done using image content.

The images are very rich in the content like color, texture and shape information present in them [2]. Retrieving images based on color similarity is achieved by computing a color histogram for each image that identifies the proportion of pixels within an image holding specific values (that humans express as colors) [11]. Color searches usually involve comparing color histograms [16], color averages [19], BTC [20] and other methods. Texture measures look for visual patterns in images and how they are spatially defined [14]. The identification of specific textures in an image is achieved primarily by modeling texture as a two-dimensional gray level variation, GLCM [10], vector quantization codebooks [6], image transforms [7]. Shape does not refer to the shape of an image but to the shape of a particular region that is being sought out. Shapes will often be determined first applying segmentation or edge detection to an image [12]. Other methods use shape filters to identify given shapes of an image [14]. In some case accurate shape detection will require human intervention because methods like segmentation are very difficult to completely automate [15]. Here the paper discusses shape extraction using edge detection masks like Sobel, Roberts, Prewitt and Canny gradient operators [13]. The edge texture is generated using row mean of transformed columns of the extracted edge image with slope magnitude method.

II. MORPHOLOGY

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image.

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion. This table lists the rules for both dilation and erosion.

Dilation - The value of the output pixel is the *maximum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1.

Erosion - The value of the output pixel is the *minimum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0.

III. EDGE EXTRACTION

The problem with edge extraction using gradient operators is detection of edges in only either horizontal or vertical directions, as the gradient operators take the first order derivative of image in either vertical or horizontal direction only. Shape feature extraction in image retrieval requires the extracted edges to be connected in order to reflect the boundaries of objects present in the image.

Assume an image f and a 2-D structuring element K. Erosion followed by dilation represents an important morphological transform called opening, denoted by $f \circ K$. Its dual, closing, denoted by $f \bullet K$, is a dilation followed by an erosion. The residual of the opening compared to the original signal, i.e., $f - (f \circ K)$ represents the *top-hat* transform. Thus, when the opened signal is subtracted from the original, the desired detail is obtained. Its dual, the *bottom-hat* transform, is defined as the residual of a closing compared to the original image f, i.e., $f - (f \bullet K)$.

Edge extraction is carried out in three ways [21] :

- Simple Morphological Edge Extraction (SMEE) - Dilating the query image and then subtracting the original image from the dilated image.
- Top-Hat Morphological Edge Extraction (THMEE)
- Bottom-Hat Morphological Edge Extraction (BHMEE)

IV. IMAGE TRANSFORMS

Image transforms [17,18] can be simple arithmetic operations on images or complex mathematical operations which convert images from one representation to another. In the paper seven image transforms are used. The list of these image transforms is given below

- Discrete Cosine Transform(DCT) [8,9]
- Discrete Sine Transform (DST)
- Haar Transform
- Hartley Transform
- Kekre's Transform [4]
- Slant Transform
- Walsh Transform [5]

V. PROPOSED TECHNIQUES

Here edges are extracted using 3 morphological edge extraction techniques. The 'Morphology shape' image thus obtained acts as a feature vector for the image. For an 256x256 image, size of the feature vector is 65536 values.

The three morphological edge extraction techniques discussed above can be extended by applying image transforms onto the shape image obtained. Here the edges of the image are extracted by applying morphological edge extraction techniques on the image and then the transforms is applied on each column of obtained 'Morphology Shape' image. The row mean of these transformed column Morphology-Shape image is obtained and treated as image signature for CBIR. The row means for individual R, G and B planes forms the feature vector. This has been shown in figure 1. Total 21 variations of proposed CBIR technique are possible by using 3 morphological edge extraction techniques with seven orthogonal image transforms namely DCT, DST, Haar, Hartley, Walsh, Kekre and Slant. Based on the method to obtain 'morphology shape', per transform three variations of proposed image retrieval methods can be obtained as Simple Morphology Edge Texture (SMET) based CBIR, Top-Hat Morphology Edge Texture (THMET) based CBIR and Bottom-Hat Morphology Edge Texture (BHMET) based CBIR. Table 1 explains the feature vector sizes of both existing and the proposed techniques. The feature vector size in the existing Morphological Edge Extraction techniques for an NxN image is N^2 [21]. The feature vector size of the proposed techniques is reduced to Nx3 in proposed CBIR methods using edge texture, which in turn reduces the time required for query execution.

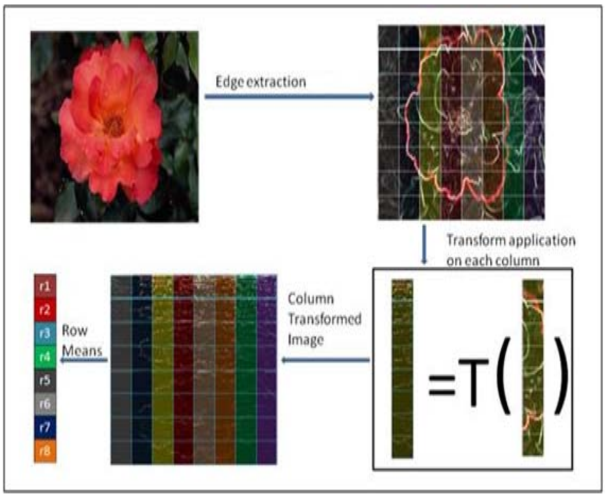

Figure 1: Edge texture extraction using morphological operator and image transforms

TABLE I

Feature Vector size for proposed CBIR techniques

CBIR Technique	Morphological Operators based CBIR	Morphological Edge Texture based CBIR
Feature Vector size for NxN image	N^2	Nx3

VI. IMPLEMENTATION

The discussed image retrieval methods are implemented using MATLAB 7.0 on Intel Core 2 Duo processor T8100(2.1 GHz) with 2 GB of RAM. To check the performance of proposed technique a database of 1000 variable sized images spread across 11 categories has been used [3]. Five queries were selected from each category of images. Mean Squared Error (MSE) is used as similarity measure for comparing the query image with all the images in the image database. Let Vpi and Vqi be the feature vectors of image 'P' and Query image 'Q' respectively with size 'n', then the MSE can be given as shown in equation 1.

$$MSE = \sum_{i=1}^{n} (Vpi - Vqi)^2 \qquad (1)$$

To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters for our proposed technique of CBIR. The standard definitions of these two measures are given by following equations.

$$\text{Precision}=\frac{\textit{Number of relevant images retrieved}}{\textit{Total number of images retrieved}} \quad (2)$$

$$\text{Recall}=\frac{\textit{Number of relevant images retrieved}}{\textit{Total number of relevant images in database}} \quad (3)$$

VII. RESULTS AND DISCUSSIONS

Figure 2 is average precision and recall plotted against and number of retrieved images for Morphological Edge Extraction. In this graph the crossover points are not clearly distinguishable. Figure 3a is a zoomed version of the figure 2, where the crossover points are somewhat clearer. Figure 3b shows a bar graph of crossover points of precision and recall for Morphological Edge Extraction techniques.

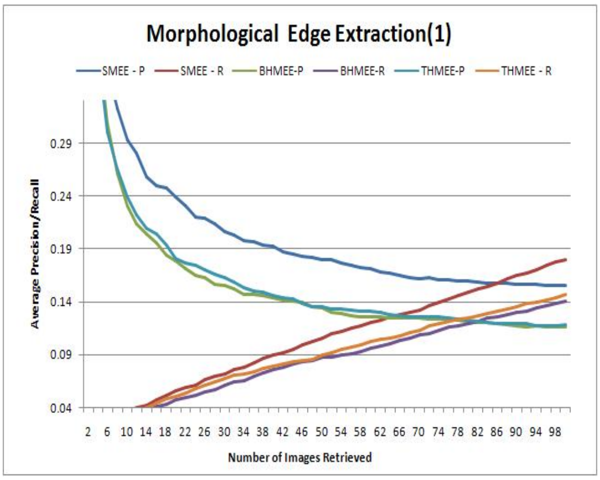

Figure 2: Morphological Edge Extraction Techniques

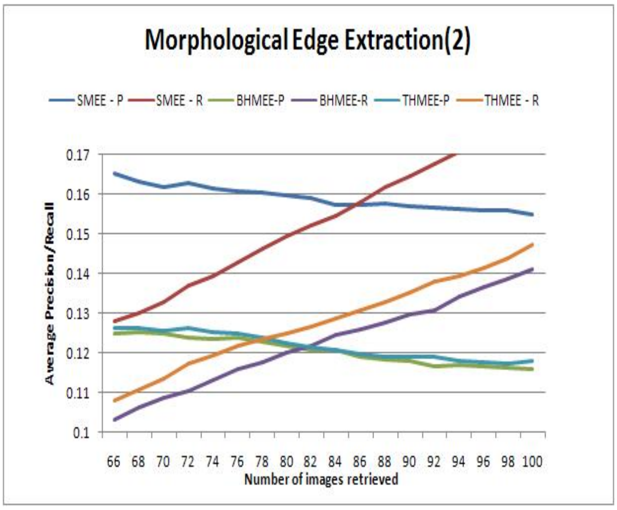

Figure 3a: Morphological Edge extraction based CBIR.

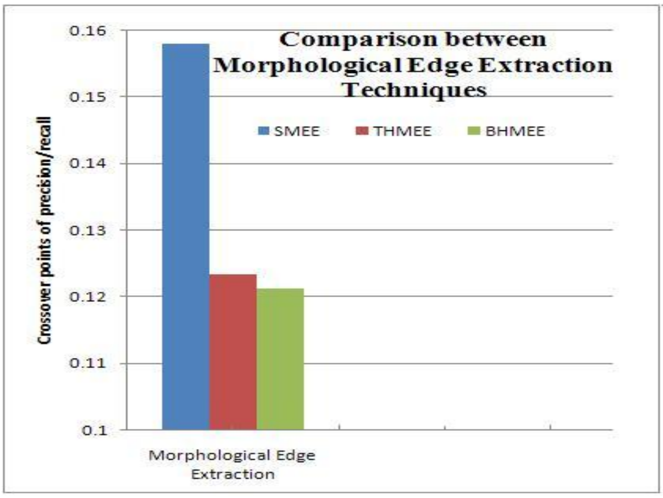

Figure 3b: Crossover points of Morphological Edge Extraction based CBIR as Bar Graph

The comparison between the crossover points of three Morphological Edge Texture based CBIR techniques is shown in Figure 4. In each image transform Top-Hat Morphological Edge Texture (THMET) based CBIR gives best Performance while worst is given by Simple Morphological Edge Texture (SMET) based CBIR. The Precision-Recall crossover points of proposed row mean of transformed column morphological edge image based CBIR methods are higher than the existing morphological edge based image CBIR.

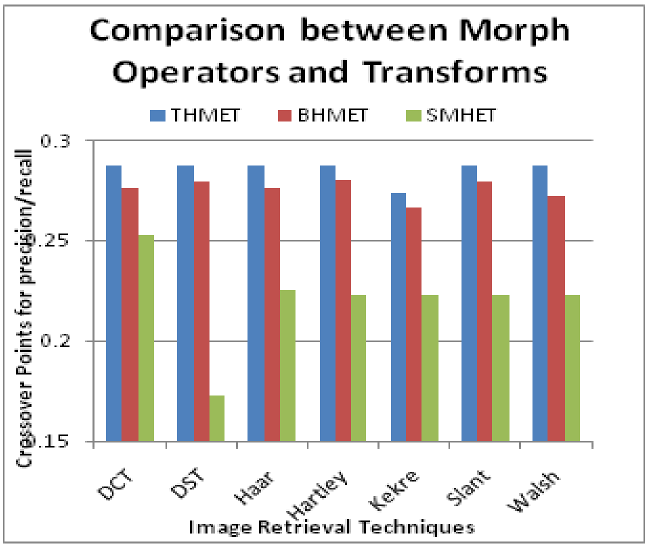

Figure 4: Performance of proposed morphological edge texture based CBIR methods for each image transform

From Figure 5 it is evident that Top-Hat Morphological Edge Extraction based CBIR technique gives best and consistent performance with all Transforms. In Top-hat Morphological Edge Texture (THMET) based CBIR all transforms are showing same performance except Kekre transform. In Simple Morphological Edge Texture (SMET) based CBIR, DCT out performs other transforms.

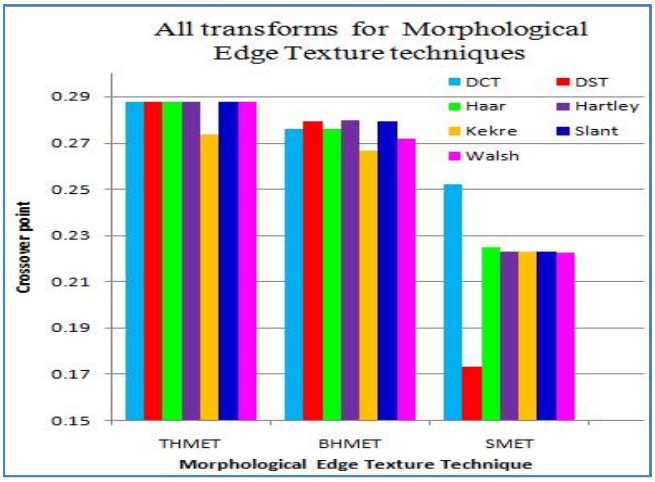

Figure 5: Performance of considered image transforms for individual Morphological Edge Texture based CBIR techniques

VIII. CONCLUSION

Image retrieval based on image content has become hours need because of tremendously growing number of application area where image search is evident. The thirst to get better and faster CBIR methods is not satisfied till date, leaving lot of scope for researchers to work in this area. The paper has proposed novel image retrieval methods using shape texture as row mean of transformed columns of morphological edge images. With help of seven assorted image transforms and three morphological edge extraction methods, in all 21 variants of proposed CBIR techniques are tested on image database of 1000 mages. The performance comparison of proposed CBIR methods is done by means of crossover point values of average precision and average recall of 55 queries (randomly selected 5 from each image category) fired on image database. The proposed CBIR methods are proved to be faster and better. In all best performance is given by Top-Hat Morphological Edge Texture (THMET) based CBIR methods with every image transform.

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