Image Retrieval Using Gradient operators

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***Abstract*—**The images are described by its content like color, texture, and shape information present in them. In this paper novel image retrieval methods discussed based on shape features extracted using gradient operators like Robert, Sobel, Prewitt and Canny. Masking of Gradient operators takes place for continuing the discontinue edges. Morphological operations like erosion and dilation are used along with canny. The proposed image retrieval techniques are tested on generic image database images spread across different categories. Gradient operator's features are extracted using Figure of Merit (FOM). The average precision and recall of all queries are computed and considered for performance analysis. The performance ranking of the masks for proposed image retrieval methods can be listed as Robert, Canny, Prewitt, and Sobel.

Index Terms: *CBIR, FOM, Gradient operators*

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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. Automated information retrieval systems are used to reduce what has been called "information overload"[1,2]. Many universities and public libraries use IR systems to provide access to books and journals. Web search engines are the most visible IR applications. Images do have giant share in this information being stored and retrieved.

Content Based Image Retrieval (CBIR)

The images are very rich in the content like color, texture, shape information present in them. Retrieving images based on color similarity is achieved by computing color histogram for each image that identifies the proportion of pixels within an image holding specific values (that humans express as colors). Color searches will usually involve comparing color histograms, though this is not the only technique in practice. Texture measures look for visual patterns in images and how they are spatially defined. The identification of specific textures in an image is achieved primarily by modeling texture as a two-dimensional gray level variation[3]. The relative brightness of pairs of pixels is computed such that degree of contrast, regularity, coarseness and directionality may be estimated. 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. Other methods use shape filters to identify given shapes of an image. In some case accurate shape detection will require human intervention because methods like segmentation are very difficult to completely automate. Here the paper discuss shape extraction using edge detection masks like Sobel, Roberts, Prewitt and Canny gradient operators[4].Some other CBIR systems with their disadvantages are QBIC – Query by Image Content reqires long indexing time[17].The problem associated with Virage are weights attached to each image. VisualSEEk considers spatial relationships between objects.Global features like mean color, color histogram can give many false positives. Disadvantage of MARS are weight updating, Modification of distance function. Disadvantage of Pic-Hunter is Probability asoociated with each image[18,19].

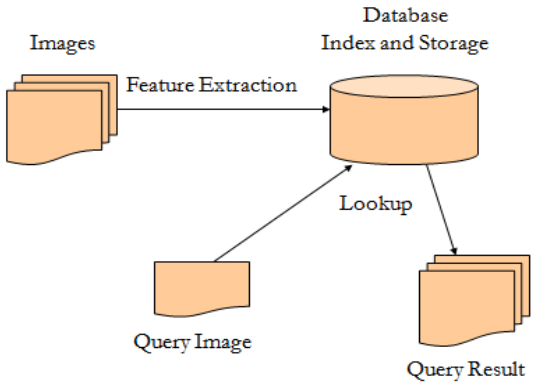

Figure1 : Basic CBIR System

II. First Order Derivative Based Edge Detection (Gradient method):

Edges gives maximum information,it detects by analysing for the maximum and minimum in the first derivative of the image.Sharpening an image results in the detection of fine

details as well as enhancing blurred ones. The magnitude of the gradient is the most powerful technique that forms the basis for various approaches to sharpening.[5,6] The gradient vector points in the direction of maximum rate of change. For a function f(x, y), the magnitude of the gradient of f at coordinates (x, y) is defined as

$$|\Delta f(x,y)| = \sqrt{(\partial x(f(x,y))2 + (\partial x(f(x,y))^2} \quad (1)$$

While the gradient orientation is given by,

$$\Delta f(x,y) = ArcTan(\partial y(f(x,y)/\partial x(f(x,y)) \quad (2)$$

III. SLOPE MAGNITUDE METHOD

The problem with edge extraction using gradient operators is detection of edges in only either horizontal or vertical directions. 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. Slope magnitude method is used along with the gradient operators (Sobel, Prewitt, Robert and Canny) to extract the shape features in form of connected boundaries. The process of applying the slope magnitude method is given as follows. First one needs to convolve the original image with theGx mask to get the x gradient and Gy mask to get the y gradient of the image.[7] Then the individual squares of both are taken. Finally the two squared terms are added and square root of this sum is taken as given in equation.

$$\text{Edge Magnitude } G = \sqrt{Gx^2 + Gy^2} \quad (3)$$

$$\text{Edge Direction } d = \tan^{-1}(Gy/Gx) \quad (4)$$

Orignal Image


Sobel operator


Prewitt operator


Roberts Operator


Canny operator with Erosion & Dilation

Figure 2 : Gradient operators with slope magnitude technique.

IV. PROPOSED CBIR TECHNIQUES

The paper proposes image retrieval techniques using four different gradient operators (Roberts, Sobel, Prewitt and Canny) using slope magnitude technique. The performance of proposed image retrieval methods is compared with Gradient operators based CBIR techniques.

Gradient Operators using Figure of Merit

The shape feature vector of Gradient operator consist of Figure of Merit(FOM) of query image considered for finding the similarity with database images. Morphological operations erosion and dilation used with canny.. The problem of this technique is that all the images in the database must have same dimensions as that of query image. The selection of gradient operators like Robert, Sobel, Prewitt and canny results into four variations of Gradient operator based image retrieval. The Figure of Merit calculated as,

$$FOM = \frac{1}{\max\{Ii,Ia\}} \sum_{i=1}^{Ia} \frac{1}{1+\alpha d^2} \quad (5)$$

where Ii and Ia are the number of ideal and actual edge points, d is the pixel miss distance of the ith edge detected, and α is a scaling constant chosen to be α = (1/9) to provide a relative penalty between smeared edges and isolated, but offset, edges.

V. IMPLEMENTATION

The discussed image retrieval methods are implemented using MATLAB 2008b on Intel Core i3-380M processor with 2 GB of RAM. To check the performance of proposed technique a database of 1000 variable sized images spread across different categories has been used.

Figure 3: Sample Images from Generic Image Database

Figure 3 shows sample image of generic image database. The queries each category are fired on the image database.

VI. PERFORMANCE EVALUATION

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.

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}} \quad (6)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \quad (7)$$

Table 1: Performance analysis of discussed CBIR technique

Parameter	PRECISION	RECALL
SOBEL	0.6	0.4285
PREWITT	0.8	0.5714
CANNY	0.9	0.6138
ROBERTS	1	0.7142

The values of crossover points of precision and recall for all proposed image retrieval methods are given in above table. As shown in figure 4 and figure 5 among all Gradient Operators Robert gradient operator performs the best followed by Canny.

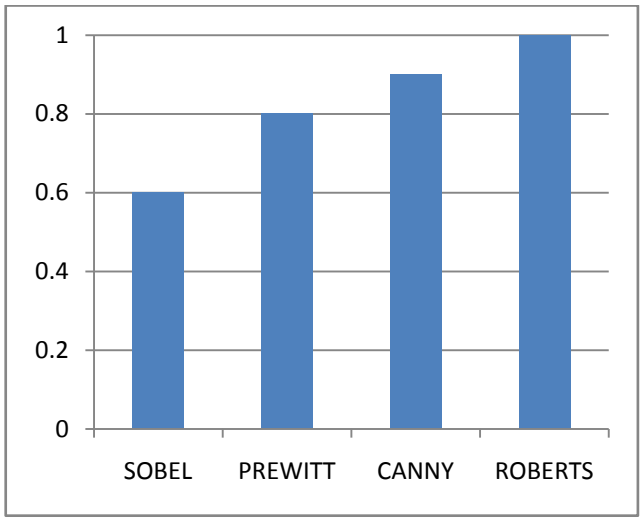

Figure 4: Precision parameter for gradient operators

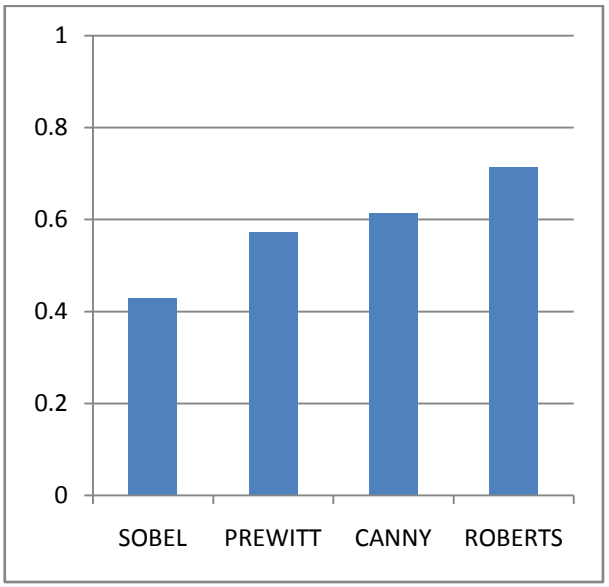

Figure 5: Recall parameter for gradient operators

VII. CONCLUSIONS

Image Retrieval is gaining momentum among researchers working in image processing and computer vision areas because of the wide number of applications. Image retrieval using shape features is the theme of work presented here. The shape features can be extracted using Figure of Merit applied on gradient of images taken in both horizontal and vertical directions. Using Roberts, Sobel, Prewitt and Canny used with erosion and dilation gradient operators four variations in gradient operator methods can be obtained. The experimentation results show that the Robert gradient operator gives best performance followed by Canny, Prewitt and Sobel Operator.

VIII. REFERENCES

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