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A Survey on Object Based Image Retrieval using Local and Global Features

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Abstract: ***An image is an artifact that depicts or records visual perception. Object Based Image Retrieval (OBIR) is a technique to find specific object from image database. Similar images can be retrieved from image database by comparing image features. A feature is a piece of information which is relevant for solving the computational task related to a certain application. Visual content of the entire image refer to the global features. Locally rich information like interesting point detection can be addressed in local features. This paper include color features and edge detection feature as global feature and corner detection feature as local feature. Some techniques for finding each features and comparison of those techniques are mentioned here.***

Keywords: Color feature, Edge detection, Corner detection, Object based image retrieval

1. Introduction

An image retrieval system is a computer system for browsing, searching and retrieving images from a large database of digital images. Latest technology like mobile, internet and the falling price of digital cameras and image scanners becomes the reason of rapid growth of digital images. This criterion has paved the way for the efficient storage and image retrieval systems. Before some year the retrieval technique is text-based. To get more appropriate result of searching or browsing, the image retrieval techniques come in the picture. CBIR is a technique for retrieving the similar images to that of a query image by comparing the features of the query image with the features of the images in the database [1]. CBIR has increasingly become a growing area of study toward the successful development of image mining technique [2]. Object based image retrieval (OBIR) has the potential to greatly improve CBIR systems [6]. It gives the CBIR system the ability to locate objects of interest even in the face of background clutter. Image processing algorithms are used to extract feature vector that represent image properties. These properties can be its local features or global features. The global features refer to the visual content of the entire image [1]. So the global features fail in describing the important features of the components of that image. This makes the global features unsuitable for retrieving images based on parts of whole image. This drawback of the global features is overcome by the local features like interest point detectors. These interest points are preferred since they provided locally rich information about the image. The local invariant points were traditionally used for stereo matching initially [1].

In this paper Color histogram [1,4], Color moment [4,7,9] and Color coherent vector(CCV) [3,4] techniques are addressed for finding color feature. Among this technique it is concluded which is best. Next Sobel operator [5], Prewitt's operator [5], Robert's operator [5] and Canny edge detection [5,8,10] techniques for finding edge feature is introduced. And the comparison of all with conclusion of best one. For corner detection SUSAN corner detection [12,14] and Harris corner detection [12,13,14] techniques mentioned and then comparison of both.

The remainder of the paper is organized as follows: in section 2 three well-known techniques for finding color feature is introduced. The edge detection technique introduction and comparison included in section 3. In section 4 two corner detection techniques mentioned. The last section 5 contains the overview of comparison of all the above techniques. Conclusion is written in the section 6.

2. Color Feature Introduction

A feature is a characteristic that can capture a certain visual property of an image either globally for the entire image or locally for regions or objects. Color, texture and shape are commonly used features in CBIR systems. Color is a widely used important feature for image representation. In this paper number of different color descriptors for object-based image retrieval introduced. Color histograms, color moments and color coherent vector (CCV) are the techniques used for color feature extraction. This is very important as it is invariant with respect to scaling, translation and rotation of an image. Color space, color quantification and similarity measurement are the key components of color feature extraction.

2.1 Color moments

The mean, variance and standard deviation of an image are known as color moments [4]. Color moments are measures that can be used differentiate images based on their features of color. Once calculated this moments provide a measurement for color similarity between images. These values of similarity can then be compared to the values of images indexed in a database for tasks like image retrieval.

Mean [4]

$$\text{Mean} = \sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij}/mn$$

Mean can be understood as the average color value in the image.

Variance [4]

$$\text{Variance} = \frac{1}{mn}\sum_{i=1}^{n}\sum_{j=1}^{m}(x_{ij} - \text{Mean})^2$$

The variance is a parameter that describes, in part, either the actual probability distribution of an observed population of numbers, or the theoretical probability distribution of a not-fully-observed population from which a sample of numbers has been drawn.

Standard Deviation [4]

$$\text{Standard Deviation} = \sqrt{\text{Variance}}$$

The standard deviation is the square root of the variance of the distribution.

In above equation x_{ij} is the pixel value of i^{th} Row and j^{th} Column.

2.2 Color histogram

A color histogram is a representation of the distribution of colors in an image. The number of elements in a histogram depends on the number of bits in each pixel of an image [4].

For very large data sets, color, moments can be computed based on color histogram as follows [4].

$$\text{Mean} = \sum_{i=0}^{255} i * h(i) / \sum_{i=0}^{255} h(i)$$

$$\text{Variance} = \sqrt{\frac{\sum_{i=0}^{255} h(i)*(i-\text{Mean})^2}{\sum_{i=0}^{255} h(i)}}$$

Where h is histogram of the image.

2.3 Color coherent vector (CCV)

Color coherence vector (CCV) is a more complex method than color histogram. Color histogram does not consider the spatial information of pixels. This may result in similar color distribution for different images [4]. CCV classifies each pixel as either coherent or incoherent. Coherent pixel means that it's part of a big of connected component while incoherent pixel is part of a small connected component. Of course first we define the criteria which we use to measure whether a connected component is big or not.

3. Edge Feature Introduction

Edge is an important feature in an image and carries important information about the objects present in the image. Extraction of edges is known as edge detection [1]. Image Edge detection significantly reduces the amount of data to be processed and filters out useless information, while preserving the important structural properties in an image [4]. Edge detection techniques localize the boundary of objects so that the amount of data to be processed reduces. In this paper four different edge detection techniques that is Sobel operator, Prewitt's operator, Roberts operator and Canny edge detection technique are introduced.

3.1 Sobel Operator

The Sobel operator represents a rather inaccurate approximation of the image gradient, but is still of sufficient quality to be of practical use in many applications [5]. More precisely, it uses intensity values only in a 3×3 region around each image point to approximate the corresponding image gradient, and it uses only integer values for the coefficients which weight the image intensities to produce the gradient approximation.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

The two kernels Gx and Gy, where Gy is simply the Gx rotated by 90° [5].

At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude using:

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

Using this information we can also calculate the gradient's direction.

$$\theta = \arctan(G_y / G_x)$$

Where for example θ is 0 for a vertical edge which is lighter on the right side.

3.2 Robert's cross operator:

According to Roberts, an edge detector should have the following properties: the produced edges should be well-defined, the background should contribute as little noise as possible, and the intensity of edges should correspond as possible to what a human would perceive. The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point [5].

In order to perform edge detection with the Roberts operator we first convolve the original image, with the following two kernels [5].

+1	0
0	-1

Gx

0	+1
-1	0

Gy

These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations [5]. From above two kernels the Gradient magnitude is given by:

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by:

$$\theta = \arctan(G_y / G_X) - \frac{3\pi}{4}$$

3.3 Prewitt's operator:

Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images [5]. At each point in the image, the result of the prewitt operator is either the corresponding gradient vector or the norm of this vector. The prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and therefore relatively inexpensive in terms of computation. On the other hand, the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image.

Mathematically the operator uses two 3×3 kernels which are convolved with the original image to calculate.

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

Same as sobel operator at each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude using:

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

Using this information we can also calculate the gradient's direction.

$$\theta = \arctan(G_y / G_x)$$

Where for example θ is 0 for a vertical edge which is lighter on the right side.

3.4 Canny Edge Detection Algorithm

The canny edge detection algorithm is optimal with regards to the following criteria:

1. Detection: The probability of detecting real edge points should be maximized while the probability of falsely detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio.
2. Localization: The detected edged should be as close as possible to the real edges.
3. Number of response: One real edge should not result in more than one detected edge.

The algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edge should be marked be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

Here is an example which shows the result of all above four edge detection technique for same input image.

Input image [5]:

I. 

Fig 1. Input image

Output image [5]:

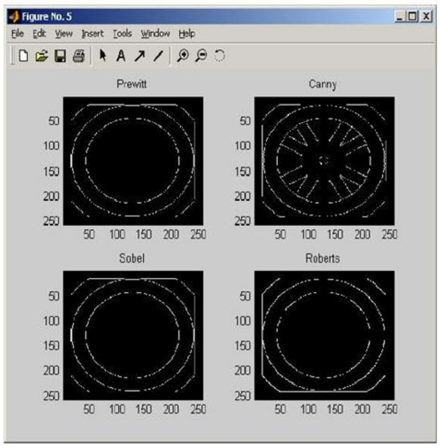

Fig. 2. Output image

4. Corner Feature Introduction

Corner detection is an approach used within computer vision systems to extract certain kinds of features and infer the contents of an image. Corner detection is important in many applications, such as image registration, mobile robots, and computer vision [14]. Corner detection overlaps with the topic of interest point detection. An interest point is a point in an image which has well-defined position and can be robustly detected. In this paper two well-known corner detection techniques are mentioned that are SUSAN corner detection and Harris corner detection.

4.1 SUSAN Corner Detection Algorithm

SUSAN is acronym for Smallest Univalue Segment Assimilating Nucleus. The SUSAN algorithms cover image noise filtering, edge finding and corner finding. For feature detection, SUSAN places a circular mask over the pixel to be tested the nucleus. If the brightness of each pixel within a mask is compared with the brightness of that mask's nucleus then an area of the mask can be defined which has the same (or similar) brightness as the nucleus [12].

In order to detect the corner of image by SUSAN corner detection the efficient similarity function is given by the following formula [12].

$$C(r, r_0) = \exp\{-[\tfrac{I(r)-I(r_0)}{t}]^6\}$$

And the size of the SUSAN region is given by following formula [12].

$$n(r_0) = \sum_{r \in c(r_0)} c(r, r_0)$$

4.2 Harris Corner Detection Algorithm

Harris corner detector method is based on assumption that the corners are associated with local maxima functions [13]. It finds the corner value at each and every pixel of the image. Here the threshold value is pre-defined. So after calculating the corner value at each pixel the value below threshold are corner pixels. Harris corner detector is applied both to the gray-scale image using gray-level intensity information and to the color image using the RGB information [14].

The Harris corner detector is defined as follow [12].

$$R = \det(M) - k\,tr^2(M)$$

Where

$$M(x,y) = \begin{bmatrix} I_u^2(x,y) & I_{uv}(x.y) \\ I_{uv}(x,y) & I_v^2(x,y) \end{bmatrix}$$

Here,

$$I_u^2(x,y) = X^2 \otimes h(x,y)$$
$$I_v^2(x,y) = Y^2 \otimes h(x,y)$$
$$I_{uv}(x,y) = XY \otimes h(x,y)$$

$$h(x,y) = \frac{1}{2\pi} e^{\frac{-x^2+y^2}{2}}$$

where,

$I_u(x,y)$ and $I_v(x,y)$ are the partial derivatives of the gray value in direction u and v at point(x,y),

$I_{uv}(x,y)$ is second-order mix partial derivative,

k is an empirical value,

h(x,y) is Gaussian function,

X and Y are first order directional differencials,

5. Comparison overview

In this paper many different techniques of color feature, edge detection and corner detection are addressed. Color feature is relatively robust to background complication and independent of image size and orientation. In color feature there are three techniques that are color moment, color histogram and color coherent vector (CCV) mentioned. When the images having uniform color distribution, the color histogram technique gives best result [4]. When the images have widely scattered color, CCV technique give better result [4]. Color moment is best for each type of image and gives efficient result among all techniques [4,7,9]. Edge detection results in the edge map of image which shows the important information about the image. In edge detection in this paper four different methods are introduced that are Sobel operator, Robert's operator, Prewitt's operator and Canny edge detection. The canny edge detection method is expensive than others [5]. Canny performed a more systematic investigation incorporating an explicit localization criterion as well as a detection criterion to find an optimal edge operator [11]. When noise is present in image canny perform well than others [5]. For finding similar images from image database canny edge detection algorithm is more appropriate [5, 8, 10]. As Figure shown in section 3 describes that among all 4 edge detection technique canny edge detection gives efficient result. Corners gives important information about image, extracting which properly, we can reduce the work for finding similar image for image retrieval. SUSAN corner detector work well when noise is present in image as it does not require derivative [14]. Fixed global threshold, shape of mask and week anti-noise ability are some disadvantages of SUSAN corner detection algorithm. By comparing the complexity, stability, execution time and so on, the Harris corner detection algorithm is better than SUSAN corner detection algorithm [12,13,14].

6. Conclusion

Finding similar images from the image database is the main goal of image retrieval. To measure similarity one should find the feature of image so that the images can be compared by its features. In this paper three different features of an image that is color feature and edge detection which are global features and corner detection that is local features are introduced. By analyzing all three color feature we can say color moment is best efficient algorithm for finding color feature. For finding edges of image the canny edge detection is appropriate technique which gives adequate result. Harris corner detection is well-known and very efficient algorithm for finding corner of image.

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