Sketch Based Image retrieval from large database using geometric approach

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Abstract:
Sketch based image retrieval is an efficient method for the retrieval of images from the database matching the sketch query. Drawing a sketch does not require the user to have a high skill and that it is a reliable approach compared to text-based image retrieval. Sketch-to-image matching on a large-scale image database should ensure the retrieval of related images for a given sketch query. Efficient sketch-based image retrieval from large database is presented in this paper. Features are extracted by slicing the contour of the image using angle and radial partitioning approach. Different distance measures are used to measure the distance between sketch and database feature. The experiment is evaluated on flickr15k dataset. The proposed method shows effective retrieval performance compared to other methods present in the literature.

Keywords: Angle, Contour, Features, Large database, Radial, SBIR, Similarity measures.

1 Introduction

In recent years, there is a vast increase in digital images stored in multimedia databases raising demand for powerful and efficient retrieval systems for browsing, searching and retrieving images. Text based image retrieval system (TBIR) searches for the images given a text description (keyword, label, or annotation) of the image. Textual based search becomes a time consuming task for very large databases or for the images that are generated continuously from devices such as surveillance cameras. During the search process, many images may be missed that use different synonyms in their descriptions.

Content Based Image Retrieval (CBIR) plays a major role in a retrieval system and is widely studied in recent years [1, 2]. CBIR avoids the use of textual descriptions. Images are retrieved from the database based on similarities in the image contents (colors, shapes, textures, etc.) between user-supplied query image or features of the query image and images from the database. Several CBIR methods have been proposed for image retrieval [3]. However, due to the lacking of universal features extraction and effective database indexing, its works efficiently on only small-scale image database. Humans look for images using other images and generally follow this approach for categorizing the images. In Sketch-Based Image Retrieval (SBIR), one of the approaches in CBIR, a sketch of the object (in the form of freehand sketches) is used as a query to retrieve images whose shapes match the sketch provided by the user. With the non-availability of an appropriate and complete set of tags, sketch-based image retrieval techniques become vital for retrieving images from large databases.

In SBIR, many studies have been focused on extracting descriptors. Generally, sketches are divided into the blocks and the descriptors such as color, texture, and shape are determined for matching the images. After matching, the system will retrieve the related images stored in the database. Global features like Edge histogram descriptor (EHD) [4], Histogram of gradients (HOG) [5], and Angular Radial Partitioning (ARP) [6] are widely used for image analysis and classification.

In our previous work [7] global contour of the natural image is extracted using Otsu's method and weak edges are eliminated. Angle and concentric circle wise features are extracted. Using weighted based similarity approach images are then retrieved from the large database. Following a similar approach, in this paper, the image is sliced in 300 angles and concentric circles are placed on the image resulting in sectors. Features are computed for each sector occupying some portion of the image. Matching of a sketch with an image is carried out distance measures.

2 Review of literature

Many methods have been proposed in the literature to extract descriptors, global or local. In this section, we briefly describe a few approaches which are widely used in the SBIR system in recent years. The direct approach of a sketch to image comparison is impractical. A better approach is to extract the descriptors of the sketch and image and then proceed to the matching process. The descriptors can be represented as points in a high-dimensional space and a close match is found by searching the nearest neighbours in this space.

SBIR based angular partitioning using radial partitioning is presented in [6]. By using the canny operator and Gaussian mask edges are extracted, then to obtain abstract image edges are thinned. Features are computed by partitioning the image into M×N sectors. Considering various distance measures, Manhattan distance is chosen to measure the similarity between the query vector and data-based vector. The method is sensitive to small offsets in location and scale and is rotation invariant. From literature [16,17], early works in sketch-based image retrieval systems involved queries described using blobs of color or predefined texture. Later shape descriptors based image retrieval [23] and the use of spectral descriptors such as wavelets [24] are found predominantly in the literature. An invariant descriptor encapsulating local spatial structure facilitating codebook based retrieval using HoG variants is found in [25, 26].

In the recent work [9], two candidate maps are used to cover the main region and the region of interest and lessen the impact of background thereby making full use of the salient contour. Identification of unsubstantial images, as demanded in criminal investigation, can be supported by SBIR systems and applications are found in [10, 11, 15,27].

3 Dataset description and preprocessing

The proposed method has experimented with a flickr15k dataset created by Hu [12]. Canny edge detector is used for extracting the contour from the natural images. The detail description of the dataset and pre-processing are presented below.

3.1 Dataset description

Images of the flickr15k dataset [12] are used for performing experiments. The dataset contains 60 classes of natural images and contains 10 classes of sketch images, each class drawn by a different user. Each sketch class contains 33 sketch images, the total number of sketch images are 10×33= 330, and 60 natural image classes contain 14660 natural images like bicycle, bicycle, Indian_arch, a sample of the dataset images illustrated in fig.1.

Fig.1. Example of sample natural and sketch images of flickr15k dataset

3.2 Preprocessing

In the pre-processing stage, we extract global information from the natural images. Canny edge detection is used to obtain the contour of the natural images. Subsequently, weak contours are eliminated by applying a threshold Fig.2.

Fig.2. First row contains natural images and second-row contains preprocessed images.

4 Methodology

The image retrieval process can be carried out in two main phases. The first phase involves database construction, in that features are extracted from the preprocessed image and stored as feature vector; this is an offline phase. This phase involves computation-intensive tasks, on all the images in the database, such as synthesizing the color image to yield the sketch-similar object and compute descriptors, which has to be done before the program actual use. The second phase is the retrieval process, which is an on-line process. The user draws loads of the sketch image for feature computation. A similarity measure is used to retrieve the most similar images from the database matching the sketch query.

4.1 Offline phase

In this phase, we propose a combination of angle and radial partitioning method for feature extraction. Extract contour of the image and partition the image at increments of 30^0. Then concentric circles are placed over this image to obtain sectors of the image. Features are then extracted from each sector. The feature extraction algorithm is presented below.

Algorithm

Start :
Step1: Read an image (Fig. 5a)
Step2: Extract contour from image
Step 3: Find the center value of the contour image
Step 4: Divide the contour image into 12 regions with an angular increment of 30^o
Step 5: Place concentric circles over the contour image to obtain sectors(Fig. 5b)
Step 6: Count the number of edge pixel in each sector
Step 7: Concatenate features of all sectors to obtain feature vector.

End.

In our proposed approach, the contour image is sliced using an angular approach resulting in 12 partitions of the image. Placing then 3 concentric circles over the image obtained 36 partitions (sectors). Cyan color indicates in Fig. 3 b indicates the number of radials and green color shows angles.

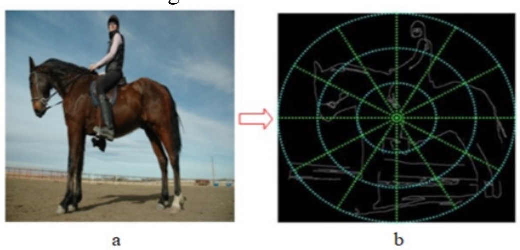

Fig.3. Example of propose feature extraction method

For each sector, edge pixels are counted and the mean of the edge pixels is noted. The edge and mean features of each sectored in feature vector of each image.

4.2 Online phase

In this phase, the process starts with the query image as input. When the query image is given into the system, first it will preprocess the query image to get the contour image. Feature extraction procedure defined in the above section is followed for feature retrieval from the sketch image Fig.4.

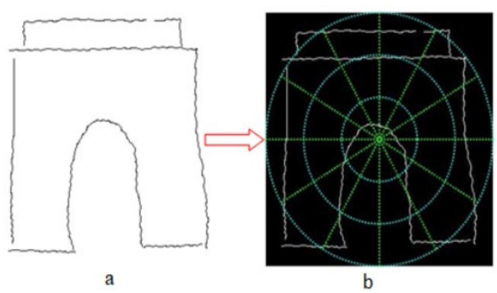

Fig.4. feature extraction of sketch

To retrieve the sketch-matching images from the database similarity between the sketch feature with that of the image features stored priori is computed. Distance measures like Euclidean distance measure and its variations are frequently used for similarity measure.

4.3 Results obtained by propose method using different distance measures

The distance between sketch feature and database features are measured by using different distance measure like Euclidean distance, Manhattan distance, and Mahalanobis distance. The resulting images are selected based on minimum distance. The results are presented in top 5, 10,15,20,25, and 50, respectively for different number of sectors obtained using radial and concentric circle portioning approach. Table 1, Table 2 and Table 3 presents the results in terms of percentage accuracy of retrieval. Figures 5 through 7 presents the results using Mahalanobis distance measure. From the results presented in the table and figures it is evident that the results for partitioning the image into 36 sector yielded better results compared to other partitions.

Table 1. Proposed method results using one radial partition

Partitions	Distance measures	Top retrievals in %					
		Top 5	Top 10	Top 15	Top 20	Top 25	Top 50
1*8	Euclidean distance	81	80	79	77	74	68
	Manhattan distance	82	81	79	78	75	70
	Mahalanobis distance	84	83	82	80	78	71
1*10	Euclidean distance	82	81	81	80	76	71
	Manhattan distance	84	83	82	81	77	72
	Mahalanobis distance	86	85	84	83	79	73
1*12	Euclidean distance	85	84	83	82	79	73
	Manhattan distance	86	85	84	83	82	74
	Mahalanobis distance	88	87	86	85	84	76
1*14	Euclidean distance	86	85	84	82	81	73
	Manhattan distance	87	86	85	83	82	74
	Mahalanobis distance	89	88	87	86	86	76

Table 2. Proposed method results using two radial partitions

Partitions	Distance measures	Top retrievals in (%)					
		Top 5	Top 10	Top 15	Top 20	Top 25	Top 50
2*8	Euclidean distance	82	81	80	78	76	70
	Manhattan distance	83	82	80	79	77	72
	Mahalanobis distance	85	84	83	81	79	73
2*10	Euclidean distance	84	83	82	80	79	73
	Manhattan distance	85	84	83	82	80	74
	Mahalanobis distance	88	86	85	84	82	76
2*12	Euclidean distance	87	86	85	83	80	77
	Manhattan distance	88	87	86	84	82	78
	Mahalanobis distance	**90**	**89**	**88**	**87**	**85**	**80**
	Euclidean distance	88	87	85	84	82	77

2*14	Manhattan distance	89	88	86	84	82	78
	Mahalanobis distance	**91**	**90**	**88**	**87**	**86**	**80**

Table 3. Proposed method results using three radial partitions

Partitions	Distance measures	Top retrievals in (%)					
		Top 5	Top 10	Top 15	Top 20	Top 25	Top 50
3*8	Euclidean distance	82	81	80	79	77	71
	Manhattan distance	84	83	81	80	78	73
	Mahalanobis distance	86	85	83	82	80	74
3*10	Euclidean distance	85	84	82	81	80	74
	Manhattan distance	86	85	84	83	81	75
	Mahalanobis distance	89	87	86	85	83	77
3*12	Euclidean distance	87	86	85	84	80	77
	Manhattan distance	89	88	87	85	82	78
	Mahalanobis distance	**91**	**91**	**90**	**88**	**85**	**80**
3*14	Euclidean distance	88	87	86	84	81	77
	Manhattan distance	90	89	87	85	82	78
	Mahalanobis distance	**92**	**91**	**90**	**88**	**86**	**80**

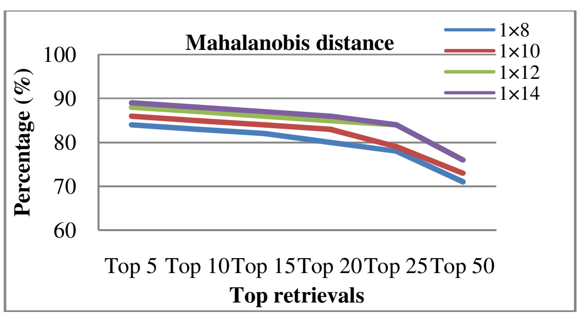

Fig.5. Percentage curves of 1 radial partitions of Manhattan distance

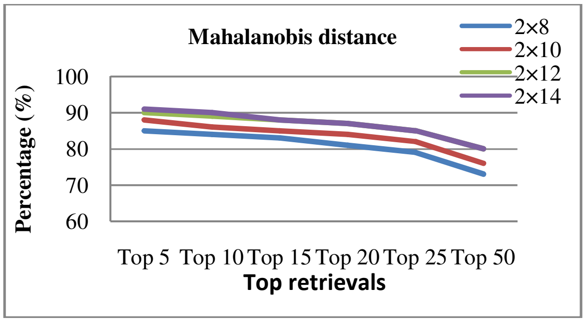

Fig.6. Percentage curves of 2 radial partitions of Manhattan distance

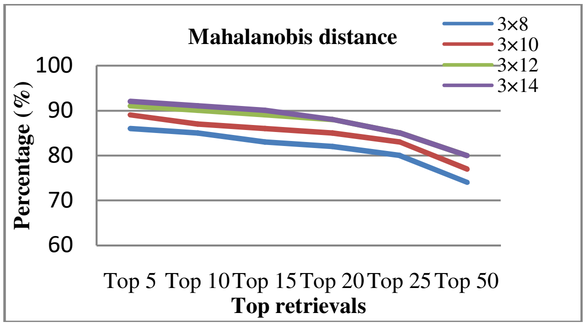

Fig.7. Percentage curves of 3 radial partitions of Manhattan distance

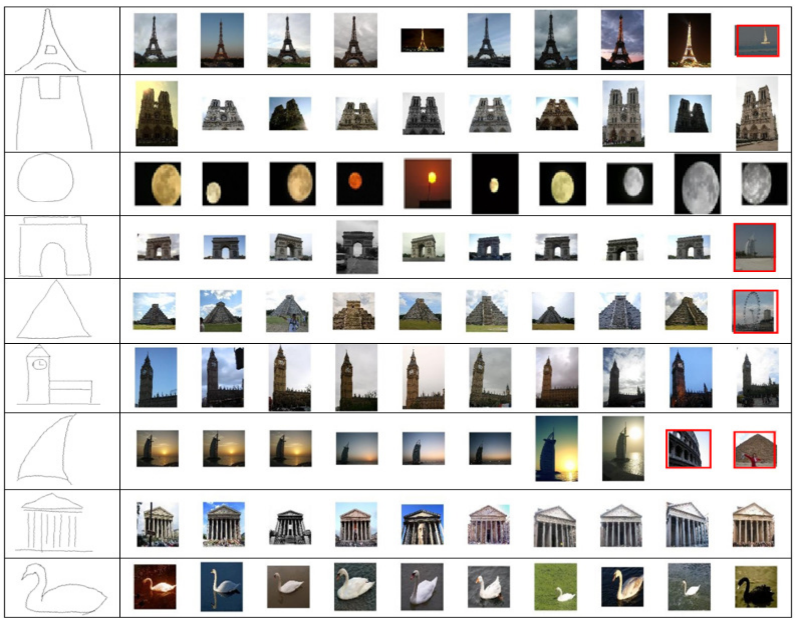

Fig.8. Sample of proposed method results

In the propose method, the Mahalanobis distance measure yielded better results as compare to the other distance measures. Fig.8 shown the sample images retrieved using the Mahalanobis distance approach. Our method retrieved the most relevant images from the dataset for all queries as shown (mismatched images are highlighted in red color).

5 Performance evaluation

The performance of the proposed method is compared with other methods in the literature using Mean average precision (MAP) [27].

$$\mathrm{MAP} = \frac{1}{S}\sum_{s=1}^{S} \mathrm{AP}(q), \quad \mathrm{AP} = \frac{1}{R}\sum_{k=1}^{N} p(k) * \mathrm{rel}(k) \qquad (2)$$

Where S represents the number of Sketch's; R denotes the number of related images in retrieved images; N represents the total number of retrieved images; p(k) represents top precision score; and rel(k) is an indicator function, if rank r is relevant to the sketch query rel(r)=1, otherwise rel(r)=0. Proposed method is compared with existing methods; Perceptual Edge [18], GF-HOG[14], HOG[14], SSIM [20], SIFT [13], Shape Context[21], Angular Partitioning [19], Structure Tensor[22]. The comparative scores in terms of MAP are shown in Table 4.

Table 4. Comparison of the proposed method with other methods based on the MAP (20)

Approaches	**MAP(20)**
Proposed Approach	**0.1932**
Perceptual Edge	0.1513
GF-HOG	0.1222
HOG	0.1093
SSIM	0.0957
SIFT	0.0911
Shape Context	0.0814
Angular Partitioning	0.081
Structure Tensor	0.0798

The comparison reveals that our methods yielded better MAP values compared to MAP values of other methods on the flickr15k database and that performance of the method for portioning the image into 36 sectors yielded better MAP value of 0.1932.

6 Conclusion

In this paper an efficient SBIR system on large-scale database has been presented. Mean and edge features are extracted from contour image by partitioning the contour into sectors. Various distance measures are used to measure the distance between sketch query feature with features of database images. Compared to different partitions considered, 3*12 partition yielded better results using Mahalanobis distance. The proposed method retrieved most similar images from the chaotic dataset as compared to the results of other methods in the literature.

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