Content-Based Facial Image Retrieval Using SIFT Descriptor with Reduced Number of Matched Keypoints

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Abstract – **In this paper a Content-Based Facial Image Retrieval system is presented. To extract interesting keypoints in a given face a SIFT descriptor is used. For calculation of the distance between two faces the number of matched keypoints is reduced based on naive Bayes classifier which is previously trained on spatial distances. Finally it is shown the performance of the system.**

Keywords – **Lucene Image Retrieval (LIRe), Open toolkit for Intelligent Multimedia Analysis in Java (OpenIMAG), Content Based Image Retrieval (CBIR), Scale Invariant Feature Transform (SIFT).**

I. Introduction

Today's Content-based image retrieval (CBIR) algorithms have still limited retrieval performance. This is due to the fact that the visual representation of the images in a form of low-level features not necessarily describes their semantic content. This often causes inaccurate images to appear in the first positions of the list of results. There are many implementations of facial CBIR and recognition systems [1]. In this work a CBIR system adapted for searching of similar faces based on Scale Invariant Feature Transform (SIFT) is proposed. SIFT features are scale and rotation invariant and provide robust matching across addition of noise, different illumination and changes in angle view. There are several works that use SIFT features for facial content based image retrieval. Some of these are presented in [2-4]. In the current work the number of pairs of keypoints to be compared is reduced by ignoring the number of false matches. To distinguish between false and true matches the distance between each pair is classified using naive Bayes classifier.

II. Database and Performance Measures

For experiments of the proposed algorithm, we used Georgia Tech Face Database [5]. It contains a total of 750 images that represent faces of 50 people (15 images per person). To estimate the retrieval accuracy of the system each image from the database is used as a query. Then by scanning the list of results if the current image shows the face of the person from the query it is considered relevant. The performance measures used are Mean Average Precision (MAP), precision at the first ten retrieved results (p@10) and Error Rate [6].

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III. Algorithm Description

For the investigations of this work, an extension of LIRe [7], [8] is developed using a SIFT feature implementation available from OpenIMAJ [9]. First many several interesting keypoints are extracted from the face images in the database using the Difference-of-Gaussian (DoG) feature detector - set of filters applied at different scales over the image. Then some of these locations are refined by ignoring points of low contrast. Based on local image features an orientation for each keypoint is determined. Further a local feature in form of 128 dimensional vector is computed for each keypoint. This feature is orientation invariant and captures the local gradient around the keypoint according to its orientation. Next all features (for all keypoints per image) are stored in a feature database. When a query image is given to the system the same process of keypoints extraction is performed and the similar distance to each target image from the database is calculated. Finally the results images are displayed in ascending order with respect to their distances to the query.

Basically in calculation of the similarity of two images using SIFT the first goal is to pick a keypoint from the query image and then find its closest match in the second set of keypoints that belong to the target. The similarity d of two matched keypoints is calculated as Euclidian distance between their respective feature vectors (q and t):

$$d(q,t) = \sqrt{\sum_{i=1}^{128} (q_i - t_i)^2}\ , \qquad (1)$$

where q_i and t_i are i-th coordinates of vectors q and t respectively.

The final similarity distance D of two images (Q and T) that contain P numbers of matched keypoints is given as mean of distances calculated for each pair of matched keypoints:

$$D(Q,T) = \frac{1}{P}\sum_{p=1}^{P} d(q,t)_p\ , \qquad (2)$$

where $d(q,t)_p$ is p-th pair of matched keypoints.

Because a lot of matches found in this way are incorrect we perform a distance check and filter out such matches based on probabilistic model that was trained using naive Bayes classifier of distances. The parameters of this model are taken from the source code of OpenIMAJ. According to its description the model was trained on 4128 manually annotated match pairs (3380 correct and 748 incorrect).

IV. Experimental Results

Table I shows an experimental comparison of the performance of SIFT feature proposed in this article and some other global features [6]. It can be seen that SIFT reaches the highest value of MAP and p@10 and the lowest Error Rate among all other examined features.

TABLE I
PERFORMANCE COMPARISON IN TERMS OF MEAN AVERAGE PRECISION, P@10 AND ERROR RATE OF SIFT AND SEVERAL GLOBAL FEATURES

Feature Name	MAP, %	p@10, %	Error Rate, %
SIFT	**48,689**	**56,84**	**22,667**
Scalable Color	41,571	44,88	33,467
Edge Histogram	36,413	42,04	24,133
DCT Coefficients	32,666	39,12	30,933
Tamura	20,119	23,827	58,8
Gabor	13,25	12,453	79,467

Fig. 1 allows for a visual interpretation of the performance values from Table I.

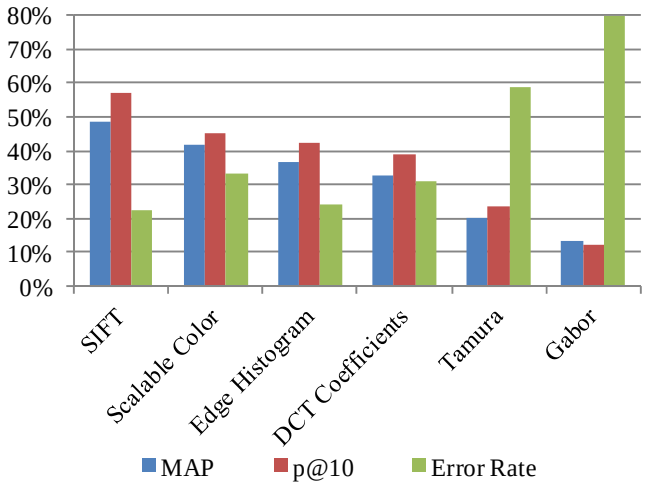

Fig. 1. Graphical comparison of Mean Average Precision, p@10 and Error Rate of SIFT and several global features

In Fig. 2 is depicted an example of a query face image and the first five retrieved images from the database. It can be seen that each of them contains the face of the same person as those from the query image.

Query Results

Fig. 2. Example of given query image and the first five retrieved using SIFT

V. Conclusion

The contribution of this work has both scientific and practical aspects.

From the scientific point of view this article presents an approach for facial CBIR, based on SIFT features with reduced number of matched keypoints. The approach is compared to five low-level global features and the experiments show increasing of retrieval performance from 41,57 % to 48,69 % in terms of MAP and from 44,88 % to 56,84 % in terms of p@10 in comparison to the best global feature examined (Scalable Color). The Error Rate is reduced from 33,47 % to 22, 67 % which can be considered as improvement of the classification performance of the system.(Table I).

From the practical point of view a system for Facial Content Based Image Retrieval is built.

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