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EVALUATION OF FEATURE EXTRACTION ALGORITHM FOR MULTI-ETHNIC FACIAL SKETCH RECOGNITION

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ABSTRACT

There are many cases of criminal where some biometrics factors difficult to be identified and the photo image of a suspect is not available. Therefore, facial sketch recognition system to identify suspects face from sketches is very important to assist the process of investigation. Main purpose of this research is to get the best facial sketch recognition system by comparing the ROC (Receiver Operating Characteristics) curve using local-feature based approach and appearance-based approach. Based on the experiments, the ROC curve proves that local-feature based approach using LFDA framework [1] show better recognition result with less error rate than appearance-based approach. Local-feature based implemented inside facial sketch recognition system return between 85% to 90% accuracy rates against good quality viewed sketches.

Keywords: biometrics, facial sketch recognition, local-feature based discriminant analysis, scale invariant feature transform, multi-scale local binary pattern histogram.

INTRODUCTION

With crime rising in recent years, authorities are under pressure to find suspected criminals as efficiently and effectively as possible. Therefore, automated system to predict suspect face image from police mug shot databases is very important to assist the process of investigation.

However, there are many cases where some biometrics factors cannot be identified and the photo image of a suspect is not available. Advance in biometrics innovation has provided law enforcement agencies additional way to help determine identify of criminals [1] Therefore with the help of witnesses, police can reconstruct the face of a suspect by doing a sketch based on the description given by the eyewitness, also known as a forensic sketch.

After making the sketch, the next step is to match the sketch with every mug shot in police databases. This search requires considerable time and effort because of the size of very large databases. Therefore, automating face sketch identification could make the process faster and also more accurate. The system should be able to search against large mug shot databases to obtain the mug shot of suspect that are similar to the forensic sketch made by the artist [2].

In this research, there are two different types of face sketches discussed, which are viewed sketches and semi-forensic sketches (see Figure. 1 and 2). Viewed sketches are drawn by an artist while looking directly to a person or a photograph of the person. Forensic sketches are drawn by an artist by interviewing a witness in order to get a description of the suspects face.

RELATED WORK

Previous work of sketch recognition has shown that the accuracy of facial sketch recognition is very low, compared to conventional face recognition techniques. Research in sketch matching area is considered relatively new, because it started only a decade ago. This is in turn due to a large texture difference, between a sketch and a photo. Even though most of the works in sketch recognition are started from viewed sketches, there are a lot of errors that can be occurred during sketch reconstruction.

Actually most of the technique that are applicable for viewed sketches, are also applicable to forensic sketches. However, different sketching capability of the trained artist led to a lack of standard test procedure on the latter one. Therefore, most of the early work consists of tests on viewed sketches only.

Most of the work in matching viewed sketches was performed by Tang and Wang [3], [4]. Tang and Wang [3] first approached the problem using an Eigen transformation method to either project a sketch image into a photo subspace, or to project a photo image into a sketch subspace.

On the next 5 years, Wang and Tang [4] offered an improvement to the previous method, where the relationship between sketch and photo image patches was modelled with a Markov random field. Here, the synthetic sketches generated were matched to a gallery of photographs using a variety of standard face recognition algorithms.

On the other hand Sharma and Devale [5] discussed a method for representing face, which is based on the features that uses geometric relationship among the facial features like mouth, nose and eyes using PCA approach and Neural Network. Feature based face representation is done by independently matching templates of three facial regions i.e. eyes, mouth and nose.

Ahonen [6] presents a novel and efficient facial image representation based on feature using local binary pattern (LBP) features. However, Ahmed and Bobere [7] research shows an efficient algorithm to identify forensic sketches. Both sketches and photos are considered for

extracting feature descriptors using Scale Invariant Feature Transform (SIFT).

A feature-based method for matching sketches was presented by Klare and Jain [8], which serves as the motivation for the sketch matching method presented in this project. In this feature-based sketch matching approach uniformly samples both sketch and photo images using SIFT feature descriptors at different scales. Since the previous research show very good result, Anil Jain [1] proposed a new system, which used SIFT and multi-scale local binary pattern (MLBP) as feature descriptors with a new framework called as Local Feature Discriminant Analysis (LFDA).

In the next year, Jain [9] presents surveys about forensic face recognition approaches and the challenges they face in improving the matching and retrieval results as well as processing the low quality images.

PROPOSED SYSTEM

As two different approach used for the same purpose, this section will be divided into two subsections giving overview of each approach. The first approach will use the *Local Feature Discriminant Analysis* (LFDA) as a framework and feature descriptor that usually includes the location of the feature as well as other information. The second approach will use Eigenface and Fisherface algorithm.

a) SGU-MB-1 preparation

SGU-MB-1 dataset is created during this study. This dataset consists of two pairs of iris image, two pairs of point finger fingerprint image, two pairs of sketches and it's correspond face images of 111 Swiss German University's staffs and students. However, this research will be used only SGU-MB-1 107 face dataset that consists of pairs of face images and two type of sketches, which are semi-forensic and viewed sketches, to test the proposed facial sketch recognition system as an input (see Figure-1 and Figure-2). Each image was taken by using Samsung Galaxy S4 camera that has 13 megapixels camera. The images will be used only for research purpose.

Figure-1. SGU-MB-1 semi-forensic sketches and it's corresponding photographs.

Figure- 2. SGU-MB-1 viewed sketches and it's corresponding photographs.

b) Appearance-based matching

Appearance based matching will use Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) algorithm for feature extraction (see Figure-3). As being known, bad quality of image will influenced successful rate of further processes. Therefore, both sketches and photograph will be preprocessed in order to improve the accuracy. Then, facial sketches will be directly matched with the database of face images. In this phase, PCA and LDA will be used separately in order to determine the better feature extraction method.

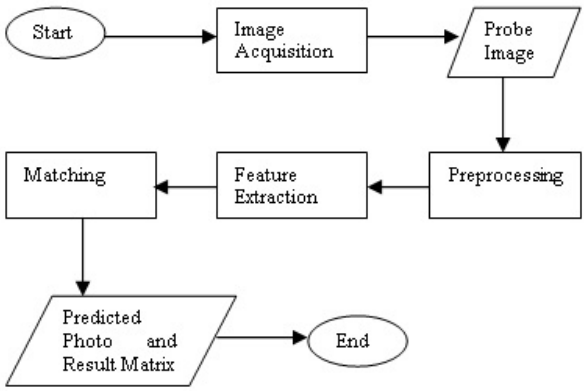

Figure- 3. Representation of appearance-based matching.

c) Feature-based matching

Local feature-based discriminant analysis (LFDA) can be used to perform minimum distance matching between sketches and photos in order to solve modality gap between photos and sketches [1]. In LFDA framework feature descriptors are used to describe an image using a feature vector include the location of the feature as well as other information. In face recognition, image-based features have been shown to be successful, especially with the use of local binary pattern [6].

In this work, LFDA framework will be implemented in conjunction with Scale Invariant Feature Transform (SIFT) and Multi-scale Local Binary Pattern (MLBP) as a feature descriptor (see Figure-4). Since most image descriptors are not sufficiently described a face image entirely, the descriptors will be computed over a set of uniformly distributed sub regions of the face. Based on feature-based technique [1], the feature vectors at sampled regions are then concatenated together to describe the entire face.

There are two parameters need to be setting, which are a region (or patch) size s and a displacement size δ to choose feature sampling points. The region size s represents the size of the square window of respective region. The displacement size δ defines the number of pixels the patch is displaced or not overlapping each other for each sample. Therefore, $(s - \delta)$ is the number of overlapping pixels in two adjacent patches. For an $H \times W$ image, the number of vertical and horizontal sampling locations that represent by $M \times N$ is given by:

$$M = \frac{H - s}{\delta} + 1 \qquad N = \frac{W - s}{\delta} + 1 \tag{1}$$

At each of the $M \times N$ patches, we compute the d-dimensional image feature vector ϕ. These image feature vectors are concatenated into one d-dimensional image vector Φ. Minimum distance sketch matching can be performed directly using this feature-based representation of subjects i and j by computing the normed vector distance φ.

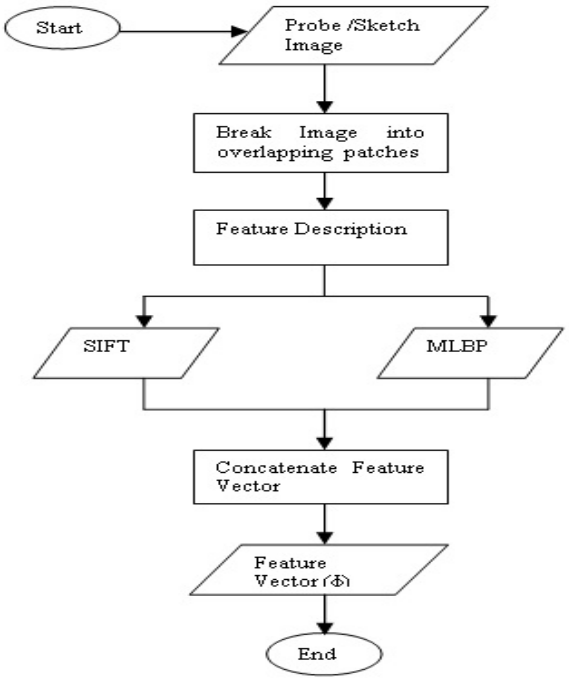

Figure 4. Representation of feature-based matching.

EXPERIMENTAL RESULT

The sketches and face images used in this experiment was obtained from two sources which are CUHK Face Sketch FERET Database (CUFSF) [3] and SGU Face Sketch Database (SGU-MB-1). In this work, to conduct the initial experiment, we used the 188 faces from the Chinese University of Hong Kong (CUHK) student database and 107 faces from Swiss German University (SGU) student and staff database. CUHK contains data of single ethnic community, while SGU-MB-1 contains data from multi ethnic, including Javanese, Padang, Chinese, Arab among others. Result in this research divided into two main results, which are: result of appearance based approach and local-feature based approach. Following are the detailed discussion.

a) Appearance based result

The FMR (False Match Rate) and FNMR (False Non-Match Rate) produced by using PCA and LDA for feature extraction against specific threshold value shows bad matching result by using CUHK viewed sketches dataset because the both curve indicates the huge area under curve (AUC). Despite CUHK student dataset known as good quality dataset, the result using appearance-based approach still produce poor outcome. Figure-5 shows the ROC curve result for appearance-based approach.

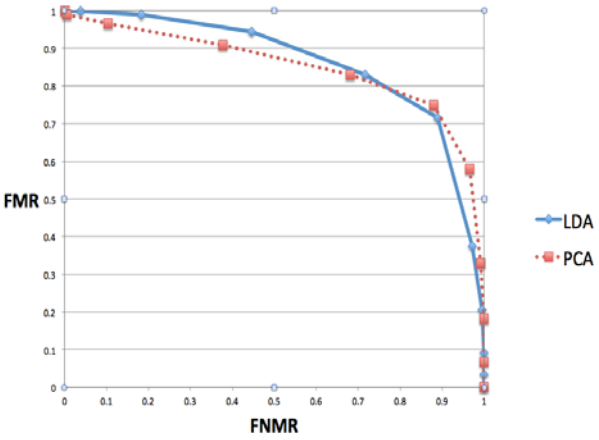

Figure 5. ROC curve appearance based approach using CUHK viewed sketches dataset.

b) Feature based result

We conduct 3 experiments using CUHK viewed sketches dataset, SGU-MB-1 viewed sketches dataset, and SGU-MB-1 forensic sketches dataset. The first experiment is using CUHK dataset that known as good quality dataset shows 90% accuracy rates, which is very good. Initially, training was performed using 100 face sketches and it's corresponding photographs. And the probe set consisting of 88 viewed sketches was used to match against a gallery of images. Then, second experiment is using SGU-MB-1 viewed dataset return 50% accuracy rates. The last experiment that using SGU-MB-1 forensic dataset return 25% accuracy rates. Both second and third experiment performs training phase using 55 face sketches and it's corresponding photographs. And the probe set consisting of 52 sketches was used to match against a gallery of

images. Figure-6-8 shows the ROC curve for each dataset used in this research.

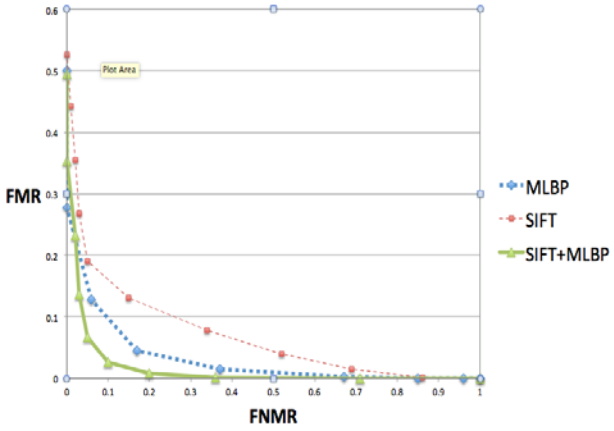

Figure-6. ROC curve feature based approach using CUHK viewed sketches dataset.

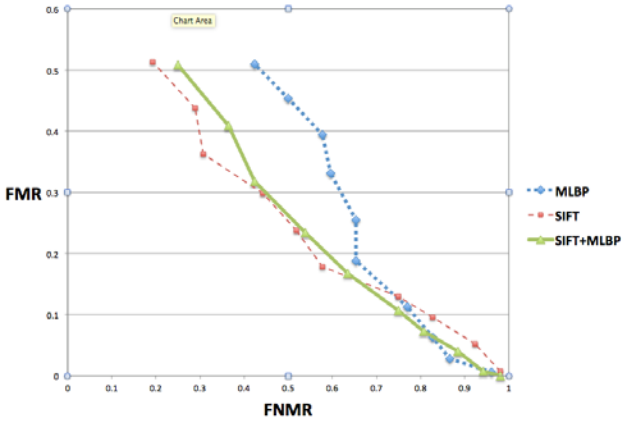

Figure-7. ROC curve feature based approach using SGU-MB-1 viewed sketches dataset.

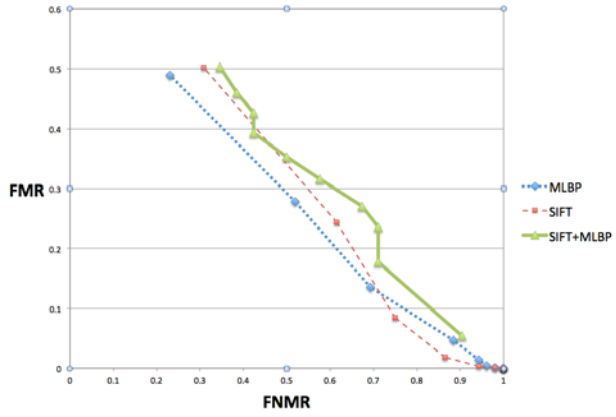

Figure-8. ROC curve feature based approach using SGU-MB-1 forensic sketches dataset.

CONCLUSIONS

In this study, we evaluated the performance of face recognition from sketch using various features : MLBP, SIFT and their combination. Experiment on single-ethnic dataset (CUHK) showed that the best accuracy was obtained by combining both features. The same experiments on multi-ethnic dataset (SGU-MB-1) showed different result. The ROC curves as shown in Figure-7 and Figure-8 showed that the best feature descriptor is different in each ROC curve. Combining MLBP and SIFT did not always produce the best result. It indicates multi ethnic dataset also influence the accuracy of the system itself rather than single ethnic dataset. Further evaluation using comprehensive dataset is left as future work of this study.

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