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Unsupervised Method for Face Photo - Sketch Synthesis and Recognition

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Abstract-Today face recognition is very important field in biometric identification. Face sketch recognition is one of the special typeface recognition. In this paper, presents an unsupervised method for face photo- sketch recognition. The face photo- sketch synthesis has two main steps. One is edge detection for only recognition of face, and secondly is for hair detection. In the recognition step, the artist sketch is compared with the generated sketch. PCA and LDA are used to extract features from the sketch images. The k-nearest neighbour classifier with Euclidean distance is used in the classification step. It has a useful application for digital entertainment and law enforcement.

Keywords: Face Recognition; Gradient Edge Detection; Hair Detection; Gaussian Blur; Contrast Stretching.

I. INTRODUCTION

It is very important for forensic application and is required for many other fields. It is commonly used in the security system and crime investigation [1].The first step to the face recognition system to detect the face in an image. The main objective of the face recognition is to detection is to find whether there are any faces in the image or not. If the face is present, then it finds the location of the image. Processing is done to remove noise and then detect the facial features. The facial feature detection is the process to detect the presence and location of features, like nose, eyebrow, eyes, lips, nostrils, mouth, ears, etc. this is done with the assumptions that there is only a single face in an image. In the Face recognition process, the input image is compared with the database then it gives a match report and then the classification is done to identify the subpopulation to which new observations belong Normal face recognition is between two face photos. Put in crime investigation, the photo of the criminal is rarely available. It is replaced by a sketch which is drawn by an artist upon the description of eyewitnesses. The direct comparison between the photographic image and the sketch image doesn't produce a good recognition because they are in different modalities. For overcoming this problem, one of the two images must convert to the other. Converting a photo to a sketch or a sketch to a photo is the searching point in this field. In this paper, we propose a new method for converting the photo image to a sketch image. The proposed method is an unsupervised method and it is the only unsupervised method that deals with face sketch recognition. It divides into two steps, edge detection, and hair detection. Most researchers in this field use Gaussian smoothing as a pre-processing step [2, 3] for removing noise that affects edge detection results. After that, they apply an edge detection technique. The gradient is used for the edge detection and the black and white image with a proper threshold in hair detection. Pseudo-sketches are used instead of photos for recognition. PCA and LDA are used to extract features and then match the artist sketch with pseudo sketches using the k-nearest neighbour classifier with Euclidean distance. The accuracy of the generated sketch image is evaluated and compared with the artist sketch, (Liu and Tang [5]) and (Tang and Wang [4]).

Methods that convert a photo to a sketch can be classified into two types: supervised and unsupervised methods. The supervised methods convert a photo to sketch by learning sketch features from a training set. The training set contains photo-sketch pairs. The advantage of the supervised methods is their generated sketch is rich of details. Also, of the supervised methods can be used to convert the sketch to a photo. The disadvantages of the supervised methods, first, they require training set that may not exist. Second, they take a long time in learning. To the contrary, the unsupervised methods don't require any training and they are very fast. The disadvantage of the unsupervised methods, they cannot be used to convert a sketch to the photo.

The unsupervised methods: Lu et al. [3] proposed a new system to produce a pencil drawing from natural images. They used the gradient with convolution a line in 8 directions for obtaining a strong stroke. They combined the tone and stroke structures to obtain on rich and well-ordered lines to express the original scene vividly. The edge information in an image by using Coherence shock

filter. They preserved the boundary line drawing in the image by using the bilateral filter. They preserved the local structure orientation features by using a 2D anisotropic filter. The Edge Flow Estimation and Step Edges Detection to detect a lot of meaningful features effectively in the photo. They produced strong lines with good edge localization. The image divided into many meaningful regions using an efficient method of image segmentation. They applied an edge detection Sobel operator besides the image is sharpened by Unsharp Mask (USM). The only lines drawing researchers who focused on hair and skin similarity. They presented bilateral filter with a large parameter for extracting prominent facial features and bilateral filter with a small parameter for texture.

The supervised method: Tang and Wang [5] proposed a new method based on Eigenfaces method. They converted the input photo to a sketch by projecting the photo in the Eigenspace of the training sketches. Finally, the mean of the training sketches is added to the result of this projection to produce the synthesis sketch. They achieved accuracy 75% by PCA classifier and 81% using Bayesian classifier. Liu and Tang present a new sketch synthesized method to map the nonlinear relation between the photo and the sketch. They divided the input photo into local patches. For each patch, they found its local nearest neighbor patches, using the Euclidean distance, in the photo training set. Then, the corresponding sketch patches to these neighbor patches are used to synthesize a new patch in the output sketch. They used 13x13 patch size; the number of the nearest neighbors is 5 and the overlapped region equal 2/3 of the patch size. These parameters produced a performance rate 87% by using KNDA classifier.

II. LITERATURE ANALYSIS

Zhang et al.[4] compared the performance of humans and PCA-based algorithm formatting sketch-photo pairs with variations in gender, age, ethnicity, and inter-artist variations. They also discussed the quality of sketches in terms of artist's skills, experience, exposure time, and distinctiveness of features. We compared the performances of humans and a principle component analysis (PCA)-based algorithm in recognizing face sketches. A total of 250 sketches of 50 subjects were involved. All of the sketches were drawn manually by five artists (each artist drew 50 sketches, one for each subject). The experiments were carried out by matching sketches in a probe set to photographs in a gallery set. This study resulted in the following findings: 1) A large interacts variation in terms of sketch recognition rate was observed; 2) fusion of the sketches drawn by different artists significantly improved the recognition accuracy of both humans and the algorithm; 3) human performance seems mildly correlated to that of PCA algorithm; 4) humans performed better in recognizing the caricature-like sketches that show various degrees of geometrical distortion or deviation, given the particular data set used; 5) score level fusion with the sum rule worked well in combining sketches, at least for a small number of artists; and 6) the algorithm was superior with the sketches of less distinctive features, while humans seemed more efficient in handling tonality (or pigmentation) cues of the sketches that were not processed with advanced transformation functions.

X. Wang and X. Tang [5] proposed a novel face photo-sketch synthesis and recognition method using a multistage Markov Random Fields (MRF) model. Our system has three components: 1) given a face photo, synthesizing a sketch drawing; 2) given a face sketch drawing, synthesizing a photo; and 3) searching for face photos in the database based on a query sketch drawn by an artist. It has useful applications for both digital entertainment and law enforcement. We assume that faces to be studied are in a frontal pose, with normal lighting and neutral expression, and have no occlusions. To synthesize sketch/photo images, the face region is divided into overlapping patches for learning. The size of the patches decides the scale of local face structures be learned. From a training set which contains photo-sketch pairs, the joint photo-sketch model is learned at multiple scales using a multi-scale MRF model. By transforming a face photo to a sketch (or transforming a sketch to a photo), the difference between photos and sketches is significantly reduced, thus allowing effective matching between the two in face sketch recognition. After the photo-sketch transformation, in principle, most of the proposed face photo recognition approaches can be applied to face sketch recognition in a straightforward way.

Klare et al. [6] extended their approach using Local Feature Discriminant Analysis (LFDA) to match forensic sketches. Matching a face sketch against mug shots, which plays an important role in law enforcement and security, is an interesting and challenging topic in face recognition community. Although great progress has been made in recent years, the main focus is the face recognition based on a SINGLE sketch in existing studies; we present a fundamental study of face recognition from multiple stylistic sketches. Three specific scenarios with corresponding datasets are carefully introduced to mimic real-world situations: (1) recognition from multiple hand-drawn sketches; (2) recognition from hand-drawn sketch and composite sketches; (3) recognition from multiple composite sketches. We further provide the evaluation protocols and several benchmarks on these proposed scenarios. Finally, we discuss the plenty of challenges and possible future directions that worth to be further investigated

III. THE PROPOSED METHOD

This paper presents an unsupervised method for face photo-sketch synthesis. The method converts a photo image into a sketch image as discussing in the following subsection and summarizing in Figure. 1. The recognition phase verifies the effectiveness of the synthesized sketches by measuring the similarity between the synthesized sketches and the artist drew sketches [1].

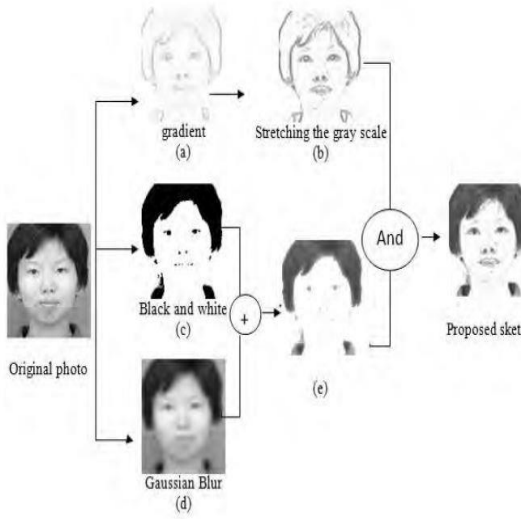

Figure: 1 The proposed method for converting photo to a sketch

A) FACE PHOTO-SKETCH SYNTHESIS

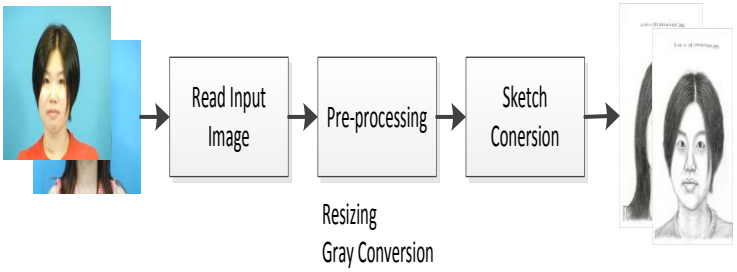

Figure: 2 Block diagram for face to sketch conversion

1) Edge detection: **Acc**ording to the nature of the artist sketch, it describes the face by emphasizing on its dominant features. These features are represented by lines which called edges in image processing. So the edge detection [7] step is considered the main step. For that, we use an edge detector for detecting lines in the photo to build the sketch around these lines. There are many edge detection techniques [3] but the gradient is the best in the process of line drawing or sketching. Because it generates smoothed edges like a pencil drawing superior to the other technique that generates sharp edges. Moreover, the gradient detects fine edges that have to mean for completing the drawing. Figure.1 (a) shows the complement of the gradient edge detection. The generated edges and the details in Figure.1 (a) are not emphasized well. This is what distinguishes the gradient; its grayscale range is narrow and its histogram is always skewed. This problem can be solved by making a contrast stretching as shown in Figure.1 (b). The contrast stretching extends the image grayscale range to the full range (0-255). Figure.1 (b) shows the improved gradient after stretching the gray scale. The next sub-section discusses this process in details.

The gradient image is an edge detection technique [8]. Edge detection plays an important role in converting a photo image to a sketch image. Edges are represented in the image by the changes in two adjacent pixels' intensities from high to low or from low to high. When these changes occur in continues pixels, it represents a line called an edge. Gradient describes the differences between pixels by taking the first derivative in X axis and Y axis. In the gradient image, each pixel is computed by the gradient magnitude. The gradient is the best edge technique dealing with sketches because it generates smooth edges.

2) Hair detection: Adding the hair to the sketch is a feature of interest to the artist. The hair is detected by converting the photo image to a black and white image with a proper threshold that is found empirically, see Figure. 1(c).The target of the Black and white (binary) image is to select which pixels will set as an important and which pixels don't mean. This can be done by determining a suitable threshold operator. The threshold value split the image pixels to 0's if the pixel value is large than or equal to a certain value and 1's if it is less than the determined value. After detecting the hair, it has to be made similar to the sketch hair. It is done by Gaussian blurring the original photo with a suitable sigma (equal to one) founded empirically, see Figure.1 (d). Gaussian blurring [9] helps in removing noise and preserves high intensities unchanged. Gaussian blurring uses weighted kernel mask in which the central pixels have more weights than the neighbor pixels. These weights derived from a Gaussian distribution function. The mask size and radius (sigma) are the parameters of the Gaussian blurring. Adding the black and white image with the blurred image produces the detected hair to be like the sketch hair, as shown in Figure.1 (e). Finally, the result of edge detection and hair detection are combined by the AND operator to produce the final sketch. Figure.1 summarizes the unsupervised face sketch synthesis process.

B) FACE PHOTO-SKETCH RECOGNITION

The different modality between photos and sketches make the direct recognition of them difficult. The proposed method has reduced these differences by converting photos to pseudo-sketches. In the recognition phase, we verify the effectiveness of the proposed method on improving the recognition performance. The recognition phase consists of two steps, feature extraction, and matching. In feature extraction two different methods are used mutually, PCA and LDA in order to find a good performance. PCA [10] concerns in preserving the global features and LDA [11] concerns in preserving the clustering structure. PCA extracts features from images by projecting the unknown sketch (test sketch) on the pseudo-sketches space

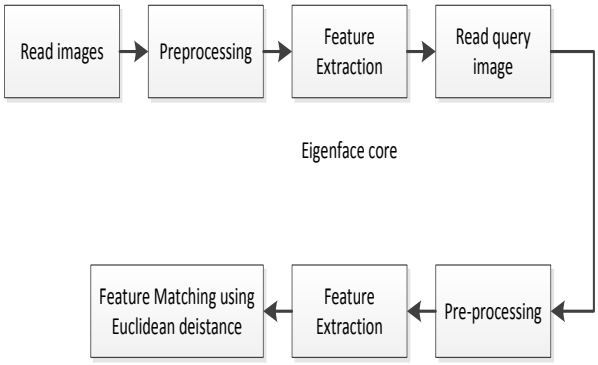

Figure: 3 Block diagram for face recognition

LDA uses training set and testing set, each contains 2 images (the real sketch and the pseudo-sketch) per class. LDA extracts features by projecting the testing set in the training set space. In matching K-NN classifier with Euclidean distance [12] is used. Each artist sketch in the database is considered the query image and matched with the generated pseudo-sketches, as illustrated in Figure. 4. After the artist sketch is matched with the whole pseudo-sketches in the database, the matching vector is generated. The matching vector is ordered in a descending form according to the similarity score (from the highest to the lowest similarity value). The rank plays an important role in the crime investigation. In order to narrow down the mug shots database, the highest similarity photos are shown to the eye witness by a parameter called a rank. For example, if the rank is 5 then the first 5 images that have the greatest matching score in the matching vector will be displayed on the eyewitness. And so on, by increasing the rank until the correct identification is found.

IV. APPLICATIONS

As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during the past several years. At least two reasons account for this trend: the first is the wide range of commercial and law enforcement applications, and the second is the availability of feasible technologies after 30 years of research. Even though current machine recognition systems have reached a certain level of maturity, their success is limited by the conditions imposed by many real applications. Face recognition has attracted great attention in recent years [2]. An important application of face recognition is to assist law enforcement. Automatic retrieval of photos of suspects from police mug-shot database can help the police narrow down potential suspects quickly. However, in most cases, the photo image of a suspect is not available. The best substitute is often a sketch drawing based on the recollection of an eyewitness. However, due to the great difference between sketches and photos, and the unknown psychological mechanism of sketch generation, face sketch recognition is much more difficult than the normal face recognition based on photo image.

One can broadly classify FRT systems into two groups depending on whether they make use of static images or of the video. Within these groups, significant differences exist, depending on the specific application. The differences are in terms of image quality, the amount of background clutter (posing challenges to segmentation algorithms), the variability of the images of a particular individual that must be recognized, availability of a well-defined recognition or matching criterion, and the nature, type, and amount of input from a user.

During the past three decades, many face recognition techniques have been proposed, however, few face sketch recognition systems can be found effective. There are so many methods to do face recognition like PCA, LDA, and NN etc. Now a day's important of face recognition and application on face recognition goes on increasing. The market of Biometric application is now in huge demand .eg. Multimedia management, Security, Smart card, banking etc. each and every sector have the great importance of face recognition.

CONCLUSION

This paper presents an unsupervised method for face photo sketch recognition. The method synthesizes a sketch image from a single photo image to use it for photo-sketch recognition by comparing the synthesized sketch with the artist sketch. The method synthesizes a sketch through image gradient to emphasize the dominant feature and image threshold to preserve hair features. Therefore, the method is completely unsupervised and free from any user intervention. Moreover, it is very simple and fast. The proposed method achieves a recognition rate at the1- nearest neighbour (rank1: first-match) range from 82% with PCA to 94% with LDA. The highest recognition rate is obtained at the5-nearest neighbour (rank 5) is 98%, which improves the recognition by about 10% better than the reported results of the state-of-the-art methods. In the recognition phase, both PCA and LDA are used to extract the feature of the synthesized sketches and the test sketch. The test sketch is projected on the feature space of the PCA or LDA features.

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