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Matching Facial Composite Sketches to Police Mug-Shot Images Based on Geometric Features.

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Abstract: *Composite sketches are frequently used to help track down suspects in a crime in which there is no photographic evidence. Automatic retrieval of photos of suspects from police mug-shot databases can help police narrow down potential suspects quickly. This paper describes a novel approach for matching facial composite sketches to police mug-shot images. Proposed method is based on Geometric Features. To recognize a facial composite we focussed on face geometric features like eyes, eyebrows, nose, lips, and face cutting along with their length and width ratios. This system has five components 1) Extract components from a face image/composite sketch 2) Compute Ratios of Length, Width and Area 3) Represent each image component as a vector 4) Mean of the vectors are computed and subtracted from each component vector to get a set of vectors called zero-mean vectors 5) Searching for mug shot images in the database based on a query sketch drawn by an artist. It has useful applications for both law enforcement and digital entertainment. We assume that mug shot images to be studied are in frontal pose, under normal lighting with neutral expression, and have no occlusion. Extensive experiment has been conducted with 50 male and female face/sketch database from CUHK face database.*

Keywords*: Composite sketches, Geometric features, Mean vectors, Face image components, CUHK face database*.

I. INTRODUCTION

A facial composite is a sketch or computer generated image used to create a visual representation of a suspect based on the memory and description of eyewitnesses. Composite sketches are much different from photos in texture shape and it is difficult to match photos and sketches as they are found in two different modalities [8]. Fig. 1 depicts our Facial composite recognition system.

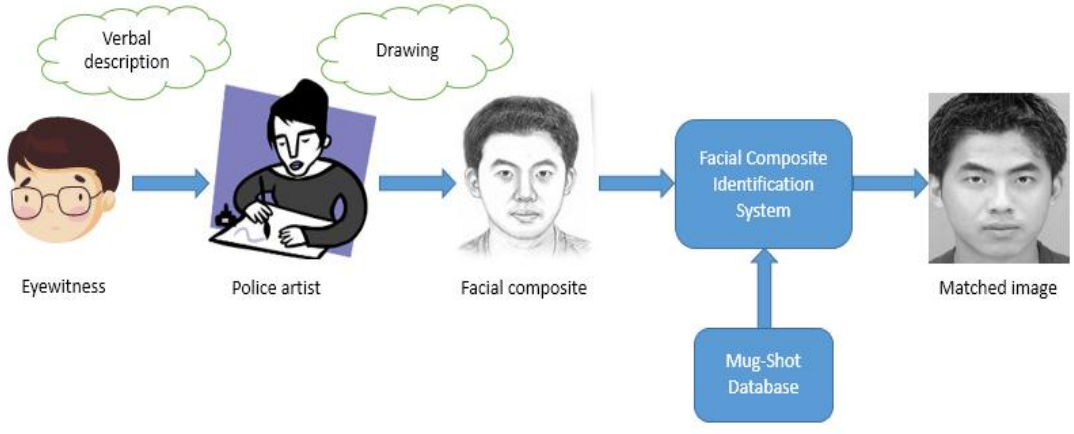

Fig.1 Facial composite recognition system

Composite sketches frequently used in both investigative and prosecutorial areas of law, critics suggest that facial composite sketches and the newer computer-generated versions are extremely prone to misuse and error. If judges and juries rely heavily on facial composites to make decisions, critics say that innocent people are at risk of jail and other consequences as a result of mistaken identity. The sketch is composed of facial components, chosen from a facial identification catalogue and recognized by the witness as being features similar to those of the unnamed person. The human face description that our system accepts has been determined by a psychological study. The study reveals that seven facial features, namely Face Cutting, Right

eye, Left eye, Right eyebrows, Left eyebrows, Nose, Lip are generally referred in describing a human face.[3]. These drawings will assist the public and law enforcement in locating a wanted person for the purpose of identification, thus shortening the time from offence to apprehension.

1.1. RELATED WORK

A lot of works on face recognition and facial feature extraction have been reported in [3], [4], [5], [6], [7], [2], [12].In [10] [11], a face sketch synthesis and recognition system using Eigen transformation was proposed. In [12] proposed a nonlinear face sketch synthesis and recognition method. It followed the similar framework as in [10] [11]. The drawback of this approach is that the local patches are synthesized independently at a fixed scale and face structures in large scale especially the face shape cannot be well learned. In [2], [12] proposed methods for extraction of facial features. It can not only help police locate a group of potential suspects, but also help the witness and the artist interactively to modify the sketch during drawing based on similar photos retrieved [8], [9], [10], [11], [12].

1.2. FEATURE EXTRACTION TECHNIQUES

Different researchers have proposed different methods to find the facial feature regions in a face image [18]. Some image processing techniques extract feature points such as nose, eyes, mouth are extracted and then used as input data to application. Four basic approaches are:

a) Geometric feature based method
b) Template based method
c) Color segmentation based method
d) Appearance based method

Feature extraction is most important part of face recognition because classification is totally depend on how we extract facial features. A best feature extraction is not determined without evaluation of face recognition algorithm. That's why best feature set for face recognition are still a problem.
Every method has pros and cons such as Template based methods are easy to implement but not represent global face structure. While color segmentation based methods used color model for skin detection with morphology operation to detect features. So different color model and illumination variation these factors can affect performance. Appearance based methods represent optimal feature points which can represent global face structure but disadvantage is high computational cost. Geometry based methods was considered most successful for extraction of facial features from face images and composite sketch.

FACIAL FEATURE EXTRACTION TECHNIQUES	ADVANTAGES	DISADVANTAGES
Geometric Feature Based Method	• Small Database • Simple manner • Recognition rate 95%	• Large number of features are required.
Template Based Method	• Simple manner • Recognition rate 100%	• Computational Complexity • Description between templates and images has a long time • Only effective when query and modal images have same scale, orientation and illumination properties
Color Segmentation Based Method	• Small Database • Simple manner • Recognition rates 85%	• Illumination, Hue, Rate of quality are effective on recognition rates • Discontinuity between colours • In profile and closed eyes have a problem
Appearance Based Method	• Small number of features • Recognition rates 98%	• Needs good quality Images • Large size of database • Illumination

Table 1. Pros and Cons of various facial feature extraction techniques [17]

II. Composite Sketch Recognition Using Facial Feature Extraction (Geometrical Feature Based Method)

Overall system description for composite sketch recognition based on facial feature extraction is given in this section. The features are extracted by using relative positions and sizes of the important components of face. This methods concentrates in two directions. First, detecting edges, directions of important components or region images containing important components, then building feature vectors from these edges

and directions. Filters such as canny filter are used to detect eyes or mouth region of face image. This has been divided into three section:

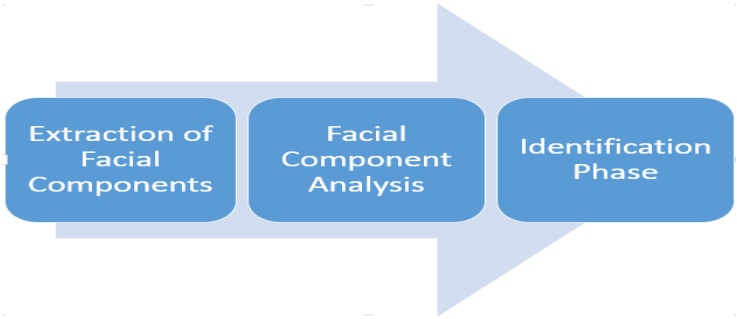

Fig.2 Overall system description

2.1 PRE-PROCESSING

Before extraction of facial components, some pre-processing tasks to rescale photos and composite sketches are required. Photos and composite sketches has been standardized as having max of 200 pixels in length and 150 pixels in width. Face image database containing RGB images are converted to gray scale images before extraction of facial features. Facial composite sketches are also rescaled in similar fashion. Fig 2 show some face images and their cropped images.

Fig. (A1)Original color face photo (A2) Corresponding gray face photo (A3) Corresponding cropped face photo

Fig. (A1)Original face sketch (A2) Corresponding cropped face sketch

A. EXTRACTION OF FACIAL COMPONENTS

Facial feature extraction in general refers to the detection of eyes, nose, eyebrows, lips, and other important parameters of face. To detect Image regions in face images/sketches we have used Geometric feature method. In this method facial feature are extracted using relative position and sizes of face features.

EXTRACTION METHODOLOGY

In the present work, to recognize a composite sketch, extraction of facial component is required from images. The regions of different facial components are predicted using geometric feature method. It is not possible to extract all the facial component with one algorithm. Therefore we design separate algorithm for each facial component. The first and the most important step in facial component detection is to track the position of eyes. The rule for prediction of different facial component are designed with respect to the row on which eye ball exists. Here we have used Geometric model [1] shown in Fig.3 to predict the positions where the facial components may appear by applying proper algorithms.

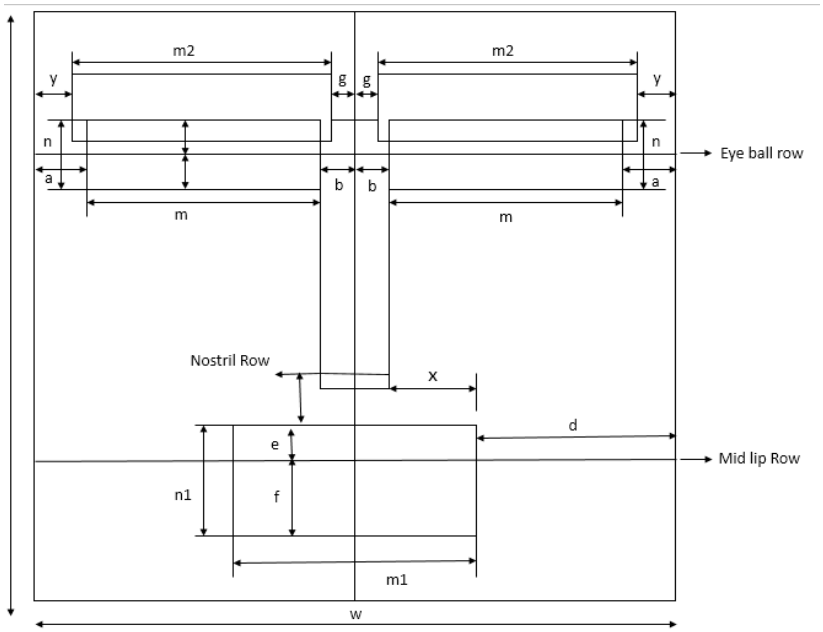

Fig. 3 Geometric model [1]

Here we have considered two points(x1, y1) and(x2, y2) as the co-ordinates of the top left corner and bottom right corner of the predicted rectangular regions for each facial component.

Face region extraction: Face region was extracted by first converting face image to binary image followed by morphological closing and opening operations. The goal of morphological operation in this work is to extract the face region.

Eye ball row: For prediction of the eye-region, first extract the face region. After that we add each row intensity values. Row where the eye-ball exists will have the minimum value among the rows. Therefore, based on minimum value row we can predict the eye region. (Called e_ball_row)

Right eye extraction

- ✓ Predict the Right eye region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
R_EYE_x1=e_ball_row-c;
R_EYE_y1=a+1;
R_EYE_x2=R_EYE_x1+n-1;
R_EYE_y2=R_EYE_y1+m-1;

Left eye extraction

- ✓ Predict the Left eye region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
L_EYE_x1=e_ball_row-c;
L_EYE_y1=W/2+b;
L_EYE_x2=L_EYE_x1+n-1;
L_EYE_y2=L_EYE_y1+m-1;

Right eyebrow extraction

- ✓ Predict the Right eyebrow region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
R_EYEBROW_x1=e_ball_row-(c*3);
R_EYEBROW_y1=initial_column +y;
R_EYEBROW_x2=R_EYEBROW_x1+n2-1;
R_EYEBROW_y2=W/2-g;

Left eyebrow extraction

- ✓ Predict the Left eyebrow region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
L_EYEBROW_x1=e_ball_row-(c*3);

L_EYEBROW_y1=W/2+g;
L_EYEBROW_x2=L_EYEBROW_x1+n2-1;
L_EYEBROW_y2=L_EYEBROW_y1+m2-1;

Lips extraction

- ✓ Predict the row between two lips (called mid_lip_row).
- ✓ Predict the Lips region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
LIP_x1=e_ball_row-e;
LIP_y1=d+1;
LIP_x2=LIP_x1+n1-1;
LIP_y2=LIP_y1+m1-1;

Nose extraction

- ✓ Predict the Nose region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
NOSE_x1=R_EYE_x1;
NOSE_y1=R_EYE_y2;
NOSE_x2=NOSE_x1+m2-1;
NOSE_y2=LIP_y2-10;

Actual Nose

- ✓ Find nostril location(called nostril_row)
- ✓ Predict the Actual nose region with (x1, y1) and(x2, y2) co-ordinates according to the geometric model

Where,
ACTUAL_NOSE_x1=R_EYE_x1;
ACTUAL_NOSE_y1=R_EYE_y2;
ACTUAL_NOSE_x2=nostril_row+2;
ACTUAL_NOSE_y2=NOSE_y2;

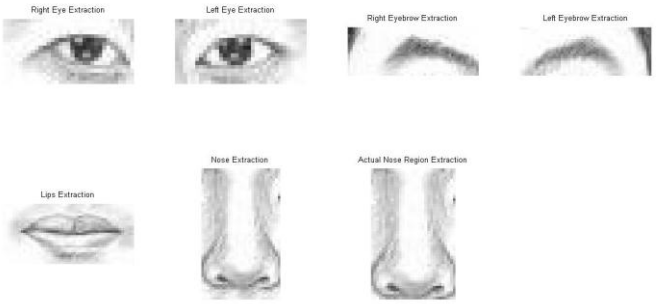

Fig. 4 Extracted facial components

B. FACIAL COMPONENT ANALYSIS

After extracting required face regions, analysis of extracted face component is done. In a gray-level image, the intensity values vary from 0 to 255. Also the edge regions are darker from the other portions of an image. So, if we add a large integer value (obviously between 0 and 255) with each pixel intensity value of the image then the pixel intensities of the image other than edge region reaches 255 or higher which can be considered as 255 [2]. Now from this new image we can easily determine the edges. That is why, during the extraction process for the facial components we have normalized the predicted regions of the components by adding an integer 127 (half of 255) with each intensity value of the components.

The components of face are extracted by using relative positions and sizes of the important components of face**.** In this proposed method we have analyzed ratios of following face components.

- ✓ Ratio of Length and Width of face.
- ✓ Ratio of Length of Left eye and Right eye
- ✓ Ratio of Length of Left eyebrow and Right eyebrow

- ✓ Ratio of Length and Width of Actual Nose
- ✓ Ratio of Length and Width of Lips
- ✓ Distance between upper lip and nostril. [1]

To calculate ratios

First step is to detect edges of required face regions using filters such as canny filter. Then by finding location of first pixel and the last pixel, we can find the length and width of facial components.

C. IDENTIFICATION PHASE

In this final phase, identification of composite sketch takes place for (N_i) number of face images,

Steps to match composite sketch to mug shot images are as follow:

- Facial features for each face image/composite sketch is extracted (nj), then their length or width or area ratio is calculated and these extracted facial features are represented as a feature vector (υ_i). If there are ***n*** images then there will be ***n*** number of vectors.
- Mean (M) for every vector is computed and subtracted from each feature vector for centering of the feature vectors (δ_i=M-υ_i).
- K-NN classifier is used to identify facial composite sketch from existing database with K=5 and Euclidean Distance is used.
- Finally we get best matching five face images with composite sketch.

III. Conclusion

Geometric model is used for extraction of facial features. We were concentrated on important components of face. For extraction of each of those facial components we have design different algorithms. After extraction of facial components, their length or width, are calculated from edge or binary images and then ratios of length or width are computed to construct discriminating feature vectors. Finally, K-NN classifier has been used to recognize composite sketch from face images database. [CUHK Face Sketch Database].

IV. Experimental Results

In this section, we provide final results of identified face images corresponding to the composite sketch. Facial component extraction performance can be given by a formulae

$$\frac{Total\ successful\ extraction\ of\ a\ facial\ component}{Total\ no.of\ images} * 100$$

Fig.5, shows the composite sketch and Fig.6 shows the best matching five face photos (in ascending order) with the composite sketch.

Fig.5 Composite sketch

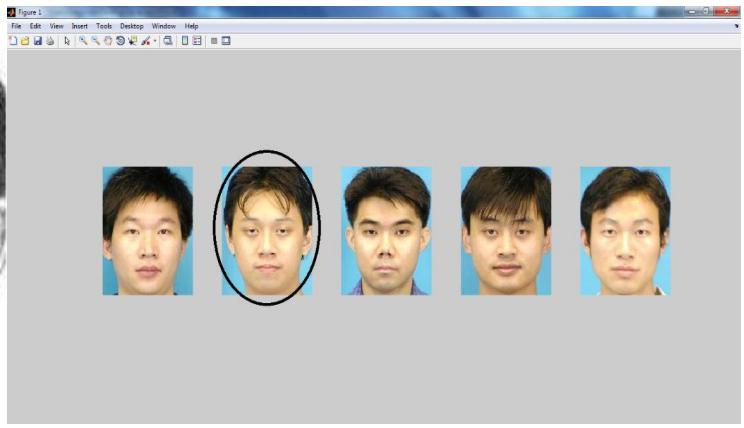

Fig.6 Snapshot of best matching face photos

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