Comparing Forensic Blueprint Sketches with Headshots

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Abstract

The continuous development of biometric technology has provided criminal investigators additional gadgets to discover the identity of criminals. In addition to DNA and incidental proofs, if a hidden fingerprint is found at an investigative sight or a surveillance camera captures an image or an footage of a suspect’s face, then these clues may be used to discover the culprit’s identity using automated biometric identification. However, many crimes occur where there is above information isn’t present, but instead an eyewitness of the crime is present. In these situations a forensic artist is often used to work with the witness or the victim in order to draw blueprints that depicts the facial features of the culprit according to the verbal illustrations. These blueprints are known as forensic sketches. This problem of comparing a forensic sketch to a gallery of headshots images is addressed here using a robust framework called local feature-based discriminant analysis (LFDA).

Keywords- headshots, forensic blueprints, forensic sketches, local feature based descriminent analysis, feature based approach, texture descriptors, feature descriptors.

1. Introduction

Continuous developments in biometric technology bring law enforcement groups additional gadgets which helps in determining the identity of the criminals. Besides incidental proofs, if a hidden fingerprint is found at the sight of crime or a surveillance camera captures an image of the face of a suspect, then these clues are helpful in discovering the identity of the suspect. However, most of the time when crime occurs where there is above information is not present. The lack of technology to effectively capture the biometric data like finger prints within a short span after the scene of crime is a routine problem in remote areas. Despite this consequence, the eyewitness of the crime is available who had seen the crime. The police department work arranges a forensic artist who works with the eyewitness for the purpose of draw the blueprints that illustrate the facial description of the culprit. Once the blueprint is ready, it is sent to law enforcement executives and broadcast release with the belief of tackle the suspect. Here 2 sequence of events may emerge for the convict:

I. The person may have already captivated once.

II. The person has not been captivated for a once or this is the first time, he is carrying out the crime.

In general, blueprints are categorized into two categories:

A. Viewed Sketches: These are the blueprints drawn by an artist, directly looking at the original subject.

B. Forensic Sketches: These are the blueprints drawn by the especially trained artist based on the description of the original subject given by an eyewitness.

Since viewed sketches are drawn, by directly looking at the subject or the photograph of the subject, they carry a very good detail of the original subject in terms of accuracy. On the other hand, since forensic sketches are drawn, just based on the verbal description, their accuracy is considerably low. It is succinct to say that the accuracy of forensic sketches is directly proportional to the remembrance capability of the eye witness.

2. Related Work

Even though there existed number of face identification strategy since the past three decades, research on sketch to image comparing started only two decade ago. This is because of the complication in the problem compared to standard identification and also this is turned into large texture difference between a blueprints and a photo. Even though all the methods that are applicable to viewed sketches, are also applicable to forensic sketches, the unavailability of a public database for forensic sketches led to a lack of standard test procedure on the latter one.

That is why most of the early work consists of tests on viewed sketches only.

On viewed sketches, most of the early work is done by Tang et. Al. A simulated photo is generated from blueprint sketch in these works. And then comparing is performed with traditional face identification algorithms.

Klare and Jain published a scale invariant feature transform based approach for the sketch to photo comparing. Klare and Jain published a local feature based descriminent analysis approach for comparing forensic sketches to head shots photos. A feature-based method for comparing sketches was presented by Klare and Jain, which serves as the motivation for the sketch comparing method presented in this project. In this feature-based sketch comparing approach uniformly samples both sketch and photo images using SIFT feature descriptors at different scales.
We propose a technique based on speed up robust feature that can make the process of forensic sketch comparing in better manner. Our results are compared to LFDA; since it is the one with the highest accuracy in comparing forensic sketches till date. We examine that with a preprocessing technique in the combination of detectors and descriptor power of SURF that we can get the better accuracy than LFDA.

3. Proposed Approach

The proposed feature-based method for sketch to photo comparing system is shown in the following given block diagram:

```
Input Sketch Image as test image
      Feature Extraction
      Feature Value

Feature Database
      Feature Extraction
      Feature Database

Matching Algorithm

Result Image
```

Here we have a set of sketches (Probe images) and a set of headshots photographs.

The steps involved in sketch to photo comparing are as follows:

i. For the input sketch image and the corresponding photo, apply feature extraction techniques on each of them and store results in the database.

ii. Store this feature extraction results for every image into a feature database.

iii. For every delving image, the corresponding match is that with the minimum distance calculated with the nearest neighbor comparing method.

iv. The final top fetched images from the database are then displayed.

From the above figure, we can say that the image database represents the gallery of images of the culprits. These images are called as the headshots images. A headshot is a photographic portrait taken after one is arrested. Sketch image is the delving sketch which is the input given to the comparing system that is to be identified against the available headshots images.

- **Feature extraction:** Feature extraction represents any feature-based sketch comparing technique. For example there are different types of feature (image) descriptors which can be used.

- **Feature database:** Feature database is the database maintained where all the results or values obtained from the feature extraction method are stored.

- **Comparing algorithm:** Comparing algorithm is used to find a proper match between the probe sketch image with the headshot images. We can match sketch to photos using ‘nearest neighbor comparing’ method in which the minimum distance between the calculated values of the headshot images and the delving sketch is found out.

4. Pre-processing Approach

A novel pre-processing technique is discussed in this paper. This pre-processing is different from the conventional face recognition pre-processing techniques where the face is pre-processed so that the region only from forehead to chin and cheek to cheek is visible.

![Example shows how our proposed method done the pre-processing, we haven’t lost the external features of the image after pre-processing of image.](image)

Above figure shown how we pre-process the image so that hairline and neck region and also the ears are visible and this happens due to two reasons:

- Experiments conducted by Frowd et. Al showed that human beings remember the known faces with the help of inner features and unknown faces with the help of outermost features of the face. Since a culprit is actually unknown and you don’t come beyond him in your everyday life, the external features of the facial region are very important.

- Forensic sketch artist not only drawn the internal parts of the face, but also the external ones. Moreover, logically from the first point, it is clear that external features are more saliently remembered and hence drawn with a good accuracy. Further in their experiments, they found out that using both inner and outer features gave better accuracies compared to using only external features.

5. Scale Invariant Feature Transform (SIFT)

- Lowe's method for image feature generation transform an image into a large collection of feature vectors, each of which is invariant to image translation, scaling, and rotation, partially invariant to illumination changes and robust to local geometric distortion.
The SIFT algorithm discards low contrast Key-Points (remaining points are shown in the middle image) and then filters out those located on edges.

Given SIFT’s ability to find distinctive Key-Points that are invariant to location, scale and rotation, and robust to affine transformations (changes in scale, rotation, shear, and position) and changes in illumination, they are usable for object recognition. The steps are given below:

Step 1: Scale-Space Extrema Detection:
The scale space is defined by the function:
\[ L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \]
Where * is the convolution operator, \( G(x, y, \sigma) \) is a variable scale Gaussian and \( I(x, y) \) is the input image. Difference of Gaussians technique is used for locating scale space extrema, \( D(x, y, \sigma) \) by computing the difference between two images, one with scale \( k \) times the other.
\[ D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma) \]

Step 2: Key-Point Localization
Elimination of more points by finding those that have low contrast or are poorly localized on an edge. This is achieved by calculating the Laplacian.

Step 3: Orientation Assignment
To assign an orientation we use a histogram and a small region around it. Using the histogram, the most prominent gradient orientation(s) are identified. If there is only one peak, it is assigned to the Key-Point. If there are multiple peaks above the 80% mark, they are all converted into a new Key-Point (with their respective orientations).

Next, we generate a highly distinctive “fingerprint” or “feature vector”, having 128 different numbers for each Key-Point.

Step 4: Key-Point Descriptor:
Key-Point descriptors typically uses a set of 16 histograms, aligned in a 4x4 grid, each with 8 orientation bins, one for each of the main compass directions and one for each of the mid-points of these directions. This result in a feature vector containing 128 elements. These resulting vectors are known as SIFT keys and are used in a nearest-neighbours approach for sketch to photo comparing. The nearest neighbours are defined as the Key-Points with minimum Euclidean distance from the given descriptor vector. The probability that a match is correct can be determined by taking the ratio of distance from the closest neighbour to the distance of the second closest. All matches are rejected in which the distance ratio is greater than 0.8, which eliminates 90% of the false matches while discarding less than 5% of the correct matches.

6. Design Plan
The original implementation of the SIFT algorithm feature detection can be summarized with the diagram shown in below Figure.

Hess’s implementation follows these steps in the algorithm. As explained in his paper, the SIFT Library it comprises four main components:
- SIFT feature detector
- Kd-tree feature database information
- RANSAC transform computation
- Invariant image feature handling

To detect the interest features for the input images it is only necessary to use the first component. This SIFT Library allows you to call one of two function for detecting SIFT features both located at the “sift.h” header file that comes with the code. The first function will compute the feature detection process using the default parameters suggested by Lowe in 2004 (Lowe, 2004). The other function allows the user to select the desired parameter based on their particular interest or needs. For the tests showed here we used the default Lowe’s parameters.

7. Experimental Results
The experiments are performed using the combination of viewed sketches and forensic sketches to increase the size of dataset.

The database consists of 142 viewed sketch-photo pairs from CUHK database [2] and 70 viewed sketch-photo pairs from IIIT- D database [9]. Forensic pairs are collected as 25 pairs from Forensic composite sketch database [10], which contains sketch photo pairs from L. Gibson [11] and 27 pairs are taken from IIIT-D forensic database. Initially training was performed on all the sketches with its corresponding photographs. And the probe set consisting of 52 forensic sketches were used to match against a gallery of 264 gallery
images. Comparing forensic sketches to large headshot galleries is different in several respects from traditional face identification techniques.

First we create the database of digital images and every time we add the image into database, image features are extracted from the image and arrange in one matrix. There are the following features we are extracted from the image are given below:

- Eye Width, Eye Height
- Nose Width, Nose Height
- Mouth Width, Mouth Height
- Eye to Eye Distance
- Left eye to nose Distance
- Right Eye to Nose Distance
- Left Eye to Mouth Distance
- Right Eye to Mouth Distance
- Nose To Mouth Distance

We convert the digital image into grayscale image because grayscale image features are easy to extract as compared to color image.

After creation of database we input the blueprint sketch for comparing with the digital image which is stored in the database with the same features we had extracted from the digital image while creating the database. We extract the same feature from sketch image compare it with every digital image that which image is nearly same as input sketch image.

8. Conclusions

We are using a robust feature based method LFDA with extra pre-processing method. This pre-processing strategy helps us to enhance the forensic images by removing the deviation and lamentation. Comparing forensic blueprints is a very difficult problem in discordant face recognition for two main reasons:

- Forensic blueprints are often an incomplete description of the subject's face.
- We must match across image process since the gallery images are photographs and the probe images are sketches.

Forensic sketches are drawn by consulting a witness to gain a description of the suspect. Research on sketch to photo comparing to this point has primarily focused on comparing viewed sketches despite the fact that real-world scenarios only involve forensic sketches. Forensic sketches pose additional challenges due to the inability of a witness to exactly remember the appearance of a suspect and her subjective account of the description, which often results in imprecise and incomplete forensic sketches. Comprehensive analysis, including comparison with different methods is performed using the viewed, semi-forensic, and forensic sketch databases.

The Image Feature generation module of Comparing Forensic Blueprint Sketches With headshots 50% completed. The following drawbacks have been eliminated:

- Lots of manual work by Investigators.
- Maintaining an Image Feature descriptor which is to be used for matching.
- Wastage of time by giving more time to calculate Image features.
- Matching images from a large number of databases.

Here we get the Image Feature descriptor of each input image which is used to match the images from the database images whose descriptors are already been stored in database and display maximum correctly matched images.
This module when adopted by all the departments of college, then misconduct done by any student can be minimized by identifying them.

Even this module can be imported to other colleges, schools and other government departments and in private departments also for their security purpose.

9. References


Author’s Profile

Dipanshu Pathak received B.E. (Computer Science & Engineering) from Priyadarshini Institute of Technology Nagpur affiliated to Nagpur University in June-2013 and currently pursuing M.Tech in Computer Science from Kashi Institute of technology Varanasi affiliated to Dr. APJ Abdul Kalam Technical University Lucknow.

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