Mugshot Identification from Manipulated Facial Images

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Abstract. Editing on digital images is ubiquitous. Identification of deliberately modified facial images is a new challenge for face identification system. In this paper, we address the problem of identification of a face or person from heavily altered facial images. In this face identification problem, the input to the system is a manipulated or transformed face image and the system reports back the determined identity from a database of known individuals. Such a system can be useful in mugshot identification in which mugshot database contains two views (frontal and profile) of each criminal. We considered only frontal view from the available database for face identification and the query image is a manipulated face generated by face transformation software tool available online. We propose SIFT features for efficient face identification in this scenario. Further comparative analysis has been given with well known eigenface approach. Experiments have been conducted with real case images to evaluate the performance of both methods.

Keywords: Mugshots, Image Tampering, Face Identification, SIFT, PCA

1 Introduction

Photo editing software tools are becoming more sophisticated and user friendly day by day. Face is an important biometric trait for the identification of a person. Forensic investigation and law enforcement is one of the major applications of face recognition problem. Rigorous research has been carried out so far for recognition of faces by considering different viewpoints, illuminations, facial expressions, occlusions etc. Changing appearance to the hide identity of a person is very common. Some examples are shown in fig. 1. In which original face images are modified by altering almost all facial features like eyes, ears, nose, hair style, mouth, shape of the face etc. Such identity modifications are simulated using face transformation software tool. In this paper, we deal with the problem of face identification from altered facial images.

Modifications to the face image are not a well defined notion and it is always depending on the purpose of usage. For a magazine cover or posters, skin softening and some local editing may be required. Change of complete appearance of the face may be necessary to misguide the face identification system or agency. In our face identification problem, the query face image to the system is suspected to be a manipulated face image and the system reports back the identified person from a face database of known individuals. In this research work we concentrate only on mugshot
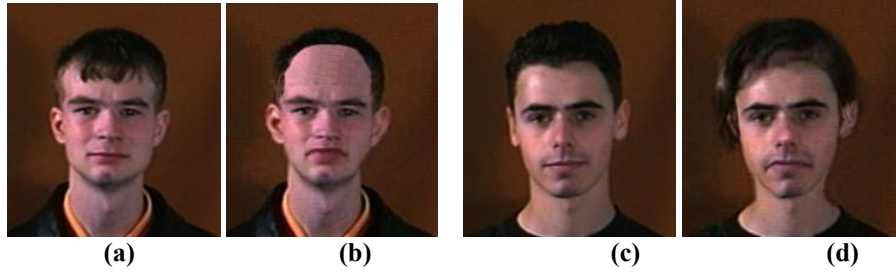
Figure 1. (*a*) *& (c) are original images; (b) & (d) are modified images*

identification. Mugshots consists of two views (frontal and profile) of each criminal. Mugshots are downloaded from **http://www.thesmokinggun.com/mugshots**. We considered only frontal view to train the system. Image editing software tool like Adobe Photoshop is commonly used to perform alterations on digital images. For instance a skilled person can create old age face or childhood face from young adult face. Such a job can also be done by various software tools available on web and is called as face transformation. The aim of this research is to measure similarity between query (manipulated or transformed) face image with all the face images in database and retrieve the image which has got highest similarity i.e. nearest neighbour. Since query is created from one of the database image (source or original image), the system should assign highest rank to the right source image and retrieve it. Query image is created using the face transformation tool implemented by the University of St. Andrews available in **http://morph.cs.st-andrews.ac.uk.**

Face identification is a narrow definition of face recognition problem. Face identification is carried out with registered persons. In which query face is compared with each face image in the database and retrieve/identify the face which has got highest similarity. Thus the problem is one-to-one matching where as face recognition is one-to-many matching. In this paper, two well known face recognition techniques using Scale Invariant Feature Transform (SIFT) features [6] and Eigenfaces [9] are evaluated and their performances compared.

2   Related Work

In the literature, we can notice that much work has been done on face recognition. As far as our knowledge, this is the first attempt for mugshot identification from modified face images. Here we review related work on face recognition problem that deal with different form of face representatives and we also review prior work that evaluated the robustness of SIFT features for face recognition.

Robert et. al [1] have presented a theory and practical computations for automatically matching a police artist sketch to a set of true photographs. This method locates facial features in both the sketch as well as the set of photograph images. Then, the sketch is photometrically standardized to facilitate comparison with a photo and then both the sketch and the photos are geometrically standardized. Finally, for matching, eigenanalysis is employed. But the author uses only seven sketches for the

experimentation. However, human intervention in decision making is very much required.

Xiaogang Wang et. al [2] have proposed a novel face photo-sketch synthesis and recognition method using a multi scale Morkov Random Fields (MRF) model. To synthesize sketch/photo images, the face region is divided into overlapping patches for learning. From a training set which contains photo-sketch pairs, the joint photo-sketch model is learnt at multiple scales using a multiscale 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.

Wolfgang Konen [3] has compared facial line drawings with gray-level images using a software tool called PHANTOMAS. Yongsheng et. al [4] have presented a methodology for facial expression recognition from a single static using line-based caricature. The proposed approach uses structural and geometrical features of a user sketched expression model to match the Line Edge Map (LEM) descriptor of an input face image. A disparity measure that is robust to expression variations is defined.

Rich Singh et. al [5] have presented a novel age transformation algorithm to handle the challenge of facial aging in face recognition. The proposed algorithm registers the gallery and probe face images in polar coordinate domain and minimizes the variation in facial features caused due to aging. The efficiency of the proposed age transformation algorithm is validated using 2D log polar Gabor based face recognition algorithm on a face database that comprises of face images with large age progression.

In this paper, we introduce another form of face representative that is, altered or modified face created by using sophisticated image editing software. We also propose that SIFT features for face identification in which modified face is used as a query. However, Mohamed Aly [6] used SIFT features for general face recognition problem. He compared SIFT with Eigen faces and Fisher faces, and reported the superiority of SIFT features for face recognition. Similarly Han Yanbin et. al [7] also used SIFT for extracting face features. Face recognition is conducted by comparing real extracted features with training sets. They experimented with ORL face database and reported recognition rate for SIFT, PCA, ICA and FLD as 96.3%, 92.5%, 91.6% and 92.8% respectively.

3 Backgound

3.1 SIFT

Lowe [8] invented robust image features called Scale Invariant Feature Transform which are invariant to scale, rotation, affine transformations, noise, occlusions and are highly distinctive. Detection and representation of SIFT features consist of four major stages: (1) scale-space peak selection; (2) keypoint localization; (3) orientation assignment; (4) keypoint descriptor. In the first stage, potential interest points are identified by scanning the image over location and scale. This is implemented efficiently by constructing a Gaussian pyramid and searching for local peaks (termed

keypoints) in a series of difference-of-Gaussian (DoG) images. In the second stage, candidate keypoints are localized to sub-pixel accuracy and eliminated if found to be unstable. Stage 3 identifies the dominant orientations for each keypoint based on its location. The final stage builds a local image descriptor for each keypoint, based upon the image gradients in its local neighbourhood. Every feature is a vector of dimension 128 distinctively identifying the neighbourhood around the key point.

3.2 PCA

Eigenfaces are based on the dimensionality reduction approach of Principal Component Analysis (PCA) [9]. The basic idea is to treat each image as a vector in a high dimensional space. Then, PCA is applied to the set of images to produce a new reduced subspace that captures most of the variability between the input images. The Principal Component Vector (eigenvectors of the sample covariance matrix) are called the Eigenfaces. Every input image can be represented as a linear combination of these eigenfaces by projecting the image onto the new eigenfaces space. Then, we can perform the identification process by matching in this reduced space. An input image is transformed into the eigenspace, and the nearest face is identified using a nearest neighbor approach. Euclidean distance is used to match the input image against all images in the database.

4 Proposed Approach

In this section, we introduce a novel image matching strategy based on SIFT features for detecting source image which has been used in the creation of its altered version. The proposed face identification system consists of three processing steps: In the first step, SIFT [8] features are extracted from all faces in the database and from the query face image. In second step, the features extracted from the query face are compared against the features from each face in the database. A feature is considered as matched with another feature when the Euclidean distance to that feature is less than a specific fraction of the distance to the next nearest feature. The third step is to verify the spatial distribution of matched features between the query and candidate image in the database. We introduce a novel pattern matching technique to efficiently reduce the number of false matches. The spatial topology is verified by Angle-Line Ratio (ALR) statistics [10] among the matched feature distributions. This is done by finding angle between two lines (made by 3 corresponding points in the two images) and the ratio of line segments. If the angles and the line ratios are same, in other words if the difference of angles and the difference of line ratios made by 3 corresponding points in the two images are zero then it implies that the relative spatial arrangement of the 3 points in the two images (query and the candidate image) are same. Note that both the directed relative angle and the length ratio attributes are invariant to the changes of scale (uniform), rotation and translation.

The face in the database with the largest number of matching points that agrees with the spatial distributions of the keypoints is considered as the nearest face and is used for the classification of the new face.

5 Experiments

5.1 Dataset

The frontal views of the mugshots are usually with neutral expression. Our mugshot dataset consists of 100 face images downloaded from **http://www.thesmokinggun.com/mugshots.** Some examples are shown in fig. 2.

Images are of different resolutions varies from 321x442 to 700x875. Only the face portion is cropped and created the database. We have created 100 query face images from the 100 database images by performing various transformations to the database images. This is done by using the face transformation tool implemented by the University of St. Andrews available online in **http://morph.cs.st-andrews.ac.uk.** Original face image and its transformed versions are shown in fig. 3. Further, images are converted to gray scale and resized to 300x300 pixels to assess the efficiency of the algorithms considered for comparison. Figure 4 shows the preparation of database image as well as the query image.

Figure 2. *Frontal view of Mugshots*

5.2 Results

The aim of this face identification system is to measure similarity between query face image with all face images of database and retrieve the image which has got highest similarity i.e. nearest neighbour. Since query is created from one of the database images (source or original image), the system should retrieve that specific original face image. We have 100 manipulated faces as queries and 100 original face images of the criminals in the database.

The performance of the proposed method, as described in section 4 is compared with PCA. Eigenfaces are computed for each face in the database and the eigenface of the query face is compared with all faces in the database. Comparison is done by computing Euclidean distance between two eigenfaces. Nearest neighbour of the query is retrieved which has got minimum distance.

In order to evaluate performance of the system we input each query at a time. The identification rate is computed as follows;

$$Identifica\,tion\ Rate = \frac{Number\ of\ times\ Correct\ Positives\ \text{Re}\,trieved}{Number\ of\ Queries}\ x\ \ 100$$

Some resultant face images from both SIFT and PCA are shown in figure 5. Figure 5 shows two false positives and one correct positive retrieved using PCA and correct positives retrieved in all three cases using SIFT approach. The face identification rate is shown in table 1. It is evident from table 1 that SIFT performs better in face identification even under deliberate modifications because SIFT tries to match with each local patch of the image. Since PCA tries to match with whole face, the system needs to train with training faces. However, mugshot database contains only one front view of each criminal thus, PCA performs very poor in this scenario.

Figure 3. *Original face images and its transformed versions*
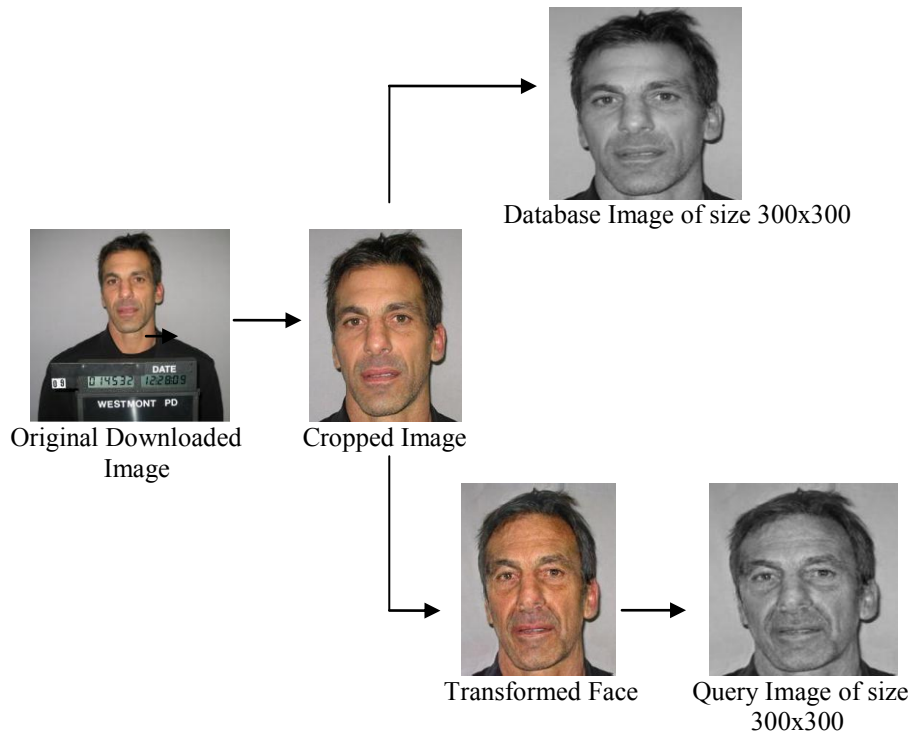
Figure 4. *Preparation of Database image and query image*

PCA   SIFT
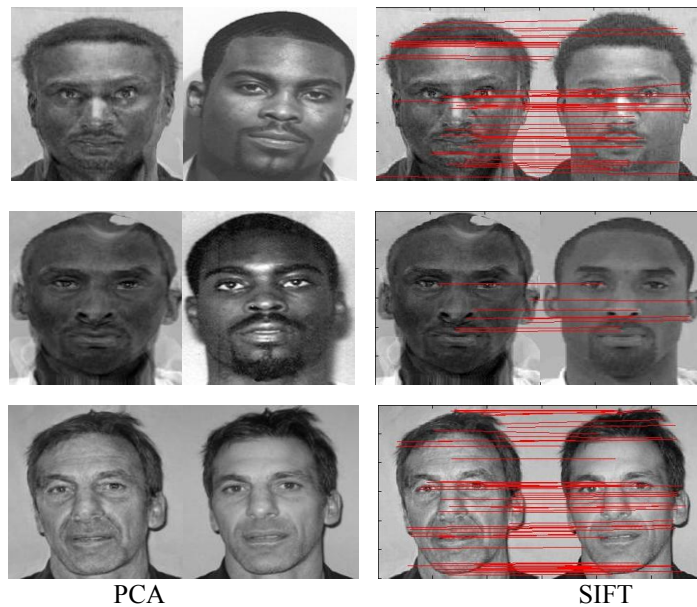
Figure 5. *Retrieved faces from PCA and SIFT approaches*
Table 1. Face identification rate

	SIFT	PCA
Identification Rate	92%	58%

6 Discussion and Conclusion

This paper presents a new approach for face identification from manipulated facial images based on SIFT features. We also introduce a novel pattern matching technique to efficiently reduce the number of false matches. The proposed face identification system aims to measure similarity between query (manipulated or transformed) face image with all face images in the database and retrieve the original image which was used in the creation of query image. Query image is a transformed face image created by using the face transformation software tool. The proposed approach is compared with eigenfaces and proved its superiority through experiments. In this paper, we concentrated only on mugshot identification. As an extension, we are investigating the use of SIFT features for retrieval of correct face with other forms of face tampering.

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