An Efficient Approach in Face Recognition for Invariant Faces using SIFT, SURF and PCA

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Abstract

This paper presents an efficient algorithm based on SIFT (Scale Invariant Feature Transform), SURF (Speeded up Robust Features) and PCA. The method applies the SIFT and SURF algorithm in the detection and description for image features for a particular image and then applying PCA to the image for the better performance in matching in terms of rotation, expression and pose. The SURF technique is fast and robust interest point detector which is used in many computer vision applications. The basic process of face recognition system and improvement in matching the invariant faces is described in this paper. Performance can be seen on the basis of Recognition rate and Computation time. Image Processing Toolbox under MATLAB Software is used for the implementation of this proposed work.

Keywords: Face Recognition, Face Recognition Algorithms, SIFT, SURF and PCA, Matching, Recognition Rate, Computation Time

1. Introduction

Face Recognition is one of the most relevant applications of image analysis. Face Recognition is a task of identifying an already detected face and telling exactly whose it is and also deals with unique facial characteristics of human beings. It can be applied in various challenging fields like video retrieval, security systems and identity authentication. It involves the pattern recognition and image processing. There are mainly two types of comparisons which are described as verification and identification.

1) **Verification** – When the system compares the given individual with the individual whom he says he is and gives a yes or no decision.

2) **Identification** – When the system compares the given individual to all other individuals stored in the database and gives a ranked list of matches [1].

1.1. Face Recognition Algorithms

1.1.1 PCA: Principal Component Analysis commonly uses the eigenfaces in which the probe and gallery images must be the same size as well as normalized to line up the eyes and mouth of the subjects whining the images. Approach is then used to reduce the dimension of data by the means of image compression basics and provides most effective low dimensional structure of facial pattern. This reduction drops the unuseful information and decomposes the face structure into orthogonal (uncorrelated) components known as eigenfaces. Each face image is represented as weighted sum feature vector of eigenfaces which are stored in 1-D array. A probe image is compared against the gallery image by measuring the distance between

their respective feature vectors then matching result has been disclosed. The main advantage of this technique is that it can reduce the data needed to identify the individual to 1/1000th of the data presented [10].

This is a linear method and widely used in appearance-based approaches for FR (Face Recognition). This approach aims at solving the recognition problem within a representation space of lower dimension than image space [2].

1.1.2 SIFT: In 2004 Lowe, invents SIFT descriptor which is invariant to scale, rotation, affine transformation, noise, occlusions and is highly distinctive. SIFT features consist of four major stages in detection and representation; they are (1) finding scale-space extrema; (2) key point localization and filtering; (3) orientation assignment; (4) key point descriptor. The first stage is to construct the key points of images by using Difference-of-Gaussian (DoG) function. The second stage, candidate key points are restricted to sub-pixel accuracy and removed if found to be unreliable. The third stage represents the dominant orientations for each essential point of the images. The final stage constructs a descriptor for each key point location depends upon the image gradients in its local neighborhood. Then the SIFT descriptor is accepting the 128- dimensional vector which used to identify the neighborhood around a pixel. The SIFT extracts the key points (locations and descriptors) for all the database images. Then given an altered image SIFT extracts the key point for that image and compares that point to the dataset [2].

1.1.3 SURF: The SURF also extracts the key points from both the database images and the altered images. This method matches the key points between altered image and each database image. In 2008, H. Bay invents SURF descriptor which is invariant to a scale and in-plane rotation features. It consists of two stages such as interest point detector and interest point descriptor. In the first stage, locate the interest point in the image. Use the Hessian matrix to find the approximate detection [2].

SURF is a scale and in-plane rotation invariant detector and descriptor [13].
SURF detectors are find the interest points in an image, and descriptors are used to extract the feature vectors at each interest point just as in SIFT. SURF uses Hessian-matrix approximation to locate the interest points instead of difference of Gaussians (DoG) filter used in SIFT. SURF as a descriptor uses the first-order Haar wavelet responses in x and y, whereas the gradient is used by SIFT. SURF usually uses 64 dimensions in SURF to reduce the time cost for both feature matching and computation. SURF has three times better performance as compared to SIFT [18].

2. Related Work

In [1], a pose-invariant face-verification method is proposed, which is robust to alignment errors, using the HR information based on pore-scale facial features. A new keypoint descriptor, pore-Principal Component Analysis (PCA) - Scale Invariant Feature Transform (PPCASIFT) - adapted from PCA-SIFT is devised for the extraction of a compact set of distinctive pore-scale facial features.

This article [3] provides the overview of Scale invariant feature transform (SIFT) to extract distinctive invariant features from images can be used to perform reliable matching. Results show that SIFT is flexible recognition algorithm as compared to Contour matching algorithm for heterogeneous images.

[5] Presents a novel human face identification approach. This approach consists of three parts: de-noised face database, Adaptive Principle Component Analysis based on Wavelet Transform (APCAWT), and the Scale Invariant Feature Transform approach, (SIFT). For feature extraction the eigenface of PCAWT entered to SIFT algorithm, and

thus only the SIFT features that belong to clusters, where correct matches may be expected are compared according to a specific threshold.

Article [6] presents expressions invariant face recognition by detecting the fiducial points and employing speeded up robust feature (SURF) along with Gabor filter. The presented method is tested with test images with different expressions and found to be a better performer over the conventional SURF algorithm.

(Shungang Hua et al, 2012) Focuses on the matching of the SIFT features between two images, and calculating the distance for SIFT feature vectors to evaluate the degree of similarity between the original and the resized image.

In [7] article, a robust face recognition scheme is proposed. Speeded-Up Robust Features algorithm is used for extracting the feature vectors with scale invariance and pose invariance from face images. Then PCA is introduced for projecting the SURF feature vectors to the new feature space as PCA-SURF local descriptors. Finally, the K-means algorithm is applied to clustering feature points, and the local similarity and global similarity are then combined to classify the face images.

In [11], an evaluation of using various methods for face recognition is presented. As feature extracting techniques we benefit from wavelet decomposition and Eigenfaces method which is based on Principal Component Analysis (PCA). After generating feature vectors, distance classifier and Support Vector Machines (SVMs) are used for classification step.

The objective of [12] is to develop the image processing and recognize the faces using PCA-based face recognition technique. MATLAB based programs are implemented to identify the faces using Indian databases and the Face recognition data, University of Essex, UK. For matching unknown images with known images, different techniques like sum of absolute difference (SAD), sum of squared difference (SSD), normalized cross correlation (NCC) etc. can be used which has been shown.

[17] Examines (and improves upon) the local image descriptor used by SIFT. Like SIFT, the descriptors used encode the salient aspects of the image gradient in the feature point's neighborhood; however, instead of using SIFT's smoothed weighted histograms, principal components analysis (PCA) are applied to the normalized gradient patch. Our experiments demonstrate that the PCA-based local descriptors are more distinctive, more robust to image deformations, and more compact than the standard SIFT representation.

3. Previous Work

In the previous work, SIFT (Scale Invariant Feature Transform) is used for the extraction of features of the image. After the feature extraction, eigenvectors to be extracted from each face image, PCA (Principal Component Analysis) is applied directly to that image. The goal of PCA is to extract the important information (features) from the face data to depict it as a set of new orthogonal variables which are called principal components. But in case of PCA-SIFT, the problem arises when there is a change in expression or contrast. Rotation also does not give better results. Recognition rate decreases under varying expressions, contrast as well as rotation. Hence, computation time also increases in this case.

4. Proposed Approach

A new approach is proposed with better results in case of rotation, change in expressions and contrast for invariant faces. The block diagram of the proposed system is shown in the following figure:-
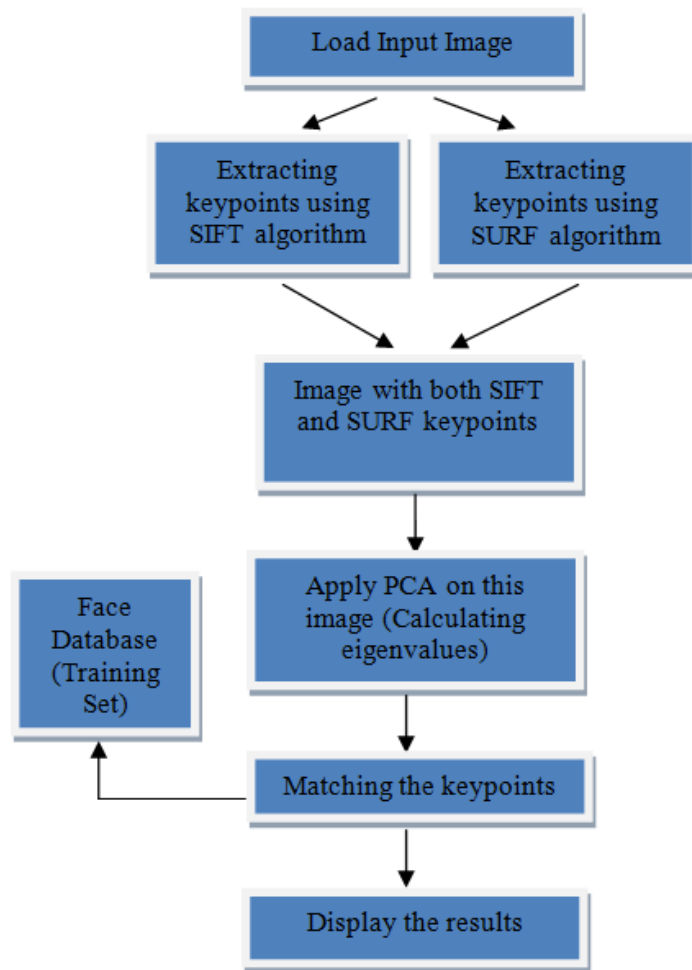
Figure 1. Methodology of Proposed Approach

Step 1: The input image will be loaded into the system.

Step 2: The image then will be pre-processed into gray-scale image.

Step 3: The features will be extracted from that image using both SIFT and SURF algorithms respectively.

Step 4: And then there will be an image produced which consists of both the features using SIFT and SURF.

Step 5: PCA will be then applied directly to that image. The goal of PCA is to extract the important information (features) from the face data to depict it as a set of new orthogonal variables which are called principal components.

Step 6: Now matching will take place between the input image and the image on which PCA is applied having different expressions, contrast and rotation for invariant faces.

5. Results and Discussion

The proposed algorithm is tested on the facial images. The Matlab tool is used for extracting various features. The Matlab tool is a software package that allows for doing mathematics and computation, to analyze data, to develop algorithms, to do simulation and modeling and to produce graphical displays and graphical user interfaces. It allows us to test algorithms immediately without recompilation. Matlab commands are either

executed in scripts or functions, or directly at the command window. All of the current variables, as well as basic information about them, can be viewed in a convenient graphical window called the workspace. The current directory window displays the files in the current working directory.
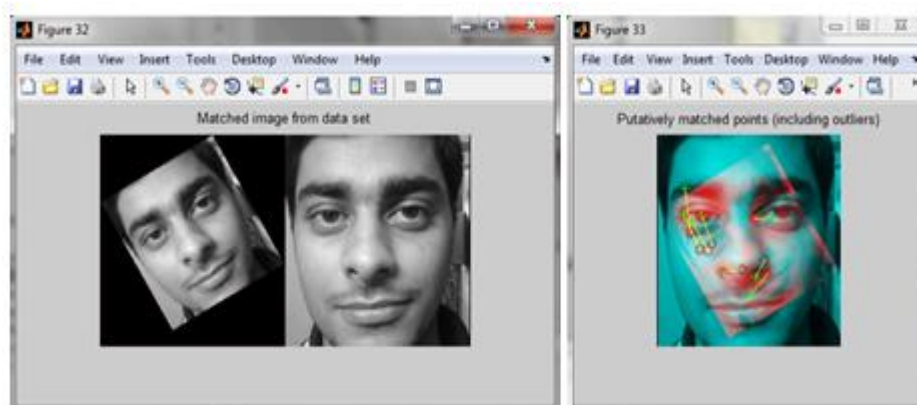
We have evaluated our results using invariant face images categorized as follows:
 ➢ Case I: Image is Normal.
 ➢ Case II: Image is Rotated.
 ➢ Case III: Image is Rotated and change in Contrast of Image.
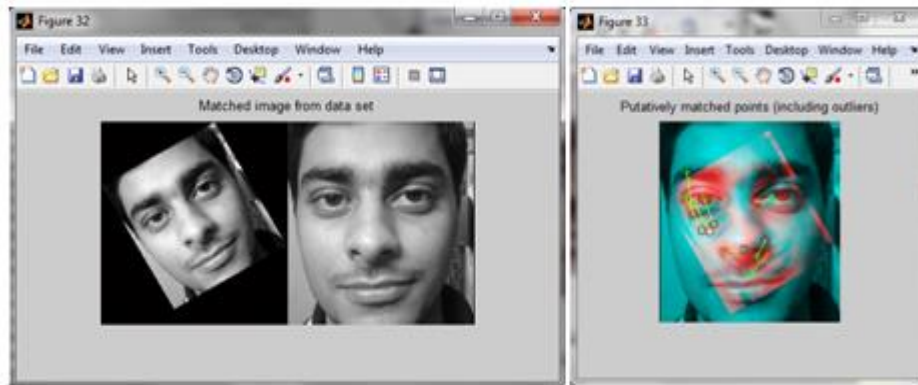 ➢ Case IV: Image is Rotated and change in Expression.

The results of all images are shown in Figure 2 to 5.

Figure 2. Input Normal Image Matched to the Image Stored in the Database

Figure 3. Input (Rotated) Image Matched to the Image Stored in the Database

Figure 4. Input (Rotated) Image as well as with Different Contrast Matched to the Image Stored in the Database

Figure 5. Input (Rotated) Image as well as with Different Expression Matched to the Image Stored in the Database

Performance of the proposed work has been examined by comparing the proposed scheme with the existing one for face recognition of invariant faces on the basis of Recognition Rate and Computation Time.
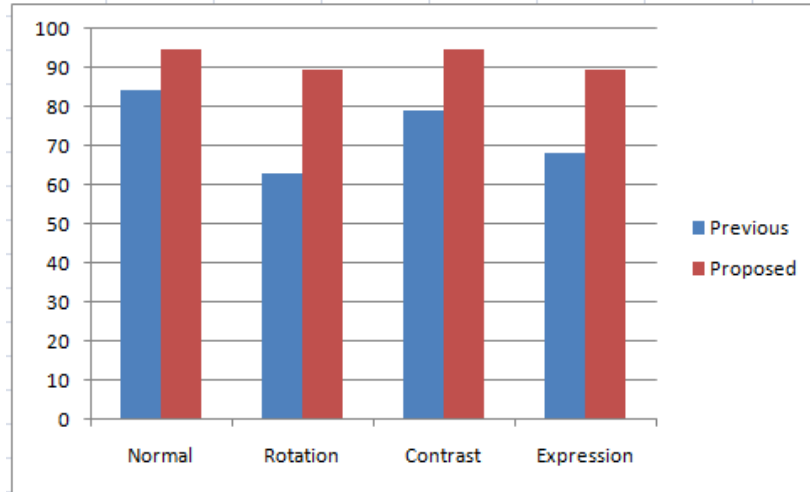
5.1 Recognition Rate

Recognition rate is defined as the recognized number of faces divided by the total number of images presented.

Recognition Rate = Number of faces recognized/Number of faces presented

Table 1. Recognition Rate between Previous and Proposed Approach

Case	Previous %	Proposed %
Normal	84.21	94.73
Rotation	63.15	89.47
Contrast	78.94	94.73
Expression	68.42	89.47

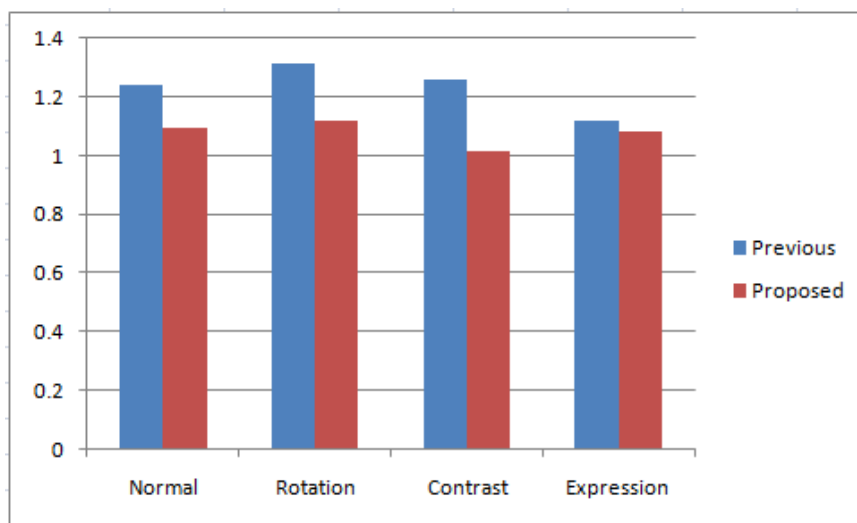**Figure 6. Bar Chart Representation of Recognition Rate Results**

In our proposed work we are using SIFT, SURF and PCA for better results. But in previous methods the results are not good. So, in Table 1 and Figure 6, we can say our approach is better as compared to previous work.

5.2   Computation Time

Computation Time uses tic and toc functions and enables the time our code takes to run. Invoking tic starts the timer, and the next toc reads the elapsed time.

Table 2. Computation Time between Previous and Proposed Approach

Cases	Previous %	Proposed %
Normal	1.240	1.098
Rotation	1.312	1.120
Contrast	1.260	1.014
Expression	1.120	1.082

Figure 7. Bar Chart Representation of Computation Time Results

It has been observed from Table 2 and Figure 7 that our proposed approach is better than the previous approaches in different types of images.

6. Conclusions

The work presents the new method to solve the problem of matching of images in case of invariant faces. This method is fast and provides better recognition rate. This is an effective face recognition method which uses SIFT and SURF features to extract the features from face images and finally PCA technique is applied to the image for better matching results in case of change in expressions and contrast as well as rotation. PCA-based SIFT and SURF local descriptors are more robust than original SIFT local descriptors.

Acknowledgments

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