Face recognition method combining SVM machine learning and scale invariant feature transform

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Abstract. Facial recognition is a method to identify an individual from his image. It has attracted the intention of a large number of researchers in the field of computer vision in recent years due to its wide scope of application in several areas (health, security, robotics, biometrics...). The operation of this technology, so much in demand in today's market, is based on the extraction of features from an input image using techniques such as SIFT, SURF, LBP... and comparing them with others from another image to confirm or assert the identity of an individual. In this paper, we have performed a comparative study of a machine learning-based approach using several classification methods, applied on two face databases, which will be divided into two groups. The first one is the Train database used for the training stage of our model and the second one is the Test database, which will be used in the test phase of the model. The results of this comparison showed that the SIFT technique merged with the SVM classifier outperforms the other classifiers in terms of identification accuracy rate.

1 Introduction

Image processing is an advanced technology that combines several domains (AI, Big Data, Machine Learning, Deep learning...) used to analyze images with different constraints (rotation, change of brightness...) and compare them. It has undergone a rapid and enormous evolution thanks to the technologies of Big Data and neural networks [1]. Recognized for its performance in terms of identification, image processing is now experiencing very strong growth, due to the various fields of use such as lung cancer detection [2] [3], as well as skin cancer detection [4], in the health field. It is also used in the security field for the identification of individuals in video surveillance cameras [5].

Facial recognition is part of the field of image processing. It aims at identifying individuals by analyzing an image with different methods and comparing them to others via a face recognition system. This is done by going through an elaborate process in several steps defined as follows:

1. Original image or video
2. Face Detection and Normalization
3. Feature extraction
4. Comparison of characteristics
5. Identification

Firstly, the face recognition system detects the face in an image, or video sequence [6]. The result of this detection has a direct influence on the performance of the face recognition system. Several existing methods are dedicated to face detection (head shape, skin color, or facial appearance...), while others use multiple techniques that are combined into one.

Face detection methods can be divided into four categories [7]:

- Knowledge-based methods
- Feature invariant approaches
- Template Matching Methods
- Appearance-based methods

Then the face image is captured and isolated for analysis using feature extraction algorithms [8] such as SIFT [9], SURF [10], FAST [11], LBP [12]. These are in turn used in the matching phase by performing a comparison to a face database where classifiers such as LDA [13], PCA[14], SVM, CNN [15], KNN [16] are used, which increases the accuracy of the match and gives more performance to the system that integrates it.

In this paper, we propose a state of art on the different works done on face recognition and a comparative study of our method using several classifiers, which is based on the machine learning technique to better optimize this phase in terms of accuracy rate. This study was performed using two databases of faces with different variances (occlusion, luminosity, rotation...). The rest of this paper is structured as follows: Section 2 discusses the state of the art and the description of our studied method, Section 3 presents the results and discussion of our proposed method. In the end, section 4 is a general conclusion that evokes some perspectives of this research axis.

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2 State the art and methods

2.1. Methods based on feature extraction

Key points or points of interest are existing areas in an image that characterize them. Most of the new approaches are based on this approach to improve the accuracy and processing time of Matching between two images. In [17] two new approaches were developed, the first one uses a SIFT detector and a SURF descriptor, the second one uses a SURF detector and a SIFT descriptor. Tests on two databases LFW and Face94 showed that both methods gave good results up to 87.765%, an accuracy rate for the first method amounts to 85.005% for the second method. [18] Proposed a method that is based on the normalization of vector descriptors and combined with the RANSAC and SIFT algorithm to cancel outliers to calculate the Hessian matrix. This method gave an accuracy rate of up to 96.6%. [18] Examined the quality of various combinations of a detector (SURF, Hariss-Stephen, and Min-Eigen Features) and descriptor (LGHD, PCEHD, and EHD), with the incorporation of dimension reduction using the Hypercomplex Fourier Transform HFT and noise reduction by RANSAC. The result of this examination showed that the method using Eigen Features as the detector and LGHD as the descriptor is the most efficient with a score up to 90.67%. [20] Proposed the exploitation and comparison of SURF and SIFT features in face recognition using SURF-64, SURF-128, SIFT-128, SURFdbl-128, and SIFTdbl-128 where 64 and 128 indicate the dimensions of the feature vectors and dbl indicates that the image size was doubled before feature extraction. This comparison showed that the recognition rate of SURF features (96%) is only slightly higher than that of SIFT features (96.6%). The different results of the state of the art are summarized in the table below (Table 1).

Table 1. The accuracy rate of key point approaches

Method	Database	Accuracy rate
SIFT detector and SURF descriptor [17].	LFW and Face 94	87.765%
SURF detector and SIFT descriptor [17].	LFW and Face 94	85.005%
SIFT and RANSAC [18]	Orl, Grimace, Face 95 and 96	96.6%
Eigen Features and LGHD [19]	Face 94 and Grimace	90.67%
SURF-128 [20]	Feret	96%
SIFTdbl-128 [20]	Feret	96.6%

2.2 Classification methods

In the literature, there are new classification methods to improve the accuracy rate based on different classification techniques. In this section, we discuss some of the existing methods such as [21], which evaluated the classification rate of two techniques based on classifiers. The first technique uses the two methods PCA-SIFT and SURF associated with the RANSAC algorithm for feature extraction and uses the Euclidean and Manhattan distance metric for classification. This technique gave a classification result of 96.65% in the case of the Euclidean metric and 93.125% in the Manhattan case. Moreover, the second technique uses TPLBP (Triple Local Binary Pattern) feature extraction method with the SVM (Support Vector Machine) classification method, which gave a result of 98.125800% classification rate. [22] Proposed the design and evaluation of a real-time face recognition system using CNNs, which achieved an accuracy of up to 98.75% on a real-time dataset containing 10 images of 40 individuals for 400 images. A hybrid approach was proposed in [23] using SPA- KNN (SIFT-PCA-KNN). This method is divided into three steps. The first step is to use the Graph-Based algorithm and the SIFT descriptor for image preprocessing. The second step is to extract the important data from the face and represent them as a set of new variables, and then apply the PCA (Principal Component Analysis) method to eliminate the outliers. Finally, the KNN classifier is used in the last part to classify the images. This method gave an accuracy result of up to 96%. Another hybrid method was used in [24] by merging the two techniques Gabor and LBP in the feature extraction part, then the dimension reduction method is used to reduce the pattern vectors, and finally, in the identification phase, two techniques are combined, KNN and SRC. The accuracy rate reached a value of 94.16%.
The different results of the state of the art are summarized in the table below (Table 2).

Table 2. The accuracy rate of approaches using classifiers

Method	Database	Accuracy rate
PCA-SIFT and Euclidean [21]	Orl	96.65 %
SURF and Manhattan [21]	Orl	93.125 %
TPLBP and SVM [21]	Orl	98.125800 %
CNN [22]	Orl	98.75 %
SPA-KNN [23]	ESSEX face	96%
KNN-SRC [24]	LFW	94.16%

2.3 Discussion

Based on the results of this brief overview of the work done, have deduced that the two feature extraction techniques "SIFT and SURF" are robust, with an accuracy rate score exceeding 96% and that the two classification techniques "SVM and CNN" are the most reliable with an accuracy rate score exceeding 98% (see figure below Fig. 1)

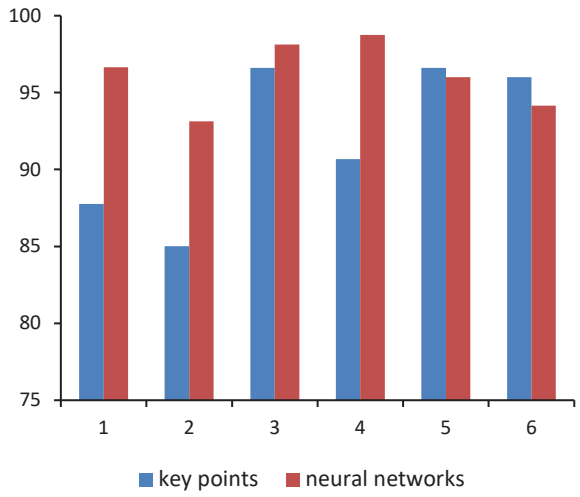

Fig. 1. The accuracy rate of approaches using classifiers

2.4 Database used

2.4.1 Orl dataset

The Orl face database [25] contains 400 images of 40 individuals, taken under different conditions, either by lighting variation, facial expression, or facial details. All images have an identical size of 92x112 pixels, with 256 gray levels per pixel.

2.4.2 Sheffield dataset

The Sheffield face database [26] contains 564 images of 20 individuals where each individual is represented by a set of poses ranging from profile to full face. The images have an identical size of 220x220 pixels and a 256-bit grayscale.

2.5 Proposed method

To carry out this comparison, we had to carry out several processing steps to arrive at the calculation of the accuracy rate. The set of data processing steps is as follows:

Step 1: The first step is to divide the two databases used into two parts with two different percentages for each part. The first will be named Train and the second will be named Test.

Step 2: In the second step, a classification prediction model was formed from the Train part by applying one of the classification methods used (SVM, KNN, PCA, and 2D-PCA).

Step3: Finally, in the last step, the prediction model was applied on the Test part of the database used and the accuracy rate of the model was calculated using the following formula:

$$\textbf{Accuracy rate} = \frac{\text{True result}}{\text{Total number of images}} \times 100$$

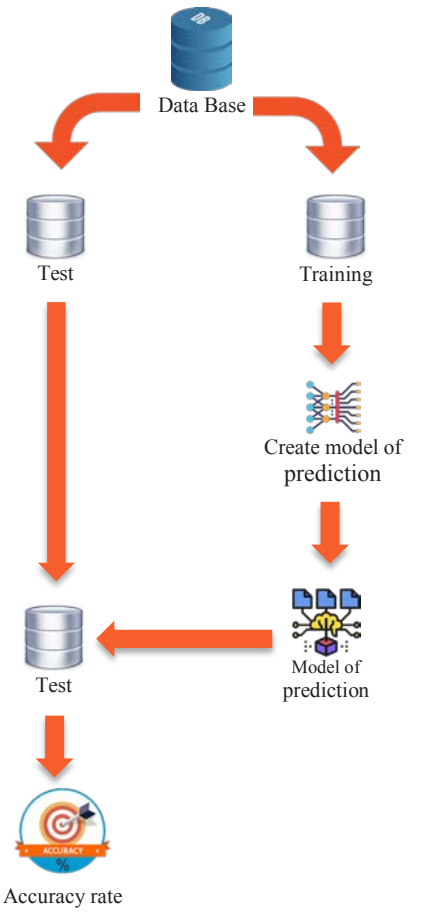

Fig. 2. Schematic of the proposed method

2.6 Results and discussion

The performance evaluation of the different methods was carried out on two orl [25] and Shiefilled [26] databases to test their identification efficiency in the case of a single individual image variance. The results of these tests showed that the proposed technique based on SIFT (Speed Up Robust Features) feature extraction fused with SVM (Support Vector Machine) classification technique performed well in both databases with up to 99.16% accuracy rate for the orl database and up to 99.44% for the Shiefilled database. These results prove that the technique is too efficient despite the presence of variances in the images. For the PCA and 2D_PCA techniques, the results showed that they are effective in the case of slight variance in the orl database with an accuracy rate of up to 96.25% in the case of the 2D_PCA

method. On the other hand, both techniques are weak in identification in the case of the presence of large variance in the images with a rate varying between 27.11% in the case of the PCA method and 43.10% in the case of the 2D_PCA method.

Table 3. Percentage accuracy rate

Method	Orl DataSet	Shiefilled DataSet
SIFT + SVM	99,16 %	99,44 %
LDA + KNN	96 %	96%
PCA	92,5 %	27,11 %
2D_PCA	96,25 %	43,10 %

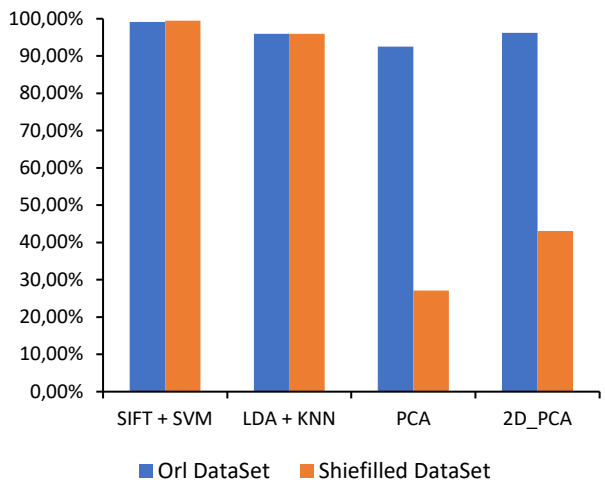

Fig. 3. The accuracy rate of the tested approaches

3 Conclusion

In this paper, we have developed a new face recognition technique that combines the SIFT method for the key point extraction part and the SVM method for the classification part. To validate our method, a comparison of accuracy rates with other classification techniques (LDA-KNN; PCA. 2D_PCA) had to be performed using two face databases (Orl and Shefielld). Simulation results show that our SIFT-SVM technique performed well in both databases, with an accuracy rate of 99% in both cases of image variance (small variance for the Orl database and large variance for the Shefielld database). Finally, it is important to perform more tests on other databases that contain more images of individuals such as LFW (Labeled Faces in the Wild) [27] which gathers more than 13,000 images of faces collected on the Web, to concretize and evaluate the performance of these techniques to choose and use the most optimal technique in particular that helps to elaborate better results.

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