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# Partition-based Face Recognition Using LDP and SVM

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## ABSTRACT

In this paper, an efficient face recognition algorithm has been presented. First, the face image is extracted to reduce the data dimensions. Next, five important facial components are located using Active Shape Model (ASM). Features from these important components are extracted using Local Directional Pattern (LDP). In the recognition module, Support Vector Machine (SVM) is used to train and tested on the resultant features. The high recognition rate of 97% has been obtained by utilizing a minimum number of features using ORL face database. The results of the proposed technique are substantially accurate.

**Keywords:** Face Recognition, Support Vector Machine (SVM,) Local Directional Pattern (LDP), Active Shape Model (ASM), Spatial Coordinate System.

Author`s Contribution
*[1] Data analysis, interpretation and manuscript writing, Active participation in data collection*
*[2] Conception, synthesis, planning of research and manuscript writing*
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## INTRODUCTION

With the advancement of biometric technologies, the face is an important visual part of a human body with respect to identification. In the last decades, face recognition is gaining popularity in the research community. Apart from computer science, researchers from diverse fields like neurosciences, psychology and other sciences are actively working in this emerging field.1In the previous approaches, passwords, IDs and other identification, elements can be stolen or copied. The biometric era eliminates these drawbacks. Such systems are based on fingerprints, Iris, face etc. that cannot be stolen or copied. Face recognition systems have numerous applications in CCTVs, smartcard-based identification cards, driving licenses, video surveillance, video games and many more. Due to widespread terrorism across the globe face recognition became mandatory for the law enforcement and other security agencies[2].

Generally, face recognition systems store face images in the database and it takes decisions on the basis of a stored sample. Face recognition is a challenging task due to age, face poses, expressions,

accessories (glasses, jewelleries) and illuminations. Due to the advancement in this area, the systems are now capable to recognize other objects like vehicles, insects, plants etc. The human face is volatile in nature and is changing quite rapidly with respect to time (from daily to yearly basis). Therefore, cost effective systems are needed to cope with the complexities occurring in the human face (De Marsico, 2015)[3]. Moreover, lightning effects also complicate face recognition (Happy, 2015)[8].

## LITERATURE REVIEW

(De Marsico, 2015)3 proposed a novel approach based on face components, which were taken as witnesses for criminals face recognition. It is very difficult to identify any criminal face, therefore; they proposed the solution in three basic categories like low, medium, and high. In this paper, they have discussed the proposed system that updates the database with criminal list and each face of an individual criminal is stored into the database after dividing a face into five different parts like “nose, eye, mouth, forehead and chin," using the proposed system perform on each face image some pre-processing, cut all unwanted data like background etc. In the proposed partition-based approach, the input image by the eyewitness is considered as a basic part of any face detection. The system then compares the eyewitness with database face partitions. If the single match is found by a single eyewitness, then a system gives the signal to verify criminal face. But in the proposed system during the comparison, it is possible to have many same eyewitnesses, therefore; they suggest a comparison with other parts stored in the database to verify criminal face. They prove that partition based system has some advantages over other techniques for face recognition like fast and accurate face recognition, In a single frame many processes at a time and last database operation. The proposed technique takes less time in recognition process and provides accurate results for different parts matching. The proposed system has the ability to perform multiple faces processing for recognition. Moreover, it is reliable for a large database.

(Happy, 2015)8 suggests face recognition approach for authentication of terrorists. In this paper, the system is divided into two phases, (face database formation phase and training phase). In the first phase, the system takes an image using different resources and applies different techniques for normalization or pre-processing and histogram equalization for reducing the background, for unwanted data and for enhancement of images for further processing. In the proposed system, the second phase is related to saving training set values or vector, which is also called Eigen faces using Principal Component Analysis (PCA). PCA is used in this paper for calculation of Eigenfaces and stored in the specified database for later use. In this paper, PCA extracts those image values that have more information. In this paper combine techniques for accurate and fast recognition system development. In this paper, the application of the proposed system is discussed that could be implemented for the security of airport and border crossing points. In this paper, the given approach is firstly trained with images of terrorists gathered from different terrorist lists, using Principal Component Analysis to extract some features from images. The features contain width and height of the eyes by calculating ration between height and width; find the ratio between two eyes distance. The height and width of face, fine skin color ratio and different colors of the eye like red, blue and green are also extracted as features and find the ratio between these colors like the ratio of the red and green (RG), ratio between green and blue (GB) and the ratio between red and blue (RB) to find the actual process for feature extraction. In this paper, the feature extraction technique is also used to find the location of the eyes and calculate distance average colors values and store. After that, the proposed approach calculates the average value of the eye from combining width and height of the divided by two. In this paper, the authors describe that before calculating the weight of the terrorist image stored in the database, the value of weight must be calculated from these features which are denoted by different numbers and finally sum all these denoted values for finding aggregate values of each face image. The weights are then stored in the database with another information (name, etc.) of terrorists. In this paper, they combine feature based technique with principal component analysis for the efficient system. The aggregate weights of a single image are calculated through principal component analysis after individual feature's extraction from each image and thus finally stored in the database.

In the paper, the recognition phase is explained by the authors: according to them, the input image should be taken by the camera and normalized for any effects and resize to default on size. In recognition phase, the PCA is then used for calculating a weight for an image from these features. PCA is calculated to find Eigenface from the extraction phase. The decision is taken after comparing two weights, database weight and testing weights (acquired image). In this paper, the proposed system checks the similarities, "known" if find similarities otherwise "unknown." Finally, they prove after the experiment that the proposed system is presented as best recognition rate as compared to the existing techniques.

(Huang, 2015)9suggest new component-based approach for face detection which is based on Support Vector Machine (SVM) classifiers. The proposed system is trained for gray and still images. In each image, the system focuses on the frontal view of face specially targeted eyes, nose, and mouth. The authors suggest two steps for proposed system; in the first step, the classifiers detect components independently, while the second step performs matching of geometrical components. For learning purpose, they suggest automatic learning method for components using 3-D head models while this model extracts components automatically from 58x58 image window. Components based system (proposed system) consists of fourteen Support Vector Machine (SVM) linear classifiers for detection components and for geometrical classification a single SVM classifier is used.

(Ma, 2010)10 has presented component-based online learning method for face verification and detection using unsupervised clustering. For highly repetitive tasks, online learning is quite different from previously proposed techniques. If the cluster contains some similar features to existing cluster then the system assigned to that cluster, in case of dissimilarity the system creates a new cluster. Similarities between clusters are found using distance measurement. Component-based model is used for face verification and detection to provide high accuracy in case of illumination variation, pose, and occlusions. The system detects each component independently i.e. eyes, nose, and lips. The proposed system uses Lip Map and Eye Map for detection, NoseMap for verification purpose which angles between these components for relation and distances between these components. After performing experiment the author claimed that the online learning proposed system was faster than existing approaches because of automatic component detection and findings of the relationship between components.

(PVSSR, 2016)11 proposed two-layer component-based framework for identification/detection. In this model, the first layer contains component classifiers for detection/identification of an independent component of the face. In the second layer, a single combination classifier is used for combining the output, generated by the component classifiers. The component classifiers are basically second-degree polynomial Support Vector Machines (SVMs), trained on synthetic face images. The authors have used four types of combination classifier for component classification: Classification which based on the maximum vote between component classification, a classifier based on the product of real-valued, classifier based on the sum of real-valued component classifiers output and trained linear SVM on component classifier outputs. After performing experiments on different component-based and global feature, PCA, LDA, and SVM, the accuracy of using linear SVM was very high as compared to others.

(Ullah, 2017)18 suggest two global methods and component-based method for face recognition. In the proposed system, firstly all face components are located, secondly these components are extracted and finally combined into a single feature vector, classified by SVM classifier. In this paper the authors have explained that both global systems detect the whole face which is extracted from the image and is given to SVM classifiers as input. The first system contains single SVM for every person in a particular database while the second system contains the clustered database for each individual and trained classifier. The performance of component-based system was very high as compared to global systems even included 40o rotated images.

## RESEARCH METHODOLOGY

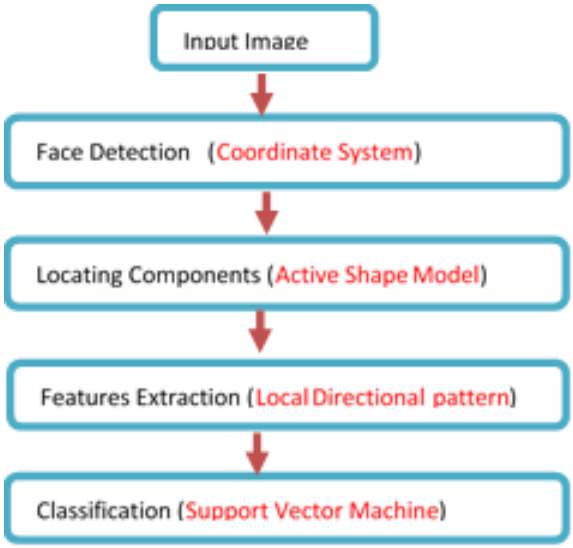


**Figure 1: Block Diagram of Proposed Model**

## Face detection

A small image contains thousands of pixels, and the processing of such huge number of pixels consumes more computational time. Discarding the unwanted area from an image is important to reduce the computational complexity. To discard the background region and extract only the facial portion, the spatial coordinate system is used in this work. In the spatial coordinates system, the face can be represented in term of X, Y coordinates. These coordinates are used to find out face using hit and trial method. After finding the spatial coordinate of the face image, the face portion is extracted.

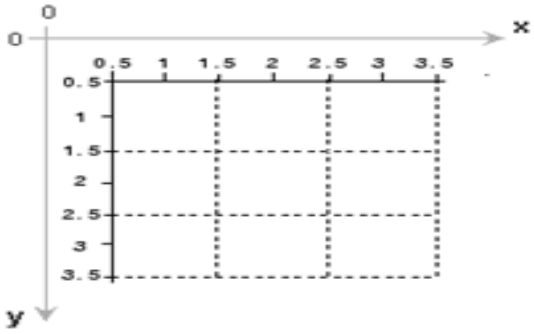


**Figure 2: Spatial Coordinate System**

**Figure 3: Extracted Faces from images using the spatial coordinate system.**

## Facial Feature Extraction

To control the face alignment and occlusion problem, we preferred to extract local features instead of global features. In the feature extracting phase, we have used active shape model (ASM) (sharma 2016)15 for locating five facial components (forehead, eyes, nose, mouth, and chin). These facial components are then cropped using spatial coordinates system.

## Local Directional Pattern (LDP)

Local Directional Pattern (LDP) is more robust in face recognition which is used to overcome the drawbacks of Local Binary Pattern (LBP). LBP considers surrounding neighbor pixels intensities while LDP considers the edge response values in all directions. This behaviour of LDP provides more stability in the existence of noise. Local Directional Pattern is basically an eight-bit binary code which is assigned to each pixel of given input image. This pattern is computed by comparing edge response value of each pixel in eight different directions using Kirsch masks with eight different orientations.

$$\begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix}$$ East ($M_0$)

$$\begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}$$ North East ($M_1$)

$$\begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}$$ North ($M_2$)

$$\begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}$$ North West ($M_3$)

$$\begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix}$$ West ($M_4$)

$$\begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{bmatrix}$$ South West ($M_5$)

$$\begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix}$$ South ($M_6$)

$$\begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix}$$ South East ($M_7$)

**Figure 4: Kirsch edge response masks in eight directions.**

After applying eight Kirsch different masks, we get eight edge response values (M0, M1… M7), each value represents edge response in a particular direction. These values are not equally important, while the presence of edge present high response value in the respective direction. We are concerned to identify the k most important direction to generate LDP. Then the top k values set to 1 and another set to zero 0.

## Support Vector Machine

Support vector machine (SVMs) performs pattern recognition through finding the surface of decision between two points, in the training set which has a maximum distance to the nearest points (support vectors). Therefore, SVMs fall into maximum margin classifiers class. Support vector machine is mostly used for face recognition. With probabilistic output, we use support vector machines. Let assume that training data is

presented in $D^t = \{(x_i^t, d_i^t)\}_i^N = 1$ the form of for components. In the above formula t {forehead, eyes, nose, mouth and chin}. Presents the feature of a particular component of the image, where belonged to(Bengoechea, Villanueva, & Cabeza, 2016), where ("1" for recognized and "0" for not-recognized). Using Dt the component classifier it is trained, after that the classifier results are integrated using different combining approaches. These integration approaches of SVM which is widely used are sum, maximal, product and voting rules. These rules are very simple, no need to train using these approaches. The simplicity of these approaches relies on irrational suppositions that all classifiers are commonly independent. This irrational supposition shows inconsistency in a real environment.

**Fuzzy Approach for Classifier Combination**

To reduce the effect of such suppositions; (Yuan, 2016) proposed the concept of fuzzy integration approach. Fuzzy integral is very famous for multi-attribute classification. Fuzzy integration is basically the integration of a real function with a fuzzy measure which is an expansion of classical measures.

Fuzzy integral contains two basic positive aspects, fuzzy integral with a suitable design measure which simulates any of four methods (maximal, sum, product, voting). Secondly, we can show the significance each classifier and its interaction along with any subsets of the classifiers by using the suitable fuzzy measure.

$\mu$ Present the fuzzy measure on X, Choquet integral function $f : X \to R^+$ with respect to $\mu$, defined by:

$$C_\mu(f(x_1),....,f(x_n)) \Delta \sum_{i=1}^{n} (f(x_i) - f(x_i - 1))\mu(S_i)$$

Where i indicate it indices permuted:

$$0 = f(x_0) \le f(x_1) \le ... f(x_n) \le 1 \text{ and } S(i) \Delta \{x_1, ..., x_n\}.$$

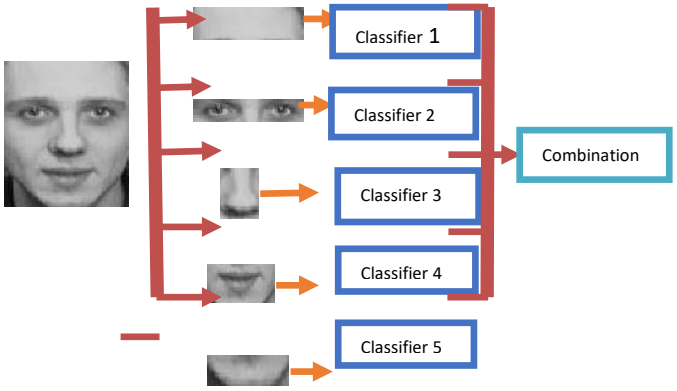


**Figure 5: Block diagram of dividing the face into components and using classifiers.**

## RESULTS AND DISCUSSTION

We have used Matlab R2012a environment for our proposed technique experiments which are on ORL database. ORL database is a free and well-known database of face images. It contains face images of 40 individuals, and each person has 10 different view images. This different view of each individual face is looking to the left, looking for the right upward and downward. The pixels size of ORL database images is 92×112, and images are presented in gray-level. The face images are taken between April 1992 and April 1994 at a different time, with different lighting conditions and different facial expressions (Rieul, 2018)14. In the Preprocessing step, spatial coordinates system is implemented to extract the facial portions and to avoid the background region. Important facial components like forehead, eyes, nose, mouth, and chin are located on the face by using Active Shape Model (ASM) (Sharma, 2016)15 strategy which is shown in Figure 6.

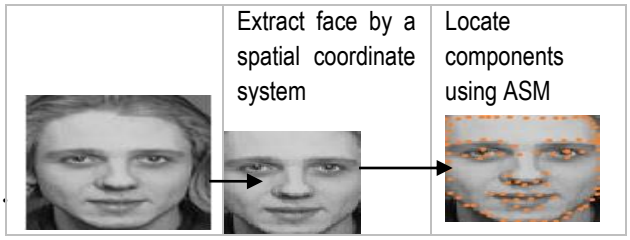


**Figure 6: Extract face from the image and locate components**

After locating important facial points, the facial component is then extracted from face portion. In the features extraction step, Local Directional Pattern (LDP) technique is used to extract both local and global features. After extracting face features, we trained five

Support Vector Machine (SVM) classifiers for each individual component feature. For a combination of the results of different SVM classifiers, we propose a fuzzy integral method. The size of the local and global feature vectors are given below.

Local Feature Vectors: FS-1 30, FS-2 50 and FS-3 60.

Global Feature Vectors: FS-1 50, FS-1 70, FS-1 90

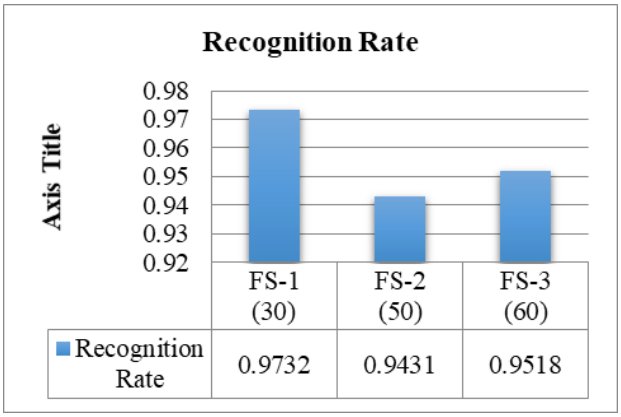


**Figure 7: Recognition rate using local features**

As shown in figure 7, the high accuracy rate of 97% has been obtained by using feature set of size 30. It is noted that feature set of size 30 contains more discriminative features as compared to the feature set of size 50 and 60. The accuracy rate of global features set is also measured and shown in figure 8.

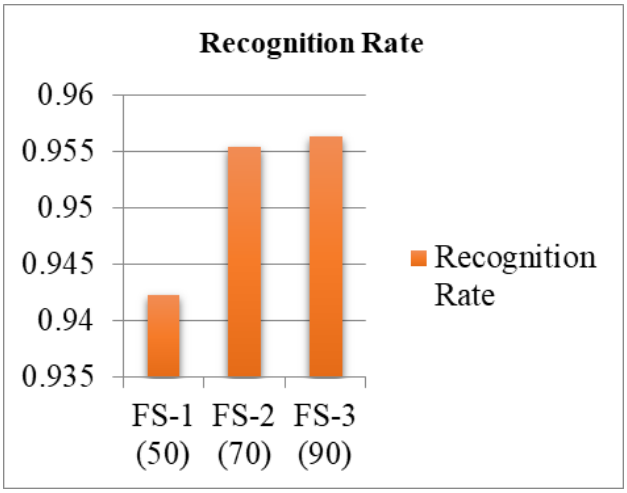


**Figure 8: Recognition rate using global features**

The figure shows that average highest accuracy rate is 96% in the case of FS-3 (90). It is crystal clear that the accuracy rates of local features are higher than the global features 8.

**Table 1: Recognition rate of different techniques with different dimension**

| Techniques | Dimensions | Accuracy Rate |
|---|---|---|
| Proposed Technique | 30 | 97% |
| LBP | 90 | 92% |
| EHMM-LBP | 85 | 92.5% |
| Multi-LBP | 85 | 94.5% |

Experiments are also performed on some standard technique like LBP and then the results are compared with the proposed technique. The table below shows these facts. It has been noted that proposed technique is more accuracy and having less time complexity due to reducing data dimension as compared to other standard techniques. In table 1, the proposed technique is compared with some other face recognition standard techniques. The proposed technique is having more accuracy rate as compared to other techniques.

## CONCLUSION AND FUTURE WORK

The component-based approach is presented in this paper which is more accurate in face recognition and computationally more efficient. The proposed system takes 3 seconds to recognize face image. It has been concluded that the component extracted from the face using LDP produce good results as compared to the global feature extracted from the face image. Selection of the appropriate classifier (i.e. SVM in our case) also contributes to improving the overall recognition accuracy rate. We are planning to implement the proposed technique on real-world face image.

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