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Biometric Security System for Watchlist Surveillance

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Abstract

We propose a biometric security system to identify miscreants (Watchlist person) whose information is already provided in the database. With huge volumes of information being brought forth from these surveillance cameras, methods are needed to automatically analyze these surveillance videos. In our approach we combined Principal Component Analysis (PCA) with Nearest Neighbor replacing threshold value by confidence value. The proposed approach works with only one image per person. We are able to reduce recognition time and an alarm needs to be generated as soon as a Watchlist person is caught in the video.

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Keywords: Principal Component Analysis (PCA); Nearest Neighbor (NN); Euclidian Distance; Biometric Security; Watchlist, Confidence Value;

1. Introduction

Face recognition has become a very hot topic of research and its major application is public security with the help of surveillance cameras. Due to an increase of terrorist actions in recent days, it is not possible to watch over miscreants all the time with human eyes. So we need surveillance cameras to be installed in public and private areas like country border, metro station, open market and confidential offices and so forth. And a system which can detect miscreant peoples efficiently. Our primary motive here is to pick out those suspected people from the crowd who are present on a Watchlist under outdoor and uncontrolled conditions. Video surveillance is a smart way to recognize

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any object or human, living and non-living things. It is a wide area of research under image processing and computer vision. When it comes to recognizing a human being, we can use his/her single or multiple biometric features for this purpose. A person has many unique features which can be used for authentication, recognition and identification purpose. For example, fingerprint, iris, body structure and face, etc. are the main components which we can use to judge any individual. But in the case of surveillance fingerprint, hand geometry and iris do not work in a real environment, for surveillance, we need reliable biometric information, in case of human recognition for surveillance point of view face is the only reliable biometric feature which we can use for video surveillance in real environment. Automated watch list surveillance is a very important application area using the face recognition technique, here we simply acknowledge those little sets of suspected people who are present on a Watchlist, and rule out everybody else.

2. Literature Review

Yang et al.[1] proposed new kind of approach in the field of face recognition; they worked on well known traditional face recognition approach called Principal Component Analysis (PCA) and they measured the performance of PCA in all directions and after analyzing the results he found if we use PCA with high dimensional images and it will take more time to calculate the covariance matrix. Fortunately eigenvectors can also be calculated by Singular Value Decomposition (SVD) method and then the role of the covariance matrix is out of the picture. But by using SVD these eigenvectors cannot be determined efficiently, so author proposed 2D PCA where 2D matrix need not to transform into a 1D vector and this proposed approach is fully based on 2D matrices and covariance matrix and eigenvectors can be directly computed in less time with high efficiency. But one limitation author found is the storage requirement in 2D PCA is more when compared to conventional PCA.

Gottumukkal et al.[2] proposed modular PCA technique and this approach that is based on partition the face image. In this approach, each face image is partitioned or divided into a number of sub images. And then author applied PCA on each module and this approach provides more recognition rate when compared to conventional PCA under condition of large variations in facial expression and illumination. But one shortcoming the author found is it does not work well under the condition of pose variance. And no threshold value is used in this paper for recognition.

Parsi et al.[3] proposed a novel approach on a biometric security system in which author used face as a biometric feature and author is motivated by human perception to recognize people from the crowd and he used his own classifier for that purpose. In this approach author recognizes only those individuals who are present on a watch list. Author proposed image morphing technique for recognition and it involves two steps. Firstly, source image features move toward destination image and secondly, adjusting the gray level of the source image to the destination image. Author used Active Shape Model (ASM) to locate feature points in a face image.

Lee et al.[4] proposed a novel approach to recognize human faces in video sequences. In this approach, each enrolled user is having many pose variance appearances and it can be represented by low dimensional manifold Images with varying viewpoint can be considered as low dimensional manifold in image space. It is a very challenging task to recognize an individual from a video with varying pose (not a frontal view). Author uses L^2-Hausdorff distance between the image and its manifold. In which temporal information can be approximated. Images having large variation in a pose can be approximated by taking the union of the entire view specific manifold. Author uses several probabilistic equations[4] for approximation purpose from the video frame so that partial occlusion problem in recognition can be resolved. Author also utilizes temporal information with the help of transition matrix which can be helpful to recognize any individual with partial occlusion. A limitation which author found in that work is, face images need careful alignment with control data set and it is sensitive to large illumination change.

Fan et al.[5] proposed a novel approach for video based face recognition method using both temporal and spatial information simultaneously. One of the hard authors found problems in video-based face recognition is how to effectively combine the facial configuration and temporal dynamics for the recognition task. The proposed method deal with this problem and solution consist two steps. Firstly view specific manifold need to be learned from the surveillance video frame and it is performed using Locally Linear Embedding (LLE)[5]. And while recognition a general Bayesian inference model is then applied[5]. Some views specific Sub-manifold need to be learned. Author uses K-means clustering by LLE for this purpose. It is a novel video-based face recognition method using both

spatial and temporal information simultaneously. Advantages of this paper are, manifold learning and Bayesian inference are combined and approach for integrating prior knowledge and observe data to improve the classification performance. One limitation which authors concluded that view-specific manifold need to be learned.

3. Face Recognition Process

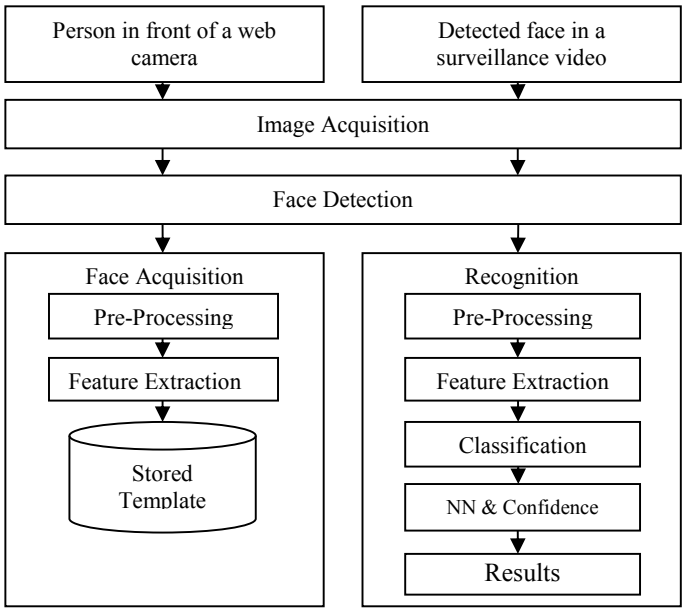

Fig. 1. Proposed process flow of face recognition systems.

Recognition of face in surveillance videos is a more challenging and difficult task because it handles some of the major challenges like image background, illumination, pose, etc. We can divide face recognition process into three parts namely

- Face Detection
- Feature Extraction
- Face Recognition

4. Overview of the System

The proposed biometric security system acts in two phases, namely enrollment/acquisition and recognition/verification. We present a technique that uses PCA for feature extraction and Nearest Neighbor for classification, PCA is not counted for real time recognition, in fact, it is likewise not suitable for videos as well when it comes to accuracy. And then to make PCA work in real life environment, we replaced the threshold value concept of PCA with Nearest Neighbor (NN) and we provide confidence value for each detected image which defines the probability of test images to the gallery image. The threshold value is itself a vast field of the research so by using nearest neighbor with confidence value we overcome this issue. Our system consists of several modules, namely Image acquisition, enrollment, face detection, recognition, and verification. The weakness of the PCA algorithm, however, is that, when it is used for surveillance purpose, it does not give fast and accurate results. Moreover, the training requires multiple images of the same individual. The proposed approach works with only one image per person in the database. For single image per person, we need to set specific threshold value depending

upon the environment for recognition. We are able to reduce recognition time so that we can do surveillance in real environment with better accuracy.

1.1 Enrollment Phase

Firstly, in the enrolment process, the face image is acquired with the help of a web camera and at the meantime pre-processing is done and after normalization, the entire details of each face are saved in a database (Watchlist).During enrollment process face image is pre-processed. And after that facial features are extracted using PCA (Principal Component Analysis) and these features along with person data are stored in a database.

1.2 Recognition Phase

In this phase of our system person face is again acquired from live videos and then system identify who the user is and whether the user is presented in a Watchlist, And verify the target person from the crowd. While identification involves comparing obtained biometric information with test image.

- **Image Acquisition**

The purpose of this module is to seek and then extract region of the face from a video and then face detection techniques are applied to detect only facial information that is to be used for recognition purpose and then the image is resized, geometrically corrected and all other background information is eliminated which unrelated to face for better recognition.

- **Face Recognition / Verification**

In face recognition module, our purpose is to recognize any face found in a video from a web camera, recognition is performed between web camera and database images. It contains pre-processing, feature extraction and classification module.

- **Pre-processing**

The purpose of pre-processing is very crucial in face recognition it is practiced to eradicate or reduce some variation in face image due to illumination and natural environmental noise, it also posses normalization process. It includes image cropping, resizing, and conversion of face image to character image and histogram equalization.

- **Feature Extraction**

The purpose of this process is to extract facial features and these facial features are extracted as feature vector here we use Principal Component Analysis (PCA) as feature extraction technique.

5. Principal Component Analysis with Nearest Neighbor

The Principal Component Analysis (PCA) method is a well known conventional technique. Here we use the PCA method for training and feature extraction and with the help of this method we are able to reduce dimensionality of our data and recognition process can be performed easily. PCA generally not considered good algorithm for video surveillance, but considered one of the best dimensionality reduction approaches in still image recognition and if PCA is used for video surveillance, then it may be combined with some other approaches as well and with more than three images or maybe ten for each person. But here we are using only single image per person for recognition in surveillance in outdoor activity. PCA extracts eigenvectors from face image which are considered as face vectors and it is calculated using covariance matrix. Later on all the steps of PCA we need to define a threshold value which specifies if the test image is good for recognition or not, but putting this value for real life circumstance is very

difficult and it is a separate research topic in itself. Here if we take only the single image of a person than the test image is supposed to be in the exact location with the same angle, same brightness and illumination like gallery image. Otherwise, it will discard these images and would not cross a threshold limit.

Fig. 2. Average image calculated by proposed approach.

Fig. 3. Resulting Eigen faces of each individual.

We apply PCA on this dataset and get the unique feature vectors using the following method. Here we have only one image per person.

- The database of Watchlist people is laid aside and each image is represented as a face vector an image here we have taken eight eigenvector having face size 120 * 90.
- Next step is to calculate a mean image

$$(\bar{x}) = \frac{1}{M}\sum_{i=1}^{M} xi \tag{1}$$

- After calculating mean image, we subtract this average face from each of our normal face vectors (xi), then we will be left with normalized face vectors(ϕi)

$$\phi i = xi - \bar{x} \tag{2}$$

- Transformation matrix (A) is formed by normalized face vectors and covariance matrix (C) is computed.

$$C = AA^T \quad \text{where } A = \{\phi 1, \phi 2 ..... \phi m\} \tag{3}$$

- After this process feature vector is formed. Each face vector represents a face image.
- Euclidean distance between test image and all the gallery image is computed where X= {X1....Xm} and Y = {Y1....Ym}.

$$d(x, y) = \sum_{i=1}^{M} \sqrt{(xi - yi)^2} \tag{4}$$

- Each gallery image which is having least distance with the test images from a surveillance video is tagged as a target person.

Nearest Neighbour

This classifier works on a simple algorithm that stores all the available training data and classifies new instances of training data on the basis of similarity measure. For each test image, locate the k closest members (k-NN) of the training data set. In general, we put k=1 generally it has been tested that larger value of k reduces the effect of a noise at the time of classification but the boundaries between classes become less distinct. And the smaller value of

k gives better result. Then it acts simply as NN. In our proposed approach we need not to use clustering technique because we are already having a small number of people on over Watchlist. Euclidean distance is used to measure the distance between contiguous test image and each trained image from our data set.

INPUT: Surveillance Video
OUTPUT: Candidate name with confidence value if the person is present on a Watchlist
Begin
***Step 1**: Initialization*
***Step 2**: Detect the biggest face (best fit) from contiguous video frames by using cascade classifier*
***Step 3**: Pre-Processing*
3.1 Crop Image
3.2 Resize Image
3.3 Convert float to character image
3.4 Histogram Equalization
***Step 4**: Apply PCA*
***Step 5**: For all Eigen faces do*

$$d(x,y) = \sum_{i=1}^{M} \sqrt{(xi - yi)^2} \tag{5}$$

End for
SORT(d(x, y)); // Calculate distance of test image to all gallery images and sort in ascending order
End for
Select smallest distance

$$Confidence(C) = 1 - \frac{\sqrt{d(x,y)/(nT \times nE)}}{255} \tag{6}$$

***Step 6**: If C lies between predefined selected range of value Then Create Bounded box around face*
*Return label with **name** with **confidence value.***
***Step 7**: Go to Step 3*
***Step 8**: End.*

Where, nT = number of Train faces &
nE = number of eigen faces.

Algorithm 1: Proposed algorithm for watchlist surveillance security system

We use NN to increase the recognition rate in case of a video surveillance it is very useful and if we use NN as a classifier in case of still image and it may take some time in classification. NN may face slow classification problem because of high dimensionality of data. To address this issue we use PCA to reduce the dimensionality and we have seen in our experiments that the recognition speed is very high in live videos and with the help of single image only it can do recognition easily with good accuracy and it is very fast. The confidence value gives a numeric value between -1 to 1. And it predicts how much a test image is related to target gallery image. There may be many ways of calculating this confidence value. But after some empirical experiments we find this formula useful. And we can apply it with nearest neighbor so that we set it accordingly. While recognition in real time video confidence value is shown along with subject name and if this confidence value lies between deciding limit, then the system will draw a bounded box in a frame when any face is detected and show his/her name with this confidence value otherwise not. During Watchlist surveillance, speed is a major concern because an alarm needs to be generated as soon as a person whose image is in the database is caught in the video.

6. Experiments and Results

We have conducted an experiment on live videos. Each having 1 hour duration we are working in a real life environment and our proposed approach is for real life scenario. So here we did our experiments in the surveillance videos of the main entrance gate of GLA University, Mathura here we set up an arrangement for recognition from videos from a laptop camera. The system detects a face using Haar cascade classifier provided by Intel Open Source Computer Vision Library (OpenCV). And the eyes are located and then it detects a face. And discard all the face image sequences which are far out from frontal view. Because Haar Cascade Classifier only deals which frontal image in which both eyes can be seen.

Fig.4. (a) Non-Target person correctly discarded; (b) and (c) Target person correctly recognized by the system.

Live test has been conducted by taking the system to the main gate of the college campus (fig. 4). And the testing have been outside, lighting condition have been quite different in different times of the daylight. In total 115 people (including 8 people in a Watchlist) have participated in live tests, our system works without any error. The test is being conducted approx 1 hour of video in different days and different conditions. Our approach is to recognize only those people who are present on a watch list and refuse all other masses.

Table 1.Confusion matrix for positive and negative tuples.

	Positive	Negative
True	68	15
False	15	09

True positive denotes the target person correctly recognized and non-target person correctly discarded by the system, True negative represents the target person incorrectly recognized by the system, false positive denotes the unknown person recognized by the system and false negative determines the target person missed by the system.

Table 2.Recognition accuracy of various methods, where N = Number of training images.

Techniques	N = 1	N = 4	N = 8	N = 16
Asym_shrp[10]	N.A.	67.5%	67.6%	70.5%
Gabour_asym[11]	N.A.	75.4%	71.4%	74.5%
DFFS[9]	N.A.	74.7%	70.3%	74.6%
Proposed Approach	77.57%	N.A	N.A	N.A

Table 3.Comparision with some other video based recognition methods.

Methods	Accuracy
Learning based likelihood[12]	68%
Image sets alignment [13]	74.6+-0.03
Proposed Approach	**77.57%**

After conducting tests and full examination of videos we have calculated all the positive and negative values required to measure the performance of the system. The system gives an accuracy of 77.57 percent and precision of 81.98 percent. In our live test we found target person and then system detects and recognize those and rejects all other participants from the system. Sometimes the system may not give high accuracy because of varying pose and illumination. But of course in real life application of biometric security many cameras will be installed with good range and quality. And if any person is missed by one camera can be captured by other.

6. Conclusion

The main motive of our approach is to identify and recognize any individual from his/her biometric information, i.e. Face. Our system is able to work in real life conditions by using only single face image of a person. At this time much of work has been done in the field of face recognition both in still image and surveillance recognition. We have seen PCA is an approach which is not considered good for recognizing faces from a video or live video. Merely it is one of the best dimensionality reduction approaches in the field of still image face recognition. So we have been motivated by this issue and we take it as a challenge to recognize any individual from his/her single image. So to do this process we have done some research in this area. Firstly, we see, in the PCA process after all steps of PCA algorithm threshold value is set to correctly recognize any individual. And setting and finding a correct threshold value is a very difficult in terms of video surveillance. Then we apply Nearest Neighbor (NN) algorithm in place of threshold value concept in PCA by which recognition became fast and in addition we introduces confidence value which yields a probability of test images to the gallery image. Our approach is to recognize people from a Watchlist only so we set a confidence value which helps us to recognize a person from a Watchlist only and discard all other peoples processed through the system. Finally, it gives an accuracy of 77.57%. In future we can do recognition with high quality camera and having more than one image of a single person in a Watchlist. And by doing this we might improve system accuracy.

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