Securing Public Places with PCA Based Recognition of Criminal Faces Detected from Surveillance CCTV Footage

Suyash Luniya, Nishigandha Dhengale, Yugali Bafna, Prathamesh Kulkarni.
Department of Computer Engineering
Pimpri Chinchwad Education Trust's
Pimpri Chinchwad College of Engineering
Sector 26, Pradhikaran, Nigdi, Pune 411 044,India.
suyashluniya@gmail.com, nishidhengle@gmail.com
yugalibafna13@gmail.com,prathameshkulkarni255@gmail.com

Abstract— This paper aims in ensuring the safety of common people at public places by using the existing CCTV systems which are deployed for the surveillance and to determine the security of that place, by identifying the suspicious faces that are captured and notifying the officials. The existing video surveillance systems capture data through CCTVs and store it in their database. After an unpredicted incident already taken place, these databases are used to recognize the culprit. Instead of this, the proposed system keeps a track of the live videos and exacts out frames from it after a fixed interval of time. These frames are then used to fetch faces and compare them with the criminal faces which are already stored in a suspicious faces database, using the feature extraction technique. If the comparison is successful, an alarm is generated which gives an alert about the presence of a criminal at that place. Various face detection algorithms and recognition techniques are used to identify the suspicious face in the crowd and enhances the safety of the public places.

Keywords—: *Surveillance, Video Footages, PCA, Face Detection, Feature Extraction, Face Recognition.*

*****

I. INTRODUCTION

Security is an important aspect of concern for ensuring protection of people, property, offices, etc. For this purpose, use of security cameras is considered as best way of deterring the criminals from causing harm to public places, keeping away intruders. But the only drawback of these systems is that, they only record the data through CCTVs and keep it stored in the storage devices. In case of any unexpected incident or criminal activity has taken place, these databases are used to draw conclusion on that incident and hence catch the offender. Instead of arresting the culprit after the crime has already done or destruction is caused, can we make a system which will help us to detect the criminal before he tries to carry out any criminal activities using these security systems? Hence, the proposed system is designed to eradicate the limitations of the existing systems.

Whenever any criminal who had a history and is registered in the suspicious face directory tries to enter a public place which is under surveillance, and if captured through a CCTV camera can be traced on entry point itself and can prevent his actions beforehand. For this purpose, at an initial stage, all the criminals are registered, and a database of suspicious faces is created. When the surveillance system captures the activities, the frames are extracted after every fixed interval of time which includes skin pixels and non-skin pixels. Thus, by eliminating the background and considering only the face regions, it is then compared to the images already stored in the criminal directory using feature extraction technique. By considering the parameters for comparison of both the faces, the matching is done using PCA algorithm and the presence of criminal at that place is detected. This will help the security system to identify that person and arrest him before he could carry out such activities.

II. EXISTING SYSTEM

The security and surveillance system capture the data and makes an entry in the database which is further used for detection. The crime branch which contains the criminal records generally contains personal information about person along with photographs having the frontal view, side views. Whenever the criminal is to be identified, these records are used. The suspicious faces are observed in the video footage and that frame is extracted, out of which the suspected face is obtained further which is mapped with the faces in the record. This matching is done after the crime had already occurred. To identify any criminal, we need some identification regarding person, which are given by eyewitnesses. Based on the information provided by the eyewitness, the criminal involved in the crime can be identified manually.

Limitations in existing system:

a. The video footages are stored dynamically in the databases. To extract out data of a period is tedious.

 ISSN: 2454-4248
89 – 94

b. Sometimes the video captured is not very clear, the pixels are not proper and hence authenticating the suspected face is difficult.

c. These footages are not tracked on a regular basis. So detecting the suspicious face at run time and preventing the crime, is not possible.

d. These databases are stored for a limited amount of time after that it is been replaced with the new data. So tracing of the suspects from previous entries cannot be done.

III. LITERATURE SURVEY

From the study of various papers, the understanding of the detection of suspected faces captured by the surveillance systems along with the algorithm used for the recognition of such faces can be drawn. Hence the conclusion from [1] is obtained that, Principal Component Analysis (PCA) is one of the most successful techniques that have been used in face recognition. Here four criteria for gray image pixel selection to create feature vector were analyzed, the first one has all the pixels, the second one is based on taking row mean of the face image, the third one is based on taking column mean of the face image and the fourth criterion is based on taking row and column mean of the face image. These face image pixel distributions are used to generate feature vectors with the help of Principal Component Analysis (PCA), Discrete Cosine Transform (DCT) and Walsh Transform.

The earliest developed face recognition algorithms used individual features on the faces, such as organs i.e. eyes, mouth or nose region to perform identification. These were purely feature set-based classifiers that held a huge impact on the use of face and classifier-based datasets [4]. However, such methods did not lead to good results because of the variability and the low amount of information used.

From [2], in face recognition based on PCA taking all image coefficients give better performance than row mean, or column mean of face image. In case of the techniques based on DCT and Walsh Transform, row mean, and column mean based techniques out performs the techniques with all coefficients considered for extracting feature vector of face images at much reduced computational complexity. Comparing the row mean and column mean based methods of face recognition using PCA and using transforms, transform based methods are giving superior performance.

From the conclusion obtained from [3], face detection rate of the four-color models i.e. RGB, HSV, CIELAB and YCbCr are obtained, out of these four-color model YCbCr has highest detection rate and lowest false detection rate. To increase the speed, accuracy of the system and to overcome on false face detection rate these four-color models can be combined to get better result, after combining all these models we can get correct detection rate which can be up to 92%.

[7] This paper presents a system to improve the public safety by utilizing the visual data from network cameras. The public cameras are discovered from heterogeneous sources and the metadata such as locations and viewing angles are determined using the visual content from the cameras. Our system can be used to improve the safety in multiple cities. We demonstrate the system using two case studies: (1) using crime data for investigative analysis and (2) enhancing the situational awareness using social media content. As part of the future work, we plan to extend our system to monitor multiple cities. We also plan to automate the process of determining the metadata information.

A) FACE DETECTION[6]

After the extraction of frames, human faces are to be obtained out of those frames. For which, detecting those human faces is necessary. The frames which are captured via video surveillance system consist of various elements like humans, infrastructure etc. We need to eliminate all the other things in background i.e., all the non-skin pixels regions are discarded and only the skin pixel regions are to be considered.

In real time, the proposed system will directly detect the faces present in the frames without affecting the other parts in that frame and obtain a tag on it which specifies that the tagged region is a human face and save those tagged faces i.e., only the skin pixel parts of a human face. These detected faces are then used for recognition of the criminal faces present in that area or not.

B) COLOR MODELS FOR FACE DETECTION[12]

After the detection of skin pixels there might be chances of detecting skin color pixels excluding face regions. Skin segmentation using different skin color models for face detection has many advantages as this technique is scale independent, rotation independent, and fast. By using this method, we can reduce computational cost for face detection. Different color models used for skin color segmentation are RGB, HSI, YCbCr, HSV, etc.

1. RGB: [3] RGB Colors are specified in terms of three primary colors i.e. Red (R), Green (G), and Blue (B). In RGB color space, a normalized color histogram is used to

ISSN: 2454-4248
89 – 94

detect the pixels of skin color of an image. This localizes and detects the face regions. The values of RGB color model lies between the given ranges:

$90<R<255$ (1)

$45<G<255$ (2)

$45<B<255$ (3)

$R-G>23$ (4)

$R-B>29$ (5)

2. YCbCr : The YCbCr color model (Y - Luminance component i.e. light intensity, Cb- Blue difference of the chromaticity component and Cr- Red difference of the chromaticity component). YCbCr color space is used because of its advantage over lower resolution potential of human visual system for color with respect to luminosity [5].

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.5 \\ 0.5 & -0.81 & -0.81 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}, \quad \textbf{(6)}$$

3. HSI: In this color model, H-Hue describes the main color i.e. depth of color and ranges from 0 to 360. S-saturation gives purity of the color and its range is from 0 to 100. I-Intensity indicates the brightness of the shade. For color description, HSI color model is preferred over RGB color model[5]. The conversion between RGB to HSI color model is as shown in following equations:

I = (R + G + B) / 3
(7)
S = 1 - [3 x (min(R, G, B) / (R + G + B))]
(8)
e = [(R-G) + (R-B)] / [2x [(R-G)'2 + (R-B)(G-B)] '0.5]
(9)

If G 2: B then H = e otherwise H = 360 - e
(10)

C) FACE RECOGNITION METHODS[9]

Depending on the face data acquisition methodology, face recognition techniques can be broadly divided into three categories [9]: methods that operate on intensity images, those that deal with video sequences, and those that require other sensory data such as 3D information or infra-red imagery [8]. The categories are as follows-

Holistic Matching Methods,

Feature-based (structural) Methods,
Hybrid Methods

In holistic approach, the complete face region is taken into account as input data into face catching system. One of the best example of holistic methods are Eigenfaces [14] (most widely used method for face recognition), Principal Component Analysis, Linear Discriminant Analysis [13] and independent component analysis etc.

Feature extraction is an important step in the construction of any pattern classification and aims at the extraction of the relevant information that characterizes each class. In this process relevant features are extracted from objects/ alphabets to form feature vectors. These feature vectors are then used by classifiers to recognize the input unit with target output unit. It becomes easier for the classifier to classify between different classes by looking at these features as it allows fairly easy way to distinguish. The major goal of feature extraction is to extract a set of features, which maximizes the recognition rate with the least amount of elements [10][11].

Hybrid face recognition systems use a combination of both holistic and feature extraction methods. Generally 3D Images are used in hybrid methods. The image of a person's face is caught in 3D, allowing the system to note the curves of the eye sockets, for example, or the shapes of the chin or forehead. Even a face in profile would serve because the system uses depth, and an axis of measurement, which gives it enough information to construct a full face.

D) PCA (PRINCIPAL COMPONENT ANALYSIS) [1]:

The task of facial recognition is to differentiate between the input images into several classes (persons). Whenever the face pixel regions are to be detected, the input signals are considered as to be highly noisy (e.g. the noise is caused by differing lighting conditions, pose etc.), yet the input images are not completely random and in spite of their differences there are patterns which occur in any input signal. Such patterns, which can be observed in all signals, could be in the domain of facial recognition – the presence of some objects (eyes, nose or mouth) in any face as well as relative distances between these objects. These characteristic features are called eigenfaces in the facial recognition domain (or principal components generally). They can be extracted out of original image data by means of a mathematical tool called Principal Component Analysis (PCA)[15][16].

E) PCA ALGORITHM [2]

The various steps to calculate eigenfaces are:

A. Prepare the data A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image × columns of image) representing a set of sampled images. Then the training set becomes: Γ1, Γ2, Γ3.....ΓM.

B. B. Subtract the mean The average matrix Ψ has to be calculated, then subtracted from the original faces (Γi) and the result stored in the variable Φi:

$$\Psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n \qquad (11)$$

$$\Phi_i = \Gamma_i - \Psi \qquad (12)$$

C. Calculate the co-variance matrix In the next step the covariance matrix A is calculated according to:

$$A = \Phi^T\Phi \qquad (13)$$

D. Calculate the eigenvectors and eigenvalues of the covariance matrix In this step, the eigenvectors (eigenvectors) Xi and the corresponding eigenvalues λi should be calculated.

E. Calculate eigenfaces:

$$[\Phi]X_i = f_i \qquad (14)$$

where Xi are eigenvectors and fi are eigenfaces.

F. Classifying the faces The new image is transformed into its eigenface components. The resulting weights form the weight vector Ω^T_{new}:

$$\omega\kappa = \Omega k T \Gamma_{new} - \Psi \quad k=1,2,3, \ldots\ldots M \qquad (15)$$

$$\Omega^T_{new} = [\omega_1\omega_2\omega_3 \ldots\ldots\omega_M] \qquad (16)$$

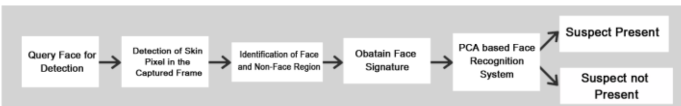

FIG 4.1: REGISTRATION OF SUSPICIOUS FACES

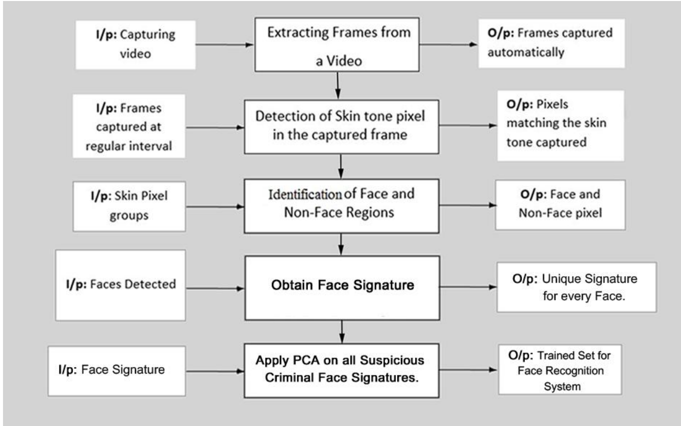

Fig 4.2: Recognition of Images from CCTV Footage

IV. PROPOSED SYSTEM FOR SUSPICIOUS FACE DETECTION METHODS

The proposed system detects the human faces from the live videos and also recognize that the human face is present in the criminal database which tells that the person is suspicious and can carry out some suspicious activities or not. This system ensures the safety of that place and prevents criminal activities.

A. REGISTRATION OF CRIMINAL FACES

The proposed system works to detect the suspicious faces at entrance only by using the video surveillance system. To achieve this, the first step is to register all these faces to the system. So, a database which contains all the criminal faces is created. When a new criminal face is added to the records, it needs to be updated to the database also. After registering the criminal face to the directory, we need to train the system to work on the database and obtain a result. So basically, registration is the first phase of proposed system.

B. EXTRACTION OF SKIN PIXELS FROM THE FRAMES

After the registration of criminal faces in the suspicious faces directory, the next important step is to extract faces from the live videos and create tags only around the human faces and obtain those tagged regions for the further comparison purpose.

FACE SIGNATURE GENERATION

After extracting skin pixels from the frames, we need to generate face signatures which will extract only the face part (excluding neck, hands and other skin pixels) using the Walsh-Hadamard texture pattern [12] or Haarlet Pyramid [17] or walshlet pyramid [18].

C. RECOGNITION OF SUSPICIOUS FACES

ISSN: 2454-4248
89 – 94

Recognition of suspicious faces is the final step in which the human faces which are extracted from the frames captured from live video. The comparison is done with the help of PCA algorithm which matches that the obtained face is present in the suspicious face directory or not.

V. RESULTS AND DISCUSSION

For developing and implementing the proposed system, MATLAB is used. The results obtained after implementing the proposed system is that the human faces are tagged in the obtained frames and with the help of matching algorithms, the tagged faces are compared, and the matching is done. The results are as follows-

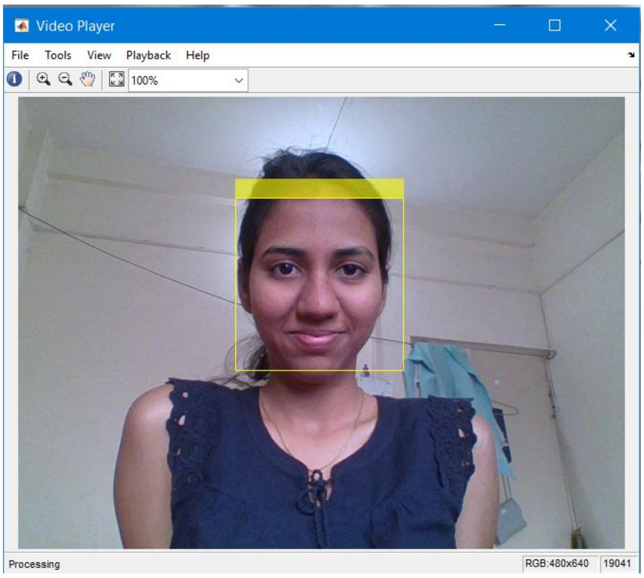

Fig 5.1: Training the criminal face

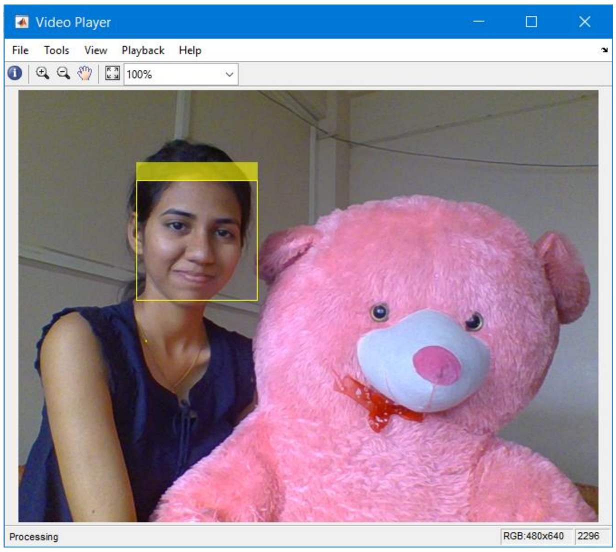

Fig 5.2. Testing the detection of Human faces only

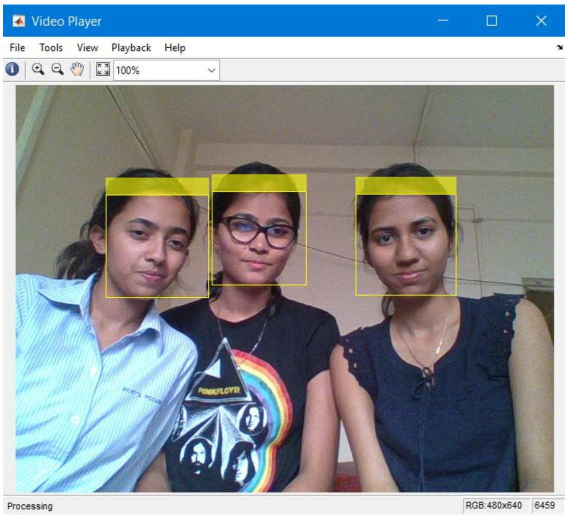

Fig 5.3. Multiple Faces are tagged at runtime

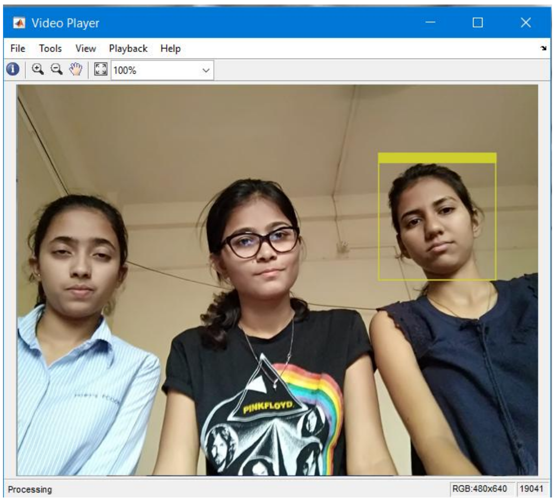

Fig 5.4. Trained Suspect Detected

VI. CONCLUSION

The proposed system concentrates on tagging the suspicious faces present in a live video which is captured from CCTV cameras situated at public places. The frames are captured from the live videos after specific interval of time. From those extracted frames, suspicious or criminal faces are detected if present. For the detection of faces, skin and non skin pixels are identified. For this identification of skin pixels different color models like YCbCr, HSI, RGB were used. After obtaining the human faces, tags are generated around those faces. These tagged faces are then used for recognition of suspicious faces from the directory of suspicious faces. If the match is found the tag obtained on the face of criminal will specify that the suspect is found and prevents him from causing any damage to lives and infrastructure.

VII. REFERENCES

[1] Eigenvectors of Covariance Matrix using Row Mean and Column Mean Sequences for Face Recognition,

HB Kekre, SD Thepede, A Maloo, International Journal of Biometrics and Bioinformatics (IJBB) 4 (2), 42

[2] Performance Comparison for Face Recognition using PCA, DCT &WalshTransform of Row Mean and Column Mean, HB Kekre, SD Thepade, A Maloo - ICGST International Journal on Graphics, Vision and Image processing,2010

[3] Ekta Rewar1 and Saroj Kumar Lenka2 “COMPARATIVE ANALYSIS OF SKIN COLOR BASED MODELS FOR FACE DETECTION”, Signal & Image Processing: An International Journal (SIPIJ) Vol.4, No.2, April 2013

[4] N. Dalal and B. Triggs. Histograms of oriented gradients for human detection. Conference on Computer Vision and Pattern Recognition (CVPR), 2005.

[5] Mrunmayee V. Daithankar, Kailash J. Karande, Avinash D. Rarale, ‘India Analysis of Skin Color Models for Face Detection’, International Conference on Communication and Signal Processing, April 3-5, 2014

[6] FACE DETECTION AND RECOGNITION FOR AUTOMATIC ATTENDANCE SYSTEM, Dr. Nita Thakare, Meghna Shrivastava , Nidhi Kumari, Neha Kumari , Darleen Kaur5 , Rinku Singh, IJCSMC, Vol. 5, Issue. 4, April 2016

[7] Improve Safety using Public Network Cameras ,Youngsol Koh, Anup Mohan, Guizhen Wang, Hanye Xu, Abish Malik, Yung-Hsiang Lu, and David S. Ebert, 2016 IEEE

[8] ‘A Survey of Face Recognition Techniques’, Rabia Jafri and Hamid R. Arabnia, Journal of Information Processing Systems, Vol.5, No.2, June 2009

[9] Divyarajsinh N. Parmar , Brijesh B. Mehta, Face Recognition Methods & Applications, IJCTA Jan-Feb 2013

[10] ‘A Detailed Review of Feature Extraction in Image Processing Systems’, Gaurav Kumar, Pradeep Kumar Bhatia, 2014 Fourth International Conference on Advanced Computing & Communication Technologies

[11] Performance comparison of feature vector extraction techniques in RGB color space using block truncation coding for content based image classification with discret, S Thepade, R Das, S Ghosh, India Conference (INDICON), 2013 Annual IEEE,1-6

[12] H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Amelioration of Walsh-Hadamard Texture Patterns based Image Retrieval using HSV Color Space”, International Journal of Computer Science and Information Security, Volume 9, Issue 3, 2011

[13] S. Suhas, A. Kurhe, Dr.P. Khanale, “Face Recognition Using Principal Component Analysis and Linear Discriminant Analysis on Holistic Approach in Facial Images Database”, IOSR Journal of Engineering, Dec. 2012

[14] M. A. Turk and A. P. Pentland, "Face Recognition Using Eigenfaces", 1991.

[15] Prof. Y. VijayaLata, Chandra KiranBharadwajTungathurthi, H. Ram Mohan Rao, Dr. A. Govardhan, Dr. L. P. Reddy, "Facial Recognition using Eigenfaces by PCA", In International Journal of Recent Trends in Engineering, Vol. 1, No. 1, May 2009, Pages 587-590.

[16] H. B. Kekre, Kamal Shah, Tanuja K. Sarode, Sudeep D. Thepade, ”Performance Comparison of Vector Quantization Technique – KFCG with LBG, Existing Transforms and PCA for Face Recognition”, Int. Journal of Information Retrieval (IJIR), Vol. 02, Issue 1, pp.: 64-71, 2009.

[17] H. B. Kekre, Sudeep D. Thepade, Akshay Maloo, “Face Recognition using Texture Features Extracted from Haarlet Pyramid”, Volume 12, Issue 5, 2010

[18] “Face recognition using texture features extracted from walshlet pyramid”, ACEEE International Journal on Recent Trends in Engineering and Technology (IJRTET), Volume 6, Number 1, 2010