IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Person Identification in Group Photographs with Artificial Intelligence

Ms. Priyanka G. Patil[1], Dr. Manasi R. Dixit[2]

[1]Student, Dept. of Electronics and Telecommunication Engineering, KIT's college of Engineering Kolhapur, Maharashtra, India.

[2]Professor, Dept. of Electronics and Telecommunication Engineering, KIT's college of Engineering Kolhapur, Maharashtra, India.

Abstract: **Now a days, taking pictures using camera of smartphone is very practical. Extremely at that time when any person is chilled out with their friend circle or family members, sometimes when they attending any occasions or functions and so on. At that time, they are busy in capturing one or more group photographs with their relatives and friends. But when sort out from all these group photographs, many times, a particular person is sorted out only those photographs in which he himself is present. For finding a particular person from crowded areas or public spaces it must requires continuously attention on that person and also good identifying quality for recognition is required. The testing photos are also real, images of criminals from custody and also images from social media are required for application on real time basis. By using this particular way we fulfil the difference between real life time experiments and lab-based experiments with CCTV footage. This work is regularly done by police and Crime Investigation Department officers throughout the world. Here identify and recognize particular person from group photographs with artificial intelligence. Our point is to develop a system for person identification that is correct and fast need to work on real time database. Haar Cascade (Adaboost Algorithm) [15] is using for extracting the features and detect the particular face. OpenCV DNN (Deep Neural Network) model also using for face detection. Dlib machine learning [8] library is used to extract features of face. After Classification, face will be recognize using LBPH [1] Recognizer and DNN Caffe model. Then that recognized photo or image display with caption like name of that person. So, a particular person identification is very easy.**

Keywords: **Machine Learning, Deep Learning Neural Networks, Face Detection, Feature Extraction, Adaboost Classifier, Dlib machine learning library, OpenCV DNN Caffe Model, LBPH Recognizer, Face Recognition, Image Display with Captioning.**

I. INTRODUCTION

Person identification in photo or in CCTV footage is also important to recognize faces of celebrities, politicians, or other persons like VIPs in public spaces which is the most interesting work for reporters. While talking about many countries, the placement of closed-circuit television (CCTV) surveillance in public areas is very common. The presence of these CCTV footages has spread a significant changes in various area and finding the culprit or a gangster.

Digital Camera images, Video Surveillance images and images or photos taken by smart mobile phone are act as input for this face recognition or person identification methodology. These images are very important for identification of a particular person. In real time database store the images of individual person which is required for face recognition. Take a photographs for identification using laptop webcam, External webcam connected to PC, images capture from CCTV footage and also cropped images taken from videos. These taken pictures are compare with the stored real time database and face will be recognize. Face recognition is more important in the area of security.

The need of person identification methodology at various areas as well as in various application are given below.

1. **Criminal/Culprit Identification:**
   Face recognition system is useful for finding criminals. The database contains all the information related to that culprits or gangster which is very useful to find them. If system identify that particular person by matching with database using some algorithms. Then this recognition system stops the crime before it occurs.
2. **Record Attendance:**
   Face recognition system is useful to record the attendance of students in schools and colleges for avoiding any spiteful activity. Biometrics system is used in colleges, offices for recording attendance of staff. Face recognition technique is also used for record attendance of office employees, college staff and also for hospital staff.
3. **Bank Security Facilities:**
   Bank takes one of the security measure as person identification with Artificial intelligence to detect and recognized any doubtful person. Primarily, this face recognition method useful to keep banks away from any frauds.
4. **E-Transactions:**
   The Intelligence services are having safe E-transactions. Now a days, fingerprint is rarely used for unlock the account same as we can use face for unlock the account. So it will increase the security of transaction. When the customer's face is matched with database then only transactions are done.
5. **Airport Security:**
   In many countries, airports use face detection and recognition technology with artificial intelligence to recognize faces of passengers, staff and other people. It can avoid any malware activities on airport. Using facial recognition, the information obtained is genuine. So it keeps away from any harmful situation.

II. LITERATURE

Bhawna Ahuja et. al [1] have worked on a system which is based on face identification with local feature extraction and learning algorithm techniques. They have worked on two different techniques and algorithm i.e. LBP (Local Binary Pattern) operator and KELM (Kernel based Extreme Learning Machine) algorithm. LBP Operator is used for feature extraction and classification of same class images. KELM learning algorithm used for the classification of images with different classes. Authors have implemented the face recognition system by using combination of LBP and KELM (LBP-KELM) algorithm.

Mang Ye et. al [2] have implemented a system for person re-identification using learning algorithm based on tri modal method. The system have calculated modality of gray scale image from their visible images without training the data. Especially, they have solved the features based on methods like classification and retrieve of multiple images. The system have used regularizers which reduces variations in modality of multiple images. Furthermore, author have developed a ranking loss having three directions with some weight. It improves the distance between modalities of positive and negative images.

Wenbi Rao et. al [3] have designed a system for person re-identification based on metric learning method. These metrics are not similar in nature. It will increase the robustness of images. This asymmetric metric method have found out matrix features of all cameras. It also mapped and located the vectors present in combined areas. For controlling the influence of system using regularization of metric. The metric method used for development the system have mapped the feature matrices of every camera with increasing no. of iterations.

Vimala Mathew et. al [4] have implemented a system based on video surveillance using networking. These videos are taken from various cameras and merged in the main server. Verification of these all videos have used to prevent crimes from crowded areas. The system have developed for identifying person from collected videos taken by various cameras (CCTV). They have used CNN and Viola algorithm for implanting the particular system. The overall operation of identification occurred on the cropped detected faces from group photos.

Zhedong Zheng et. al [5] have designed the pedestrian alignment network. Authors have used CNN for mapping the features on human body. CNN have mapped the features of human body instead of other background from image. It also have generated the strong activated features on human body. The proposed system have taken advantage of the activation. The system have done the adjustment of pedestrians which is bounded in a box.

Zimian Wei et. al [6] have implemented a network for person re-identification. The network consists of classification module and metric learning module. The network have partitioned number of features from given image and calculate the loss of classification in every part of human face individually. The calculation of distance between two or more images with some shortest path using the metric module. The data have trained using the loss between images with alignments of dynamic parts of the network.

Monica Chillaron et. al [7] have implemented system based on face detection and recognition for android application. The system developed using Raspberry Pi and android base application. For the system, Viola Jones algorithm used for extracting features of faces. The boosted cascade (adaboost) algorithm used for detection of face. And based on the Haar cascade classification, faces were classified into some categories. After classification, faces were recognized by using PCA of eigenface algorithm. The system implemented on Raspberry Pi and android base smartphones. The system has operated under OpenCV platform with C++ bindings for python code. Raspberry Pi connected with 5 megapixel camera having Bluetooth connection.

Avani Sakhapara et. al [8] have developed an Android based system. They have automated the system by planning and generating the android based application. The system have designed with deep learning approach using RNN and CNN as a neural networks. The application have developed an automatic detecting and identifying persons from group photographs using deep neural networks.

Ya Zhao et. al [9] have designed a hashing network based on the semantic hashing structure. The Deep SSH framework have used middle and high level attributes and IDs for development. Based on those semantic hashing structure, they have decoded the hashing code with respect to specific level of attributes. The Deep SSH method designed a system with parts which gives overall information of semantic structure. The system have embedded the semantic attributes of hash code using datasets.

Jalendu Dhamija et. al [10] have designed a live video feed based face recognition system. They have described some algorithms for extracting the features. The proposed system have used PCA method with eigen vectors for extracting features of face. The Fisherface Algorithm which tells the similarities in two or more people based on comparison using projection of vectors. The SVD (Single Value Decomposition) or 2D-PCA model based algorithm used for decomposition of projection and recognition of face. This face features are stored after the composition of matrix with left and right singular vectors. Authors have used combination of these three algorithms for better accuracy of face recognition.

Teddy Surya Gunawan et. al [11] have implemented a Raspberry Pi based face recognition security system for smart home system. In this system, they have used eigenface algorithm for extracting the features of face. After the detection of face, face recognized by using PCA algorithm. This system showing result through Raspberry Pi. They have used Python and OpenCV platform for implementation of feature extraction and classifier using eigenface and PCA respectively.

Dwi Ana Ratna Wati et. al [12] have designed a system for smart security of home which detected and recognized the faces from photos. It has atmosphere of myrio and labview. The system have connected to computer with Wifi connection. Images used for implementation have taken by camera (webcam) connect to MyRIO. This face detection system is done by template matching. Then after detection and classification, face recognition is done PCA (Principal Component Analysis). PCA algorithm have extracted all the features and gave result as face recognition. This system needed to combine with some password as additional security point code which had given more secure system for home.

III. METHODOLOGY

The project based on the real time application. This is based on real time database. So we collect the images or photographs of persons for identification. A dataset is a collection of photographs of various people for training the data. For identification and recognize face, data training is very important.

First of all, take a picture from webcam of laptop (or input image from directory for testing) for detection. This is nothing but read the image from user's gallery or taking a picture from web camera or any external camera. Then compute the features of particular image like edge, line and center surrounded features required for detection. For detection of face Haar Cascade Classifier (i.e. Adaboost Algorithm) is used.

Block diagram of the proposed work is given below.

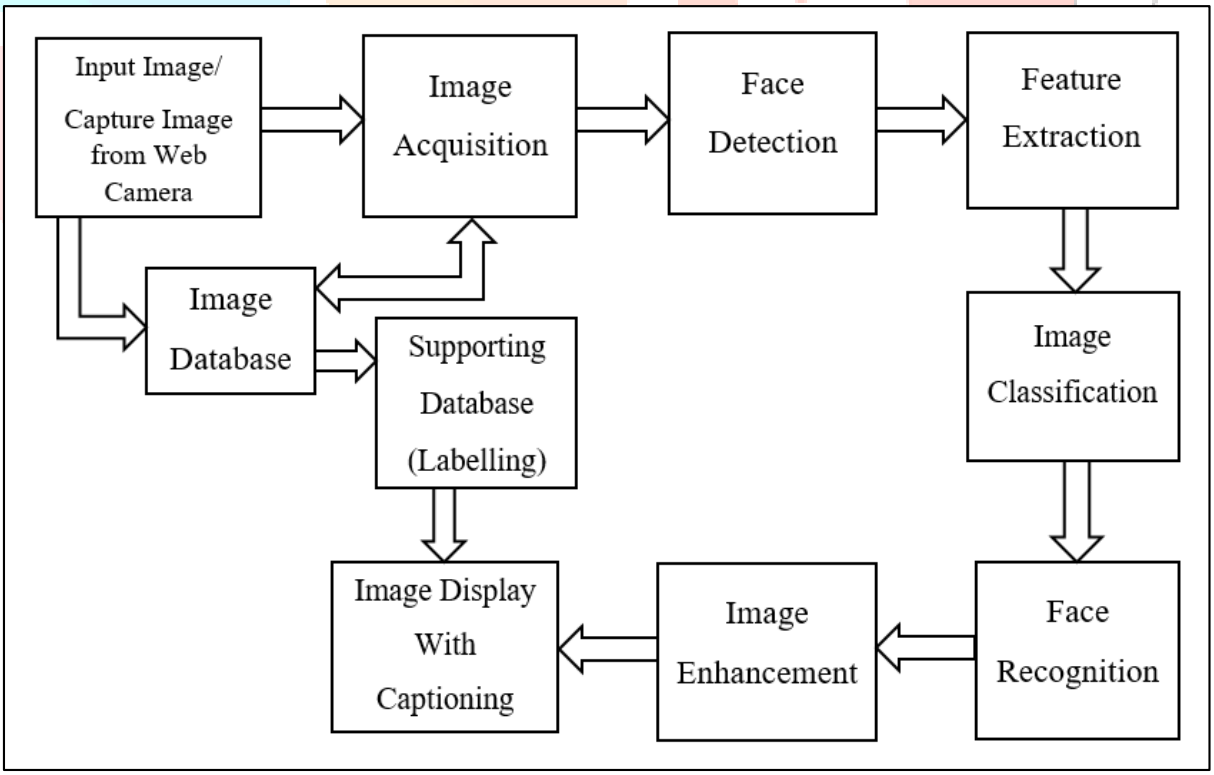


Figure 1: The System Block Diagram of Face Detection and Face Recognition

And also DNN Caffe Model is used for detecting the face. Then Measure or Compute the image parameters. The no. of detected faces are cropped from group photograph and stored it in specific directory. After process of detection, classification of image will be required. So this classification is done using Haar Cascade Classifier using OpenCV platform [5]. No of faces present in group photos are match with the individual photo of person stored in the database. For matching this faces, there is requirement of training the images stored in the dataset. After successful training faces are recognized using LBPH Recognizer and

also by using DNN Caffe Model. After recognition, a particular person is identified and the image of that person is displayed with captioning like name of that person.

Step I - Image Database

Database is the collection of various photographs. It includes the various group photographs. Here we have collected approximate 700 photographs for the process of face recognition. And it also consists of some individual photographs of a person. These photographs are useful for the face detection of person in group photographs. Faces of person present in group photograph is matches with all these photos and from that person will be identified or recognized successfully. Input Image is also take from camera itself and video frames also.

The Support Database stored the labels of each images (i.e. Name of the particular person, Its Qualification and other information, etc.). When training of data is occuring it will check and compare each and every image present in database with its label and then give the output of recognition with caption as name of person.

Step II - Image Aquisition

The conversion of original colored image of each person or photo to a gray scale. Each person's original RGB colored image converts into a grayscale. The intensities of grayscale includes various 256 shades from white and black. The section having pixel values smaller than 205 are transformed in black (0) shade and remaining pixels greater than 205 are transformed in white (1) shades of gray scale, which overall forms black and white picture of each photograph. So, here an image taken from camera is converted into the grayscale image. And also we take pictures from camera that is video frames so images are converted to gray scale image. This process is first it will take picture from camera then it capture it frame by frame and it will read that frames and then convert it into gray scale. cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY) function is used in opencv python for conversion of original to grayscale.

Step III - Face Detection using Python-OpenCV

Process of detecting the face is nothing but part of computer technique includes in deep networking. The process is used to identifying faces of human from video frames or also from tested images. The process of detecting the human faces is very useful in various approaches like Face recognition, Smart mobile phone unlocking, Advertisement handling smartly, Interferencing emotions of human face, etc. The concept of Deep learning is nothing but a subpart of machine learning algorithm based on artificial intelligence technique (AI) which is networking based structure operated on face using neural networks.

In this using various algorithm if a human is present in particular photograph then only that human face is detected, it will not detected the non-human face. In this particular project we have worked on approximate 70 to 80 images for detecting all the faces present in group photos. And it has given perfect result for detection of human faces from group photos using python and opencv.

Step IV - Face Recognition using Python-OpenCV

Face recognition is based on various algorithms. Face detection is very important for face recognition. For this reason before recognizing the face, face must be detected. Face detection shows sizes and locations of human faces present in group photographs. For face recognition, face detection comes first to identify and isolate faces before digital image is recognized. So for recognition or identification of face training and testing of data is very important requirement.

The faces present in group photographs matches with all the images present in database. For this reason data training is important. In this project we have used 50% data samples from overall database is used for training the image data and from that approximate 46% data is tested for recognize the particular face from no. of faces present in photo. After the classification data will be trained and target face will be recognized. When training of data is occuring it will check and compare each and every image present in database with its label. Then it gives the output of recognition with caption as name of person. An identified face display with captioning. It gives variation in accuracy of result according to various algorithms.

IV. ALGORITHMS & TECHNOLOGIES

Various algorithms and technologies are mentioned below. i) Haar Cascade Classifier which follows Adaboost algorithm ii) LBPH Recognizer algorithm iii) DNN Caffe Model in OpenCV iv) Dlib Machine Learning Technology.

1) Haar Cascade based on Features Classifiers

For recognizing the faces and objects features of digital images are used which are also called as features of Haar cascade. The first face detector on the basis of real-time application have used Haar wavelets features which are already exist in the name of features of images. The paper or system based on Fast object detection with boosted cascade classifier for some features have developed by **Jones** and Viola have given an important classifier haar cascade which is related to wavelets of haar transform [2]. The tasks related to detecting the faces is widely done by using this type of classifier present in CV techniques. A machine learning techniques are used through haar cascades for detecting the faces and visual objects. It is able to process on digital images very quickly and also achieve rate of detection very high.

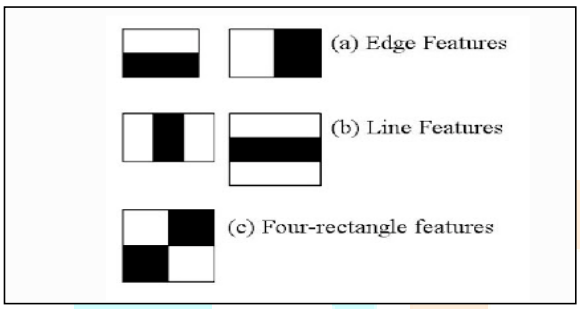


Figure 2: Examples of Features source

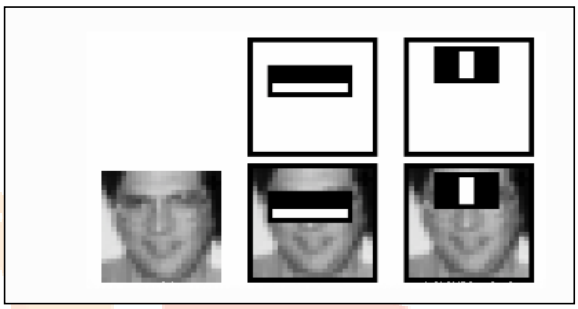
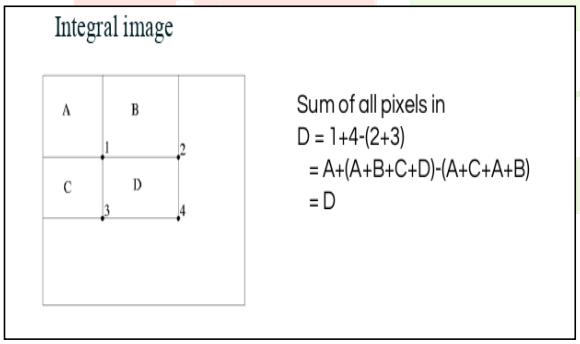


Figure 3: Feature used for Extraction source

(Note: Images have downloaded from viola-cvpr-01.pdf, 'Rapid Object Detection using a Boosted Cascade of Simple Features', in 2001)



Integral Image Concept

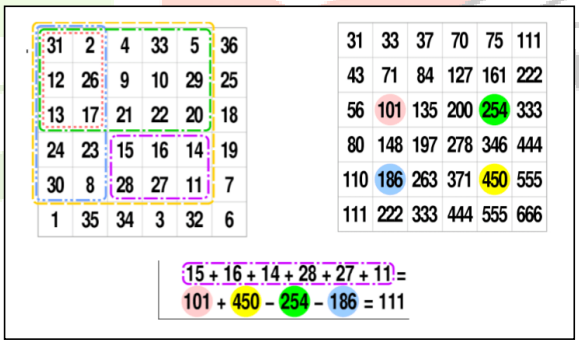


Figure 5: Computation with 4 Corner Values source

Figure 4: source

(Note: Images have downloaded from viola-cvpr-01.pdf, 'Rapid Object Detection using a Boosted Cascade of Simple Features', in 2001 and from https://en.wikipedia.org/wiki/Summed-area_table)

The concept of the integral image is nothing but it is used to compute overall sum of the pixels in rectangle form, for this we must have 4 corner values. It means that, to compute sum of all the pixels in any window of feature, we don't want sum of individual feature. Here 4 corner values used to compute the concept of integral image.

2) LBPH algorithm for Face Recognition

LBPH algorithm is nothing but Local Binary Patterns Histogram was developed which is also part of OpenCV. LBPH algorithm is useful for recognizing the face. This algorithm is operated using local bit binary operator and it is also known as a best descriptor of texture. LBPH is used for extracting all the features of test image and then find similarities between testing images and images of human faces present in database.

When LBP is merged with histograms of oriented gradients (HOG) descriptor, it enhances the detection performance.

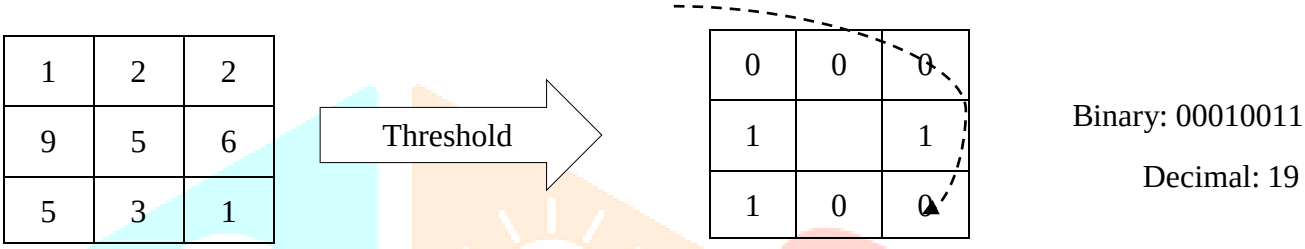
The LBP operator is presented in every section of an image. This operator is described in 3*3 size window.

$$\mathrm{LBP}(x_c, y_c) = \sum_{p=0}^{p-1} 2^p s(i_p - i_c)$$

where '(Xc,Yc)' is central pixel with intensity 'Ic'. And 'In' is the intensity of the neighbor pixel. Using median pixel value as a threshold value, it compares a pixel to its 8 closest pixels using following function.

$$s(x) = \begin{Bmatrix} 1, x \geq 0 \\ 0, x < 0 \end{Bmatrix}$$

If the value of neighbor pixel is greater than or equal to the central pixel value it is set to 1 if not then it is set to 0. Thus, we obtain a total of 8 binary values from the 8 neighbor pixels.



Later it was stated that a fixed neighborhood failed to compute varying in scale. For a given point (Xc,Yc) the position of the neighbor (Xp,Yp), p belonging to P can be computed by:

$$x_p = x_c + R\cos(\frac{2\pi p}{p})$$

$$y_p = y_c - R\sin(\frac{2\pi p}{p})$$

where R is the radius of the circle and P is the number of sample points. If a coordinate on the circle doesn't match to image coordinates, it gets introduced by bilinear interpolation:

$$f(x,y) \approx [1-x\ x] \begin{bmatrix} f(0,0)\ f(0,1) \\ f(1,0)\ f(1,1) \end{bmatrix} \begin{bmatrix} 1-y \\ y \end{bmatrix}$$

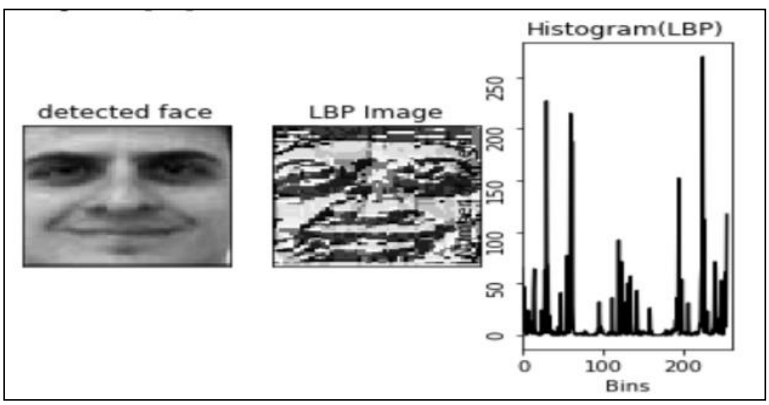


Figure 6: LBP Image and Histogram
source

The Euclidean distance is computed by comparing the test image features with features presented in the database. The minimum distance between test image and original image computes the matching rate.

$$d(a,b) = \sqrt{\sum_{i=1}^{n} |a_i - b_i|^2}$$

When LBP is merged with histograms of oriented gradients (HOG) descriptor, it enhances the detection performance.

3) DNN Caffe Model

The latest OpenCV involves a module name it as deep neural network, which gives one of the nice detecting the face with pre-trained CNN. This developed model increases the performance of detecting the face as of the traditional old models, such as Haar. The Caffe Framework used to train the new model. It is showing that a fast and easy way to port the model into the latest Caffe by extracting all pre-trained neural network coefficients out.

We have to require 2 things to operate the whole caffe model which is having pre-trained functions using openCV platform and DNN modules. First is the model.caffemodel file which contains the pre-trained weights. And second one is the model architecture file which has a .prototxt extension. It is like a plain text file with a JSON like structure containing all the neural network layers' definitions.

4) Detection of Face Features using Python Dlib (machine learning) and OpenCV

Extract facial features (upto 6) and Identify faces with python, dlib on opencv platform. There are number of solutions we will do all this things as per pre-processing procedure such as taking images from camera for identifying persons from group photos through machine learning technique as well as manually. Now we can extract face features from an image using dlib machine learning library. Faces of human are having some of the features which can be recognized and identified such as nose, mouth, eyes, etc. Dlib machine learning library have used to detect the features of faces for which we have required a map of points of each feature.

Following map consists of sixty seven landmark points which is useful to recognize the given features: Points of Jawbone = 0 to 16, Points of Right Eye-Brow = 17 to 21, Points of Left Eye-Brow = 22 to 26, Points on Nose = 27 to 35, Points on Right Eye = 36 to 41, Points on Left Eye = 42 to 47, Points on Mouth = 48 to 60, Points on Lips = 61 to 67

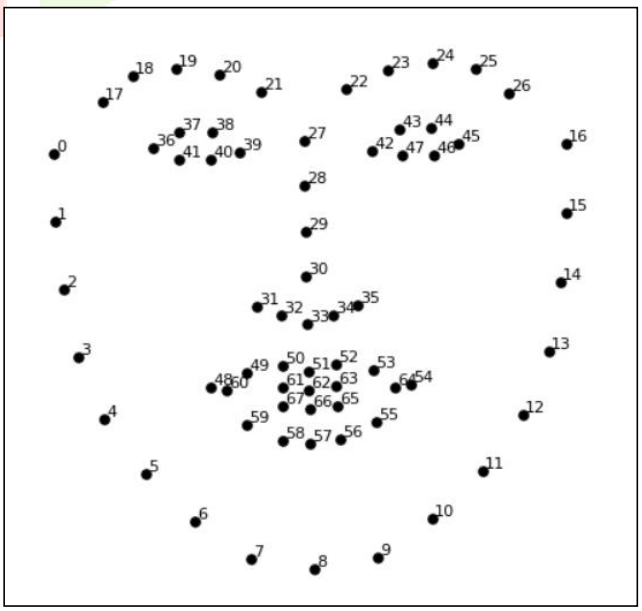


Figure 7: Landmark Point Map

V. FLOWCHART

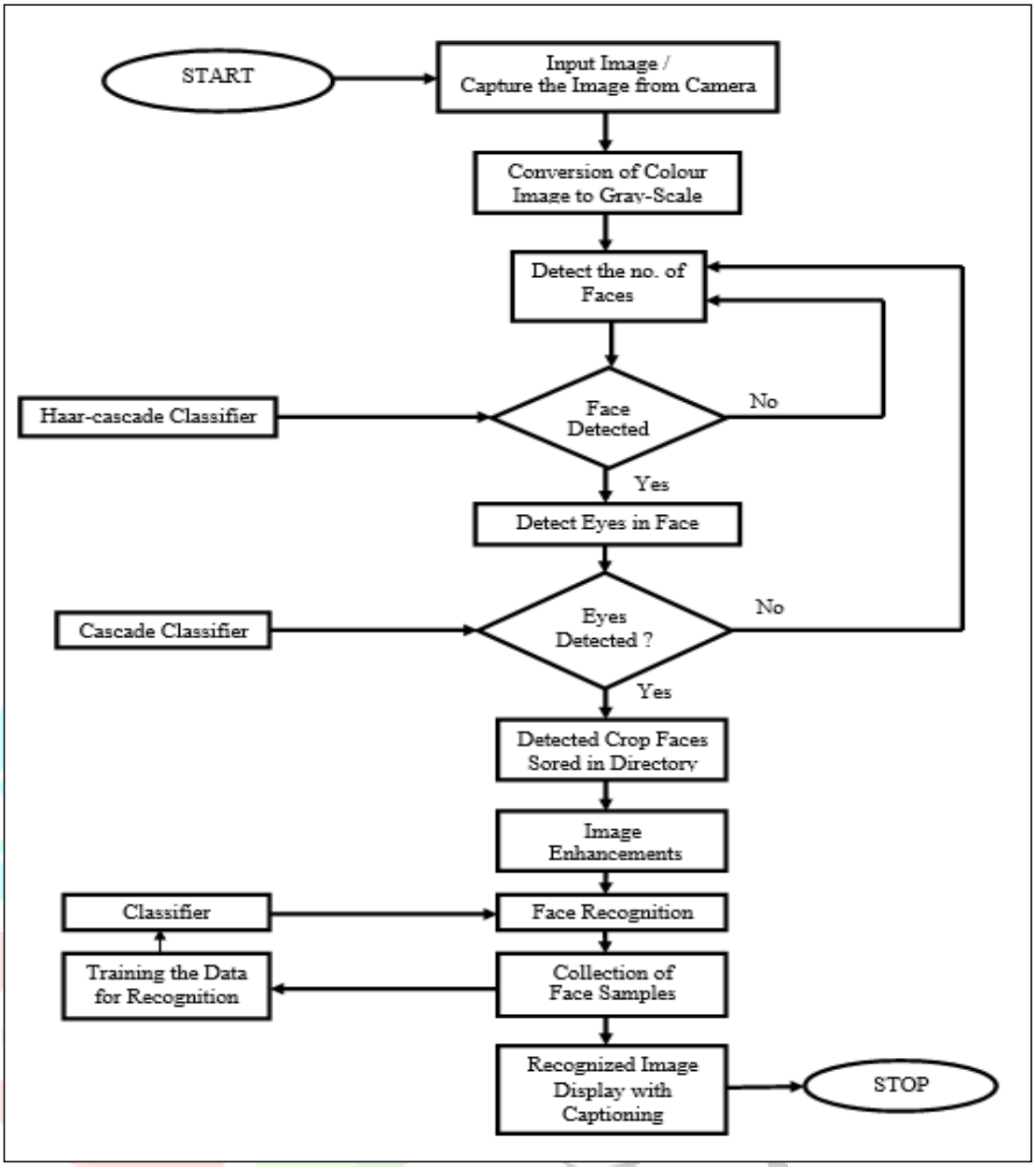


Figure 8: Flowchart of System Development for Person Identification

As describes in the fig. given above, it shows the step by step procedure which is a flowchart required for implementation of system.

VI. EXPERIMENT AND RESULT

This section is all about the results of face detection from group photos as well as results of face recognition i.e. person identification in group photographs with real time data gives 83% to 87.8% of accuracy using some machine learning and deep learning algorithms which are implemented using python-opencv platform. It has step by steps results of system.

Step I – Finding and Detecting Human face and Non-human face

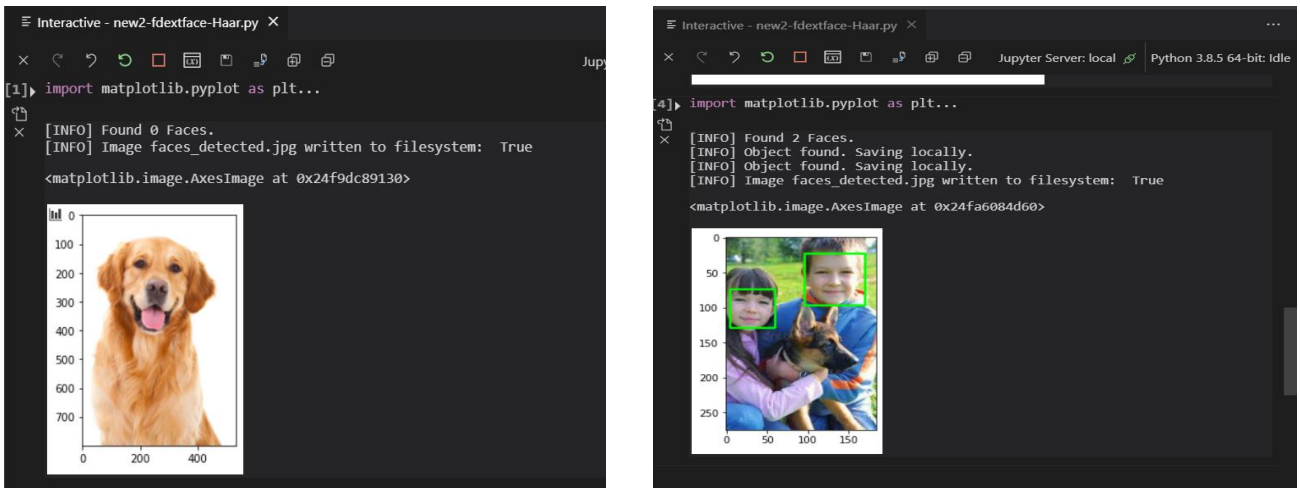


Figure 9 (i, ii): No. of human faces and non-human faces present in photograph

Step II – Detecting Multiple Faces from Group Photograph

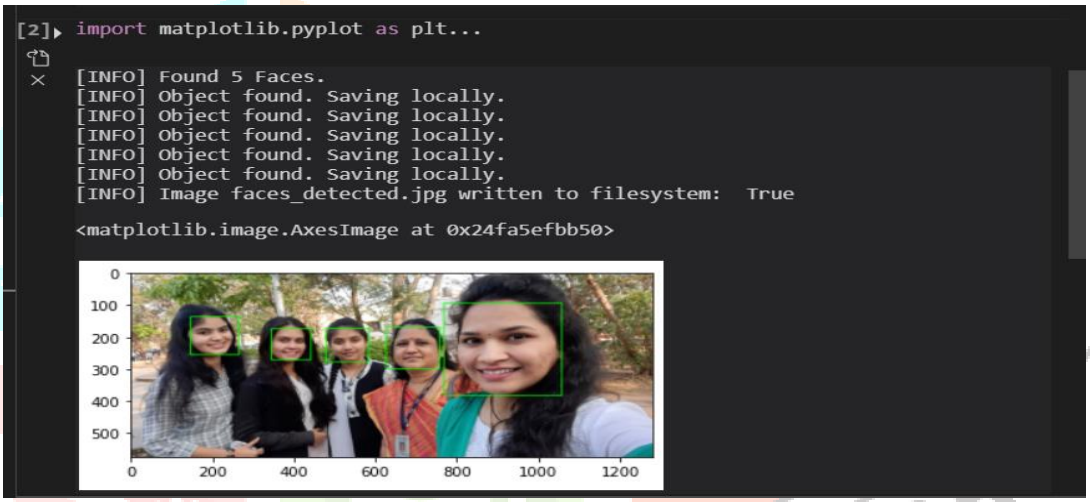


Figure 10: No. of founded faces in Group Photograph

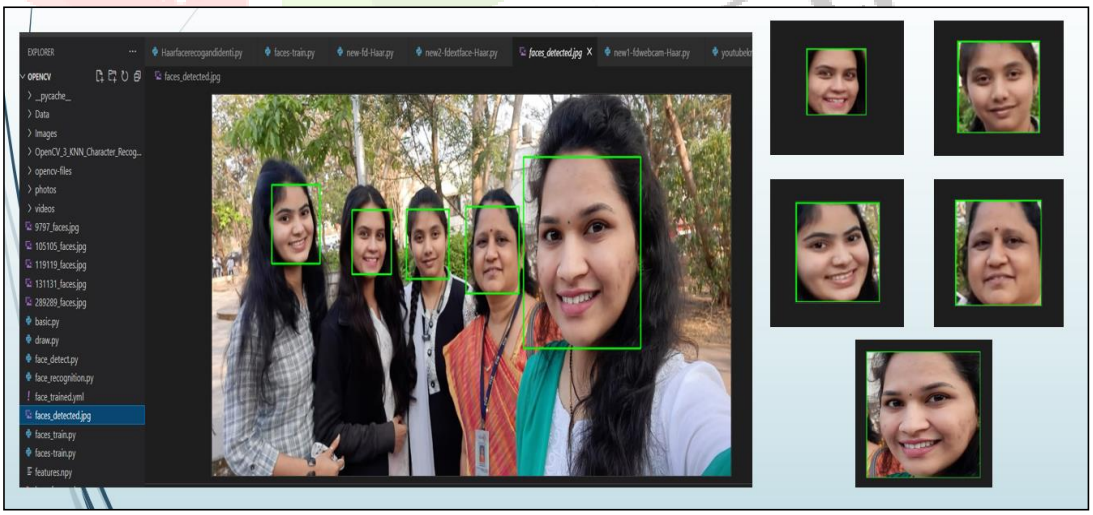


Figure 11: Detected and Cropped faces in Group Photographs

Step III - Detecting Features of face using Dlib, Python and OpenCV

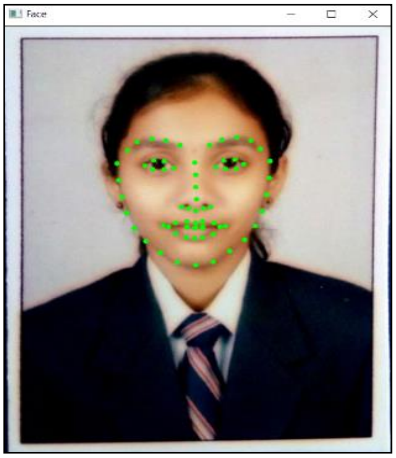


Figure 12: Point map detected on Single Face

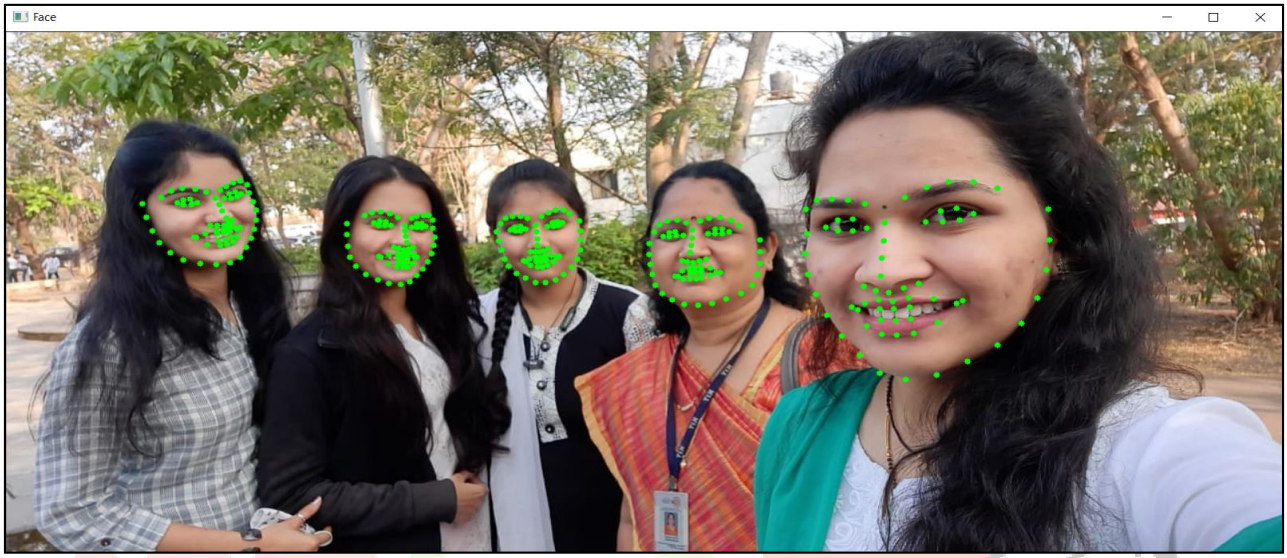


Figure 13: Point map detected on multiple faces from group photo

Step IV - Face Recognition using LBPH Recognizer

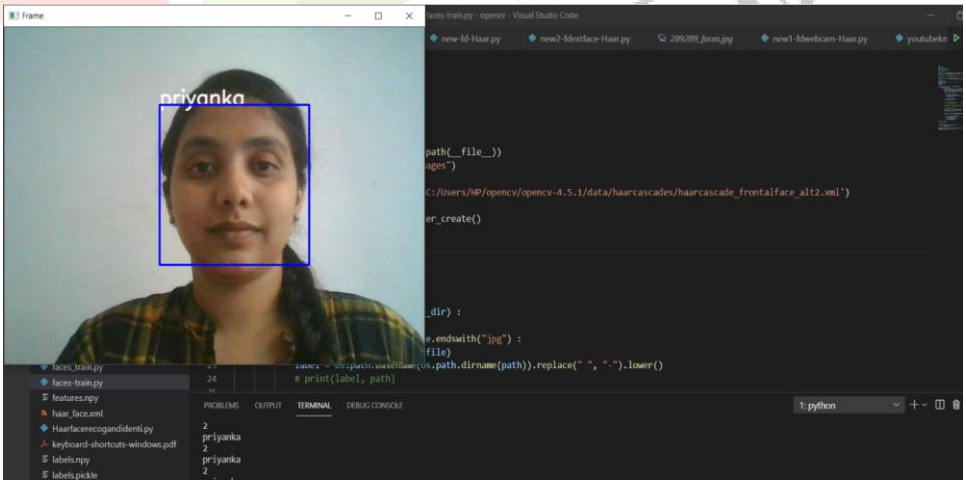


Figure 14: Result of Face recognition of Single Face with displaying name

Figure 15: Result of Face Recognition of Multiple Faces from group photo

Step V - Face Recognition using OpenCV DNN Caffe Model

Figure 16: Result of Person Identification with Confidence

VII. RESULT ANALYSIS

Sr. No.	Figure No.	Image Description	Algorithms	Description of Result
1.	9 (i)	Photo of Dog	Haar Cascade & LBPH	No. of faces found = 0.
2.	9 (ii)	Group Photo of Girl, Boy with Dog	Haar Cascade & LBPH	No. of faces found = 2.
3.	10	Group Photo of 5 Persons	Haar Cascade & LBPH	No. of faces detected = 5.
4.	11	Group Photo of 5 Persons	Haar Cascade & LBPH	No. of faces detected = 5. And detected faces are stored in directory.
5.	12	Photo of Single Person	Dlib Machine Learning Library	No. of faces detected = 1.
6.	13	Group Photo of 5 Persons	Dlib Machine Learning Library	No. of faces detected = 5.
7.	14	Webcam Image of Single Person	LBPH Recognizer	No. of faces detected = 1. No. of faces recognized = 1.
8.	15	Group Photo (Webcam Image) of 3 Persons	LBPH Recognizer	No. of faces detected = 3. No. of faces recognized = 3. The result of recognition is display with captioning i.e. name of person
9.	16	Group Photo of 2 Persons	OpenCV DNN Caffe Model	No. of faces found = 2. No. of faces recognized = 2. The result is display with captioning and shows recognition with confidence i.e. accuracy of result

Table 1: Analysis of Result using Various Algorithms

Sr. No.	Algorithm	Result Analysis
1.	Haar Cascade Classifier (Adaboost algorithm) (Only For Face Detection)	90.04% (Face Detection)
2.	LBPH Recognizer algorithm (Detection + Recognition)	95.63%
3.	DNN Caffe Model in OpenCV (Detection + Recognition)	83.35%
4.	Dlib Machine Learning Technology (For Detection)	91.08% (Face Detection)

Table 2: Result Analysis

VIII. CONCLUSION

The developed system is works on real time database. The complete process is executed in only few seconds. So it is very useful for real time application. The technique only detects human faces, it cannot detect non-human faces present in photographs. LBPH can locate local features in the images for getting absolute results and also powerful in case of repetitive gray-scale variations. Dlib is a machine learning library for face detection by extracting features of faces using point map that is by using landmark shape predictor. The system works on both face detection and recognition methodology with input image as digital image and it also works on video frames. DNN Caffe model is beneficial for both face detection and recognition system which is working with deep neural networks for detecting, extracting and identifying the person from group photograph with captioning. So the system is very user friendly for the real time application for security purpose, record and for monitoring system on real-time database.

IX. ACKNOWLEDGMENT

I take the opportunity to express our deep sense of gratitude & respect towards all who helped us to complete my project. I sincerely & humbly express my gratefulness to my family, friends, neighbors and relatives for helping me to collect the real time database i.e. photographs & thank them for their valuable time, support, encouragement & cooperation without which this project would not be completed.

X. REFERENCES

[1] Bhawna Ahuja, Virendra P. Vishwakarma, "Local Binary Pattern Based Feature Extraction with KELM for Face Identification", University of New South Wales, from IEEE Xplore, October 01, 2020.

[2] Mang Ye, Jianbing Shen, Senior Member, IEEE and Ling Shao, "Visible-Infrared Person Re-Identification via Homogeneous Augmented Tri-Modal Learning", IEEE Transactions on Information Forensics and Security, June 2020.

[3] Wenbi Rao, Menghan Xu, Junwei Zhou, "Improved Metric Learning Algorithm for Person Re-Identification Based on Asymmetric Metric", 2020 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA).

[4] Vimala Mathew, Tom Toby, Anu Chacko, Udhayakumar A, "Person re-identification through face detection from videos using Deep Learning", IEEE, 2020.

[5] Zhedong Zheng, Liang Zheng, Yi Yang, "Pedestrian Alignment Network for Large-scale Person Re-Identification", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 29, No. 10, October 2019.

[6] Zimian Wei, Wenjing Yang, Wanrong Huang, Huadong Dai and Dongsheng Li, "Person Re-Identification Based on Multi-Parts of Local Feature Network", IEEE, Volume 7, 2019.

[7] Monica Chillaron, Larisa Dunai, Guillermo Peris Fajarnes, Ismael Lengua Lengua, "Face detection and recognition application for Android", IECON2015-Yokohama, November 9-12, 2015.

[8] Prof. Avani Sakhapara, Prof. Dipti Pawade, Mr. Saumil Dedhia, Ms. Twinkle Bhanushali, Mr. Vinit Doshi, "Machine Learning Based Approach for Person Identification in Group Photos", Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), 2018.

[9] Ya Zhao, Sihui Luo, Yezhou Yang, Mingli Song, "Deepssh: Deep Semantic Structured Hashing For Explainable Person Re-Identification", Alibaba-Zhejiang University Joint Research Institute of Frontier Technologies(AZFT) Zhejiang University, Hangzhou 310027, China, ICIP 2018.

[10] Jalendu Dhamija, Tanupriya Choudhury, Praveen Kumar and Yogesh Singh Rathore, "An advancement towards efficient Face Recognition using Live video feed", International Conference on Computational Intelligence and Networks, 2017.

[11] Teddy Surya Gunawan, Muhammad Hamdan Hasan Gani, Farah Diyana Abdul Rahman and Mira Kartiwi, "Development of Face Recognition on Raspberry Pi for Security Enhancement of Smart Home System", Indonesian Journal of Electrical Engineering and Informatics (IJEEI), Vol. 5, No. 4, pp. 317~325, December 2017.

[12] Dwi Ana Ratna Wati, Dika Abadianto, "Design of Face Detection and Recognition System for Smart Home Security Application", 2nd International Conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE), 2017.