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Automatic Face Recognition and Detection Using OpenCV, Haar Cascade and Recognizer at Different Angle of Face

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ABSTRACT- This research is based on real-time automatic face recognition and detection which is performed at different angles with different light conditions using OpenCV library and recognizers. The recognizers used are Eigenface, Fisherface and LBPH with Haar cascade. These algorithms are first trained with images stored in database and then the testing is done using real-time images captured through camera. The results have been compared based on accuracy of recognition rate. It is found that with tilt frontal face the system using LBPH and Fisherface gave best work performance with ±10% tilt angle, and for complete up and down frontal face positions, the performance of system using Eigenface algorithm was better in both normal light condition (day) and low light condition (night). The overall performance comparison shows that LBPH has better results.

KEYWORDS-Face Recognition and Detection, OpenCV, Haar Cascade, Eigenface Algorithm, Fisherface Algorithm, LBPH (Local Binary Pattern Histogram) Algorithm.

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I. INTRODUCTION

Today's world is all about automation. Automation is a technology by which a process or procedure is performed with minimum human assistance. The application of automation is in robot, traffic light, access and security, medical application, cars, etc. Now a day's the biometrics technology is a specialized solution for automation and advance real-time monitoring of biotech manufacturing.

The biometric technology is a technological system that uses physical information about a person to identify that person. Biometric technology can be either morphological or biological.

There are two categories of biometrics:

1. Physiological measurements: Physiological measurements mainly consist of fingerprints, the shape of the hand, vein pattern, the eye (iris and retina), and the shape of the face, for morphological analyses.
2. Behavioral measurements: Behavioral measurement most common are voice recognition, signature dynamics (speed of movement of pen, accelerations, pressure exerted, inclination), keystroke dynamics, the way objects are used, gait, the sound of steps, gestures, etc.

Here the research is based on the automatic face recognition and detection from physiological measurements which take less time and give accurate results. Due to this automatic face recognition and detection system has received lots of attention from both research and industrial communities. Automatic face recognition and detection system is a technology capable of identifying or verifying a person from a digital image or a video frames.

The work flow of Automatic Face Recognition and Detection is as given in Figure 1. The Automatic Face Recognition and Detection system consist four steps:

1. Face Detection: In this section the human faces are detected using Haar Cascade from real-time image.
2. Detect Region of interest (ROI): Region of interest is a part of an image where the required operation is performed [1]. Here our region of interest is human face from the whole image.
3. Feature Extraction: Feature Extraction is the process of extracting features from the face that can be used for the recognition. In image processing the feature extraction is dimensionality reduction technique. Feature extraction is used to obtain the most relevant information from the original data and represent that information in a lower dimensionality space [2].
4. Face Recognition: Here face is compared with one or more number of known face images which is prepared in database and according to those images the system recognizes the authorized person.

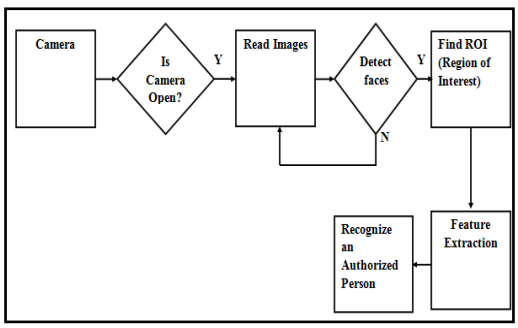

Figure 1. Automatic Face Recognition and Detection Workflow

In this paper, the literature review is presented in section II. In section III, research design is elaborated. Illustration of the experiments performed and results obtained is done in section IV. Finally conclusion is presented in section V.

II. RELATED WORK

Eigenface algorithm has been used by I. U. Wahyu Mulyono et al. [3] to recognize facial images. The author used public database of different facial images captured under three cases like, normal light, changing expressions and night mode wherein the accuracy of recognizing face images are 100%, 88% and 67% respectively, with an average of recognition of face is 85%. T.Mantoroet al. [4] proposed a Multi-Faces Recognition Process Using Haar Cascade and Eigenface Method. The system was non-real time performed with 60 images stored in the database and out of which 55 images were recognized with 91.67% recognition rate. J. Dhamija et al. [5] used ORL databaseconsisting of images captured in different conditions like varied illumination and facial expressions. They proposed Face Recognition system using live video feed using Fisherface, PCA, SVD and PCA+Fisherface+SVD algorithm and obtained 80.7%, 96.6%, 98.4% and 99.5% respectively.

F. Malik et al. [6] proposed a face recognition and detection system using Eigenface algorithm which recognizes the person in both day and night mode. Here the researcher got recognition ability between 0 to 50%.S.V.Tatheet al. [7] proposed a non-real-time face recognition and detection system for human face detection using Haar features and recognition using Eigen and Gabor filter in videos. M. Arsenovicet al. [8] proposed Face Time-Deep Learning Based Face Recognition Attendance System in which they used LBPH Algorithm and RFID based attendance system with small data size and they got 95.02% recognition rate. Various researchers have used LBPH and MLBPH (Median Local Binary Pattern Histogram)algorithms for face detection and recognition which includes images captured varying light condition, tilt angle and changing facial expressions.

P. Kamencayet al. [9] proposed face recognition system for wild animal using PCA, LDA and LBPH. Comparatively, LBPH gave higher recognition rate as 88%. B. M. Naira et al. [10] proposed a real time system for person detection, recognition and tracking using frontal and profile faces. The system integrates face detection, face recognition and tracking techniques. The face detection algorithm uses both frontal face and profile face detectors by extracting the Haar features and uses them in a cascade of boost classifiers. The system was able to recognize the side face up to $\pm 30^0$ angle. J. Kavitha at al. [11] proposed a real time system which can detect and recognize frontal and side view with $\pm 22^0$ faces.

III. RESEARCH DESIGN

There are three main parts of automatic face recognition and detection system which are Database [1], Training Module [2], and Testing Module [3].

A. Database: Database is the first and most important part of automatic face recognition and detection system. The database consists of lots of images of authorized persons who the owner/user want to allow in his/her region.

In this automatic face recognition and detection system, end user can easily create his/her own database. The block diagram of database is as shown in Figure 2. Whenever the owner/user wants to add new authorized person in his/her region then at that time owner/user needs to run the code and can enter the new authorized person's ID. After then the camera will be open and detect face and take real-time images of new authorized person which takes 2-3 minutes. These captured color images are read by computer which is then converted into Gray Scale Images. Haar Cascade Classifiers are then loaded on images. In python the OpenCV provide 16 Haar Cascade Classifier for detecting face, eyes, text, object etc. Using frontal face Haar Cascade classifier, the system will detect human face. Haar Cascade uses adaboost algorithm to detect facial organs like eyes, nose and mouth. If the human face is detected then the rectangular frame is displayed on face and the image which is present inside the rectangle is saved at assigned location.

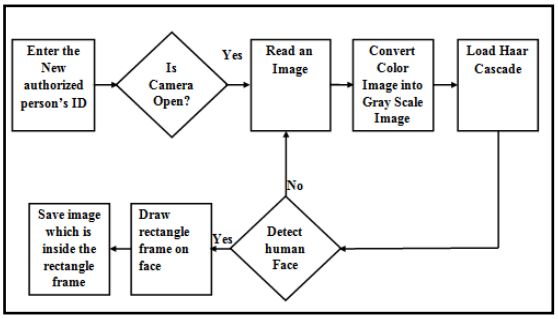

Figure 2. Flow Diagram of Database Process

B. Training Model/Part: Training Model/Part is the second important part of automatic face recognition and detection system. Here the recognizer is used to train the recognizer using a pre-set label Image database.

Figure-3 shows a linked state machine flow diagram of research design. The flow diagram shown in Figure 3(b) is Training Model/part of AFRD system. Here the gray scale images which are stored into database are converted into matrix using Numpy. The Numpy is a library /general purpose array processing package which provides a high-performance multidimensional array object, and tools for working with arrays. Afterwards, Haar Cascade Classifier and Recognizer is loaded on these gray scale images. The Haar Cascade detects the face from the image and the recognizer help to perform the operation of feature extraction of images. After then the data will be stored into a file at an assigned location with a label.

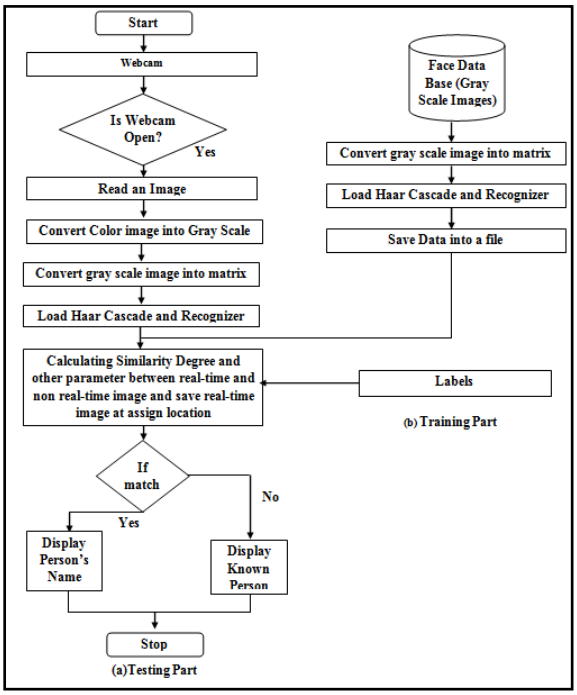

Figure 3. Flow Diagram of Research Design

C. Testing Model/Part: Testing Model/Part is the third important part of automatic face recognition and detection system. In Testing Model, the real-time image is compared with the non-real-time images and recognizes the authorized person.

Figure-3 shows a linked state machine flow diagram of research design. The flow diagram Figure 3(a) is a Testing Model/Part of AFRD system. The process is going to start when the real-time color image which is captured the camera and it is sent to attached computer. Now this real-time image is converted into Gray Scale image after then it is converted to matrix using Numpy. The next step is to load Haar Cascade and recognizer on image. Here the Haar Cascade detects face from image and find Region of Interest (ROI) and the recognizer performs feature extraction operation. Then this real-time image is compared with the non-real-time images stored in the database. The real-time image captured is also stored at assigned location for later use by owner. If the real-time is matched then the authorized person's name is displayed on rectangular frame, otherwise unknown person is displayed.

IV. EXPERIMENT AND RESULT

In this research work we are performing four different experiments. All these experiments are performed using Eigenface, Fisherface and LBPH (Local Binary Pattern Histogram) algorithms.

The automatic face recognition and detection system has been developed usingComputer with specification as follows: Intel® Core™2 Duo CPU T6670@ 2.20GHz processor, 4 GB RAM and 32-bit Operating system and 46Mega pixels night vision camera used to capture images. The code is written using python and its associated libraries which includes numpy, OpenCV, pip and pillow. The distance between camera and person is kept at minimum 35cm and maximum 150cm.

The design of Automatic Face Recognition and Detection for Security Lock Technology is based on the parameters, like User friendly structure [1], varying surrounding light condition [2], facial expression [3], distance between person from camera [4], Angel [5] .

Here the system has been designed using three different algorithms such as Eigenface, Fisherface and LBPH. All these experiments are performed in day (with normal light condition) and night (with very low light condition) mode with both varying facial expressions and without varying facial expressionstaken from different angles. The results are then compared using the parameter, Recognition rate.

The equation of recognition rate is:

$$\text{Recognition Rate} = \frac{Number\ of\ correctly\ identified\ images}{Total\ number\ of\ mages} \times 100$$

The system has been trained by running each algorithm ten times and then an average is taken. The training time is 85seconds.

In the first three experiments, to obtain the degree up to which person is detected and recognized, he/she is made to move the head 90 degrees from center to left and then center to right, in front of camera. Here, left is considered as minus angle and right as positive angle.

While moving head in either of the direction, head is kept stable at a position and camera is allowed to take 20 frames at an instant, and then the head is moved to next position to capture frames. Each experiment is repeated in similar manner 10 times, and then average of recognition rate is taken.

Table 1 is prepared from the test results of first experiment which is performed under the normal light condition. It shows the comparison between the test results and performance of algorithms obtained at different face angles. The Figure 4, 5 and 6 are the test images of the implemented system using Eigenface, Fisherface and LBPH algorithms respectively. From these images the 1st image is about the face detection and Recognization at frontal face. The 2nd image is about the face detection and Recognization of best left side angle of the face. The 3rd image is about the face detection and Recognization of best right side angle of the face.

Algorithm	Recognition Rate At Different Angle with normal Light Condition								
	Left				Center	Right			
	75^0	60^0	45^0	30^0	0^0	30^0	45^0	60^0	75^0
Eigenface	0%	0%	0%	100%	100%	100%	80%	0%	0%
Fisherface	90%	100%	100%	100%	100%	100%	100%	100%	0%
LBPH	90%	100%	100%	100%	100%	100%	100%	100%	90%

Table 1.Result of experiment 1

In this comparison, the LBPH algorithms gave best work performance and as per the Figure 6 and Table 1, LBPH algorithm detect and recognize the person from -75^0 to +75^0 with 90% recognition rate. Beyond 75^0 from both the sides it cannot detect the person. As per the Figure 5 and Table 1, the Fisherface algorithm can finely detect and recognize the person from -60^0 to +60^0 with 100% recognition rate but it also detects and recognize the face moved 75^0 left with 90% recognition rate. As per the Figure 6 and Table 1, the Eigenface algorithm can detect and recognize the faceof person from -30^0 to +30^0 with 100% recognition rate. Beyond 30^0 it isunable to detect the person.

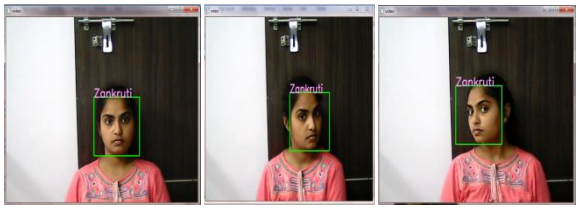

Figure 4.Test Image of Face Recognition and Detection Eigenface

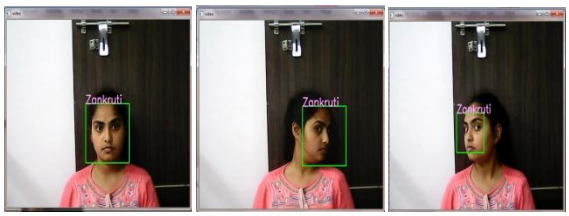

Figure 5.Test Image of Face Recognition and Detection Fisherface

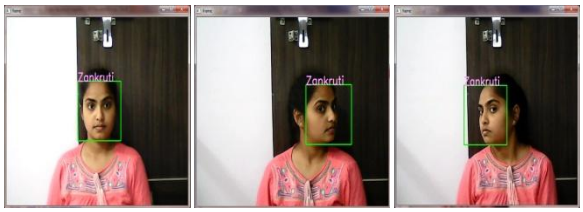

Figure 6. Test Image of Face Recognition and Detection LBPH

Table 2 is prepared from the test results of 2nd experiment which is performed under the low light condition (night). It shows the comparison between the test results and performance of algorithms obtained at different face angles. Figure 7, 8 and 9 are the test images of the implemented system using Eigenface, Fisherface and LBPH algorithms respectively. From these images the 1st image is about the face detection and recognization at frontal face. The 2nd image is about the face detection and recognization of best left side angle of the face. The 3rd image is about the face detection and recognization of best right side angle of the face.

Algorithm	**Recognition Rate At Different Angle with Night Vision Condition**								
	Left				**Center**	**Right**			
	75^0	**60^0**	**45^0**	**30^0**	**0^0**	**30^0**	**45^0**	**60^0**	**75^0**
Eigenface	**0%**	**0%**	**0%**	**100%**	**100%**	**100%**	**0%**	**0%**	**0%**
Fisherface	**0%**	**90%**	**100%**	**100%**	**100%**	**100%**	**100%**	**90%**	**0%**
LBPH	**20%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**80%**

Table 2. Result of experiment 2

In this comparison again the LBPHface algorithms gave best work performance and as per the Table 3 and test images, LBPHface algorithm detect and recognizes the person from -60^0 to +60^0 with 100% recognition rate. Beyond 60^0 to 75^0 from the right side it can detect and recognize the person with 80% recognition rate. But from 60^0 to 75^0 from the left side it cannot detect and recognize the person properly, the recognition rate is just 20%. So as per the results, the LBPH system gave the best result between angles -60^0 to +75^0 and gave worst results between +60^0 to +75^0 . Beyond 75^0 from both the sides it cannot detect the person. As per the Table 2, the Fisherface algorithm can finely detect and recognize the person from -60^0 to +60^0 with 90% recognition rate and beyond 60^0 angle, it cannot detect the person. As per the Table 3, the Eigenface algorithm can detect and recognize the person from -30^0 to +30^0 with 100% recognition rate. Beyond 30^0 it cannot detect the person.

Figure 7. Test Image of Face Recognition and Detection Eigenface

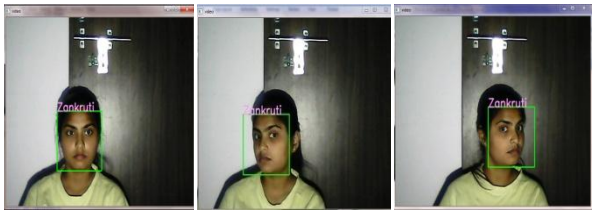

Figure 8. Test Image of Face Recognition and Detection Fisherface

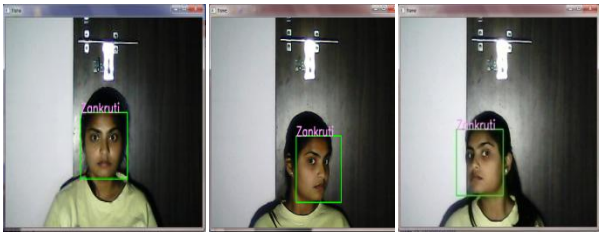

Figure 9. Test Image of Face Recognition and Detection LBPH

Table 3 is prepared from the test results of third experiment which is performed by including expressions like smile, anger look, and pout poses in normal light (day) and low light condition (night) taken at different angles. A comparison is done between the test results and performance of algorithms. Figure 10, 11 and 12 are the test images of the implemented system using Eigenface, Fisherface and LBPH algorithms respectively. The Figure includes the images captured under both normal light (day) and low light conditions (night).

Algorithm	**Recognition Rate At Different Angle with Some Expression**								
	Left				**Center**	**Right**			
	75^0	**60^0**	**45^0**	**30^0**	**0^0**	**30^0**	**45^0**	**60^0**	**75^0**
Eigenface	**0%**	**0%**	**0%**	**100%**	**100%**	**100%**	**0%**	**0%**	**0%**
Fisherface	**0%**	**90%**	**100%**	**100%**	**100%**	**100%**	**100%**	**90%**	**0%**
LBPH	**50%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**60%**

Table 3. Result of experiment 3

In this Comparison the LBPHface algorithms gave best work performance and as per the Figure 10 and Table 3, LBPHface algorithm detect and recognize the person from -60^0 to $+60^0$ with 100% recognition rate. But after 60^0 to 75^0 from the right side it can detect and recognize the person with 60% recognition rate and from 60^0 to 75^0 from the left side it can detect and recognize the person with 20% recognition rate. So as per the results, the LBPH system gave best result between -60^0 to $+75^0$ and gave worst result between -60^0 to $+75^0$. Beyond 75^0 angle from both sides it cannot detect the person. As per the Figure 11 and Table 3, the Fisherface algorithm can finely detect and recognize the person from -60^0 to $+60^0$ with 90% recognition rate and After 60^0 it cannot detect the person. As per the Figure 12 and Table 3, the Eigenface algorithm can detect and recognize the person from -30^0 to $+30^0$ with 100% recognition rate. Beyond 30^0 it cannot detect the person.

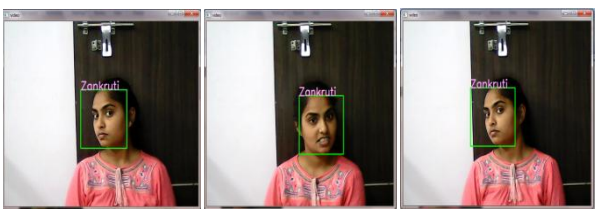

Figure 10. Test Image of Face Recognition and Detection Eigenface

Figure 11. Test Image of Face Recognition and Detection Fisherface

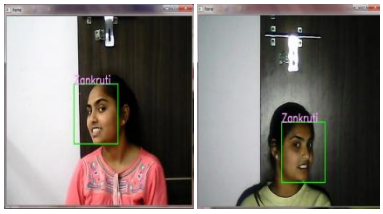

Figure 12.Test Image of Face Recognition and Detection LBPH

In this fourth experiment, we are rotating our frontal face around the camera from up to down and vice-versa and we can also tilt our frontal face. This experiment is conducted in both normal light condition (day) and low light condition (night). Here we Read 20 frames at a time, repeat each experiment 10 times, and take the average of it.

Table 4 is prepared from the test results of fourth experiment. A comparison between the test results and performance of algorithms is done. Figure 13, 14 and 15 are the test images of the implemented system using Eigenface, Fisherface and LBPH algorithms respectively. The Figure includes the images taken in both normal light (day) and low light condition (night). From these images the 1st two images is about the face detection and recognization from up to down in low light condition (night). The middle two images are about the face detection and recognization from up to down in normal light condition (day). The 5th image is about the face detection and recognization when we tilt our front face.

Algorithm	Recognition Rate At Different Angle with Some Expression		
	Up	Down	Tilt
Eigenface	**100%**	**100%**	**30%**
Fisherface	**100%**	**100%**	**100%**
LBPH	**100%**	**100%**	**100%**

Table 4.Result of experiment 4

It is inferred from Table 4 and Figure 13, 14 and 15, that all the algorithms can detect and recognize the person very well when he/she rotate his/her frontal face from up to down and vice-versa. But from that the system using Eigenface gave best work performance compared to other algorithms in both normal light condition and low light condition. It can also detect and recognize the person when person rotate his/her face fully up and down. Whereas the Fisherface and LBPH algorithm cannot detect and recognize the person when person rotate his/her face fully up and down in both conditions.

Table 4 and 5th image from Figure 13, 14 and 15, shows that the system using Fisherface and LBPH gave best work performance with 100% recognition rate and it detects and recognizes the person with ±10 %. The system using Eigenface gave worst performance with 30% recognition rate and recognizes the person with ±5 %.

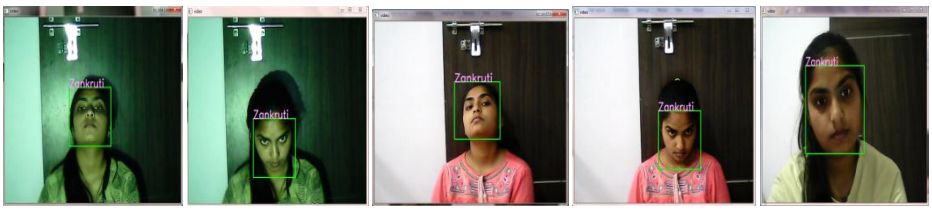

Figure 13. Test Image of Face Recognition and Detection Eigenface

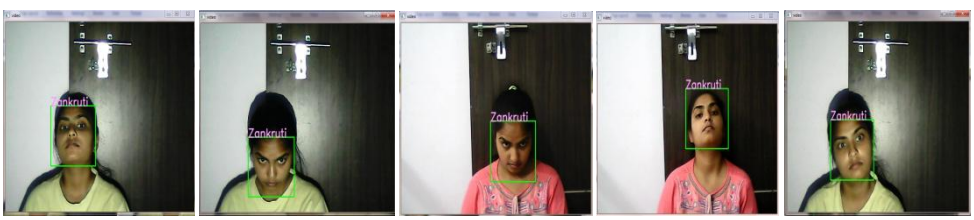

Figure 14. Test Image of Face Recognition and Detection Fisherface

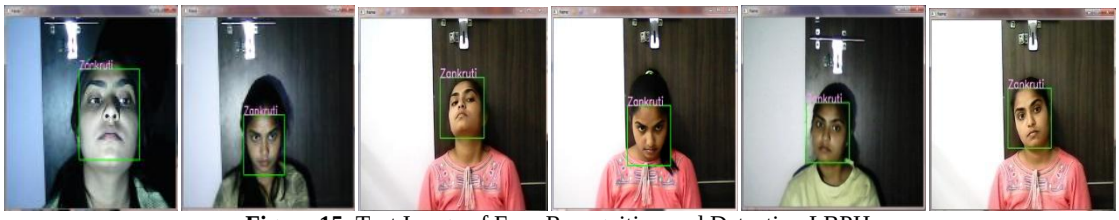

Figure 15. Test Image of Face Recognition and Detection LBPH

V.CONCLUSIONS

This research paper represents a real-time automatic face recognization and detection system using three different algorithms which are Eigenface, Fisherface and LBPH algorithm. As per the above experiments we can conclude that the system using the Eigenface, Fisherface and LBPH algorithm with frontal face Haar Cascade can successfully detect and recognize the person from -30^0 to $+30^0$, -60^0 to $+60^0$ and -60^0 to $+75^0$ angle respectively in both normal light condition (day) and low light condition (night) with minimum 35cm and maximum 150cm distance.

Here we can also detect the person when person rotates his/her frontal face from up to down and vice-versa and also can detect and recognize the person with tilt frontal face. In order to detect and recognize the person with tilt frontal face the system using LBPH and Fisherface gave best work performance with ±10% tilt angle and for completely up and down frontal face angle the system using Eigenface algorithm gave best result in both normal light condition (day) and low light condition (night).

So if we compare overall performance of the systems then than the system using LBPH algorithm gave best result in both normal light condition (day) and low light condition (night).

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