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Automatic Face Recognition and Detection Using OpenCV, Haar Cascade and Recognizer for Frontal Face

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Abstract: This research is based on real-time automatic frontal face recognition and detection using OpenCV, Haar Cascade and recognizers. The recognizers used are Eigenface, Fisherface and LBPH with Haar cascade. These algorithms are firstly 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 if we increase the distance between person and camera the Eigenface cannot detect and recognize the person properly. On other hand the LBPH and Fisherface gave best work performance withcapability to detect and recognize the authorized person with ±5% tilt angle and varyingfacial expressionsin both normal light condition (day) and low light conditions (night).

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

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I. INTRODUCTION

Technological advancements in automation, robotics and use of artificial intelligence have made life of human being more comfortable. People are leadinga very busy life style. Due to their busy life style they want technologies which can make their life secure and easier. To secure their home, car, office, mobile, laptop, etc they are using security lock technology. The security lock technology uses Remote keyless Access technology, Near-Field Communication technology, Touch-Screen technology, biometric or multi biometric system. Out of these technologies, the biometric and multi-biometric system providesbetter security, gives fast and more accurate results.

The Automatic face recognition and detection is the one of the important research projects of biometric systems. In the field of computer vision and pattern recognition a person is identifiedby person's face image data base [6]. This technology is not only used to secure our home, office, shop but it is also used widely used in authentication, criminal investigation, video surveillance, robot intelligence and medical science. One of the applications of automatic face recognition and detection system is Security Lock Technology.

The important step in Automatic Face Recognition and Detection system is to prepare a database which consists of images of authorized persons whom we want to allow in our region or place.

The work flow of Real-time Automatic Face Recognition and Detection is as shown in Figure-1.The process starts with camera in open condition where the captured images are stored and then processed. The first step of the automatic face recognition and detection isto detect face from real-time image. The second step is to find region of interest (ROI). Region of interest is a portion of an image on which we want to perform some operation like filtering image, find boundary of image etc [1]. Here our region of interest is face from the whole image. The third step is feature extraction. In image processing the feature extraction is dimensionality reduction technique [2]. Feature extraction is used to obtain the most relevant information from the original data and represent that information in a lower dimensionality space. The fourth step is torecognize the face.

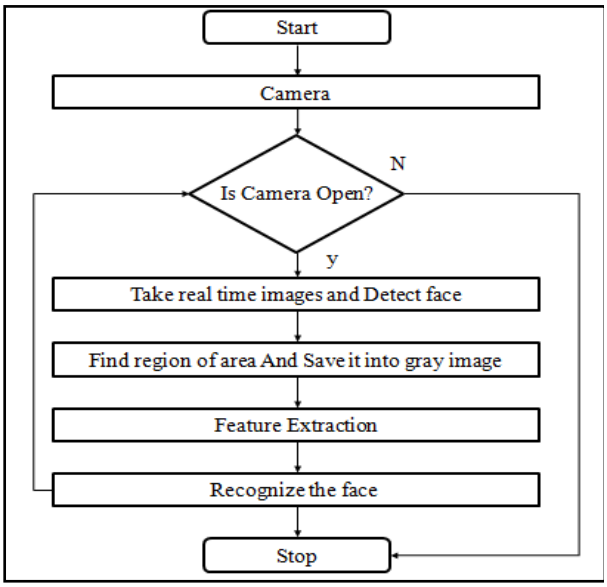

Figure 1. Automatic Face Recognition and Detection Workflow

There are multiple number of algorithms available for the Automatic face recognition and detection, however the most widely used algorithms are Eigenface, Fisherface and LBPH (Local Binary Patten Histogram). In this work, these three algorithms have been used for automatic face recognition and detection.The code has been implemented using Python and OpenCV library.The rest of the paper is organized as follows; a brief description of related work has been illustrated in Section II. Research design has been discussed in section III. Section IV includes results obtained and analysis. 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. Mantoro [4] proposed a Multi-Faces Recognition Process Using Haar Cascades 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.Tathe [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. Arsenovic et 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. Kamencay at 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 ±30° angle. J. Kavitha at al. [11] proposed a real time system which can detect and recognize frontal and side view with ±22° faces.

III. RESEARCH DESIGN

There are three main parts of Automatic Face Recognition and Detection system which includes Database, Training Module, and Testing Module.

A. Database: Database is the first and most important part of Automatic Face Recognition and Detection system. The database consistsof lots of images of authorized persons who the owner/user want to allow in his/her region. The block diagram of database is as shown below.

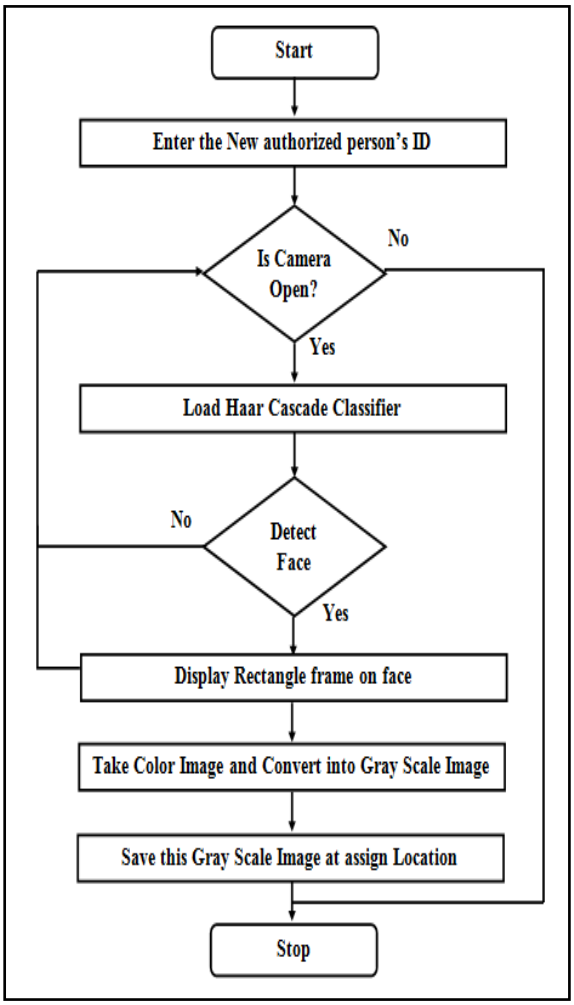

Figure 2. Flow Diagram of Database Process

Whenever the owner/user wants to add new authorized person in his/her region at that time owner/user run the code to capture images and enters the new authorized person's ID. When the camera opens, then the Haar Cascade classifier is loaded on image. Using frontal face Haar Cascade classifier, the faceis detected from the image.If the face is detected then the system takes images of that person and stores image at assignedlocation. The system takes 2-3 minutes for making database of one person. Thus,it consumes less time of owner/user.

B. Training Model/Part:Training Model is the second important part of Automatic Face Recognition and Detection system. Here we are going to train our recognizer using a pre-set label Image database.

Figure 3, shows the research design of Automatic Face Recognition and Detection.The above part of the flow diagram of Research design is Training Model. 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 these arrays. In the next step, Haar Cascade Classifier and Recognizer are loaded on these gray scale images. The Haar Cascade detects the face from the image and the recognizer helps the system toperform the operation of feature extraction from images.The OpenCV provides 16 Haar CasCade to detect face, eyes, object, and text. Haar Cascade use adaboost algorithm to detect facial organs like eyes, nose and mouth. Using Haar wavelet it draws rectangular frame around the face. After the feature extraction step, the data is stored into a file at an assigned location.

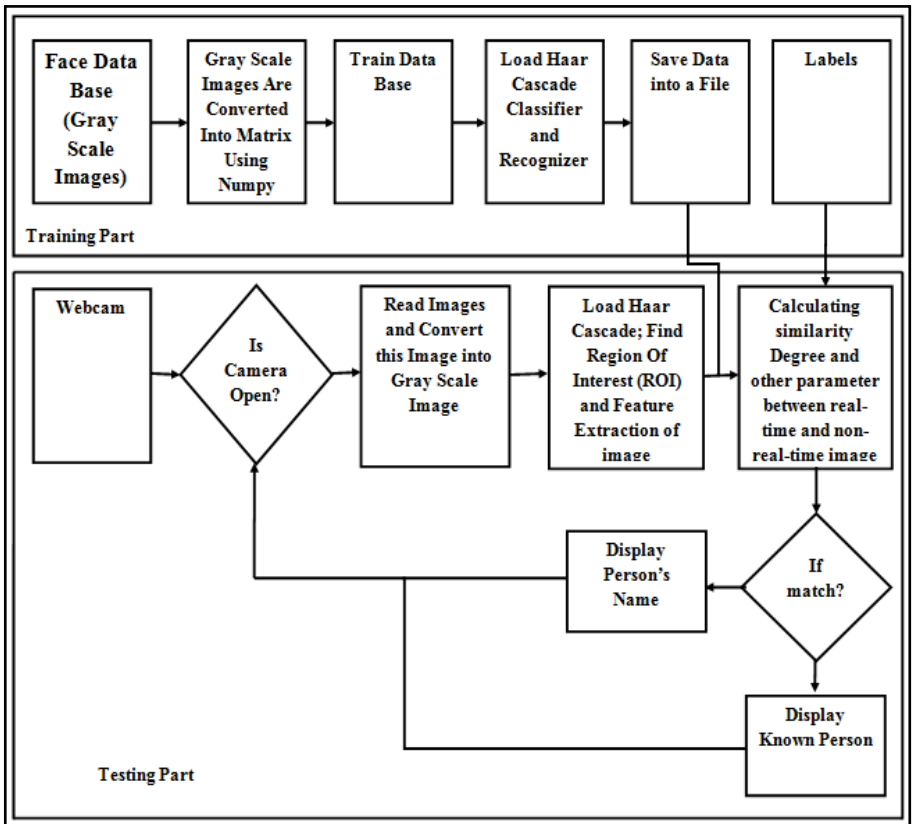

Figure 3. Flow Diagram of Research Design

C. Testing Model/Part: Testing Model 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 recognize the authorized person.

The below part of the flow diagram of Research design is Testing Model. Here the real-time color image which is captured by camera is converted into gray scale image. Using Haar Cascade and recognizer system detects the face from the image andperforms feature extraction operationon images. The next step is to calculate the degree of similarity and other parameters between real-time image and non-real-time image. Here system compares theface between real-time image and non-real-time image. In this automatic face recognition system, the angle of face, surrounding light conditions, distance between person and camera and facial expressionsare also considered while recognition. If the degree of similarity and other parameters between real-time image and non-real-time image are matched thenthe authorized person's name is displayed on rectangular window, otherwise unknown person is displayed on rectangular window.

IV. RESULT& ANALYSIS

In this research, three different cases have been used. The first case is implemented under the normal light condition. In the second case, we add some expression and the third caseis implementedunder night light vision. All the cases are considered using three different algorithms which are Eigenface, Fisherface and LBPH algorithms.

The Automatic Face Recognition and Detection system is developedon Computer with specification as follows: Intel® Core™2 Duo CPU T6670@ 2.20GHz processor, 4 GB RAM and 32-bit Operating system. 46Mega pixelnight vision camera has been used to capture real-time images. The size of image considered in paper 224 x 224 pixels. The code has been written using python with Numpy, OpenCV, pip, pillow libraries.

The design of Automatic Face Recognition and Detection forSecurity Lock Technology is based on theparameters like User friendly structure, varying surrounding light condition, facial expression anddistance between person from camera. The distance is varied from 35 cm to 85cm. The results have been compared using the metric 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 obtained is 7.2282 seconds.

The test results are mentioned in Table 1, wherein Eigenface recognizer has been used for feature extraction process.

Distance Between Person and Camera(cm)	Recognition Rate using Eigenface		
	Day	Night	With Expression
35	100%	100%	100%
40	100%	100%	100%
50	100%	100%	100%
60	100%	100%	100%
70	100%	100%	80%
80	20%	20%	0%
Total	86.66%	86.66%	80.00%

Table 1. Face recognition usingEigenface recognizer

Figure 5. Face recognitionusing Eigenface with different expressions

Figure5 shows the system recognizing different expressionsusing Eigenface. Here the system recognizes the face from varying distance with different expressions like confusing, smile, anger look and also recognize the face of person when he/she is talking. The third image from Figure 5 represents the face, where system is detecting and recognizing the person when he\she is talking. The results obtained shows that as distance between camera and person is kept up to 70cm, recognition rate is 100% in daylight, night condition and with varying expressions. However, as distance is increased to 80cm, the recognition rate reduces to 20% for both the light conditions and 0% with varying expressions. Thus up to 70cm feature extracted using Eigenface algorithm helps in face recognition perfectly but after that the performance degrades.

In the second case, Fisherface recognizer has been used for feature extraction. The results so obtained are mentioned in Table 2.

Distance Between Person and Camera(cm)	Recognition Rate Using Fisherface		
	Day	Night	With Expression
35	100%	100%	100%
40	100%	100%	100%
50	100%	100%	100%
60	100%	100%	100%
70	100%	100%	100%
80	100%	100%	100%
Total	100%	100%	100%

Table 2.Face recognition using Fisherface

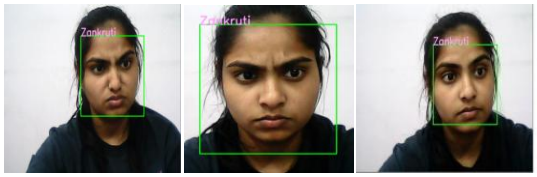

Figure 6.Face recognition with different expressions using Fisherface Algorithm

Figure 6 shows the system which can recognize different expressions using Fisherface. Here the system recognizes the face fromvarying distance with different expressions like confusing, smile, anger look and also recognizes the face of person when he\she is talking. The third image from Figure 6 represents the face where system is detecting and recognizing the person with ±5% face tilt. The results obtained in Table2 shows that Fisherface algorithm performs better in all the cases. Keeping distance up to 80cm also Fisherface algorithm gives 100% recognition rate, with varying expressions and tilt in face position, as shown in Figure in Figure 6.

Table-3 is prepared from the test results of third case, in which we use LBPH recognizer for feature extraction process.

Distance Between Person and Camera(cm)	Recognition Rate Using LBPH		
	Day	Night	With Expression
35	100%	100%	100%
40	100%	100%	100%
50	100%	100%	100%
60	100%	100%	100%
70	100%	100%	100%
80	100%	100%	100%
Total	100%	100%	100%

Table 3. Face recognition using LBPH recognizer

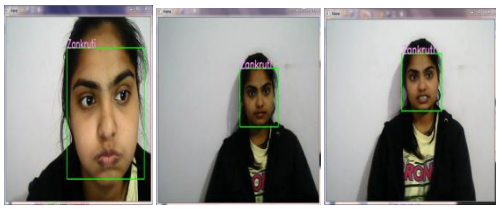

Figure 7. Face recognition using LBPH Algorithm with varying Face expressions

Figure 7 shows the system which recognizes different face expressions using LBPH recognizer. Here the system recognizes the face from varying distance with different expressions. The results mentioned in Table 3, shows that LBPH algorithm gives 100% recognition rate in both day and night light conditions while varying distance up to 80cm with different face expressions. As LBPH analyzes each image independently in contrast to Fisherface and Eigenface algorithms where complete dataset is considered as a whole, so the performance of LBPH is better comparatively.

V. CONCLUSION

This research paper represents a Real-time automatic face recognization and detection system using three different algorithms which are Eigenface, Fisherface and LBPH algorithm with frontal face Haar Cascade and database consisting of images of varying face expressions. As per the results so obtained it can be concluded that as we increase the distance between person and camera the system using Eigenface algorithm is not able todetect and recognize the person but the system using Fisherface and LBPH can detect and recognize the person with 100% recognition rate. LBPH can also detect the face positioned at ±5% tilt angle.

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