An Implementation of Real-time Automatic Masked and Unmasked Face Recognition Using LBPH Algorithm

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Abstract: ***Face recognition is an important research in computer vision technology. Face recognition is biometric technologies which identify identities from their visual features of face images. There are many challenges to make a face recognition system like light illumination, pose variation, angle of face, distance between face and camera. But Due to COVID-19 one of the biggest challenge is added into the challenge list which is detect and recognize person face with facemask. Here the research is based on a real-time automatic masked and unmasked face recognition system. This is implementing using OpenCV, Haar Cascade and LBPH Algorithm which is able to detect and recognize a single person and multiple(two) person at a time with and without facemask. And also recognize multiple authorized persons when one-person ware facemask and another person didn't ware facemask.***

Keywords: Real-time, Face Recognition, Masked faces, Non-masked faces, LBPH algorithm

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I. INTRODUCTION

From the Biometric technologies the Face recognition technology is one of the most important research projects in the field of computer vision and pattern recognition [1], which identify person and other information according to the visual features of face image within less time and less interaction between machine and person. Due to this feature, it is using everywhere like in mobile, laptop, ATM, bank, office, school, hospital, industry, criminal investigation, surveillance, finding missing persons for security purpose.

Normally the face recognition system identifies (recognize) the authorized person without the mask. But now a day due to COVID-19 the mask is compulsory for all us at any place. But the normal face recognition system cannot identify (recognize) the authorized person with the mask. To solve this problem here we implement a Face Recognition System which recognizes the authorized person with masked and non-masked face. Here the system is implemented using Haar Cascades, OpenCV and LBPH (Local Binary Patten Histogram) Algorithm. This system is design to detect and recognize the person in real-time.

The system takes real-time image of person from camera and detects face from the whole image using Haar Cascade after then it finds Region of interest (ROI)and feature extraction process is performed on that image using LBP operator. After feature extraction process the capture image is

compared with non-real time images which are store into database. And recognize the person based on similarity.

II. LITERATURE SURVEY

After fingerprint recognition biometric system, the face recognition is second most accurate biometric system. For developing a face recognition system, researchers want to face various challenges which will affect on the accuracy of face recognition rate. The challenges are light illumination, face angle, different facial expression, pose changes and distance between face and camera. For getting an accurate system and to overcome this challenge the researchers propose different methods.

F. M. A. Aziset, al.in [2] proposed a face recognition system using PCA algorithm in which working parament is light illumination. Here the researchers try to design a system which will able to recognize the person with normal light condition and night vision condition but using PCA algorithm they didn't get an accurate result in night vision condition. T. Mantoro et al. in [3] propose a same system by using a traditional method of machine leaning. In which the face detection process and recognition is performed using Haar CasCade and eigenface algorithm and the researchers can successfully recognition multiple (two) at time.

A. M. Jagtap et al. [5] proposed a face recognition system using three different algorithms which is eigenface, fisherface and LBPH algorithm using OpenCV. For detecting face, the researchers use Haar-like feature which is an implemented version of Haar CasCade. After performing experiments, they conclude that the system which is design with LBPH algorithm give highest accurate compare to eigenface,

fisherface. P. Kamencay et al. [4] proposed same system using PCA, LDA, LBPH algorithm for detecting wild animal by increasing and deceasing size of images of database from 1-59 and 50-10 respectively and they also get highest accurate face recognition rate with LBPH using 59 database images.

X. Zhao et al. [6] proposed face recognition system using LBPH and MLBPH (Median Local Binary Pattern Histogram) algorithm. MLBPH is an improved version of LBPH algorithm. The Working parameters of this research work are illumination, expression change and attitude Deflection parameter. According to the experimental results they conclude that the MLBPH gave quit better performance compare to the LBPH.

M. Arsenovic et al. [8] and Khaled Mohammed [24] introduce a deep learning base an attendance system using multi biometric system. The reason behind to use multi biometric system is to getting more accurate result. To develop an accurate attendance system the researchers, choose RFID system along with face recognition system. Using multi biometric system the researcher got 91% recognition rate.

K. Salvi et al. [18] proposed an Intelligent Home Security System by combining principles of A.I. and IoT. For implementation of security system researcher use face recognition along with voice recognition which is developed on computer, raspberry-pi and NodeMCU platform. Here Raspberry-Pi and NodeMCU are used as clients and laptop is being used as server. When the person enters into authorized area the camera takes real-time image of that person and using microphone the system will take voice sample of 4 second and if the threshold value of both image and voice match then gate will open otherwise the owner get an SMS and a picture of unauthorized persons on Email-id.

M. S. Ejaz et al. [9] introduce a non-real-time PCA base masked and non-masked face recognition system. For developing a frontal face masked and non-masked face recognition system they use ORL database in which they took total 500 face images in their database. After performing experiments, they got 95.43% and 70.53% recognition rate for non-masked face and masked face respectively. M. S. Ejaz et al. [11] proposed a face reorganization system for recognizing real-time Masked Face and non-mask face using Convolutional Neural Network. They use the Face Net pre-trained model has been used for improving masked face recognition.

III. RESEARCH DESIGN

The research design of Real-time Automatic Masked and Unmasked Face Recognition system is as shown in Fig.1. The Fig.1 consist linked state machine flow diagram which consists two parts which is testing part and training part.

Before testing, firstly we want train our system/machine. In the training part, the system/machine is going to train using lot of non-real-time images of authorized persons which is stored in database. In training process, the face detection procedure is conduct using Viola-Jones algorithm and for feature extraction procedure the LBP operator is used.

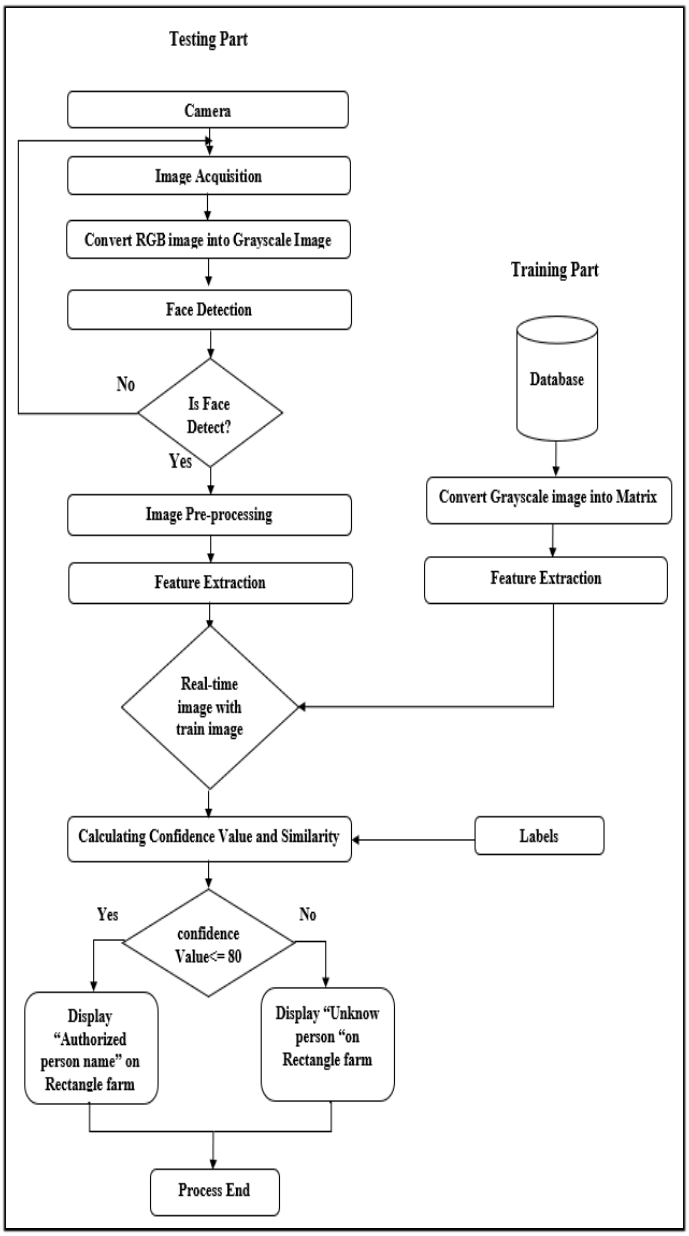


Fig.1. Research Design

After training process, the system/machine is ready for testing process. In testing part, the face recognition process will be conduct. In which the system will compare person's real time image with non-real time images and try to find similarity between two images and recognize the person based on the percentage of getting similarity between both images. This process consists some steps like image acquisition, face detection, image pre-processing, feature extraction, calculating confidence value and find similarly. The section:4 and section: 5 gave a brief introduction about the steps of face recognition process and database.

IV. FACE RECOGNITION PROCESS

Face recognition technology is process of identifying human from video or form digital images. The steps of face recognition process are given below:

Step 1. Image Acquisition using OpenCV: Without any image the face recognition processing cannot happened. Image acquisition is an action of retrieving and grabbing an image from some source or it is a creation of a representation of the visual characteristics of an object, such as a physical scene or the interior structure of an object. In this research the OpenCV is used to read real-time images of camera. OpenCV is an open-source computer vision and machine learning software library to provide a common infrastructure for computer vision applications.

Step 2. Convert RGB Image into Grayscale Image: The real-time image which is retrieving from the camera is in form of RGB channel (Red, Green, Blue) or we can say it is color image. In process the color image is converted into grayscale image because when we convert color image into grayscale image it is easy to process, required less storage space and contains only one channel of black-white.

Step 3. Face detection: After image acquisition and converted RGB image into Grayscale image the next step is face detection. Face detection is process of finding face from whole image. For detecting face from the whole image, the Haar Cascade is used because the Haar Cascade gave high detection rate and gave best performance with frontal face images. The Haar CasCade is proposed by Paul Viola and Michael Jones. The Haar CasCade consist some rectangle features using it Haar CasCade can find faces from whole image.

Fig.2. Haar CasCade

Fig.2 shows use different types of rectangles using it cascade will detect face from whole image. This rectangle is based on it Haar-like feature [3]. These rectangles consist two colors Black (dark) and White (bright). According to the difference between the sum of pixels of the black (dark) area and white (bright) are a Haar-like feature will be calculate. The equation of finding Haar-like feature is below:

$$F(Haar) = \sum FWhite(Bright) - \sum F\ Black(Dark) \quad \ldots \quad (1)$$

F (Haar) = Value of Haar-like feature
$\sum F_{White}$= Value of sum of all pixels of white (bright) area
$\sum F_{Black}$= Value of sum of all pixels of black (dark) area

Working process of Haar Cascade is as shown in fig.3. The Haar Cascade use AdaBoost algorithm and Haar wavelets to detect face from rectangular area. Using filters, the Cascade will find the value of Haar-like feature. If the value of Haar- like feature is higher than a certain threshold value, it can be stated that a face or faces are within the area [2].

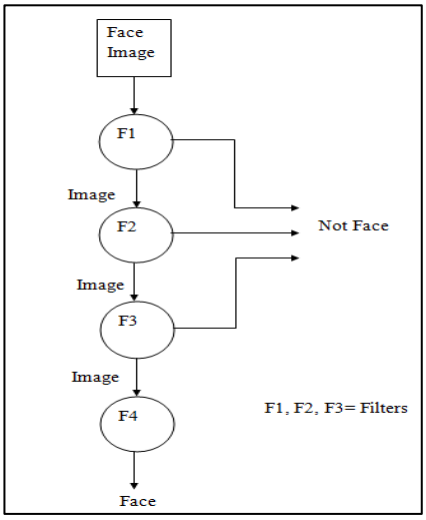


Fig.3. Working Process of Haar CasCade Classifier

Step 4. Image pre-processing: After detecting face from whole image the next process is image pre-processing which perform image resizing as well as image normalization operation.

Step 5. Feature Extraction: In this research the feature extraction process is conduct using Local Binary Pattern (LBP) operator. LBP is a local descriptor of the image based on the neighborhood for any given pixel. LBP reflects the correlation among pixels within a local area which mainly represents the local information [5].

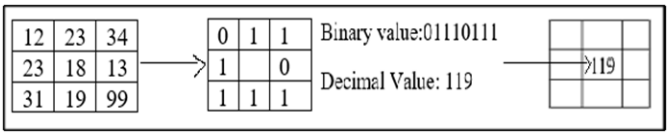


Fig.4. Operation of LBP

The original LBP operator always works with 3X3 matrix window. The operation of LBP operator is shown in Fig.4. Firstly, the LBP operator will choose 3X3 matrix window. After then according the color intensity the LBP operator will put threshold value of each pixels and take middle one pixel of the matrix window for matrix operation which is called as g_c. And it has 8 neighborhood pixels around it. The neighborhood pixels call as g_p. Fig.5 shows the relation between g_p and g_c. The dark (black) dots are g_p and the middle one light (gray) dot is g_c. Now the LBP operator will compare the threshold value of g_p with threshold valve of gc. If the threshold value of g_p is grater or equal to the threshold value of gc then the LBP operator will set 1 otherwise put it will put zero this operation is shown in the second image of fig.4. After than it will calculate and set the decimal value of g_c the from getting binary value which is shown in fig 4. After completing this operation, the LBP operator choose new 3X3 matrix window and did this operation so this is continued using the concept of the sliding window and

this new pixel value for the image gives much better characteristics than the original image [25].

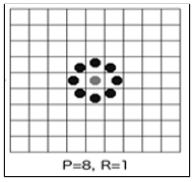


Fig.4. Relation between gp and gc

Step 6. After feature extraction process the system/machine will compare real-time image with non-real-time images and system/machine will calculate the confidence value. If the confidence value is less or equal to 80 than displays "Authorized Person's name" on rectangular farm. Otherwise display "Unknown Person" on rectangular farm.

V. DATABASE

Database is the most important part of the face recognition system. Because the accuracy of the system is also depending on the database. For this research work we make our own database which is quite different from another database. This database consists total three authorized person's both face images and eyes images. This database contains total64 gray images of each person in which there are 32 eyes images and 32 face images which are taken by 46 Mega pixel night vision camera.

For this research work we make a proper database by taking frontal and side images face and eyes at each different horizontal and vertical angles with different facial expressions.

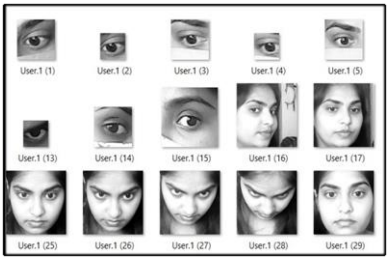


Fig.5. Database

VI. EXPERIMENTS AND RESULT

To develop a Real-time Automatic Masked and Unmasked Face Recognition system we use a computer with specification: Intel® Core™2999 Duo CPU T6670@ 2.20GHz processor, 4 GB RAM and 32-bit Operating system. To capture images, we use 46Mega pixels night vision camera. The software part is developed using Python with associated libraries which includes OpenCV, NumPy, pip, pillow and Time.

Before training and testing Face Recognition system firstly we want to make a propre database and using that database we train our system/machine. After making database normally we want to train our system/machine only once. But do some changes or add the images another authorized persons at that time we want furtherly train our system/machine. Here we are training our system/machine 30 times to find out average training time and every time we note time and take average of it. After that we got 12.96 seconds. After training process our system/machine is ready to detect and recognize authorized person. Here the system is design to recognize the person from minimum 35cm and maximum 90cm between camera and person. Equation which is used for finding the Recognition Rate of system:

$$\text{Recognition Rate} = \frac{\text{Number Of Correctly identified images}}{\text{Total number of images}} \text{ X } 100 \quad \ldots (2)$$

Here the face recognition is performed in the both normal light condition (day) and dim light condition (night vision condition) with masked and unmasked face using same database. To find out an accuracy of face recognition rate each experiments are performed 30 times and then take average of recognition rate. Here the face recognition process is performed in four different manners which performed under normal light condition(day) and dim light condition (night vision condition). All these experiments are given below.

In the first two experiments are performed to find out face attitude Deflection parameter(angle) of system in both the normal light condition(day) and dim light condition (night vision condition). In which person want to rotate his/her head from 0^o to 90^o horizontally right and 0^o to 90^o horizontally left direction. At every angle the person wants kept to his/her head stable at a position for 3 to 5 seconds then moved his/her head to next position to capture frames.

Experiment 1: This experiment is performed to recognizes a person individually at a time with unmasked face. The Table. 1, Graph.1 and 2 show comparative result of face recognition without any facemask which is prepared from test images of this experiment which is shown in Fig. 6.

Table.1. Result of face recognition without any face mask

Illumination Condition	**Recognition Rate at Different Angle**						
	Left 60°	***Left 45°***	***Left 30°***	***0° (Frontal)***	***Right 30°***	***Right 45°***	***Right 60°***
Normal light condition	93.3%	100%	100%	100%	100%	100%	86.6%
Dim light condition	93.3%	100%	100%	100%	100%	100%	83.3%

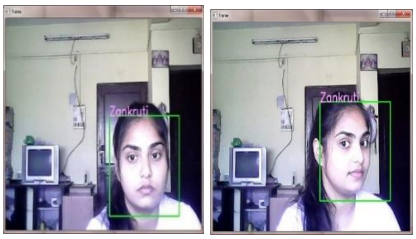


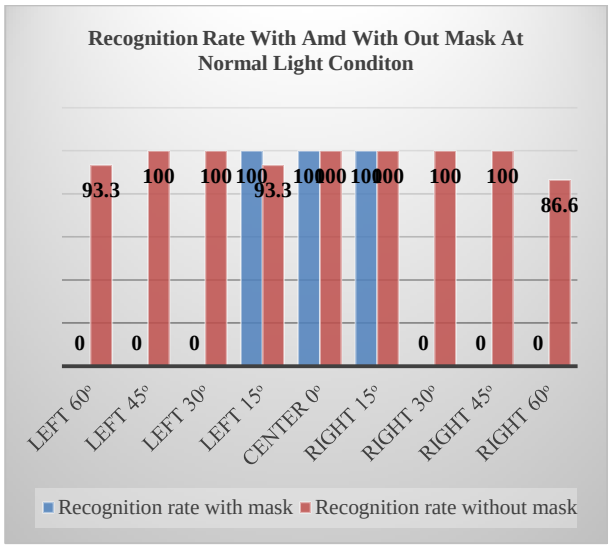
Fig.6 Recognize Authorized person at different angle of face

Experiment 2: The second experiment is performed to recognizes a person individually at a time with masked face. The Table.2 and Graph.1 and 2 shows comparative result of face recognition with face mask which is prepared from test images this experiment. The test images are shown in Fig.7.

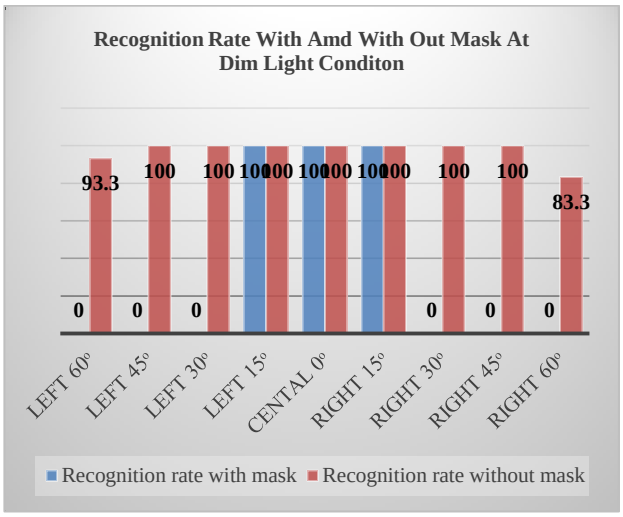
Table.2. Result of face recognition with mask

Illumination Condition	**Recognition Rate**		
	Left 15°	***0° (Frontal)***	***Right 15°***
Normal light condition	100%	100%	100%
Dim light condition	100%	100%	100%

Fig.7. Recognize Authorized person at different angle of face



Graph.1. Comparative Result of Recognition rate with and without mask at Normal Light Condition



Graph.2. Comparative Result of Recognition rate with and without mask at Dim Light Condition

Experiment 3: The third experiment is performed for detecting multiple persons at a time with both masked face and unmasked face conditions. Table.3 and Table.4 shows the result of recognition rate of face recognition of detecting multiple persons at a time with mask and without any facemask respectively. The test images of these experiments are shown in Fig. 8.

Table.3. Result of face recognition for detecting multiple persons without mask

Illumination Condition	**Recognition Rate 0°(frontal)**
Normal light condition	90%
Dim light condition	90%

Table.4. Result of face recognition for detecting multiple persons with mask

Illumination Condition	**Recognition Rate 0°(frontal)**
Normal light condition	80%
Dim light condition	80%

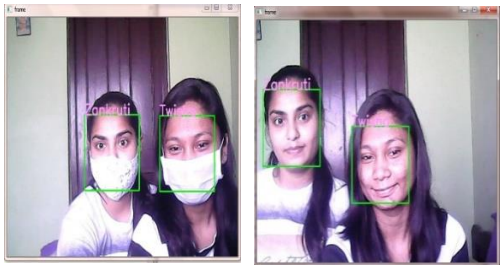


Fig.8. Recognize multiple authorized persons with and without facemask

Experiment 4: In the fourth experiment we are trying to recognize multiple authorized persons a time in which one-person is in facemask condition and another person is in unmask face condition. Table.5 show the result of recognition rate of face recognition which performed without mask at different angle of faces. The test images of these experiments shown in Fig.9.

Table.5. Result of face recognition for detecting multiple persons

Illumination Condition	**Recognition Rate 0°(frontal)**
Normal light condition	90%
Dim light condition	90%

Fig.9. Recognize Authorized person at different angle of face

VII. CONCLUSION

This research paper represents a Real-time Automatic Masked and Unmasked Face Recognition System Using LBPH Algorithm which is able to recognize a single person and multiple (two) person at a time with and without any facemask. And also recognize multiple authorized persons when one-person ware facemask and another person didn't ware facemask.

As per the above experiments we can conclude that the system can accurately recognize the single person from horizontally left 60° to right 60° face angle without facemask. And with facemask the system can able to recognize person from horizontally left 15° to right 15° face angle. In case of recognizing multiple persons, the system can accurately recognize both persons only at 0° (frontal face) face angle.

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