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Face Recognition Using Haar - Cascade Classifier for Criminal Identification

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Abstract: Security and Authentication is an imperative part of any industry. In Real time, Human face recognition can be performed in two stages such as, Face detection and Face recognition. This paper implements "Haar-Cascade algorithm" to identify human faces which is organized in Open CV by Python language and"Local binary pattern algorithm" to recognize faces. Collating with other existing algorithms, this classifier produces a high recognition rate even with varying expressions, efficient feature selection and low assortment of false positive features. Haar feature-based cascade classifier system utilizes only 200 features out of 6000 features to yield a recognition rate of 85-95%.

Index Terms: face recognition, raspberry-pi, Hear – Cascade, LBPH, Open CV, criminal identification, recognition rate

I. INTRODUCTION

Face recognition is a biometric software application adapted to identify individuals via tracking and detecting. The main intention of this paper is to recognize the faces of people. This approach can be executed practically in crowded areas like airports, railway stations, universities and malls for security. The main target of this paper is to enhance the recognition rate.

After the event of 9/11, developing security systems has become more concerned importance to provide safety to the citizens, particularly in crowded areas like airports, railway stations, in borders, organizations where detection and recognition is imperative[1].

To identify the individuals, Surveillance camera with face recognition system can be provided. Face recognition system has the dexterity to mitigate the danger and ultimately ward off any future assault from happening.

There are countless applications for this Face recognition system over the world. It has also elevated in applications like facebook, instagram and in many social media platforms. It will suggest the user to tag the person who has been detected in images.

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The Fig.1 represents the steps taking place in face recognition. There are three steps: face detection, face extraction and face recognition.

In this paper, Viola Jones algorithm is adapted for face detection. AdaBoost algorithm is united with Viola Jones algorithm to make a strong classifier. Haar like features are adapted by Viola -Jones for face detection

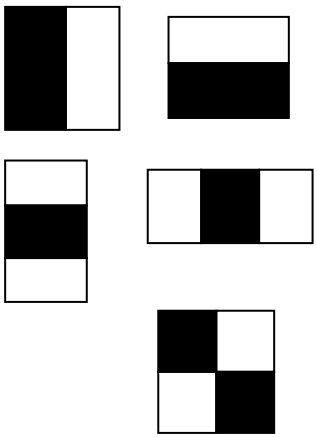

Fig. 1: Block diagram

Examples for Haar-like features are displayed in Fig.2, which is to identify dissimilarities in dark and white regions of the images.

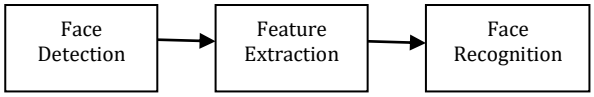

Fig. 2: Haar like features

From this representation, light region explain "to add" and dark region is "to subtract".

Linear binary pattern histogram is mainly preferred for "Feature extraction". It operates with powerful discrimination. The features from the image will get extracted in live stream using this algorithm [2].

Linear Binary Pattern Histogram algorithm has two steps, training period and evaluation period. The process in training period is to train the image samples to be recognized and subsequently in estimation period, the image to be tested will be compared with the samples trained in dataset [1].

The binary number is considered as an outcome in local binary pattern. On account of its powerful discernment and mathematical simplicity, this algorithm became popular in various face recognition applications [3].

The main target of this paper is to get high recognition rate and cost efficiency. In this paper, Section II deals with related work and Section III explains the methodology in detail and finally comes the results and discussion part.

II. RELATED WORK

In the year 2018, Suma S L [1] implemented a real time face recognition algorithm using Linear Binary Pattern Histogram (LBPH) and Viola Jones algorithm. This method consists of com fusion and recognition. is done using Viola Jones algorithm is applied is for Face detection, feature extraction is done by LBPH technique and Euclidean Distance Classifier is used for face recognition. This work have recognition rate of about "85%-95%". This work can be further amended to favor in all conditions such as brightness, in case of twins, beard and wearing goggles.

In the year 2017, Li Cuimei [2] implemented a human face detection algorithm using three weak classifiers including Haar cascade classifier. Skin hue histogram, Eye detection and Mouth detection are the three classifiers adopted by this method. This yields sufficiently high detection. The proposed method generates a position prediction value (PPV) to about 78.18% - 98.01%. This can be amended to detect human faces only of multiple races and reduce the delay for detecting and recognizing various faces among different images of people with variation in light and background conditions.

In the year 2017, Souhail Guennouni [4] implement a face detection system by collating with Haar cascade classifiers and edge orientation matching. Edge orientation matching algorithm and Haar-like feature selection combined cascade classifiers are the two techniques used in this system. This algorithm produces a better matching but the detection speed is comparatively less.

In the year 2015, Jiwen Lu [5] using learning CBFD proposed a face recognition system. The face representation and recognition is implemented via Compact Binary Face Descriptor (CBFD) feature learning method while coupled CBFD is executed for heterogeneous face matching by minimizing the modality gap of feature level. Collating with other Binary Codes Learning techniques, CBFD extracts compact and discriminative feature, hence produces a better recognition rate of about 93.80% is obtained. In this work, feature is learned only from one single layer. This system can achieve better performance by Learning Hierarchal features in deep networks.

III. METHODOLOGY

A. System implementation

In Raspberry pi to stream a live stream video Web camera is connected. The captured image from the web camera will get detected first and then cropped to reach the computer. This detection is performed through Viola-Jones Haar cascade classifier. Using a python-based Open CV software, face is saved in Raspberry Pi and forwarded to the available servers which are Linux-based. Whenever an image arrives, the server commences LBPH algorithm on this face, evens-up the image to minimize the variations and finally compares the emanated LBPH from detected image with the pre-saved LBPH in the database. The result of comparison is generated by sending a notification as authorized or unauthorized person via Internet of Things (IOT) [6].

B. Block diagram

As in Fig.3, the proposed technique deploys two progresses of images such as the input images and the image captured through live streaming. Both these process undergoes four common procedures namely, face acquisition, pre-processing, face detection using Haar-cascade classifier and feature extraction using Linear Binary Pattern algorithm to compute LBP values. These values are stored in the database only in case of processing an input image. Finally, comparison of the values in the database with the values computed via live streaming takes place which recognizes the human face as known or unknown based on the matching.

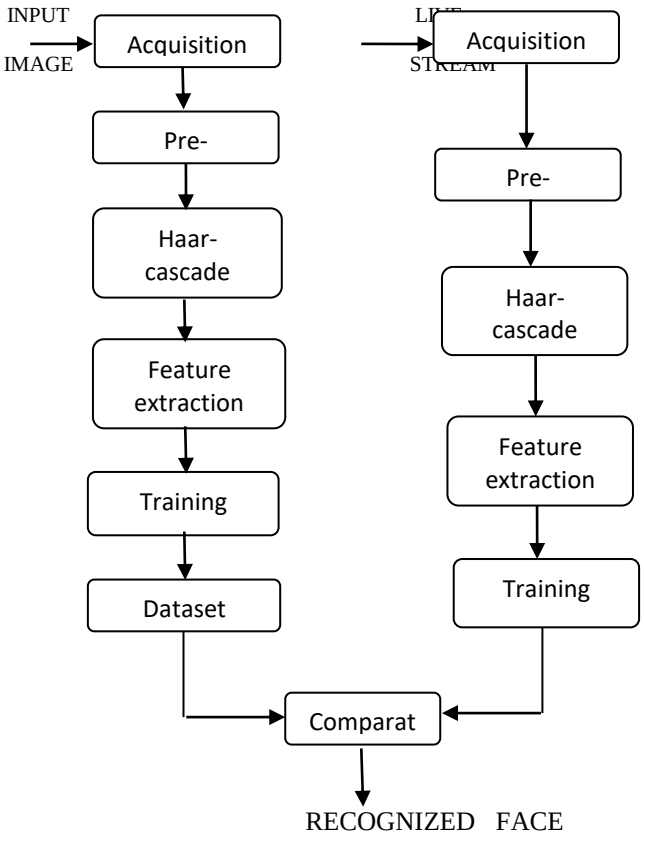

Fig. 3: Proposed Block Diagram

C. Phases of recognition

The three main process followed in face recognition system are Detection, Feature extraction and Comparison.

C.1. Face detection

For face detection, Viola Jones algorithm is a beneficial method. In general, this algorithm is not only limited for face detection but can also be utilized for many rigid structured object detection tasks. The Viola-Jones algorithm is composed of three main concepts that make it possible to develop a real time face detector: Haar-like features, Image integral, Adaboost training and Cascading classifier. By applying these features, the system can determine the presence or the absence of a human face [7].

C.1. 1. Haar-like features

Haar-like features is used by Haar cascade classifier for human face detection. There are three formations of Haar-like features. From the Fig.4, the first format is the edge feature, second type is the line feature and the last type is the four rectangle feature. Using the integral image, Haar like principle will provide fast computation. It's called Haar-like features[7].

The Algorithm looks for specific haar feature of a face. This detection takes the image and converts it into 24X24 window and smears each Haar feature to that window pixel by pixel. Initially, the algorithm requires a lot of positive images (images of faces) and negative images (images without faces) to train the classifier.

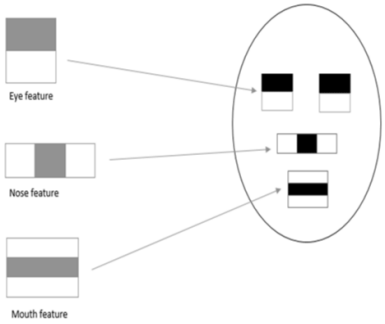

Fig. 4: Types of Haar- like features

Then, these features are extracted. Features are numerical values determined from images that are used to distinguish one image from another each feature is a single value acquired by subtracting the sum of the pixels beneath the white rectangle from the sum of the pixels beneath the black rectangle [6].

$$\text{Feature} = \Sigma_{\text{dark}}(\text{pixels in black area}) - \Sigma_{\text{white}}(\text{pixels in white area}) \quad (1)$$

All possible sizes and locations of each kernel calculate a plenty of features. A 24×24 window results in over 160,000 features. For each feature calculation, it is necessary to find the sum of the pixels under the white and black rectangles. To solve this, the concept of integral image and adaboost algorithm is utilized, which reduces 160000 features to 6000 features [7].

C.1.2. Integral Image

Rectangle features can be determined rapidly via an intermediate representation of the image called the integral Image. The integral image comprises of small units representation of a given image.

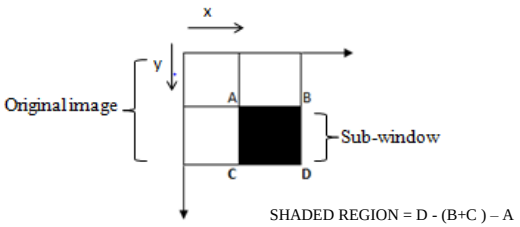

Fig. 5: Integral image schematic diagram

For example, the value of this integral image at position1 is the sum of pixels in rectangular A. The value at position 2 is A + B and so on. So, the sum total of pixels in rectangular D is:

$$S(D) = ii(4) - (ii(3) + ii(2)) + ii(1) \quad (2)$$

Where, S(D) is the sum of pixels in the rectangular D only - which is the sum of pixels in the rectangle A + B + C + D, represented by ii(4); ii(3) is the integral image of rectangle A+C ; ii(2) is the integral image of A+B and finally ii(1) is the integral image of the rectangle A (the addition is executed since the region A is subtracted twice in ii(3)and ii(2)). The integral image is outlined as:

$$ii[x, y] = i[x', y'] \quad (3)$$

Where, ii[x, y] represents integral image, and
i [x', y'] represents original image. [7]
The pixel value of integral images at any *(x,y)* location is the sum of all pixel values displayed before the current pixel. The integral value of an individual pixel is the sum of pixels on the top and the pixel towards the left. For example,

5	4	3	8	3
3	9	1	2	6
9	6	0	5	7
7	3	6	5	9
1	2	2	8	3

Fig. 6(a): Input image

5	9	12	20	23
8	21	25	35	44
17	36	40	55	71
24	46	56	76	101
25	49	61	89	117

Fig. 6(b): Integral image

The image is integrated in fewer pixel operations, since the traversing begins from the top left towards the bottom right. This makes the calculation of the addition to the entire

pixels within any specified rectangle using only four values. In the integral image, these values are the pixels that resemble with the edges of the rectangle in the input image

C.1.3. AdaBoost Learning

AdaBoost is an adequate boosting algorithm which combines weak classifiers while reducing significantly not only the training error but also the more elusive generalized error. The main idea of Boosting lies in connecting the simple classifiers which are known as weak classifiers. Since the weak classifiers do not expect even the best classification function to classify the data well, they are called as weak classifiers. Here a classifier is combined with a single feature to easily link the Haar features with weak classifier. Haar-like feature is used as a threshold in AdaBoost learning algorithm by Viola and Jones. The Haar-classifier is the strongest classifier since it uses the strongest features. The positive and negative samples are best separated by the feature. In order to build a strong final classifier AdaBoost is used [8]. It reduces the features from 160000 to 6000, thus making the computation simpler and hence it is less in computational complexity.

1. D. Cascade Classifier:

Cascade classifier is a cascading of weak classifiers used to boost the face detection process and reduce the computational complexity. Each node in the series contains a weak classifier and filter for one Haar feature. AdaBoost provides weights to the nodes and the highest weighted node primarily arrives. When a filter ignores to permit image regions, that specific sub window of the image is eliminated for further processing. It is then considered as a non-face, which means that the image regions that are processed do not contain the face to be detected. This is very imperative to the performance of the classifier, since all or nearly all negative image sub-windows will be eliminated in the first stage.

On the contrary, when image regions successfully passed the filter, they go to the following stage, which contains a more complex filter. Only regions that successfully pass all filters are considered to contain a match of the face. This means that regions of the image contain the facial subject for detection. The reason behind the multi-stage classifier is to eliminate efficiently and rapidly the non-face sub-windows. The classifier is used to reject more false positives (non-face regions) of the sub-windows. The number of false positive rate is drastically reduced after several steps of processing [8].

C.2. Feature extraction and Comparison

After the face is detected, next step is to extract features this is done using linear binary pattern algorithm. Initial step of this algorithm is to convert the test image into gray scale. This L x M pixel size image will get divided into regions. The same pixel size is used for the regions, producing n x n regions. Each region will goes through Linear binary pattern operator.

In this process, it will compare the center pixel with its neighbor pixels. If the pixel size is greater to center pixel it is '1' or it is '0'.

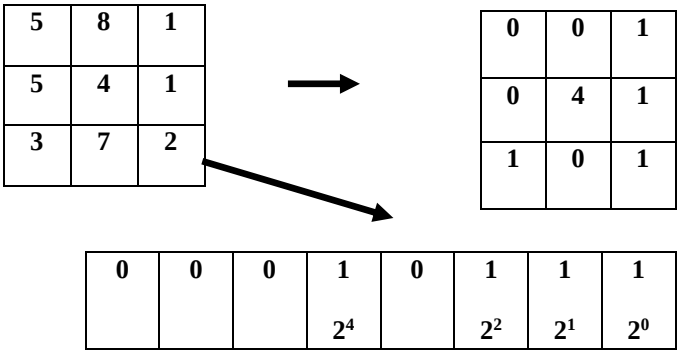

Fig. 7: LBPH algorithm example

Executing this process will result in 8binary values. By linking the binary values it results in binary number. The LBP value is obtained by translating 8binary number into a decimal number, it will be in the range of 0-255. This algorithm implementation is shown in the above Fig. 7.

The histogram for each region is drawn using the LBP Values of each region. Each region will contain 256 cases. This implementation is shown in the below equation:

$$N_X = \sum_{i,j} X\{LBP?(Y(i,j)) = x\},\ x = (0,\ldots,255) \quad (4)$$

Where, N_x is a case of value x, Y (i , j) is the (i , j) pixel of Image and X is the conditional operator, providing '1' when it is true or '0'. After finding the histogram for each region, the sole histogram is created by uniting each region histogram. The final histogram is in the form of 256 *n *n cases and it is determined as the image feature vector [1]. The drawback of this algorithm is it has a fixed scale (3 x 3 scale). To overcome this, there is an extension of original LBP implementation to handle multiple neighborhoods. There are two parameters: first is 'p' which is the number of points in the symmetric circle neighborhood, second is 'r' the circle radius.

There is an important concept called LBP uniformity. A LBP is uniform if it has at most two 1-0 or 0-1 transitions, for example: consider pattern 10000000(1 transition) when

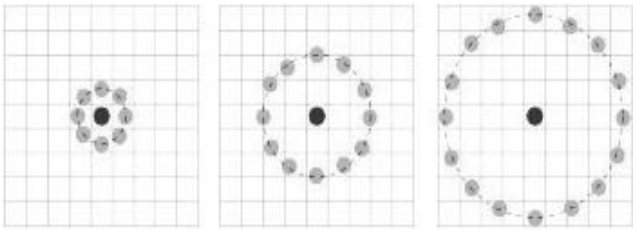

Fig. 8: Represents varying p and r to form a Local Binary pattern.

00100000(2 transitions) they both are uniform, the pattern

00100100(4 transitions) is considered as uniform. LBP uniformity completely depends on the 'p' value. When p increases resulting histogram dimensionality increases [11].

IV RESULTS AND DISCUSSION

At the time of forming the dataset, each person will get designated using an id number. While recognition, when the test person image matches with the dataset then a message will get send like an unauthorized person symbolizes criminal or thief through internet of things, if the test person image does not get matched with the dataset then no message will get send symbolizes a normal human being.

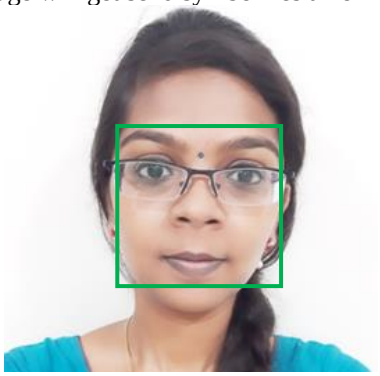

Fig. 9: recognized face

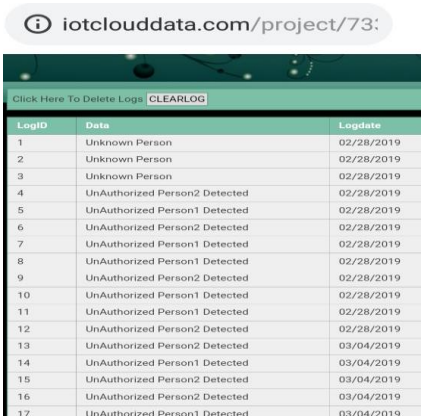

Fig. 10: IoT update of unauthorized person

In this paper, face detection is done using Viola- Jones algorithm and face extraction is done by LBPH algorithm as said earlier in this paper. By following this process, there will be recognition rate accuracy of 95%.

The Table I displays the delay in time period when there is increase in number of images.

It is scrutinized from the above table that even with an increase in the number of images, the time period will not produce a significant increase since images are reduced in size. The system efficiency get boosted and thus accelerates the processing and reduces the lag.

Fig. 11 shows the analogy between captured images and time period taken for recognition.

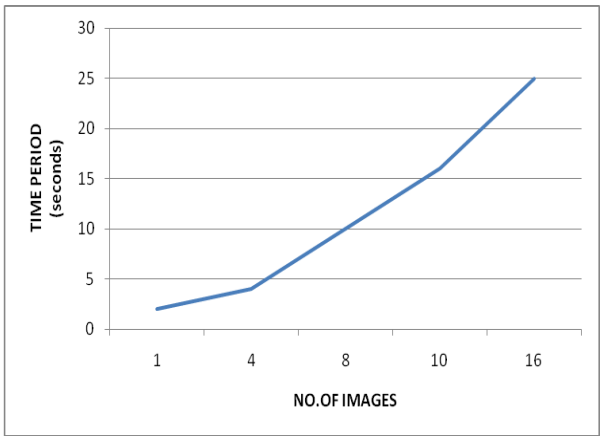

Fig. 11 : Processing time for different images (No.of images vs. Time period)

Table II displays the increase in the training period when number of images increases.

TABLE II: TRAINING PERIOD FOR VARIOUS IMAGES

NO. OF IMAGES	5	10	15	20	30
TRAINING PERIOD (seconds)	0.02	0.06	0.09	0.2	0.5

It is scrutinized from the above table that increasing the number of images, will not induce any drastic increase in the training period.

Fig. 12 shows the analogy between images and training period.

NO. OF IMAGES	1	4	8	10	16
TIME PERIOD (seconds)	2	4	10	16	25

TABLE I: PROCESSING TIME FOR RECOGNITION

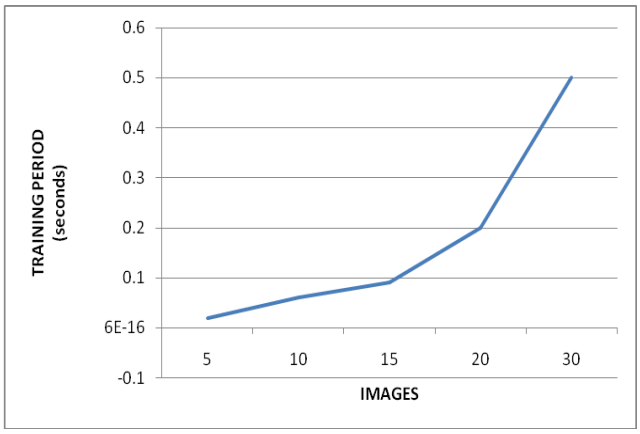

Fig. 12 : Training period for different images
(Images vs. Training period)

Table III displays the performance analysis of various algorithm.

TABLE III: PERFORMANCE ANALYSIS

ALGORITHM	LDA	PCA	SVM with binary	CAMSHIFT	HAAR-CASCADE
RECOGNITION RATE	85%	88%	91.2%	93%	95%

Fig. 13 shows the performance analysis

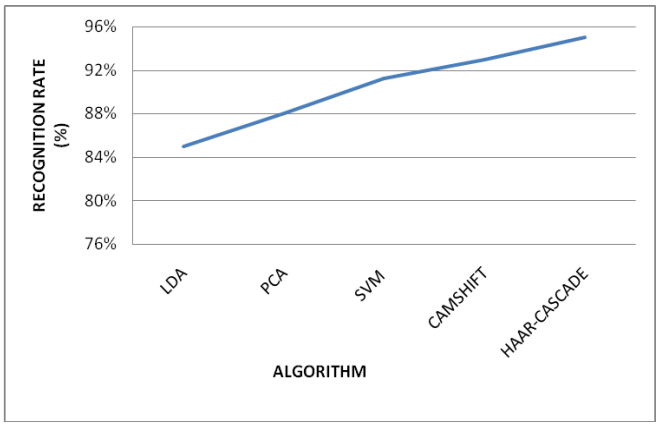

Fig. 13 : Performance analysis
(Algorithm vs. recognition rate)

V . CONCLUSION AND FUTURE WORK

Security is an imperative part of any industry. This work is most particularly for criminal identification. The algorithms carried out in this paper were Viola-Jones algorithm and Linear binary pattern algorithm. The presented system will get implemented using Open CV and Raspberry pi. The recognition rate attained by this process is 90%-98%. There will be deviation in the result on account of the distance, camera resolution and lightning. Advanced processors can be put to use to reduce the processing time. By affixing more number of recognition servers to attenuate the processing time for collection of images.

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