Security System Using Face Recognition

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Abstract- **Face recognition is a dynamic topic for research. The applications of face recognition in security systems can be many like personal identification, to identify law enforcement, authenticate banking and authentication for mobile devices, home security systems. The research work presented here is primarily divided into four major aspects i.e., representation of the face, extraction of the features from that face, classification and finally building on the accuracy of recognition to try and develop a Security system. Representation of the face tells about modeling a face and determining the consequent algorithms of detection and identification. The extraction of features aspect covers the part where the mainly important and distinctive features of the face are extracted. During classification phase, the face image gets dynamically analyzed with the images already present in the database. The recognition of face is dynamically evaluated where shape and surface data both are considered to represent facial images dependent on Local Binary Patterns (LBP) for unique individual-particular face recognition. The LBP are linked into a solitary feature vector. This feature vector frames a productive portrayal of the face and is utilized to measure similarities between pictures.**

Keywords* — *classification, feature extraction, feature vector, local binary pattern (LBP), pattern recognition.

I. INTRODUCTION

For identification and access control, biometric authentication is widely used. Biometric authentication depends on the physiological and behavioral characteristics. For biometric verification various traits are used like acceptability and circumvention, performance, measurability, permanence and uniqueness. These traits are used to verify an individual. Biometric authentication is of different types such as face recognition, voice analysis, fingerprint identification, iris scan, and retina scan. Factors to be considered to develop a face recognition system are:

- The face recognition should be immediate.
- It should be immensely accurate.

The number of faces that can be identified by the system should be easily updated and increased. Face recognition can be applied to computer entertainment, human computer interaction, multimedia, database recovery, information security like operating system, virtual reality, online banking, medical records, biometric for example, personal identification - driver licenses, passports, automated identity verification - border controls, personal security - driver monitoring system, home video surveillance system, law enforcement for example, investigation, video surveillances.

The following methods are used for face recognition.

1. Holistic Matching Methods
2. Feature-based (structural) Methods
3. Hybrid Methods

A. Holistic Matching methods.

In this method, input to the face matching system is the complete face region. Extensively used examples of face recognition using holistic method are principal component analysis, independent component analysis, Linear Discriminant Analysis (LDA) [1], eigenfaces [2], etc. Turk and Pentland first recognized faces successfully in 1991 using eigenfaces [3].

B. Feature based (structural) methods

In Feature based (structural) method the locations or local statistics (appearance and/or geometric) of mouth, nose and eyes are extracted. These serve as an input to a local classifier. Local features such as eyes, nose and mouth are extracted first and their locations and local statistics are given into a structural classifier. The threat involved here is in feature restoration. This occurs when the system retrieves invisible features owing to the large variations like head pose when frontal image is matched a with a profile image [4]. Various extraction methods are:

I. Generic methods based on edges, lines, and curves

II. Feature-template-based methods

III. Structural matching methods which considers geometrical constraints on the features.

C. Hybrid Methods

The blend of holistic and feature extraction methods is used in hybrid face recognition systems. 3D image is used to

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capture the face of a person. The shapes of the chin, forehead or curves of the eye sockets are used. Profile image of the face can also be used since the axis of measurement used is depth to construct complete face. The steps involved in the 3D system are: Detection, Position, Measurement, Representation and Matching. Detection involves with the face capturing by either taking a photo of a face or scanning a photo. The location, size and angle of the head are determined in the position step. Then each curve of the face is assigned a measurement and a template is made with focus on inside and outside of eye and the angle of the nose. This template is then converted into code which is the numerical representation of the code. In the matching step the data received is compared with the existing faces in the database.

II. Related Work

Research on face recognition has boosted speedily in current years. Face recognition is a challenging task. Researchers having different background have worked on it such as from: psychology, pattern recognition, neural networks, computer vision, and computer graphics. In the early 1970's this problem was considered as a 2D pattern recognition problem [3]. The faces were recognized based on the distances between important points, e.g. measuring the distance amid the eyes or further important points or measuring different angles of facial components. These are known as local descriptors of face [5], [6]. The local descriptors are split into two classes: the learning-based descriptors and the handcrafted descriptors. LBP texture descriptor for face was proposed by Ahonen *et al.* [7]. The binary code in it was fabricated by encoding the gray-value difference amid each pixel and the pixels neighboring to it. Second order statistics along the distribution directions of facial components were encoded in the Dual-Cross Patterns (DCP) descriptor by Ding *et al.* [8]. Gabor-based descriptors and Local Phase Quantization (LPQ) [9] are other effective handcrafted local descriptors. Binarised Statistical Image Features (BSIF) [10], [11] and Discriminant Face Descriptor (DFD) [12] are Representative learning-based descriptors. The pattern encoding step is optimized employing machine learning algorithms in learning based descriptors. Local descriptor-based face representations is comprehensively described in a contemporary survey [13] and a large scale precise evaluation amid existing local descriptors for face recognition can be found in [8]. The local descriptor-based approaches are easy to use but have restrictions. The constructed face representation is sensitive to the non-linear intra-personal variations, e.g., illumination [6], pose [14], and expression [15]. Especially, the intra-personal appearance change caused by pose variations may substantially outperform the divergence created by identities [14].

Active contour model [16] and deformable template model [17] are the algorithms normally employed for face recognition. Geometrical characteristic is the basis of this model. This model is adapted first for the face recognition problem. Everyone's face is different owing to the differences in elements of every face, such as the nose, eyes, mouth and jaws. This is the main idea behind this method. Therefore, the set of architectures and shapes of these elements of face are used by the system as the features of the face recognition problem. So, in the past, five practicle methods for face recognition have been developed.

Another, frequently used method in face recognition is sub-space analysis method. The sub-space analysis method consists of two approaches which are Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). In PCA technique small numbers of uncorrelated variables are identified from a larger set of data. These uncorrelated variables are called principal components. Using this technique variation can be emphasized and strong patterns are captured in the data set. Principal component analysis is treated as a useful statistical method. This model is employed in predictive model and exploratory data analysis. In 1991, Turk [18] forwarded PCA based Eigen face method which is known as the most classic method.

In the PCA method, face images are taken as the random variables, where face image is represented by $N \times N$ vector which is turned into $2N \times 1$ vector. The mean data vector is subtracted from it, and then K-L transformation is employed to get a set of orthogonal basis. After extracting the principal components, the reduced dimension vector space of face images is obtained. The main aim of the LDA [19] is to separate the samples. Projection direction is found in it, the purpose of which is to make the within-class distance small and between-class distances as large as possible. The basis of which is the projection direction of training samples. Comparing both the methods LDA can get better results than PCA only if the size of training sample is large.

Hidden markov model (HMM) is employed by the researchers to solve the problem of difference in appearance of facial features and their connection to each other. According to this model, the observed features are considered as a sequence of unobserved states. Different HMM parameters are used for various people; same parameters are used for same person in this model so that the observed sequence of gestures and facial expressions can be represented. Rectangular window sampling face images from top to bottom were used by the model proposed by Samaria [20]. Neural network (NN) is further frequently used practice for face recognition. To extract and recognize facial features using neural network the face images are first learned and then classified. A face recognition system was proposed by Lin et al. [21] based on probabilistic decision-based neural networks. The positive

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and negative samples were used for reinforcement learning. And then the modular network was applied to increase the learning speed. Ya Wang's Deep learning method [22] for Face Recognition was the inspiration behind the proposed system. The dataset is generated automatically from real world surveillance video. The dataset is generated in various light illuminations, having different facial expressions, etc. The face recognition field has been currently dominated by deep convolutional neural networks (CNNs). The ability of CNNs to learn rich image representations is the reason behind the CNNs success. Face recognition performance of Convolutional neural network (CNNs) is improved by using non-CNN features in Ze Lu's system [23]. The non-CNN features display the attributes from a distinct perspective of the targeted face images.

Comparing the face recognition methods, deep neural network method gives the best results till now [24]. Using CNN age invariant face recognition can also be fabricated. CNN consists of three layers, one convolution layer, one pooling layer and one fully connected layer. The variations of data can be learnt in the CNN without prior knowledge. Additional features can also be used in this method to identify a person. To implement it, Labeled Faces in the Wild (LFW) dataset can be used. This dataset consists of more than 13,000 images of faces collected from the web. This dataset was designed for studying the problem of unconstrained face recognition. The research is still going on the topic of face recognition [25-27].

In the current work, the prime focus is on face recognition task. The research work is primarily divided into four major aspects i.e., representation of the face, extraction of the features from that face, classification and finally building on the accuracy of recognition to try and develop a security system. Representation of the face tells about modeling a face and determining the consequent algorithms of detection and recognition. The extraction of features aspect covers the part where the most important and unique features of the face are extracted. In the classification phase, the face image gets dynamically compared with the images already present in the database. Facial expressions are the most natural and instantaneous way for human beings to communicate amongst themselves and convey their emotions and intentions. The ability of humans to analyze and recognize faces is commendable and in this research, it is tried to emulate this nature in the computer system.

III. THE MODEL OF FACE RECOGNITION

There are many commercial face recognition systems available now-a-days but the main interest is in the way of identification. Owing to the fact that this system heavily relies on a controlled environment, it performs well in the same but as soon as some changes in the environment occur, like the pose of a person, facial expressions, viewpoint, lighting conditions etc., the performance gets degraded.

So the aim in this research area is to decrease the consequence of these factors affecting the recognition system and to build a powerful and dynamic face recognition system. A model for face recognition framework is provided beneath:

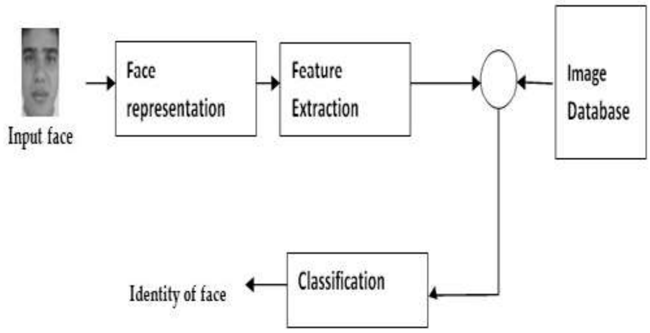

Fig. 1 Face recognition model

So the identification process of the person from the image can be divided into 3 parts: representing the face, extracting features from the image and classification. The first task of the face representation is pretty basic, which is how to model a face. How we depict the face decides the algorithms for face detection and identification. To decide if a face is delineated in the image or not, we have to transform the image i.e. we change the properties of the image by scaling and rotating it, so that its position matches with the position as the image present in the database.

In the next phase, we begin to extract features from the image. Features are unique and most useful properties of the face image which is important to differentiate between two images. So with the features acquired from the extraction, we start to compare the face image with the images from the database. And this is done in the last phase, which is, classification phase. So the two images should have the highest matching score to decrease the difference between them. Also, a margin value can be used to decide if the difference is small or not.

IV. LOCAL BINARY PATTERN

Extracting essential features/properties from the face image is a major step to perform face recognition which is known as preprocessing. There exist a few strategies to separate these highlights, and one of them is the Local Binary Pattern (LBP) technique. With this relatively new methodology, it is possible to depict the surface and state of a digital picture by segregating the picture into a few little regions from which features are extricated.

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Fig. 2 LBP process

The highlights are acquired from the regions, which comprises binary patterns that assist in portraying the surroundings of pixels in the region. At that point, the procured highlights are integrated into one feature histogram, which frames picture representations. Images can be broken down and after that the distance (similarity) is estimated between their histograms.

Various investigations demonstrate that as far as speed and discrimination performance are concerned; an arrangement of face recognition implementing LBP technique gives great outcomes. It is a result of the manner in which the surfaces and states of a picture is portrayed, and the manner in which the most imperative features are extracted, the strategy ends up being very powerful and dynamic against face pictures with various properties like illumination, expressions of the face, aging of humans and image rotation.

V. Principles of Local Binary Patterns

The LBP operator operates on the closest eight pixels of a particular center pixel and calculates their values by taking the value of the center pixel as a threshold. If the value of the closest eight pixels is higher than the threshold value then their value is assigned to be equal to 1 else 0.

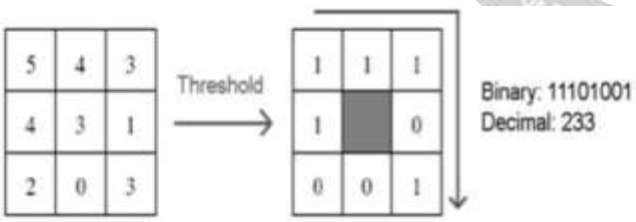

Fig. 3 The LBP Operator

Further, this LBP operator was expanded to use closest pixels of dissimilar distances. A circle with radius R is made from the center pixel in this case. Next, N testing points on the periphery of this circle are chosen and coordinated with the estimation of the center pixel, i.e. threshold value. Bilinear interpolation is necessary to get the values of all sample points in the nearest pixels for any radius and any no. of pixels. The notation (N, R) is employed for neighborhoods. Fig. 4 depicts the three neighbor-sets for various values of N and R.

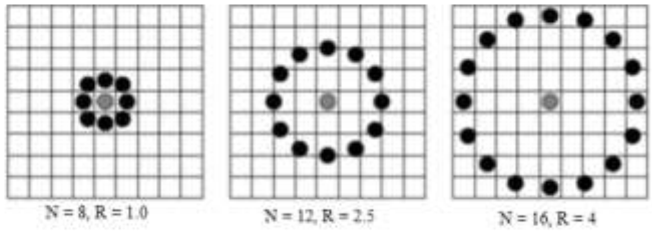

Fig. 4: Nearest neighbor-sets for 3 different values of variables N and R

Let us assume that the coordinates of the centre pixel be (x_o, y_o) and the coordinates of N neighbours be (x_i, y_i), where $i \in \{1 \text{ to } N\}$ that are on the periphery of the chosen circle with radius R that can be calculated with the sine and cosine:

$$x_i = x_o + R\cos(2\pi n/N) \quad (1)$$

$$y_i = y_o + R\sin(2\pi n/N) \quad (2)$$

Let's say the grey value of the center pixel be g_o and the grey values of its nearest pixels be g_i with i=1, ….., N, then the texture T in the local nearest pixels be (x_o, y_o) can be written as:

$$T = t(g_o, g_1, \ldots, g_N) \quad (3)$$

After obtaining the values of these points, the texture can also be expressed in another way. To perform this, from the values of the points on the circle, value of the center pixel is subtracted. The local texture describes the value of center pixel and differences as a joint distribution in such fashion:

$$T = t(g_0, g_1 - g_0, \ldots, g_n - g_0) \quad (4)$$

Since $t(g_i)$ displays the comprehensive luminous of an image. The luminous of the image is not related to the texture of the image and hence does not give any relevant knowledge for texture analysis. That is why most of the details regarding the textural features in the original joint distribution (Eq. 3) is saved in the joint difference distribution:

$$T \approx t(g_0, g_1 - g_0, \ldots, g_n - g_0) \quad (5)$$

In spite of shifting of the grey scale against invariant, the dissimilarities are implicated by changing the size. Only the signs of the dissimilarities are considered to gain invariance with respect to any monotonic change of the grey scale. According to this, if a point on the circle has a greater grey value than the center pixel (or the same value), the point is returned else a zero value is assigned:

$$T \approx t(s(g_1 - g_0), \ldots, s(g_n - g_0)) \quad (6)$$

Where

$$s(x) = \begin{cases} 1, & x \\ 0, & x \end{cases} \quad (7)$$

In the final step, in order to fabricate the LBP for the pixel (xc, yc) a binomial weight 2^n is equated to each sign $s(g_i - g_0)$. These binomial weights are summed:

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$$LBP_{P,R}(x_c, y_c) = \sum_{p=0}^{P-1} s(g_p - g_c)2^p \quad (8)$$

The. LBP portrays the local image design around the point (x_0, y_0). The original LBP operator in Fig. 3 is nearly the same as the operator with values N = 8 and R = 1, thus $LBP_{8,1}$. The fundamental dissimilarity among these operators is that in $LBP_{8,1}$ the pixels first need to be embedded to calculate the values of the points on the circle.

VI. Uniform of Local Binary Pattern

The local binary pattern can be represented using two bits i.e. 0 and 1. Its uniformity can be decided by examining visually at the bitwise transitions of the patterns. The transition has to be not more than two. The transition can be either 0 to 1 or 1 to 0 and binary strings are considered circular, so the number of transitions cannot be 1. Example of no transition can be 00000000 and for two transitions it can be 00011100. N(N-1) can be feasible combinations for patterns having two transitions. For uniform patterns, if P is the sampling point and R is the radius then notion used is $LBP^{u2}_{N,R}$.

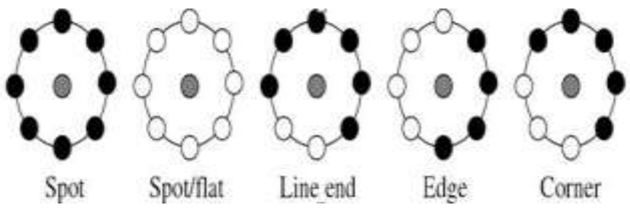

Fig. 5: Important textures

There are some benefits of using uniform local binary patterns. Whenever we are doing some operation the first thing that we have to take care of is the memory. It helps in saving a lot of memory as it has p(p-1)+2 possible patterns whereas in the case of non-uniform it is 2^P. Our faces have lots of features and for a machine to recognize a face it is important to use only the important features and uniform pattern uses only the important textures like edges, corners etc.

VII. Uniform Binary Pattern

The author clarified the extraction of the facial highlights by applying LBP technique on pictures and finding the degree of likeness between pictures. The initial step in the application of LBP is the computation of LBP-code. At that point, every conceivable pattern is recorded and based on these patterns the histograms include feature vectors and accordingly represent textures of images. These histograms at that point, help in ascertaining the comparability between the pictures.

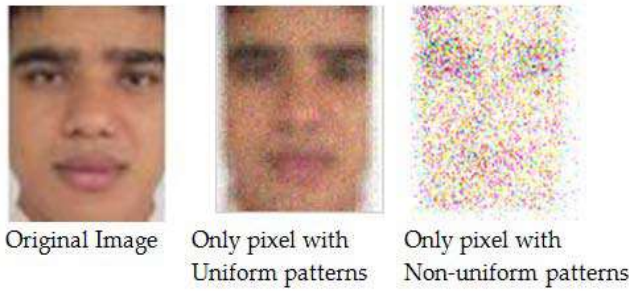

Fig. 6: Demonstration of patterns

Above figure demonstrates three images. First one is an image of a person, second is only pixels with the uniform pattern of the first image and the third image shows pixels with a non-uniform pattern. To create the images with pixels only uniform pattern, the $LBP^{u2}_{16,2}$ operator is used. From the first image, it is observed that only pixel with uniform patterns contains around 99% of the original pixels which means that 99% of the pixels in an image have a uniform pattern. An additional interesting thing is that if we only take pixels with uniform patterns then we can preserve the backgrounds of the images also because almost all background areas in images have the same grey value due to which their patterns contain no transition. It has also been observed that majority of the pixels around mouth, nose, and eyebrows have a uniform pattern.

VIII. Feature Vector

Subsequent to estimating the Local Binary Pattern for every pixel, construction of the feature vector of the image takes place. The image is partitioned into K^2 regions to represent the image effectively, for example for K=8, an image will be divided into 8^2=64 regions. For each region, a completely labeled histogram gets build. The signification of which is that each bin present in a histogram denotes a pattern and includes the count of appearances in that region. Then all the regional histograms are integrated to one big histogram to construct the feature vector.

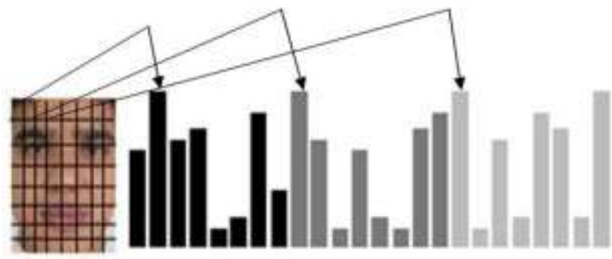

Fig. 7: Construction of histogram

For each region, all the patterns having more than two transitions (non-uniform patterns) are labelled together under a single label.

The count for the number of bins in each regional histogram is

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N*(N - 1) + 3 bins where,

N*(N - 1) denotes the bins for patterns with 2 transitions, 2 bins for the patterns with zero transitions and 1 bin for patterns with more than 2 transitions.

The count for the number of bins in the total feature vector of an image is K*2*(N (N − 1) + 3) bins. For the pixels in the regions which are at a distance R from the edges of the image, we cannot compute the LBP-code. Hence, the small area remains unused on the borders of the image when constructing the feature vector.

For each N × M image the feature vector gets constructed after calculating the LBP code for each pixel (X_0, Y_0) with

$X_0 \in \{R + 1, . . . ,N − R\}$ and $Y_0 \in \{R + 1, . . . ,M − R\}$. If an image is segregated into k × k divisions, then the histogram for division (kx, ky), with kx∈ {1, . . . , k} and ky∈ {1, . . . , k}, can be defined as:

$$H_i(K_x,K_y) = \Sigma_{x,y} I\{LBP_{P,R(x,y)} = L(i)\}, i = 1, \ldots P(P - 1) + 3 \quad (9)$$

$$x \in \begin{cases} \{R+1, \ldots\ldots, \frac{N}{K}\} & Kx : \\ \{(Kx-1)\left(\frac{N}{K}\right)\} + 1, \ldots\ldots N-R \\ \{(Kx-1)\left(\frac{N}{K}\right)\} + 1, \ldots, Kx\left(\frac{N}{K}\right) \end{cases}$$

$$\in \begin{cases} \{R+1, \ldots\ldots, \frac{M}{K}\} & Ky : \\ \{(Ky-1)\left(\frac{M}{K}\right)\} + 1, \ldots, M-R \\ \{(Ky-1)\left(\frac{M}{K}\right)\} + 1, \ldots, Ky\,(\end{cases} \quad (10)$$

in which L is label of i bin

The feature vector is adequately a portrayal of the face on three distinct dimensions of the region:

1. Pixel level - the labels contain data about the examples on a pixel-level.

2. Regional level - the regions where the diverse names are calculated contain data on a small regional level.

3. Global description - integrated histograms present a worldwide depiction of the face.

IX. COMPARING THE FEATURE VECTORS

Let's assume the first one to be A and other one be B, in the event that we need to think about these two pictures, we have to find the dissimilarity among the feature vectors. This may be feasible with a few imaginable dissimilarity measures for histograms:

− Histogram Intersection

$$D(A,B) = \Sigma^{k\wedge2}_{j=1}(\Sigma^{p(p-1)}_{i=1}\min(A_{i,j},B_{i,j})) \quad (11)$$

−Log-likelihood Statistic

$$L(A,B) = \Sigma^{k\wedge2}_{j=1}(-\Sigma^{p(p-1)+3}_{i=1}A_{i,j}\log(B_{i,j})) \quad (12)$$

− Chi-square statistic (χ^2)

$$\chi^2(A,B) = \Sigma^{k\wedge2}_{j=1}(\Sigma^{p(p-1)+3}_{i=1}(A_{i,j}-B_{i,j})^2/(A_{i,j}+B_{i,j})) \quad (13)$$

In the equations mentioned above, $A_{i,j}$ and $B_{i,j}$ represent the sizes of bin i from region j (number of appearance of pattern L(i) in region j). Our face has several different regions containing thousands of features, some of these regions contain further useful information than the others and according to the importance of the information each region can be given a weight. As indicated by the [31] the χ^2 performs marginally superior to histogram crossing point and the log-probability measurement. By applying a weight W_j to district j, the equation for the weighted χ^2 becomes:

$$\chi^2_w(A,B) = \Sigma^{k\wedge2}_{j=1}w_j(\Sigma^{p(p-1)+3}_{i=1}(A_{i,j}-B_{i,j})^2/(A_{i,j}+B_{i,j})) \quad (14)$$

This weighted χ^2 for two (face) images, which is computed from the histograms, is a measure of the closeness of the two images. The lower the estimation of the χ^2 (which is in like manner called the 'distance' amid the two pictures), more comparative the two pictures are.

X. IMPLEMENTATION OF FACE RECOGNITION

Sufficiently we can say that the task of face recognition is not that simple as the face image we got after extracting its features and the face image after the classification phase is usually different. The LBP features have been obtained from the facial image for recognition, however, we still have to analyze the input face image to a variety of images collected in the database. Many environmental factors affect the face image like lighting, facial expressions etc. which changes the facial image. Because of the flexibility and efficiency of the research work, it should solve these problems.

After completing these tasks, the face recognition system can be used in a security system. In a security framework, the facial recognition device collects facial images of a person dynamically, frame by frame, and performs the identification process on those images. And after this process, it contrasts the face image with the images gathered in the database. So, if the images have a high matching score, the person gains the access.

XI. FACE RECOGNITION ALGORITHM

Local binary patterns approach is proposed in the research work to perform the face identification. In LBP, it works on those features that use the LBP operator which encapsulate the local special structure of the face image.

LBP can be described as the pixels intensities involving the center pixel and the eight pixels in its vicinity, in an ordered set of binary comparison.

It carries out this task by using this formula:

$$LBP(x_c,y_c) = \Sigma^7_{n=0}s(i_n - i_c)2^n$$

Where i_c depicts the value of the center pixel (x_c, y_c), i_n to the value of eight encircling pixels. This formula is employed to find out the features which are important in the

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face by using the basic LBP operator. The feature matrix is originally a 3x3 matrix and the values in it are analyzed by the value of center pixel, then the binary code is generated. This binary code is used to get the LBP code by just concerting this binary code into decimal one.

A. The Face Recognition Algorithm.

Input: Training Image set.

Output: Features extracted from the face image consisting of analysis of center pixel and the extracted features recognized with unknown image of face.

a) First of all temp = 0 is initialized.
b) FOR each image I in the training image set
c) The pattern histogram, H = 0 is initialized
d) FOR each center pixel t_c ε I
e) Compute the pattern label of t_c, LBP(1)
f) The corresponding bin is increased by 1.
g) END FOR
h) Highest LBP feature for each face image is found and combined into a single vector.
i) Comparison is made with test face image.
j) If the match occurs for the most similar face in the database then the face is recognized successfully.

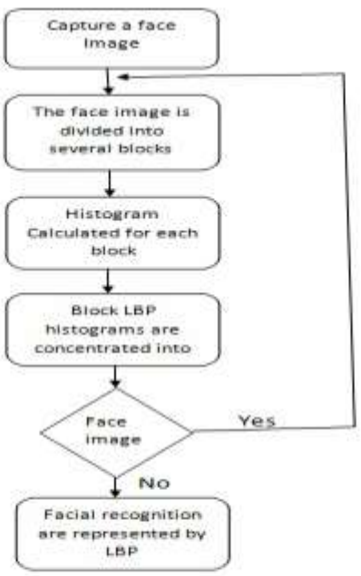

Fig. 8 Flowchart of LBP Process

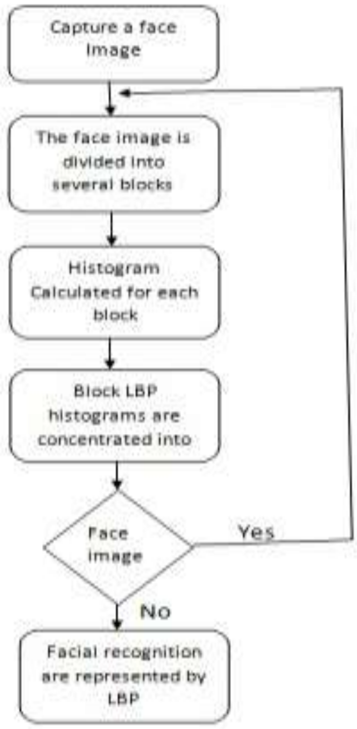

Fig. 9 Flowchart of the proposed system

XII. Result and Discussion

This implementation of LBP is used to build a security system using face recognition with less response time and higher accuracy of recognition. Detecting and recognizing the faces in real-time frames and simultaneously printing the accuracy of recognition on the screen are performed in this work. If the accuracy crosses 85% within 10 seconds, then the lock gets opened and the person will be granted access to the home/office. If the accuracy crosses 85% within 10 sec then the pop-up says **Access Granted**. The screen shot is presented in Fig. 10 below.

Fig. 10 Successfully granting access to the user via pop-up

But if in case the accuracy fails to cross the margin 85% then the pop-up says **Access Denied.** The screen shot in this case is also presented in Fig. 11 below.

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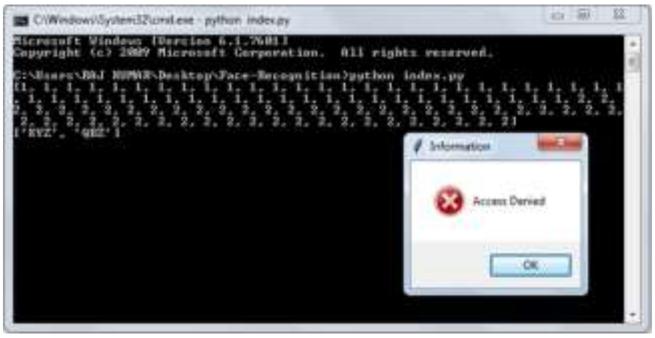

Fig. 11 Denying the access if recognition fails via pop-up

So in a nutshell the image if face is taken from webcam and compared with the images stored in the database using the face recognition algorithm, if the accuracy of the face matched is greater than 85 % then the access is granted otherwise not. This work can be utilized as a security system.

XIII. Future Scope

For now, some multinational companies and few homes have acquired system software like ours and have been using it efficiently but its reach has been limited to them only. There have been issues with the accuracy of such a system in the past. In the future, there are some areas where professionals need to work in order to improve and make it more secure:

1. First and foremost priority must be to increase the accuracy of the software as much as possible and thereby making it more secure.
2. With face recognition algorithm, we can further use natural language processing which will help in making this process more accurate and fast.
3. Make this software affordable for everyone because if it does not solve everyone's problem then it is very unlikely that the technology will last.

Key-lock system was very reliable for a long time but now people have found ways to crack open these locks. So people are looking for improved ways to secure their homes and our solution of no keys and only using the face will surely help a lot. Later on, at some point, everyone will have to rely on these security systems so it's better to improve the software and make it affordable for everyone.

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