Fast Local Binary Patterns for Efficient Face Recognition

Mallikarjuna Rao G[1], Vijaya Kumari G[2], Babu G R[3], Rajesh V[4]

[#]Department of Computer Science and Engineering, Gokaraju Rangaraju College of Engineering and Technology
Hyderabad, India

[1]gmr_333@yahoo.com
[2]vijayakumari.gunta@gmail.com
[3]babu_gr@yahoo.com
[4]rajesh.viswanadula@gmail.com

***Abstract*—— LBP, Local Binary Patterns, is an accepted technique for efficient face recognition. The local features improve the recognition process. However, high memory and computational resources are needed for LBP required approaches to improve the performance. Many people used LBP for extracting features and Support Vector Machine (SVM), histogram matching, neural networks as recognition tools. These approaches consume considerable computational resources. We have proposed a fast LBP which uses Two-level Correlation for the classification & recognition. The exhaustive experiments on FERET database 8750 images has resulted correct recognition rate 77.95% performance substantiate the performance compared to computational intensive LBP with histogram matching.**

***Keywords*—— Face Recognition, LBP, Histogram Matching, Two-level Correlation, FERET data set.**

I. INTRODUCTION

Face recognition is the process of identifying a person with a system that has a collection of face images labeled with each person identity. Face recognition [1] has been a popular area of research over the past few years as a result of its growing usage in many applications in fields such as banking, security and multimedia applications. Compared to other biometrics, such as fingerprint, DNA, or voice, face recognition is more natural, nonintrusive and can be used without the cooperation of the subject. Since the very first automatic system for face recognition there has been a growing attention given to face recognition. Due to powerful computers and recent advances in pattern recognition, face recognition systems can now perform in real-time and achieve satisfying performance under controlled conditions, leading to many potential applications.

Acquiring both accuracy and high performance in face recognition is challenging. Many methods and models were proposed over the years but they consume a lot of computational resources.

The most popular and general classification schemes are as follows:

1) *Holistic methods:* These methods use the overall face information. These methods are used to recognize faces in an image. For instance, the PCA [2], statistical approaches use to extract the feature parameters to create a specific face model or space to be used for the recognition stage. The training data is used to create a face space where the test faces can be mapped and classified.

2) *Feature-based methods:* These are non-holistic methods. These methods are based in identifying structural face features such as the eyes, mouth and nose, and the relations between them to make the final decision. First feature matching strategies were based on the manually definition of facial points and the computation of the geometric distances between them, resulting in a feature grid for people identification. Recent evolved algorithms place the facial points automatically and create an elastic graph in order to resolve previous algorithms' insensitivity to pose variations.

3) *Hybrid methods:* Hybrid approaches try to take advantage of both techniques.

4) *Neural network algorithms:* This technique [3] can be considered as statistical approach (holistic method), because the training procedure scheme usually searches for statistical structures in the input patterns. However, due to the fact that it is based on human brain biological understanding, a conceptually different principle, neural networks can be classified as separately approach. After giving a general overview of the different methods, this work has been focused on a technique based in the use of the LBP operator which can be used for both face detection and recognition, motivated by its robustness to pose and illumination changes and due to its low computation complexity. Next chapter will explain in detail how LBP can be used for both tasks.

II. LOCAL BINARY PATTERNS (LBP)

LBP [4] is a powerful discriminative feature space that is invariant with respect to monotonic gray scale transformations (i.e. as long as the order of the gray values remains the same, the LBP operator output continues constant) and it can be extracted in a single scan through the whole image. Briefly, the procedure consists of dividing a facial image in several regions where the LBP features are extracted and concatenated into a feature vector that will be later used as facial descriptor.

A. *LBP Operator*

The LBP operator assigns a label to each pixel of an image by thresholding a 3x3 neighbourhood with the centre pixel value and considering the result as a binary number. In different publications, the circular 0 and 1 resulting values are read either clockwise or counter clockwise. In this research, the binary result will be obtained by reading the values clockwise, starting from the top left neighbour, as can be seen in the following figure.

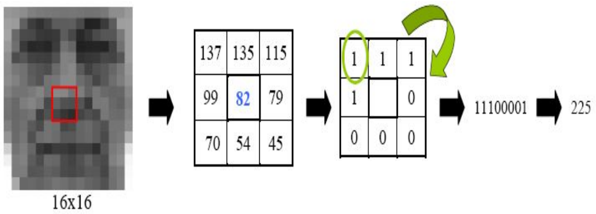

Fig. 1 LBP labelling: binary label is read clockwise starting from top left neighbour.

In other words, given a pixel position (xc, yc); LBP [4] is defined as an ordered set of binary comparisons of pixel intensities between the central pixel and its surrounding pixels. The resulting decimal label value of the 8-bit word can be expressed as follows:

$$LBP(x_c, y_c) = \sum_{n=0}^{7} s\,(l_n - l_c)2^n \quad (1)$$

Where lc corresponds to the grey value of the centre pixel (x_c, y_c), l_n to the grey values of the 8 surrounding pixels, and function s (k) is defined as:

$$s(k) = \begin{cases} 1, & k \geq 0 \\ 0, & k < 0 \end{cases} \quad (2)$$

B. Local Binary Patterns Extension

In order to treat facial images at different scales, the LBP operator was extended to make use of neighbourhoods at different sizes. Using circular neighbourhoods and bilinear interpolation of the pixel values, any radius and number of samples in the neighbourhood can be handled. Therefore, the following notation is defined: (P, R) which means P sampling points on a circle of R radius.

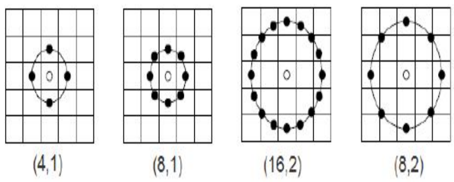

Fig. 2 LBP different Sampling point and Radius

In (4,1) LBP case, the reason why the four points selected correspond to vertical and horizontal ones, is that faces contain more horizontal and vertical edges than diagonal ones. When computing pixel operations taking into account NxN neighbourhoods at the boundary of an image, a portion of the NxN mask is off the edge of the image. In such situations, different padding techniques are typically used such as zero-padding, repeating border elements or applying a mirror reflection to define the image boarders. Nevertheless, in LBP operator case, the critical boundary, defined by the radius R of the circular operation, is not solved by using a padding technique, instead of that, the operation is started at image pixel (R, R). The advantage is that the final LBP labels histogram will be not influenced by the borders, although the resulting LBP labels image size will be reduced to (Width-R)x(Height-R) pixels.

III. Histogram Matching

The Histogram Matching [4] (also called Histogram Specification) algorithm generates an output image based upon a specified histogram. The process of Histogram Matching takes in an input image and produces an output image that is based upon a specified histogram. The required parameters for this algorithm are the input image and the specified image, from which the specified histogram can be obtained.

The algorithm works as follows:

The histograms for the input image $P(f)$ and the specified image $P_d\,(g)$ are generated. Here, the desired histogram of the specified image is denoted as $P_d\,(g)$. Cumulative histograms - P (f) and Pd (g) are then generated using the following equations:

$$P(f) = \sum_{k=0}^{f} P(k) \quad (3)$$

$$P_d\,(g) \sum_{k=0}^{g} P_d(k) \quad (4)$$

where f and g are the pixel intensity levels.

The transformation function is obtained by choosing g for each f, such that if g > f, then Pd(g) > P(f). The transformation function is then applied to the input image to produce an output image by remapping the pixel intensities. The objective is to find a transformed digital picture of a given picture, such that the sum of absolute errors between the intensity level histogram of the transformed picture and that of a reference picture is minimized.

Limitations:

- The histogram does not retain local regions relationship
- Histogram matching is based on the statistics of the image only. It does not consider the intrinsic facial characteristics.
- To improve the accuracy after histogram matching, we need to opt for the other recognition tools such as SVM, Neural networks, etc.

IV. Our Approach—Two-Level Correlation

After extracting the local features of an image by using LBP, we need to use a recognition tool such as SVM, histogram matching or neural networks. These recognition tools consume a considerable amount of computational resources and yet performance issues were observed.

To avoid the usage of recognition tools which consume high memory and computational resources, here in this work we are proposing a simple method which uses two-level correlation.

Briefly, we first organize our data set into different class templates such that each class template has similar characteristics. Then we apply the first level correlation between the test image and the class templates. We present the best three class template matches. Then we apply the intra class template correlation i.e. second level correlation. We compare the test image against the images in the first best matched class template and present the best two matched images to the user. By using the two-level correlation model, we are reducing a huge number of comparisons between test image and data set images. Thus the performance and accuracy are very high in this proposed system.

A. Proposed System

In our system, as shown in figure 3, we proposed correlation as the recognition tool at two levels. We first resize the training data set facial images to a common optimal size so that the recognition process is faster. After resizing the images, we apply LBP on each image to get the local features. Based on the local characteristics obtained, we divide the data set images into different class templates. After getting the local features of the test image, we apply the first level correlation between test image and the class templates. The best three best matched class templates are provided by our system. In the second level correlation test image matched with the images of first best class. The best three matched images are presented to the user against the test image. If the first best matched class template images are not found be satisfactory with respect to the test image, then the correlation is made between test image and second best matched class template and best two matched image set is presented to the user.

B. Procedure

- Resize the images in the training data set
- Apply the LBP to each image in the training data set
- Based on the local characteristics obtained, divide the training data set into different class templates.
- Apply the LBP to the acquired test image to get the local features
- Apply first level correlation between test image and class templates
- Identify the best three matched class templates
- Apply second level correlation between test image and the images in the first best matched class template.
- Identify the best two matched images and present them to the user.
- If the matches obtained are not satisfactory then apply the correlation on the second best matched class template.

C. Significance of Correlation

In statistics, dependence refers to any statistical relationship between two random variables or two sets of data. Correlation [5] refers to any of a broad class of statistical relationships involving dependence. The Pearson's correlation is excessively used in the pattern matching. The matching strength is given as +1, -1 and 0. The +1 stands for maximum positive matching while -1 stands for maximum negative matching. The zero denotes no-correlation (no similarities).

The correlation coefficient gives degree of matching between the two images.

There is a TWO- LEVEL matching (First matching is for image class template and second matching is for intra class image).

- r = corr2 (A, B);
- Description:

r = corr2 (A, B) computes the Correlation Coefficient between A and B, where A and B are matrices or vector of the same size.

- Class Support:

A and B can be numeric or logical. The return value r is a scalar double. Algorithm-corr2 computes the correlation coefficient using the following formula

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\sum_m \sum_n (A_{mn} - \bar{A})^2 \sum_m \sum_n (B_{mn} - \bar{B})^2}} \quad (5)$$

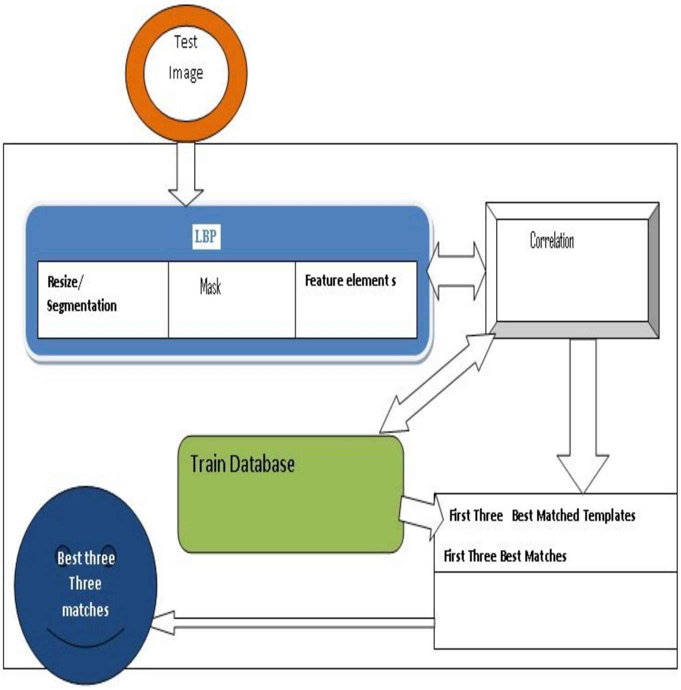

Fig. 3 Proposed LBP with Correlation

D. Experimental Results

The exhaustive experiments are performed on the FERET face recognition database. The database contains 8750 images ranging of 950 subjects. The images ranging from 3 to 40 within each class (subject) contains wide variations in terms of facial expressions, poses and lighting conditions. Further the images are acquired at different times (a year ago, a year later and so on). In the first level correlation all the images randomly selected in different trails against face templates of 950 subjects. The best mated class indicate the class of concerned test image. The second level correlation is made against remaining images of the concerned class. The first three best matches nearly matching the expression / pose with tested one are generated by the proposed system.

FIG 4: Testing with Local Distortion

The subjects containing 10 or less images has given the correct recognition rate 94% while overall recognition rate for all the images is 77.95%. In our testing process we have introduced local distortion (15% to 20%). New test set is formed using the local distortion. The recognition is invariant, as shown in figure 4, to the local distortion.

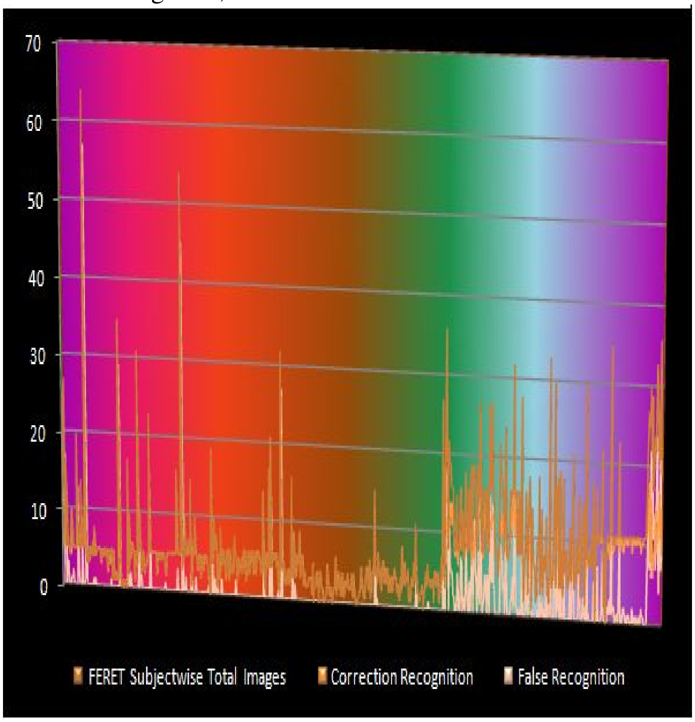

FIG 5: Recognition (Correct and False) in trail 79

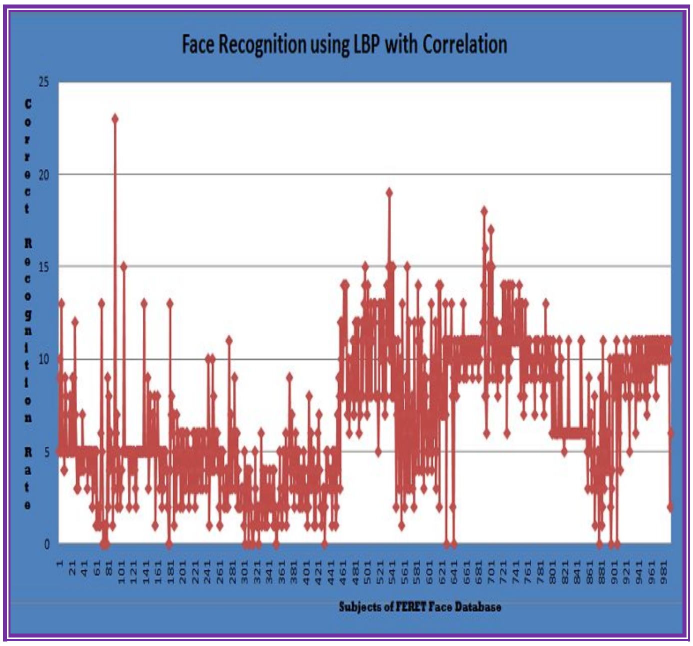

FIG 6: Recognition Correct and False) in trail 18

100 Trails each having 400 test images are made. The result of 79th trail is given figure 5. The figure 6 is the correct recognition rate in the 18th trail. The second and third best matched class templates raise the recognition rate to 82%.

V. CONCLUSIONS

Face recognition can be done using Local Binary Patterns in an efficient manner which reduces the number of comparisons for instance the image (64*96) which is read as a matrix in MATLAB has a total of 64*96=6144 values, for a normal comparison the process should compare all the values for a match, using LBP these values reduce to 6144/9=672 (approx) for each image thus reducing the complexity in calculating the proximity of images. The authors [6] proved that time space requirements of LBP are fairly high. The programs were executed using MATLAB 7 on Dual core 1.88 GHZ processor with 2GB RAM. The table 1 gives the time requirements of LBP variants and LBP with correlation.

TABLE 1. COMPUTATIONAL TIME FOR LBP VARIANTS AND ACTIVE PIXEL

Approaches	LBP with PCA	LBP with LDA	LBP with correlation
Time	10 hrs	12 hrs	8 hrs

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Mallikarjuna Rao G. is presently professor in Dept. of Computer Science, GRIET, Hyderabad. He completed first Masters Degree in Digital Systems from Osmania University in the year 1993 and second masters degree in CSE from JNTU Hyderabad in the year 2002. He is currently pursuing the PhD in Image Processing area from JNTUH. In his credit there are 1 journal publication and, 6 international conference publications. He has worked at various capacities in reputed affiliated colleges in Hyderabad from 1989 till today. He won the best Teacher award in 2005 at GNITS. His research interests are Neural Networks, Pattern Recognition.

Vijayakumari G. is presently working as professor and co-coordinator AICTE projects at JNTU College of Engineering Hyderabad in department of Computer Science & Engineering .Dr Vijaya Kumari received PhD from Central University of Hyderabad. She served the University and the department at various capacities. With the rich 15 years experience she is the source of inspiration for many undergraduate, post graduate and research scholars. Her research interests are Artificial Intelligence, Natural Language Processing and Network Security.

Ravindra Babu, Gurram is an exceptional academician and philosopher. He completed his PhD in 1969 from Imperial College of Science and Technology (University of London) in Microwave Engineering / Micro-Striplanes and microwave Integrated Circuits. The distinguished at present extending his valuable services to the student community of KMITS, Hyderabad.

Rajesh Viswanadula has completed his Masters degree in Computer Science and Engineering from Jawaharlal Nehru Technological University, Hyderabad. He is presently working as a software engineer.