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Design, Implementation and Evaluation of an Algorithm for Face Recognition Based on Modified Local Directional Pattern

Face Recognition using LDP5

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Abstract—**Face Recognition is one of the most researched fields of image processing and computer vision. Recent developed algorithms were restricted controlled by the environmental condition such as illumination, expression. Proposed Algorithm aims to implement face recognition based on the Modified Local Directional Pattern (LDP) in which the concept of Local Binary Pattern which is strong enough to select good features under real world environmental condition. In the modified LDP, the face area is divided into small regions. An LDP histogram is extracted for each smaller region. All the histograms of each and every small regions are concatenated into a single vector to represent the face efficiently. This combined histogram is the final analysis of each and every image and stores the features for each ad every image. The classification is performed by using KNN classification. The performance of the algorithm has been checked for the different databases – YaleDB, ORL and CMU-PIE .**

Keywords-Face Recognition; Local Binary Pattern; Local Directional Pattern; K- Nearest Neighbour;

I. INTRODUCTION

Face Recognition is a part of image processing where an image is the input and an image or set of parameters is the output. The input image may be picture or video stream. Face recognition technology is used in applications such as person authentication, access control and surveillance. Research activity has increased significantly from the past few years. Two or more image of the same face vary due to illumination and rotation Many of the image processing techniques or algorithm considers the image as a two dimensional signal. A standard appropriate algorithm is applied on it according to the required output and the parameters. Early face recognition algorithms used simple geometric models, but the recognition process has now matured into a science of sophisticated mathematical representations and matching processes. Major advancements and initiatives in the past ten to fifteen years have propelled face recognition technology into spotlight [14]. Face recognition can be used for both verification and identification.

Feature extraction plays a vital role in face recognition techniques. In this process we extract the features from the sample input data by applying the transformation process on it. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desire task using this reduced representation instead of the full size input. In the global feature extraction process, the image is taken into account, while local features are considered within the image. Global features are generated by Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) etc. The performances of global features get deteriorated in the changing environment. Local features are generated by Local Features Analysis (LFA), Elastic Bunch Graph Mapping (EBGM) etc. Ahonen et al. [4] proposed Local Binary pattern for illumination variant description. Later Jabid et al. [1] proposed a Local Directional Pattern for human face recognition by computing the edge response values.

According to a recent survey on face recognition, this research domain is having a great significance [2] and high progress [3]. However a robust face recognition system in an uncontrolled environment is a major challenge.

This paper describes a Modified Local Directional Pattern (LDP5) which works on the drawbacks of Local Binary Pattern (LBP). The proposed LDP5 is a local descriptor which considers the edge response values in 15 different directions. This provides more consistency as edge response value is more stable.

II. LOCAL BINARY PATTERN (LBP)

The LBP operator is a gray scale invariant text primitive and is significantly popular for describing an face image [5]. It labels each pixel value of a face image by thresholding its P-neighbour values with the center value and gives the result in a binary number by using (1). The values of the P-neighbour are compared with the threshold value and the value to each pixel is assigned.

$$LBP_{P,R}(x_c, y_c) = \sum_{p=0}^{P-1} s(g_p - g_c)2^p, \quad s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases} \qquad (1)$$

Where Ojala et al. [5] observed the local binary pattern more significant in certain image area. These local binary patterns are termed as uniform as they contain few 0 to 1 or 1 to 0 transitions. Ahonen et al. [4] has used the variant of LBP for their face recognition. This variant is sensitive to noise and illumination variation.

99	94	97	94	76
102	88	77	77	80
96	78	80	73	76
87	78	75	71	69
82	74	67	60	59

1	1	1	1	0
1	1	0	0	0
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0

Figure 1: LBP Operator

III. LOCAL DIRECTIONAL PATTERN (LDP)

The proposed Local Directional Pattern (LDP) is a sixteen bit binary code assigned to each pixel of an input face image. Initially Jaqib et al. [1] has proposed the LDP for an eight bit code. It was calculate by using Kirsch Mask. The proposed LDP code is calculated by comparing the relative edge response value of a pixel in sixteen different directions. For this purpose we calculate sixteen directional edge response value of a particular pixel using a modified mask in sixteen different orientations (M0 to M15). The four different orientations of the mask are shown in the fig. 2.

By applying these sixteen masks, we obtain sixteen edge response value m_0, m_1, m_2, ………. , m_{15}. Each mask value represents the edge significance in its respective direction. The different edge response value has different significant [6]. We are keen to know the k most prominent directions in order to generate the LDP5. For this we find the k most prominent values $|m_i|$ and assign 1 to them. All the rest values are set to 0.

$$C[f(x,y)]:=(c_i=1) \qquad \text{if } 0 \le i \le \text{and } m_i \ge \Psi \qquad (2)$$

$$\text{where } \Psi = k^{th}(M); \qquad M=\{m_0,m_1,m_2, \ldots\ldots, m_{15}\}$$

The LDP5 code produces a stable pattern in the presence of noise.

The LDP features encode the texture of the image by ranking the most significant responses in the different sixteen directions [7]. The presence of noise may change its relative position. Even if the relative value changes, it is mostly likely to occur in lesser significant direction [8]. Thus the Local Directional Pattern gives more stable pattern in the presence of noise.

M0

-2	-2	-2	-2	4
-2	-3	-3	5	4
-2	-3	0	6	5
-2	-3	-3	5	4
-2	-2	-2	-2	4

M1

-2	-2	-2	4	4
-2	-3	-3	5	5
-2	-3	0	6	4
-2	-3	-3	5	4
-2	-2	-2	-2	-2

M2

2	-2	4	4	5
-2	-3	5	6	4
-2	-3	0	5	4
-2	-3	-3	-3	-2
-2	-2	-2	-2	-2

M3

-2	4	4	5	4
-2	-3	5	6	4
-2	-3	0	5	-2
-2	-3	-3	-3	-2
-2	-2	-2	-2	-2

Figure 2: Mask in four orientations

IV. LDP BASED FACE RECOGNITION

The Local Directional Pattern is robust against random noise and non-monotonic changes in illumination. The LDP feature of an image is used to represent face in the application of face recognition. In this section we are going to explain how to use the proposed LDP5 operator to represent the appearance of face image and to use that feature for the identification of the face. The proposed LDP uses a LBP operator of 5*5 matrix.

A. Face Representation using LDP5

The face representation process using LDP5 consist of three steps. First of all, the LDP image is obtained from the raw image using the LDP5 operator. Secondly, after getting the LDP image, a histogram is extracted from each local region of the LDP image [9]. These histograms make the local representation of the image. And third, all the histograms of local representation are concatenated into one histogram which is a feature vector for the global representation of the image. The proposed LDP5 has been demonstrated in figure 4.

1) Getting LDP image from the raw image: The very first step is to get the LDP image using the LDP5 operator. The LDP5 operator is applied to the raw face image. In this

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Mask	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M1 0	M11	M12	M13	M14	M15
Mask Value	-412	-348	-125	-15	299	433	638	674	505	373	42	-153	-439	-509	-511	-412
Rank	8	11	14	16	12	7	2	1	5	10	15	13	6	4	3	9
Code Bit	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
LDP code	1538															

Figure 3: Generating LDP5 Code

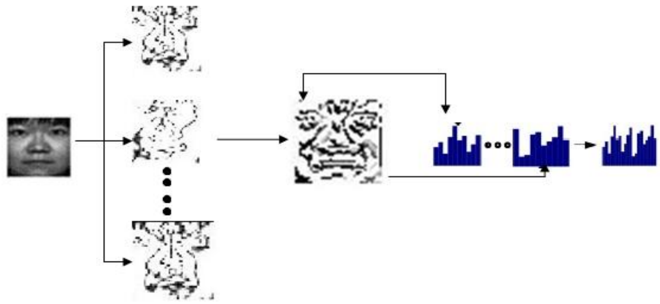

Figure 4: Face Recognition using LDP5

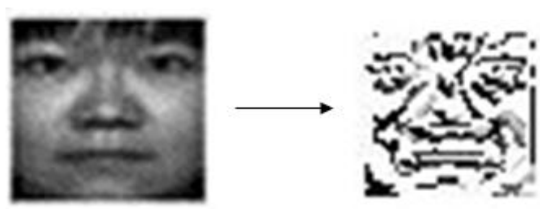

Figure 5: Original Image vs LDP5 image

experiment, we are using k=3 to generate the LDP5 code. An example of LDP5 image which is generated from the raw image is shown in the figure 5. On operating LDP5 operator on the raw face image sixteen different LDP5 image is obtained and these image result in a final LDP5 image of a raw image.

2) Histogram of LDP5 image: After obtaining LDP5 image using LDP5 operator, the image is divided into twenty-five local regions. This division is to obtain the local representation of the image. A histogram of 56 bin is obtained for each local region. As a result twenty-five histograms is obtained for a image as shown in the figure 6

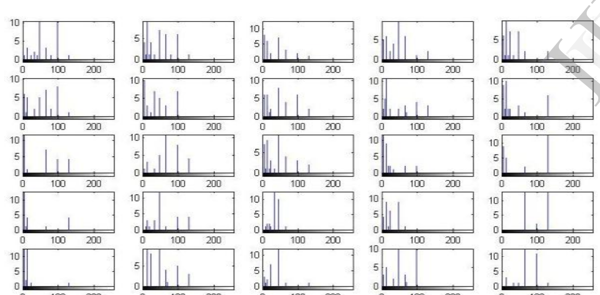

Figure 6: Histogram for Local Representation

3) Concatenation of Histogram: During the face representation, each face is represented with a LDP5 histogram [12]. This LDP histogram gives the detain information of an image such as edges, spot, corner, and other texture features. In order to get the higher degree of information the image was divided into small regions and histogram of each small region is obtained [13]. These histograms of small regions are concatenated into a spatially combined LDP histogram which gives the global representation for the global feature for the given face image as shown in the figure 7.

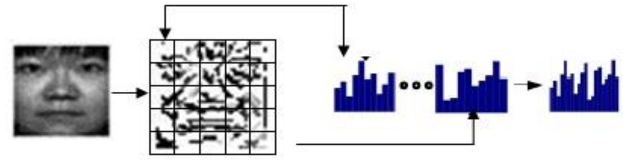

Figure 7: Spatially Combined Histogram feature

B. Classification with k- Nearest Neighbour (KNN)

The global feature of the LDP5 image generated using LDP5 descriptor is used for the recognition of the face with k-Nearest Neighbour (KNN). KNN is a well defined method for classifying objects based on closest training. It is a type of instance based learning [10]. It is simplest among all machine learning algorithms. The object is assigned to the class which is most common among its k nearest neighbour. The k is a positive integer value. If k=1, then the object is assigned to the class of its nearest neighbour. Neighbours are teken from a set of objects with correct classification [11]. This classifier is sensitive to the local structure of the dataset.

This classifier is based on Euclidean distance. Usually Euclidean distance is used as the distance metric. The Euclidean distance between the points x and u may be defined as

$$d(x,u) = \Sigma(x_i-u_i)^2 \quad (3)$$

where i is number of elements in the vector. This classifier assign the object to the class of the object having the minimum Euclidean distance.

Table I

Classification Accuracy with Different Database

Database	Accuracy
YaleDB	81.1
ORl	61.8
CMU-PIE	59.4

Table II

Classification Accuracy with Different Ratio

Train/Test	LDP5	Earlier LDP
1/9	74.1	71.4
2/8	77.4	75.6
3/7	76.2	74.8
4/6	87.3	86.5
5/5	99	98.1

V. EXPERIMENTAL RESULT

The performance of the face recognition using the LDP5 feature is evaluated with the images from YaleDB, ORL and

CMU-PIE database. The YaleDb database contains 5,760 single light source image of 10 persons under 9 poses and 64 illumination conditions. The ORL database contains 10 different images of 40 distinct persons. Each image is of size 92x112 pixels. The CMU-PIE database is a collection of 41,368 images under 43 illumination conditions, 13 different poses, and 4 different expressions. In our study, the face images are cropped and normalized to 40x40 pixels. Each image is partitioned into 5x5 sub-blocks to generate spatially combined LDP histogram feature vector as discussed in section IV. The performance of LDP5 for different database has been checked as shown with Table I. The performance of the matrix is enhanced as we increase the train data. The classification performance in respect to different train data to test data ratio is shown in Table II. The comparison of the proposed LDP5 algorithm with the earlier LDP algorithm has also been shown in Table II.

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