A Review of Dimensionality Reduction in Face Recognition

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Abstract – Face recognition is playing a significant role especially in the field of security, banking, social and judicial area. Face recognition techniques are used to compare an input image with a database of stored faces in order to identify the person in that input image. Number of techniques has been introduced and lot of work has been done in recognizing face under small variations in face orientation, expressions, lighting, back-ground. The dimensionality reduction is necessary in image processing including face recognition. This paper combines the feature extraction algorithm LBP with the dimensionality reduction methods PCA and LPP.

Index Terms – Feature Extraction, Dimensionality Reduction, Principal Component Analysis (PCA), Locality Preserving Projections (LPP), Local Binary Pattern (LBP).

1. INTRODUCTION

Face recognition is one of the most popular areas of image identification and understanding and it has recently received special attention, especially during the past several years. The researchers gave valuable results for the still images i.e., images are taken under the controlled conditions. Researchers are concentrating on the real time applications. Most of the surveys are carried out on the topic of face recognition [1-7] they depicts various existing techniques for feature extraction and the face recognition process.

Biometric is an emerging area with many opportunities for growth. Biometric-based technologies contain identification based on certain human body features (fingerprints, face, hand veins, palm, iris, retina, ear and voice). Techniques that depend on hands and fingers can be useless if the epidermis tissue is damaged (i.e., injured or crushed), Iris and retina identification require costly equipment and are much too sensitive to any body motion, and voice recognition is adaptable to background noises in public places and audio fluctuations on a phone line or tape recording. Signatures can also be forged. However, facial images can be easily obtained by different type of cameras. But face recognition algorithms and appropriate preprocessing techniques of the images can compensate for noise and slight variations in orientation, scale and illumination [8]. Many algorithms implement the face-recognition task as a binary pattern-classification task.

The face recognition is a very good research area to identify the location and size of many faces in the photos (digital photo). This technique discovers features of faces and ignores other things such as vehicles, building, trees, body, etc.

Face recognition system can be used in:

- Checking for criminal records
- Surveillance improves the security in conjunction with face recognition system.
- If any children missed, Search the lost children's by using the images received from the cameras fitted at some public places.
- Knowing in advance if some VIP is entering the hotel.
- Criminal detection at public places.
- In science entity comparison.
- Etc…

2. RELATED WORK

2.1. LOCAL BINARY PATTERN

There are several methods for extracting the useful features from (pre-processed) face images to perform face recognition. One of these feature extraction methods is the Local Binary Pattern (LBP) method. This relative new approach was introduced in 1996 by Ojala et al. [9]. With LBP it is possible to describe the texture and shape of a digital image. This is done by dividing an image into several small regions from which the features are extracted.

The standard local binary pattern (LBP) encodes the relationship between the referenced pixel and its surrounding 8-neighbours and then calculates the gray-level difference.

$\mathbf{N_1}$	$\mathbf{N_2}$	$\mathbf{N_3}$
$\mathbf{N_8}$	$\mathbf{N_o}$	$\mathbf{N_4}$
$\mathbf{N_7}$	$\mathbf{N_6}$	$\mathbf{N_5}$

Fig.2.1. Eight – neighbourhood around N_0

LBP is a gray scale invariant texture measure and is a useful tool to model texture images. In LBP, it labels the pixels of an image by thresholding the 3 x 3 neighbourhood of each pixel with the value of central pixel and concatenating the bits from top left. Where the threshold vale is set into zero.The thresholding function for $f(\cdot,\cdot)$ for the basic LBP can be represented by the following equation

$$f(I(N_o), I(N_i)) = \begin{cases} 0, & if\ I(N_i) - I(N_o) \le \text{threshold} \\ 1, & if\ I(N_i) - I(N_o) > threshold \end{cases} \quad .... (1)$$

Where N_i, i=1,2,...8 is an eight neighbourhood point around $N_{\square}$ as shown in Fig. 2.1. Concatenation of the binary gradient direction is called a micro pattern. Fig. 4.2 shows LBP micro pattern, when the threshold is set to zero.

These features consist of binary patterns that describe the surrounding eight neighbours in the regions. The obtained features from the regions are concatenated into a single feature histogram, which forms a representation of the image. Fig 2.2 compares 4 with all other eight neighbours and generates the bit pattern 11010101. Assign its decimal equivalent to z_0. This feature extraction is a special form of dimensionality reduction.

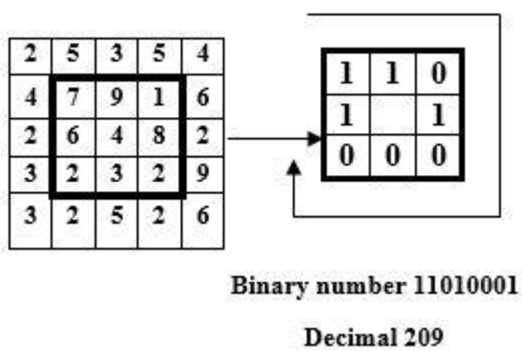

Fig.2.2. Micro pattern obtained from the black square

These features consist of binary patterns that describe the surrounding eight neighbours in the regions. The obtained features from the regions are concatenated into a single feature histogram, which forms a representation of the image. This feature extraction is a special form of dimensionality reduction.

2.2 DIMENSIONALITY REDUCTION TECHNIQUES

Several schemes have been proposed that can do statistical dimensionality reduction methods to obtain and retain the most meaningful feature dimensions before performing recognition. The most vital problem in face recognition is the dimensionality problem [21]. When the system starts to store the high dimensional data then it needs more memory space and also causes computational complexity becomes the heavy task. This dimensionality problem is reduced by dimensionality reduction techniques [11]. In statistics, dimension reduction is the process of reducing the number of dimensions and can be divided into feature selection and feature extraction. The basic flow of dimension reduction in face recognition is illustrated in figure 2.3.

Many algorithms for dimensionality reduction have been developed to attain dimensionality reduction. Various feature extraction techniques are available [10] to extract necessary features from the human face.

The classic dimensionality reduction algorithms include Principal Component Analysis (PCA) [12, 13] and linear manifold learning algorithm, called Locality Preserving Projections (LPP)[14,15]. LBP is an efficient and simple feature extraction algorithm. LBP is efficient while processing the problematic image like hair inclusion, lighting condition and so on.

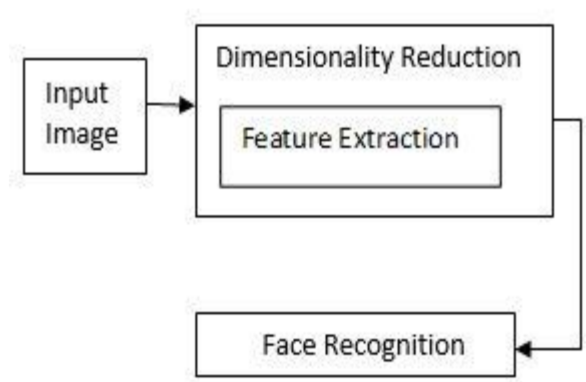

Fig.2.3 Dimensionality Reduction

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2.3.PRINCIPAL COMPONENT ANALYSIS (PCA):

PCA algorithm is obtained from Karhunen-Loeve's transformation. PCA is one of the popular techniques for dimensionality reduction. Given an m-dimensional vector denotes each face in a training set of images, Principal Component Analysis (PCA) tends to find n-dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. This new subspace is normally lower dimensional (n<<m).

PCA is a very effective technical tool and this technique change a set of observations of possibly associated variables into a set of values of disassociated variables called principal components. The purpose of using PCA for face recognition is to express the large one dimensional vector of pixels from two dimensional facial images into the compact principal components of the feature space. This is called as eigen space projection. Eigen space is computed by finding the eigen vectors of the covariance matrix of facial images. Many survey papers are provided the information for PCA techniques [1- 6].

2.4 MATHEMATICAL ANALYSIS OF PCA:

1. Input data: A user made data set is used which has got only two dimensions to show the PCA analysis for every step.

2. Mean Subtraction: Subtract the mean value from each of the data dimensions. The subtracted mean value is the average across each dimension.

3. Compute the covariance matrix.

4. Compute the eigen vectors and eigen values of the covariance matrix. These are quiet important, and they tell us useful information about our data. Next, here are the eigen vectors and eigen values; these eigen vectors are both unit eigen vectors. Their lengths are both 1. This is very important for PCA and in most of the mathematical packages when asked for eigenvectors will give unit eigen vectors.

5. By selecting components and forming a feature vector then order them by eigen value, highest to lowest. This gives the important components.

6. The new data set: This is the last step in PCA, and it is also the easiest. Once the components are chosen (eigen vectors) that that should be kept as data and formed a feature vector, then simply take the transpose of the vector and then multiply it with the left of the original data set, transposed. It will give the original data solely in terms of the vectors [2].

PCA algorithm permits the system to represent the necessary data for comparing the faces using very few information once the mathematical representation accomplished which it is need to have a lot of faces to be store.PCA is one of the useful in linear regression, because it identifies and eliminate the nonlinearities in the data [19].

2.5. LOCALITY PRESERVING PROJECTIONS (LPP):

LPP is an alternative to Principal Component Analysis (PCA). When the data with higher dimensional lies on a lower dimensional manifold embedded in the surrounding space, the Locality Preserving Projections are obtained by calculating the optimal linear approximations to the eigen functions of the Laplace Beltrami operator on the manifold. As a result, LPP shares many data representation properties of nonlinear techniques such as Laplacian Eigen maps or Locally Linear Embedding [7].

LPP finds an embedding that preserves local information and obtains a face subspace that best detects the intrinsic face manifold structure. The computational complexity of the LPP algorithm is small. Therefore, LPP is better than PCA and LDA for face recognition. In the proposed face recognition algorithm, LPP is used to reduce the dimensionality of the LBP feature vectors [18].

Locality Preserving Projections (LPP) is an excellent linear dimensionality reduction algorithm, LPP constructs the adjacency graph to model the manifold structure of face space, and then creates a set of basis images. Get the LPP by finding the optimal approximations to the Eigen functions of the Laplace Beltrami operator on the face manifold. They reflect the intrinsic face manifold structures. Therefore LPP is very suitable for face recognition.

3. PORPOSED MODELLING

The feature extraction algorithm LBP is combined with dimensionality reduction algorithms PCA and LPP to improve the processing speed of the facial features.

3.1. LBP-LPP:

This paper proposes combination of Local Binary Pattern and Principal Component Analysis on eyes, nose region and facial features for the face recognition. LBP extract features and helps to recognize face image with small orientation, illumination variances and expression. PCA will reduce the length of the feature vector. LBP works with 8 neighbours of pixel, using the value of centre pixel as a threshold. All neighbours have values greater than the value of centre pixel will be given value 1 and all those that have less than or equal to value of centre pixel will be given value 0.The eight binary numbers assigned 8 neighbours are then concatenated sequentially in the clockwise direction to form a 8 bit binary number. Assign this binary number or its equivalent decimal number to central pixel. The LBP feature vector is a simplest form. For each pixel in a cell, compare the pixel to each of its 8 neighbours. Calculate the histogram, over the cell, of the frequency of each "number" occurring (i.e., each 8-bit pattern of which pixels are smaller and which are greater than the centre). If it is necessary normalize the histogram and then concatenate the normalized histograms. This will give the feature vector for the image.

Linear projection method is used to reduce the number of parameters generated by LBP. PCA transfers a set of correlated variables into a new set of uncorrelated variables and maps the data into a space of lower dimensionality [17]. PCA can be observed as a rotation of the existing axes to new positions in the space defined by original variables [20]. New axes correspond to the directions with highest variability and are orthogonal. The PCA steps carried out for dimension reduction can be explained as: First step is to calculate the mean of the LBP feature vector and then calculate the deviation to make covariance calculation easier. Third step is to calculate covariance matrix using standard formula. Fourth step is to calculate the Eigen vectors and Eigen values of the covariance matrix. Then reduce the dimensionality by eliminating the Eigen vectors. The Eigen vector with the highest Eigen value is the principal component of the data set. Final step is to get the final data using standard formula.

3.2 LBP-LPP:

Initially the face image is divided into small regions from which the Local Binary Pattern (LBP) features [8,9] are extracted and concatenated into a single feature histogram clearly represents the face image. The textures of the facial regions are locally encoded by the LBP patterns while the whole shape of the face is recovered by the construction of the face feature histogram.

Suppose a face database has n face images. For each face image find the d dimensional LBP feature vector set $X = [x_1, x_2, \cdots, x_n]$, $x_i \in R^d$. LPP reduces the dimensionality of the LBP feature vectors and finds a transformation matrix W that maps these n points of the set X to a set of points $Y = [y_1, y_2, \cdots, y_n]$, $y_i \in R_k$ $(k \ll d)$, where $y_i = W^T x_i$.

4. HISTOGRAM INTERSECTION

The method used to measure the similarity between two histograms is histogram intersection. It is.

$$S_{HI}(H,S) = \sum_{i=1}^{B} \min(H_i, S_i) \quad (2)$$

In this equation $S_{HI}(H,S)$ is the histogram intersection with $H=(H_1, H_2, H_3 \ldots\ldots\ldots.. H_A)^T$ and $S= ((S_1, S_2, S_3 \ldots\ldots\ldots.. S_A)^T$. Equation (2) is used to calculate the similarity of the nearest neighbour classifier. This measure is a useful method for the calculation of common parts of two histograms [23].This is a very simple equation with simple operations.

5. EXPERIMENTAL RESULTS

In [22] 16 train images are tested, each individual with three variations. The numbers of test images considered are 50, out of 50 images 42 test images got passed and rest failed. Recognition performance is reported in Table 1.

The ORL database comprises of 50 test images with 3 samples for each person. The samples are grey scale and sized at 112*92 pixels. All the images were taken against a dim background with the subjects in an right oriented, front position, with acceptance for some tilting and with small at 112*92 pixels. All the images were taken against a dim background with the subjects in an right oriented, front position, with acceptance for some tilting and with small alternation. Both Train and Test input images are resized to image size of 200*140.Tzone image size is of 66*140.After applying PCA, the feature vector get reduces from 9240*16 to 15*15 for Train images. Chi-Square equation is used to compare the reduced feature vectors. Fig. 5.1 expresses the sample ORL test images used by this paper.

Number of test images	Recognition rate
44	95.45
46	91.30
50	84
54	77.77

Table 1 Recognition Rate

Fig. 5.1 Sample Images of ORL Data Set

6. CONCLUSION

Feature selection is to find a subset of the original variables. By applying LBP, the face features are extracted. Feature extraction is a mapping of the multidimensional space into a space of fewer dimensions. The feature vector generated by LBP is the input to the linear algorithms PCA and LPP. This approach automatically reduces the dimension. It improves the efficiency of face recognition. This recognition rate can be improved by various other feature extraction algorithms.

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