Face Recognition using Symmetric Local Graph Structure

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Abstract

Biometrics is the process of making use of physical, biological and behavioral traits for identification purposes. Biometrics finds applications in wide variety of fields such as security, access control, and military. Among the various kinds of biometrics, face biometrics is one among the fast growing biometrics due to its flexibility in usage and easy availability of equipments. This work is focused on the area of face biometrics, which incorporates the concept of image processing along with it. The proposed work is aimed to determine the recognition accuracy of face recognition technique and compare its accuracy with existing techniques and also addresses the problems related to facial details, illumination and facial expressions in face recognition. This work shows the higher and gradual increase in accuracy of face recognition and enables to implement wide variety of applications in computer vision using standard face databases.

Keywords: Discrete Cosine Transform, Gabor Filter, Local Binary Pattern, Symmetric Local Graph Structure

1. Introduction

Biometrics refers to the technology of measuring and analyzing physical, biological and behavioral characteristics. Biometrics provides extremely accurate and secured access to information. Moreover, biometrics provides unique data sets, when done properly and overcomes most of the drawbacks of traditional authentication techniques.

Biometrics can be mainly classified based on physiological and behavioral traits. Face recognition has received great deal of importance over last few years, because of its wide range of application in fields like image analysis, computer vision and security purposes. Face recognition considers entire face or the characters like eyes, nose, mouth, etc. and other fiducial marks. Unlike all other biometrics, face recognition doesn't need any voluntary participation or action from the user side, thus finding application in security and surveillance purposes. One of the main advantages of face biometrics is, facial images can be obtained by inexpensive equipments and images cannot be forged. Also, slight variation in images due to noise, illumination, orientation and scale can be solved using appropriate preprocessing using effective image processing algorithms. Since face recognition doesn't involve any physical contact with the equipments, transmission of germs and other impurities from other users can be prevented. Also, biometrics finds applications in wide range of areas such as access control, surveillance, commercial and health care. They are used to secure facilities, protect access to computer networks, counter frauds, fight crimes, border security, etc. Along with the above advantages, face recognition has several limitations that make it difficult to implement in real-time systems. It is difficult to predict the differences or similarity among faces. There is a possibility of having faces with similar characteristics, thus making it difficult to recognize. The possibility of having high degree of accuracy is impossible. Another important factor is numerous factors (age, gender, illumination, pose, etc.) can cause variations in the appearance of face since it is not unique and rigid object. The performance of most of the systems degrades under unregulated condition as surveyed in[4].

Face Recognition from intensity images involves two categories: (i) Feature-based and (ii) Holistic. Feature-based involves identifying and extracting local features like eyes, nose and other fiducial points and then computing the geometric relationship between these features. Holistic features identify faces using global representation of face. This method is computationally very expensive and sensitive to minor variations and utilizes the principles of neural networks and machine learning techniques to recognize faces.

Face Recognition has two main tasks: Face Verification and Face Identification. Face verification can be referred as one-to-one matching, while Face identification is one-to-many matching. During Face verification, the given two images are checked for their matching. Face identification recognizes an image by cross-checking it with a set of images in a database. Here the proposed concept Symmetric Local Graph Structure (SLGS) is a holistic approach for face Identification. SLGS initially calculates a value for each pixel by thresholding neighbor's pixel. From this value, histograms are generated for all training sets during training phase. In testing phase, feature matching can be done using the similarity measurement. The overview of the proposed system is shown in Figure 1.

2. Related Works

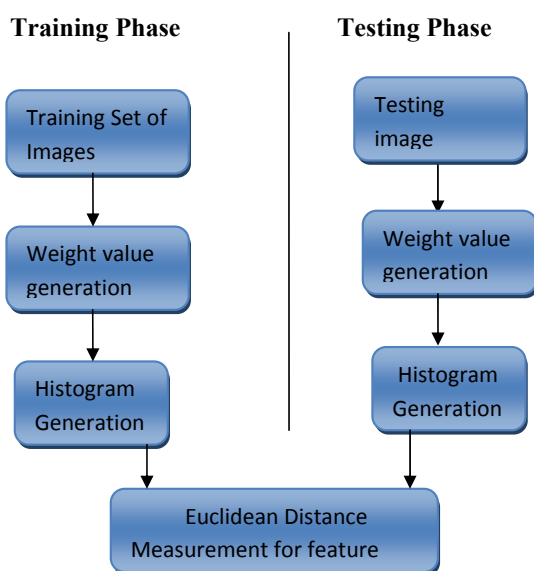Related works involves Face recognition based on Local Binary Pattern (LBP), Gabor filters[3] and Discrete Cosine Transform (DCT). Ahonen et al.[1] proposed face recognition with LBP operator by considering both shape and texture information. LBP is a non-linear method of face recognition and it operates on its 3×3 neighborhood pixels for each center value and considers the result as a binary value. The structure of LBP operator is given in Figure 2.

LBP exhibits computational simplicity and higher discriminative power

LBP exhibits computational simplicity and higher discriminative power which is robust against the monotonic grey-scale changes that were caused due to variations in illumination. Some limitations include its narrow coverage of neighborhood that extracts smaller spatial information. Aman et al.[2] proposed face recognition using Discrete Cosine Transform (DCT) for global and local features. By comparing the ranks for global and local features, the false acceptance rate for DCT can be minimized. Sharif et al.[3] proposed an Elastic Bunch Graph Map (EBGM) algorithm that successfully implements face detection using Gabor filters. Gabor filters find applications in many fields, such as texture segmentation, target detection, fractal dimension management, document analysis, edge detection, retina identification, image coding and image representation.

3. Proposed Work

The main aim of this work is to show the highest recognition accuracy of SLGS based face recognition that is an advancement of Local Graph Structure (LGS). LGS extracts the information from neighborhood pixel and based on the direction of graph, all neighborhood pixels gets threshold with the source pixel. Neighborhood pixels are at a radius of one and two from the source pixel. When compared to LBP, LGS extracts more spatial information from its neighbors. LGS is illumination invariant and computationally simple. The Graph Structure of LGS is shown in Figure 3. Due to the non-symmetric graph structure,
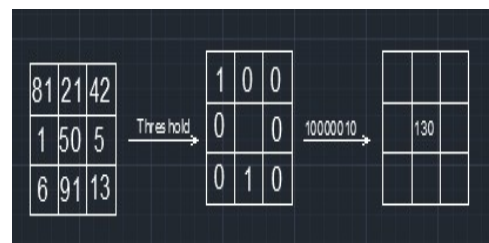

Figure 1.   SLGS Operation.

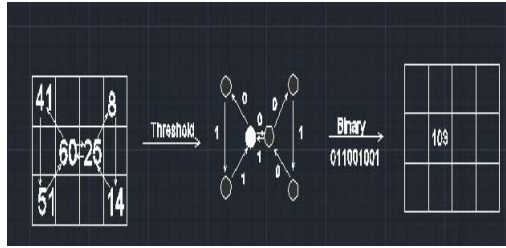**Figure 2.**   Graph structure of LBP operator.

Figure 3. LGS operator.

LGS extracts more pixel information from left side than right. Due to this drawback, SLGS was introduced to balance the pixel information from both sides.

3.1 Symmetric Local Graph Structure

The proposed work is a face recognition technique based on non-linear method known as SLGS. SLGS operates on its neighborhood pixels for every central pixel and finally calculates a binary value, which then be converted into a decimal value. The most important specialty of SLGS is its symmetric structure, so it extracts more spatial information. It extracts texture information from both left and right side in a more balanced way. The graph structure of SLGS and SLGS operation is shown in Figure 4.

In SLGS, each image is read and is resized to 128×128 pixels. The image is divided into a group of 3×5 matrixes. For each matrix, a binary value is calculated from the neighborhood pixels and a decimal value is obtained for each matrix. For each image we obtain 15624 features.

SLGS computes a histogram from these values and the distance measures between the histograms will give the recognition accuracy. The stepwise representation of SLGS is shown in Figure 5.
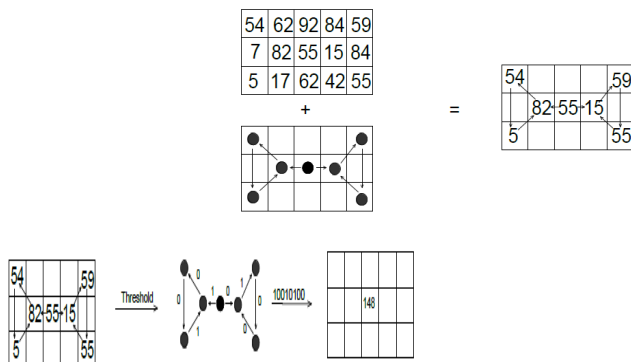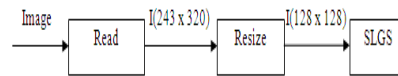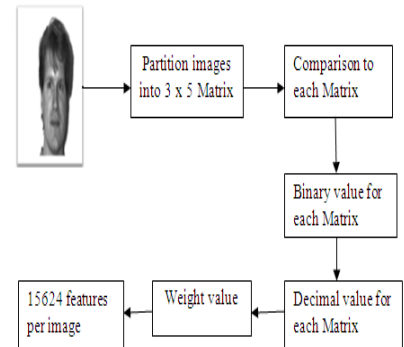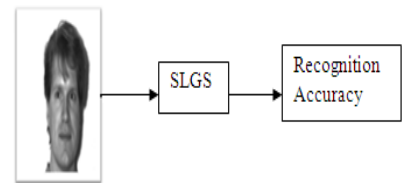

Figure 4. The SLGS operator.

(a)

(b)

(c)

Figure 5. Stepwise operation of SLGS **(a)** Image sampling, **(b)** SLGS operation and **(c)** Recognition Accuracy

3.2 Distance Measurement

Three distance measures are commonly used for histogram comparison. They are

Euclidean distance (E)

$$E\left(A, B\right) = \sqrt{\sum_i (A_i - B_i)^2} \tag{1}$$

Correlation coefficient (C)

$$C\left(A,\ B\right) = \frac{\sum (A_i - A')(B_i - B')}{\sqrt{([\sum_i (A_i - A')^2])([\sum_i (B_i - B')^2])}} \tag{2}$$

Chi-square statistics (X^2)

$$X^2\left(A, B\right) = \sum_i \frac{(A_i - B_i)^2}{A_i + B_i} \tag{3}$$

Where A and B are histograms with 'i' bins and A' and B' are average values of A and B. Here, we use Euclidean distance for distance measurement.

3.3 SLGS Algorithm

Let I be a set of images I = $[I_1, I_{2,......}, I_n]$ ∈ U, where U is the entire set of images. Each Image is of size (243×320; Yale and 112×92; ORL)

S1 = read img (I_1)

S2 = resize (S1) to 128×128

S3 = SLGS (S2)

for I=1 to N,

{

    Considering 3×5 marix;

    Choose a source pixel;

    Binval= compare(pixels(3×5));

    Weighval=concat(Binval);

    Decval=convert(Weighval);

    Replace the source pixel with the calculated decimal value;

    return (15624 features);

    Repeat in column wise for entire I;

}

Thus for Yale database, we will obtain 165 × 15624 features and for ORL database, we obtain 400 × 15624 features.

4. Results and Discussions

For experimenting with the proposed SLGS approach, two databases are used. They are: (i) Yale Database and (ii) ORL database. Both databases consist of images under varying expressions and illumination whose details are shown in Table 1.

Recognition accuracy for the mentioned techniques for Yale and ORL database are shown in Table 2 and Figure 6.

4.1 Yale Database

From the above interpretations, it is clear that SLGS based recognition provides higher performance when compared to DCT, LBP and Gabor filter.

4.2 ORL Database

The above interpretation shows that SLGS performs well and shows gradual increase in accuracy when compared to LBP, DCT, and Gabor.

Table 1. Image databases

Database	Image Size	No. of classes
YALE	243×320	15
ORL	112×92	40

Table 2. Accuracy for various recognition methods SLGS, Gabor (angle & magnitude), DCT, LBP)

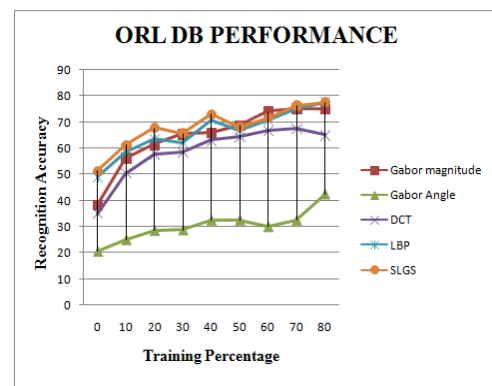| Training percentage	Gabor magnitude	Gabor angle	DCT	LBP	SLGS
10	24.6	10	30.66	56	52
20	66.6	41.48	59.25	82.22	80
30	74.16	54.16	73.33	83.33	80.83
40	82.85	62.85	83.80	80.95	82.85
50	80	64	82.66	85.33	86.66
60	98.33	78.33	96.66	91.66	96.66
70	100	82.22	97.77	93.33	97.77
80	100	86.66	96.66	93.33	96.66
90	100	86.66	100	100	100

Figure 6. Accuracy for various recognition methods (SLGS, Gabor (angle & magnitude), DCT, LBP).

5. Conclusion

In this paper, we proposed that the face recognition based on SLGS provides higher recognition accuracy when compared to LBP, DCT and Gabor. We used Yale and ORL database for experimenting with the proposed method. The Limitations in LGS leads to face recognition based on SLGS. From the above results, it is clear that SLGS based face recognition has higher and gradual recognition accuracy for different training percentage in Yale as well as ORL databases. SLGS based Face Recognition is robust to facial expressions, facial details and illumination. SLGS based recognition can be enhanced for Local Matching Methods (both Local region and Local component).

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