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Face Recognition using Multilevel Block Truncation Coding

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ABSTRACT

Face Recognition is one of the fastest growing biometric technologies to be used in real time applications as it requires lesser user co-operation when compared to other biometrics like fingerprint and iris recognition. Such applications require a very less recognition time and allow for a little leeway on the accuracy front; this is achieved by finding out the feature vector of a face image. The paper presents use of Multilevel Block Truncation coding for face recognition. In all four levels of Multilevel Block Truncation Coding are considered for feature vector extraction resulting into four variations of proposed face recognition technique. The experimentation has been conducted on two different face databases. The first one is Face Database which has 1000 face images and the second one is "Our Own Database" which has 1600 face images. To measure the performance of the algorithm the False Acceptance Rate (FAR) and Genuine Acceptance Rate (GAR) parameters have been used. The experimental results have shown that the outcome of BTC Level 4 is better as compared to the other BTC levels in terms of accuracy, at the cost of increased feature vector size.

Keywords: Face recognition, BTC, RGB, Multilevel BTC, FAR, GAR.

1. INTRODUCTION

Face recognition refers to identifying and verifying a face image. A face recognition system accomplishes this by comparing the input query face image with the existing face images stored in the database. It exploits the unique characteristics of an individual's face.

Face recognition is the fastest growing biometric technology. Biometrics may be defined as an automated method of recognizing person based on the physiological and behavioural characteristics. There are many biometric systems such as finger prints, iris, voice, retina and face. Among these systems, face recognition has proved to be the most effective and universal system. These systems are used in a wide range of applications that require reliable recognition of humans. Some of the applications of face recognition include security, physical and computer access controls, law enforcement [11],[12], criminal list verification, surveillance at various places[14], authentication at airports[16], forensic, etc.

Face recognition has become a centre of attention for researchers from the field of biometrics, computer vision, image processing, neural networks, and pattern recognition system. Many algorithms are used to make effective face recognition systems. Some of the algorithms include Principle Component Analysis (PCA)[1],[2],[3],[4], Linear Discriminant Analysis (LDA)[5],[6],[7], Independent Component Analysis (ICA) [8] ,[9] ,[10] etc.

The face images in a database might not be of constant size. Thus, to make the algorithm independent of the size of a face image, Block Truncation Coding (BTC) [12],[13] has been used. This coding technique has been implemented till four levels in two color face image databases.

2. BLOCK TRUNCATION CODING

Block truncation coding (BTC) [11] [12] [13] is a relatively simple image coding technique developed in the early years of digital imaging more than 29 years ago. Although it is a simple technique, BTC has played an important role in the history of digital image coding in the sense that many advanced coding techniques have been developed based on BTC or inspired by the success of BTC. Block Truncation Coding (BTC) was first developed in 1979 for grayscale image coding [13].In the given implementation of BTC, the color face images database in the RGB (Red, Green, and Blue) color space [16], [17] has been used.

3. MULTILEVEL BLOCK TRUNCATION CODING [19]

To calculate the feature vector in this algorithm, Block Truncation Coding has been used (For further information refer [11],[12],[13]). It has been implemented on four levels which are explained below:

3.1 BTC Level 1

A face image is taken from the database and the average intensity value of each color plane of the image is calculated. The color space considered in this algorithm is the RGB color space [16], [17]. So the average intensity value of each of the RGB plane of a face image is calculated. The further discussion is done using the Red plane of an image. The same has to be carried out for the Blue and Green color space.

After obtaining the average value intensity value of the Red color plane of the face image, each pixel is compared with the mean value and the image is divided into two regions: Upper Red and Lower Red [18]. The average intensity values of these regions is calculated and stored in the feature vector as UR and LR. Thus, after repeating this procedure for the Blue and the Green color space our feature vector has six elements: Upper Red, Lower Red, Upper Green, Lower Green, Upper Blue and Lower Blue (UR,LR,UG,LG,UB,LB)[18].Refer figure 1.

3.2 BTC Level 2

At level two the values Upper Red and Lower Red are extracted from the feature vector of BTC level 1 and using these values, the Red plane of face image is now divided into four regions. These are Upper-Upper Red, Upper-Lower Red, Lower-Upper Red and Lower-Lower Red [18]. The average intensity values in these four regions is calculated and stored in the feature vectors.

The above process is reiterated for the Blue and Green color spaces of the face image. Thus the feature vector at this level has 12 elements, 4 elements for each plane. Refer figure 1.

3.3 BTC Level 3 and BTC Level 4

Using the procedures described in the Levels 1 & 2, the face images are further divided into more regions in each of the color space. These regions are depicted in figure1. The average intensity value at these regions are calculated and stored in the feature vector. The feature vector has 24 elements at BTC-level 3 and 48 elements at BTC-level 4. The feature vectors obtained in BTC-levels 1,2,3,4 are used for comparison with the database images set. Figure 1 depicts the four BTC-levels with their respective feature vectors.

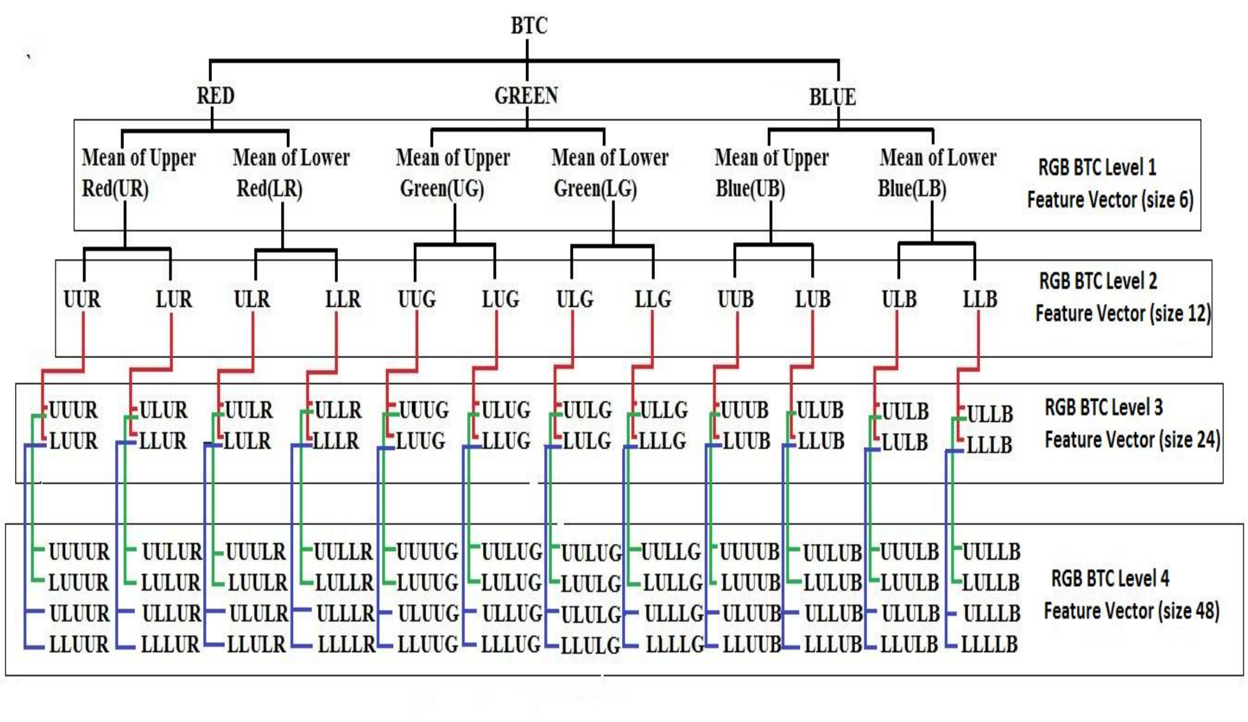

Figure 1. Feature Vector Elements in Multilevel BTC.

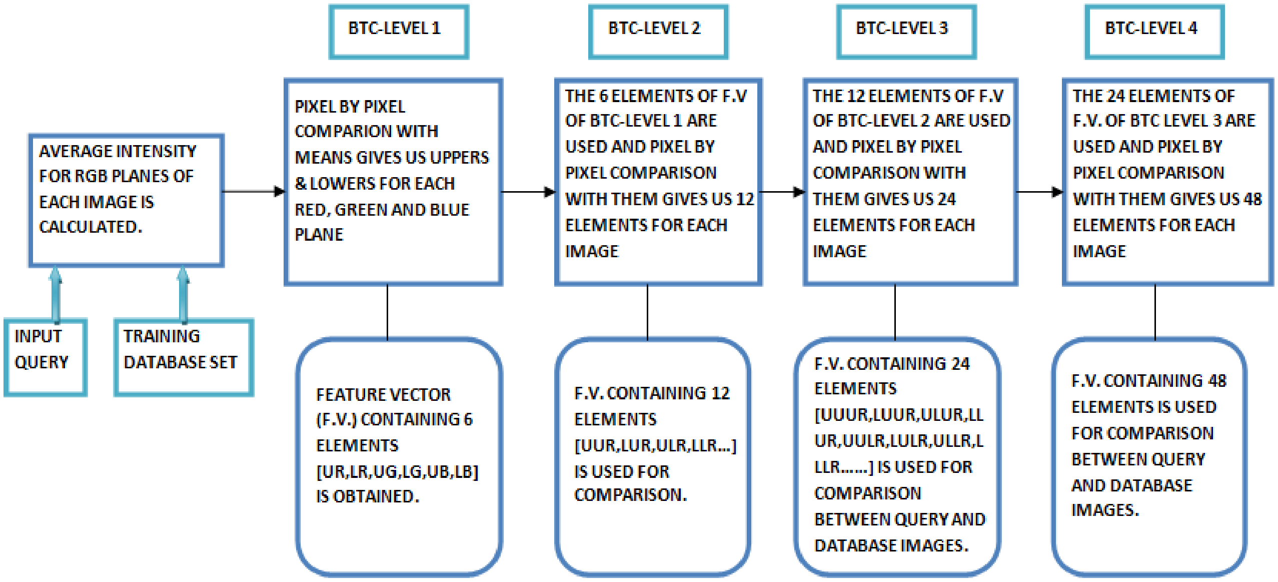

Figure 2. Steps in the proposed technique

4. PROPOSED METHOD

4.1 Feature vector extraction

The Feature vector at each BTC level for the query image and database set is extracted by using the method described in the previous section (section 3). This Feature vector is then use in the face recognition system. As shown in figure 2.

4.2 Implementation using feature vectors

The feature vectors obtained in each level of BTC are used to compare with the database images (Training set). The comparison (Similarity measure) is done by Mean Square Error (MSE) given by equation 1.

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2 \qquad (1)$$

Where,
I & I' are two feature vectors of size M*N which are being compared.

False Acceptance Rate (FAR) and Genuine Acceptance Rate (GAR) are used to evaluate the performance of the different BTC levels based face recognition techniques. Figure 2 describes the steps of feature extraction and describes the feature vector size of each BTC level.

5. IMPLEMENTATION

5.1 Platform

The implementation of the Multilevel BTC is done in MATLAB 2010. It was carried out on a computer using an Intel Core i5-2410M CPU (2.4 GHz).

5.2 Database

The experiments were performed on two databases:

1) Face Database [15]:

Created by Dr Libor Spacek this database has 1000 images (each with 180 pixels by 200 pixels), corresponding to 100 persons in 10 poses each, including both males and females. All the images are taken against a dark or bright homogeneous background, little variation of illumination, different facial expressions and details. The subjects sit at fixed distance from the camera and are asked to speak, whilst a sequence of images is taken. The speech is used to introduce facial expression variation. The images were taken in a single session. The ten poses of Face database are shown in Figure 3.

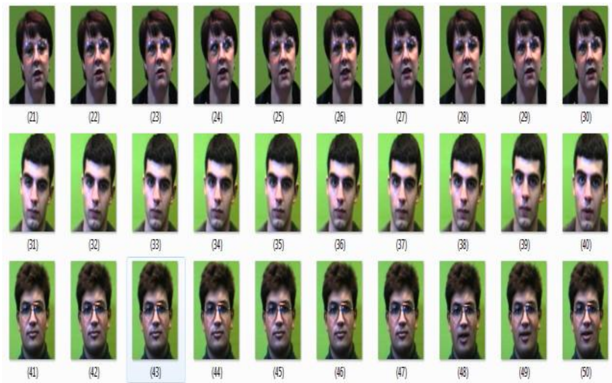

Figure 3. Sample images from Face database

2) Our Own Database [19]:

This database has 1600 face images of 160 people (92 males and 68 females).Each person has 10 images. The images in the database are taken under various illumination settings. The images are taken with a homogenous background and the subjects have changed their expressions. The images are of different sizes, unlike the Face database. The ten poses of Our Own Database are shown in Figure 4

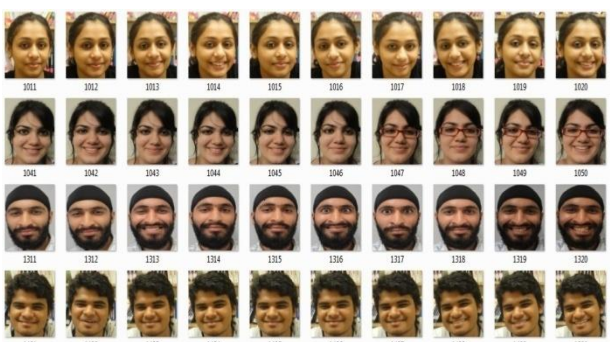

Figure 4. Sample images from Our Own Database

6. RESULTS AND DISCUSSION

False Acceptance Rate (FAR) and Genuine Acceptance Rate (GAR) are standard performance evaluation parameters of face recognition system.

The False acceptance rate (FAR) is the measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

FAR = (False Claims Accepted/Total Claims) X 100

The Genuine Acceptance Rate (GAR) is evaluated by subtracting the FAR values from 100.

GAR=100-FAR (in percentage)

In all 10000 queries (10 images for each of 1000 persons) are fired on face database and 16000 queries (10 images for each of 1600 persons) are fired on our own database. For each query, FAR and GAR values are calculated for respective BTC level based face recognition technique. At the end the average FAR and GAR of all queries in respective face databases are considered for performance ranking of BTC levels based face recognition techniques.

6.1 Face Database [15]

In all 10000 queries are tested on the database for analysing the performance of proposed algorithms. The feature vectors of each image for all four BTC levels were calculated and then compared with the database.

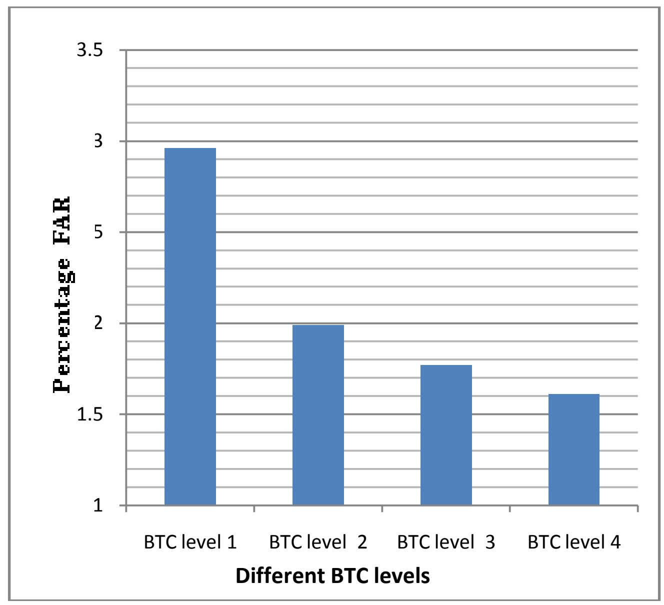

Figure 5. FAR values for Face Database

Figure 5 gives the FAR values of the different BTC levels based face recognition techniques tested on face database. Here it is observed that with each successive level of BTC the FAR values go on decreasing. This indicates that the accuracy of face recognition increases with increasing level of BTC. The BTC-level 4 gives the best result with the least FAR value. Since the Face database is a normalized database the FAR values are quite low.

Figure 6 gives the GAR values of the different BTC levels for Face database. Here it is observed that with each successive level of BTC the GAR values go on increasing.GAR is the measure of the efficiency of the algorithm. Thus it is observed that the BTC-level 4 gives us the best performance.

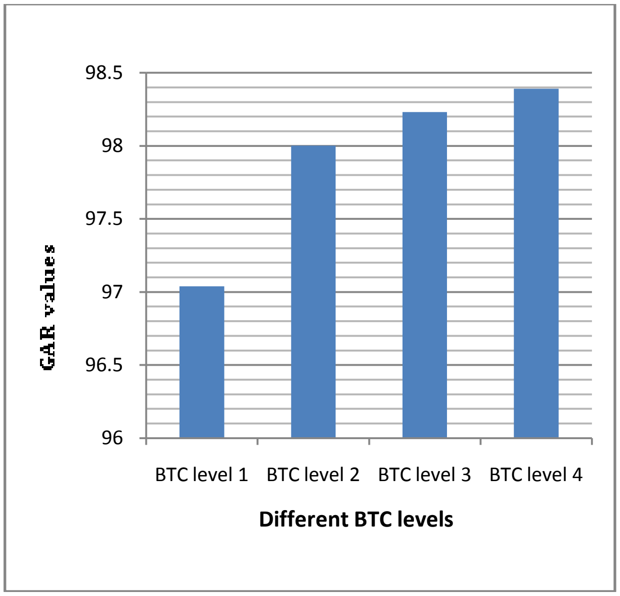

Figure 6. GAR values for Face Database

Table 1. Performance comparison of BTC levels for Face Database

NAME	Total Claims	False Rejections	GAR=100-FAR (in percentage)
BTC Level 1	10000	296	97.04 %
BTC Level 2	10000	199	98.001 %
BTC Level 3	10000	177	98.23%
BTC Level 4	10000	161	98.39%

In table 1 the total claims, false rejections and GAR values of the four BTC levels based face recognition methods tested on face database are shown. False rejections refer to number of relevant images which were rejected. Thus BTC-level 4 based face recognition technique gives us the least false number of rejections and highest GAR value indicating best performance.

6.2 Our own database [19]

In all 16000 queries were tested on the database for analysing the performance of the proposed BTC level based face recognition algorithms. The experimental results of proposed face recognition techniques have shown that BTC level 4 Gives the best performance. The efficiency of the Multi level BTC based face recognition increases with the increasing levels of BTC.

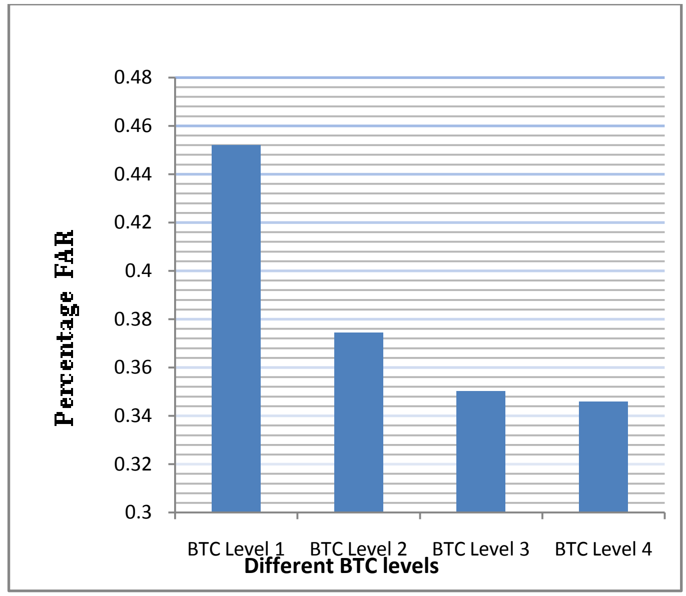

Figure 7. FAR values of Our Own Database

Figure 7 shows the FAR values for the four BTC levels. Here it is observed that the FAR value for BTC-level 4 is the lowest and for BTC-level 1 is the highest. Thus BTC-level 1 gives us the worst performance and BTC-level 4 gives us the best performance.

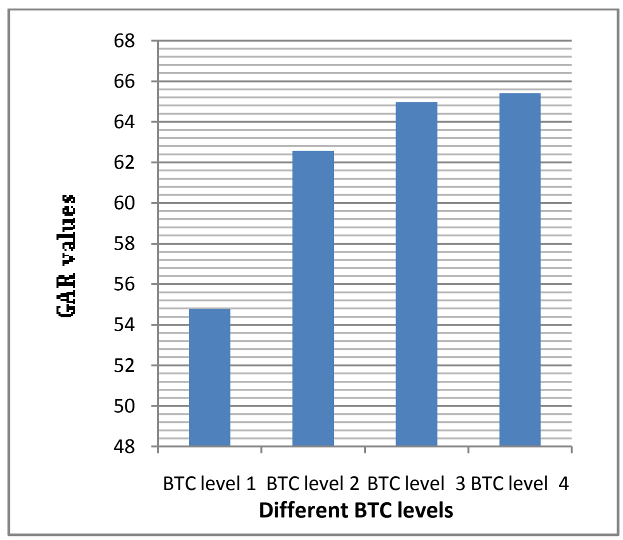

Figure 8. GAR values of Our Own Database

Figure 8 gives the GAR values for the four BTC levels. Here it is observed that GAR value of BTC-level 4 is highest indicating best performance.

Table 2. Performance comparison of BTC levels for Our Own database

NAME	Total Claims	False Rejections	GAR=100-FAR (in percentage)
BTC Level 1	16000	7,233	54.79 %
BTC Level 2	16000	5,989	62.57 %
BTC Level 3	16000	5,605	64.97 %
BTC Level 4	16000	5,535	65.41%

Table 2 gives the number of False Rejections for each BTC level based face recognition technique tested on Our Own database. The false rejections for BTC-level 4 face recognition technique are the lowest and for BTC-level 1 face recognition technique are the highest.

As seen from both the database the performance of face recognition method ameliorates with each successive level of BTC.

Face database being a normalized database the FAR values are very low as compared to FAR values obtained in Our Own Database. This is due to high variation in the intensity, size and expressions in Our Own Database.

7. CONCLUSION:

The recognition accuracy and the computational cost are the two primary aspects to ponder upon when analysing a face recognition algorithm.

It can be concluded that there is a trade-off between accuracy and computational cost when switching between the BTC Levels. The FAR/GAR values show that BTC level-4 shows the best performance in terms of accuracy amongst all the BTC levels tested on both the database sets. This can be attributed to the relatively larger size of the feature vector at this level.

The proposed technique can be implemented in real world scenarios choosing the appropriate BTC level implementation.

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