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PERFORMANCE EVALUATION OF DISCRETE COSINE TRANSFORM (DCT) AND PRINCIPAL COMPONENTS ANALYSIS (PCA) FOR FINGERPRINT RECOGNITION SYSTEMS.

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Abstract

*Fingerprint recognition is the oldest biometric technique that criminal science has been using for more than 150 years. A typical fingerprint includes several singular points called minutiae (generally a number from 12 to 30) [1]. These specific points correspond to the places of ending, bifurcation or crossover of ridges and valleys of the finger. Extraction of the relative positions and orientations of these minutiae allows creating a specific signature for each user guaranteeing a secured identification. Conflicting report on the performance of the most widely adopted feature extraction techniques for fingerprint recognition remain an open challenge. Hence, this paper sets to conduct the performance of DCT and PCA for fingerprint recognition. The system was designed using MATLAB R2009b programming studio, Fingerprint images were acquired, the acquired images was compressed by breaking it into 8 X 8 blocks of pixels, working from left to right and top to bottom, the DCT was applied to each block to remove the redundancy between neighboring pixels. Each block is compressed through quantization. The array of compressed blocks that constitutes the image is stored in a drastically reduced amount of space. Training phase and testing phase was carried out on both processes of Discrete Cosine Transform (DCT) and Principal component Analysis (PCA) to obtain the time taken for both training and testing of the images, with 70*70, 75*75, 80*80, 85*85 as image resolution. The results show that the DCT exploits interpixel redundancies to render excellent decorrelation for most natural images.*

Keywords: Fingerprint, Discrete Cosine Transform, Principal Component Analysis, Verification, Recognition System.

1.0 Introduction

Biometrics technology is based on using physiological or behavioral characteristics in personal identification, and can easily differentiate between an authorized person and a fraudulent impostor, fingerprint recognition is the oldest biometric technique and criminal science has been using it for more than 150 years [1]. A typical fingerprint includes several singular points so called minutiae (generally a number from 12 to 30). These specific points correspond to the places of ending, bifurcation or crossover of ridges and valleys of the finger. Extraction of the relative positions and orientations of these minutiae allows creating a specific signature for each user guaranteeing a secured identification.

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The Discrete Cosine Transform (DCT) is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. It is equivalent to a DFT of roughly twice the length, operating on real data with even symmetry "since the Fourier transform of a real and even function is real and even [2]", where in some variants the input and/or output data are shifted by half a sample, by comparison it is discovered that Discrete Cosine Transform is superior over other image transforms. More especially the two linear transforms: the Karhunen-Loeve Transform (KLT) and Discrete Fourier Transform (DFT).

The principal advantage of image transformation is the removal of redundancy between neighboring pixels. For example, someone with a web page or online catalog that uses dozes or perhaps hundreds of images will more than likely need to use some form of image compression to store those images. This is because the amount of space required to hold unadulterated images can be relatively large in terms of cost. The major concern of this research is to be able to extract, acquire, and store fingerprint image at a reduced size with low image redundancy level, with the assessment of the discrete cosine transform and principal components techniques.

2.0 Review of Related Works

Several works have been done in the field of biometrics and some of them take advantage of the DCT and PCA for feature extraction and image transformation develop several applications. Dale *et al*., (2007) introduced a model based on Discrete Cosine Transform (*DCT*) for fingerprint matching, which divided the transformed image into different blocks, calculate the standard deviation of each block and form a feature vector of all blocks. Recognition rate of 100% is obtained for a typical threshold value [3] Ani *et al.* (2008) extracted global features from the fingerprint images based on *DCT* [4]. Similarly, Tewari *et al*. (2014) used *DWT*, Fast Fourier transform (*FFT*) and *DCT* to extract feature from the fingerprint images. Karna *et al*. (2008) has proposed a fingerprint recognition method based on normalized cross correlation. The method correlates the common region of two fingerprint images by the image rotation and scaling.

Wei *et al.* (2009) has proposed quadrangle based matching algorithm. The quadrangle is composed of two ridge lines that connect two minutiae points with the associated two ridge points. The line matching has been emphasized. The local quadrangle set is formed using the type, the length of the basic ridge lines and angle between the basic edge and the ridge. The fake pairs are removed by considering correlation among pairs. The fingerprint matching is done using the shrunken set. Xiao long Zheng et al. (2008) has presented a minutiae scoring method which considered various aspects influencing the quality of minutiae. The image quality is described from three aspects viz: the global factor, the block image quality factor and the neighborhood detailed structure. These three factors were investigated and combined by the product rule and linear weight. The minutiae score was incorporated into fingerprint matching by checking the scores of corresponding minutiae pairs.

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3.0 Material and Methods

The system is designed as a windows application program, executable on any windows platform and was designed using MATLAB R2009b programming studio. The analysis of this application is divided into two, namely training phase and testing phase which was carried out on both processes of Discrete Cosine Transform (DCT) and Principal component Analysis (PCA). In order to develop a robust and reliable computational model we need a benchmark dataset to train and test the system. For this purpose, we select *FERET* Fingerprint Image Database Version_5.0 to evaluate, containing equal number of instance for both left and right hand classes, all the images are stored in *BMP* format.

A. Preprocessing

The image is first processed to improve the quality and prepares it to next phases of the system. This module automatically reduces every image to X*Y pixels, can distribute the intensity of images in order to improve fingerprint recognition performance.

B. DCT Compression

There are several methods of image compression available today. These falls into two general categories: lossless and lossy image compression. The JPEG process is widely used form of lossy image compression that centers around the Discrete Cosine Transform. The DCT works by separating images into parts of different frequencies. During a step called Quantization, where parts of compression actually occurs, the less important frequencies are discarded, and only the most important frequencies that remain are used to retrieve the image in the decompression process. As a result, reconstructed images contain some distortion, these levels of distortion can be adjusted during the compression stage.

The Compression Process

The following is a general overview of JPEG process.

1. The image is broken into 8 X 8 blocks of pixels.
2. Working from left to right, top to bottom, the DCT is applied to each block.
3. Each block is compressed through quantization
4. The array of compressed blocks that constitutes the image is stored in a drastically reduced amount of space.
5. When desired, the image is reconstructed through decompression, a process that uses the Inverse Discrete Cosine Transform (IDCT).

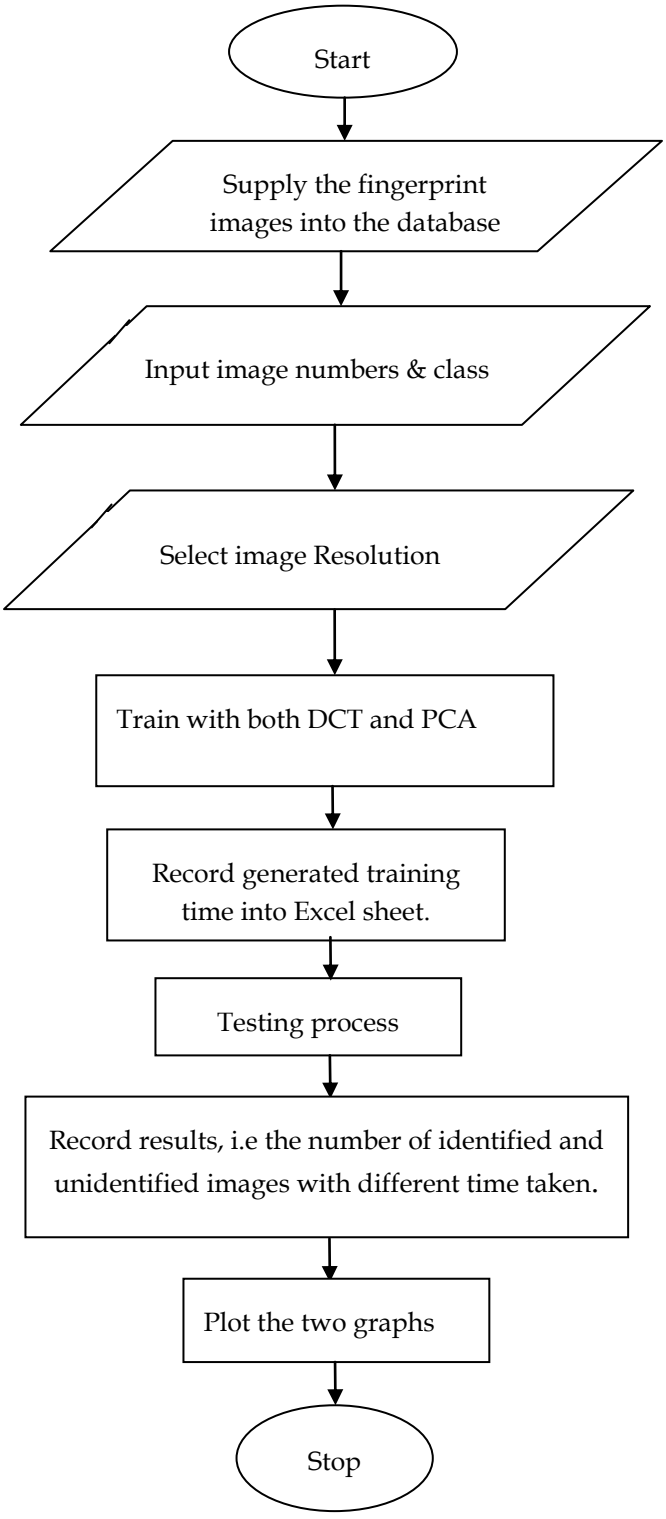

Fig 1: Flowchart showing the operational processes

C. Fingerprint Library Formation

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Fingerprint images are stored in a fingerprint library in the system. Every action such as training set or Eigen face formation is performed on this fingerprint library. The fingerprint library is further divided into two sets – training dataset (60% of individual image) and testing dataset (rest 40%images).

D. OPERATION PHASE

The operation phase can be best explained using the below Graphic User Interface (GUI). At this first stage, the graphic user interface (GUI) is waiting for user to supply the value information on which operation is to be performed. First and foremost, the user must provide the number of images to be trained, these numbers of fingerprint images must have been stored earlier in the database. The image class field denotes the total numbers of fingerprint images to be processed, while each image field denotes the numbers of samples collected for an individual fingerprint.

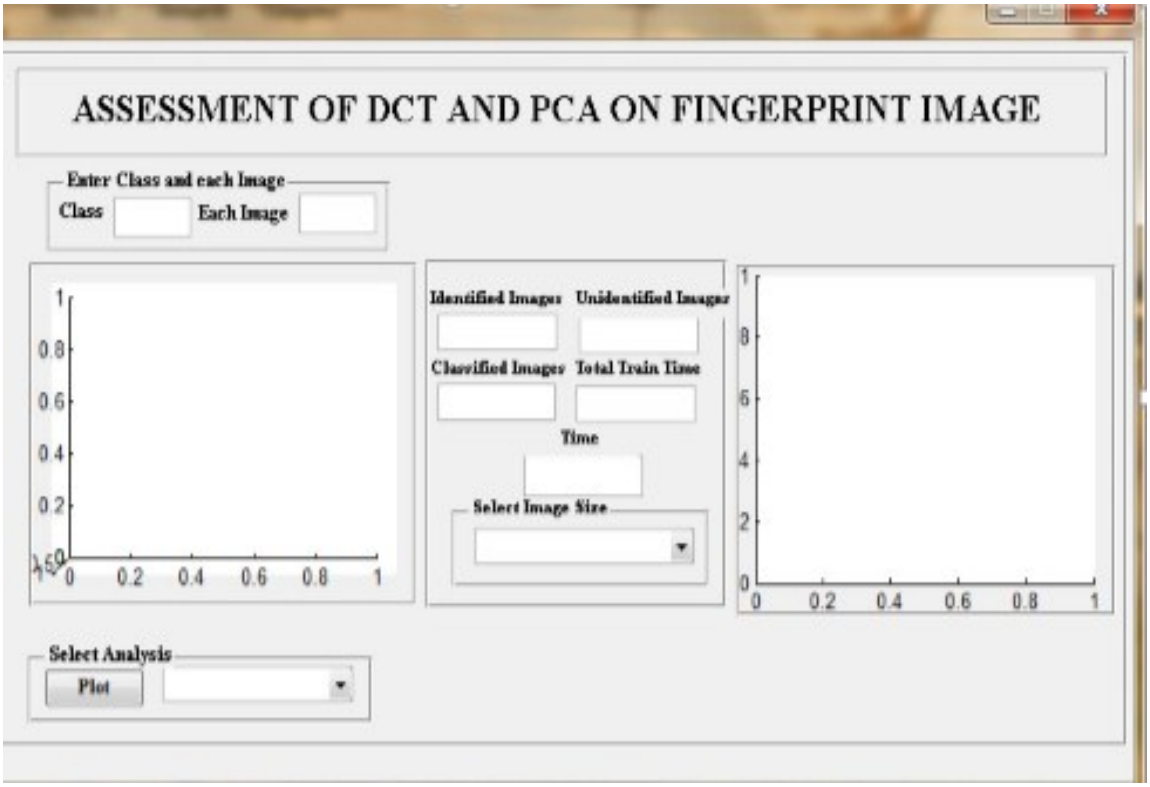


Fig 2: Operation phase of the System

E. TRAINING WITH PCA AND DCT

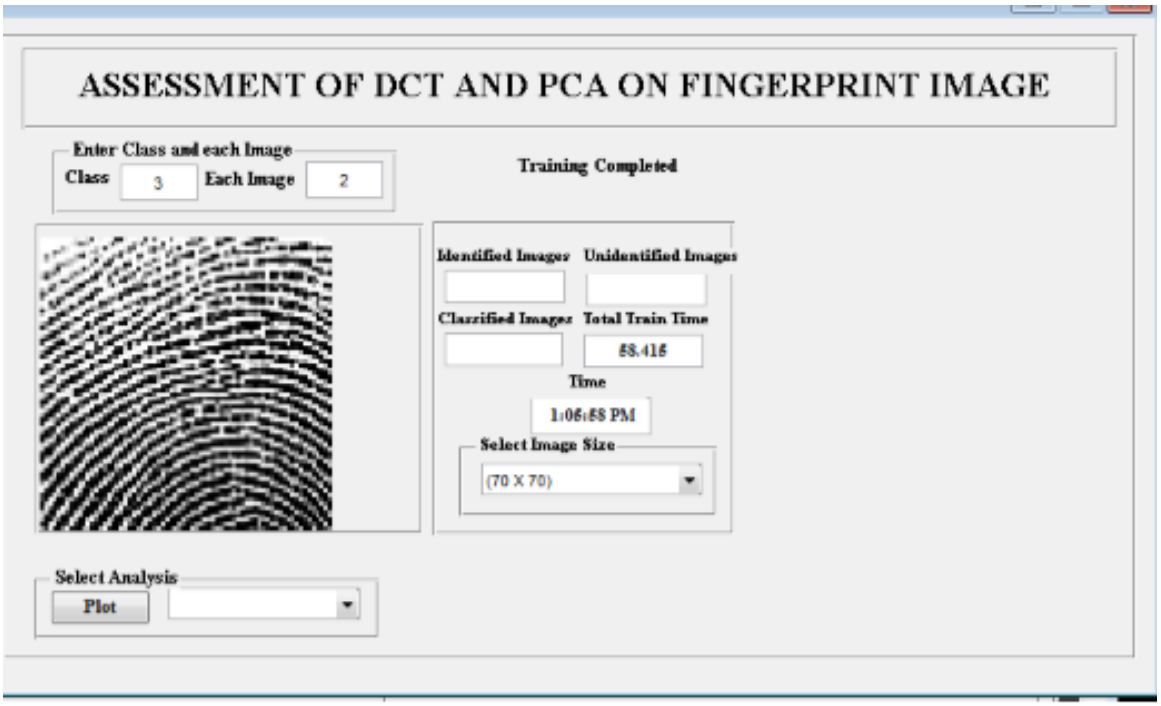


Fig 3: Training Phase of the System

In this section the option Train with PCA or DCT must be selected from the menu box of the application thereby the application runs the PCA or DCT analysis on the number of selected images in the database as shown in the left panel (Figure 3) the application and the equivalent result i.e total time taken is generated, recorded and displayed on the screen as well.

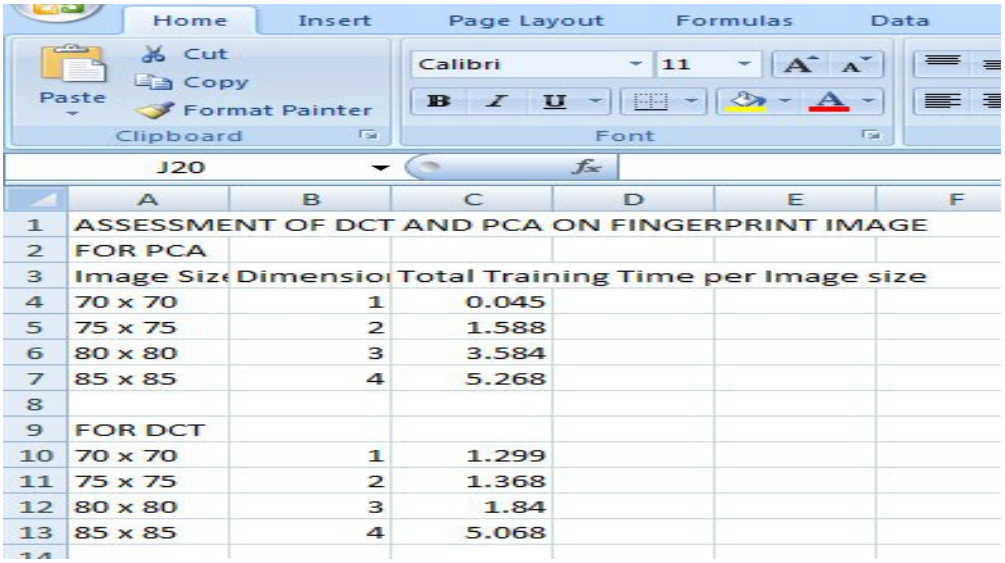
F. TEST OPERATION

This process is carried out for both the PCA and DCT, which generate their equivalents results. For the test operation to be carried out the test button is selected from the menu on the application (Figure 4), then the application does the testing and tells us the number of identified images, the numbers of unidentified images, the classes of the images and the total time taken to train those images.

Fig 4: Testing Phase of the System

3.0 Results and Discussion

Series of experiments were performed on the assessment system for the Discrete Cosine Transform (DCT) and Principal Component Analysis (PCA) methods, using fingerprints images at varying resolutions. As the series of experiments are being carried out, the equivalent results for each is automatically generated and recorded in an excel sheet (Figure 5).



	A	B	C	D	E	F
1	ASSESSMENT OF DCT AND PCA ON FINGERPRINT IMAGE					
2	FOR PCA					
3	Image Size	Dimensio	Total Training Time per Image size			
4	70 x 70	1	0.045			
5	75 x 75	2	1.588			
6	80 x 80	3	3.584			
7	85 x 85	4	5.268			
8						
9	FOR DCT					
10	70 x 70	1	1.299			
11	75 x 75	2	1.368			
12	80 x 80	3	1.84			
13	85 x 85	4	5.068			

Fig 5: Image of the Result generated

From the above set of data stored in the excel sheet, the results of the experiments is tabulated below.

Table 1: PCA Train and Test Results

DIMENSIONS		PCA TOTAL TRAIN TIME (Sec.)	PCA TEST RESULT	
Image size	RESOLUTIONS		IDENTIFIED	UNIDENTIFIED
1	70*70	0.045	2	1
2	75*75	1.588	3	0
3	80*80	3.584	3	0
4	85*85	5.268	3	0

Table 2: DCT Train and Test Results

DIMENSIONS		DCT TOTAL TRAIN TIME (Sec.)	DCT TEST RESULT	
Image size	RESOLUTIONS		IDENTIFIED	UNIDENTIFIED
1	70*70	1.299	2	1
2	75*75	1.368	3	0
3	80*80	1.840	3	0
4	85*85	5.068	3	0

Results obtained shows a total training time of 1.299 for image size of 70 * 70 and a total training time of 1.368 for image size of 75 * 75, 1.840 for image size of 80 * 80, 5.068 for image size of 85 * 85 for DCT training of images and training time of 0.045 for 70 * 70, 1.588 for 75 * 75 and 3.584 for 80 * 80, 5. 268 for 85 * 85 respectively for PCA training of images, the PCA test time is 2.5 for 75 *75, 4.7 for 80 * 80, 5.2, and for 85 * 85 is 5.85 seconds respectively, while that of DCT is 0.3 for 70 * 70 pixels, 0.4 for 75 *75, 2.3 for 80 * 80, and 2.7 seconds for 85 * 85 respectively. In this paper, we have represented a new fast DCT based fingerprint recognition method based on PCA. PCA can be regarded as a very fast algorithm with a more or less high robustness and DCT is used for time reduction of recognized output images. The performances of DCT are almost comparable with those of PCA but with a higher computing time. So finally, we conclude that the combination of PCA with DCT offers better rates of recognition.

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