The Use of Two Transform Methods in Fingerprints Recognition

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Abstract: Finger prints are the oldest and most widely used form of biometric identification. Despite the widespread use of fingerprints, there is little statistical theory on the uniqueness of fingerprint minutiae. Fingerprint matching is the process used to determine whether two sets of fingerprint ridge detail come from the same finger. There exist multiple algorithms that do fingerprint matching in many different ways. Some methods involve matching minutiae points between the two images, In this paper used median filter to enhance the images, and then use DCT (Discrete Cosine Transform) and FDCvT Via Wrapping to compute the feature extraction from the images. The Template Matching can be applied by finding the more similar values between the original image and the template.The proposed system includes two stages: first stage is implemented by taking individual natural fingerprint images with several positions and calculation of the features vector (Mean and standard deviation) by using FDCvT via Wrapping and DCT. The second stage is implemented by taking several samples of new fingerprint images for testing the work. The results show that the fingerprints Recognition rate by the (FDCvT via Wrapping and DCT) achieves better recognition rate (84%).

Keywords: Fingerprint Recognition, DCT, Curvelet Transform, FDCvT Via Wrapping.

Introduction

The use of one's fingerprints as a means of identification has existed long before its common usage today in the field of criminal investigation. Prior to the nineteenth century, fingerprints were primarily used only as a signature for indicating authorship or ownership. The advantages of fingerprints are that they are universal and unique. In other words, everyone has them and no two have ever been found to be identical. Fingerprints are also Unchangeable. They are formed before birth and remain until decomposition of the skin occurs some time after death [1].

The transformation is a process that transforms an object from a given domain to another which can be used for its recognition, and it is very important to extract the features of   image.One of the transformations methods is the Fourier transform which usually transforms the signal from its time domain to the frequency domain. Due to the Fast Fourier Transform (FFT) it finds a wide area of application [2]. Discrete Cosine Transform (DCT) has mostly used in the area of image processing, its basic operation is to take a signal and transforms it from one type of representation to another, in this case the signal is a block of an image [3].

Curvelet Transform allows representing edges and other singularities along curves in a more efficient way when it is compared with other transforms, and Curvelet Transform is one kind of new multi-scale transforms and non-adaptive transforms, which possess directionality and anisotropy [4,5].

The structural elements of Curvelet Transform include the parameters of scale, location, and orientation parameters [6].Two separate digital (or discrete) curvelet transform (FDCvT) algorithms are introduced. The first algorithm is Unequispaced Fast Fourier Transform (USFFT), where the curvelet coefficients are found by irregularly sampling the Fourier coefficient of an image.

The second algorithm is the Wrapping transform, using a series of translations and wraparound technique, both algorithms have the same output, but the Wrapping Algorithm gives both a more intuitive algorithm and faster computation time [7,8].

In this paper, fingerprint recognition technique based on both DCT and Curvelet Transform is proposed. The FDCvT via Wrapping is one type of Curvelet Transform. Pre-processing steps and feature extraction processes have to be implemented before a fingerprint image can be applied on the matching stage.

The structural activity extracted from the FDCvT via Wrapping and DCT of the fingerprint image can be

analyzed statistically to generate a fingerprint feature vector used in the classifier to create classification rules. The statistical measures used are (Mean and Standard Deviation).

privacy issues are very mission to the patient, through development of E-control system, the following figure 1 shows the construct of the monitoring system in the patient section:

DCT TRANSFORM

The Discrete Cosine Transform was introduced by Ahmed et al [9] in 1974, is one of the extensive family of sinusoidal transform [10].The concept of this transformation is to transform as set of points from the spatial domain into an identical representation in a frequency domain [3]. The two dimensional DCT then can be written in terms of pixel values $f(i,j)$ for i,j =0,1,………….N-1 and the frequency-domain transform coefficients F(u,v) would be[11,12] :

$$F(u,v) = \frac{1}{\sqrt{2N}} c(u)c(v)\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} f(i,j)$$

$$\times \cos\left[\frac{(2i+1)u\pi}{2N}\right] \cdot \cos\left[\frac{(2j+1)v\pi}{2N}\right] \quad .. (1)$$

For u,v =0,1,…,N-1

Where

$$C(u),c(v) = \begin{cases} \dfrac{1}{\sqrt{2}} & \text{For u,v =0} \\ \\ 1 & \text{Otherwise} \end{cases}$$

The inverse DCT transform is given by

$$f(i,j) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} c(u)c(v)F(u,v)$$

$$\times \cos\left[\frac{(2i+1)u\pi}{2N}\right] \cdot \cos\left[\frac{(2j+1)v\pi}{2N}\right] \quad ….. (2)$$

for i,j =0.1,…, N-1.

$f(i,j)$ is the i,jth element of the image(intensity of the pixel) represented by the matrix f.

N is the size of block that DCT is done on. u,v are frequency coordinates in the transform domain.

As Figure 1.a and 1.b, each sub block contains one DC coefficients and other AC coefficients that shows lower frequency coefficients that contain (useful data for the image) gather at the top-left Corner and higher frequency ones that (Contain less useful information) at the bottom-right corner of the transformed matrix [12, 13].
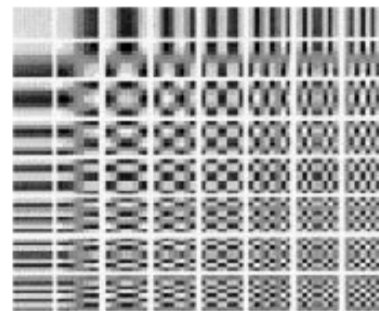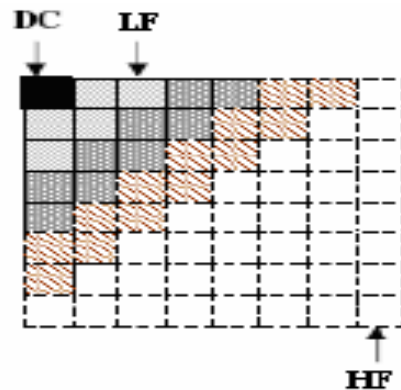

(a)

Figure 1: (a) DCT basis pattern.
(b) Vector element from frequency components [14].

CURVELET TRANSFORM

Curvelets as proposed by E. Candes and D. Donoho, developed to overcome inherent limitations of traditional multiscale representations [8]. There are two generations of the curvelet transform, first generation curvelet (1999), used complex series of steps involving ridgelet analysis of the radon transform of an image, the performance exceedingly slow [15]. The second generation curvelet (2003), which does not use ridgelet transform thus reducing the mount of redundancy in transform and increasing the speed considerably [16].

The structural elements of curvelet transform include the parameters of dimension, location and orientation parameter more, which let it have good orientation characteristic [6].

In 2003, Emmannel Candes and David Donoho proposed a simplified implementation of second generation curvelet directly in the frequency plane, that relied on interpolation by means of the USFFT, and Wrapping of Fourier samples instead of interpolation [8]. In this research, Fast Digitial Curvelet Transform via Wrapping is used because the wrapping is much faster than the USFFT. Fast Digital Curvelet Transforms (FDCvT) can be implemented via two methods [8,17]:

1-Unequispacee FFTs.
2-Wrapping.

These digital transformations are input Cartesian arrays of the form $f[t1, t2]$, $0 \leq t1, t2 < n$, which allows us to think of the output as a collection of coefficients cD(j,ℓ,k) obtained by

$$c^{D}(j,\ell,k) := \sum_{0 \leq t_1,t_2 < n} f[t_1,t_2] \overline{\varphi^{D}_{j,\ell,k}[t_1,t_2]},$$

… (3)

The two implementations essentially differ by the choice of spatial grid used to translate curvelets at each scale and angle

method gives both a more intuitive algorithm and faster computation time [7].

The FDCvT via Wrapping Algorithm involved four steps[17,8,18]:

1- Apply the 2D FFT and obtain Fourier samples $f^{\wedge}$ [n1, n2] , $-n/2 \leq$ n1, n2 $< n/2$.
2- For each scale j and angle ℓ,form the product Ũj,ℓ [n1,n2] $f^{\wedge}$ [n1, n2] .
3- Wrap this product around the origin and obtain f`j,ℓ [n1, n2]=W(Ũj,ℓ $f^{\wedge}$)[n1,n2], ……………(4)
   where the range for n1 and n2 is now $0 \leq$ n1 < L1,j and $0 \leq$ n2 < L2,j (for θ in the range (- $\pi/4$, $\pi/4$)).
4-Apply the inverse 2D FFT to each f~j,ℓ ,hence collecting the discrete   coefficients CD (j, ℓ , k).
The proposed technique enter texture image to the FDCvT via Wrapping and the output is coefficients matrix, this coefficients matrix enter into feature extraction to compute feature vector such as (Mean,STD).
It is clear that this algorithm has computational complexity O(n2 log n) and in practice, its computational cost does not exceed that of 6 to 10 two-dimensional FFTs [17].

PROOPSED METHOD

In this paper, we take the fingerprints images of ten persons and there are three rotated images for every person. Therefore the database consists of 30 images, and the size of each image is (128*128) , as shown in Figure 5.
The system is train using these 20 images and when an input image is given to the system, it should recognize the person if there is a match.The proposed technique for fingerprints recognition based on (DCT and Curvelet Transform) are shown in Figure 2.
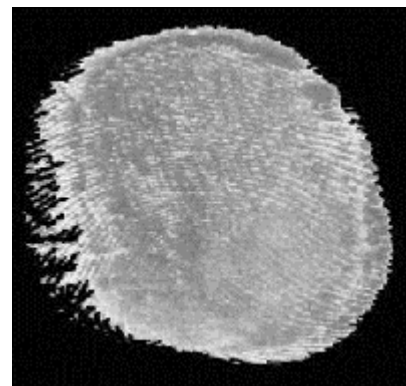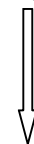
The procedure that used in this project to identify the fingerprint image from other fingerprint images includes the following pre-processing stages:

4.1 IMAGE CONVERSION

First stage involves convert Color Images to gray level (128*128), as shown in figure 3.
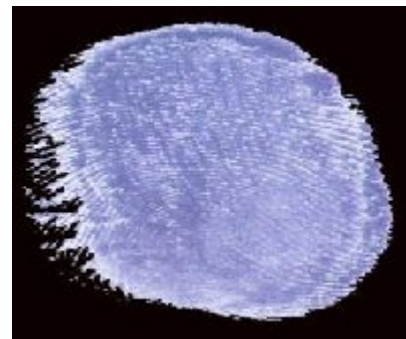

A= Color Image

B=Gray Image
Figure 3: Convert Image
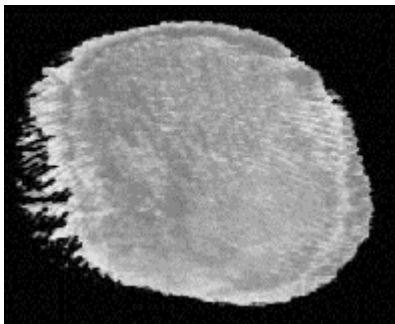
IMAGE ENHANCEMENT

Second stage involves image enhancement (reduce the noise) by using function Median Filter, as shown in figure 4.

Table 1
Ranges of Mean and Standard Deviation for 12 person fingerprint

| Group | FDCvT via Wrapping & DCT | |
| | Mean | STD |
	MIN - MAX	MIN - MAX
P1	305-313	2042-2078
P2	16-34	1655-1711
P3	80-232	1333-1382
P4	37-54	1735-1773
P5	298-306	2196-2205
P6	0-20	1524-1525
P7	28-44	1757-1794
P8	13-34	1702-1713
P9	23-43	1780-1799
P10	37-43	1604-1618
P11	54-70	1629-1663
P12	39-48	1738-1743
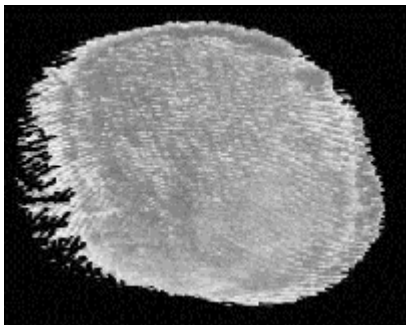
C=Gray Image

D=Enhancement Image
Figure4: Image Enhancement

FEATURE EXTRACTION

This stage involves feature extraction from the image using Discrete Cosine Transform and Curvelet Transform(FDCvT via Wrapping).One applies the steps of the proposed technique on these fingerprint image for purpose the extraction of features vector (Mean, STD). One can put the values of the same group as a range which consists from the Min value and Max value for each feature extraction of the same group. These values are used in classification, for example if the unknown image has value from Mean=15 and group A has the range from 12 to 15, the type of image is group A.Table 1 illustrates the range for each person from the feature extraction.

STORING IMAGES

After pre-processing stages, the images are stored image in size (128*128) in data base of images.

MATCHING STAGE

The finally, the compare stage and it is the more difficult stage in this paper .The input image makes on it the same steps in (1, 2, and 3) and then compare with the images in data base to verify from results. The template matching can be applied by finding the similar values between the original image and the template. The original image must be larger than template image, and the ratio of matching between will be computed, then the image with high ratio is considered to be the high matching and so on.

THE RESULTS DISCUSSION

For different unknown fingerprint images is apply same work in learning stage to calculate the feature vector (Mean, STD).The feature vector derived from the unknown fingerprint images is compared with the features vector (for learning stage) using (IF….Then) statement to classify the fingerprints into the class to which it belongs. To evaluate the performance of any fingerprints recognition system, the rate of the system result should be calculated as follows:

Recognition Rate= Number of correctly classified fingerprint images * 100/ Total number of fingerprint images ……. (5)

The recognition rates of over 84 % were obtained for combination of FDCvT via Wrapping and DCT. The results indicate that combination between FDCvT via Wrapping and DCT is the most effective for fingerprint recognition. Table (2) illustrates the results of different testing fingerprint images

Table 2:**The Testing Stage**

Sample	Mean	STD	Result	Original
T1	308	1977	P5	P5
T2	15	1523	P2	P2
T3	310	2183	P4 or p7	P8
T4	23	1663	P3	P3
T5	49	1777	P1	P1
T6	231	1355	P6 or p11	P11
T7	0	1647	P5	New
T8	309	2082	New	New
T9	304	1993	P1	New
T10	309	2061	P9	P9
T11	-4	1921	P10	P10
T12	31	1795	P10	P10
T13	-16	1604	P4	P4
T14	48	1771	P11	P11
T15	16	1518	P7 or p9	P7
T16	-2	1643	P7	P7
T17	-3	1618	P3	P3
T18	37	1791	P3	P3
T19	23	1977	P9	P9
T20	-2	1757	P4	P12
T21	41	1368	P2	P2
T22	-15	1735	New	P10
T23	83	1388	P1	P1
T24	22	1666	P6	P6
T25	-21	1602	P2 or p6	P6

The results indicate the improvement of data entering the DCT (the information that come out from the FDCvT via Wrapping is useful information). They also indicate the reduction of overlapping between the 12 groups by the combination between the FDCvT via Wrapping and DCT.

CONCLUSIONS

Fingerprint recognition is a challenging problem and there is still a lot of work that needs to be done in this area. Over the past ten years, fingerprint recognition has received substantial attention from researchers in biometrics.

In this paper DCT with FDCvT via Wrapping were used for Fingerprint Recognition.The following points are concluded :

1- This work is applied on a set of fingerprint images, which is divided into 12 person,each fingerprint images is taken in several (angles),because the unknown fingerprint images can come in any angle.

 It is concluded that the use of rotation leads to obtain high accuracy of discrimination,as well as reducing the overlap.

2- The results show that the Fingerprint Recognition Rate by the (FDCvT via Wrapping and DCT) achieves better recognition rate (84 %).

3- Enhancement Stage is very important in the process of fingerprinting Recognition because of their importance in reducing effect of noise in the image.

4- The Proposed Algorithm produce better results at lower and higher values.As the algorithm takes fewer computations it can be implemented using the real-time processor.

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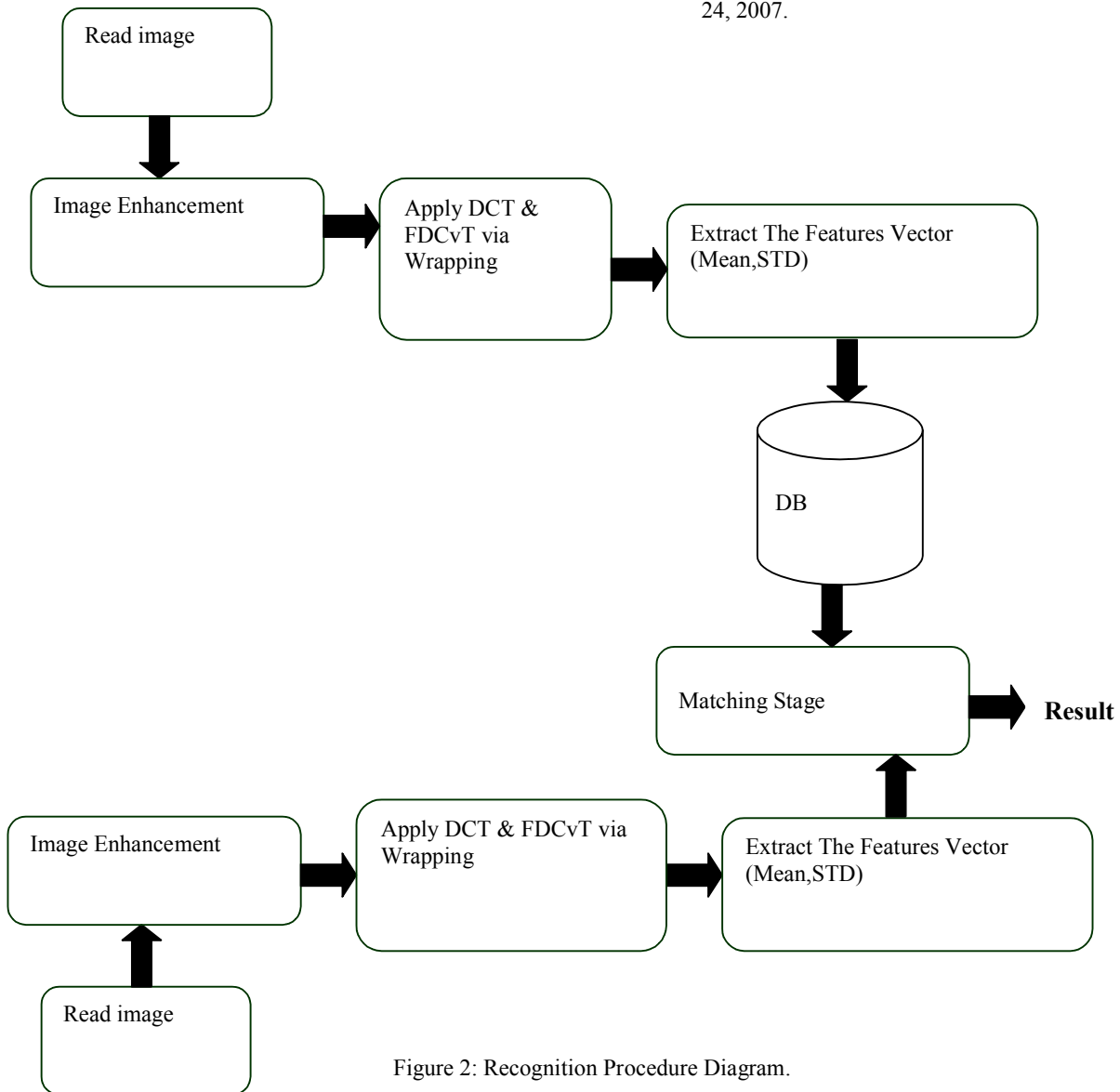

Figure 2: Recognition Procedure Diagram.
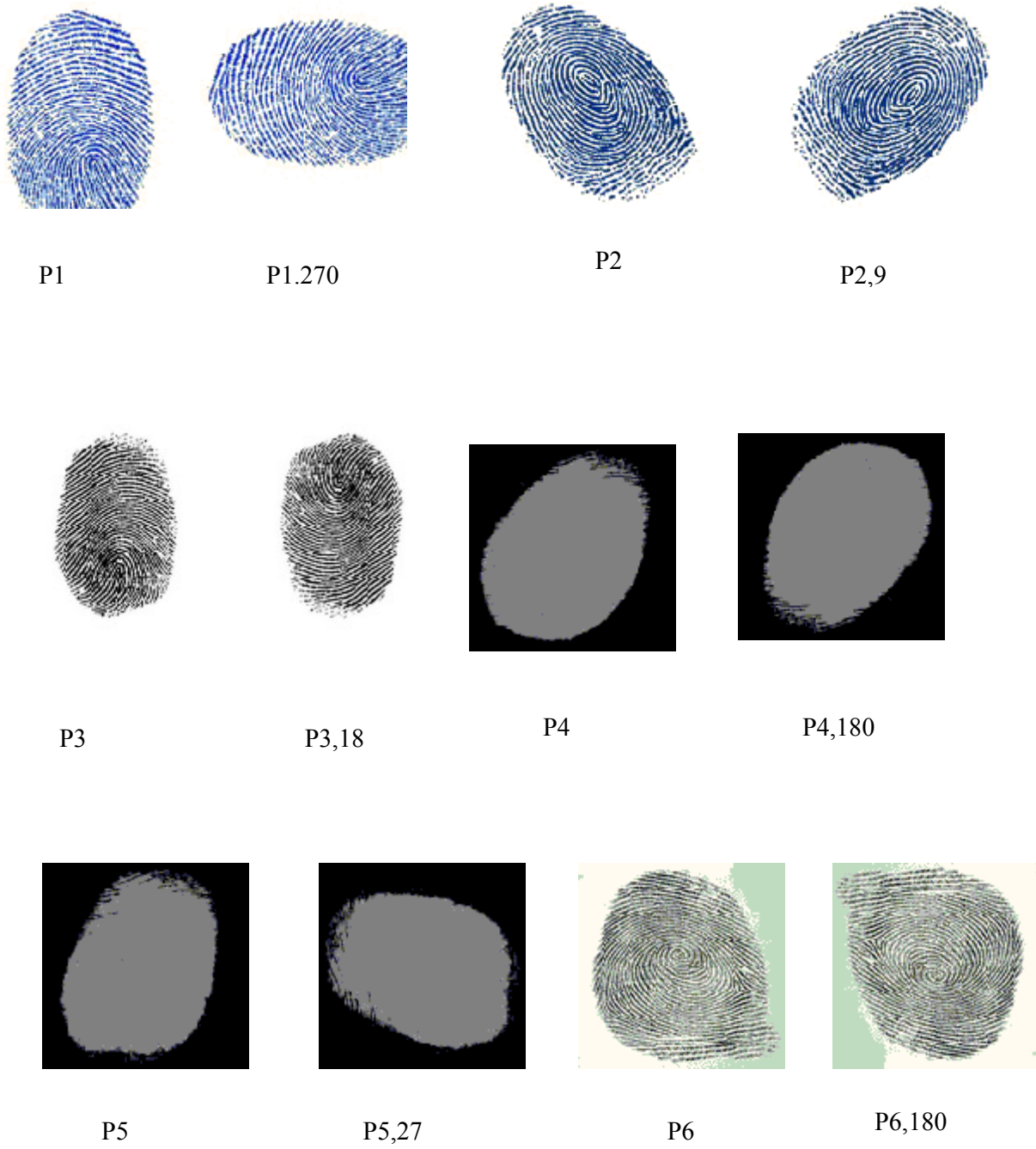
Figure 5: Some of Finger prints Images.

استخدام اثنين من طرق التحويل في التعرف على بصمات الأصابع

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الخلاصة:

بصمات الأصابع هي الشكل الأقدم والأكثر استخداما على نطاق واسع لتحديد الهوية. على الرغم من الاستخدام الواسع النطاق للبصمات، يوجد قليل من النظريات الإحصائية عن تفصيلات تفرد البصمات. إن مطابقة بصمات الأصابع هي العملية المستخدمة لتحديد ما إذا تفاصيل مجموعتين من بصمة الإصبع تأتي من نفس البصمة. توجد عدة خوارزميات لمطابقة البصمات بطرق عديدة ومختلفة. بعض الطرق تنطوي على تفصيلات مطابقة النقاط بين الصورتين، في هذا البحث نستخدم فلتر (المتوسط) لتحسين الصور، وبعد ذلك نستخدم DCT و FDCvT via Wrapping لاستخلاص الصفات من الصور. Template Matching يمكن تطبيقه من خلال إيجاد عدة قيم متشابهة بين الصورة الأصلية والقالب. النظام المقترح يتضمن مرحلتين، المرحلة الأولى تنفذ من خلال اخذ صور بصمات طبيعية ومنفردة وبعدة مواقع وحساب الصفات (المتوسط والانحراف المعياري) باستخدام FDCvT via Wrapping and DCT.المرحلة الثانية تنفذ بواسطة اخذ عينات جديدة من صور البصمات لغرض فحص العمل.النتائج تبين إن نظام تمييز البصمات بواسطة FDCvT via Wrapping and DCT ينجز أفضل نسبة تمييز وهي (84٪).