Enhance Criminal Investigation by Proposed Fingerprint Recognition System

Soukaena H. Hashem[1] Abeer T. Maolod[1] Anmar A. Mohammad[1]

[1]*Computer Sciences Department, University of Technology, Baghdad/Iraq*

Ph. 00964 7811332431

Abstract

Law enforcement officers and forensic specialists spend hours thinking about how fingerprints solve crimes, and trying to find, collect, record and compare these unique identifiers that can connect a specific person to a specific crime. These individuals understand that a basic human feature that most people take for granted, can be one of the most effective tools in crime solving.

This research exploits our previous work to be applicable in criminal investigation field. The present study aims to solve the advance crime by strength fingerprint's criminal investigation to control the alterations happen intentionally to criminals' fingerprint. That done by suggest strategy introduce an optimal fingerprint image feature's vector to the person and then considers it to be stored in database for future matching. Selecting optimal fingerprint feature's vector strategy deal with considering 10 fingerprints for each criminal person (take the fingerprint in different time and different circumstance of criminal such as finger is dirty, wet, trembling, etc.). Proposal begun with apply a proposed enrollment on all 10 fingerprint for each criminal, the enrollment include the following consequence steps; begin with preprocessing step for each of 10 images including enhancement, then two level of feature extraction (first level to extract arches, whorls, and loops, where second level extract minutiae), after that applying proposed Genetic Algorithm to select optimal fingerprint, master fingerprint, which in our point of view present the most universal image which include more detailed features to recognition. Master fingerprint will be feature's vector which stored in database. Then apply the proposed matching by testing fingerprints with these stored in database.

While, measuring of criminal fingerprint investigation performance by calculating False Reject Rate (FRR)and False Accept Rate (FAR) for the traditional system and the proposed in criminal detection field. The obtained results encourage to publish this work.

Keywords: Crime Analysis, Criminal, fingerprint, minutiae, genetic algorithm, feature extraction, FRR, FAR.

تعزيزالتحقيقات الجنائي بأقترح نظام التعرف على بصمات الأصابع

سكينة حسن هاشم عبير طارق مولود انمار علي محمد
[1]قسم علوم الحاسب ، جامعة التكنولوجيا ،بغداد / العراق

ملخص

ضباط إنفاذ القانون و الأخصائيين في الطب الشرعي يقضون ساعات في التفكير في كيفية حل الجرائم من خلال الاستقصاء عن بصمات المجرمين، ومحاولة إيجاد وجمع و تسجيل و مقارنة هذه المعرفات الفريدة (البصمات) التي تمكن توصيل شخص معين لجريمة محددة . هؤلاء الأفراد يعرفون تماما ان لكل انسان ميزة أساسية، يمكن أن تكون واحدة من أكثر الأدوات فعالية في حل الجريمة.

هذا البحث سوف يعتمد على بحثنا السابق ليكون قابل للتطبيق في مجال التحقيق الجنائي. لذلك ، الهدف هنا للمضي قدما لحل الجريمة من قبل التحقيقات الجنائية للبصمات للسيطرة على التحويرات التي تحدث عمدا إلى بصمة المجرمين. تم القيام بهذا العمل من خلال اقتراح خطة عمل للحصول على مجموعة خصائص بصمة الاصابع الامثل للشخص ومن ثم يتم تخزينها في قاعدة البيانات للمطابقة في المستقبل. اختيار مجموعة الخصائص الأمثل لبصمة الاصابع سيأخذ بنظر الاعتبار 10 بصمات لكل شخص (أخذ بصمات الأصابع الجنائية في أوقات مختلفة و ظروف مختلفة مثل عندما تكون الاصابع قذرة او رطبة او يرتجف ، الخ). تبدأ تطبيق المقترح بالتسجيل لكل بصمات الأصابع الجنائية بحيث لكل مجرم 10 بصمات ، وتشمل تطبيق الخطوات التالية والتي تبدأ مع خطوة المعالجة الاولية لكل من الصور 10 ، ثم المستوى الثاني المتضمن استخراج الميزات (المستوى الأول لاستخراج والأقواس وفلكات المغزل والحلقات والمستوى الثاني استخراج التفصيلات الدقيقة) ، بعد ذلك يتم تطبيق الخوارزميات الجينية المقترحة لتحديد بصمة الاصابع الأمثل ، البصمة الاساسية ، والتي في وجهة نظرنا تقدم الصورة الأكثر عمومية بحيث تشمل ميزات أكثر تفصيلا تقود الى التمييز الادق. وسوف تكون البصمة الاساسية عبارة عن مجموعة خصائص تخزن في قاعدة البيانات. ثم اجراء المطابقة المقترحة من خلال اختبار بصمات المجرمين مع بصماتم الاساسية التي تم تخزينها في قاعدة البيانات.

لقياس مدى نجاح النظام المقترح لتميز بصمة الاصابع للمجرمين يتم حساب معدل الرفض الكاذب (FRR) ، ومعدل القبول الكاذب (FAR) للنظام التقليدي و المقترح في مجال الكشف الجنائي وكانت النتائج مشجعه لنشر هذا العمل.

كلمات البحث: تحليل الجريمة ، مجرمين ، البصمات ، تفصيلات البصمة، الخوارزمية الجينية ، واستخراج الميزة، FAR . ،FRR

1. Introduction

Every person is born with his own unique set of fingerprints. There is no two fingerprints have ever been found to be exactly alike; not on identical twins (although these are extremely similar), not even on a person's own hand. The unique whorls and lines that make up an individual's fingerprints are formed in the fetal stage and remain the same throughout the entire life span. This makes for a unique mark that can positively identify one individual against another, particularly useful when a person of interest already has a recorded set of fingerprints on file with police, military or other government institutions [1].

Fingerprints are made up of a collection of swirling lines. The way these lines form and pattern themselves is what makes each fingerprint unique. Despite the incredible number of different fingerprints, there are only seven different types of lines that make up fingerprints. These lines may start, stop or split at any place within the print. The formations, angles, lengths, heights and widths make billions and billions of different prints. With their unique qualities, it becomes easy to see how fingerprints can help solve crimes. Leaving a fingerprint is like leaving a calling card at the crime scene. There are few different ways fingerprints get left behind by careless crooks. The most common way is from fat or oil that is transferred from the finger to an object like a doorframe or table. Amino acids from the finger may also leave a discernable mark. Fingerprints can also be detected as an impression in a soft substance such as putty. Finally, they can be made by a substance on the finger such as blood or paint. Uncovering fingerprints to help solve a crime can be done in a few ways. Adhering powders to fresh fingerprints will cause the powder to stick to the grease and make the fingerprint visible. Another method is by using a few drops of cyano-acrylate or superglue. When these drops are heated, they vaporized and the smoke attaches to the fingerprint leaving a clear white print. Specialized crime scene laboratory equipment can also find fingerprints, but not all authorities have access to all equipment.

Fingerprints can be saved for further investigation in a number of ways, including: take a photograph of the print, store it on a rubber lifter or tape, keep the original ground the print is on, and copy the print using digital technology. Ideally, from a crime-solving perspective, it is hoped the interconnected nature of our society will eventually lead to having all fingerprint databases linked for easy cross-reference. However, there are several issues to be dealt with, such as funding, jurisdictional bickering, security and privacy to consider before such a fingerprint system can exist [1, 2, 3].

Fingerprint Recognition System is a free tool that will recognize and verify fingerprints. Fingerprint recognition identifies people by using the impressions made by the minute ridge formations or patterns found on the fingertips. Finger printing takes an image of a person's fingertips and records its characteristics - whorls, arches, and loops are

recorded along with patterns of ridges, furrows, and minutiae. Information is processed as an image and further encoded as a computer algorithm [4, 5, 6].

2. Related works

Munir M. A.*et. al.,*[7] presented a fingerprint matching scheme that utilizes a ridge feature map to match fingerprint images. The technique described here obviates the need for extracting minutiae points to match fingerprint images. The proposed scheme uses a set of 16 Gabor filters, whose spatial frequencies correspond to the average inter-ridge spacing in fingerprints, is used to capture the ridge strength at equally spaced orientations. A circular tessellation of filtered image is then used to construct the ridge feature map. This ridge feature map contains both global and local details in a fingerprint as a compact fixed length feature vector. The fingerprint matching is based on the Euclidean distance between two corresponding feature vectors. Basca C. A. *et. al.,*[8]introduced a method of optimizing Gabor Filter Banks using an evolutionary approach. Texture segmentation has multiple usages from medical imaging to satellite terrain mapping. Gabor filters are the most widely used texture feature extractors. Multi-channel approach to texture segmentation using Gabor filters is subject to optimization. Genetic algorithms are used to generate an optimal filter bank for the source image. Malathi, A.***et. al.,*** [9]used a clustering/classify based model to anticipate crime trends. The data mining techniques are used to analyze the city crime data from police department. The results of this data mining could potentially be used to lessen and even prevent crime for the forth coming years. Malathi, A***. et. al.,*** [10] discussed that a major challenge facing all law-enforcement and intelligence gathering organizations was accurately and efficiently analyzing the growing volumes of crime data. There is an enormous increase in the crime in the recent past. They looked at outlier detection algorithm with some enhancements to aid in the process of filling the missing value and identification of crime patterns. They applied these techniques to real crime data and use semi-supervised learning technique here for knowledge discovery from the crime records and to help increase the predictive accuracy. Rai R*., et. al.,*[11]described a fingerprint recognition system consisting of three main steps-fingerprint image preprocessing, feature extraction and feature matching by two different processes. First processes were based on Gabor filter and second was based on FFT (Fast Fourier Transform) filter. We used this process in the fingerprint image preprocessing steps and after getting result by first step then used feature extraction and feature matching steps simultaneously and separately for each process. After applying all the steps, we calculated the FAR (False Accept Rate) and FRR (False Reject Rate) for both processes separately and compare results on the basis of FAR and FRR of Gabor filter based and FAR and FRR of FFT Filter based. Mande, et. al., [12]introduced binary clustering and classification techniques were

used to analyze the criminal data. The crime data considered from Andhra Pradesh police department that aimed to potentially identify a criminal based on the witness/clue at the crime spot an auto correlation model was further used to ratify the criminal. Hashem, et. al.,[13]introduce genetic algorithm as a tool to select optimal fingerprint, master fingerprint, which in their point of view present the most universal image which include more detailed features to recognition. Master fingerprint will be feature's vector which stored in database and will be depended for investigation.

3. Proposal of Criminal Investigations Advanced by Fingerprint Recognition

For the crime database, various data fields were identified to cover real world scenarios. The entities that were identified in our proposal only are Criminals (Suspect and Convict). So we see any crime investigation highlights primarily on one direction of the crime; this is criminal direction. For the criminals we select the most critical attributes (variables) are very interested and repeated in crime registration. The criminal direction is a dataset has it is own attributes are two classes, Informatics and Bioinformatics:

- Information Attributes: this is the first class of criminal which is present most of important attributes related to analyze and investigate the crimes depending on what information available about criminals, these attributes are: Criminal identified, Criminal gender, Criminal age, Criminal address, Criminal income, Criminal job, Criminal marital stat use, Criminal signs difference, Criminal religion, Criminal national, Criminal weapon, Criminal victim, Criminal witness.
- Bioinformatics Attributes: this is the second class of criminal which is concentrate on get optimal fingerprint for the criminals so even they try to alternate their fingerprint we could discover that by the modest proposal of fingerprint recognition using genetic algorithms

The Proposed Fingerprint Recognition for Criminals investigation

Now will explain the proposal tend to strength fingerprint recognition to overcome on alternations of criminal fingerprints. There are many points must be considered in account for avoiding the failure and unreliability of the system, these are summarized as follow:

Direct matching between the fingerprint pattern to be identified and many already known patterns has problems due to its high sensitivity to errors such as various noises, damaged fingerprint areas, or the finger being placed in different areas of fingerprint scanner window and with different orientation angles, finger deformation during the scanning procedure. A single registered fingerprint may have 100 or more identification points that can be used for identification purposes. There is no exact size requirement as the number of points found on a fingerprint impression depends on the location of the print. A good reliable

fingerprint processing technique requires sophisticated algorithms for reliable processing of the fingerprint image: noise elimination, minutiae extraction, rotation and translation-tolerant fingerprint matching. The algorithms must be fast for comfortable use in applications with large number of criminals. Fingerprint weaknesses, requires careful enrollment, potential high False Reject Rate (FRR) due to: pressing too hard, scarring, misalignment, dirt. Here will introduce the proposed framework of fingerprint recognition in generic steps of algorithm, and then explain each step separately.

Algorithm: Proposed Framework of Fingerprint Recognition

Input: database of fingerprints images of criminal persons each one have 10Fingerprints.

Output: Fingerprint recognition system with high quality.

Initialization: Image specifications are 8-bit gray scale (256 levels), 500 dpi resolution, (1-by-1) inch size.

Process:

Step1:*Enrollment*, for each person input the 10 fingerprints image into the following consequences steps to select optimal fingerprint feature's vector to accomplish the enrollment,

1. ***Image preprocessing***, enhancement using histogram equalizer.
2. ***Apply rough segmentation using Gabor filter***, here the aim is to extract the global features, global patterns (plain arch, tended arch, left loop, right loop, and whorl).
3. ***Image Binarization*** will binarized images so that it will be in black and white (matrix of zeros and ones elements).
4. ***Apply soft segmentation for*** findinginteresting area of the image what is called region of interest (ROI). It presents the preliminary step of thinning process.
5. ***Thinning is*** how the ridges will reduce into 1 pixel so that the useful and useless ridges will be clear. Here the aim is to extract the local features; local patterns (Minutia features).
6. ***End For***

Step2: Build proposed vectors and applying proposed Genetic Algorithm, each vector will consist of both patterns of global features obtained by Gabor filter and patterns for Minutia obtained by thinning so will get 10 vectors. Then apply GA to optimize a solution, to get optimal vector which present full description of fingerprint global and local features.

Step3: Identification, Recognition and matching, when some of criminal persons entered his fingerprint image, this image will enhanced, rough segmented by Gabor filter, binarized, soft segmented to find ROI, finally thinned. All that to build it is vector to match it with identical stored vector of that criminal person.

End of Process

3.1. Enrollment

Now will begin with fingerprint database enrollment process, the last process have consequence steps (from enhancement to feature extraction) will be introduced in the following subsections. Enter 10 fingerprints for one criminal. For each 10 image will apply the following image processing steps, figure 1 present one of ten images of criminal fingerprint.

- ***Fingerprint Image Enhancement,*** Enhancement for the 10 fingerprint image will perform using some algorithms, the proposal will use Histogram equalization, see figure 2, to spread pixels of an image so that it will fill the pixel values distribution of an image to increase the perceptional information. This step will introduce enhanced image using Histogram equalization. The enhanced image then will take the range from 0 to 255 pixels.

- ***Fingerprint Image Rough Segmentation,*** Fingerprint images may have background information that does not represent the fingerprint itself. Segmentation removes the background information and is the effective step in the pre-processing of the fingerprint image. A Gabor filter is linear filter whose impulse response is defined by a harmonic function multiplied by Gaussian function. The Fourier transform of a Gabor filter's impulse response is the convolution of Fourier transform of harmonic function and the Fourier function of Gaussian function. g(x, y) = s(x, y) w_r (x, y), where s(x, y) is a complex sinusoidal, known as the carrier, and w_r(x, y) is a 2-D Gaussian-shaped function, known as the envelop. The general function of Gabor filter can be represent as [],

$$G(x,y,\theta,f_0)=\exp\left\{-\frac{1}{2}\left(\frac{x_\theta^{\,2}}{\sigma_x^2}+\frac{y_\theta^{\,2}}{\sigma_y^2}\right)\right\}.\cos(2\pi f_0 x_\theta), \quad (1)$$

$$\begin{bmatrix} x_\theta \\ y_\theta \end{bmatrix}=\begin{bmatrix} \sin\theta & \cos\theta \\ -\cos\theta & \sin\theta \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} \quad (2)$$

…… (1) and (2) [11]

where θ is the ridge orientation with respect to vertical axis, f_0 is the selected ridge frequency in xθ – direction, σ_x and σ_y are the standard deviation of Gaussian function along the xθ and yθ axes respectively and the [xθ, yθ] are the coordination of [x,y] after a clockwise rotation of the Cartesian axes by an angle of (90-θ). Referring to the function in (1), the function $G(x,y,\theta, f_0)$ can be decomposed into two orthogonal parts, one parallel and the other perpendicular to the orientation θ.

$$G(x,y,f_0)\big|_{\theta=90^\circ}=G_{BP}(x,f_0)G_{LP}(y)$$

$$G_{BP}(x,f_0)=\exp\left\{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}\right)\right\}\cos(2\pi f_0 x)$$

$$G_{LP}(y)=\exp\left\{-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2}\right)\right\}$$

……(3) [11]

where G_{BP} is only a band-pass Gaussian function of x and f_0 parameters while G_{LP} is only a low-pass Gaussian filter of y parameter. This step will introduce peace of fingerprint image (center) after applying Gabor method on it and also

present Gabor visualization for this image (figure 3).

- ***Fingerprint Image Binarization,*** Gray scale image will binarized, so that it will be in black and white (matrix of zeros and ones elements) the binarization will done by choosing carefully a threshold value where the values for image matrix over the threshold value will become 1 (black) and values less than threshold will be 0 (white), binarization show the minutiae in the image (figure).

- ***Fingerprint Image Soft Segmentation.*** After binarization a segmentation for the image will done where the interesting area of the image identified and as what we call region of interest (ROI), there are two steps for segmentation was Block directionand the second step was identifying the region of interesting. Block direction(figure 5), considering the block direction was done by calculating the x-direction and y-direction for a given block this done by using sobel filter and calculating the gradient value by formula.

$$tg2\,\theta = 2\sin\theta\cos\theta\,/(\cos2\theta - \sin2\theta)\ldots\ldots\ldots (4)$$

the formula is to calculate x-direction and y-direction for each block and consider them as sine and cosine values, when that done for every block we could got blocks with useful information so that no ridges and furrows in the region as a result we shall remove them. The following formula is for discovering and discarding the unnecessary blocks,

$E = \{2\sum\sum (gx*gy)+\sum\sum (gx2-gy2)\}/ W*W*\sum\sum (gx2+gy2)$ …….. (5) [11]

Where if E is under a certain threshold value then the block is considered as a back ground block not belongs to the fingerprint.

Region of Interest(figure 6),after specifying the valuable direction we used the 'OPEN' and 'CLOSE' to present that region, the 'OPEN' operator is to show the new image and cut off the peaks in background, where the 'CLOSE' operator was to reduce the image so that removing the small cavitations. By subtracting the close area form the open area will got a bound area and inner area.

- ***Fingerprint Image Thinning,*** in thinning stage the ridges will reduce into 1 pixel so that the useful ridges will be clear and the useless ridges will clear also. An advantage of this method is that it doesn't produce a discontinuity on the lines, the algorithm is deleting points that lie outer boundaries of the ridge where the width is longer than one pixel but if that may cause a disconnectivety on the graph the pixel will not be deleted (figure 7).

The thinned image may contain some unnecessary spikes and breaks which may lead to recognition of false minutiae those spikes and breaks should be removed in order to extract the minutia, as in traditional, if an angel comes with a

branch and ridge is larger than the 70 degrees and less than the 110 degrees, and if the length of the branch is less than the 20 pixel so that this branch will be removed. Also if a break in some ridge is less than 15 pixels and no other ridges will pass through it, then this break will connected. Aligning minutia, in windows is to decide making minutia as bifurcation or termination. For the matrix that will be saved, the following steps are prepared: present the each bifurcation as three terminations, each termination will be presented by three elements: x-coordinate, y-coordinate, and orientation, see figure (8).

3.2. The Proposed Genetic Algorithm to Select Optimal Feature's Vector From all above we can say the proposal apply two levels of segmentations, these are:

1. Rough segmentation which done by Gabor filter, from this segmentation extract the global patterns of fingerprint (plain arcs, tented arcs, left loop, right loop, and whorl).
2. Soft segmentation which done by there are two step for segmentation is block direction and the second step is identifying the region of interesting followed by thinning, from these three steps will extract local patterns of fingerprint (miniature).

Build vectors are constructing the population of GA; each vector will contain both global patterns and local patterns. To apply a genetic algorithm for solving problem of selecting master fingerprint from one class, this research proposes to define or to select the following component:

Note: oi represent symbol of global patterns and pi represent symbol of local patterns.

1. A genetic representation or encoding schema for potential solutions to the problem, here each fingerprint will be presented as a vector each vector consist from the following:

(*no. of global pattern, (o1, (position (x, y coordinates), orientation, texture, object shape and topology), o2(…..), on(……), no. of local patterns, (p1, (position (x, y coordinates), orientation, texture, object shape and topology), p2(…..), pn(……)*).

2. A way to create an initial population of potential solutions, the initial population already created with image processing algorithms which established the vectors. So this mean the initial population of each 10 criminal's fingerprint, will be these 10 images represented by vectors.
3. An evaluation function that plays the role of the problem environment (best fingerprint), rating solutions in terms of their "fitness". Here the proposed evaluation function for each fingerprint is ***f(vector) = (no. of object + ∑ (features of each objects))***.
4. Genetic operators that alter the composition of offspring. *One-point crossover* is the most basic crossover operator, where a crossover point on the genetic code is selected at middle of vector which separate global and local

features, and two parent vectors are interchanged at this point.

5. Crossover exploits existing vectors potentials, but if the population does not contain all the encoded information needed to find the best vector, no amount of vector mixing can produce a satisfactory solution. For this reason, a mutation operator capable of spontaneously generating new vector is included. The most common way of implementing mutation is to flip some feature with a probability equal to a very low, given mutation rate (MR). A mutation operator can prevent any single feature from converging to a value through the entire population and, more important, it can prevent the population from converging and stagnating at any local optima.
6. Values for the various parameters that the genetic algorithm uses population size, rate of applied operators, etc..In our particular problem we use the following parameters of the genetic algorithm: Population size, *pop-size* = 10 (the parameter was already used), Probability of crossover, PC = 1, Probability of mutation, PM = 0.001 (the parameter will be used in a mutation operation).
7. Continue with genetic processing until obtain the optimized vector to be the master vector.
8. Order the other nine vector according their nearest from the master vector and store them as a measure in some suspected instances of recognition.

3.3. Identification, Recognition and Matching

After accomplishing the six steps above, the enrollment would be accomplished. When enrollment performed for all criminal persons, the system of fingerprint recognition will be ready to recognize images of fingerprint criminal or not. Recognition process depend on method used in matching, matching will done when some of criminal persons entered his fingerprint image, this image will submitted to the five consequence image processing enhancement, rough segmentation by Gabor filter, binarization, soft segmentation to find Block Direction and ROI, finally thinning. All that to build it is vector to match it with corresponding stored vector of that criminal person.

Fingerprint matching will applied in this research is based on finding the Euclidean distance between the corresponding feature vectors (entered and stored). The Euclidean distance of the vector of the entered fingerprint image and vector of corresponding stored can be calculated as follows,

$$\varepsilon = || \Omega - \Omega_k || \quad \ldots\ldots\ldots \quad (6)$$

where Ω kis a vector of stored fingerprint. When get a minimum score that belong to the best alignment of the two fingerprints being matched? If the Euclidean distance between two feature vectors is less than a decided threshold, then the decision that the two fingerprint images come from the same finger, otherwise a decision that the two

fingerprint images come from different fingers.

4. Experimental Works and Results

In this proposal since we deal with crime domain the data are so sensitive and not be ready available for us, for that from our environment as teachers we assume 50 student as criminal and depend on 500 fingerprint images for 50 student (as criminal), so each criminal will has 10 images. Enrollment process will do for all these 500 images to finally detect the master image for each person and other nine nearest images. So there are two databases in this enrollment: preliminary and secondary. Preliminary will store master images vectors, which has in our experimental just 10 vectors. Secondary will store the most nearest vector to the master vector, which will used in uncertainties cases. The matching stage must be flexible because 100% match may never occur, for that the matching stage is depending on determined a threshold value, in our proposal will give 98.5% -98% as a threshold, so if the two global patterns or two local patterns is in a box and no scaling for them they are matched. In traditional matching score calculated as in the following equation,

$$\text{Matching Score} = \frac{\text{Number of minutia pairs that match}}{\text{Total number of minutia pairs}}$$

…… (7)

In our proposal will as in follow,

$$\text{Matching Score} = \frac{\text{Number of global pairs and local pairs that match}}{\text{Total number of global pairs and local pairs}}$$

…… (8)

In both traditional and proposal there are the two probabilities these are: two fingerprint from two different persons may produce a high Matching Score (an error); two fingerprints from the same person may produce a low Matching Score (an error). So as usual in all systems there are **two types of error**: **FAR** = ratio of number of instances of pairs of different fingerprints found to (erroneously) match to total number of match attempts.

$$FAR(n) = \frac{\text{Number of successful independent fraud attempts against a person n}}{\text{Number of all independent fraud attempts against a person n}}$$

…… (9)

FRR = ratio of number of instances of pairs of same fingerprint are found not to match to total number of match attempts.

$$FRR(n) = \frac{\text{Number of rejected verification attempts for a qualified person(or feature)n}}{\text{Number of all verification attempts for a qualified person(or feature)n}}$$

…… (10)

The performance of a fingerprint recognition system can be evaluated by measuring its false reject rate (FRR) and false accept rate (FAR). By evaluating the FRR and FAR, the threshold of matching score deciding whether to reject or accept a match is set to optimizing the performance. If we take less threshold value it means the probability of

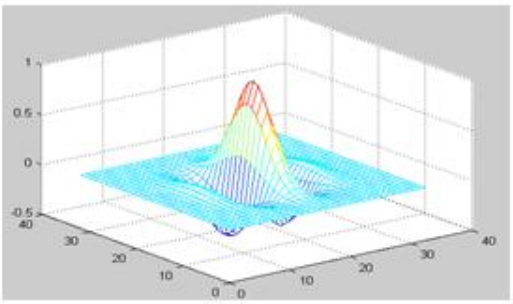
accepted image will be high and rejected image will be low and due to this, chances of occurring error will be increased and vice versa. Our obtained simulation results are shown in table (1).

5. Conclusions

In our previous work [13], we introduce the proposal of enhance fingerprint recognitions using genetic algorithms without any applicable domain. Here, the proposal applied in a very sensitive and important field it is the criminal investigation, where the most of the criminals try to alternate their fingerprint, so we introduce our proposal in which depend on an idea to optimize feature's vector of fingerprint image that by taking several impressions for one person in different circumstances that to consider all features may be losses in some cases of person's impressions or in some cases of alternation. GA was a good tool for optimizing features vector among 10 vectors for each person. Using Gabor filter in rough segmentation level enhance the extractions of global pattern features. The reason for increase accuracy of the proposal belongs to considering both patterns ridges and minutiae in calculating matching scores. Our proposal calculates the results FAR and FRR with two thresholds to ensure of proposal accuracy as shown in table (1).

Figure1. Source fingerprint image

Figure2. After histogram



(a)

(b)

Figure3.a-Gabor visualization for an Fingerprint image, b- Enhanced fingerprint image.

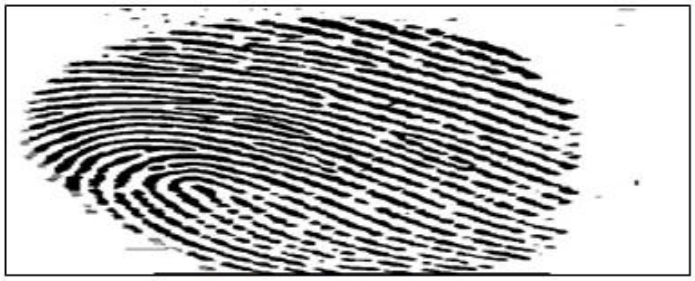


Figure4. Binary image

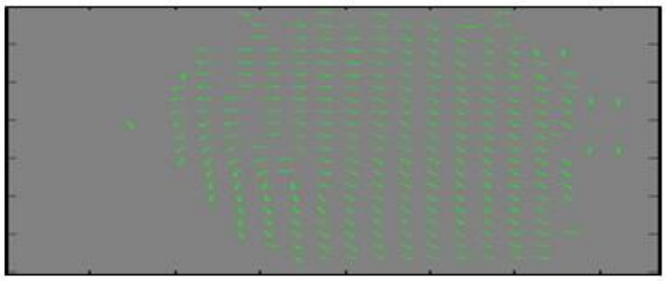


Figure5. Block direction

Figure6. Region of Interest

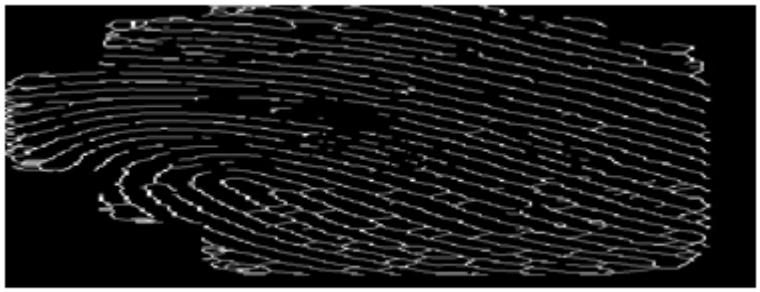


Figure7. Thinning

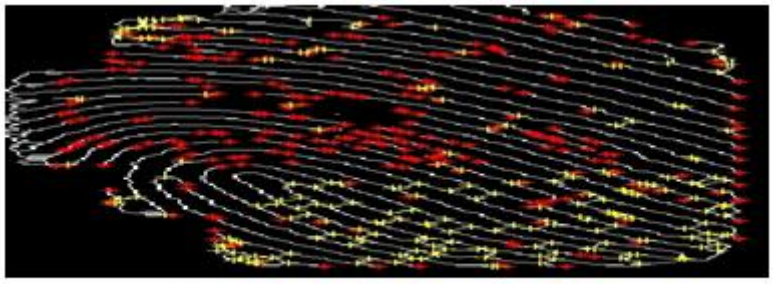


Figure8. Extract minutia from the fingerprint

Table 1. FAR and FRR with traditional, proposal [13] and applicable proposal.

Recognition System	FAR Threshold # 98%	FRR Threshold# 98%	FAR Threshold# 98.5%	FRR Threshold# 98.5%
Traditional	0.95%	23.11%	0.84%	24.41%
Proposal [13]	0.22%	15.57%	0.11%	15.98%
Applicable Proposal of Criminal	0.20%	14.25%	0.10%	14.67%

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