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A Comparative Study of Fingerprint Matching Algorithms

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ABSTRACT: The main idea in this paper, is to implement a fingerprint recognition to recognize the fingerprint of humans. The method used to design a pattern recognition system for fingerprints is also described**.** Fingerprint recognition is one of the most well known biometrics, and it is the most used biometric solution for authentication on computerized systems. The two different fingerprint recognition algorithms are used .The automatic classification of fingerprints which is based on the minutiae-matching algorithms (Hough Transformation Algorithm) and the verification-search technique which is based on genetic algorithms. we compared both algorithm and finded which is the best algorithm for the fingerprint recognition.

KEYWORDS: Fingerprints, Recognizing fingerprints, Hough Transformation algorithm, fingerprint genetic algorithm

I. INTRODUCTION

Finger-scan technology is the most widely deployed biometric technology, with a number of different vendors offering a wide range of solutions. Among the most remarkable strengths of fingerprint recognition, is its maturity, providing a high level of recognition accuracy. In the growing market of low-cost small-size acquisition devices, it allows us to use in a broad range of applications, like electronic commerce, physical access, PC logon. It is easy-to-use, ergonomic devices, not requiring complex user-system interaction.

The biometric features are known as “Galton features” due to Francis Galton who developed a probabilistic model of fingerprint individuality in term of minutiae distribution. These Galton features called also minutiae.[3,4]

In practice, police agencies tend to focus solely on two fingerprint identification techniques. The first one is concerned with the uniqueness of a configuration of fingerprint feature and the second one deals with the processing and feature matching parameters.

The task of comparing an input fingerprint’s minutiae with only one target is relatively easy. The problem becomes tedious when the matching is concerned with comparing one fingerprint’s minutiae to many others, for instance the input fingerprint with those ones from a specific database. The existing techniques used in pattern recognition as the relaxation and simulated annealing which are in general ineffective due to time consuming and the exponential computation of the problem. In this work, we adopt the technique of direct scale minutiae detection. We have applied two different techniques: the first one is concerned with the programming of the well-known Hough transform procedure,[4] and the second one is a singular one based on the application of genetic algorithms. Different experiments have been carried out successfully and the obtained results show that genetic algorithms are highly efficient in fingerprint recognition than other classical techniques.

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II. FINGERPRINT

Finger skin is made of friction ridges, with pores (sweat glands). Friction ridges are created during fatal live and only the general. Shape is genetically defined. Friction ridges remain the same all life long, only growing up to adult size. They remain the same if not too severe injury.

Figure 1: Fingerprint details

Minutiae refer to specific points in a fingerprint, these are the small details in a fingerprint that are most important for fingerprint recognition. There are three major types of minutiae features: the ridge ending, the bifurcation, and the dot (also called short ridge). The ridge ending is, as indicated by the name, the spot where a ridge ends. A bifurcation is the spot where a ridge splits into two ridges. Spots are those fingerprint ridges that are significantly shorter than other ridges.[1]

III. DESIGN OF A PATTERN RECOGNITION SYSTEM FOR FINGERPRINTS

Patterns have to be designed in various steps expressed below:

Step 1:**Data collection:** During this step collect the training and testing data.

Step 2:**Feature selection:** During this step various details have to be investigated such as Domain dependence and prior information ,Computational cost and feasibility, Discriminative features Similar values for similar patterns, Different values for different patterns, Invariant features with respect to translation, rotation and Scale, Robust features with respect to occlusion, distortion, deformation, and variations in environment.

Step 3:**Model selection:** During this phase select models based on following criteria: Domain dependence and prior information., Definition of design criteria, Parametric vs. non-parametric models, Handling of missing features, Computational complexity Various types of models are :templates, decision-theoretic or statistical, syntactic or structural, neural, and hybrid. Using these models we can investigate how can we know how close we are to the true model underlying the patterns?

Step 4:**Training:** Training phase deals with How can we learn the rule from data?

Supervised learning: a teacher provides a category label or cost for each pattern in the training set.

Unsupervised learning: The system forms clusters or natural groupings of the input patterns.

Reinforcement learning: No desired category is given but the teacher provides feedback to the system such as the decision is right or wrong.

Step 5:**Evaluation:**During this phase in the design cycle some questions have to be answered such as how can we estimate the performance with training sample.[3,5]

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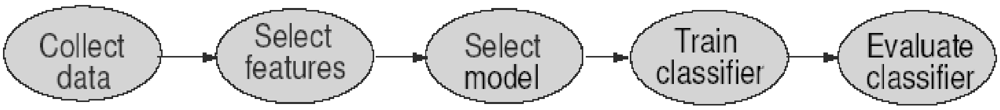

Figure 2: The Design of pattern recognition system for figure prints.

IV. FINGERPRINT RECOGNITION PROCEDURE

Consider the problem of comparing two different fingerprints selected from complete prints. The first segment is obtained from a known user at the time of enrolment, or registration, into the system as collection of fingerprints in a database. The second segment results from a live-scan acquired for the purpose of verifying a user's identity. To decide if the live - scan segment either matches or does not match the registered segment lead us to calculate the matching degree. This becomes effective after choosing a pre specified acceptance level. For this case, we have used two algorithms. One based on the Hough transformation and the second and new one based on genetic algorithm. In the following paper, we will discuss the detail of these algorithms.

4.1 Hough Transformation Algorithm:

The principal objective of this algorithm is to compute the function $F = (s, \theta, \delta x, \delta y)$ which transforms the set of minutiae P into the set Q, where

s represents a scaling factor, θ an angle of rotation and ($\delta x, \delta y$),a translation in the xy-plane as shown in Figure. P and Q are the two fingerprints to be compared which can be re-written as follows:

$P = \{p_1, K, p_m\}$ and $Q = \{q_1, K, q_n\}$, where $p_i = (x_i, y_i, \alpha_i)$ and $q_i = (u_j, v_j, \beta_j)$, for $1 \le i \le m$, $1 \le j \le n$. The Hough transform applied on the detection of the lines can be applied on the point correspondence as shown in Figure . Thus, Hough transform $F(p) = (x', y', \alpha')$ of a minutiae $p = (x, y, \alpha)$ is computed as follows:

$$\begin{vmatrix} x' \\ y' \\ \alpha' \end{vmatrix} = S \begin{vmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1/S \end{vmatrix} \begin{vmatrix} x \\ y \\ \alpha \end{vmatrix} + \begin{vmatrix} \delta x \\ \delta y \\ \theta \end{vmatrix}$$

F(p) is the transform of p.

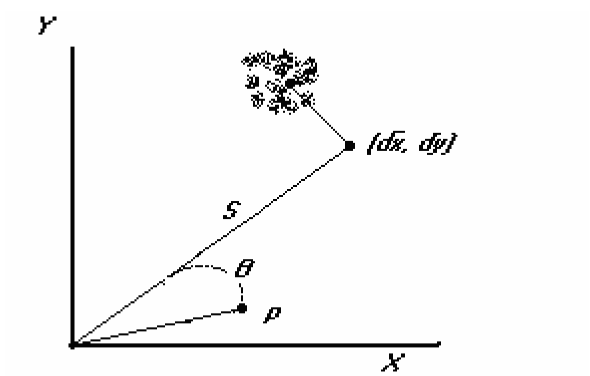

Figure 4: F(p) is the transform of p.

The computing results are grouped in a string table called A (k, l, m, n). Hough algorithm is presented as follow:

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Procedure Hough

A (k, l, m, n) $\leftarrow$ *0; k = 1, …, K; l = 1, …, L; m = 1,…,M; n = 1, …, N*

For (p r , p p , α) ∈ P do

For (q r, q p, β) ∈ Q do

For θ ∈{ θ 1 , …, θ L } do

If α + θ = β then

For s ∈{s 1 , …, s L } do

$$\begin{pmatrix}\Delta x\\ \Delta y\end{pmatrix} = \begin{pmatrix}qr\\ qp\end{pmatrix} - sk\begin{pmatrix}cos\theta 1 & sin\theta 1\\ -sin\theta 1 & cos\theta 1\end{pmatrix}\begin{pmatrix}pr\\ pp\end{pmatrix}$$

Add evidence for $F_{sk\beta 1\Delta x\Delta y}$

End for

End if

End for

End for

End for

Result $\leftarrow$ *arg max* $_{k, l, m, n}A_{(k, l, m, n)}$

End Procedure

4.2. The Genetic Algorithm Detection

Genetic Algorithms (GA's) are search and optimisation methods based on evolution in nature. They were first developed by John Holland from the University of Michigan in 1975 . The power of GA's is, instead of working with a particular point in the solution space they proceed using more than one points and they are not necessarily concerned with finding the optimal solution, but with producing a "satisfactory'' one. The structure of a genetic algorithm is based on natural selection. First, an initial population of feasible solutions is randomly generated. The initial population consists of chromosomes, encoded representations of solutions. The Selection takes place between members of the population, and a child is formed from combination of the parent chromosomes. Whether or not the child becomes a member of the population depends on its fitness value. Each new child chromosome is compared against the worst member of the population, and the better one is kept in the population. By producing new generations in this manner, the population improves and the best member of the final population is the solution returned by the algorithm.[2,7]

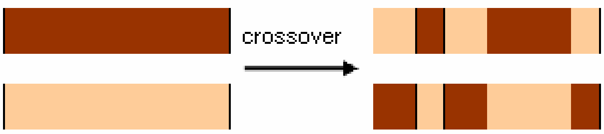

Figure 5.Uniform crossover transformation .

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The genetic algorithm proceeds as follows:

Genetic Algorithm

Begin

Initialisation: population size, number of

generations;

Repeat

Select two individuals I 1 and I 2 in the population;

Apply the crossover operator on I 1 and I 2 to

Produce a child I 3 ;

Replace one of the two individuals by I 3 ;

Delete Individuals in the population, which will be

replaced by I 3 ;

Perform immigration;

Until the population converges;

Report results.

End

The above algorithm is summarized and applied forth detection and comparing the minutiae from two fingerprint's say A (target one) and B (memorized). It proceeds as follows.

Coding the Population Characteristics

The population is presented according to Figure

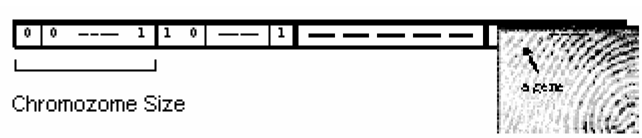

Figure 6: Chromosome's population coding.

A gene in such coding corresponds to the value '0'or '1' (Boolean values), where:

'1': There is a relation between the fingerprint minutiae of A and of those of B.

'0': The opposite case.

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The size of the population is equal to the natural number 10 “chromosomes”.

After the coding we create two classes called respectively “POP” and “CHROMO” representing the population and the chromosome.

Initial Population Generation Mechanism

The initial population is generated by the following

Boolean procedure:

```
Public intmyRand(int range) {

If (range = = 0)

return 0 ;

Return (int) Math.round(Math.tandom( )/(1.0 / (range– 1))) ;

}
```

The fitness value expressing the quality of each solution is generated and used to select the candidate solutions that will contribute to the next generation. The fitness function is identified as the correspondence rate computed from the relation between both images. The algorithm computes for each chromosome the evaluation function EVAL (Vj), and then the complete evaluation is performed as follows: $F = \Sigma j$ EVAL (Vj).

In the next step, the selection mechanism uses the following method (roulette ‘casino’) to choose randomly each individual chromosome.

```
Public double [] roulette (int U)

{

If (U = = 1)

{

For (int k = 0, k = 0 ; k  <taille_pop ; k++)

random [k] = getRandom(1) ;

Return random;

}

Else

{

For (int k = 0, k  <taille_pop*taille_chrom ;k++)
```

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randomMut [k] = getRandom (1) ;

Return randomMut ;

}

}

The roulette method returns a Boolean vector of dimension 10 (number of chromosomes). We then compute the probability Pj to select the chromosome Vjas follows:

Pj= $_{EVAL}$(V)/F

and the cumulative probability Q j = P 1 + P 2 +…..+ P j .

The selection is performed by running the roulette ten times. At each time the system generates randomly the number r taken in the interval [0, 1].

If r < Q 1 (the cumulative probability (Q 1 = P 1), the chromosome Vj is chosen as the best one. Otherwise we select the chromosome V j with 2 $\leq$ j $\leq$ population size and Q (j - 1) < r <Q j .

V. COMPARISON OF THE ALGORITHMS

Algorithm	Space requirement	Time requirement	Detecting shapes
HT	High	Long	slow
GA	Medium	Medium	Fast

VI. RESULT

A large number of fingerprint's images have been tested (about 100) using Math lab. They have been collected from friends and family members to avoid data errors. We have tested and verified one to one the fingerprint's images using both the part of the system based on Hough procedure and the second part using verification algorithm based on genetic algorithm. The results of our experiments have shown that genetic procedure is more accurate than the Hough procedure and gives about 99% of precision where Hough procedure gives about 96%. We have also verified manually the conclusion of the system about minutiae features. A relevant part shows that about 6% of type feature (arch, loop, whorl, etc.) are false or missed.

VII. CONCLUSION AND FUTURE WORK

We have presented a fingerprint verification system based on the gray-scale ridges to recognise and classify minutiae of various types. In addition to that processing, the system is used to match two sets of minutiae, the traditional algorithm of Hough and the technique of evolutionary programming based on genetic algorithms. The experimental results on a database of 100 fingerprint's image have shown that the additional-based genetic algorithm is more effective in term of correctness and less time consuming than Hough procedure and Fourier transform.
As a future work, our vision will be extended to the useof Genetic Programming (GP) .GP is different from GA-genetic algorithms, to capture the information in the image and for image filtering, pixel classification, segmentation and the detection of minutiae.

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BIOGRAPHY

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