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A Review on Pattern Recognition Using Genetic Algorithms

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ABSTRACT
Pattern recognition is a process to classify types of objects appearing in the input pattern. In computer science pattern recognition is the imposition of identity on input data, such as speech, images, or a stream of text, by the recognition and delineation of patterns it contains and their relationships. In this paper, pattern recognition is applied in Fingerprint Recognition system, face recognition system and lastly Speech recognition system. Efficient genetic algorithms are applied in recognizing fingerprints, face detection and recognition and speech recognition and they are compared with traditional methods for their efficiency. In this paper Section 1 gives the introduction to pattern recognition system. Section 2 describes various traditional and genetic algorithms techniques applied to Fingerprint Recognition System, Face Recognition System and Speech recognition System. Section 3 concludes the use of genetic algorithms over traditional techniques for pattern recognition system.

I. INTRODUCTION

Pattern recognition is a process to classify which types of objects appearing in the input pattern. In computer science pattern recognition is the imposition of identity on input data, such as speech, images, or a stream of text, by the recognition and delineation of patterns it contains and their relationships. Stages in pattern recognition may involve measurement of the object to identify distinguishing attributes, extraction of features for the defining attributes, and comparison with known patterns to determine a match or mismatch. Applications of PR cover many areas such as computer vision, face recognition, speech recognition, character recognition, signal classification and analysis, medical diagnosis etc. The PR techniques have also been used **as** an important component of intelligent system for data preprocessing and decision making. There are different approaches for pattern recognition like:

1. Statistical Pattern Recognition [Devijver1982]
2. Syntactic Pattern Recognition [Fu 1982]
3. Neural Pattern Recognition [Pao 1989]

But above these approaches have their own limitations like:

- Statistical Pattern Recognition has difficulty in expressing structural information of a pattern since the structural information are irrelevant and not in use in this approach.
- Moreover, Syntactic Pattern Recognition is based on using structural rules for extracting primitives that are difficult to learn and derive.
- In neural networks structural patterns are hidden inside the network and cannot be drawn from its computation.

So besides these three approaches, Genetic Algorithm is an another approach which is capable to solve optimization and machine learning problems. Genetic algorithms works in following steps [Mitchell et al 1996]:

- **Encoding**: GA encodes potential solution as a string of 0 and 1 called a chromosome.

- **Evaluation**: The fitness of each individual in the population is then computed. This fitness value is used to find individual probability for crossover.
- **Crossover**: After the selection process is over chromosomes chosen to be parents of next generation are recombined to form new chromosomes by using crossover operators.
- **Mutation**: Mutation is used to preserve the genetic diversity of population. In this one or more gene values get altered to prevent falling GA into local extremes.

II Applying Pattern Recognition for fingerprint recognition, face recognition, speech recognition

A. Fingerprint Recognition

Fingerprint matching technique is the most popular biometric approach used to identify people. These biometric features are known as 'Galton features' also called minutiae which contain particular information that enables their use in identification analyses[Asker M.B et al 2000]. In this paper, fingerprint matching is concerned with comparing one fingerprint minutiae with large database. It uses two different techniques:

- Hough transform procedure [Stoney D.A 1988]
- Second using genetic algorithms

1. Fingerprint Characteristics

A fingerprint is a textual image containing large number of ridges valley patterns where

- the ridges are black lines and
- the valleys are depicted by white lines.

They form groups of parallel curves, whorls, loops, deltas and bridge crossing as shown in figure 1[Maltoni et al 2003]:

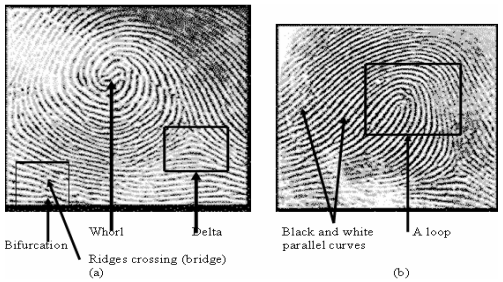


Figure 1 Basic fingerprint patterns

In order to extract minutiae from grey-scale fingerprint image different successive steps are there:

- **Image acquisition and data generation.**
- **Block direction, computation and smoothing:** It uses Coetzee method [Coetzee L 1992] which divides the image of size 256x256 pixels into small block of size 16x16 pixels in which information contained in each block is represented by intensity of each pixel as shown in figure below:

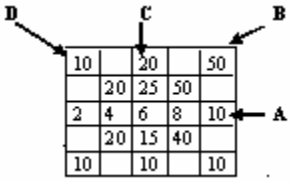


Figure 2 Intensity value of grayscale block image

- **Segmentation and binarization:** In this step image pixels are labeled with ranked number and grouped into classes or regions. In order to convert grayscale image "G" to binary mean value (U) of pixel is calculated :
  - Pixel with the value little than the mean value (U) are transformed to 0 value (white value).
  - Pixel with value greater than or equal to (U) is transformed to value 1 (Black value).
- **Skeleton post processing:** This step involves thinning or cleaning of binary image. The cleaning routine includes the ability to detect and classify ridge structures.

- **Minutiae Detection Procedure:** This step is used to develop minutiae map as shown below:

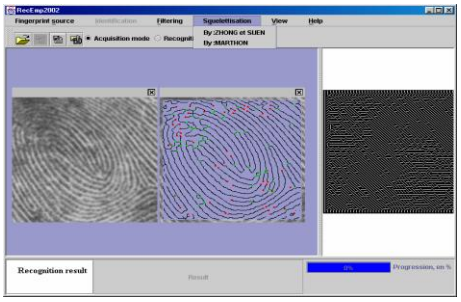


Figure 3 (a) Fingerprint image (b) Skeleton after detecting minutiae (c) Direction image

- **Fingerprint recognition procedure:** In this step, two different fingerprints are selected out of which one segment is obtained from known user and second segment is selected from live-scan in order to verify the user. For this, there are two different algorithm are given which are discussed in next section.

2. Hough Transformation Algorithm

The objective of this algorithm is to compute the function F= (s, θ, δx, δy) which transform the set of minutiae P into Q where s is the scaling factor, θ an angle of rotation and (δx,δy) a translation in the xy-plane as shown in figure 3:

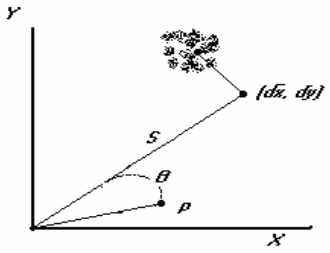


Figure 3: F(p) is the transform of p.

Hough procedure is given below:

Procedure Hough

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

For $(p_x, p_y, \alpha) \in P$ *do*
  For $(q_x, q_y, \beta) \in Q$ *do*
    For $\theta \in \{\theta_1, \ldots, \theta_K\}$ *do*
      If $\alpha + \theta = \beta$ *then*
        For $s \in \{s_1, \ldots, s_L\}$ *do*

$$\begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix} = \begin{pmatrix} q_x \\ q_y \end{pmatrix} - s_k \begin{pmatrix} \cos\theta_l & \sin\theta_l \\ -\sin\theta_l & \cos\theta_l \end{pmatrix} \begin{pmatrix} p_x \\ p_y \end{pmatrix}$$

Add evidence for $F_{x_k, y_l, s_k, \theta_l}$

        Endfor
      Endif
    Endfor
  Endfor
Endfor

Result $\leftarrow \arg\max_{k,l,m,n} A(k, l, m, n)$
End Procedure

3. Genetic Algorithm for Fingerprint Recognition

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 comparing of two minutiae is done in the following manner:

a. Coding the population

A gene is represented by Boolean values '0' or '1'
'1': if there exist a relation between two fingerprint minutiae.
'0': if there is no matching of two minutiae.

b. Initial Population Generation Mechanism

The procedure for initial population generation is given as follows:

The initial population is generated by the following Boolean procedure:

```
Public int myRand(int range) {
If (range = = 0)
      return 0 ;
Return (int) Math.round(Math.tandom( )/(1.0 / (range
      – 1))) ;
}
```

c. Roulette Wheel Selection Mechanism

The chromosomes are selected randomly by using Roulette Wheel selection mechanism which is given as follows:

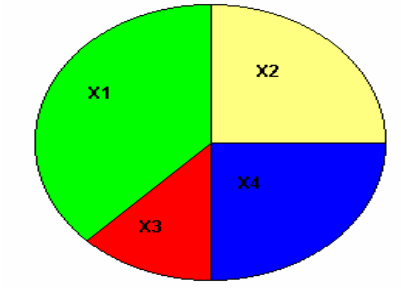


Figure 4: The Roulette Wheel

```
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++)
         randomMut [k] = getRandom (1) ;
      Return randomMut ;
    }
 }
```

d. Crossover

In this fingerprint matching algorithm, uniform crossover operator is used to crossover the two selected chromosomes which are two fingerprint minutiae. The probability Pc is taken in the range of 70% and 80%.

e. Results

Two fingerprint minutiae are tested using both the procedure that is Hough procedure as well as genetic algorithm. The results of experiment have shown that genetic procedure is more accurate than Hough procedure and gives the precision of 99% whereas Hough procedure gives 96% precision.

f. Face Recognition

Digital images and videos are gaining popularity in this multimedia era. The human face is an important object in an image or video. Detecting the location of human faces and extracting facial features in areas like human face recognition, surveillance systems, video conferencing etc. As a result this paper gives efficient face detection algorithms.

1. Problem in Face Detection and facial feature Extraction

It is very difficult to detect and extract facial features accurately because there are several parameters that affect the detection performance like wearing glasses, different skin tones, facial expression etc. moreover human face is a 3-D object. As a result true face may not be detected.

2. Face detection procedure

Face detection is divided into sub-procedures that are given in the figure 5:

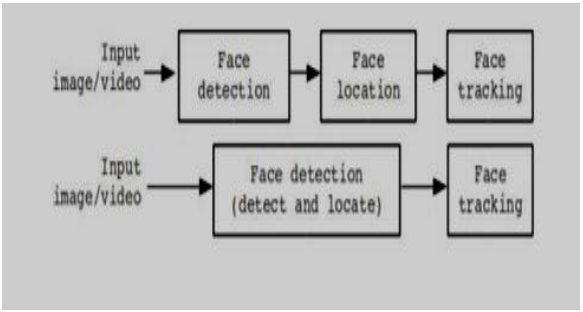


Figure 5: Face Detection Processes

2.1 Detection depending on scenarios

There are various approaches for face detection based on different scenarios which are given as follows:

- **Controlled environment**: In this scenario photographs are taken under controlled light, background etc.
- **Color images**: Different skin tones are used to find faces. The skin color differ from person-to-person and race to race so it is distributed over small region in the chrominance plane.
- **Motion images**: In this approach faces present in real time videos are detected and localized by using eye blinking detection algorithms.

2.2 Traditional Detection Methods

- **Knowledge based methods:** They are rule-based methods that try to capture knowledge of faces, and translate them into a set of rules. It is easy to guess simple rules. For example, a face usually has two eyes, and the eye area is darker than the cheeks in gray-level images. Facial features could be the distance between eyes or the color intensity difference between the eye area and the lower zone. The problem with these methods is the difficulty in building an appropriate set of rules. However, this approach alone is very limited. It is unable to find many faces in a complex image.
- **Template Matching:** Template matching methods defines a face as a function. This approach tries to find a standard template of all the faces. For example, a face can be

divided into eyes, face contour, nose and mouth. A face model can be built by edges. The templates use the relation between face regions in terms of brightness and darkness. These standard patterns are compared to the input images to detect faces. This approach is simple to implement, but it is inadequate for face detection because it cannot achieve good results with variations in pose, scale and shape.

2.3 Human Face detection using genetic algorithm and Eigenface Technique

This method is for detecting and extracting facial features in gray-level images which divided into different stages:

- Firstly, the human eye regions are detected by testing valley regions in the image.
- Genetic algorithm[Goldberg 1989] is used to select pair of eye candidates to form possible face candidate.
- After that fitness value of each candidate is measured based on its projection on the eigenfaces[M. Turk et al 1991].
- Face candidates with high fitness values are selected. And possible face symmetry is measured.
- Extraction of facial features is based on eyebrow, iris, nostril and mouth corner.

2.3.1 Possible eye candidate detection

The eye regions are located by detecting valley points in an image. The equation for valley field extraction[P. Maragos 1987] is

$\Phi_v = f(x,y)$. B- $f(x,y)$

Where f(x, y) is the image . A pixel (x,y) is considered possible eye candidate iff:

$f(x,y)<t1$ and $\Phi_v(x,y)>t_v$ where t1 and t_v are threshold values. Therefore in genetic algorithm only two entries are selected from the buffer to form possible face candidate which restrict the search space to possible eye candidates which in turn reduce the run time.

2.3.2 Structure of a chromosome

The structure of chromosomes is represented by two components which are given as follows:

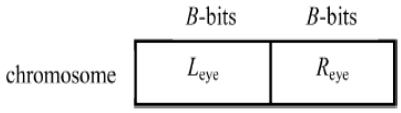


Figure 6: Structure of a chromosome

The number of bits used to represent L_{eye} and R_{eye} is B= $\log_2 N$ where N is total number of detected eye candidates. thus total number of bits in each chromosome is 2B. Figure 7 shows the selected face region based on location of an eye pair.

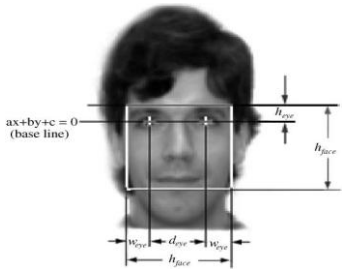


Figure 7 Head Model

As a result initial population of chromosomes is produced randomly from N(N-1)/2 chromosomes.

2.3.3 The fitness value

Fitness value of face candidate can be calculated using eigenfaces which are obtained by extracting components from training set of pre-processed face images. The fitness value of possible face region for n^{th} chromosome is given as:

f(n) = 1/Є(n) where Є(n) is a measure of the distance between input candidate and training images. It is calculated as chromosomes with smaller distance will have larger fitness value. In this method chromosomes having larger fitness value will have better chance to be selected for next generation.

2.3.4 Crossover

In this approach, two point crossover is used for crossover process. Two cutting points are selected randomly within the chromosome for exchanging the contents as shown in the figure 8:

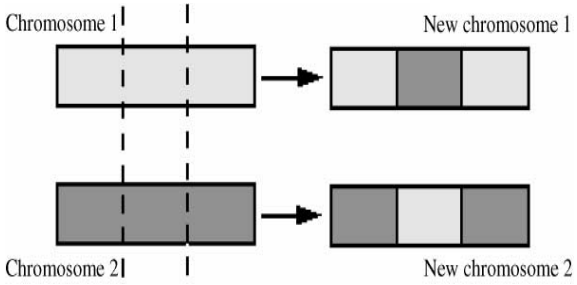


Figure 8 : The crossover process

3. Experimental Results

In this approach, if the fitness value of chromosome is greater than threshold value, it is assumed to be possible face candidate. If the difference between left and right half regions of candidate is greater than threshold value it is declared a non-facial image. So experimental results have shown that tilted human face can be detected using genetic algorithm even if the face is shirred, under shadow, under bad lighting conditions and wearing glasses.

- **Speech Recognition System**
- The Speech Recognition System consists of two speech related task:
- **Speech Understanding**: Speech understanding means getting the meaning of utterance such that one has correctly recognized all of the words or not.
- **Speech Recognition**: It is the process of simply recording the speech without necessarily knowing the meaning of utterance.

Automatic speech recognition system has many practical uses like cartographer, mail sorter, airplane pilot and handicapped persons. So in this paper different traditional and genetic algorithm based speech recognition systems are described.

1. Traditional Hidden Markov Model for Speech Recognition

Hidden Markov Model [Abushariah et al 2010] uses stochastic model to compare the unknown utterance generated by each model. HMM are described with finite state automata. In HMM model M is defined by N states, K observation symbols and three probabilistic matrices:

M= {Π, A, B}

The procedure for observation symbol generation is given as follows:

(1) Start in state i with probability π_i.
(2) $t = 1$.
(3) Move from state i to j with probability $a_{i,j}$ and emit observation symbol $o_t = k$ with probability $b_{i,j,k}$.
(4) $t = t+1$.
(5) Go to 3.

The algorithm has 3 basic steps:

- **Recognition**: This involves the classification of unknown observation sequence. Classification means identification of unknown observation sequence by choosing most likely class to produce observation sequence. For identification one must compute above given model.
- **Training**: It is the estimation of parameters of model from a set of known training data.
- **Evaluation of the probability of observation sequence**.

But this traditional model has various disadvantages which are given as follows:

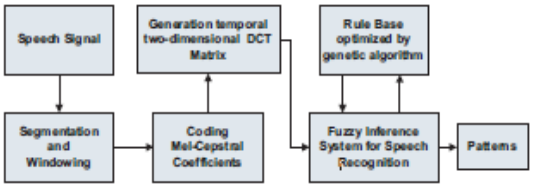
The deficiency of HMM is the poor modeling of the acoustic events related to each state.

Second weakness of HMM is the observation vectors within each state are assumed uncorrelated but these are correlated.

This leads to use of another genetic based algorithm which is given in the following section.

2. Genetic Algorithm based Speech Recognition System

The proposed Speech Recognition System ISRS block diagram is given below:



A. Encoding : A speech signal is encoded and parameterized in Two-Dimensional

Time matrix with four parameters of speech signal. The Two-Dimensional Time Matrix[T. N.N Ahmed, 1974] is given as follows:

- **Two-dimensional Time matrix DCT Coding**

➢ Initially, speech signal is digitized and divided into segments which are then encoded in a set of parameters.

➢ The DCT coefficients are computed and two-dimensional matrix is generated based on each signal to be recognized to generate rule using Madami fuzzy inference system[Z. Weihong et al 2010]

➢ The elements of matrix are obtained as follows: (a) whenever a word is spoken ten examples of utterances are obtained as P^m_j where j=0,1,2……9 and m= 0,1,2…….9.

➢ The continuous genetic algorithm is configured with population size of 100, generations of 300, and with mutation probability 15% and two chromosomes, with 40 genes to optimize cost function.

B. Experimental Results

Various training tests are performed by using speech signals of only male candidates , female candidates and it is observed that ISRS system is able to extract more reliable characteristics of speech signal and produce good recognition results as compared to traditional HMM model. So by using digital filter and increasing number of parameters ISRS system increases the performance of genetic algorithms.

III. CONCLUSION

In this paper pattern recognition is applied to various field like Fingerprint Recognition System, Face Detection System and Speech Recognition System and it is seen from experimental results that genetic algorithm performs better than traditional methods like

- In Fingerprint Recognition System genetic procedure gives more accuracy than Hough procedure as it gives the precision of 99% whereas Hough procedure gives 96% precision.
- Similarly in Face Detection System, tilted human face can be detected using genetic algorithm even if the face is shirred, under shadow, under bad lighting conditions and wearing glasses which is otherwise difficult to detect using traditional detection methods .
- Thirdly, Speech Recognition System have shown that ISRS system is able to extract more reliable characteristics of speech signal and produce good recognition results as compared to traditional HMM model. So by using digital filter and increasing number of parameters ISRS system increases the performance of genetic algorithms.

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