Rule Induction Technique for Fingerprint Identification

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Abstract **–** Pattern recognition problems computer based are very important and essential in our real life. There are many approaches have been used in pattern recognition problem such as: Fourier Descriptor, Moment Invariant. But the main defect of these methods is the long time processing and large computer space. This paper, presents a new approach Artificial Intelligence, of Rule Induction technique. By this approach, the essential and specific features of object have been extracted from contour of object to be recognized. The characteristic of these features are easy computed and requires fewer amounts of time and space, then high speed in recognition and decision. Such features are (number of curves inside the fingerprint, number of check point for each curve). It gives good and accurate results. We test the performance of this system using many contours of fingerprint, and get good and accurate results.

Keywords- Fingerprint, Pattern recognition, Image processing, Artificial Intelligence, Rule Induction, B_Spline

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1. Introduction:

Pattern recognition techniques are the important tools used in the field of machine intelligent [1].

Pattern recognition could be defined as: "the categorization of input data into identifiable classes via the extraction of significant feature of attributes of the data from background of irrelevant detail" [2].

We recognize characters, pictures, music and the objects around us. This process may be referred to as sensory recognition which includes aural and visual recognition. This recognition process involves the identification and classification of spatial and temporal patterns.

There are many techniques have been largely and earliest used in pattern recognition fields, such that Fourier descriptor [3] and moment invariants [4].

Pattern recognition techniques are widely used in real life, such that, we need system for handwritten recognition. We need a system for target detection and classification. We need system for blood cell analysis and classification, etc.

In this paper, presentation of Artificial Intelligence technique of rule induction for fingerprint recognition was employed to generate a classification rule from features extracted from examples for contour of the object of the fingerprint to be recognized. The induction technique was first developed, by Hunt at 1966, who produce the (Concept Learning Algorithm) CLS, and was subsequently improved by Quinlan at 1979, by using ID3 algorithm (Iterative Dichotomies 3) [5]. This approach presented in this paper adopts the features are essentially and specific of object such as (number of curves inside the fingerprint, number of check point for each curve …). The classification of unknown objects using rule induction was computationally inexpensive compared to the conventional approaches, (Fourier Descriptor, Moments Invariants).

2. Induction Algorithm:

This algorithm is based on inductive inference which is "the process of inferring general law from particular examples [6].

In order to be able to use induction, we require the following [7]:

1- Examples: The examples or training set from the basis of induction process.

2-Attributes: The examples have sets of characteristics that describe them, and enable comparisons to be made between different examples. The attributes may be:

a- Descriptive categories (e.g. small, medium, large).
b- Real measurements, (e.g. height in meter).
c- Integer values (e.g. age in years).
d- Logical descriptive, (e.g. true, false, on top of).

3-Classes: the classes represent the decision or classification. The ID3 algorithm is the tool of the classification mechanism, which it will describe, in the following article.

2.1. ID3 Algorithm:

The ID3 algorithm uses a training set of examples to induce IF… THEN … rules, which are form a simple decision, tree [3]. These examples describe the attributes and the resulting classes. The training set contains at least one type of cases, which the expert has deal with. The expert draws up a set of examples, then inductive system read and analysis, these examples, which describe the pattern involved. Induction rules can be produced for these examples.

3. The Developed System:

The structure of the object recognition system, which designed and implemented to recognize the object of fingerprint using ID3 algorithm, consists from the following major part:-

1- Input Image of the fingerprint.

2- Feature extraction by using B_spline method to determine the check point for each curve of the fingerprint.

3- Object classification Using Rule Induction.

Figure (1) shows the Block diagram of Fingerprint Recognition system.

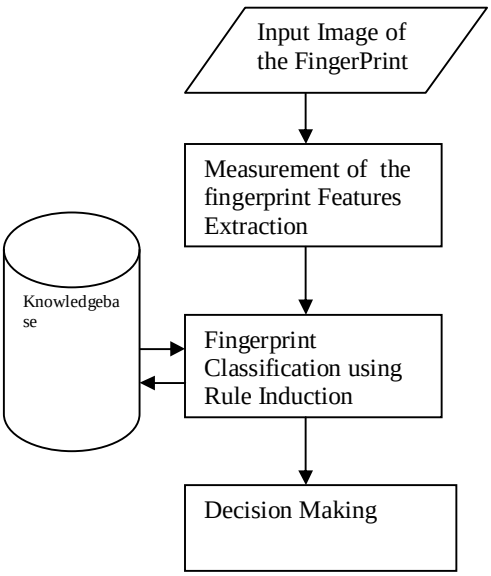

Figure (1). Block diagram of Fingerprint Recognition system

3.1. Input Image:

The input image of the fingerprint is captured by scanner, the image size is (160,160) pixel, as shown in Fig. (2).

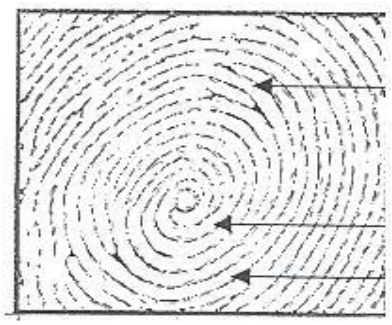

Figure (2): The input Image of fingerprint

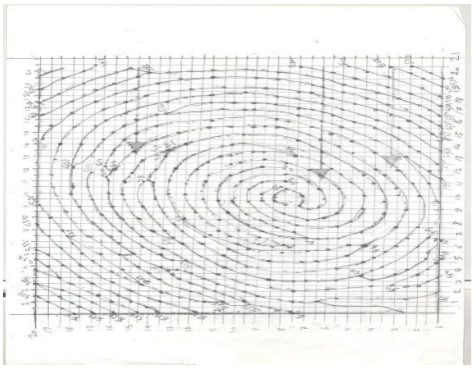

Figure (3). Processed Input FingerPrint image

3.2. Feature Extraction:

In this step, we have to extract the features of the fingerprint by using B_spline method to determine the check point for each curve in the fingerprint image, as shown in the next paragraph.

The control points of the finger were employed to generate a classification rule extracted from examples for contour of the fingerprint to be recognized.

The details of the extracted control Points will be shown in the experimental result part, as shown in Figure (4).

3.3. B_Spline Method:

From a mathematical point of view, a curve which is generated by using the

vertices of a defining polygon is dependent on some interpolation or approximation scheme to establish the relationship between the curve and the polygon.

Let P(t) be the position vector along the curve, as a function of a parameter t, a curve generated by the use of the B_spline basis is given by [8]:

$$p(t) = \sum_{i=0}^{n} p_i N_{i,k}(t) \quad .....(1)$$

Where, p_i are the n+1 defining polygon vertices.

For the i^{th} normalized B_Spline basis curve of order k, the weighting function $N_{i,k}(t)$ is defined by the recursion formulas:

$$N_{i,1}(t) = \begin{cases} 1 \ if \ \ X_i \ \le t < X_{i+1} \\ 0 \quad Otherwise \end{cases}$$

And

$$N_{i,k}(t) = \frac{(t - x_i)N_{i,k-1}(t)}{x_{i+k-1} - x_i} + \frac{(x_{i+k} - t)N_{i+1,k-1}(t)}{x_{i+k} - x_{i+1}} \quad .....(2)$$

Where x_i is an element of a knot vector which is the parameter t varies from 0 to t(max) along the curve p(t).

3.4. Fingerprint Identification Using Rule Induction:

A rule tree is automatically generated from examples by ID3 algorithm. So, we have been designed and implemented a Visual Basic program to generate and produce a decision rule tree for fingerprint identification system.

Rule induction is chosen for these approach, because it provides solution that that uses a minimum number of features (curve no., control no.), and give fast decision and accurate distinction between objects of fingerprint.

4. The System Implementation and Experimental results:

An experiment was designed to test the performance of fingerprint identification system to identify the contour of the fingerprint were selected to train the system.

After reading image of fingerprint, features of fingerprint have been measured, and then a rule tree was generated via used ID3 algorithm.

This system was implemented by written a Visual Basic Ver. 6. See Appendix A.

The following steps explain the detailed description of implementation of the designed system. This section consists of two sub-sections:

The first one provides a full description of the developed system while the second deals with the experimental results obtained by the implementation of the system.

4.1. System Algorithms:

The system is built on a set of algorithms, which can be described as follows:

1- Input Fingerprint Image algorithm.
2- Feature Extraction algorithm.
3- ID3 Fingerprint Identification algorithm.

4.1.1. Input Fingerprint Image algorithm:

This algorithm shows how to read the image of the fingerprint, display on the screen, save in data file.

Input: Image file of finger print

Output: Data file (curve number, control number)

Step1: scan image file of fingerprint by scanner device.

Step 2: read image file.

Step 3: save the coordinate of the fingerprint object in data file.

Step 4: close data file.

End.

4.1.2. Feature extraction algorithm

Input: Data file1

Output: Data file2 (curve number, control number)

Step 1: calculate number of curves for fingerprint in image file.

Step 2: calculate number of control points in each curve.

Step 3: save (Finger_no, curve_no, control_point) data file (table1).

Step 4: Call B-Spline function to draw the new image of the original fingerprint.

End.

4.1.3 ID3 Fingerprint Identification algorithm

The following decision tree is produced by Id3 algorithm to get the type of the fingerprint.

Begin

If (curve_no <= 35) then

If (control_point[1]) < 35)

Else If (control_point[2]) < 20)

Else If (control_point[3]) <25)

Else If (control_point[4]) <8)

……..

Else If (control_point[35]) <4)

Output: FingerType = : ("Finger1")

End.

4.2. The Experimental results

4.2.1. .Input Image: Figure (2) shows the input image of fingerprint.

4.2.2. Measurement of the fingerprint Features Extraction:

In order to extract features of the object from an image, there are several significant and essential features that should be extracted from the object of the fingerprint. So, the image of the fingerprint will be breakdown into the many curves. Each curve contains many of control points, as shown in Figure (3) and Figure (4).

The origin fingerprint consists of 35 curves. Curve number 1 for example consist of 32 control points and Curve number 2 consist of 20 control points, and so on, into curve number 35 which contain four curves as shown in the Table(1).

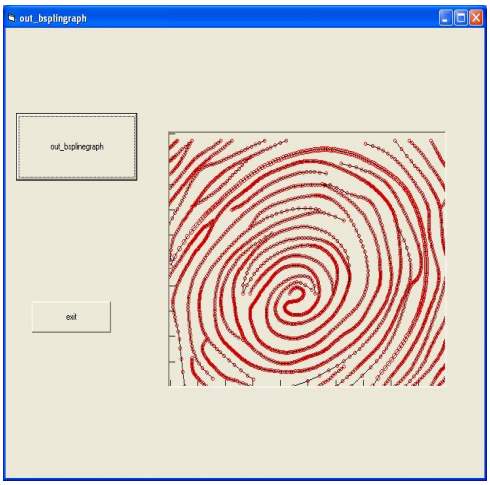

Figure (4) . The output processed curves of the origin fingerprint

Table (1): curves number, control points and fingerprints identification.

Control point No.	Curve No.	Fingerprint Class	No.
32	Curve no.1	Finger1	1
20	Curve no.2	Finger1	2
25	Curve no.3	Finger1	3
8	Curve no. 4	Finger1	4
30	Curve no. 5	Finger1	5
8	Curve no. 6	Finger1	6
32	Curve no. 7	Finger1	7
14	Curve no. 8	Finger1	8
7	Curve no. 9	Finger1	9
16	Curve no. 10	Finger1	10
5	Curve no. 11	Finger1	11
7	Curve no. 12	Finger1	12
9	Curve no. 13	Finger1	13
37	Curve no. 14	Finger1	14
3	Curve no. 15	Finger1	15
12	Curve no 16	Finger1	16
14	Curve no. 17	Finger1	17
9	Curve no. 18	Finger1	18
29	Curve no. 19	Finger1	19
19	Curve no. 20	Finger1	20
7	Curve no. 21	Finger1	21
6	Curve no. 22	Finger1	22
5	Curve no. 23	Finger1	23
6	Curve no. 24	Finger1	24
4	Curve no. 25	Finger1	25
3	Curve no. 26	Finger1	26
4	Curve no. 27	Finger1	27
12	Curve no. 28	Finger1	28
4	Curve no. 29	Finger1	29
8	Curve no. 30	Finger1	30
9	Curve no. 31	Finger1	31
7	Curve no. 32	Finger1	32
5	Curve no. 33	Finger1	33
5	Curve no. 34	Finger1	34
4	Curve no. 35	Finger1	35

4.3.3 The Decision Making and Identification Result:

The curve number and control point that extracted from step 2, are passed into decision tree (rule induction) to make a decision making and then get an accurate type of fingerprint identification, as shown in Figure (5).

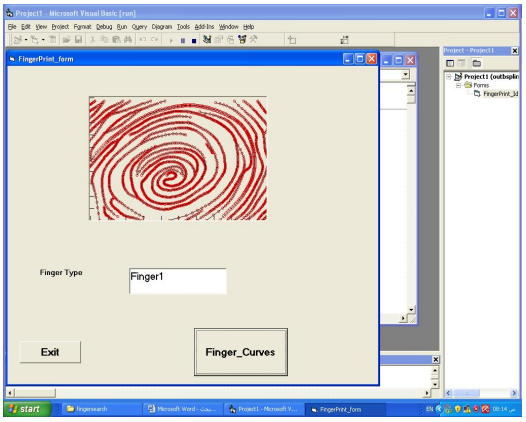

Figure (5). The output of the final fingerprint and its type

The sub code implementation of the some function of the system will be described in Appendix A.

5. Conclusion:

Using rule induction technique to generate classification rules from examples was demonstrated, and has been successfully extended to identify the true type of fingerprint via use ID3 algorithm, viewed from 35 curves. It has been demonstrated that the rule trees provided a method of identification, such fingerprint which is both computationally efficient, and faster decision and high accurate. In current research, a new technique have been adopted to segment the image of the fingerprint into many curves by using B_Spline method to make smooth and accurate curves, which each curve contain a number of check point using later in rule induction to make decision making of fingerprint type as demonstrate in the last steps.

References

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Appendix A

```
Private Sub outbsplinegraph_Click()
Dim xx(1000), yy(1000), zz(1000), t As Double
Dim ff(1000), vv(1000), xx1, yy1, xs, ys, gg, jj As
Double
Dim curveno, controlno As Integer

yt = 10: xt = 10: aa = 8
k = 0
For i = 1 To 21
k = k + 1
xx(i) = k
yy(i) = k
Next i
minx = xx(1): miny = yy(1): maxx = xx(1): maxy
= yy(1)
   For i = 1 To 20
   If (xx(i) >= maxx) Then
maxx = xx(i)
```

```
End If
If (yy(i) >= maxy) Then
maxy = yy(i)
End If
If (xx(i) <= minx) Then
minx = xx(i)
End If
If (yy(i) <= miny) Then
miny = yy(i)
End If
Next i
    xx1 = maxx - minx: yy1 = maxy - miny
 X1 = minx: Y1 = miny: X2 = p1.ScaleWidth: Y2
= p1.ScaleHeight
 gg = (X2 - X1) / xx1: jj = (Y2 - Y1) / yy1
Open "F:\outcurve19.txt" For Input As #1
Input #1, m

For i = 1 To m
Input #1, xx(i), yy(i)
Next i

 For z = 1 To m
 xs = X1 + (gg * (xx(z) - minx))
 ys = Y2 - (jj * (yy(z) - miny))
 ff(z) = xs: vv(z) = ys
  p1.Circle (xs, ys), 3, RGB(255, 0, 0)
 Next z
```