Classifying Fingerprint Images using Neural Network: Deriving the Classification State

DB & Fuzzy system

유재학

E-mail: dbzzang@tiger.korea.ac.kr

DB & Fuzzy System LAB. 유재학
Contents

1. Introduction

2. Classification System of Fingerprint Images
   1) Fingerprint Images
   2) The Network Architecture
   3) Learning rule
   4) Classification Experiment

3. Evaluation of The Internal State using Principal Component Analysis
   1) Pattern classification state

4. Conclusion
1. Introduction

• automatic fingerprint classification
  - create an efficient database for fingerprint matching
  - problem: classification efficiency and reduction in reliability

• Four-layered neural network
  - extract feature from two-dimension data (16×16 pixels)

• Supervised learning
  - back propagation algorithm with a so called two-step training method
2. Classification System of Fingerprint Images

1) Fingerprint Images

- Fingerprint patterns
  - Normal arch, Tented arch, Right loop, Left loop, Whorl
- Fingerprint classification can be divided
  - Key on feature points and ridge line orientations

![Figure 1. Categories and characteristics of fingerprint images](image-url)
- Fingerprint image data contains:
  : noise and variations in contrast
  : direction extraction is difficult
- Feature ridge pattern is extracted from fingerprints:
  : does not require additional preprocessing

Figure 2. Characteristics fingerprint pattern (Normal arch).
This pattern is an example of actual data.
2) The network architecture

- Four-layered network which has one subnetwork for each category and has connections from each horizontal and vertical

- No weights on the connections from the third hidden layer to the output layer

![Network Architecture](image-url)
- Learning state for each category falls
  : a local minimum and recognition rate will be reduced
- respect to this problem
  : one subnetwork corresponding to each category
  : a structure obtains an output using subnetwork cooperation
- each subnetwork can be trained independently
  : shortened learning time and it can expert an increase in learning accuracy
3) **Learning rule**

- Link weights and unit thresholds are adjusted using back error propagation learning rule

- The subnetwork are taught the characteristics of a category: raise the recognition accuracy

- Step

(1) First: subnetworks is being trained, the most important patterns are identified and only those patterns are learned.
output error $E_L$ at iteration $L$ is less than $\varepsilon_0$ during the first step

(2) second step

: error becomes less than $\varepsilon_1$ when

: the difference in the errors at steps $L$ and $L - 1$ becomes less than $\varepsilon_2$.

- $\varepsilon_0 = 0.001$, $\varepsilon_1 = 0.8$, $\varepsilon_2 = 0.01$
4) Classification Experiment

- Classified 100 fingerprints per category,
- for a total of 500 fingerprints.

<table>
<thead>
<tr>
<th></th>
<th>Normal arch</th>
<th>Tented arch</th>
<th>Right loop</th>
<th>Left loop</th>
<th>Whorl</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of First</td>
<td>88 (17.6)</td>
<td>52 (10.4)</td>
<td>97 (19.4)</td>
<td>98 (19.6)</td>
<td>95 (19.0)</td>
<td>430 (86.0)</td>
</tr>
<tr>
<td>candidate patterns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of second</td>
<td>12 (2.4)</td>
<td>47 (9.4)</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>65 (13.0)</td>
</tr>
<tr>
<td>candidate patterns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of misclassified</td>
<td>0 (0.0)</td>
<td>1 (0.2)</td>
<td>3 (0.6)</td>
<td>0</td>
<td>1</td>
<td>5 (1.0)</td>
</tr>
<tr>
<td>patterns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>100 (20.0)</td>
<td>100 (20.0)</td>
<td>100 (20.0)</td>
<td>100 (20.0)</td>
<td>100 (20.0)</td>
<td>500 (100.0)</td>
</tr>
</tbody>
</table>

Table 1. Classification results for 500 unknown pattern data
3. Evaluation of The Internal State using Principal Component Analysis

1) Pattern classification state

- Second hidden layer: applying principal component analysis
- three principal components
- 40 percent of the distance between the maximum and minimum values represent the same category.

![Figure 4. Results of a principal component analysis of the unit values in the second hidden layer](image-url)
4. Conclusion

- Classification of two-dimensional fingerprint data
  : first candidate (classification rates of 86.0 percent)
  : second candidate (high values of 99.0 percent)
- Principal component analysis in the second hidden layer
  : effective at classifying fingerprint patterns