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- This article presents a method to develop of Thai handwritten recognition using Fourier Descriptors and Back-Propagation Neural Networks.
- There are three steps of our methodology,
 - Data Preprocessing Method
 - Training Method
 - Pattern Recognition Method

Data Preprocessing Method

 Data preprocessing method is based on feature extraction to find the edge of character-image (described by a group of Fourier Descriptors: FD).

Training Method

 Training method is based on Back-Propagation Neural Network technique to processed Thai Handwritten character images to identify the centroid of each character, resulting in 44 prototypes.

Pattern Recognition Method

 Pattern recognition method is based on Back-Propagation Neural Network technique to identify the unknown image (Thai handwritten character).

- The processing is based on Thai characters on which preprocessing have been conducted.
- There are 44 Thai characters:
 - กขฃคฅฆง จฉชซฌญ ฏฏฐฑฒณ ดตถทธน บปผฝพฟ ภมยรถว ศษสหพอฮ

DATA PREPROCESSING METHOD

- Character-images are images of Thai handwritten characters.
- The output will be stored in the term of digital data by scanning. One bitmap file with gray scale pattern and 256 levels specifics one character.

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Figure 1 A prototype character-image.

Binarization

Binarization converts gray-level image to black-white image, and to extracting the object component from background, this scheme will check on every point of pixel.





Figure 2 The example of binarization scheme.

Binarization

- The individual bit bares 2 possible values:
 - 1 refers to background and
 - 0 refers to object 0

Figure 3 The diagram of extracting the object from the background component in the image.

 $\Delta \Delta \Lambda$

| 255 |
|-----|
| 255 |
| 251 |
| 254 |
| 254 |
| 246 |
| 254 |
| 248 |
| 255 |
| 253 |

- 0 0

(A)

255 255 255 251 255 -254 255 255 243 255 255 255 255 255 253 255 255 255 255 254 255 253 255 255 255 255 255 255 255 0 252 254 255 255 252 255 255 255 255

(B)

0 0 0 0 0 1 1

1

(C)

1 0 1 1

0 1 1

0 1 1

0 1 1

0 1 1

0 0 1 1

1 1 1

1 1 0 1

1 1

1 1 1 1 1 1 1 1 1 1

0 1 1

0

Edge Detection

- Edge detection is one of an important image processing phases.
- This paper uses chain code technique to detect the image's edge. The direction has been classified by 8 categories:
 ³
 ²
 ¹

Figure 4 Chain code with 8 directions.

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Edge Detection

- Once the edge of image has discovered, shown in figure 3, the process needs to find the character line.
- The coordinate (x_k, y_k) is represented by complex number as the formula:

| 6.0000 + 4.0000i | 5.0000 + 5.0000i | 4.0000 + 6.0000i |
|-------------------|-------------------|-------------------|
| 4.0000 +10.0000i | 4.0000 +11.0000i | 4.0000 +12.0000i |
| 4.0000 +16.0000i | 4.0000 +17.0000i | 4.0000 +18.0000i |
| 4.0000 +22.0000i | 4.0000 +23.0000i | 4.0000 +24.0000i |
| 4.0000 +28.0000i | 4.0000 +29.0000i | 4.0000 +30.0000i |
| 8.0000 +33.0000i | 9.0000 +33.0000i | 10.0000 +33.0000i |
| 14.0000 +33.0000i | 15.0000 +33.0000i | 16.0000 +33.0000i |
| 20.0000 +33.0000i | 21.0000 +33.0000i | 22.0000 +33.0000i |
| 26.0000 +33.0000i | 27.0000 +33.0000i | |
| | | |

$$u_k = x_k + iy_k$$

Figure 5 coordinate (x_k, y_k) represented in character image.

Fourier Descriptors

- **Fourier Features** used to describe the edge of the object works by identify coordinate (x_k, y_k) ; K = 0, 1, ..., N-1 where N is any other area in the image.
- All point (x_k, y_k) will be represents as complex number.
- Therefore, the DFT can be derived as below:

$$f_{l} = \sum_{k=0}^{N-1} u_{k} \exp\left(-j\frac{2\pi}{N}lk\right) \qquad l = 0, 1, ..., N-1$$
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Fourier Descriptors

- From the above formula, coefficient vector will be automatically calculated.
- This vector fits as 1 dimension with the size of 1x10 or 1xn



TRAINING METHOD

- Artificial neural networks are relatively crude electronic networks of "neurons" based on the neural structure of the brain.
- They process records one at a time, and "learn" by comparing their classification of the record with the known actual classification of the record.

TRAINING METHOD



Figure 7 The Neural Network Layer.

Training an Artificial Neural Network

In the training phase, the correct class for each record is known (this is termed supervised training), and the output nodes can therefore be assigned "correct" values "1" for the nodes corresponding to the correct class, and "0" for the others.

Training an Artificial Neural Network

- It is thus possible to compare the network's calculated values for the output nodes to these "correct" values, and calculate an error term for each node.
- These error terms are then used to adjust the weights in the hidden layers, the next time around the output values will be closer to the "correct" values.

The Iterative Learning Process

The network processes the records in the training data one at a time, using the weights and functions in the hidden layers, and then compares the resulting outputs against the desired outputs.

The Iterative Learning Process

- Errors are then propagated back through the system, causing the system to adjust the weights for application to the next record to be processed.
- This process occurs over and over as the weights are continually tweaked.
- During the training of a network the same set of data is processed many times as the connection weights are continually refined.

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EXPERIMENTAL

- The data were generate from 100 writers. Each writer wrote about 49 character by free-hand writing.
- The total data of 4840 characters were generate. The data were divided into two sets. The training set consists of 4400 and the test set is 440 data.

EXPERIMENTAL

- Each character was preprocessing to Fourier extraction and the result of preprocessing is to recognition and identified by Back-Propagation Neural Network.
- The input layer is 10 nodes, hidden layer contained 70, 40, 30 nodes and output layer is 1 node.
- The network were performed was used in the test set process is 85.5%

EXPERIMENTAL

| Training Algorithm | Back-Propagation |
|----------------------|---|
| Structure of Network | 3 hidden Layer Input node 10 Layer 1: 70 nodes Layer 2: 40 nodes Layer 3: 30 nodes Output layer : 1 node |
| Performance Function | Mean-Square Error |
| Performance Goal | 0.002 |
| Minimum Gradient | le-9 |
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CONCLUSION

- In this paper, using neural networks for handwritten recognition is a field that attracting a lot of attention.
- Handwritten recognition has become an important field of research, because Thai characters are complex and are composed of circles, zigzags, curves, and head.

CONCLUSION

- In this paper, using the Fourier descriptors extraction process. After each character is extracted, the features are fed to the Back-Propagation Neural Network with is recognition engine.
- The system performance of the network was estimated to 85.5% in the best case.
- In the future work the network, this can be done by using online handwritten.

EXPERIMENTAL RESULT

- We train the system using the RCP training scheme to find the centroid of the prototype (44 Prototypes) and membership function.
- Finally, the FD of unknown character-image is used to perform recognition step.
- In this way the experimental results of recognition, RCP can perform with accuracy up to 91.5%.