Recognition of Rotating Images Using an Automatic Feature Extraction Technique and Neural Networks

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ABSTRACT: *This paper presents a new automatic feature extraction technique and a neural network based classification method for recognition of rotating images. Image processing technique extracts global features of a image and converts a large size image into a one-dimensional small vector. An especial advantage of the proposed technique is that the extracted features are same even if original image is rotated with rotation angles from 5 to 355 or rotated and little bit distorted. The proposed technique is based on simple Co-ordinate geometry, fuzzy sets and neural networks. The proposed approach is very easy in implementation and it has implemented in C++ on Sun workstation. The experimental results have demonstrated that the proposed approach performs successfully on a variety of small as well as large scale rotated and distorted images.*

1. INTRODUCTION

Image Processing techniques which are invariant to rotation and distortion and decrease the image size can be very useful for a variety of neural network based automated pattern recognition systems.

Image fragmentation, Fourier-Transformation and feature extraction by segmentation [1, 3, 4, 6, 10] are often used to convert large size data sets into smaller before they can be used by Artificial Neural Networks (ANNs) because if the training data sets are smaller, ANNs training as well as recognition process is faster and free from many problems [1, 2].

A number of image processing and feature extraction algorithms have been proposed for feature extraction for Chinese character [11], Arabic character [5], Hindi character [1] and other images [4, 7] but most of the existing feature extraction techniques are rotation and distortion dependent and it is very difficult to extract features such as strokes, holes, endpoints, etc., if the image is little bit rotated, shifted or distorted.

In this paper we propose an approach for global feature extraction which is independent of rotation and distortion as well as converts two-dimensional large data set into one-dimensional data set and a neural network for classification of extracted features. The proposed approach is based on basics of Co-ordinate geometry, Fuzzy Sets [6] and ANNs [1, 2].

The remainder of this paper is organised as follows. In Section II, we present a full description of the proposed approach. Some experimental results are shown in Section III. Finally, Section IV concludes the paper.

2. PROPOSED TECHNIQUE

The proposed technique is based on the idea that each point on a circle (excluding inside or outside of a circle) has static distance from its centroid and it is called radius (r). A point can be moved anywhere on a circle but distance r from its centroid will not change and number of points is also static and it will not change when points are moved on a circle. Of course the number of points will be changed if we do not have a complete circle and it is a case of distorted images. One of the main roles of fuzzy techniques which we use in our approach, is to make complete circle from incomplete circle. Finally, we use feedforward neural network [1, 2] for classification of data collected from previous stage. The whole idea is described below.

2.1 Preprocessing

We convert scanned image into digitised (binary) image ie., image with pixels 0 (white) and 1(black). After converting image, we reduce unnecessary pixels (0) from the original image. For this purpose, we use following algorithm.

Algorithm 1:

- Start from top-left corner, repeat for each column and row.
 If (sum of all pixels) in column/row > 0 then save column and row
 else don't save (delete from the image) column/row
- Calculate and save height and width of the reduced binary image.

The whole process is shown in Figure 1.

Centre of the Preprocessed Image

We calculate the centre of the preprocessed image using formula as below.

$$\text{Centre_x} = \frac{\text{Width} + 1}{2}; \quad \text{Centre_y} = \frac{\text{Height} + 1}{2}$$

Once we get the centre of the preprocessed image , we draw circles with centroid (centre_x, centre_y) and various radiuses (r_max, ... ,r_min) as shown in Figure 4 and calculate the sum of all black pixels (1) as well as all black and white pixels (total pixels) belonging to each circle. This sum is fuzzy for distorted images. We use fuzzy sets with membership function as shown in Figure 5 and we calculate the membership values for each radius and those values are used by ANNs for final classification. For this purpose we use following algorithm.

Algorithm 2:

- For each black pixel (x,y), calculate radius (r) using following formula.

$$r = \sqrt{(\text{centre_x} - x)^2 + (\text{centre_y} - y)^2}$$
- Sum all pixels with same radius (sum_r_max, ... ,sum_r_min).
- Calculate membership for each circle or disk using following membership function.

$$m_f(bp) = e^{-\frac{(|bp - rbp|)}{\text{total_pixels}}}$$

where rbp = (total-pixel) div 2, total_pixel=(black+white) pixels belong to circle.

3. EXPERIMENTAL RESULTS

The proposed approach has been implemented in C++ on Sun workstation. Many images including medical, letters and faces were scanned and processed. The results are illustrated in Figures 1 and 2. The original images were rotated and distorted and then proposed approach was used. In each case, global extracted features were same for same image in the form of a one-dimensional vectors. We provided those global features to the Neural Network for classification.

We used single hidden layer FNN and EBUDS [2] training algorithm. We scanned more than 100 images such as faces, mammograms and letters, some samples are presented in this paper. We extracted features using new technique and neural networks were trained using different inputs (faces, mammograms, letters) and 10 (coded eg., 4=0000000100) outputs. Neural network classified all images correctly. The results for different images are shown in Table 1.

3.1 EXPERIMENT 1

ORIGINAL IMAGE REDUCED (9) BINARY IMAGE

ORIGINAL BINARY IMAGE

```

000000000000000000000000 000000000011110000000
000000000000000000000000 000000001011111100000
000000000000111100000000 000011111111111100000
00000000101111110000000 000111111111111100000
00001111111111110000000 001111111111111110000
00001111111111111000000 011111111111111111000
000111111111111110000 011111111111111111100
001111111111111111000 011111111111111111110
001111111111111111000 111111111111111111111
001111111111111111000 111111111111101111110
011111111111111111110 111111111110000011110
011111111111011111100 111111110110000011111
011111111111000011100 111100111000000011100
011111110110000011110 111100001100000011110
011110011100000001100 111100001100001101110
011110000110000001100 111100011000010111110
011100000110000101100 101100000000000000110
011100011100010111100 100100000000000000110
0101100000000000001100 100000000000000000110
0100100000000000001100 100100000000001000110
0100000000000000001100 110010000000000000110
01001000000000010001100 111100000000000000110
0110010000000000001100 111100000011110111100
0111100000000000001100 111110000000000011000
01111000000011110111100 111101000000000111000
0111110000000000011000 111100100000000110000
0111101000000001110000 111100001000001110000
0111100100000001110000 001110000001111111000
0111110001000001110000 000000000000011111000
0001110000001111110000 000000000000000001000
00000000000000011111000
0000000000000000010000
00000000000000000000000
00000000000000000000000
00000000000000000000000
00000000000000000000000

```

HIEGHT=30; WIDTH=22; CENTRE_X=11.5; CENTRE_Y=15.5;

RADIUSSES:

```

16.325 15.953 15.572 15.443 15.116 14.983 14.916 14.916 14.849 14.714 14.577 14.577 14.577 14.577 14.577 14.509 14.300 14.230 14.230
14.160 14.160 14.089 14.089 14.089 13.946 13.946 13.730 13.730 13.730 13.730 13.656 13.656 13.656 13.583 13.509 13.509 13.509
13.509 13.509 13.435 13.435 13.285 13.285 13.210 13.210 13.210 13.210 12.981 12.981 12.981 12.903 12.903 12.903 12.903 12.903
12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.590 12.590 12.590 12.510 12.510 12.349
12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.104 12.104 12.104 12.104 12.104 12.104 12.104 12.021 12.021
12.021 12.021 12.021 11.853 11.853 11.853 11.853 11.853 11.769 11.769 11.597 11.597 11.597 11.511 11.511 11.511 11.511 11.511
11.511 11.511 11.511 11.511 11.511 11.424 11.424 11.424 11.424 11.336 11.336 11.336 11.336 11.336 11.336 11.336 11.068 11.068 11.068
11.068 11.068 11.068 10.977 10.977 10.977 10.977 10.977 10.977 10.977 10.794 10.794 10.794 10.794 10.700 10.700 10.700 10.700 10.700
10.700 10.700 10.607 10.607 10.607 10.607 10.607 10.607 10.607 10.607 10.607 10.512 10.512 10.512 10.512 10.512 10.512 10.512 10.512
10.124 10.124 10.124 10.124 10.124 10.124 10.124 10.124 10.124 10.124 10.124 9.925 9.925 9.925 9.925 9.925 9.925 9.823 9.823
9.823 9.823 9.823 9.618 9.618 9.618 9.618 9.618 9.618 9.618 9.618 9.618 9.513 9.513 9.513 9.513 9.513 9.301 9.301 9.301 9.301
9.192 9.192 9.192 9.192 9.192 9.192 9.192 9.192 9.192 9.192 9.192 8.860 8.860 8.860 8.860 8.860 8.746 8.746 8.746 8.746 8.746 8.631 8.631 8.631 8.631
8.631 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276 8.276
7.906 7.906 7.906 7.778 7.778 7.778 7.649 7.649 7.649 7.649 7.649 7.649 7.649 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517 7.517
7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106
7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106 7.106
5.523 5.148 4.950 4.743 4.528 4.528 4.528 4.301 4.301 4.301 4.301 3.536 3.536 3.536 3.536 3.536 3.536 2.915 2.550 2.121 1.581 1.581 1.581 1.581 1.581 1.581

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BLACK PIXELS:

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1 1 1 1 1 1 2 1 1 5 1 1 2 2 3 2 5 3 1 5 2 3 4 3 5 1 3 3 2 1 0 8 6 5 2 3 1 0 4 8 6 7 4 8 8 1 0 1 1 8 5 1 0 6 5 8 5 6 6 1 1 5 1 0 2 6 7 4 3 3 4 5 2 2 4 4 1 1 1 3 2 5 1
1 1 3 1

```

WHITE PIXELS:

```

4 4 4 4 4 7 3 4 4 3 4 3 3 6 3 3 7 3 3 2 6 1 2 3 1 3 7 2 1 1 3 3 1 2 2 3 2 1 2 4 2 1 4 4 6 5 3 6 2 3 4 3 2 2 5 3 6 2 2 1 4 5 5 4 1 1 2 6 1 2 4 7 3 7 5 6 8 7
7 7 3 5 3 1

```

INPUT OF ANN (final one dimensional vector):

```

0.819 0.819 0.819 0.819 0.819 0.779 0.819 0.819 0.819 0.607 0.819 1.000 1.000 0.819 0.717 0.882 0.607 0.717 0.779 0.607 0.819 0.670
0.905 0.472 0.565 0.472 0.472 0.819 0.662 0.497 0.424 0.435 0.819 0.717 0.403 0.607 0.497 0.535 0.549 0.607 0.411 0.497 0.565 0.463
0.411 0.717 0.565 0.779 0.741 0.529 0.834 0.535 0.574 0.549 0.607 0.472 0.779 0.695 0.549 0.905 0.670 0.670 0.449 0.717 1.000 1.000
0.779 0.936 1.000 0.751 0.681 0.867 0.895 0.607 0.779 0.846 0.751 0.913 0.779 0.651 0.651 0.717 0.670 0.717

```

Figure 1. Results using proposed approach for original image.

3.2 EXPERIMENT 2

ORIGINAL ROTATED IMAGE REDUCED (0) BINARY IMAGE

ORIGINAL BINARY IMAGE

```

00000000000000000000000000000000 000000000000000000001000
00000000000000000000000000000000 0000000000000011111100
00000000000000000000000000000000 0011100000001111110000
00000000000000000000000000000000 1111100001000001111000
00000000000000000000000000000000 111110010000000111000
00000000000000000000000000000000 11111010000000011100
00011100000011111110000 111111000000000011100
01111100001000001110000 111110000001111011110
0111100100000001110000 11111000000000001110
0111101000000000111000 110010000000000001110
0111110000000000111000 100100000000001000110
011110000011110111100 100000000000000000110
01111000000000000011100 10010000000000000000110
01100100000000000011100 10110000000000000000110
010010000000000010001100 111100011100001011110
010000000000000000001100 111100001100001101110
0100100000000000000001100 1111100001100000011110
0101100000000000000001100 1111100111000000001110
011110001110000101111100 111111110110000011111
011110000110000110111100 111111111110000011110
01111100011000000111100 11111111111101111110
01111001110000000011100 11111111111111111111
01111111101100000111110 011111111111111111110
0111111111100000111100 011111111111111111110
0111111111111111111110 0111111111111111111100
00111111111111111111110 001111111111111111110000
001111111111111111111100 00001111111111111100000
001111111111111111111000 0000000010111111100000
000111111111111111110000 000000000001111000000
000001111111111111000000
000000111111111111000000
00000000010111111000000
0000000000011110000000
000000000000000000000000
000000000000000000000000

```

HIEGHT=30; WIDTH=22; CENTRE_X=11.5; CENTRE_Y=15.5;

RADIUSES:

```

16.325 15.953 15.572 15.443 15.116 14.983 14.916 14.916 14.849 14.714 14.577 14.577 14.577 14.577 14.577 14.509 14.300 14.230
14.230 14.160 14.160 14.089 14.089 14.089 13.946 13.946 13.730 13.730 13.730 13.730 13.730 13.656 13.656 13.656 13.583 13.509
13.509 13.509 13.509 13.435 13.435 13.285 13.285 13.285 13.210 13.210 13.210 13.210 12.981 12.981 12.981 12.903 12.903
12.903 12.903 12.903 12.748 12.748 12.748 2.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.748 12.590 12.590
12.590 12.510 12.510 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.349 12.104 12.104 12.104 12.104
12.104 12.104 12.104 12.021 12.021 12.021 12.021 12.021 12.021 11.853 11.853 11.853 11.853 11.769 11.769 11.597 11.597
11.597 11.511 11.511 11.511 11.511 11.511 11.511 11.511 11.511 11.511 11.511 11.424 11.424 11.424 11.424 11.336 11.336 11.336
11.336 11.336 11.336 11.336 11.336 11.068 11.068 11.068 11.068 11.068 11.068 10.977 10.977 10.977 0.977 10.977 10.977 10.977
10.794 10.794 10.794 10.794 10.700 10.700 10.700 10.700 10.700 10.700 10.700 10.700 10.607 10.607 10.607 10.607 10.607 10.607
10.607 10.607 10.512 10.512 10.512 10.512 10.512 10.512 10.512 10.512 10.512 10.512 10.124 10.124 10.124 10.124 10.124 10.124
10.124 10.124 10.124 10.124 10.124 9.925 9.925 9.925 9.925 9.925 9.925 9.925 9.823 9.823 9.823 9.823 9.823 9.618 9.618 9.618
9.618 9.618 9.618 9.618 9.618 9.618 9.513 9.513 9.513 9.513 9.513 9.513 9.301 9.301 9.301 9.301 9.301 9.192 9.192 9.192 9.192
9.192 9.192 9.192 9.192 8.860 8.860 8.860 8.860 8.860 8.860 8.746 8.746 8.746 8.746 8.746 8.631 8.631 8.631 8.631 8.631 8.515
8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.515 8.276 8.276 8.276 8.276 8.276 8.276 7.906 7.906 7.906 7.906 7.906 7.906
7.906 7.906 7.906 7.778 7.778 7.649 7.649 7.649 7.649 7.649 7.649 7.517 7.517 7.517 7.517 7.517 7.517 7.382 7.382 7.382 7.382
7.106 7.106 7.106 6.964 6.964 6.964 6.671 6.671 6.671 6.671 6.671 6.519 6.519 6.519 6.519 6.519 6.364 6.364 6.042 6.042 5.701 5.701 5.701
5.701 5.523 5.523 5.523 5.523 5.148 4.950 4.743 4.528 4.528 4.528 4.301 4.301 3.536 3.536 3.536 3.536 3.536 2.915 2.550 2.121 1.581
1.581 1.581 0.707

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BLACK PIXELS:

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111111211511122325315234351332108652310486748810118510658566115102674334522441
1132511131

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WHITE PIXELS:

```

4444473443434336337332612313721133122232124214465362343225362214554112612473
75687773531

```

INPUT OF ANN (final one dimensional vector):

```

0.819 0.819 0.819 0.819 0.819 0.779 0.819 0.819 0.819 0.607 0.819 1.000 1.000 0.819 0.717 0.882 0.607 0.717 0.779 0.607 0.819 0.670
0.905 0.472 0.565 0.472 0.472 0.819 0.662 0.497 0.424 0.435 0.819 0.717 0.403 0.607 0.497 0.535 0.549 0.607 0.411 0.497 0.565 0.463
0.411 0.717 0.565 0.779 0.741 0.529 0.834 0.535 0.574 0.549 0.607 0.472 0.779 0.695 0.549 0.905 0.670 0.670 0.449 0.717 1.000 1.000
0.779 0.936 1.000 0.751 0.681 0.867 0.895 0.607 0.779 0.846 0.751 0.913 0.779 0.651 0.651 0.717 0.670 0.717

```

Figure 2. Results using proposed approach for rotated image.

Figure 3. Original, binary and reduced binary images.

Figure 4. Preprocessed image with circles (centroid and radiuses).

Figure 5. Membership function.

	Input Images	# of Images	Classification Rates [%]
1.	Faces (24 x 36)	50	100
2.	Mammograms (2048 x 2048)	20	100
3.	Letters (24 x 40)	50	100

Table 1: Classification rates for different images with rotation and distortion using neural networks

4. CONCLUSIONS

We have presented an approach for image recognition which is independent of rotation and converts a large scale image data into a small one-dimensional vector with global features. Those extracted features are used by neural networks for classification of images. We have tested new technique using different images and results were promising. The results for classification of different rotated and distorted images by neural network are presented in Table 1.

The presented technique has proven to be very effective at recognising a wide variety of images regardless of orientation. A small one-dimensional data from large scale image data which we get using proposed techniques, avoids the computer memory-problem, long training time in learning and recognition processes and neural network has guaranteed training, better generalisation and recognition accuracy.

5. REFERENCES

- [1]. B.K. Verma, "Handwritten hindi character recognition using MLP and RBF neural networks," in Proc. of IEEE International Conference on Neural Networks, ICNN'95, Perth, November 1995.
- [2]. B.K. Verma and J.J. Mulawka "A Modified Backpropagation Algorithm," in Proc. of IEEE International Conference on Neural Networks, ICNN'94, Orlando, June-July 1994.
- [3]. D. Flotzinger and M. Pregemer, "Feature selection with distinction sensitive learning vector quantisation and genetic algorithms," In Proc. of IEEE International Conference on Neural Networks, ICNN'94, pp. 3448-3452, Orlando, June-July 1994.
- [4]. E. Cohen and J.J. Hull, "Control structure for interpreting handwritten addresses," IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 16, no. 10, October 1994.
- [5]. I.S. Abuhaiba and S.A. Mahmoud, "Recognition of handwritten cursive arabic characters," IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 16, no. 6, June 1994.
- [6]. J. Bezdek, "Fuzzy models what are they, and why," IEEE Transaction on Fuzzy Systems, vol. 1, no. 1, pp. 1-5, 1993.
- [7]. J.H. Chia-Lun, "Fourier-Transformed preprocessing used in a noniteratively-trained perceptron pattern recognizer," in Proc. of IEEE International Conference on Neural Networks, ICNN'94, pp. 3020-3023, Orlando, June-July 1994.
- [8]. J.L. Hemminger, "Using a hopfield network for rotation and scale independent pattern recognition," in Proc. of IEEE International Conference on Neural Networks, ICNN'94, pp. 3003-3007, Orlando, June-July 1994.
- [9]. J.S. Roger, "Functional equivalence between radial basis function networks and fuzzy inference systems, IEEE Transaction on Neural Networks," vol. 4, no. 1, pp. 156-158, 1993.
- [10]. J.M. Koch and M. Moya, "Feature discovery in gray level imagery for one-class object recognition," in Proc. of IEEE International Conference on Neural Networks, ICNN'94, pp. 2979-3451, Orlando, June-July 1994.
- [11]. X. Huary and J. Gu, "A constrained approach to multifont chinese character recognition," IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 15, no. 8, August 1993.