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 i.e., 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.

\[ Centre_x = \frac{Width + 1}{2}; \quad Centre_y = \frac{Height + 1}{2} \]

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.
  
  \[ r = \sqrt{(centre_x - x)^2 + (centre_y - y)^2} \]

- Sum all pixels with same radius (sum_r_max, ... sum_r_min).

- Calculate membership for each circle or disk using following membership function.

  \[ m_f(bp) = e^{\frac{(bp-\text{rbp})}{\text{total_pixels}}} \]

  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=0000050100) outputs. Neural network classified all images correctly. The results for different images are shown in Table 1.
3.1 EXPERIMENT 1

ORIGINAL IMAGE

REDUCED (b) BINARY IMAGE

Figure 1. Results using proposed approach for original image.
3.2 EXPERIMENT 2

ORIGINAL ROTATED IMAGE  REDUCED (R) BINARY IMAGE

BLACK PIXELS:

white pixels:

input of ANN (final one dimensional vector):

0.819 0.819 0.819 0.819 0.819 0.779 0.619 0.619 0.819 0.619 0.677 0.819 1.000 1.000 0.819 0.819 0.717 0.819 0.779 0.607 0.819 0.670
0.659 0.472 0.565 0.472 0.472 0.819 0.662 0.497 0.424 0.424 0.459 0.819 0.719 0.603 0.697 0.497 0.535 0.549 0.647 0.497 0.497
0.410 0.410 0.717 0.565 0.779 0.549 0.549 0.549 0.472 0.779 0.695 0.549 0.505 0.670 0.670 0.670 0.497 0.497 0.497

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 radii).

Figure 5. Membership function.
(a) faces  (b) letters  (c) mammograms

Some samples of rotated images used for experiments

<table>
<thead>
<tr>
<th>Input Images</th>
<th># of Images</th>
<th>Classification Rates [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Faces (24 x 36)</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>2. Mammograms (2048 x 2048)</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>3. Letters (24 x 40)</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

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 recognizing a wide variety of images regardless of orientation. A small one-dimensional data from large scale image data which we get using proposed technique, 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