Handwritten motives image recognition using polygonal approximation and chain-code

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Abstract: - The present paper proposes a novel algorithm for recognition of handwritten forms. The object of this paper is the pattern recognition of handwritten craft motives images. It is appropriate in one the first time to transform the forms by a polygonal forms using polygonal approximation. In the next step, the extracted the chain-code features, this features as extracted from the contour of polygonal forms. Chain code is a sequence of code directions of a polygon form and connection to a starting point which is often used in image processing "8-neighborhood method has been implemented". Aggregation chain code and the normalized chain code build the extracted feature vector for each image motive. These extracted features are used to train a feed-forward back-propagation neural network employed for performing classification and recognition tasks. Extensive simulation studies show that the recognition system using chain code features provides good recognition accuracy while requiring less time for training.

Key-Words: - polygonal; chain-code; neural network; recognition; vectorization; handwrittenCraft motives

1 Introduction

Pattern recognition is a field of study whose general goal is the classification of forms into a number of categories. Handwritten recognition is one of the well-known applications of pattern recognition. Pattern recognition deals with categorization of input data into one of the given classes based on extraction of features. The object of this work is the pattern recognition of handwritten craft motives images. For any recognition system, an important part is feature extraction because the proper feature extraction method can increase the recognition ratio. In this work, a chain code based feature extraction method is investigated for developing the pattern recognition system. These extracted features are used to train the neural networks classifier. Pattern recognition system can be used in so many applications such as face recognition, character recognition, and form recognition [1].

The first important step in any handwritten recognition system is pre-processing followed by segmentation and feature extraction. The pre-processing is a series of operations performed on the scanned input image. It essentially enhances the image rendering it suitable for segmentation. [2] Pre-processing phase enhances the image rendering. The various tasks performed on the image in pre-processing stage are binarization process that converts a gray scale image into a binary image and many more. In the segmentation [3] [4], the input image is segmented into individual motifs and then, each motif is resized into m x n pixels towards the training network.

Feature extraction is a method of automatic pattern recognition in which recognition is achieved by making measurements on the patterns to be recognized, and then deriving features from these measurements [5] [6]. The Selection of appropriate feature extraction method is probably the single

most important factor in achieving high recognition performance. Several methods of feature extraction for form recognition have been reported in the literature. The widely used feature extraction methods are Template matching, Histograms, Contour, Geometric moment invariants, Zernike moments, Racah moments, Approximation polygonal, Fourier descriptors.

An artificial neural Network as the backend is used for performing classification and recognition tasks. In the off-line recognition system, the neural networks have emerged as the fast and reliable tools for classification towards achieving high recognition accuracy. In the literature methods of classification include statistical methods based on Bayes decision rule, Artificial Neural Networks (ANNs), Kernel Methods including Support Vector Machines (SVM) and multiple classifier combination [7], [8].

In this paper, a chain-code feature extraction scheme for the recognizing off-line handwritten motives is used. In the feature extraction process, resized individual images motives of our base of the models “handwritten crafts motives” of size 250x150 pixels. These extracted features are used to train a feed forward back propagation neural network employed for performing classification and recognition tasks. Extensive simulation studies show that the recognition system using normalized chain-code features provides good recognition accuracy while requiring less time for training.

The object of this paper is the pattern recognition of handwritten basic motives craft. It is initially advisable to evaluate the forms of these last by a polygonal approximation. Extraction the chain-code and chain code normalized of the polygonal forms features is the next step of this process. We will compare then the signature of the objects to be recognized, with those of a database of known models objects using for training multilayer feed forward neural network is described in the paper algorithm of recognition proposed. The result is a sign us to appreciate the resemblances between the images of the motives requests and the images of the motives for our database. Moreover, the algorithm will enable us to know the orientation, and possibly the translation then the scale of motives to be recognized.

The paper is organized as follows. In section II, the proposed recognition system is presented. In the next section the polygonal approximation of the motives. The feature extraction procedure adopted in the system is detailed in the section IV. Section V describes the classification and recognition using neural network. Section VI presents the experimental results and, the paper is concluded in section VII.

2 The proposed recognition system

In this section, the proposed recognition system is described. A classic handwriting form recognition system consists of pre-processing, edge detection, polygonal approximation, feature extraction, classification and recognition, and post processing stages. The schematic diagram of the proposed recognition system is shown in Fig.1.

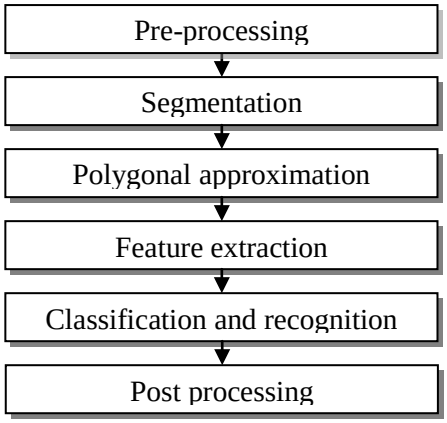

FIGURE 1: *Diagram of the proposed recognition system*

The pre-processing is a series of operation performed on the scanner input image. It essentially enhances the image rendering it suitable for segmentation.

The contour can be appreciated like the edge or the border of two areas. To detect contours of the objects is equivalent detecting changes of level of gray, or discontinuities at the border of two areas. The cells are separated by the bottom of the image, defined by low levels of gray. The knowledge of the bottom thus makes it possible to separate the cells between them. Following the change of space of representation, various thresholdings show that the bottom of the image is defined by pixels of intensity 0 to 5.

The images of our database “handwritten crafts motives” are of good quality, “after the stage of filtering” “non-ambiguous”, of a relatively large size.

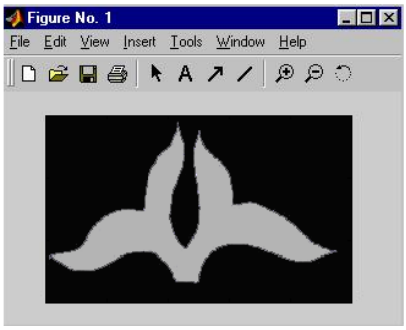

FIGURE2: *Example of a motive for the database.*

One proposes the following treatment sequence in order to extract contour close to that proposed by [9]:

- Binary thresholding, thresholding with only one value.
- The pixels take the value of the majority color, i.e at least 5 neighbors in the perimeter 3*3 must have this color. One repeatedly repeats the operation until there is no more changes in the image.
- The pixels having 4 neighbors of connexity 4 with the value “1”, take value 0. These causes «to empty the interior of the image, leaving only one contour of connexity 8, nonmean. One withdraws the pixels common to the pixels having 3 neighbors or more in their perimeter in connexity 8. This causes to make contour mean. I.e. each pixel of contour has 2 neighbors or less. It should be noted that this treatment can give a small effect of abrupt district of the angles. This is not however awkward in this context.
- One withdraws the pixels with 1 only neighbor, repeatedly until the image does not change any more. One thus removes possible features which finish savagely in space 2sd of the image.
- Finally one withdraws the isolated pixels, to eliminate from possible pixels of noises. Cf end result Appears 4 of them

The binary image of contour is the first stage of the polygonal approximation. One represents it in the form of a list called chain-code in the literature. The latter consists of a continuation whose each element gives the direction to be followed to reach the pixel of following contour. By considering a mean connexity of order 8, we have for each point given, 8 possibilities, of directions, i.e the 8 directions which a central pixel in a matrix 3*3 can take to reach one of the neighbors. The last element of the list gives the direction to be followed to reach the first element. The interest of such a list is the speed of treatment as well as the convenience of handling in order to evaluate the polygonal approximation. Contour must be closed.

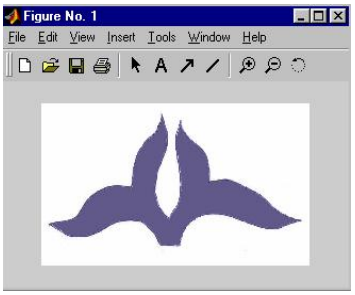

Figure 3 *Original image 8 bits greyscale*

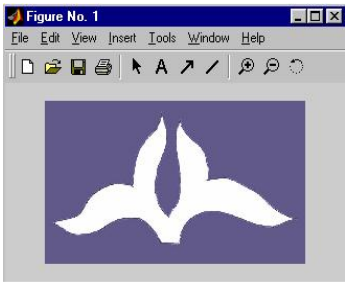

Figure 4 : *Binary thresholding*

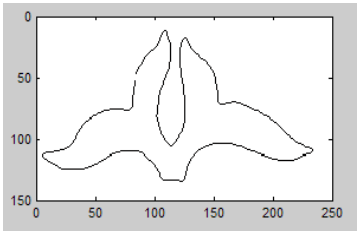

Figure 5*: Extraction of mean contour.*

3 The polygonal approximation of the motives and chain-code

The objective of a method of polygonal approximation of a contour is to extract a partition from a chain of points, contour, in successive segments in order to minimize a total criterion of error or to respect an error of approximation locally. The interest is to obtain a description more compact and more adapted for secondary treatments. Many methods were developed on the polygonal approximation of a contour [10], [11], [12].

In certain methods [13], [14], [15] one examines successively the points of contour to determine the longest segment who checks a preset tolerance level, and one repeats the process of search for such segments approaching contour.

In spite of the big number of methods of approximation, there remain main issues of robustness, stability to the geometrical

transformations and complexity. Moreover, the algorithms rest on tolerance levels of errors which are manually defined without any knowledge on the value of the most relevant threshold. Moreover, those can be different from a chain of points to the other along contour. Our choice was made on a method developed by Huang and Wang [16]. A method simple: easy to implement and not very significant, according to the authors, with the noise. The results which we obtained confirm these assertions.

The algorithm is the following:

To find the two points most distant on contour chain-code. The idea established to find this segment of right, is to consider the maximum distance from the barycentre of the object to contour giving a P0 starting point. One then repeats repeatedly the following sequence, which converges quickly according to the tests, towards the maximum segment (Pa Pb) :

1. $Pi = P_0$
2. $P_{i+1} = P_0$
3. To seek the P_{i+2} point most distant from P_{i+1} and pertaining to contour.
4. $P_a = P_{i+1}$; $P_b = P_{i+2}$
5. If $P_i = P_{i+2}$ stop, if not $P_i = P_{i+1}$; $P_{i+1} = P_{i+2}$ and return in 2.

That is to say Pi = (xi,yi) ordered points of the polygon. We have in the first iteration, $P_1 = P_a$, $P_2 = P_b$, $P_3 = P_a$. Being given 2 consecutive points of the polygon, P_i and P_{i+1}, if the distance minimum of right-hand side [P_i P_{i+1}] at a P_{max} point pertaining to contour, can be higher than X, the value of tolerance of the approximation, then, $P_{i+2} = P_{i+1}$, $P_{i+1} = P_{max}$. One repeats the operation for all P_i and P_{i+1}.

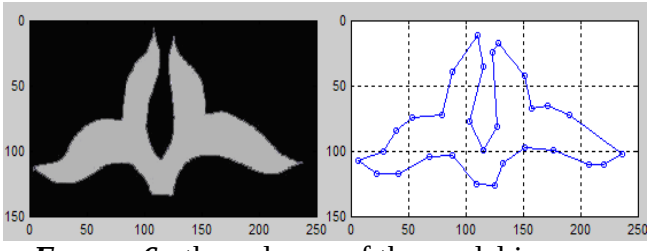

FIGURE 6 : the polygon of the model image

The total number of Pi is stored in the Pn " number of vertex".

In this work, we have implemented 8-neighborhood method for chain code. This method has been implemented as feature for polygonal handwritten forms of classification. To obtain the chain code, we just focus on the chain-code of the vertex points of the polygonal forms image. We consider the first pixel of the vertex point P1 the polygonal approximation form of image, as the start point of the chain code. Each point the polygonal form of image has received its eight neighbors; to each neighbor we assign one value between 0 and 7. After finding the start point of the chain code neighbors of a pixel and value is assigned to it in a given forms image, we move to the next neighbor pixel which also be a part of image. We interested on the chain-code stored in each vertex of the polygonal shape.

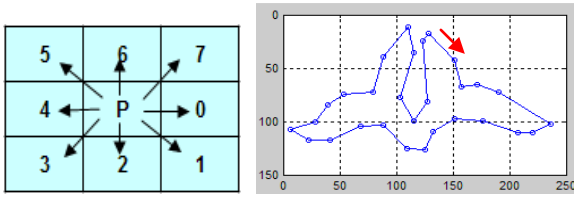

FIGURE 7: 8-neighborhood for chain code

4 Feature extraction

The feature extraction phase in a handwriting recognition system is agreed by many [17] to hold a very important role. Feature extraction can be defined as the process of extracting distinctive information from the images forms. In handwriting form recognition applications it is important to extract those features that will enable the system to discriminate between all the form classes that exist. Feature extraction is the process by which certain features of interest within an image are detected and represented for further processing.

4.1 Chain code

Freeman chain code is one of the techniques representations based on the boundary extraction which useful for image processing, shape an analysis and pattern recognition. Chain code representation gives a boundary of form image where those codes represent the direction of where is the location of the next pixel. The chain code extraction algorithm is working based on two different manners such as 4- neighborhood method or 8-neighborhood method. In this work, we have implemented 8-neighborhood method for chain code.

After receiving the chain code for all polygon form, we come to know that the chain code for different form has different size, and size of each chain code depends on the length of the desired forms. In more ever, length of the chain codes is usually high; therefore one should convert it into its

normalized form. This chain code as its length will be fixed and limited [18].

4.2 Chain code normalization

After applying chain code on image motive polygon, it is observed that that the chain code for different polygon forms has different length code and length of each chain code depends on the size of the handwritten motive. More, for the same polygonal shape, there are several different chain-codes depending on the number of vertices "according to X the value of tolerance". Drives for the same image motive are two different vectors chain-code following the starting point. More the length of chain code is very high in case of certain handwritten motive. We have solved this problem by normalizing the chain code values as explained below. We know that the following chain code is generated for a form contour by traversing it in anticlockwise direction. From this chain-code vector is calculated the frequency of occurrence of values of 0 to 7.

The chain code of the previous forms motive image is given as follows:

Vcc1=[1,2,0,1,1,3,4,5,4,3,2,4,5,4,3,4,5,7,6,7,0,6, 7,1,3,1,7,6,7]

Compute the frequency of the number 0 and 1... and 7 in Vcc1. We have the frequency vector Vcc2 as bellow:

Vcc2=[2 5 2 4 5 3 3 5]

In the next step, the second vector is obtained by dividing each element of the vector by the sum of the frequencies.

The normalized chain code, presented by vector Vcc3, is computed using the following formula:

Vcc3=Vcc2/Pn. Where “Pn” is number of vertex.

In this example above, we have:

Vcc3= [0,069 0,172 0,069 0,138 0,172 0,103 0,103 0,172]

Finally, the feature chain-code vector is obtained by concatenating the number Pn obtained in polygonal approximation stage, the vector obtained in first step “Vcc2 “ and the vector obtained in the second step “Vcc3”; we get the required feature vector of size 17.

5 Classification :

Artificial neural networks emulate the human brain’s ability to learn and recognize patterns. Neural network is mainly used for classification problems. It is made up of number of highly interconnected elements. The information is processed by their dynamic state response to external inputs. It has the capability to acquire knowledge from its surroundings and produces response by applying external stimulus.

The feed forward artificial neural network, or also known as multilayer perceptron, is a fully connected network model that maps the input data sets into the corresponding output sets. It was the first and simplest type of neural network composed by multiple layers of nodes known as the input layer, hidden layer, and the output layer. As shown in Figure 1, each layer is connected to the next layer through its processing elements known as neurons in weighted links. The activation values are propagated to the output units and the actual network output is compared with the desired output values thus producing error. The Back propagation algorithm was first proposed by Paul Werbos in the 1970. Back propagation is the most common neural network learning algorithm.

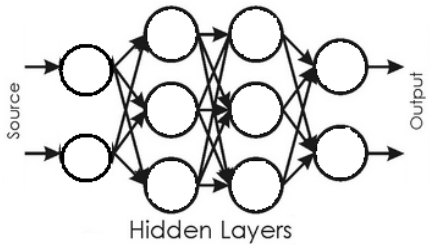

Figure 7: *Neuronal Network*

The classification stage is the decision making part of a recognition system and it use the features extracted in the previous stage. It is very important stage, in this stage input is classified that in which class particular input is belong. It very beneficial in recognizing handwritten motives which the feature are extracted from pervious stage are used to form neural network. In this paper, for Motive handwritten recognition in neural Feed Forward Multi-Layer Perceptron network (MLPN) with two hidden layer has been used. For training, back-propagation algorithm has been implemented [20].

In general the feature vector is denoted as X, and defined as X = (f1, f2,…, fd), where f denotes features and d is the total number of the features present in the each motive. The number of input neurons is determined by length of the feature vector d (d=17). The total numbers of motives n determines the number of neurons in the output layer (n=30 basic motives of handwritten craft).

All the neurons use log-sigmoid transfer functions. The back propagation algorithm with momentum and adaptive learning rate is used to obtain the parameters of the network. Two Hundred different handwritten data sets were used for training the neural network. The number of hidden layers and the number of neurons in each layer are to be obtained through trial and error. Through numerous simulations it was identified that a maximum of two hidden layers and a maximum of 100 neurons in each hidden layer would be sufficient for motive recognition. Further increase in the number of neurons did not considerably improve the accuracy. The parameters of the trained network are fixed to enable testing. The parameters of the three layer neural network for the handwritten recognition system are shown in Table.1. The most compact network is chosen and presented.

Table 1 : *Feedforward Neural Network Training Parameters*

Input nodes	17
Hidden layers	2
Hidden layers nodes	100
Output nodes	30
Training epochs	10000
Training algorithm	Gradient descent with momentum training and adaptive learning
Performance function	Mean Square Error (MSE)
Training goal achieved	10e-7

6 Experimental results

For the experimental study of this system, we used in this work our database which contains 30 basic motives. We have implemented 8-neighborhood method for chain code. This method has been implemented as feature for polygonal handwritten forms of classification; to obtain the chain code. The extracted chain code was normalized and used as features for neural network classifier. Therefore the length of the required feature vector of 17, this is considered as an input vector of the classifier feed forward neural network.

A simple and an efficient off-line handwritten motive recognition system using a new type of feature extraction, namely, chain code and chain code normalized of polygon vertex feature extraction is proposed. This approach using training and testing features are chosen to build the neural network recognition system. The structure of neural network includes an input layer with 17 inputs including row wise and column wise features, two hidden layers each with 100 neurons and an output layer with 30 neurons. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions is used for neural network training. Neural network has been trained using known dataset. A recognition system using simple chain code based feature. Show the efficient of this system, we compare this system with another system such as the system using radial basis classifier and nearest neighbor classifier and KNN classifier.

The experimental results obtained in recognizing the handwritten motive using different classifiers are summarized in Table.2. The results in Table 2 indicate the superior recognition accuracy of Feed forward neural network as compared to other classifiers. Using a motive of handwritten test data the confusion matrix was obtained for the different classifiers. This was to investigate the recognition accuracy for each motive. Among the NN based classifiers the Feed forward neural network recognizes each motive with over 90% accuracy and is the best classifier.

Table 2: *Summary of the results achieved by the proposed methods*

Classifier	N. of motives with recognition	% recognition
Feed Forward NN	28	94%
Nearest neighbour NN	26	89%
Radial basis function NN	27	90%
KNN classifier	24	85%

7 Conclusion

In this work, we have introduced a simple and efficient motives recognition system using feature extraction technique from motives images, the features is based are polygonal approximation and chain-code normalized. This system which has been evaluated on our polygonal forms database and basics motives database. The system for recognizing off-line handwritten craft motive has been developed. Different Pre-processing, segmentation techniques and classifier neuronal with different features are also discussed.

This approach using training and testing features are chosen to build the neural network recognition system. The structure of neural network includes an input layer with 17 inputs including row wise and

column wise features, two hidden layers each with 100 neurons and an output layer with 30 neurons. From the results it can be concluded that combination of Neural Network classifier and chain code feature extraction approach is best method for the recognition of handwritten craft motive.

Selection of feature extraction method is most important factor for achieving high recognition ratio. We have shown that the chain code normalized of polygonal vertex forms using neuronal network has a positive effect for recognition and accelerates the recognition neuronal technique. In the investigated work the recognition rate is 94%.

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