Postal Codes Recognition System for Myanmar Post Office using Neural Network Architecture

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Abstract

Pattern recognition plays an important role in the modern world. It can solve more complex problems and makes human's job easier. In this paper, we intend to develop a handwritten Postal Codes recognition system that can be employed in mail sorting for Myanmar Post Office. Postal Code consists of English characters and digits. This system can help humans to sort mails with Postal Codes that are difficult to identify. Two techniques applied in this system are Image processing and Artificial Neural Network (ANN). Image processing steps such as binarilization, cropping, resizing and thinning are used in this system. Multilayer feed forward neural network is used to adapt the weights that are needed to train the network using back propagation algorithm. Image processing is an important area for the application of ANN pattern recognition techniques. Simulation results are also included to show the accuracy of this system.

Keywords: *ANN, Back-propagation algorithm, image processing, pattern recognition, Postal Code.*

1. Introduction

Pattern recognition is becoming more and more important in the modern world. It helps human ease their jobs and solve more complex problem. The recognition implies classification of the object being recognized, by the subject. The recognition task can generally be classified into two categories: static recognition (also called off-line); dynamic recognition (also called on-line).Static recognition processes a scanned image of shapes to be recognized. Dynamic recognition expects temporal information about the movement of pen.

The image processing steps are needed for the desired image to be suitable for the training process of the ANN to recognize them. The intention is to convey an idea of all the methodologies that can be applied to images for different purposes and possibly with different objectives. The image processing steps may not be the same for all types of applications according to the requirements and objectives of the systems. But, there are certain common image processing steps encountered in the most of the image processing systems. A neural network is a computing paradigm that is loosely modeled after cortical structures of the brain. ANN's are also a good pattern recognition engines and robust classifiers. They have the ability to generalize by making decisions about imprecise input data. Artificial Neural Network (ANN) is a collection of very simple and massively interconnected cells [7]. The cells are arranged in a way that each cell derives its input from one or more other cells. It is linked through weighted connections to one or more other cells. This input to the ANN is distributed throughout the network so that an output is in the form of one or more activated cells [5].

Multilayer Feed Forward Neural Network is one of the important classes in neural network. The network consists of a set of sensory units (source nodes) that constitute the input layer, one or more hidden layers, and an output layer of computational nodes. The input signal propagates through the network in a forward direction, on a layer-layer basic. Multilayer perceptrons have been applied successfully to solve some difficulties and diverse problems by training in a supervised manner with algorithm known as error back-propagation algorithm is based on the error-correction learning rule.

The Artificial Neural Networks are mostly applied in the handwritten digits and characters recognition system. This system aims to develop a Postal Codes recognition system which can be applied in Myanmar Post Office. The organization of this paper is as follows: Section 2 describes the related work. Section 3 presents the system design and implements the system. Section 4 presents the simulation result and Section 5 concludes this paper.

2. Related Work

Neural Network trained using back-propagation is a popular tool for the recognition system. Neural network tries to mimic human brain in the sense that it provides an abstraction of parallel processing using digital signal processing toolkit [4].

Mahbub et al. [1] developed neural-network architecture for recognizing handwritten Bangla numerals and its application to automatic mail sorting machine for Postal system. They also discussed a classifier based on neural network and their experimental results confirm the relative effectiveness of their approach.

Palumbo et al. [6] developed the CEDAR (Center of Excellence for Document Analysis and recognition) real-time address block location system which determines candidates for the location of the destination address from a scanned mail piece image. The system was based on blackboard data structure invoking many specialized image processing and block analysis tools using a rule based system.

3. System Design and Implementation

This section presents the system design and implementation of the system. We implemented this system using MATLAB R2008b. Our Postal Code recognition system consists of three phases: preprocessing phase, training phase and testing phase as shown in Figure 1.

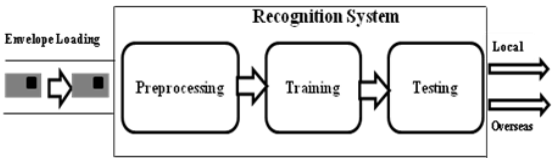

Figure 1. System Design

3.1 Preprocessing Phase

Preprocessing phase consists of scanning, binarilization, cropping, resizing and thinning. The flow of preprocessing phase is shown in Figure 2.

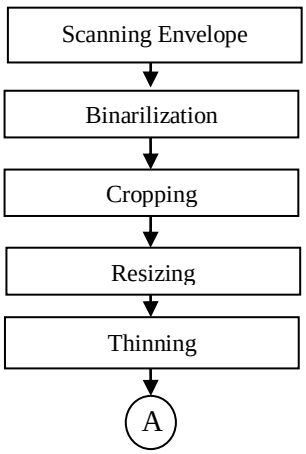

Figure 2. Preprocessing Phase

3.1.1 Scanning Process

To acquire the images of the envelope, a digital scanner is used to scan the image at the resolution of 300 x 300 dpi. After scanning the image (Figure-3), the image is saved with bit-map file type. The acquire envelope is a color image with the RGB color gamut.

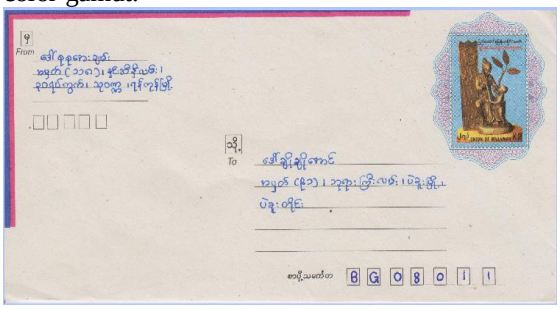

Figure 3. Scanned Envelope

A postcode frame contains eight square boxes. However, the maximum number of Postal Code is eight and the least is seven. The last five are digits and the rest are characters which represent respective State and Division for Local Mail and countries for Overseas Mail.

3.1.2 Binarilization Process

In order to get the well recognition with the accurate results of the ANN, the image of the envelope has to be converted into binary image. The color image is first of all converted in gray-valued image. The intensity values of three composite colors govern the gray values. The gray values of the pixels range from 0 to 255 since each gray value is represented with a single byte. To convert the gray image to the binary image, the threshold gray value has to be defined [2]. From the gray image, to get the corresponding binary image, certain distinct gray values are taken as black and otherwise white.

3.1.3 Cropping Process

To get the Postal Codes, cropping stage is carried out upon the binary image. The postal code is located at the right bottom of the envelope. First we will select the postal code region manually and then it will be cropped from that region. Sample cropped postal code is shown in Figure 4.

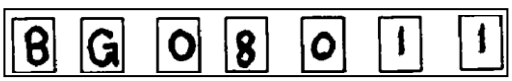

Figure 4. Cropped Postal Code Image

3.1.4 Resizing Process

The Postal Codes written by various people are certainly of various sizes. After cropping the Postal Code, it is needed to adjust the size of the cropped postal code image to get the certain standard. In this we use the predetermined matrix size of 100x100. After resizing process, we can get the resized image as shown in Figure 5.

Figure 5. Resized Image

3.1.5 Thinning Process

The thickness of the lines of the resized Postal Code may be differing due to the point of the ball-pen applied and also due to the style of handwritings. To get the abstract graph, also known as the skeleton, thinning is carried out upon the resized Postal Codes. After the thinning process, thickness of the Postal Code becomes minimum and sample thinned image is shown in Figure 6. MATLAB R2008b provides morphological operation and the 'thin' value is used in the thinning process.

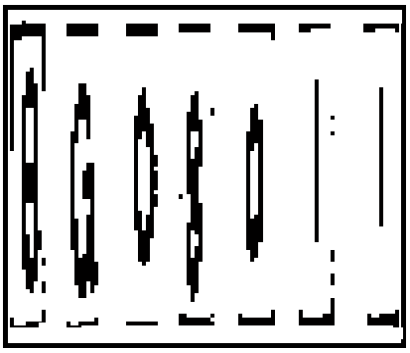

Figure 6. Thinned Image

3.2 Training Phase

In multilayer perceptrons it is not possible to decide how many layers and neurons are optimum for any problems. Number of hidden layers and neurons in network are effective on system performance. The most commonly used networks consist of an input layer, a single hidden layer and an output layer. Neural network architecture of this system is shown in Figure 7.

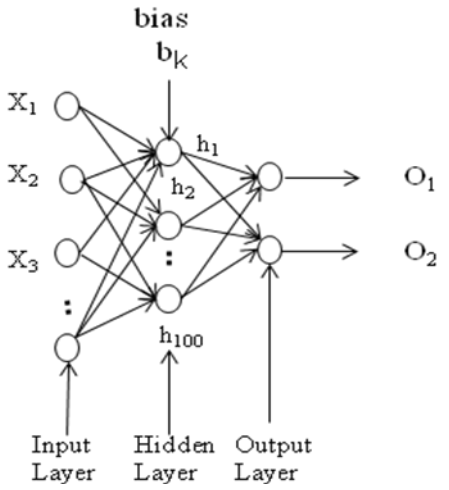

Figure 7. Neural Network Architecture of this system

The input layer of Neural Network contains 10000 neurons to accept 100 x 100 images. The network contains one or more layers of hidden neurons that are one part of the inputs or outputs of the network. This system used 100 hidden neurons. The neuronal model also includes an externally applied bias. The bias has the effect of increasing or lowering the net input of the activation function, depending on whether it is positive or negative, respectively. The recognized handwritten Postal Codes are examined to divide the Local and Overseas mail from Postal codes. The output layer contains 2 neurons to represent Local and Overseas Mail. In this system, Neural Network is designed with three layers i.e., input layer, hidden layer, output layer. The input layer converts the image into binary value. The output layer determines the types of incoming Postal Codes recognized. The Neural Network is trained by Back-propagation algorithm. The neural network using the Back-propagation algorithm is made to learn the different types Postal Codes and to identify or recognize the trained Postal Codes.

3.2.1 Back-Propagation Algorithm

According to Figure 9, back-propagation algorithm consists of two phases. First phase is the forward phase. This is the phase where the activations propagate from the input layer to the output layer. The second phase is the backward phase. This is the phase where the error between the observed actual value and the requested nominal value in the output layer are propagated backwards so it can modify the weights and bias values.

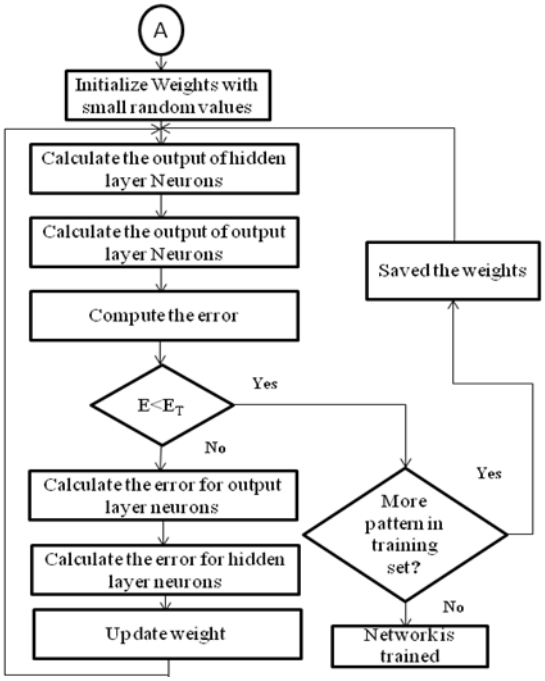

Figure 9. Flow of Back- Propagation Algorithm

In forward pass, an input vector is applied to sensory nodes of the network, and its effect propagates through the network layer by layer. Finally, a set of outputs is produced as the actual response of the network. The synaptic weights are all fixed. In backward pass, the synaptic weights are all adjusted in accordance with error-correction rule. The actual response of the network is subtracted from a desired (target) response to produce an error signal [3]. The derivation of the back-propagation algorithm is involved. A summary of the notations used in derivations as follows:

Step1: Initialize weight, learning rate η, error (or) stopping criterion

Step2: Calculate the hidden layer net input and output using following equations:

$$net_j = w_0 + \sum_{i=1}^{n} x_i w_{ij} \quad (1)$$

$$o_j = \frac{1}{1 + \exp(-net_j)} \quad (2)$$

Step3: Calculate the output layer net input and output using equations 1 and 2.

Step4: Calculate error between target output and desired output using following equation:

For output unit, (3)

$$\delta_j = (t_j - o_j)\, o_j\, (1 - o_j)$$

For hidden unit, (4)

$$\delta_j = o_j (1 - o_j) \sum_k \delta_k w_{kj}$$

Repeat step 2 until user-specific error reaches or other stopping criterion is met [3].

3.3 Testing Phase

In testing phase, need to make the preprocessing for testing data set as shown in Figure 10. Testing network consists of only forward propagation. Testing network uses training network's weight as its knowledge. In testing network, it does not need target output and the network will show appropriate output to the user.

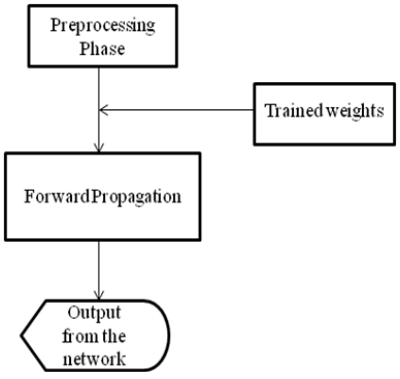

Figure 10. The Flow of Testing Phase

Table (1) shows the sample Postal Codes and their related regions used as training data set.

Table1. Postal Codes and their related regions

Local Mail		Overseas Mail	
MKN01011	Myitkyina	BN34689	Brunei
LK09011	Loikaw	CB12302	Cambodia
PA13011	Phaan	ID10410	Indonesia
HK03011	Hakha	LO10100	Laos
MLM12011	Mawlamyine	MY50480	Malaysia
ST07011	Sittwe	PH16301	Philippines
TGI06011	Taungyi	SG18801	Singapore
NPT15011	Naypyitaw	TH10310	Thailand
YGN11181	Yangon	TL29620	Timor
MDY05071	Mandalay	VN88102	Vietnam
MG04011	Magway	UK294132	United States
SGI02371	Sagaing	RU021521	Russia
BG08011	Bago	JPN00275	Japan
PT10011	Pathein	US000512	United Kingdom
DW14011	Dawei	KOR21590	Korea

4. Simulation Results

As the system error is small enough system training has stopped. In neural network system initial weights are between [-0.5] and [+0.5]. Learning parameter is chosen 0.25.For it has seen that system performance is quite well with these values. About 300 handwritten Postal Codes have been used to test the recognition system. The system uses 10000 input neurons to get the inputs, 100 hidden neurons and 2 output neurons to show the output pixel.

For example, MKN01011 where MKN represents Myitkyina and 01011 present their respective digits which includes in a Postal Code.

The Postal Codes accuracy is computed using the following formula.

$$Accuracy = 100 \times \frac{x}{y} \qquad (5)$$

where, x = no: of input envelope recognized accurately

y = total number of input envelope

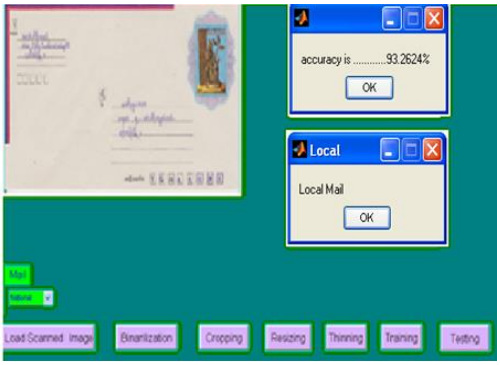

Figure 11. Simulation Result

After the scanned image (Figure 3) is tested, simulation result can be viewed as shown in Figure 11 and the accuracy of the system is shown in Table 2.

Table2. Accuracy of the System

Local/Overseas Mail	Training Dataset	Accuracy (%)
Local Mail (for each envelope)	50	70
	100	96
Overseas Mail(for each envelope)	50	75
	100	99

5. Conclusion

In this paper we have implemented the postal code recognition system. It can recognize the collection of handwritten Postal Code which consists of English characters and digits. This system builds the multilayer feed forward neural network model approach to recognize handwritten Local and Overseas Postal Codes. It is found that if the ANN of the system is trained repeatedly with a training set of Postal Codes, the system's intelligibility can be increased. In this system, more than a fifty of Myanmar Postal Codes and overseas Postal Codes are used for training data set. According to the simulation results, the accuracy of this system is promising.

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