Bangladeshi Post Office Automation System Using Neural Network

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Abstract—In this paper, bangla handwritten digit recognition based post office automation system has been proposed for Bangladeshi Post offices. Actually, postal automation is not any new concept in developed countries, as they are already practicing this. Though Bangladesh has entered in the digital era, postal systems are not digitalized still now. Proposed system automatically sorts mails according to the post code, thus it can save time and money, reducing the necessity of manual sorting. Envelopes of each mails are scanned and region containing post code information is segmented. Different positional and statistical features including Gray Level Co occurances Matrix (GLCM), Local Binary Pattern (LBP), Histogram of oriented gradients (HOG) feature based bangla handwritten digit recognition system is applied to extract each digit. According to post code, mails are stored in postal zone specific buskets. For recognising purpose, Multi Layer Neural Network is applied. Proposed system gains higher accuracy of 99.71%, thus it outperforms state-of-the-art methods.

Index Terms—Neural Network, Bangla Handwritten Digit, Recognition, Postal Automation, principle Component Analysis (PCA)

I. Introduction

For last two decades, character recognition is a topic of research interest of many researcher. Automated character recognition System is already in practice and there are many works available [1]–[4]. Several developed countries including USA, UK, France, Canada and Australia are implementing such systems for postal automation.

Actually, first concept of mail sorting started in the year 1920. In the year 1950, the first sorting machine was put into operation. A great developments were made in Optical Character Reader (OCR) after 1982. it could read the destination address and Pincode and print a Barcode for mail sorting.

Initial concept of automated sorting process is to detect the destination address block (DAB) from the envelope image. After detecting the DAB, the Zip code has to be located. From the extracted Zip code, individual digits are segmented. After recognising the digits, a relevant bar code mapping the destination address is given as output.

However, in the research of automated postal system, methods vary from the context of feature extraction techniques, classifiers, languages and performances. A vision based fast postal envelope identification system have been developed by [5] for isolated machine printed Chinese postal envelopes. They obtained 98.92% accuracy for post code with a font size no lesser than 10.5. The experiments were accomplished on 761 mail images containing 25060 characters.

An experiment with Indian postal letters has been done by [6] to segment the DAB and recognize the Pin code. They used Run length smoothing algorithm (RLSA) for vertical and horizontal smoothing. The text block (DAB) and non-text block (stamp, seal) were separated by pixel intensity. DAB was segmented using positional information.

Dynamic programming based segmentation of words has been introduced by [7]. Three MLP classifiers: General classifier, Digit Classifier, Alphabet Classifier with BP algorithm were used.

For recognition of Zip code, [8] has applied domain knowledge. To develop such system by understanding the structure of Zip code, they recognized the first digit. Their system involves 2 stages: segmentation and recognition.

Lexicon free word recognition algorithm has been used for handwritten Zip code recognition by [9]. [14] used adaptive neuro fuzzy inference system for recognising optical Character from printed text and text images. Back Propagation

Multilayer networks for performing handwritten Zip code recognition is done in [10]. Various methods have been practiced for postal automation in [11]–[13] such as Siemens sorting machine, OCR-GSA recognition system etc.

However, this paper consists of following sections: Proposed structure and methods are discussed in section II. Section III contains the results and discussions. Finally, the paper is concluded in section IV.

II. Proposed Structure and Methods

A. Preprocessing

In the preprocessing segment (figure 1), bangla digits are extracted from the images of envelopes. Also, proposed system removes the noise from the image to effectively perform recognition. However, noise in handwriting images includes dirt, interference, variability in handwriting styles, sizes, slants, thickness of the strokes etc.

Bangla Digit dataset for this work has been collected from different renowed sources:

01. https://www.kaggle.com/BengaliAI/numta
02. https://github.com/mehamasum/digits
03. https://github.com/sajibgoswami11/Bangla-Handwritten-Digit-Recognition
04. https://csc.lsu.edu/ saikat/noisy-bangla/

However, combining all datasets, a huge bangla digit dataset has been formed containing more than 1000 image for each digit classes.

1) Post Code Region Detection: A heuristic method is applied to select the post code region of 6 square boxes. The frame of 6 square box postal codes is 25 pixels wide and 142.5 pixels long.

2) Segmentation: In this step, line segmentation is used for detecting and deleting horizontal lines. Vertical pixel analysis helps in segmenting Vertical lines and numeric digits. Postal code digits are extracted from left to right depending on the positions of the vertical lines. Thus it preserves the order of the occurrence of the digits.

3) Noise Reduction: Noises contained in postal code digit image are removed for better performances.

B. Feature Extraction

Each digit images are fed into feature extraction segment to extract Statistical and Positional Features such as Histogram of oriented gradients (HOG), Local binary patterns (LBP), Gray-Level Co-Occurrence Matrix (GLCM) features.

1) Statistical and Positional Feature: Rotation and size independent feature extraction methods are applied to obtain features for each image region. Relation between the height and the width of the image, Pixels distribution in the image, Percentage of black pixels located in the upper and lower areas of images, Percentage of black pixels located in the left areas of images, percentage of black pixels located in sub-regions of the image are calculated, thus obtaining 26 image features.

2) LBP Feature: In applications, such as texture classification and segmentation, LBP (Local Binary Pattern) features perform very well.

Applying thresholding on the 3-by-3 neighborhood of each pixel with the center pixel value, pixels of an image are labeled in oroginal LBP. Also, the result is stored as a binary number.

3) HOG Feature: Actually, HOG is a feature descriptor which is used for object detection purposes. It is thought that, this method has some similarity with scale-invariant feature transform descriptors, edge orientation histograms, and shape contexts. But it differs in computing techniques. HOG features are calculated on a grid of equally spaced cells. Moreover, overlapping in local contrast normalization occurs for improved accuracy.

4) GLCM Feature: GLCM is a popular method for texture classification. It considers the spatial relationship of pixels. It extracts statistical measures from the glcm matrix. Among different measures, four measures of an image have been extracted form GLCM: Contrast, Correlation, Energy, Homogeneity.

C. Feature Reduction

The purpose of using feature selection algorithm is to reduce computational cost, increase classifier accuracy and find out the most relevant features. Variance based subspace method such as Principle Component Ananlysis (PCA) is the most popular methods for reducing dimensionality [18], [19].

In PCA, a data vector x(i) is mapped from an original space of P variables to a new space of P variables. there is no correlation between these variables over the dataset. However, there is no need to keep all the principal components. Only the first L principal components can be kept, which can be produced by using only the first L eigen vectors. Thus it gives the truncated transformation $T_L = XW_L$.

In this work, using PCA as feature reduction technique, only 8 features are selected. these 8 features are the most effective representative of bangla handwritten digit images.

D. Classification

Reduced features are fed into the classification segment. In this paper, Neural Network have been practiced for classification purpose. [15]–[17]

Neural networks are composed of elements inspired by biological nervous systems. It can be trained and perform a specific function by adjusting the values of the weights between elements. Typically, training occurs based on a
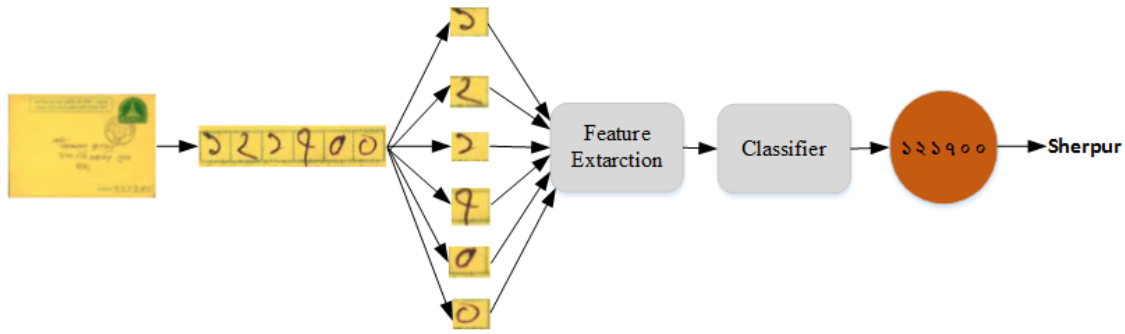
Fig. 1. Proposed Methodology

comparison of the target and the output. This process continues until the network output matches the target. Neural network can perform decision making, as it has been trained with known values.

Figure 2 shows the structure of proposed Neural Network. It has one input layer, two hidden layer, and one output layer. Input layer contains 8 input node for 8 feature set. Both Hidden layer 1 and Hidden layer 2 have 10 neurons. in the output layer, it has 10 neuron for 10 digit image classes.
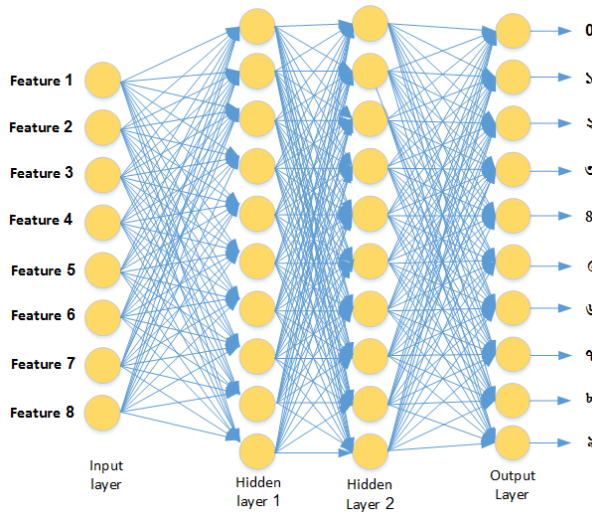

Fig. 2. Proposed Structure of Neural Network

III. RESULTS AND DISCUSSION

10-fold cross validation mathod has been used for validating proposed methodology. In 10- fold cross validation, process continues for 10 times. In each iteration, total dataset is splitted into 10 fold, where 1 fold is used for testing and rest 9 fold is used for training the classifier.

In this work, more than 1000 images for each digits have been used. However, experiments show that, proposed system is able to accurately classify every digits except some cases. In the confusion matrix of figure 4, it is seen that, this system

is in confusion about 3 and 7, 2 and 1, 8 and 4 in some cases. Moreover, there is also a confusion between 9 and 1, 5 and 6.

In the figure 3 and figure 4, a distribution table of different digits and a confusuion matrix is shown respectively. All the digits have higher level of accuracy exceeding 99%.

Also a comparison among different works have been shown in Table I. Different methodology have been used in different works including vision based system, Run Length algorithm, Multi layer Perceptron, Domain Knowledge based system etc.

More accuracy can be obtained if all the features are used instead of feature selection. But it may also cause overfitting problem. Considering this condition, only 8 features are selcted and used for training the classifier. However, Proposed method gain higher accuracy.

Digit	Percentage(%) of Error
০	99.7
১	99.6
২	99.7
৩	99.8
৪	99.7
৫	99.8
৬	99.8
৭	99.6
৮	99.9
৯	99.5

Fig. 3. Distribution of different digit error

IV. CONCLUSION

In this paper, Neural Network based system for Bangladeshi postal Automation has been proposed. Proposed system takes postal envelope as input. From the envelope image, it segments the postal code region and each digits. Different features are extracted including GLCM, LBP, HOG, Positional and

TABLE I
COMPARISON WITH OTHER METHODS

Paper	Used Methodology	Accuracy
Xue Gao et. al [5]	Vision Based	98.92%
Umapada Pal et. al [6]	Run length smoothing algorithm	94.13%
Prasun Sinha et. al [7]	MLP	98%
Chabaan Ibrahim et. al [8]	domain knowledge	88.76%
F. Kimura et. al [9]	Back Propagation Multilayer network	99.2%
Proposed Method	**GLCM+LBP+HOG+ Statistical+Positional Features+NN**	**99.71%**

Actual

Predicted	০	১	২	৩	৪	৫	৬	৭	৮	৯	Total
০	997			1					2		1000
১		996							4		1000
২		2	998								1000
৩				997			3				1000
৪					998			2			1000
৫						997	3				1000
৬						2	998				1000
৭				3				996			1000
৮					4				999		1000
৯		5								995	1000
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	10000

Fig. 4. Confusion Matrix

statistical features. Principle Component Analysis (PCA) is practiced for reducing the features. Finally 8 features are selected which are fed into the Neural Network. Neural network classify the images as 0, 1 2,... etc. From the extracted postal code, mails will be sorted according to the region based code information. Proposed method gains higher accuracy of 99.71% which outperforms the state of the arts methods. However, this system can be used efficiently for Bangladeshi post Office Automation. In future, we will use deep learning for this purpose.

REFERENCES

[1] Nashif, Md.H.H.,Miah, Md.B.A., Habib, A., Moulik, A.C., Islam, Md.S., Zakareya, M., Ullah, A., Rahman, Md.A. and Al Hasan, Md. (2018) Handwritten Numeric and Alphabetic Character Recognition and Signature Verification Using Neural Network. Journal of Information Security, 9, 209-224.
[2] Md. BadrulAlamMiah, S.M. AnamulHaque, RashedMazumder, Md. ZamilurRahman (2011) A New Approach for Recognition of Holistic Bangla Word using Neural Network.IFRSA International Journal of Data Warehousing Mining,Vol1,issue 2,Nov 2011
[3] S M Shamim, Mohammad BadrulAlamMiah, AngonaSarker, MasudRana Abdullah Al Jobair (2018) Handwritten Digit Recognition using Machine Learning Algorithms. Global Journal of Computer Science and Technology: D Neural Artificial Intelligence Volume 18 Issue 1 Version 1.0 Year 2018
[4] Mohammad Badrul Alam Miah, Mohammad Abu Yousuf, Md. Sohag Mia Md. Parag Miya (2015) Handwritten Courtesy Amount and Signature Recognition on Bank Cheque using Neural Network.International Journal of Computer Applications (0975 8887) Volume 118 No. 5, May 2015
[5] Xue Gao and Lianwen Jin. (2009),Swift post a vision-based fast postal envelope identification system. In Proceedings of the 2009 IEEE International Conference on Systems, Man, and Cybernetics, pp: 3268-3273.
[6] Umapada Pal, Rami Kumar Roy, Kaushik Roy, and Fumitaka Kimura. (2009), Indian multi-script full pin-code string recognition for postal automation. In Proceedings of the 10th International Conference on Document Analysis and Recognition, pp: 456-460.
[7] Prasun Sinha. (1997), Cursive Script Postal Address Recognition. PhD thesis, Michigan State University, East Lansing, US.
[8] Chabaan Ibrahim. (2007), Applying Domain Knowledge To The Recognition Of Handwritten Zip Codes. PhD thesis, Indiana University, South Bend, US.
[9] F. Kimura, Y. Miyake, and M. Shridhar. (1995),Handwritten Zip code recognition using lexicon free word recognition algorithm. In Proceedings of the 3rd International Conference on Document Analysis and Recognition, Vol. 2, pp: 906.
[10] Y. Le Cun, O. Matan, B. Boser, D. Denker, J.S. Henderson, W.Jacket, L.D.Baird, H.S. Howard, R.E. Hubbard. (1990), Handwritten Zip code recognition with multilayer networks. In Proceedings of the 10th International Conference on Pattern Recognition.
[11] C. M. Velu and Vivekanandan.P. (2010), Automatic letter sorting for Indian postal address recognition system based on pin codes, Journal of internet and information system,Vol.1, No.6, pp:15.
[12] M. Pfister, S. Behnke, and R. Rojas. (2000), Recognition of handwritten Zip codes in a real world non-standard letter sorting system. Applied Intelligence.
[13] Yue Lu, Xiao Tu, Shujing Lu, and Patrick S P Wang. (2010), Application of pattern recognition technology to postal automation in china. Pattern Recognition and Machine Vision.
[14] Billah, Mustain, Sajjad Waheed, and Abu Hanifa. "An Optical Character Recognition System from Printed Text and Text Image using Adaptive Neuro Fuzzy Inference System." International Journal of Computer Applications 130.16 (2015).
[15] Rajavelu, A., Mohamad T. Musavi, and Mukul Vassant Shirvaikar. "A neural network approach to character recognition." Neural networks 2.5 (1989): 387-393.
[16] Ganis, M. D., Charles L. Wilson, and James L. Blue. "Neural network-based systems for handprint OCR applications." IEEE Transactions on Image Processing 7.8 (1998): 1097-1112.
[17] Srivastava, Shriansh, et al. "Optical Character Recognition on Bank Cheques Using 2D Convolution Neural Network." Applications of Artificial Intelligence Techniques in Engineering. Springer, Singapore, 2019. 589-596.
[18] Avci, Engin, and Ibrahim Turkoglu. "An intelligent diagnosis system based on principle component analysis and ANFIS for the heart valve diseases." Expert Systems with Applications 36.2 (2009): 2873-2878.
[19] Kambhatla, Nandakishore, and Todd K. Leen. "Dimension reduction by local principal component analysis." Neural computation 9.7 (1997): 1493-1516.