Investigating the Various Approaches towards Handwritten Digit Recognition

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Abstract
Pattern recognition plays a vital role due to demand in artificial intelligence in practical problem. One of the problem is, that the machine faced problem in handwritten digit recognition. To recognize the digits, different features are considered such as style, orientation, curve, size, edge, thickness of the digit. Based on these factors they classifies the digits. This paper describes the different approaches that where followed to recognize the Handwritten digits. And the discussion about the different algorithms used. There are two steps involved, one is feature extraction for that there are many feature extraction methods available like, Linear Binary Pattern, Histogram Oriented Graph, Convolutional Neural Network and many more algorithms. Another one is feature classification for that many machine learning methods available like Support Vector Machine, K Nearest Neighbor so on. The main objective of all these approaches is to improve the prediction accuracy. So our main intention is to find the most appropriate method which could give highest prediction rate. In order to obtain that we created a comparative table, which compares with respect to classification method, feature extraction method, accuracy, purpose, pros and cons. Also plotted graph to compare them.

Keywords: *Artificial Neural Network, Convolutional Neural Network, Artificial Neural Network, Histogram Oriented Gradient, Linear Binary Pattern Variant, K- Nearest Neighbour, Support Vector Machine*

INTRODUCTION

Now-a-days, most of the application have been using images to represent as well as to transmit the information. In the research field, image recognition plays an importance role. So, many applications based on image recognition have been developed. In that, recognizing hand written digits are one of the applications in it. One of the challenges is to accurate automated recognition of handwritten digits. Since handwriting style, size, thickness are differ from person to person.

In Recent years many have worked on this application using their own approaches. Now we try to do comparisons between these works and its results. Basically, Optical Character Recognition (OCR) is nothing but it is a technology which has the ability to convert the handwritten, printed or typed images into machine encode text or languages. Applications of these OCR are used in banks statements, mails, business cards, invoices, passport documents, computerized receipts or printouts of static data. It is one of the common methods of digitizing where the handwritten text can be converted electronically which can be edited, searched easily and stored in a more compact way.

The fields like computer vision, artificial intelligence and pattern recognition uses the OCR technology. Pattern recognition is the method to study the behaviour and variations present in the data. Artificial

Intelligence and machine learning are closely related to Pattern recognition which can be used in the applications of data mining.

METHODOLOGY

Using Artificial Neural Network Approach

A system to recognize the South Indian languages hand written digit is build using Artificial Neural Network and Histogram of Oriented Gradients. Implantation of this system contains five stages, in that first one is image acquisition, instead of MNIST dataset they have chosen scanned document of hand written digit. Next stage is noise removal in that they have used wiener filter, which calculate the statistical estimate of unknown signal and main focus is to removal of noise. Next phase is segmentation, from cluster of digits separation of individual digits. Next phase is feature extraction, calculation of gradient value is preliminary stage in feature extraction. Then they used block normalization and final stage is digit recognition, which is divided into training stage and testing stage. In the training stage, train the ANN with set of input values. Testing stage helps to check the system for accuracy. The overall accuracy of this system is 83.4% for all South Indian languages [1].

Using K-Nearest Neighbour Approach

The framework is actualized for perceiving the transcribed pictures on C1 form, which is utilized for General Election Commission of Indonesia. In this framework Local Binary Pattern is utilized for highlight extraction and KNN for grouping. Data stored in MNIST data and C1 form data base are used for feature extraction process. KNN can recognize the digits up to accuracy of 89.65% for that C1 form [2].

Using Convolutional Neural Network and Support Vector Machine Approach

Blend of pre-prepared Convolutional Neural Network (CNN) and Support Vector Machine (SVM) is utilized for structure the framework that could ready to order the handwritten digit. In this strategy essentially two modules in that initially is include extractor and second module is trainable classifier. This first module will transfer raw image into feature vector for this CNN is used and for classification SVM is used. This system gives error rate 0.95% only [3].

Using Ensemble Neural Network and Ensemble Decision Tree Approach

Ensemble Learning takes significant job in AI system, so as to improve the presentation of the model, it will join various learning calculations. So they incorporated this technology in the system that could recognize the handwritten digit. Here they used Ensemble Neural Network (ENN) and Ensemble Decision Tree (EDT) together it is called as ENNEDT. This ensemble classifier achieves an accuracy of 84%, according to definition it could perform better. So, accuracy that they got is not reach the expectation [4].

Using Chemical Reaction Optimization Approach

Metaheuristics is a high level procedure to solve optimization problem. This CRO is one of the metaheuristics, it is a chemical reaction that transfers unstable substance to stable one. CRO is used to increase the accuracy of the handwritten digit recognition and it achieves very well accuracy. For classification they used SVM as classifier algorithm. Especially they used this technique to recognize the Bangla digits [5].

Using Gabor feature

Gabor filter is a sinusoidal signal with some frequency, orientation and modulation. In this paper this filter is formed by combination of Extreme Learning Machine (ELM) and Sequential minimal optimization (SMO). The direction of the

stroke is the one of the challenging element in the Arabic handwriting recognition. AHDB and CENPERMI are the database used as the database for the Arabic handwriting. In their experiment with 32*64 (5120) features got better result than 128*128 (2560) features. And they used this features on both the database as mentioned above. Usually for classification we use SVM, but they thought that it is not suitable for the large dataset so to increase the training efficiency they used SMO. It could handle more dataset than traditional SVM [6].

Using Spiking Neural Network Approach

Spiking Neural Network is one of the third-generation neural network, which fills the gap between the neuroscience and machine learning. Spiking neurons and synapses interconnection are the basic unit of SNN. They considered three layered network input layer, hidden layer and output layer. In which hidden layer perform the feature extraction and output layer perform the classification. It takes input from 28*28 pixel MNIST database and they used GPU platform with CUDA-C programming framework. GPU is subdivided into streaming multiprocessors and each of SM consist of stream processors. SP are optimized to execute the mathematical operations. The developed system could able to perform spike encoding, feature extraction and classification. System achieved 97.68% accuracy on MNIST dataset [7].

Using Histogram of Oriented Gradient Approach

In this paper they used HOG as the feature set in order to represent them in feature space and SVM used to produce the output from set of input. They used CMATERDB3.1.1 dataset to run the proposed algorithm. Along with HOG they used Color Histogram method for feature extraction method. Which provides robust feature for curve orientation and edge detection [8].

Using Mathematical Morphology Approach

The main objective of this system is to differentiate and recognize or classify the Hindu-Arabic Numerical. So they first group these ten digits into two groups in that 0, 4, 6, 8 and 9 belongs to group1 whereas 1, 2, 3, 4, 5, and 7 belongs to group2. They wrote separate algorithm for each group. In the group1 algorithm, they find out the junction point and based on number of junction point they sub divided the group. If there is no junction point then the digit is 0. If there is one junction point then digit could be 6 or 9, if there is two junction points then the digit could be 8 or if there is three junction points appears then the digit is 4. Since 6 and 9 has same number of junction point, they added one more feature named position of stem. If the stem position is above the junction point then it is 6 otherwise it is 9. In the group2 algorithm, further they sub divided into two groups one with blobs and another without blob. In this way differentiated the Hindu-Arabic Numerical [9].

Using Restricted Boltzmann Machines

Restricted Boltzmann Machines (RBM) is one of the neural network algorithms that can help in dimensionality reduction, classification and regression. The main aim of this system is to take large number of training samples and the system has to extract some of the features based on these samples. Design the powerful hardware accelerator which uses many neural networks of RBM type and they operate in parallel. In the training phase they find out the weight and bias that is used in classification process. They achieved good result in compromise between the complexity of hardware and performance of the system [10].

Using Orthogonal Feature Detection

To improve the robustness of the performance of the system orthogonal feature detection is proposed in the artificial neural network. For feature detection they used Gram-Schmidt process. The proposed orthogonal method achieves the 56.4% relative improvement in recognition error rate. The main objective of this system is to achieve noise-robustness when some training and testing data are mismatched with simple and effective methods [11].

Using Improved LeNet5 Approach

LeNet5 is one of the common modules of convolutional neural network. Usually LeNet5 consist of seven layers, in which three convolutional layers, two subsampling layer, one fully connected layer and one output layer. In improved LeNet5 little changes is done in architecture, in which last two layers are replaced with support vector machine classifier to predict the label of the input pattern. In this system LeNet5 act as automatic feature extractor and Support Vector Machine act as predictor of output. Second order method the stochastic diagonal Levenberg-Marquardt algorithm is used to improve the performance of the system [12].

Using Multiple Segmentations and Scalloped Coding

In Kinect-based recognition, the handwritten digits are written on air. So, they used multiple segmentation method in which they separated the 90 path coordinates into several number of segments. Such as two, three, five, nine, ten and effect of these different segment lengths are used to see highest recognition rate. Kinect sensors will be initialized first then they track the engine to get the joint information and using this information judge whether "start" condition is satisfied. If satisfied then it will recognize [13].

Using Zoning and Histogram Projection

Zoning and Histogram both are feature extraction method that is used in this system. Image intensity at every zone is calculated separately and it is taken as feature of that zone. This feature alone will not give high performance so it is necessary to consider some other features too. 64 features were extracted from zoning and5 features from histogram projection totally 69 features were extracted from each image. They achieved 97.83% for 8000 samples of training data [14].

Using DCT and HMM Approach

Discrete Cosine Transform is used recognize the digits and Hidden Markov Model is used as classifier in this system. Baum welch algorithm is used to train HMM parameters. To recognize the speech using HMM Sphinx tool kit is designed. The parameters are optimized empirically [15].

DISCUSSION

In the previous part, we discussed about the different approaches. In the below Table 1, we compared these approaches based on different features such as Method, Feature extraction, Accuracy, Purpose, Pros and Cons. Our main intention is to get high accuracy based on the method that is followed in order to recognize the hand writing. Looking at the below table, Chemical Reaction Optimization has got higher accuracy but it is tested for Bangla digit only, but we don't know what could be the accuracy for universal language English digits. Next higher accuracy that we got using was Convolutional Neural Network, it has high error reduction rate and could be applied to universal language English. Along with CNN, SVM is used as the feature extraction method. Artificial Neural Network with Histogram of Gradient could achieve an accuracy 83.4% only, and it is applied to South Indian language only. K- Nearest Neighbor with Local Binary Pattern Variance could able to

achieve some good accuracy rate.

CONCLUSION

It is difficult to decide the most accurate method, since they are applied on different database and different feature like some applied for only regional languages but it may not be achieve same accuracy when applied to some other regional language. Looking at the below Fig.1, CRO has highest accuracy rate, but we saw in comparison table that it is used for only Bangla digits. In the Fig.2, we sort out the method by common language that is universally acceptable language English. So, in Fig.2, CNN achieves as highly accurate method. Feature extraction methods like SVM and LBPV are better than others in comparison table. The conclusion is to use the CNN in future work in order to obtain the high accuracy. So, in my future work implementation of Recognizing Handwritten digit system will be carried out using CNN.

Table 1: Comparison of different approaches.

| Method	Feature extraction	Accuracy In %	Purpose	Pros	Cons
ANN[1]	HOG	83.4	South Indian language recognition	Can be used to Recognize old documents, religious and Ayurveda script	Compa ratively less accurate
KNN[2]	LBPV	89.65	c1 form for election purpose	recognizes c1 form data better than MNIST data	Bittime consuming process
CNN[3]	SVM	90	To reduce error rate	compare to ANN , CNN is better	CNN is bit complex to understand
ENNE DT[4]	ENN	84	Incorporate Ensemble technique	able to combine ENN with EDT	Expected performance is not achieved
CRO[5]	SVM	98.96	For Bangla digit	High accuracy	Not sure of Other languages
Gabor Filter [6]	ELM	86.74	Arabic bank cheque	Could find all Arabic stroke	Need To improve accuracy
HMM [15]	DCT	88	Optimization	predicted	Not enough accuracy
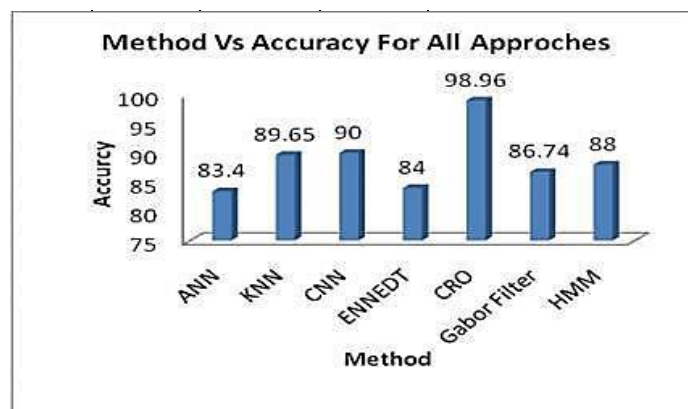
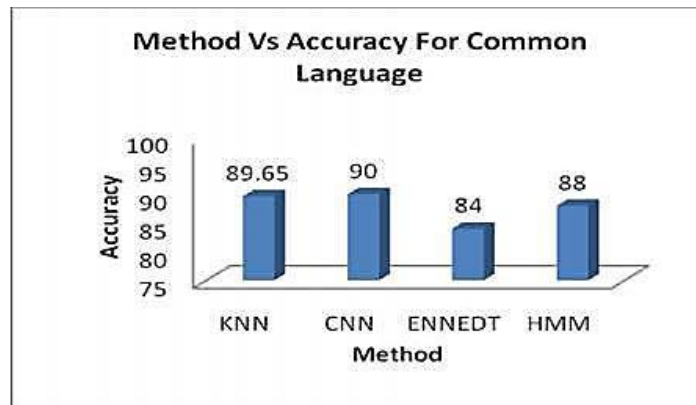*Figure 1: Method Vs Accuracy for all Approaches.*

Figure 2: Method Vs Accuracy for Common Language.

REFERENCES

1. Leo Pauly, Rahul D Raj, Dr.Binu paul (2015),"Handwritten Digit Recogition System for South Indian Languages using Artificial Neural Network".
2. Nurul Ilmi, Tjokorda (2016),"Handwriting Digit Recognition using Local Binary Pattern Variance and K-Nearest Neighbor Classification", *2106 Fourth International Conference and Communication Technologies*.
3. Yoshihiro Shima, Yumi (2017), "Pattern Augmentation for Handwritten Digit Classification based on Combination of Pre- trained CNN and SVM".
4. Retno Larasati, Dr Hak KeungLam (2017),"Handwritten Digit Recognition using Ensemble Neural Netwok and Ensemble Decision Tree", 2017 *International Conference on Smart Cities, Automation Intelligent Computing System Yogyakarta, Indonesia*.
5. Pritam Khan Boni (2018), "Handwritten Bangla Digit Recognition Using Chemical Reaction Optimization", *9th ICCCNT* .
6. Qais Al-Nuzaili (2018),"Arabic Bank Cheque Words Recognition Using Gabor Features", *2018 IEEE 2nd International Workshop on Arabic and Derived Script Analysis and Recognition (ASAR)*.
7. Shruthi R Kulkarni (2017), "Learning and Real-time Classification of Handwritten Digit With Spiking Neural Networks".
8. Amitava Choudhury (2018), "Handwritten Bengali Numerical Recognition using HOG Based Feature Extraction Algorithm", *2018 International Conference on Signal Processing and Integrated Networks (SPIN)*.
9. Ratan Kumar Baskar (2016), "Hindu Arabic Character Recognition Using Mathematical Morpology".
10. Nikolas Toulgaridis (2017), "RBM-based Hardware Accelerator for Handwritten Digit Recognition", *2017 Panhellenic Conference on Electronic and Telecommunications*.
11. Chia-Ping Chen (2016), "Integration of Orthogonal Feature Detectors in Prameter Learningof Artificial Neural Networks to Improve robustness and the Evaluation on Hand-Written Digit Recognition Tasks".
12. Naigong Yu (2015), "Handwritten Digits Recognition Base on Improved LeNet5", *27th Chinese Control and Decision Conference*.
13. Fu-An Huang (2013), "Kinect-based Mid-air Handwritten Digit Recogition using Multiple Segments and Scaled Coding".
14. Anir Nooraliei (2013), "Persian Handwritten Digits Recognition by

Using Zoning and Histogram Projection".

15. Syed Salman (2014), "Handwritten Digit Recognition using DCT and HMMs", *12th International Conference on Frontiers of Information Technology*.

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