International Journal of Advance Research in Science and Engineering
Volume No. 12, Issue No. 12, December 2023
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Handwritten Character Recognition Technique By Using Optimized Bert Enabled Deep Convolutional Neural Network Classifier

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ABSTRACT:

The world education and literary system is moving towards digitalization. In this digital working system, the process of overall documents like books, notes, papers etc can be converted into digital form known as softcopy. Such process conversion of handwritten document into digital form is known as Handwritten Digit recognition (HDR). For proper reading of documents and keeping it in the digital text i.e in softcopy this process is generally known as digital scan. This paper is a review of HDR and the reader will understand the classifiers like K – Nearest Neighbour (KNN) Model, Support Vector Machine (SVM), and Convolutional Neural Networks (CNN) Model. All above the classifier can trained with some predefined data and then process towards the scanning into the Handwritten to Digital form. In this paper we discussed about the stages of HDR system like preprocessed stage, segmented stage and classifier stage. From these review researcher can get idea about all these models of classifier and also the process of HDR in detail. In this paper we more focus on the CNN Classifier model because after taking an review we moved towards a conclusion that CNN has higher accuracy for HDR

IndexTerms **- HDR, KNN, CNN,SVM**

I. INTRODUCTION

Convolutional Neural Networks (CNNs) is very well known deep learning algorithm which can be used to process image. It assigns weights and biases to various parts of the image and very capable of differentiating one image from another same kind of image. For Higher accuracy, handwritten digits recognition used the Convolutional Neural Networks. Mammalian system of visualization is taken into consideration to create CNN architecture. CNN is created by D. H. Hubel in 1962 [1]. Character images of handwritten digits are used as an input. Artificial neural network (ANN) consists of one input layer, one output layer and some layers which exist in between input layer and output layer, these middle layers are hidden layers. Convolutional Neural Network and Artificial Neural Network both are same were Convolutional Neural Network deep learning algorithm dealt with the analysis of

visual images. CNN has wide range of applications like object detection, face identification, in field of automation and robotics, image/video processing, pattern identification, natural language processing, spam detection, speech identification, etc. For conversion of Printed document letter to text the OCR (Object character Recognition) is used. Digital documents can be created by extracting and storing information using OCR scanning tools. OCR can be implemented by pattern recognition and through segmentation method. Object character Recognition is similar to hand-written digit recognition, to recognize the digits. HDR is light and faster than OCR. HDR has various applications in medical documentations, banking, academic record etc.

All the classifiers are providing good accuracy but still there is a lot to explore in the field of HDR to further improve the performance. The performance parameters used to find the performance of classifiers are accuracy, running time and computational complexity. Convolutional Neural Network model is fully use the topological information. English Handwriting datasets like Modified National Institute of Standards and Technology (MNIST) are used to calculate the performance of HDR technique [8].

II. HDR MODELS

The popular models which are used for HDR are KNN (K nearest Neighbors), SVM (Support Vector Machine), NN (Neural Networks).

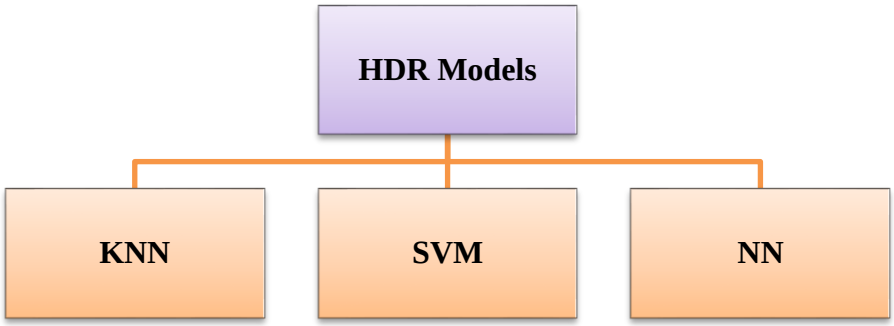

Fig. 2.1 HDR Model

2.1. K Nearest Neighbour

KNN is used to solve regression problems and also used as a classifier. In KNN classifier, since computations are calculates up to the end stage that's why it is also called as late learning classification algorithm. And since all the computation occur locally; it is also called as instance-based classification algorithms. There is no training required earlier in KNN classifier, as well as there is no generalization is performed on training data. KNN algorithm describes categorical value by making use of majority of votes of K - nearest neighbors, the K value used to differ here. It is found that votes value changes with change in K value as shown in Fig. 2.2.

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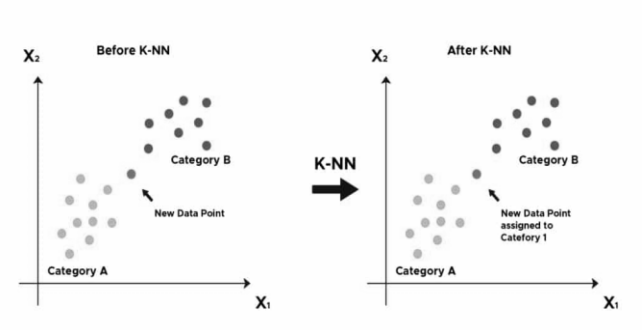

Fig 2.2 K Nearest Neighbour Model

2.2 Support Vector Machine

Support Vector Machine is a kind of supervised learning. It can be used for both regression problems and for classification purpose. SVM make use of optimal hyper plane that can be utilized to divide it into multiple categories. For 2D spaces, independent variable data points are plotted which are corresponds to dependent variables [3]. After it, classification is started to find hyper plane or linear/nonlinear plane which is used to categorize class as shown in Fig. 2.3.

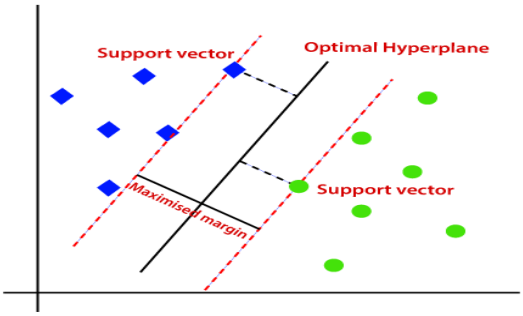

Fig 2.3 Support Vector Machine

2.3 Neural Network

The Neural Networks methodology is inspired from working of brain. It became popular in the field of computational power. NN is termed as Deep learning where multilayers are connected together to form a network. Nodes are formed by using these layers. Each node is subjected to execute some computation. This then input into node's activation function, in order to show context signal progress into the network for classification purpose [7].

III. HDR DATABASE OF MNIST

The standard database used for HDR is MNIST database (Modified National Institute of Standards and Technology database). It contains images of handwritten digits which are very frequently used to train classifiers for image processing applications. Machine learning algorithms also use this data base very frequently. This

database has training image database of 60,000 images and testing image database of 10,000 images. Some of them are shown in Fig. 4 below. Where 50% of the images are taken from MNIST's database. Many researches have been done on it to achieve good accuracy [9]. Fig.3.1. some images of MNIST.

Fig. 3.1 MNIST Database

IV. CONVOLUTIONAL NEURAL NETWORK

A CNN [1] is a deep learning method that has been extensively used in developing applications for computer vision, natural language processing, data mining, computer games and handwritten recognition[5]. LeNet5 is the base architecture of CNN[6]. LeNet-5 was one of the first multilayer neural network where the concept of Convolutional neural network (CNN) was used in 1990 [7]. As the topic was researched further, more layers were addedmaking the system more accurate but also started to increasethe computational time [8]. The computational time can be reduced to some extent by using better GPU's. But even thenachieving 100% accuracy rate is practically impossible. Although in the past few years CNN has performed well but still human beings have better ability.

4.1 Layer of CNN

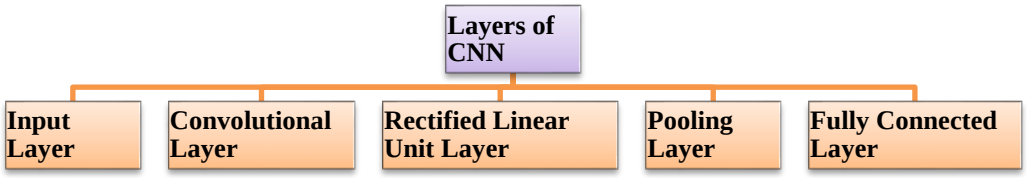

Fig 4.1 Layers of CNN

A. Input Layer: Raw pixel values are carried out.

B. Convolutional Layer: The output of input layer supplied to this layer. In this layer filter is defined.

C. Rectified Linear Unit Layer: It passes the image pixel into activation function.

D. Pooling Layer: Perform on the dimension & the result comes in the form of volume.

E. Fully connected Layer: It computes the score secured by the input.

V. STAGES OF HDR USING CNN

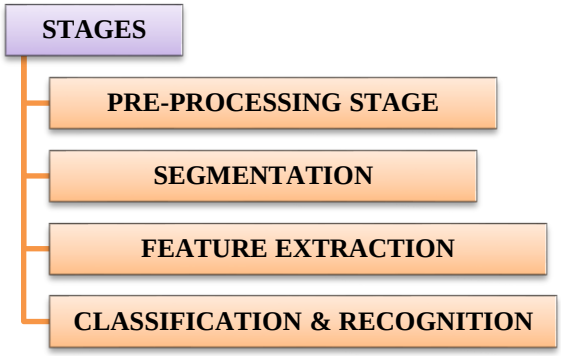

Fig 5.1 Stages of CNN

As per the mentioned stages the first stage of HDR is Preprocessing stage. In these stage the various operation are performed and make the image for segmentation. The image is converted into binary image. After preprocessing in segmentation the image is divided into small sub image which represented into single digit. After this the image is set into matrix form this stage is called feature extraction stage. This stage is used to remove redundancy from the image. After this stage the matrix is taken as input in classification and it recognized the digit in the present image.

COMPARATIVE METHODS:

The methods utilized for comparison encompass KNearest Neighbor (KNN) classifier (B1) [27], Decision Tree (DT) classifier (B2) [28], Deep CNN (B3)[29], BERT CNN(B4)[22], BERT CNN with Harris Hawk Optimization (BERTCNN with HHO) (B5)[30], BERT CNN with Coati Optimization Algorithm (BERT CNN with COA) (B6)[8], and Proposed BERT enabled Deep CNN with QHtO.

a. ***Comparative analysis with TP***

The figure represents a comparative assessment of the

Deep CNN empowered with QHtO-BERT against current methods for detection accuracy, sensitivity, and specificity. At TP 90%, accuracyof the QHtO-BERT enabled DCNN method is 94.7%, showing an improvement of 2.53 % over B1, 2.11% over B2, 1.68% over B3, 1.26% over B4, 0.84% over B5, and0.42 over B6as shown in Figure 5(a).Similarly, at TP 90, the sensitivityof the QHtO-BERT enabled DCNN approach is 95.92% indicating an increase of 3.59% over B1, 2.99% over B2, 2.39% over B3, 1.79% over B4, 1.19% over B5, and 0.59 % over B6, as depicted in Figure 5(b).Additionally, Figure 5(c) demonstrates that the specificity of the QHtO-BERT enabled DCNN is 95.02% at TP 90, showing an improvement of

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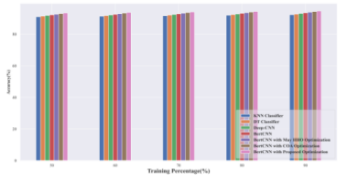
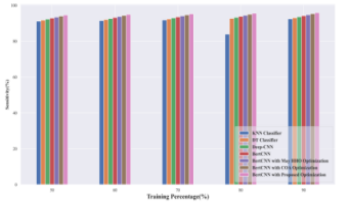
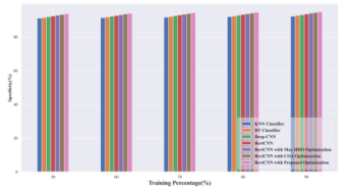


a)accuracy



b)sensitivity



c)specificity

VI. CONCLUSION

In this paper, various methods for handwritten numeral recognition based on MNIST database are compared. Over the years various scientists have proposed new methods for handwritten digit recognition which have helped in making our lives easier. In this paper with increase the number of layers of the system, the accuracy as well as the computational time

In this research, the framework combines the power of BERT's contextual understanding with the deep convolutional neural network's image processing capabilities to efficiently extract structure information from COVID-19 re-invoice documents. The optimized BERT model significantly improved the performance of the deep CNN classifier, enhancing its ability to handle complex and varied invoice layouts. The framework demonstrated robustness in handling different invoice formats, even when dealing with scanned images of this study invoices. Furthermore, the comparative analysis with conventional methods showcased the superiorit of QHtO-BERT enabled Deep CNN framework, outperforming traditional approaches. The achieved values for accuracy, sensitivity, and specificity were 94.7%, 95.92%, and 95.02%, respectively. Subsequent efforts might center on expanding the framework's capabilities to handle multilingual invoices, handling unclear data, and exploring potential integration with blockchain technology for enhanced security and transparency in invoice processing workflows.

VII. ACKNOWLEDGMENT

I would like to show gratitude to my guide Prof. V. M. Deshmukh for sharing their pearls of wisdom with as during research. I am also grateful to the SSBT's College of Engineering and Technology, Jalgaon who provided expertise, labs and instruments that greatly assisted the research. At last but not the least, I am thankful to my parents who have supported me throughout.

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