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Handwriting Recognition using Deep Learning based Convolutional Neural Network

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Abstract*: Handwriting is a learned skill that had been an excellent means of communication and documentation for thousands of years. The simple way to communicate with the computers is through either speech or handwriting. Speech has some limitation; hence input through handwriting is recommended. It is difficult to input data for computers for Indian language scripts because of their com-plex character set. This paper focuses on exploring convolutional neural networks (CNN) which is deep learning based for the recognition of handwritten script. The proposed method has shown 99% for handwritten English numerals and promising recognition accuracy for Kannada numerals.

Keywords: CNN, Deep Learning, Handwriting recognition, Kannada OCR, Preprocessing, Segmentation.

I. INTRODUCTION

Handwriting recognition is a process of correctly classifying the handwritten character and converting it to machine understandable form. This process can be either online or offline; in case of online system, handwritten input is stored in the form of sequence of coordinates along the pen tip movements, whereas offline system receives the input in the form of image containing the handwritten character. Further, handwriting recognition can be either writer dependent or writer independent. Writer independent recognition system has to recognize the input given by all writers; hence most handwriting recognition systems are writer independent. Implementation of writer independent system is quite challenging because it has to deal with handwriting style of different writers.

Handwriting recognition is gaining popularity because of rapid growth in mobile applications which supports regional language. Giving input in regional language using physical keyboard or virtual keyboard is complex compared to handwritten input because Indian regional languages has complex character set. Hence, there is lot of scope for developing applications which accepts handwritten input particularly in Indian regional languages.

Machine learning models are gaining more popularity in the area of handwriting recognition, one such model is deep learning based neural network which is based on a set of algorithms that attempt to model high-level abstractions in data, [1] [2]. Such algorithms develop a layered, hierarchical architecture of learning and representing data. Neural network simulates the working of human brain; hence it is self-learning model yields better result after proper training with huge dataset. This paper explores the technical details of using deep learning approach for recognizing handwriting characters.

II. RELATED WORK

Anirudh Ganesh *et al.,* [3] proposed a system for the recognition of Kannada Numerals. Authors implemented the CNN and Deep Belief network (DBN) and achieved accuracy of 97.76% for CNN and 98.14% for DBN.

Pardeep Kumar *et al.,* [4] proposed Handwriting Recognition using Tensor Flow and Convolutional Neural Networks for recognition of handwritten numerals. The proposed system uses CNN for the process of feature extraction and achieved 98% accuracy.

Salma Shofia Rosyda *et al.,* [5] presented a review paper. In this paper, they have discussed eight methods namely Convolutional Neural Network (CNN), Semi-Incremental Segmentation, Incremental, Lines and Words, Parts, Slope and Correction Slant, Ensemble, Zoning. Advantages and disadvantages of all the eight methods are highlighted and concluded that, in the Convolutional Neural Network (CNN), the time required for long training due to CNN is included in the deep learning study, but CNN has good accuracy for handwriting recognition because more CNN training will result in more accurate writing recognition.

The system proposed by [6] implements CNN and SVM for English and achieved 98.85% accuracy for numeral and 93.05% and 86.21% for upper and lowercase symbols respectively.

Batuhan Balci *et al.,* [7] proposed Handwritten Text Recognition using Deep Learning for English. In this, Convolutional Neural Network is used for on IAM Handwriting Dataset for training and testing. Experiments are conducted with four different models; VGG-19, RESNET-18 & RESNET-34 for word-level classification and Char-Level model for character classification. Accuracy rate obtained are: VGG-19 20%, RESNET-18 22%, RESNET-34 25% and Char-Level 31%.

Different configuration of CNN for handwriting recognition is discussed in [8]-[10].

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III. DEEP LEARNING

The generalized stages involved in Deep learning process are shown in Fig. 1.

Stage 1: First step is to analyze whether the given problem is suitable to implement using deep learning approach or not. Because not all the problems are implemented using deep learning.

Stage 2: Next step is to identifying relevant data sets and prepare them for analysis. Success rate of deep learning primarily depends on the appropriate data set selected for training the model.

Stage 3: Selecting the appropriate type of deep learning architecture to use.

Stage 4: After selecting the deep learning architecture, train the selected model with the large amount of labelled data set.

Stage 5: Test the trained model with real time unlabeled test input to measure the performance with respect to accuracy of correct classification.

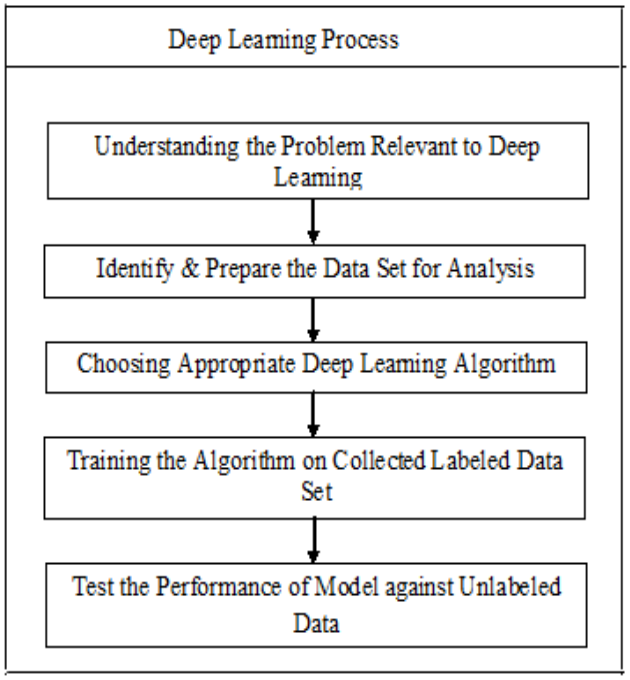

Fig. 1. Stages in Deep Learning Process

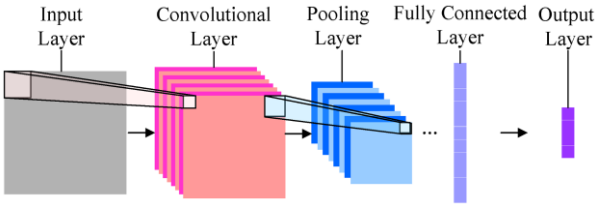

Fig. 2. Layers in Convolutional Neural Network

Deep learning is all about configuring neural network with different layers to perform complex task. CNN is one such form of neural network which consists of different layers as shown in Fig.2. Each layer consists of nodes also called as neurons which holds some data.

Each node in the Input Layer holds a feature of handwritten input sequence present in an image. Convolutional layer is used to extract important features by applying different filters. Pooling layer is used to reduce the spatial size of an input image i.e dimensionality reduction. Fully connected layer is also called as dense layer where every node is interconnected and holds a feature which is used for classification. The last layer in the CNN is called output layer where number of nodes depends on the number of classes. If there are more number of layers configured in-between input and output layer, then such configuration of neural network is called as deep learning neural network.

IV. OUR APPROACH

Fig. 3 depicts the architecture of Proposed system which uses deep learning based convolutional neural network model.

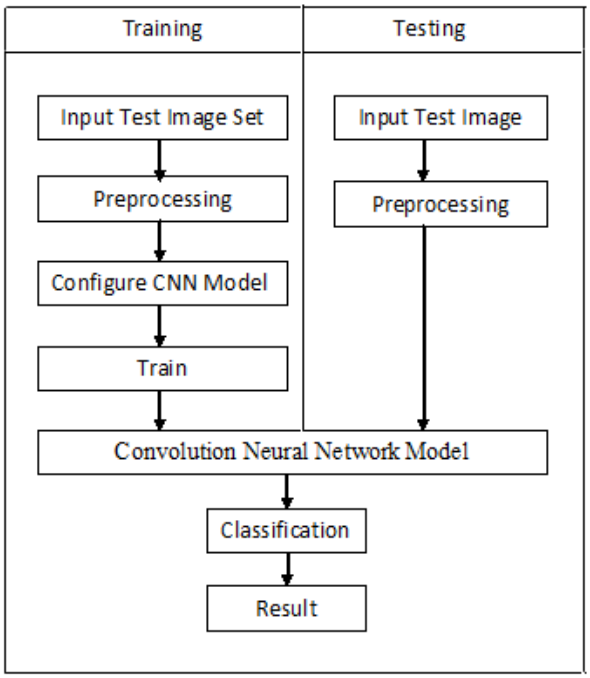

Fig. 3. System Architecture

The sequence of steps followed during training and testing are shown in the architecture. Two different datasets were used with the proposed system. MNIST dataset which consists of 70000 handwritten English numeral samples, out of which 60000 samples are used for training and 10000 for testing. Similarly, Chars74K dataset consists of 25 samples for each 657 classes of Kannada character set.

In pre-processing, size normalization and segmentation are needed if input image is a document. But in MNIST and Chars74K dataset images are normalized isolated characters.

The input images are 64 x 64 grayscale images feed to 4 convolution layers with filter size of 3x3 and activation function Relu with intermediate max pooling layers. Following is the Configuration of CNN model used to classify the images in MNIST dataset.

Layer 1 – convolution Layer: Configured using 32 5x5 filters with activation function Relu.

Layer 2 - Pooling Layer: Configured using max function with a 2x2 filters and stride of 2.

Layer 3 - convolution Layer: Configured using 64 5x5 filters, with activation function Relu.

Layer 4 - Pooling Layer: same as layer 2.

Layer 5 - Dense Layer: 10 neurons.

Configuration of CNN model used to classify the images in Chars74K dataset.

Layer 1 – convolution Layer: Configured using 52 5x5 filters with activation function tanh.
Layer 2 - Pooling Layer: Configured using max function with a 2x2 filters and stride of 2.
Layer 3 - Convolution Layer: Configured using 64 5x5 filters, with activation function tanh.
Layer 4 - Pooling Layer: Configured using max function with a 5x5 filters and stride of 5.
Layer 5 - Dense Layer: 657 neurons.

V. EXPERIMENT AND RESULT

The experiment is conducted on cloud-based Google Colaboratory. Colaboratory supports both Python2 and Python3 for code execution. GRID K520 GPU was used in the cloud instance. Fig. 4 shows the home page of Colaboratory and Fig. 5 shows the result obtained respectively.

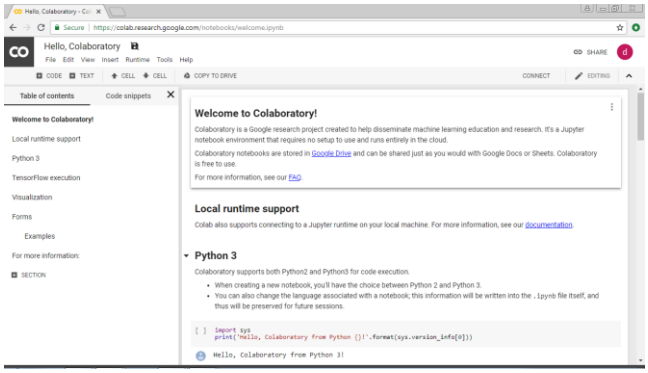

Fig. 4. Colaboratory Home Page

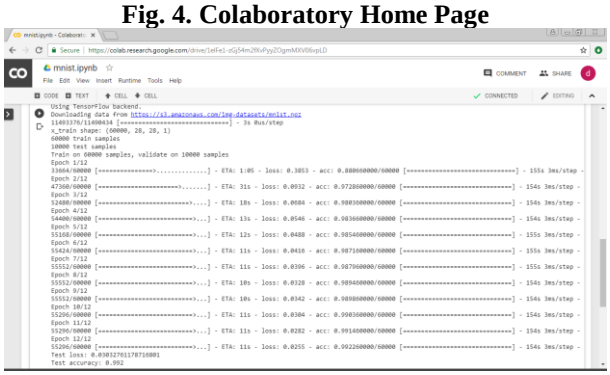

Fig. 4. Result

VI. CONCLUSION

There is a high demand for doing research in the field of Handwriting recognition system especially for South Indian languages. Deep learning approach discussed obtained 99% accuracy for English numerals and Kannada. The proposed approach can be applied to handwritten Kannada document with segmentation as pre-processing. The technical details presented in this paper can be used for the implementation of handwriting recognition system for both online and offline with little modification in the configuration.

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