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Hybrid evolutionary approach for Devanagari handwritten numeral recognition using Convolutional Neural Network

Adarsh Trivedi^{*}, Siddhant Srivastava, Apoorva Mishra, Anupam Shukla, Ritu Tiwari

*Soft Computing and Expert System Laboratory,
ABV-Indian Institute of Information Technology, Gwalior 474015, India*

Abstract

In recent years, deep learning has been extensively used in both supervised and unsupervised learning problems. Among the deep learning models, CNN has outperformed all others for object recognition task. Although CNN achieves exceptional accuracy, still a huge number of iterations and chances of getting stuck in local optima makes it computationally expensive to train. Genetic Algorithm is a metaheuristic approach inspired by the theory of natural selection and has been used for solving both bounded and unbounded optimization problems by a large success. To handle these issues, we have developed a hybrid deep learning model using Genetic Algorithm and L-BFGS method for training CNN. To test our model, we have taken the Devanagari handwritten numeral dataset. Our results show that GA assisted CNN produces better results than non-GA assisted CNN. This study concludes that evolutionary technique can be used to train CNN more efficiently.

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Keywords: Convolutional Neural Network; Genetic Algorithm; Sparse Autoencoder.

1. Introduction

Handwriting recognition (HWR) systems are models used to collect and perceive input in the form of handwritten texts from sources like paper documents and photograph. The success of handwriting recognition systems was firmly based upon the optical character recognition which is responsible for formatting and segmentation of handwritten

^{*} Corresponding Author

Email: adarshtrivedi1996@gmail.com

texts, and character recognition is the soul of this module. Character recognition is used for the identification of handwritten text to its corresponding computer documents. Several states of the art character recognition models are based on the application of deep learning model and classifiers utilizing sophisticated feature extraction methods [1].

There are more than 435 million peoples in India who uses Hindi style of writing in their daily works. Thus, there must be efficient character recognition software for the Hindi Characters which is not present yet. Therefore, with the onus to develop an effective Hindi character recognition software, we developed a model for the recognition of Hindi numerals.

The rest of the paper is divided as follows: Sect. 2 discusses the methodology of our model. Sect. 3 contains the experimental results in the form of classifier accuracy measure and other related metrics. In Sect.4, we discussed the conclusion and future works.

1.1. Convolutional Neural Network

Convolutional Neural Network (CNN) is a biologically-inspired variant of Multi-Layer Perceptron's (MLPs). The first CNN architecture was LeNet [2].

The design of the CNN can be described as the technique of shared weights or local receptive fields [3] [4]. The basic building blocks of the CNN are convolution layer, activation, and pooling. The convolution layer consists of several convolution kernels (filters) which are used to compute feature maps. In every forward pass of convolution layer, each kernel is convolved with the image to generate a feature map.

The values of feature maps then passed to activation function like ReLU and sigmoid. After activation, the features are down-sampled using pooling technique like max-pooling and mean-pooling. It partitions the image into various non-overlapping rectangles which then output the downgraded version of activated feature map.

After several rounds of convolution, activation, and pooling, the resultant images are then fed to the last layers which are a fully connected layer for the classification.

Conforming to these fundamental components, in recent years many new CNN architectures of varying complexity have come up like GoogleNet [5], ResNet [6], DenseNet[7], AlexNet [8].

1.2. Genetic Algorithm

Genetic Algorithm is a metaheuristic that mimics the natural biological genetics and belongs to a larger class of evolutionary algorithm. Genetic Algorithm was introduced by JH Holland in 1975 [9]. It can be used in solving both constrained and unconstrained problems as it searches the vast solution space efficiently. In GA, a population of candidate solutions to an optimization problem is evolved towards a better solution. In GA, there is initialization, selection, crossover, mutation and fitness evaluation as its steps. First, the initial population is generated randomly called search space, then as per their fitness, a candidate solution is generated from the original population which is most adaptable to the environment. Then, the crossover is performed on this candidate after which it is mutated, then again a new breed of the solution is selected from this population which then passed to crossover and mutation. Thus, after a specific number of crossover, mutation, and selection of solutions, the GA terminates and returns the best results.

1.3. Devanagari Numeral dataset

The Devanagari numeral database is provided by the Indian Statistical Institute (ISI), Kolkata [10]. This dataset comprises of Devanagari numerals from 0 to 9, and this dataset is considered to standard benchmark Devanagari numeral dataset, used by various authors all over the world. The dataset contains all possible handwritten numerals in Devanagari style. The Fig.1 contains few samples of handwritten Devanagari numerals from the same database. Table1 contains training sample and test sample distribution of Devanagari numerals.

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