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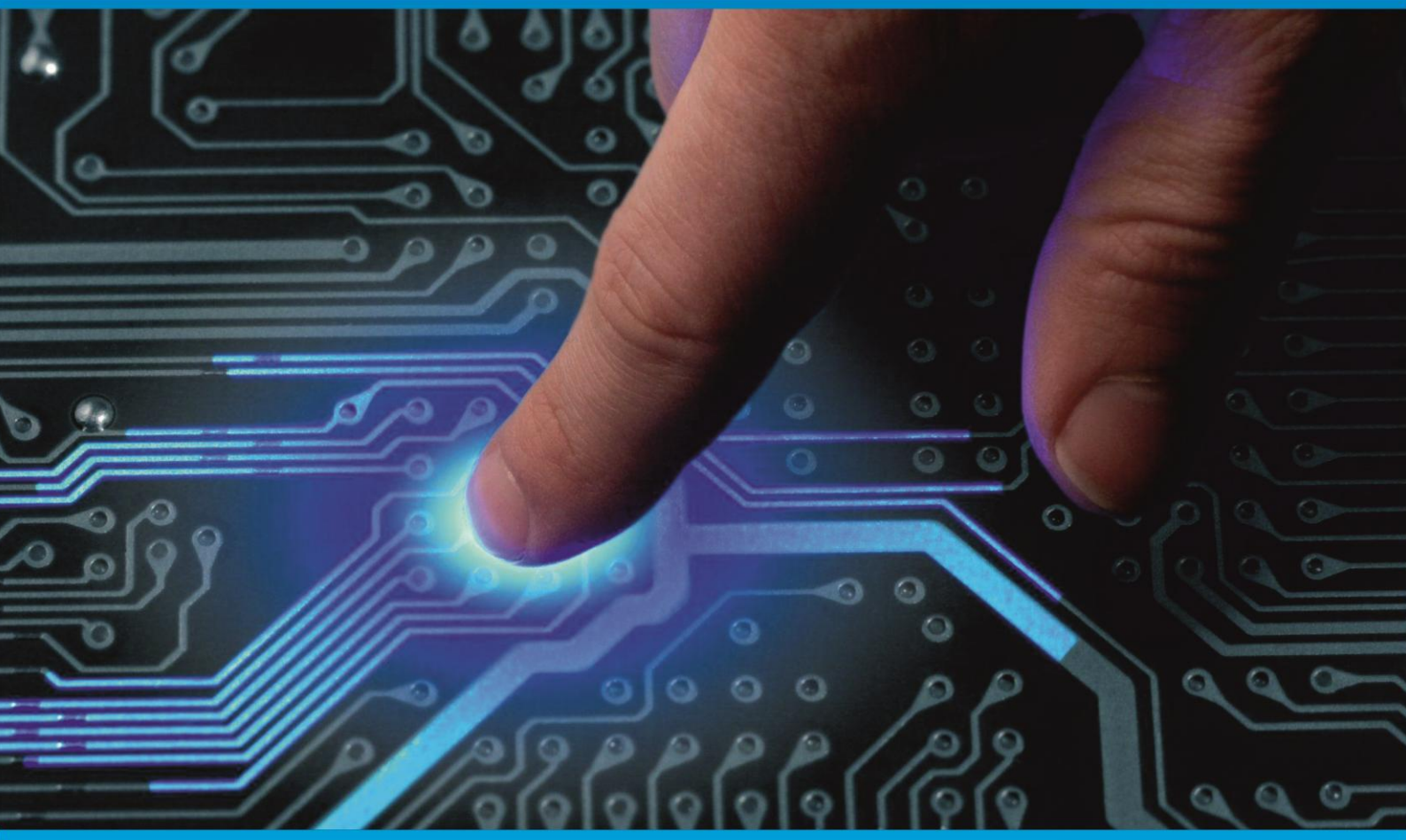

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Advanced Hand Written Character Recognition with PSO in CNN

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ABSTRACT: Hand Written Character Recognition is one of the major areas of research topics in Machine Learning. It is because there are lot of areas to improve in the existing system. This paper is about the usage of Particle Swarm Optimization (PSO) with Convolutional Neural Networks (CNNs), that is one of the basic methods in deep learning. The reason to use PSO in the training process is to optimize the results of the solution vectors on CNN in order to improve the recognition accuracy. The dataset used in this research is handwritten characters from EMNIST. The experiments conducted has shown that the accuracy can be attained in 4 epoch is 96.03%. The results obtained were better than the conventional CNN and DBN and the execution time is approximately similar to the conventional CNN. Hence, the proposed method is a promising method.

KEYWORDS: Hand Written Character Recognition, Particle Swarm Optimization, Convolutional Neural Networks, EMNIST Dataset.

I. INTRODUCTION

Optical Character recognition is becoming more and more important now a days in machine learning and computer vision. There exists numerous methods for extracting the text from a given input image, which will be discussed in the coming sections, but still there is a lot of areas to be improved in Hand written Character Recognition. They are accuracy, errors while detecting lower case letters, large time taken to recognize text.

CNN is a type of feed forward neural network inspired by the structure of visual system. In CNN, there are many neurons with weights and biases, where every single neuron receives many inputs and perform dot products. In terms of architecture CNN is composed of single or multiple convolutional layers along with subsampling stages and single or multiple layers which are connected to each other as found in a standard multi-layer neural networks.

Although conventional CNN provides considerable accuracy, there is still much space for improvements. In order to improve the performance of CNN in recognition task, we have used PSO to optimize output vector from CNNs. PSO is used because of its powerful performance in optimization problems.

PSO in an optimization method developed by Eberhart and Kennedy. PSO method is inspired by social behaviour of animals which don't have a leader in the group. PSO includes a swarm of particles, which represent a potential solution.

In order to assess our proposed system, we have compared the results obtained from proposed method with other existing results. The existing algorithms used for comparison are the original CNNs and Deep Belief Networks (DBNs). The performance criteria used in this research are error and accuracy.

1. Convolutional Neural Networks: -

Convolutional neural networks (CNNs) are widely used in the fields like pattern and image recognition since they possess a lot of advantages when compared to other techniques. A neural network is defined as a system of artificial "neurons" that are interconnected and exchange messages with each other. The connections consist of numerical weights that are tuned while training process, as this network is expected to respond correctly when given with an input of pattern or image to recognize. The network has multiple layers which consists of feature detecting neurons. Each layer has many neurons that respond to different combinations of inputs from the previous layers. As shown in Fig.1 below,the layers are built up so that the first layer detects a set of primitive patterns in the input, the second layer detects patterns of patterns, and the third layer detects patterns of those patterns, and so on. Generally, CNNs use 5 to 25 unique layers of pattern recognition.

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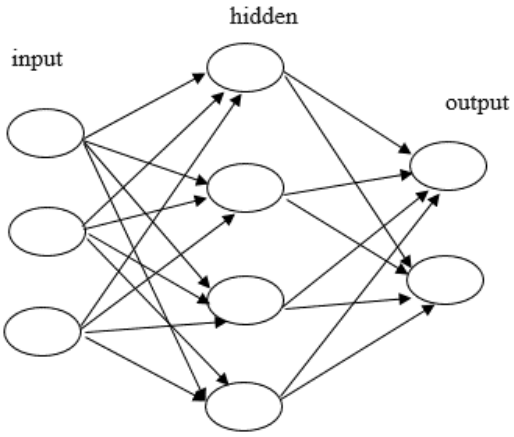

Fig.1 A Simple Neural Network

A CNN consists of one or more convolutional layers, often with a sub-sampling layer, that are followed by one or more completely connected layers like in a conventional neural network. The convolution layers present in CNN are responsible for feature extraction but are not hand designed. As a part of the training process, convolution filter kernel weights are assigned. The local features are extracted using convolutional layers since they restrict the receptive fields of the hidden layers to be local. CNNs are used in various applications including speech recognition, image and pattern recognition, video analysis and natural language processing. A number of reasons exists for convolutional neuralnet works to become important.

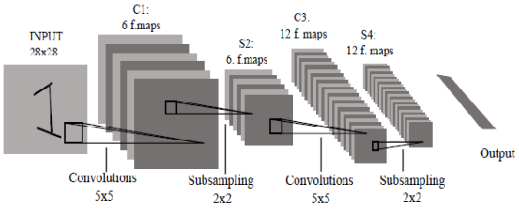

Fig.2 CNN Architecture

2. Particle Swarm Optimization : -

Particle swarm optimization (PSO) algorithm is one of evolutionary algorithm which was firstly proposed in 1995. PSO has been widely used in miscellaneous fields, for example an instance swarm robot for the purpose of odour source localization. PSO algorithm consist several consecutive steps. Firstly, initialization randomly selects the particles as searching agents (x) and also the velocities (v). Secondly the particles then inserted into cost function to find local bests(pbest) and global best(gbest). The location on which the cost is minimal for each particle is known as Local best. Whereas the location on which the cost is minimal among the local bests is known as the Global best. Thirdly, the particles are updated by empowering equation (1) and equation (2).

$$v_{n+1} = v_n + c_1 r_1 (p_{best} - x_n) + c_2 r_2 (g_{best} - x_n) \quad (1)$$

$$x_{n+1} = x_n + v_{n+1} \quad (2)$$

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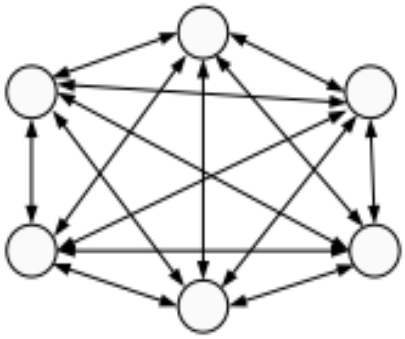

Fig.3 A g-best

Where $c_1$and c_2 are the constants, $r_1$and r_2 are random numbers, and n is iteration.

The PSO algorithm is social interaction among the particles in the entire swarm. Particles communicate with one another by exchanging information about the success of each particle in the swarm. When a particle in the whole swarm finds a better position, all particles move towards this particle.

II. EARLIER WORK

Immense research is going on in the field of handwritten character recognition. Many people have developed systems for handwritten character recognition. We have studied some of the systems:

A novel method for handwritten character recognition has been designed which does not use feature extraction. They have implemented their system in Matlab. Their system uses a feed forward neural network with back propagation.

One of the authors has proposed a unique method for handwriting recognition. Their system uses Self Organizing Map for feature extraction. They have used a Recurrent neural network for learning. They conducted their experiment on recognition of Japanese characters.

Also one method for recognition of handwritten tamil characters using Neural Networks has been developed. They have used Kohonen Self Organizing Map(SOM) which is an unsupervised neural network. The system developed by them can be used for recognition of tamil characters as well.

There are lot more works done earlier on the character recognition on their own ideas and they achieved better accuracy than previous ones. One of the most important challenges in handwritten character recognition is to overcome numerous types of handwritings available. Even the previous works have trained the Neural Networks with large datasets, still there exists various kinds of handwritings of different people. To beat this challenge, we have come with an Idea of using Particle Swarm Optimization along with Convolutional Neural Networks which has given far better results while reading different kinds of handwritings.

III. PROPOSED METHOD

Training with Dataset:

The MNIST dataset has become a standard benchmark for learning, classification and computer vision systems. The intuitive nature of the task, its relatively small size and storage requirements and understand ability and the accessibility and ease-of-use of the database itself contributes to its wide usage. The MNIST database was taken from a huge dataset called as the NIST Special Database 19 that contains digits, lowercase & uppercase handwritten characters. In this paper, a variant of the full NIST dataset is introduced, which we have termed it as Extended MNIST (EMNIST), which follows the same conversion paradigm used to create the MNIST dataset.

It results in a set of datasets that contains more complicated classification tasks that includes digits and letters, and shares the same parameters and image structure like the original MNIST task, which allows direct compatibility with the existing systems and classifiers. Benchmark results are obtained along witha validation of the conversion process by comparing the classification results with converted NIST characters and the MNIST characters.

Now let us discuss the various image processing operations which are performed on the image to be recognized.

The processing of images includes following steps:

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a. Pre-Processing:

This is the foremost step carried out in image processing. In this step the noise from the image is removed by using median filtering. Median filtering is one of the most widely used noise reduction technique. This is because in median filtering the edges in image are preserved while the noise is still removed.

b. Conversion to greyscale:

After the pre-processing step, the image is converted into grayscale. Conversion into grayscale is necessary because different writers use pens of different colours with varying intensities. Also the overall complexity of the system is reduced while working on grayscale images.

c. Thresholding:

By converting an image into grayscale, the handwritten characters are darker than its background. The darker regions of the image can be separated from the lighter regions by using thresholding. Hence by using thresholding the handwritten characters can be separated from its background.

d. Image Segmentation:

A user may write text in form of lines. This thresholded image is first segmented into individual lines. Then each individual line is segmented into individual words. Finally, each word is segmented into individual characters. Horizontal projection method is used for segmentation of image into lines. Firstly, the thresholded image is inverted so that the background becomes foreground and vice-versa.

e. Feature Extraction

The features set of handwritten characters can be grouped into two categories, local and global. In local features, the local properties of the points are considered, while in global features all the points in the image are used to analyse the overall properties. The features that have been used in our experiments extracted from thinned images and include local and global features.

IV. PROCEDURE

Figure 2 shows the CNNs architecture used in the proposed method, where it consists of an input image that will be processed using 6 convolution kernel with size 5x5 pixels, 6 sub-sampling kernel with size 2x2 pixels, 12 convolution kernel with size 5x5 pixels, 12 subsampling kernel with size 2x2 pixels and the last layer is the vector output of CNN. The proposed method process can be seen on Figure 4. In Figure 4 Y denotes the condition is met, whereas N represent the condition is not met.

PSO in this study would optimize the output vector. The output vector would be augmented by δx to acquire better value. The value of δx itself is the value which would be optimized by PSO. To calculate the fitness function, the root mean squ-are error between output vectors after augmented with δx and the true output would be employed.

Generally, the process of the proposed meth-od consists of several steps as shown below: 1) the first step is initializing the learning rate of the CNNs with the value is 1 based on experiment. Batch size of CNNs is 50, the number of CNNs epoch in the range of 1 to 4, PSO iteration is 10. The convergence status of PSO is used to check the convergences of PSO, if the error value has not changed for three iterations, then the PSO is considered as convergent; 2) after setting up the experiment, the next step is run CNNs training process, where the detail of the process can be seen in Fig 4.

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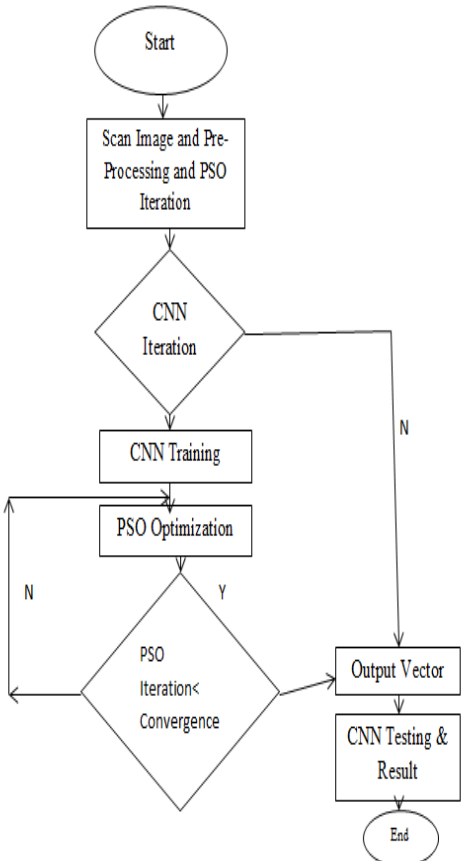

Fig.4Flow chart for Proposed System

The result of CNNs is vector output that will be optimizing using PSO algorithm. PSO optimization in this study serves to make the value of loss function on CNN becomes minimal; 3) the output vector will be update if the solution of swarm has less error compare with old vector output; 4) the PSO will run as long as the iteration number of PSO and the convergence solution have not fulfilled; 5) after the CNN Training, the model will be tested with testing data that consist of 10000 data; 6) the result of CNN test is accuracy of CNN, it represent how precise of the CNN model can predict the actual value of testing dataset.

V. RESULT

Figure 5 and Figure 6 show the results screenshots of the results obtained from the CNN-PSO Technique.

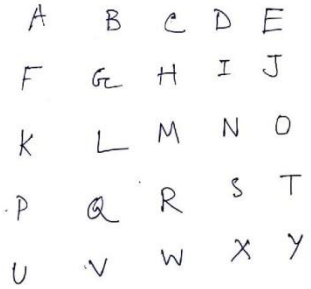

Fig.5 Input Image with Pre-Processing

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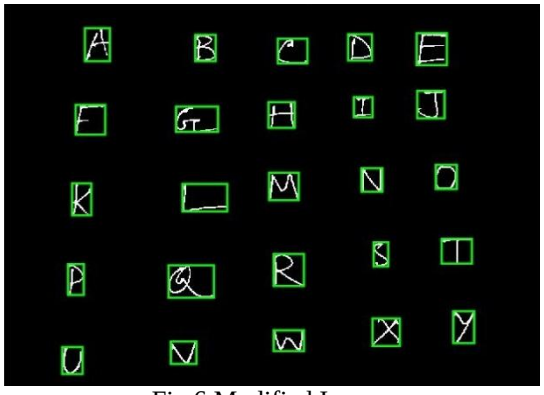

Fig.6 Modified Image

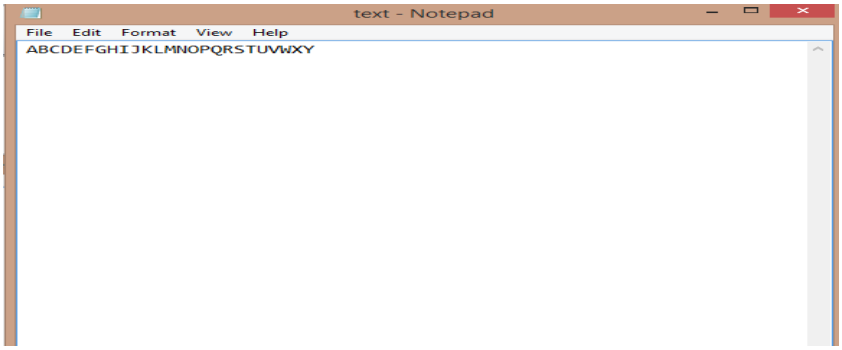

Fig.6 Output Text in Notepad

VI. CONCLUSIONS AND FUTURE SCOPE

In this study, a handwritten character recognitionmethod based on the CNN with PSO algorithm is discussed. we took a straightforward featureextraction method, the results reveal that PSO algorithm furnishes convincing performance and stable behaviour in recognizing handwritten characters. The proposed system has an improved accuracy of 96.06%.Consequently, PSO can be an option tool in solving this kind of problems. In our study, we used a simple approach to extract handwritten characters features, hence in the future, ensemble feature extraction methods can be taken for better performance of PSO in classifying the images accordingly.

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