IBM-NALAIYA THIRAN PROJECT

A NOVEL METHOD FOR HAND WRITTEN DIGIT RECOGNITION

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Abstract

Handwritten digit recognition has recently been of very interest among the researchers because of the evolution of various Machine Learning, Deep Learning and Computer Vision algorithms. In this report, We compare the results of some of the most widely used Machine Learning Algorithms like CNN- convolution neural networks and with Deep Learning algorithm like multilayer CNN using Keras with Theano and Tensorflow. MNIST is a dataset which is widely used for handwritten digit recognition. The dataset consist of 60,000 training images and 10,000 test images.The artificial neural neworks can all most mimic the human brain and are a key ingredient in image processing field.For example Convolution Neural networks with back propagation for image processing.The applications where these handwritten digit recognition can be used are Banking sector where it can be used to maintain the security pin numbers, it can be also used for blind peoples by using sound output.

INTRODUCTION

HANDWRITTEN digit recognition is the ability of a computer system to recognize the handwritten inputs like digits, characters etc. from a wide variety of sources like emails, papers, images, letters etc. This has been a topic of research for decades. Some of the research areas include signature verification, bank check processing, postal address interpretation fromenvelopes etc.

Here comes the use of Deep Learning. In the past decade, deep learning has become the hot tool for Image Processing, object detection, handwritten digit and character recognition etc. A lot of machine learning tools have been developed like scikit-

learn, scipy-image etc. and pybrains, Keras, Theano, Tensorflow by Google, TFLearn etc. for Deep Learning. These tools make the applications robust and therefore more accurate. The Artificial Neural Networks can almost mimic the human brain and are a key ingredient in image processing field. For example, Convolutional Neural Networks with Back Propagation for Image Processing, Deep Mind by Google for creating Art by learning from existing artist styles etc..

Handwriting Recognition has an active community of academics studying it. The biggest conferences for handwriting recognition are the International Conference on Frontiers in Handwriting Recognition (ICFHR), held in even-numbered years, and the International Conference on Document Analysis and Recognition (ICDAR), held in odd-numbered years. Both of these conferences are endorsed by the IEEE. Active areas of research include: Online Recognition, OfflineRecognition, Signature Verification, Postal-Address Interpretation,Bank-Check Processing, Writer Recognition.

Classification of images and patterns has been one of the major implementation of Machine Learning and Artificial Intelligence. People are continuously trying to make computers intelligent so that they can do almost all the work done by humans

Handwriting recognition system is the most basic and an important step towards this huge and interesting area of Computer Vision.

METHODOLOGY

Deep Learning has emerged as a central tool forself-perception problems like understanding images, voice from humans, robots exploringthe world. The project aims to implement the concept of Convolution Neural Network which is one of the important architecture of deep learning. Understanding CNN and applying it tothe handwritten recognition system, is the majortarget of the proposed system .
There is a reason behind using CNN for handwritten digit recognition. Let us consider a multi-layer feedforward neural network to beapplied on MNIST dataset which containsimages of size 28×28 pixels (roughly 784 pixels). So if a hidden layer has about 100 units,then the first layer weights comes up to about 78k parameters, which is large but manageable. However, in the natural world the size of the image is much larger . If we consider the size ofthe typical image which is around 256×256 pixels (roughly about 56,000 pixels), then the first layer weights will have about 560k parameters! So that becomes too manyparameters and hence make it unscalable forreal images. Hence, it will be so large that itwill become very difficult to generalize the newdata fed into the network. Convolution Neural

Network extracts the feature maps from the 2D images by applying filters and hence making the task of feature extraction from the images easier. Basically, convolution neural network considers the mapping of image pixels with the neighbourhood space rather than having a fully connected layer of neurons. Convolution NeuralNetworks has been proved to be a very important and powerful tool in signal and imageprocessing. Even in the fields of computer vision such has handwriting recognition, naturalobject classification and segmentation, CNN has been a much better tool compared to allother previously implemented tools .

The broader aim in mind was to develop a M.L. model that could recognize people'shandwriting. However, as we began developing the model we realized that the topic in hand wastoo tough and would require tremendous data tolearn. Example to accurately classify a cursive handwriting will be very tough. Thus we settled on classifying a given handwritten digit imageas the required digit using three differentalgorithms and consequently testing its accuracy.

Proposed System ofhandwritten digitrecogntion

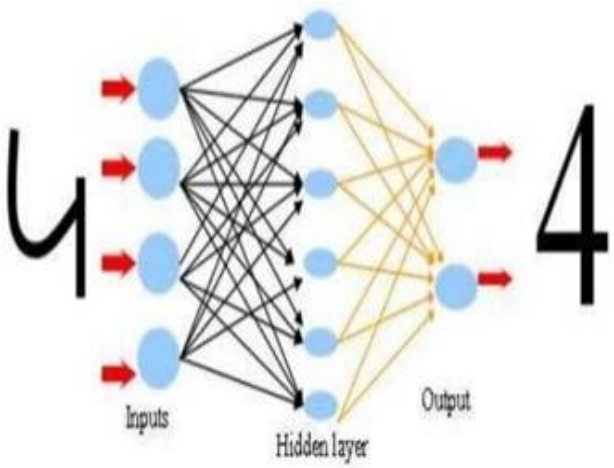


Fig.1:Handwritten Recognition system.

EXPLANATION OF THE PROPOSEDSYSTEM

• The first layer of the architecture is the User layer. User layer will comprise of the people who interacts with the app and for the required results.

• The next three layers is the frontend architecture of the application. The application will be developed using Bootstrap which is the open source platform for HTML, CSS and JavaScript. The application is deployed in the localhost which is shown on the browser. Through the app, the user will be able to upload

pictures of the handwritten digits and convert it into the digitalized form.

• The one in between the database and view layer is the business layer which is the logical calculations on the basis of the request from the client side. It also has the service interface.

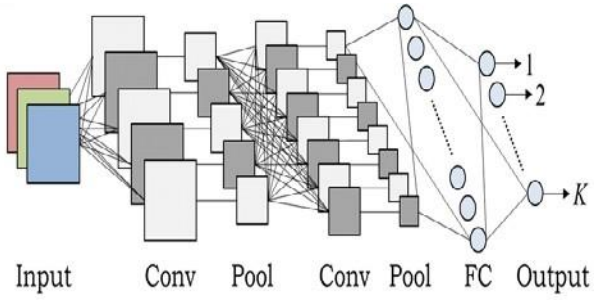
• The backend layer consists of two datasets: Training Data and Test Data. The MNIST database has been used for that which is already divided into training set of 60,000 examples and test of 10,000 examples.

• The training algorithm used is Convolution Neural Network. This will prepare the trained model which will be used to classify the digits present in the test data. Thus, we can classify the digits present in the images as: Class 0,1,2,3,4,5,6,7,8,9.

Algorithm:
Forward Propagation:

Architecture:
Below shown is a small workflow of how CNN module will extract the features and classify the image based on it. The architecture shows the input layer, hidden layers and output layer of the network. There are many layers involved in the feature extraction phase of the network which involves convolution and subsampling .

Fig.2: Architecture of CNN.



How it works:

- Neural Networks receive an input, and transform it through a series of hidden layers.
- Each hidden layer is made up of a set of neurons, where each neuron is fully connected to all neurons in the previous layer.
- Neurons in a single layer function completely independently.
- The last fully-connected layer is called the "output layer“.

A.CONVOLUTION LAYER

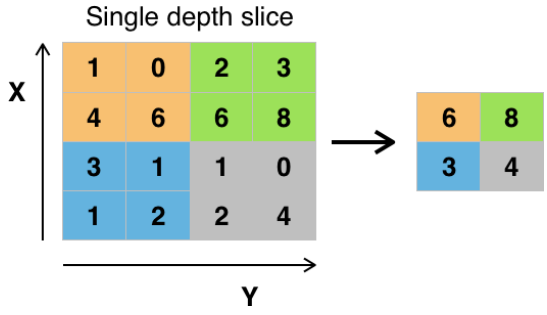
The Convolutional layer is the core building block of a CNN. The layer's parameters consist of a set of learnable filters (or kernels), which have a small receptive field, but extend through the full depth of the input volume. During the forward pass, each filter is convolved across the width and height of the input volume, computing the dot product between the entries of the filter and the input and producing a 2- dimensional activation map of that filter. As a result, the network learns filters that activate when they see some specific type of feature at some spatial position in the input..

Feature Extraction: All neurons in a feature share the same weights .In this way all neurons detect the same feature at different positions in the input image. Reduce the number of free parameters.

Subsampling Layer: Subsampling, or downsampling, refers to reducing the overall size of a signal .The subsampling layers reduce the spatial resolution of each feature map. Reduce the effect of noises and shift or distortion invariance is achieved.

Pooling layer: It is common to periodically insert a Pooling layer in-between successive Conv layers in a ConvNet architecture. Its function is to progressively reduce the spatial size of the representation to reduce the amount of parameters and computation in the network, and hence to also control overfitting. The Pooling Layer operates independently on every depth slice of the input and resizes it spatially, using the MAX operation.

Fig.3: Pooling layer



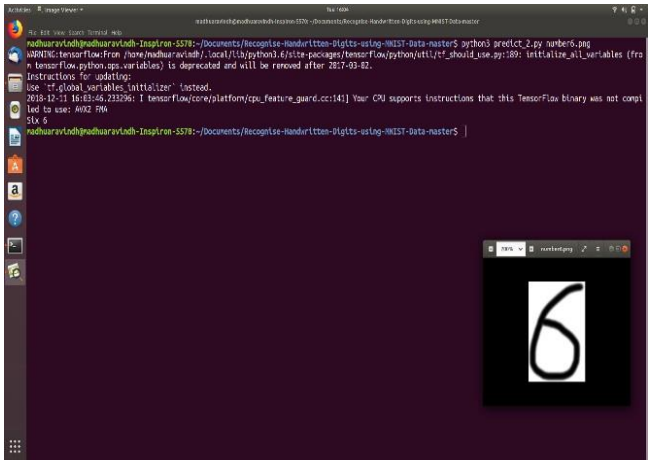
B.TENSORFLOW

TensorFlow is an open-source machine learning library for research and production. TensorFlow offers APIs for beginners and experts to develop for

desktop, mobile, web, and cloud. See the sections below to get started.
By scanning the numerical digit and convertinto png format using python3

Fig.4: Output of digit recognition ofnumerical ‘7’

Fig.5: Output of digit recognition of numerical ‘6’



RESULTS

As with any work or project taken up in the field of machine learning and image processing we are not considering our results to be perfect. Machine learning is a constantly evolving field and there is always room for improvement in your methodology; there is always going to be another new approach that gives better results for the same problem. The application has been tested using three models: Multi-Layer Perceptron (MLP), Convolution Neural Network (CNN). With each model we get a different accuracy of the classifier which shows which one is better.

The results of training the network is stored in.npz format so that whenever a user tries to recognize the digit, the application does not go into the training loop again. For classification, we have used logistic classifier, softmax function, one hot encoding, cross entropy and loss minimization using mini batch gradient descent. These are some of the basics of Neural Network which are required to process the output from the network and display in the formthe user can understand.

A. DATASET USED

The dataset used is the MNIST database of handwritten digits.It consists of a training set of 60,000 examples, and a test set of 10,000 examples.The digits have been size-normalized and centered in a fixed-size image.The images are of size 28*28 pixels.It is a good database forpeople who want to try learning techniques and pattern recognition methods on real-world data while spending minimal efforts on preprocessing and formatting. The dataset istaken fromhttp://yann.lecun.com/exdb/mnist/

Fig 6: MNIST dataset

***B.* ANALYSIS OF THE RESULTS:**

In business, System Analysis and Design refers to the process of examining a business situation with the intent of improving it through better procedures and methods. System analysis and design relates to shaping organizations, improving performance and achieving objectives for profitability and growth. The emphasis is on systems in action, the relationships among subsystems and their contribution to meeting a common goal. Looking at a system and determining how adequately it functions, the changes to be made and the quality of the output are parts of system analysis. Organizations are complex systems that consist of interrelated and interlocking subsystems. Changes in one part of the system have both anticipated and unanticipated consequences in other parts of the system. The systems approval is a way of thinking about the analysis and design of computer based applications. It provides a framework for visualizing

the organizational and environmental factors that operate on a system. Proposed Application Module: The proposed application has been implemented using Python on terminal. The user is given two options in the home image: Simple Upload, Model Form Upload. Simple Upload will allow the user to upload the image and predict it then and there. After navigating away from that page, the linkto the uploaded image is lost. The Model Form Upload will allow the user to upload the image with description. With this link, the user will be able to store the image and see its link on the home page itself. By clicking on the link, the user will be able to get the result from the CNN classifier.

```
Epoch 1/5
 - 14s - loss: 0.4236 - acc: 0.8208
Epoch 2/5
 - 12s - loss: 0.2800 - acc: 0.8854
Epoch 3/5
 - 11s - loss: 0.2147 - acc: 0.9115
Epoch 4/5
 - 11s - loss: 0.1714 - acc: 0.9329
Epoch 5/5
 - 11s - loss: 0.1344 - acc: 0.9464
```

Fig.7.Data training and Accuracy

CONCLUSION

An implementation of Handwritten DigitRecognition using Deep Learning has been implemented in this paper. Additionally, someof the most widely used Machine Learning algorithms i.e. CNN using Tensorflowhave been trained and tested on the same data to draw a comparison as to why we require deep learning methods in critical applications like Handwritten Digit Recognition. In this paper, I have shown that that using Deep Learning techniques, a very high amount of accuracy can be achieved. Using the Convolutional NeuralNetwork with Keras and Theano as backend, I am able to get an accuracy of 95.72%. Every tool has its own complexity and accuracy. Although, we see that the complexity of the code and the process is bit more as compared to normal Machine Learning algorithms but looking at the accuracy achieved, it can be said that it is worth it. Also, the current implementation is done only using the CPU Thus we settled on classifying a given handwritten digit image as the required digitusing three

different algorithms andconsequently testing its accuracy. In future we are planning to further explore the topic torecognize people's handwriting.

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