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# Handwriting Recognition using Tensor Flow and Convolutional Neural Networks

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***Abstract:*** ***Machine Learning is a field of computer science that gives computers the ability to learn without being explicitly programmed. Machine learning is employed in a range of computing tasks where designing and programming explicit algorithms with good performance is difficult or infeasible; example applications include email filtering, detection of network intruders or malicious insiders working towards a data breach, optical character recognition (OCR) learning to rank, and computer vision.***
***Many advancements have been made to classify data from handwritten data, but the computer hasn't been able to classify data efficiently. Hence, the need of handwriting recognition has come up.***
***In this project we aim at building a Convolutional Neural Network. Which will be able to recognize the handwritten digits and give the output accurately using the training and Tesing data given to it.***
***Keywords: Machine Learning, Optical Character Recognition, Convolutional Neural Networks, Tensor flow, Handwriting Recognition***

## I. INTRODUCTION

Since the dawn of mankind, many advancements have been made to pass on the knowledge gathered by the previous generations to the newer generations so that they can survive. This knowledge has majorly been passed on in the form of writings. So, these writings have been preserved for many ages and many attempts have been made to save this data in the digital form by the newer generations. Some of these scripts have been exposed to many elements such that the writings on these scripts have become unrecognizable. Hence, the need of handwriting recognition has come up. By training the computer to recognize the set of handwritten characters we can classify the handwritten characters and retrieve information from them.

## II. INTRODUCTION TO TENSORFLOW

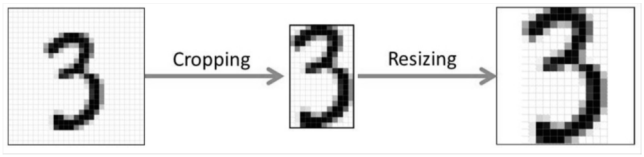
Tensor Flow is an open-source software library for dataflow programming across a range of tasks. It is a symbolic math library, and also used for machine learning applications such as neural networks. It is used for both research and production at Google, often replacing its closed-source predecessor, Dist Belief. Tensor Flow was developed by the Google Brain team for internal Google use. It was released under the Apache 2.0 open source license on November 9, 2015. Tensor Flow computations are expressed as stateful dataflow graphs. The name Tensor Flow derives from the operations that such neural networks perform on multidimensional data arrays. These arrays are referred to as "tensors". Among the applications for which Tensor Flow is the foundation, are automated image captioning software, such as Deep Dream. Rank Brain now handles a substantial number of search queries, replacing and supplementing traditional static algorithm-based search results.

## III.DATA ACQUISITION

The MNIST database of handwritten digits is used as training sets. The MNIST database has a training set of 60,000 examples, and a test set of 10,000 examples.

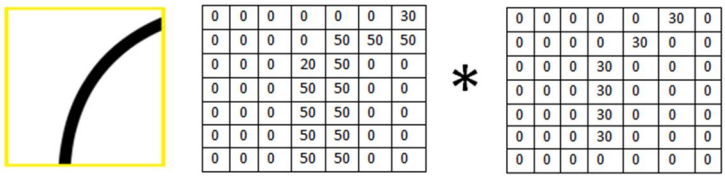
## IV.IMAGE PROCESSING

The Images which are being processed in this project have the dimensions of 28 x 28 pixels of size. All the digits are normalized and fit in the required shape without the image losing its original aspect ratio. The trainind dataset consists of images of about 60,000 digits which have been handwritten and the testing dataset consists of 10,000 images which are further segregated for further processing.




## V. FEATURE EXTRACTION

In the process of feature extraction of the image in the convolutional neural network, we use a filter to flash the filter over the image and process. This filter has the same depth as that of the input image. As the filter is sliding, or **convolving**, around the input image, it is multiplying the values in the filter with the original pixel values of the image. So now a single number is generated. This number is just representative of when the filter is at the top of the part of the image it is scanning. Now, we repeat this process for every location on the input volume.



Visualization of the receptive field

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 30 |
| 0 | 0 | 0 | 0 | 50 | 50 | 50 |
| 0 | 0 | 0 | 20 | 50 | 0 | 0 |
| 0 | 0 | 0 | 50 | 50 | 0 | 0 |
| 0 | 0 | 0 | 50 | 50 | 0 | 0 |
| 0 | 0 | 0 | 50 | 50 | 0 | 0 |
| 0 | 0 | 0 | 50 | 50 | 0 | 0 |

Pixel representation of the receptive field

*

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 30 | 0 |
| 0 | 0 | 0 | 0 | 30 | 0 | 0 |
| 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Pixel representation of filter

The Convolutional Neural Network consists of a series of layers which help improve the robustness of the network and help in making the output more efficient and accurate.

INPUT > Conv. Layer > ReLu > Pooling > Conv. Layer > ReLu > Pooling > Fully Connected

The second convolutional layer takes the activation map of the first layer and processes it and tries to extract the low level features from this activation map. The last layer is the most important layer as this layer helps in determining the class to which the output belongs to. This layer is also called as the Logits or the Dense Layer, which consists of 10 neurons(10 digits from 0-9 hence 10 neurons). This layer is responsible for giving the output to the user.

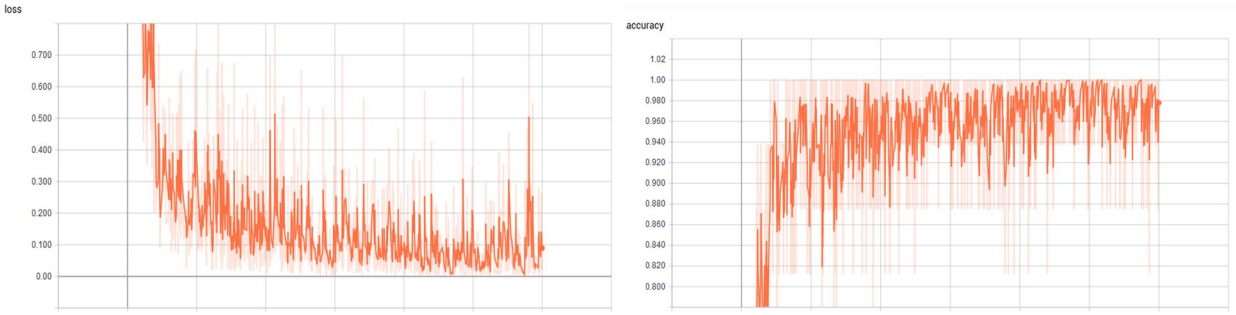
## VI. TRAINING

Adam is an optimization algorithm that can used instead of the classical stochastic gradient descent procedure to update network weights iterative based in training data. Adam was presented by Diederik Kingma from OpenAI and Jimmy Ba from the University of Toronto in their 2015 ICLR paper (poster) titled “Adam: A Method for Stochastic Optimization“. Adam is different to classical stochastic gradient descent. Stochastic gradient descent maintains a single learning rate for all weight updates and the learning rate does not change during training. The method computes individual adaptive learning rates for different parameters from estimates of first and second moments of the gradients.

Adaptive Gradient Algorithm (AdaGrad) that maintains a per-parameter learning rate that improves performance on problems with sparse gradients.

Root Mean Square Propagation (RMSProp) that also maintains per-parameter learning rates that are adapted based on the average of recent magnitudes of the gradients for the weight.

The Accuracy and the loss while training the Neural Network can be seen in the graph below. The Accuracy has increased with respect to time and the Loss has decreased with respect to time.




Loss Accuracy

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## VII. RESULT ANALYSIS

The Convolutional Neural Network is used for the process of feature extraction and give the accurate output to the user. The neural network consists of several layers which help in the training process and give the accurate output to the user. The error was reduced drastically and more accurate results have been generated using this model. By observing the graphs which have been obtained by training the neural network the Accuracy has increased to almost 0.98 and the loss has been reduced to almost 0.03.

## VIII. FUTURE ENHANCEMENTS

Due to the limitation dataset availability, only handwritten digit recognition has been implemented. This technique is currently useful only for characters which show a unique boundary and if the two characters are attached together, the model fails to recognize the character and erroneous output may be shown.

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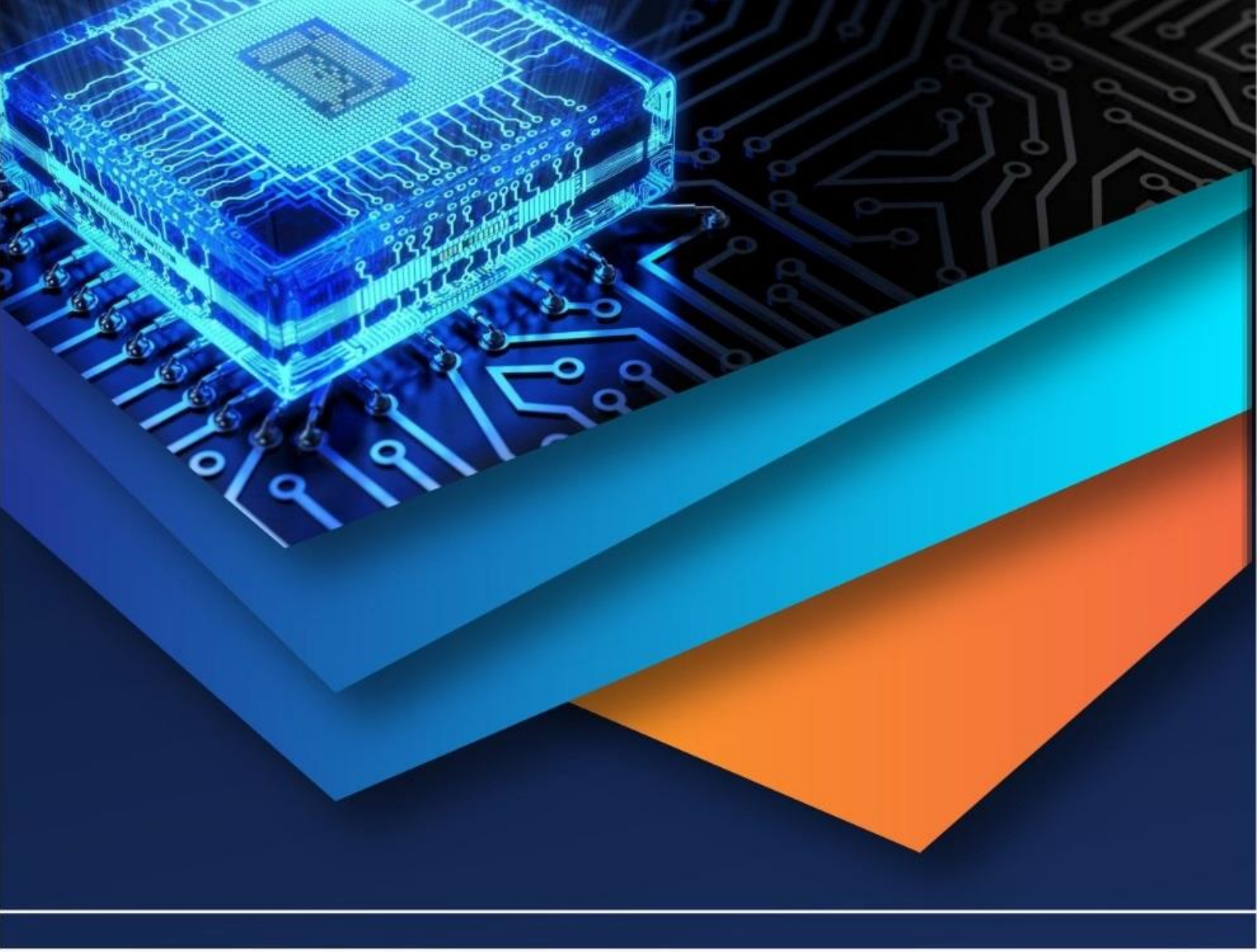

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