Handwritten Digit Classifier

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COMP9417, Assignment 2

Introduction

Handwritten digit recognition is a very trending topic in Optical Character Recognition applications and pattern classification research. Such applications include, digit recognition in postal mail sorting, bank check processing, form data entry, etc. [1].

MNIST ("Modified National Institute of Standards and Technology")[2] is the de facto dataset of handwritten digit recognition. Since its release in 1999, this classic dataset of handwritten images has served as the basis for benchmarking classification algorithms. As new machine learning techniques emerge, MNIST remains a reliable resource for researchers and learners alike.[3]

The goal of this project is to correctly identify digits from a dataset of tens of thousands of handwritten images.

Domain Specific Image Features

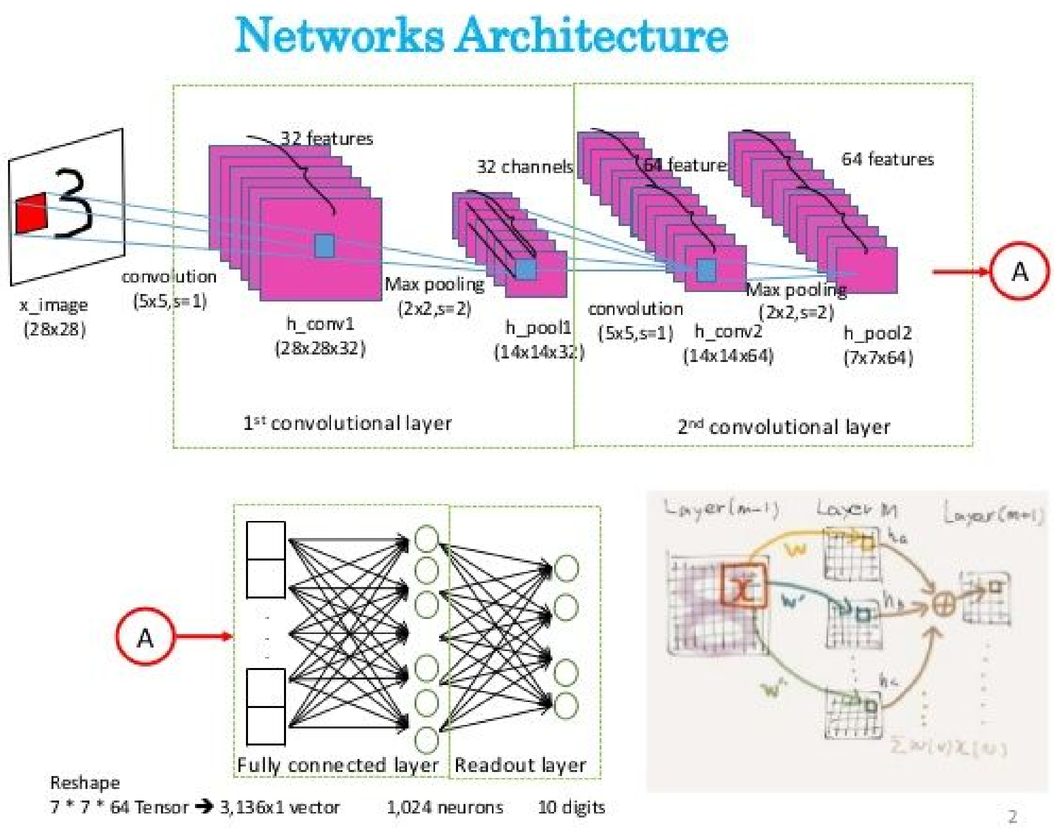
MNIST is a simple computer vision dataset. It consists of images of handwritten digits like these:

[4]

It also includes labels for each image, telling us which digit it is. For example, the labels for the above images are 5, 0, 4, and 1. My goal is to build a Machine Learning Model which learns from the images/labels and correctly classify the images as such into a particular number (between 0-9). Each image is 28 pixels by 28 pixels grey scale which can be represented as a matrix of containing each pixel value.

Method

The dataset has been downloaded from Yann Lecun's website[2]. It contains 70,000 data points which I have split into 55,000 data points for training set, 10,000 for test set and the remaining 5,000 for validation. The model is a Multilayer Convolutional Neural Network.



[7]
The network architecture with two convolutional layers (after the input of features with each pixel value as a feature) followed by max pooling is as follows:

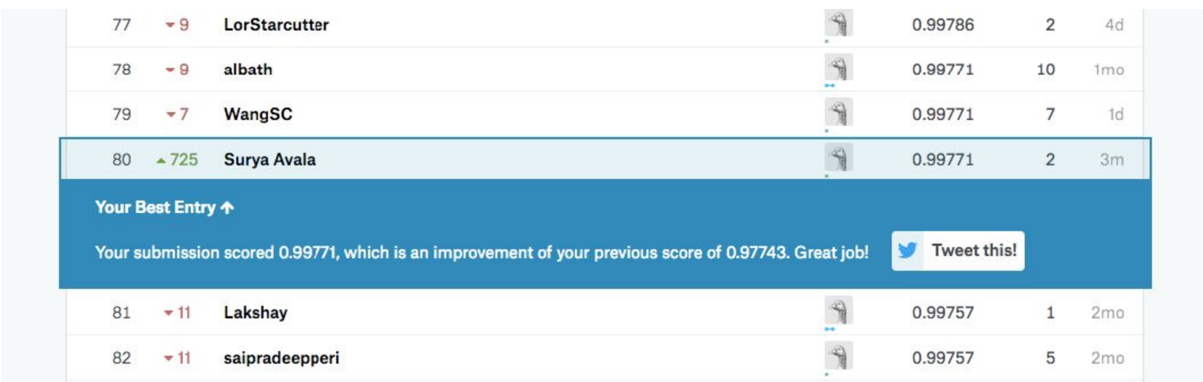
1. First Convolutional Layer: The convolution consists of 32 features for each 5x5 patch of the image.

2. Second Convolutional Layer: The second layer has 64 features for each 5x5 patch.
3. Densely Connected Layer: The image size has been reduced to 7x7, I have added a fully connected layer with 1024 neurons to allow processing on entire image.
4. Densely Connected Layer: Before the output, the matrix from the pooling layer has been vectorised and multiplied by weight matrix and a bias is added.
5. Readout Layer: I have performed Softmax Regression on the Layer 4 to obtain the probability of image classes (between 0-9)

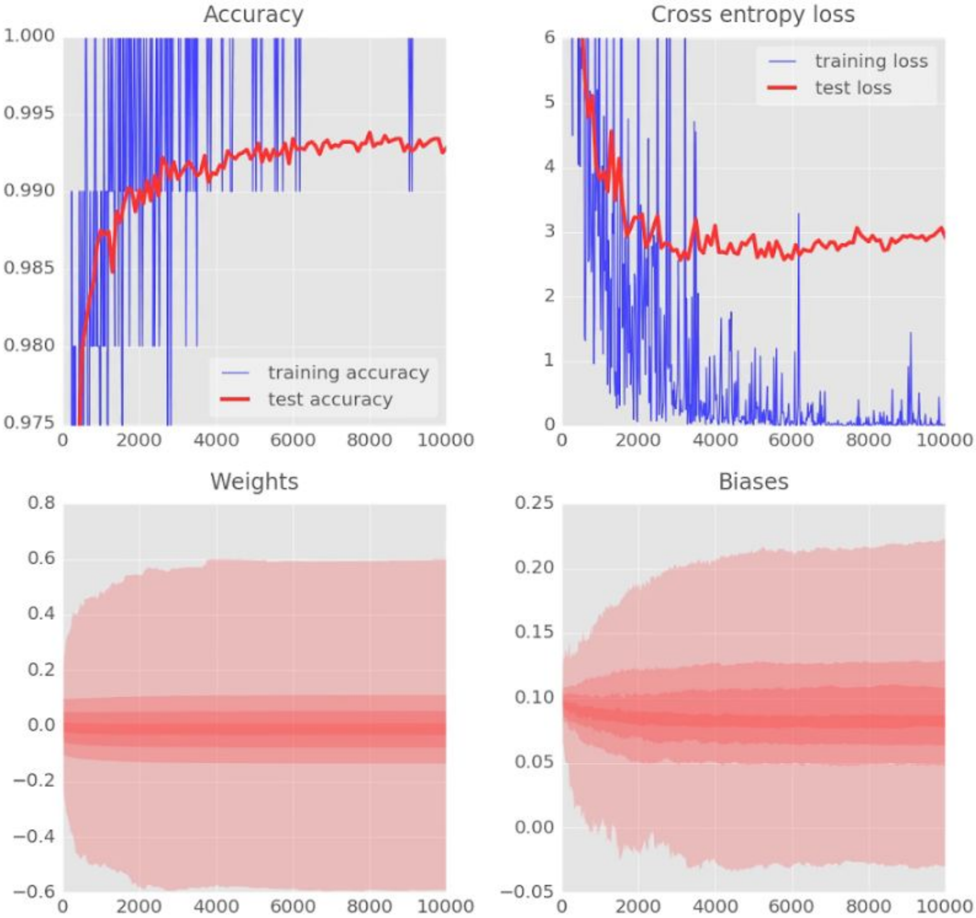
I have chosen ReLU[5] as the activation function and to reduce overfitting I have applied dropout of 0.55 before the readout layer. I have used Cross entropy to determine the distance between the output and label, and ADAM optimizer[6] with a learning rate of 1e-4 to optimize the weights and biases after each train step. The model is fed a batch of 50 images in each train step and the training is iterated over 25000 times.

Results

Final accuracy of 99.39% was achieved after 30000 training iterations[Appendix], current world record stands at ~99.7%[2] Predictions were made on the test set for Digit Recognizer competition on Kaggle[3] and a score 0.9771 has been achieved. My submission was ranked at 80 out of 1800 teams worldwide.



The results are visualized as follows:

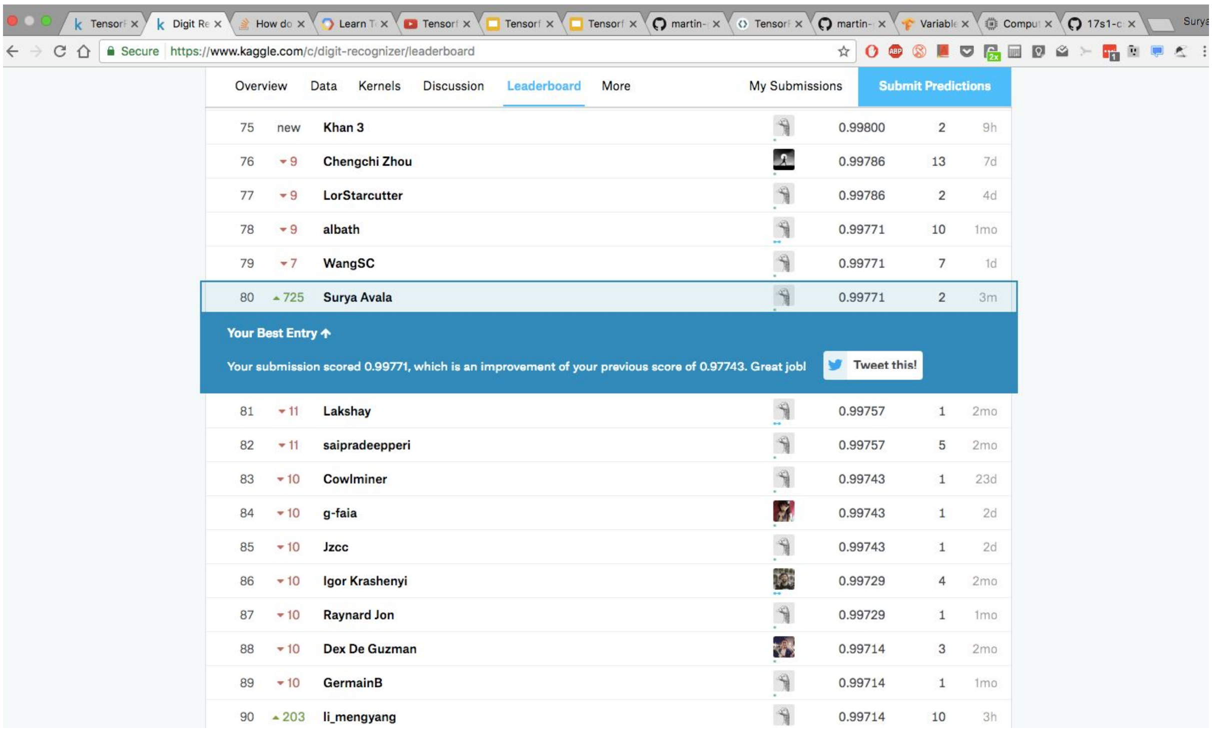


References

1. Y. LeCun, et al., Comparison of learning algorithms for handwritten digit recognition, in: F. Fogelman-Soulié, P. Gallinari (Eds.), Proceedings of the International Conference on Artificial Neural Networks, Nanterre, France, 1995, pp. 53–60.
2. http://yann.lecun.com/exdb/mnist/index.html.
3. https://www.kaggle.com/c/digit-recognizer#description
4. https://www.tensorflow.org/images/MNIST.png
5. https://en.wikipedia.org/wiki/Rectifier_(neural_networks)
6. Adam: A Method for Stochastic Optimization, Diederik P. Kingma, Jimmy Ba

7. https://image.slidesharecdn.com/deepmnistforexpert-160503224215/95/explanation-on-tensorflow-example-deep-mnist-for-expert-2-638.jpg?cb=1462764685

Appendix:



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76	▾9	Chengchi Zhou	0.99786	13	7d
77	▾9	LorStarcutter	0.99786	2	4d
78	▾9	albath	0.99771	10	1mo
79	▾7	WangSC	0.99771	7	1d
80	▴725	Surya Avala	0.99771	2	3m
81	▾11	Lakshay	0.99757	1	2mo
82	▾11	saipradeepperi	0.99757	5	2mo
83	▾10	Cowlminer	0.99743	1	23d
84	▾10	g-faia	0.99743	1	2d
85	▾10	Jzcc	0.99743	1	2d
86	▾10	Igor Krashenyi	0.99729	4	2mo
87	▾10	Raynard Jon	0.99729	1	1mo
88	▾10	Dex De Guzman	0.99714	3	2mo
89	▾10	GermainB	0.99714	1	1mo
90	▴203	li_mengyang	0.99714	10	3h

Your Best Entry ↑

Your submission scored 0.99771, which is an improvement of your previous score of 0.97743. Great job!

suryatherisingstar@instance-1:~/17s1-cs9417/src$ python3 mnist_nn.py
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
step 0, training accuracy 0.1
step 100, training accuracy 0.88
step 200, training accuracy 0.88
step 300, training accuracy 1
step 400, training accuracy 0.94
step 500, training accuracy 0.94
step 600, training accuracy 0.98
step 700, training accuracy 0.96
step 800, training accuracy 0.94
step 900, training accuracy 0.98

step 1000, training accuracy 0.96
step 1100, training accuracy 1
step 1200, training accuracy 0.92
step 1300, training accuracy 0.98
step 1400, training accuracy 0.96
step 1500, training accuracy 1
step 1600, training accuracy 0.98
step 1700, training accuracy 0.98
step 1800, training accuracy 0.96
step 1900, training accuracy 0.94
step 2000, training accuracy 0.98
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step 2200, training accuracy 0.98
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step 2400, training accuracy 0.98
step 2500, training accuracy 1
step 2600, training accuracy 0.98
step 2700, training accuracy 1
step 2800, training accuracy 0.96
step 2900, training accuracy 0.96
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step 3100, training accuracy 0.98
step 3200, training accuracy 0.98
step 3300, training accuracy 0.94
step 3400, training accuracy 1
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step 3600, training accuracy 1
step 3700, training accuracy 1
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step 4000, training accuracy 1
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test accuracy 0.9939
Model saved in file: ./model75/model.ckpt
```