

1 Using Convolutional Neural Network for Image Recognition

In this exercise, you will construct a convolutional neural network (CNN) for image recognition using the MNIST dataset. This dataset is a subset of a larger set available from NIST. The MNIST dataset contains a total of 70,000 images of handwritten digits from 0 to 9 with corresponding labels, of which 55,000 examples are in the training set, 5,000 in the validation set, and 10,000 in the test set. The digits have been size-normalized and centered in a fixed-size image, so you don't need to do any preprocessing to the images. The picture below is an example of the MNIST data:

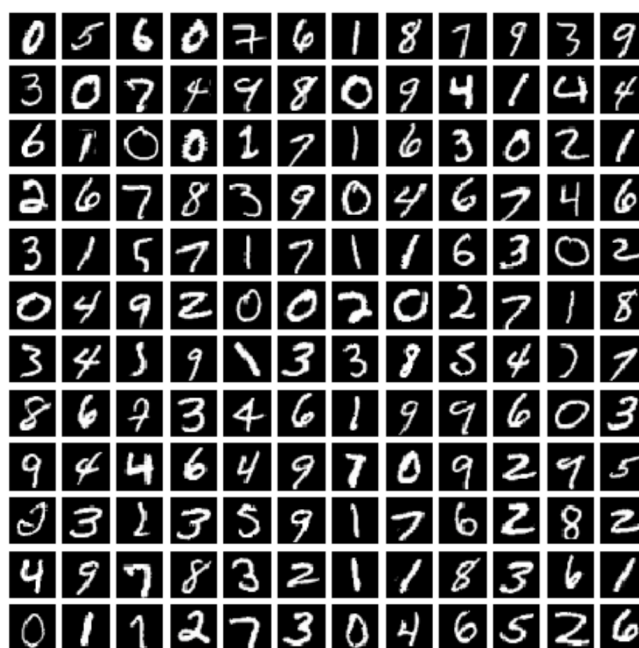


Figure 1: Examples of handwritten digits

You can download the dataset from: <http://yann.lecun.com/exdb/mnist/>, or use the code below:

```
from tensorflow.examples.tutorials.mnist import input_data
mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)
training_data = mnist.train.images
training_label = mnist.train.labels
```

(Hint: 'train' can be replaced with 'test' or 'validation')

1-1

Please implement a CNN for image recognition using the MNIST dataset. You have to **design your network architecture and analyze the effect of different stride size and filter size**. Also, plot the learning curve, accuracy of training and test sets, and distributions of weights and biases.

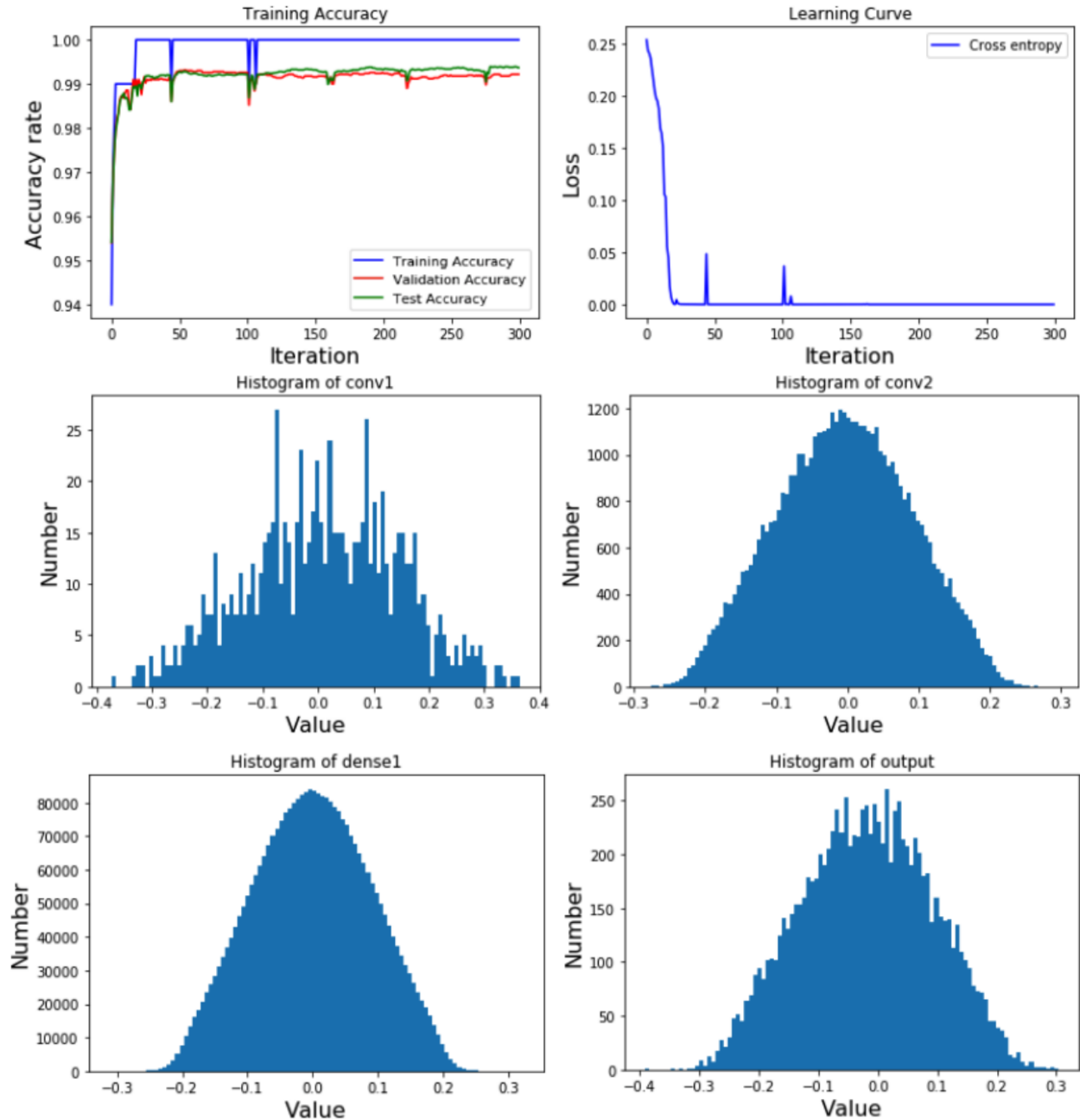


Figure 2: Training accuracy, learning curve, and histograms of layers

1-2

Show some examples of correctly classified and miss-classified images and discuss your results.

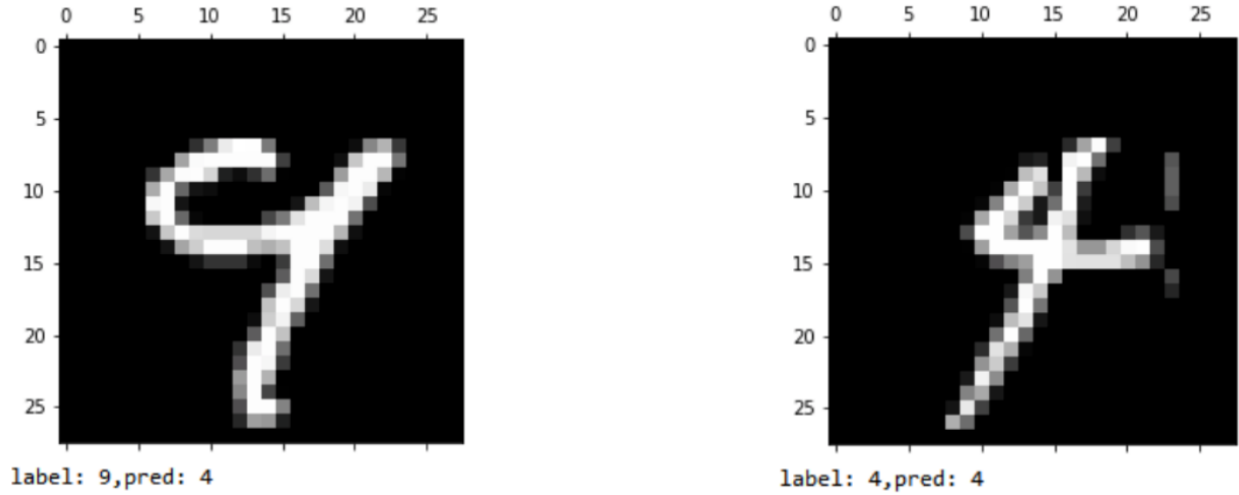


Figure 3: Examples of correctly classified and miss- images

1-3

Following 1-2, observe the feature maps from different convolutional layers and describe how a feature map changes with increasing depth.

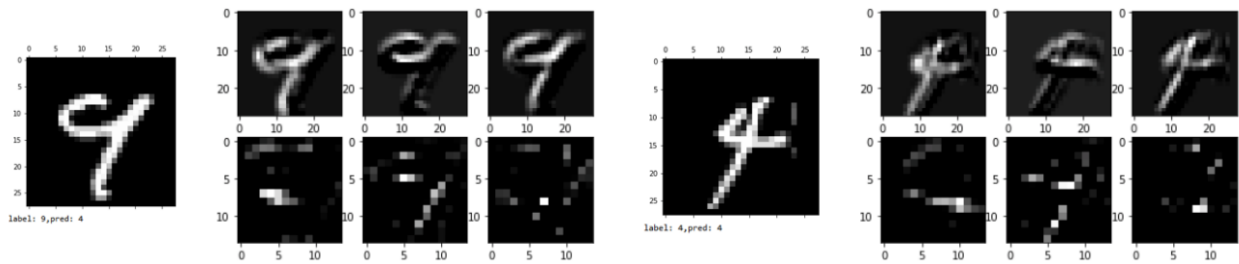


Figure 4: Examples of feature maps

1-4

Following 1-1, please add L2 regularization to the CNN implemented in 1-1 and discuss its effect.

$$E = -\frac{1}{N} \sum_{n=1}^N \sum_{k=1}^K y_{nk} \ln t_{nk} + \alpha ||w||_2^2$$

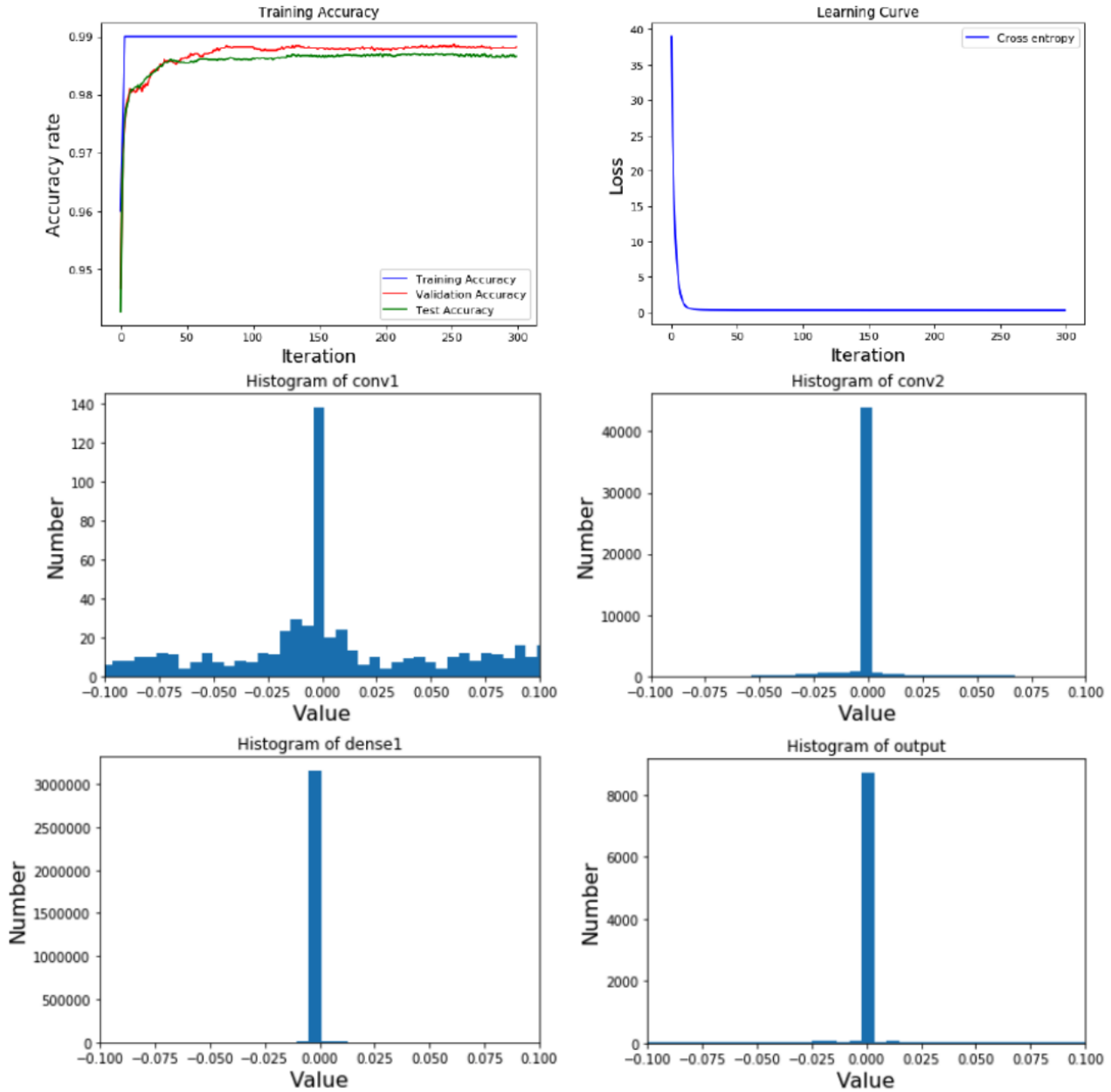


Figure 5: Results of a CNN with L2 regularization

2 Preprocessing Before Using Convolutional Neural Network for Image Recognition

This exercise is similar to exercise 1 but using the CIFAR-10 dataset. Since this dataset hasn't been processed beforehand, you need to do the preprocessing yourself and describe the preprocessing in section 2-5 of your report. The rest is identical to exercise 1. The link where you can get the CIFAR-10 dataset is below and please refer to the website for more information about the dataset.

<https://www.cs.toronto.edu/~kriz/cifar.html>