Deep Learning (Fall 2023)

Homework 2

Deadline Nov. 13

- You are allowed to use high-level API, such as Keras, slim, TFLearn, etc.
- Put your source code and the report with results into a compressed file HW2_studentID.zip and submit through e3.

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:

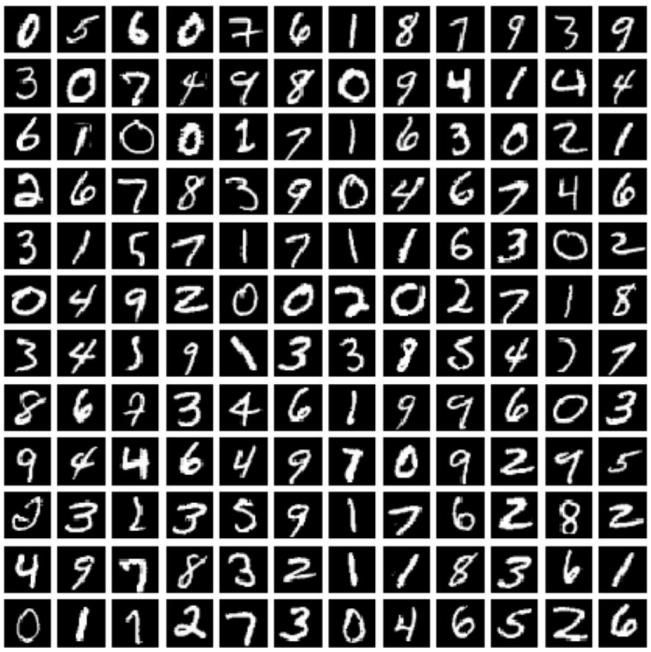

Figure 1: Examples of handwritten digits

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 = tf.keras.dataset.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

(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. (The figures shown below are only for example, you should get the results by yourself.)

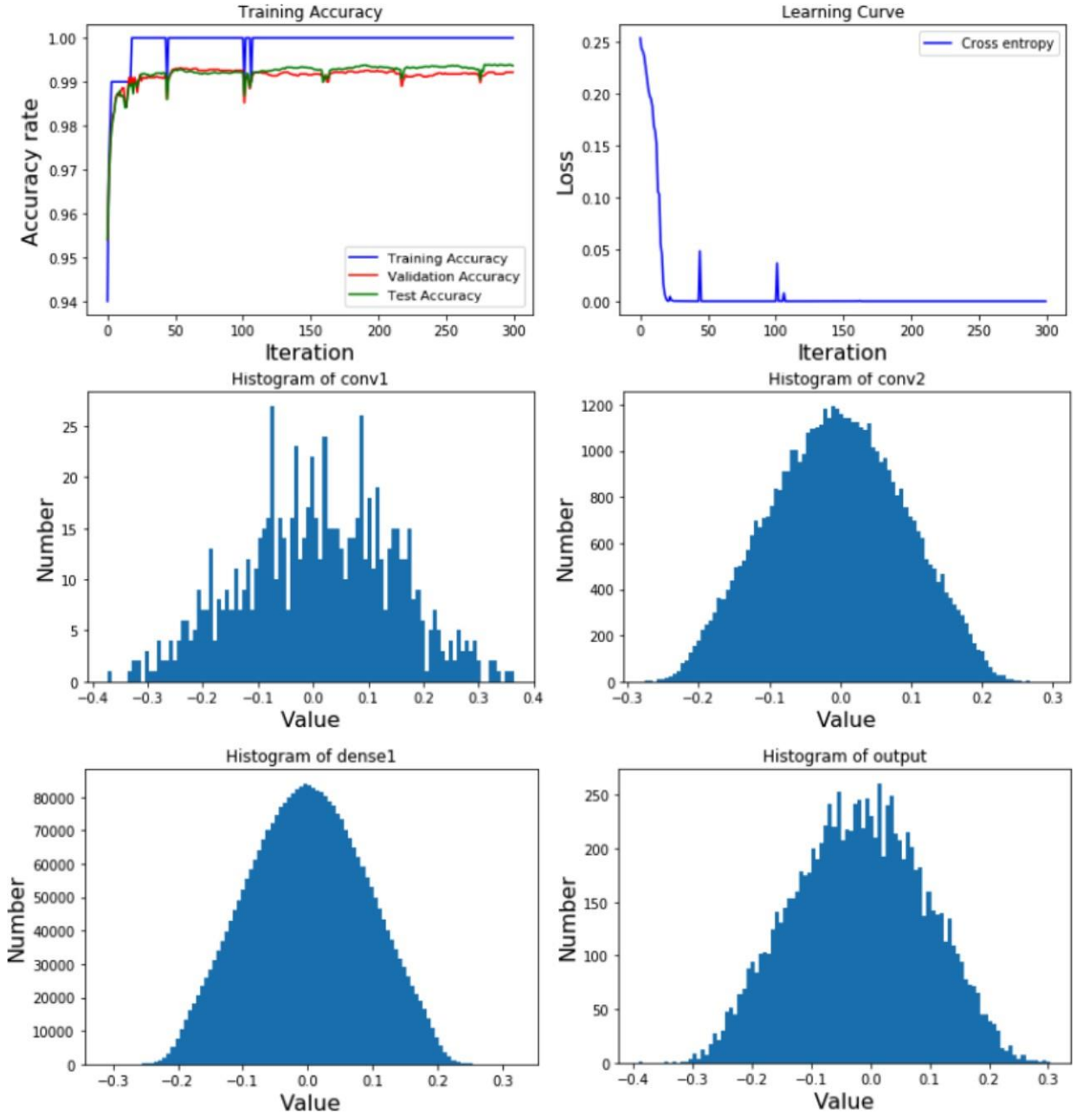

Figure 2: Training accuracy, learning curve, and histograms of layers

1-2

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

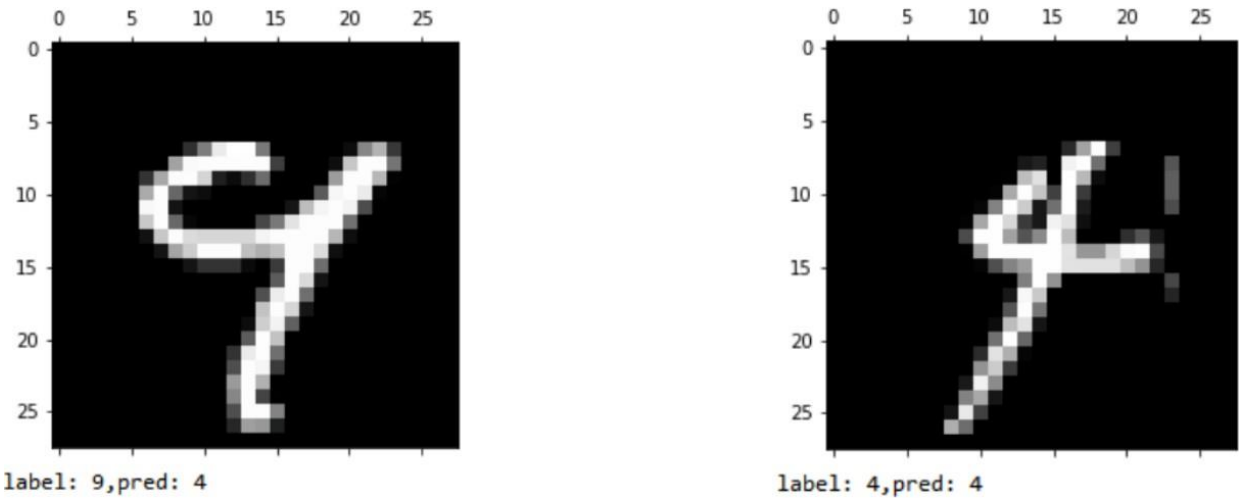

Figure 3: Examples of correctly classified and miss-classified images

1-3

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

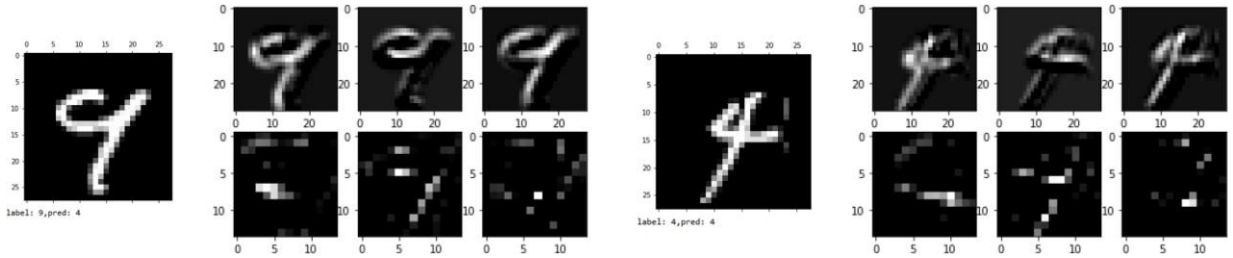

Figure 4: Examples of feature maps

1-4

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

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

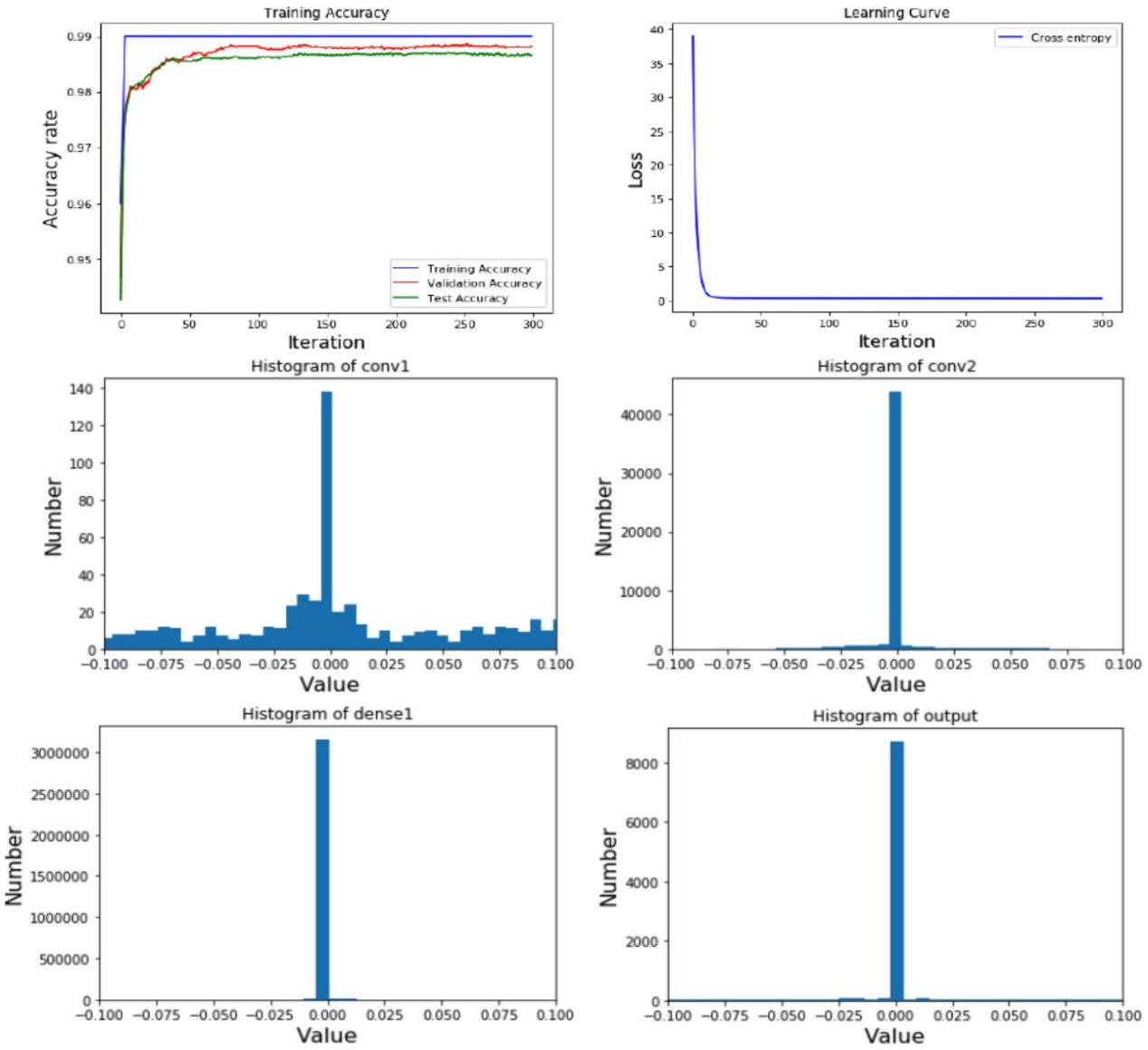

Figure 5: Results of a CNN with L2 regularization

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