COMPETITION #1
CIFAR10 Classification

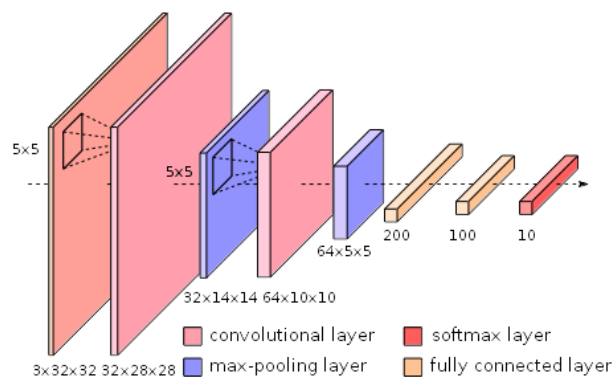**Issued: 3/23/2020**   **Due: 5/3/2020**

Xu Kangyan

4876-0109-98

kangyanx@usc.edu

Problem 2: CIFAR10 Classification

Figure 1. Network for CIFAR-10 Classification

I. Motivation and logics

1. CNN components

Architecture	Modified LeNet-5
1st Conv Layer Kernel Size	5x5x3
1st Conv Layer Filter No.	32
2nd Conv Layer Kernel Size	5x5x32
2nd Conv Layer Filter No.	64
1st FC Layer Filter No.	200
2nd FC Layer Filter No.	100
Output Node No.	10

Figure 2. CNN Parameters

This network is a modification of LeNet-5. Due to the limitation of calculation resource, the model size is not large: only **two convolution layers** (each followed by a max-pooling layer)

and the number of filters is 32 and 64 correspondingly. Then there are two FC Layers and finally the Softmax Layer. The activation function is **ReLU** (most widely used nowadays) and the optimizer is **Adam** (better performance in practical). There is no motivation to add more layers. Besides, training dataset is augmented.

2. Training parameter

Batch size is set to be 100 .

Epoch times is set to be 60 .

Optimizer learning rate is set to be 0.001 .

3. Performance improvement

In Problem 1(b), the accuracy on 10000 test images is nearly 70%. However, after **augmenting** the training dataset, the accuracy rises to nearly 80%. The augmentation includes randomly cropping the training image and randomly doing Horizontal-Flip.

II. Classification accuracy

```
Accuracy on 50000 train images: 81.586 %
Epoch 50 — Training 55.301 sec
Accuracy on 10000 test images: 79.670 %
Epoch 50 — Testing 6.143 sec
Accuracy on 50000 train images: 81.672 %
Epoch 51 — Training 61.467 sec
Accuracy on 10000 test images: 79.860 %
Epoch 51 — Testing 6.249 sec
Accuracy on 50000 train images: 81.906 %
Epoch 52 — Training 56.361 sec
Accuracy on 10000 test images: 80.210 %
Epoch 52 — Testing 6.264 sec
Accuracy on 50000 train images: 81.920 %
Epoch 53 — Training 57.609 sec
Accuracy on 10000 test images: 79.230 %
Epoch 53 — Testing 6.017 sec
Accuracy on 50000 train images: 82.150 %
Epoch 54 — Training 51.502 sec
Accuracy on 10000 test images: 79.170 %
Epoch 54 — Testing 6.309 sec
Accuracy on 50000 train images: 82.102 %
Epoch 55 — Training 59.729 sec
Accuracy on 10000 test images: 80.220 %
Epoch 55 — Testing 6.761 sec
Accuracy on 50000 train images: 82.346 %
Epoch 56 — Training 55.309 sec
Accuracy on 10000 test images: 79.240 %
Epoch 56 — Testing 6.153 sec
Accuracy on 50000 train images: 82.196 %
Epoch 57 — Training 57.213 sec
Accuracy on 10000 test images: 80.140 %
Epoch 57 — Testing 6.307 sec
Accuracy on 50000 train images: 82.346 %
Epoch 58 — Training 56.934 sec
Accuracy on 10000 test images: 80.230 %
Epoch 58 — Testing 6.012 sec
Accuracy on 50000 train images: 82.680 %
Epoch 59 — Training 60.403 sec
Accuracy on 10000 test images: 79.910 %
Epoch 59 — Testing 6.629 sec
Training Finished
Total Time 3850.426 sec
```

Figure 3. The Testing Accuracy (last ten epochs)

System Configuration

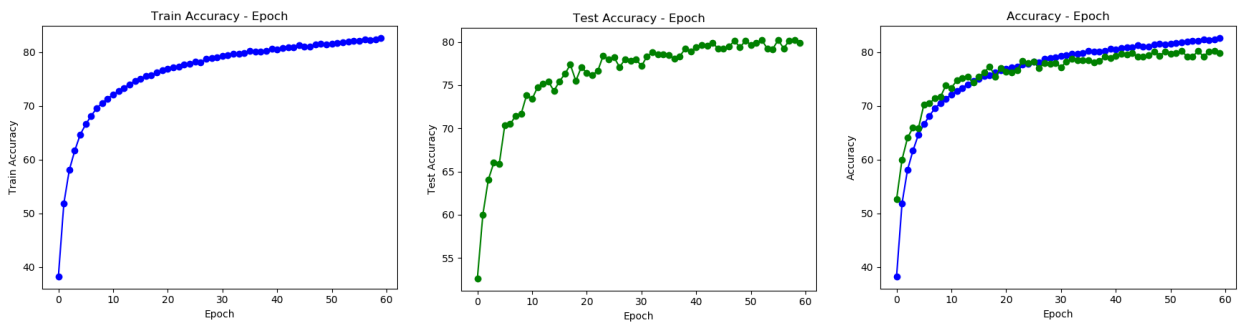Processor: Intel Core i5-9400 CPU @ 2.90 GHz

RAM: 8.00GB

OS: Windows 10

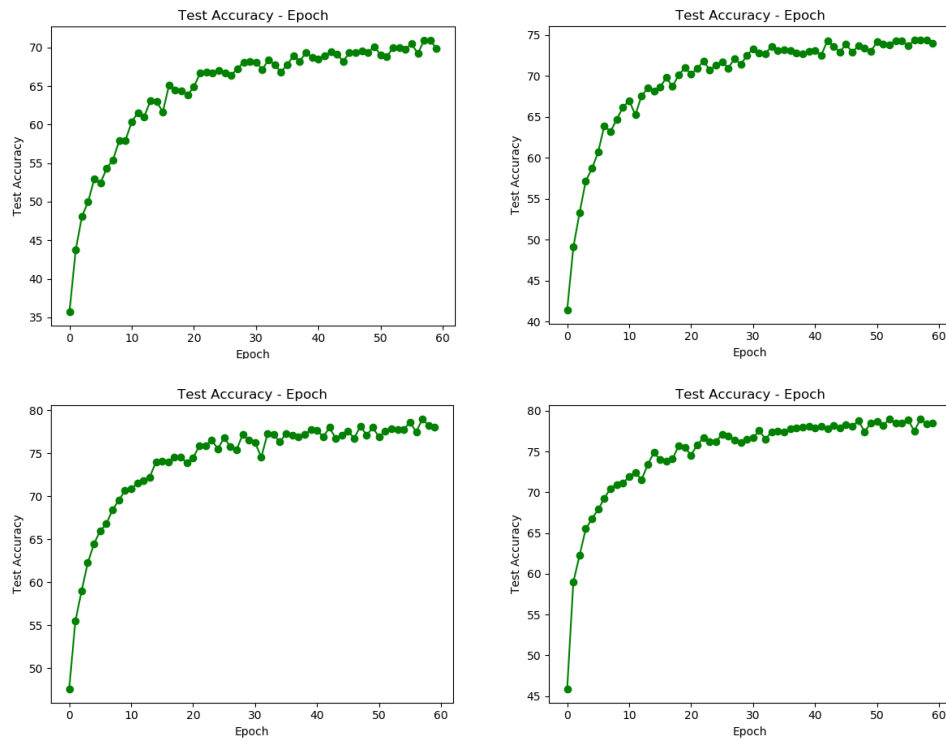The **average testing accuracy** of the last ten epochs is **79.788%** .

The **training time** is nearly **3460** sec (nearly an hour for 60 epochs).

The inference time is nearly **6.5** sec.

Figure 4. Accuracy Performance Curves

After randomly dropping training samples:

Figure 5. Test Accuracy Curves (Training data 10000 / 20000 / 30000 / 40000)

Figure 6. Test Accuracy (Training data 10000 / 20000 / 30000 / 40000)

The test accuracy rate after randomly dropping training samples is nearly 70% (10000 training data), 74% (20000 training data), 78% (30000 training data), 78.5% (40000 training data). 30000 training data can get an accuracy similar to 50000 data (2% difference).

III. Model size

$$3072 \ (input) \rightarrow 2432 \ (cov1 \ filter \ parameters) \rightarrow 51264 \ (cov2 \ filter \ parameters)$$
$$\rightarrow 320200 \ (FC1 \ parameters) \rightarrow 20100 \ (FC2 \ parameters)$$
$$\rightarrow 1010 \ (FC3 \ parameters) \rightarrow 10 \ (output)$$

$3072 = 32 \times 32 \times 3$

$2432 = (5 \times 5 \times 3 + 1) \times 32$

$51264 = (5 \times 5 \times 32 + 1) \times 64$

$320200 = (64 \times 5 \times 5 + 1) \times 200$

$20100 = (200 + 1) \times 100$

$1010 = (100 + 1) \times 10$

The total parameter number is **395006**.