CSI 5138 Assignment2

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1 Data Analysis

In this assignment, I used two dataset, including MNIST and CIRFT-10. The MNIST is a black-white handwritten digits dataset from 0 to 9, and the image dimension is 28*28. Fot the CIRFT-10, it contains several colour images with the dimension of 32*32*3 in 10 different classes. The sample images of both datasets plot in Figure 1 and Figure 2 respectively.

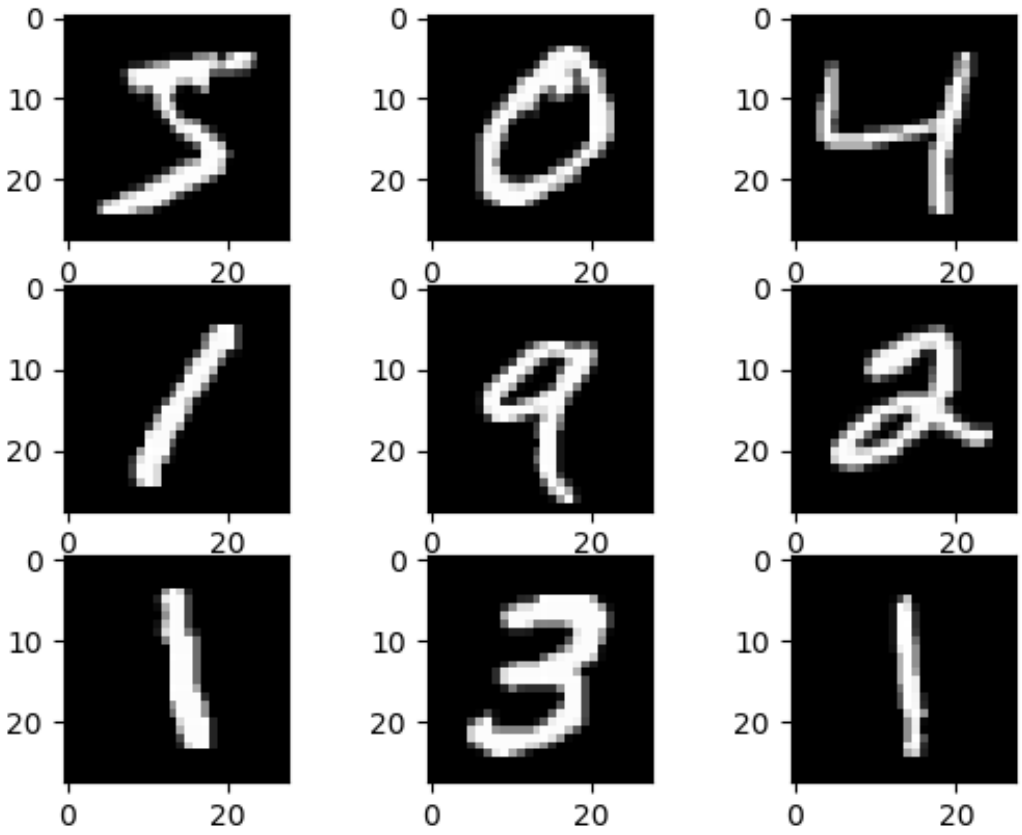

Figure 1: Sample Images of MNIST

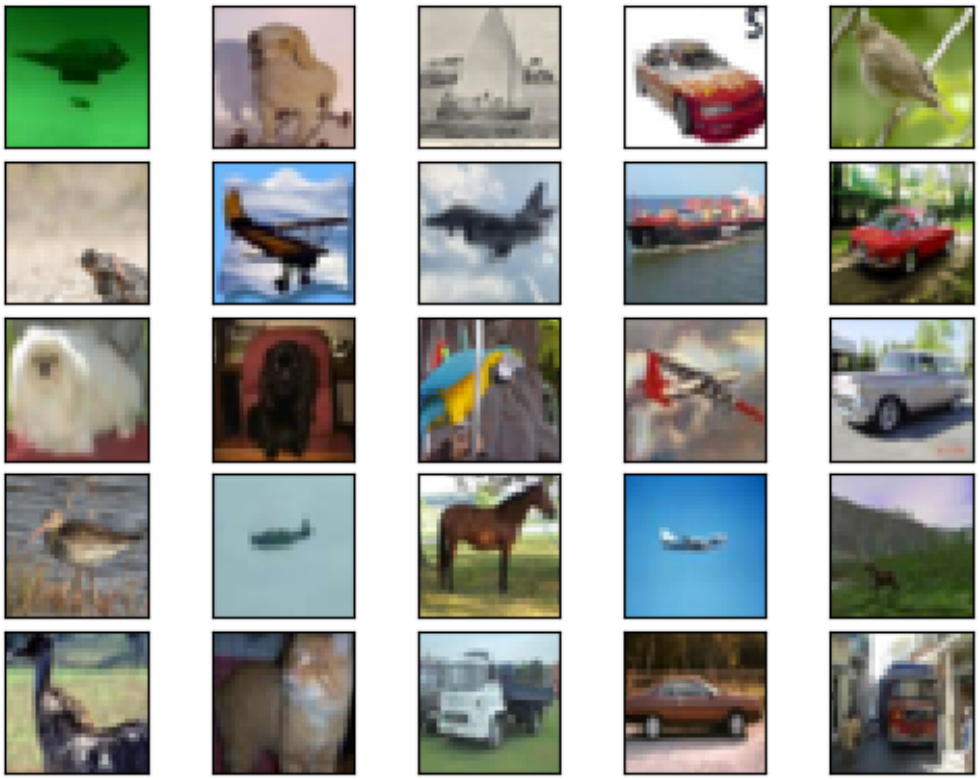

Figure 2: Sample Images of CIRFT-10

2 Model Definition

I built three main different multi-class classifiers for these two datasets, including Softmax Regression, MLP and CNN.

2.1 Softmax Regression

The Softmax Regression is similar to Logistic Regression, but it is for multi-class problem. The related calculation formulas are below:

$$y = softmax\Big(Wx + b\Big) \tag{1}$$

$$softmax(x_i) = \frac{exp(x_i)}{\sum_j exp(x_j))} \tag{2}$$

2.2 MLP

The MLP is a class of feed-forward artificial neural network, with multiple hidden layers. I buidl four MLP models in total to compare the depth and width of layer as well as dropout regularization. Except the output layer with $softmax$ activation function, all hidden layers used $ReLU$ activation function, which can reduce the problem of gradient vanish.

Figure 3 and Figure 4 are two MLP networks of MNIST and CIFAR-10. Before putting the image into the network, it need to flat into one dimension.

Model NO.	Hidden Layer Num	Hidden Neural Count	Dropout
MLP1	2	(512,256)	N
MLP2	2	(512,256)	Y
MLP3	4	(2048,1024,512,256)	N
MLP4	4	(2048,1024,512,256)	Y

Table 1: All Models of MLP

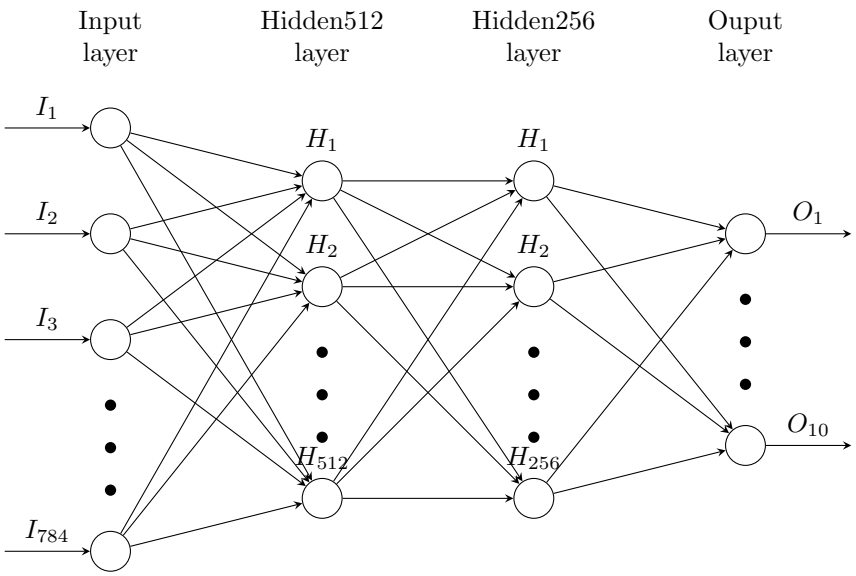

Figure 3: MLP1 model for MNIST

2.3 CNN

CNN is mainly used in the CV area, which contains convolution layer and pooling layer for extracting image features. I built 6 CNN models in total, in order to compare the kernel size, network depth and batch normalization regularization method. Before the output layer, I added two fully connected layer with $ReLU$ to classify the images.

Model NO.	Conv Layer Num	Batch Normalization	Kernel Size
CNN1	2	N	3
CNN2	2	Y	3
CNN3	2	N	5
CNN4	4	N	3
CNN5	4	Y	3
CNN6	4	N	5

Table 2: All Models of CNN

Figure 5 and Figure 6 are two CNN networks of MNIST and CIFAR-10.

3 Model Evaluation

I used 60000 images to train and 10000 images to test for the MNIST, as well as 50000 images to train and 10000 to test for the CIFAR-10. Besides, I used 10 epoch with batch size of 32 for the MNIST and 25 epoch with batch size of 64 for the CIFAR-10.

First, for the MNIST, the results are summarised in Table 3. As we can see, in my experience, the best model is CNN5 with 4 convolution layers, smaller kernel(size = 3) and using Batch Normalization. In general, the MLP and the CNN can perform better than the Softmax Regression, because the Softmax Regression is simple and no hidden layers except input layer and output layer. On the other hand, the Softmax Regression trained more faster than others due to less parameters. For MLP, deeper network can get better result with Dropout regularization,

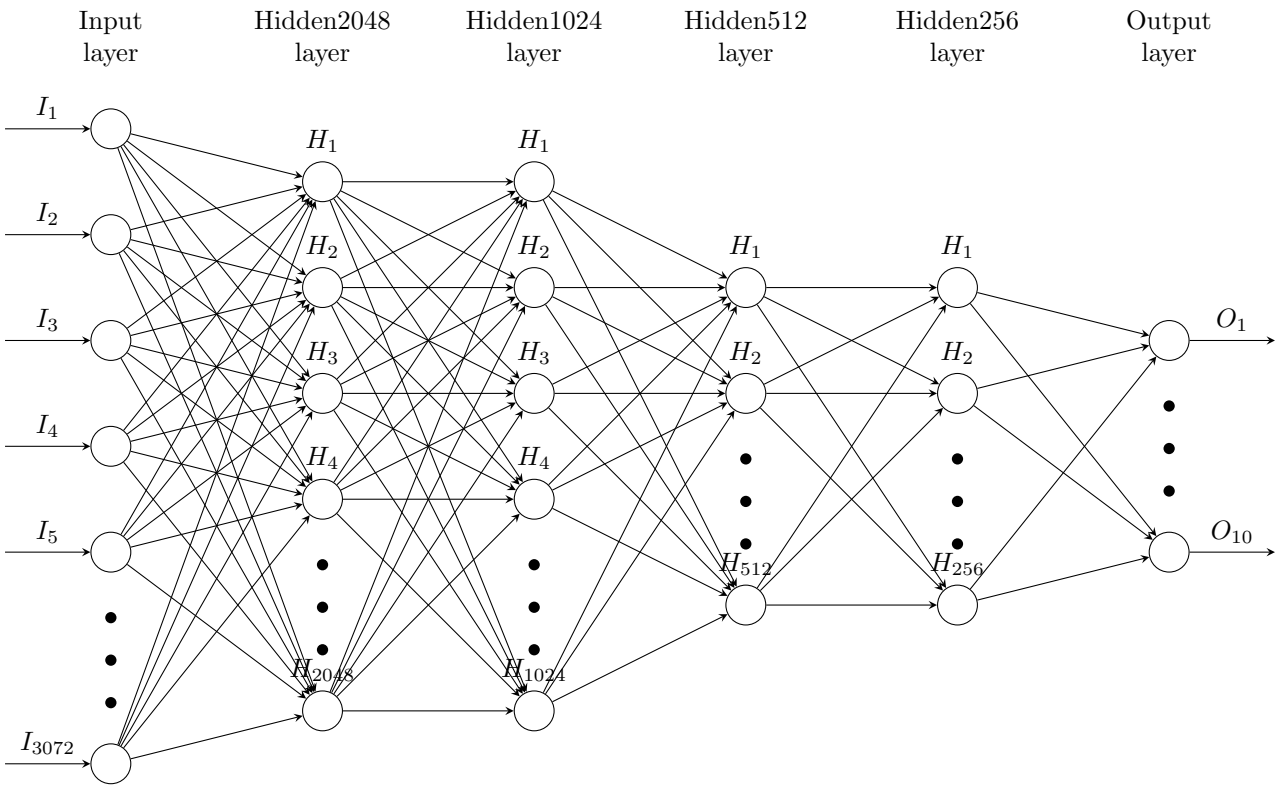

Figure 4: MLP3 model for CIFAR-10

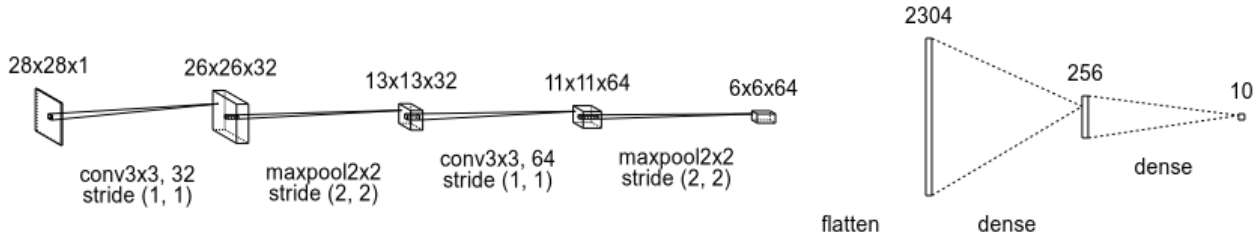

Figure 5: CNN3 model for MNIST

because it can reduce the over-fitting problem. For CNN, the smaller kernel can focus on more detail of the image, while the larger one can get more information of the image. Similarly, deeper CNN can get better result with Batch Normalization regularization.

For the CIFAR-10, the results are summarised in Table 4. The results are similar to the MNIST, but this dataset is more difficult to classify than previous one with lower accuracy in almost all models. The best model is also CNN5 with 4 convolution layers, smaller kernel(size = 3) and using Batch Normalization. The Softmax Regression is obviously poor in the dataset.

Besides, for the CIFAR-10, I also changed the location of the pooling layer, putting one pooling layer after two convolution layers. The network plot in Figure 8, and the model accuracy reached **0.8360** after 100 epoch, which is better than CNN5.

4 Discussion

The accuracy varies a lot from different dataset. For the simple classification dataset like the MNIST, all models can perform well, even the Softmax Regression. So we can choose the relative simple model to reduce calculation and training time. But for the difficult dataset like CIFAR, the simple model did not perform well. So if we want

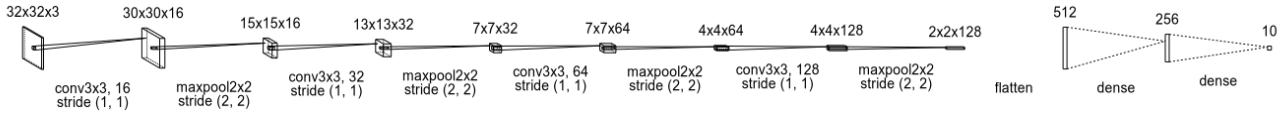

Figure 6: CNN4 model for CIFAR-10

Model	Accuracy
Softmax	0.8648
MLP1	0.9718
MLP2	0.9605
MLP3	0.9735
MLP4	0.9704
CNN1	0.9802
CNN2	0.9907
CNN3	0.9861
CNN4	0.9806
CNN5	**0.9916**
CNN6	0.9886

Table 3: Results for the MNIST

Model	Accuracy
Softmax	0.2980
MLP1	0.5116
MLP2	0.4866
MLP3	0.4607
MLP4	0.4621
CNN1	0.7387
CNN2	0.7297
CNN3	0.7182
CNN4	0.7460
CNN5	**0.7597**
CNN6	0.7036

Table 4: Results for the CIFAR-10

to get better performance, the model like CNN is the best option.

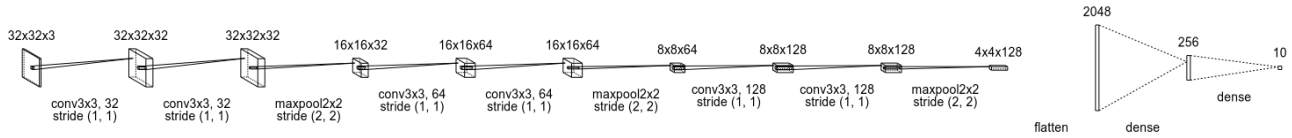

Figure 7: Another CNN model for CIFAR-10

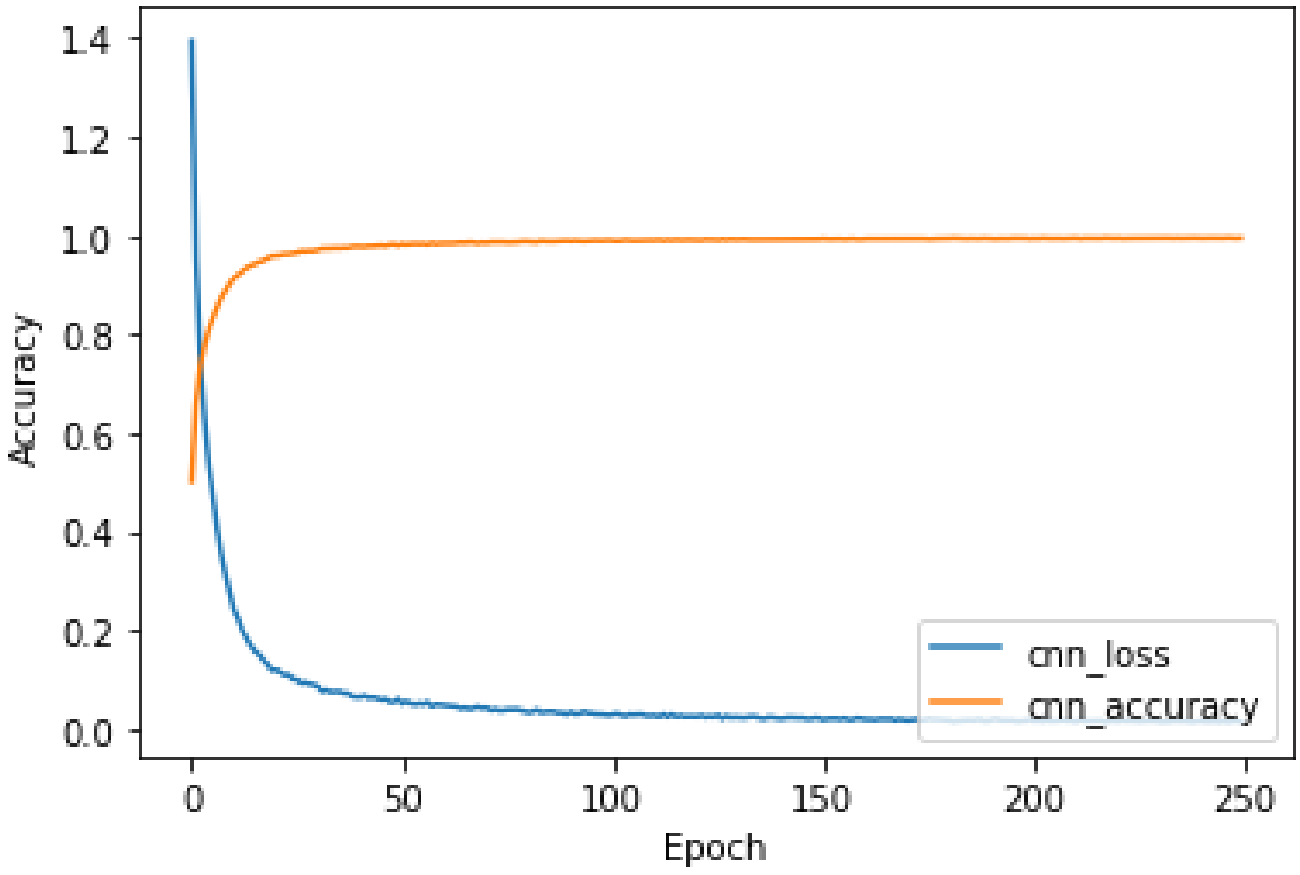

Figure 8: Another CNN model for CIFAR-10