Report - *Convolutional Neural Networks*

Assignment 4 · Dinesh Jaykumar Kodwani

***Part 2**: Adding CNN and fully connected layers to recognize handwritten digits on PyTorch.*

Introduction

In this assignment, variations of a model is tested based on the 3 following conditions:

1. Without CNN layer(s)
2. With 1 CNN layer and Max Pooling
3. With 2 CNN layers and Max Pooling

Without CNN Layer

Using 2 fully connected layers in the deep neural network and a ReLu activation function, the model achieves an accuracy of 94% on the test set.

With 1 CNN layer

The model with 1 CNN layer was further experimented with 2 different activation functions and 4 different hyperparameter settings each. The various hyperparameter settings are consistent for all parts of experiments where there exists a CNN layer, see *Table 1.* for parameters settings used in these experiments.

***Table 1.** Various hyperparameter setting types.*

Setting Type	**Hyperparameters**
A	Batchsize = 32, Epochs = 1, lr(step size) = 0.01
B	Batchsize = 64, Epochs = 1, lr(step size) = 0.01
C	Batchsize = 64, Epochs = 4, lr(step size) = 0.01
D	Batchsize = 64, Epochs = 4, lr(step size) = 0.05

To test and find the best model 2 activation functions ReLu and Sigmoid were used with each hyperparameter setting. The resulting layers were then passed through Max Pooling in the subsampling process.

With 2 CNN layers

The model with 2 CNN layers was, similarly, experimented with 2 different activation functions and 4 different hyperparameter settings each. See *Table 1* for hyperparameter settings To test and find the best model 2 activation functions ReLu and Sigmoid were used with each hyperparameter setting. Each resulting layer after passing through a CNN layer was passed through a max pooling layer for sub sampling.

Results

Two models achieved the highest accuracy of 99%, one with 1 CNN layer and other with 2 CNN layers, both with hyperparameter setting type D (Batchsize = 64, Epochs = 4, lr(step size) = 0.05). It is important to note that both these models had ReLu activation functions. On the other hand, the weakest model, with 1 CNN layer using sigmoid activation function, achieved an accuracy of 10%. It was observed that increasing the step size, the learning rate, always resulted in a higher accuracy. See *Table 2* to see how various models performed differently on different hyperparameter settings.

Table 2. *Accuracy with different models on different hyperparameter settings*

CNN Layers	**Activation Function**	**Hyperparameter type**	**Accuracy**
No CNN Layer	ReLu	A	94%
1 CNN Layer	ReLu	A	96%
		B	95%
		C	98%
		D	**99%**
	Sigmoid	A	10%
		B	10%
		C	68%
		D	95%
2 CNN Layers	ReLu	A	96%
		B	96%
		C	98%

		D	**99%**
	Sigmoid	A	21%
		B	64%
		C	61%
		D	68%