Foundations of Convolutional Neural Networks

-Niraj Yadav (b16024)

-Suryakant Bhardwaj (b16117)

-Siddharth Singh (b16147)

Group 21

DATASETS

MNIST

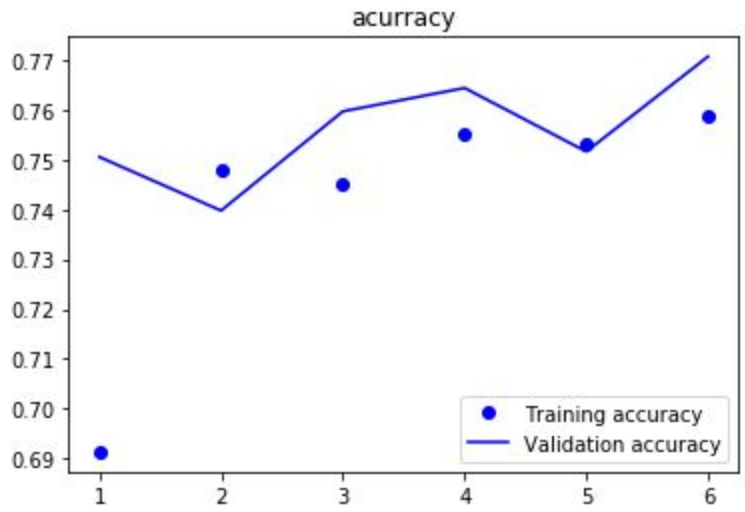
A) By predefined model architecture

Model Structure:

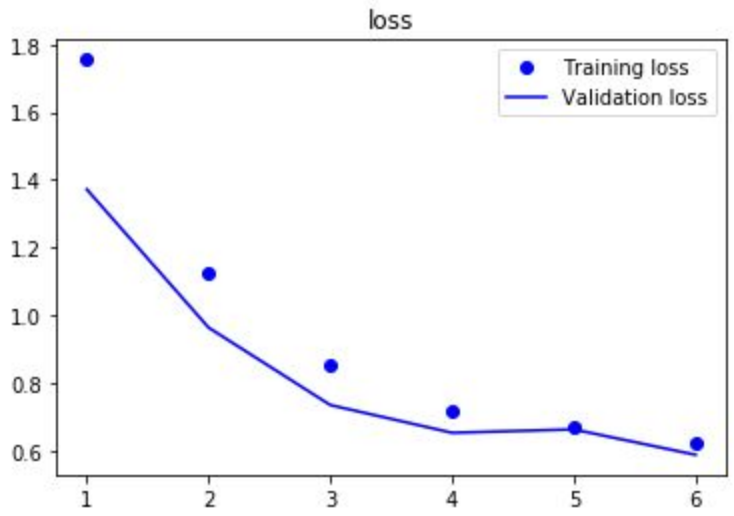
Layer (type)	Output Shape	Param #
conv2d_5 (Conv2D)	(None, 22, 22, 32)	1600
batch_normalization_5 (Batch	(None, 22, 22, 32)	128
max_pooling2d_5 (MaxPooling2	(None, 11, 11, 32)	0
flatten_5 (Flatten)	(None, 3872)	0
dense_13 (Dense)	(None, 1024)	3965952
dense_14 (Dense)	(None, 128)	131200
dense_15 (Dense)	(None, 10)	1290

Learning Curves:

Accuracy:



Loss:



Confusion Matrix:

```
[[5771   34    7   24   44    0   26   11    6    0]
 [   0 6605   23   75   10    0    2   21    6    0]
 [  18   64 5505  222   23    0   13  101   12    0]
 [   2    8   53 5992    7    0    2   52   15    0]
 [   2   26    5   19 5737    0    4   36   10    3]
 [   2    3    4 5366   13    0   15    7   11    0]
 [  27  153    1   80  114    1 5531    0   11    0]
 [   4   18   77   26   29    0    0 6108    2    1]
 [  36  138  119  479   70    0   16   92 4900    1]
 [  22    9    3  279 5149    0    0  460   11   16]]
```

F1-Score:

0.7085153502006135

Variations Tried:

Model was tested for different hyperparameters like no of epochs and batch size, after several testing and observations and with aim to reduce overfitting epochs were set to 6 and batch size was set to 50.

Inferences:

As can be seen from learning curves for accuracy and loss both validation as well as training parameters remained almost same for no of epochs which suggest that model has been tuned to reduce overfitting.

Results after 6th final epoch

oss: 0.6222 - acc: 0.7589 - val_loss: 0.5882 - val_acc: 0.7708

B) By Optimized Model

Model Structure

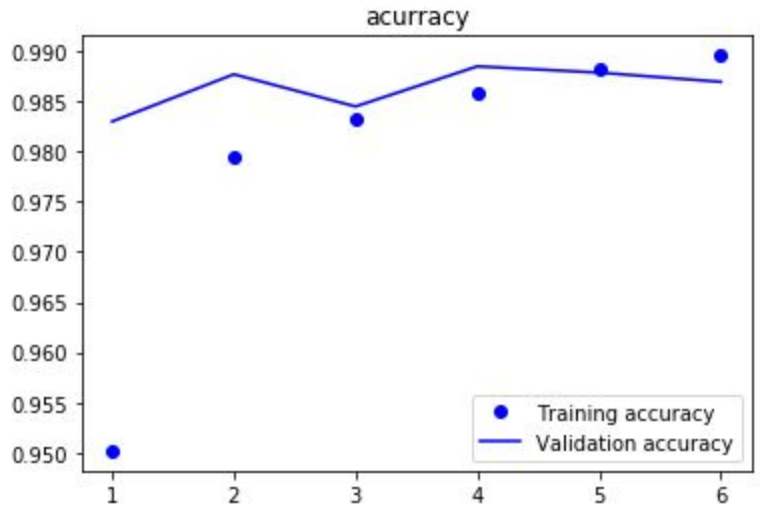
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_9 (Conv2D)            (None, 26, 26, 32)        320
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 24, 24, 64)        18496
_________________________________________________________________
max_pooling2d_8 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 10, 10, 128)       73856
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 5, 5, 128)         0
_________________________________________________________________
dropout_2 (Dropout)          (None, 5, 5, 128)         0
_________________________________________________________________
batch_normalization_7 (Batch (None, 5, 5, 128)         512
_________________________________________________________________
flatten_7 (Flatten)          (None, 3200)              0
_________________________________________________________________
dense_20 (Dense)             (None, 1024)              3277824
_________________________________________________________________
dense_21 (Dense)             (None, 512)               524800
_________________________________________________________________
dense_22 (Dense)             (None, 128)               65664
_________________________________________________________________
dense_23 (Dense)             (None, 10)                1290
=================================================================
Total params: 3,962,762
Trainable params: 3,962,506
Non-trainable params: 256
```

Confusion Matrix:

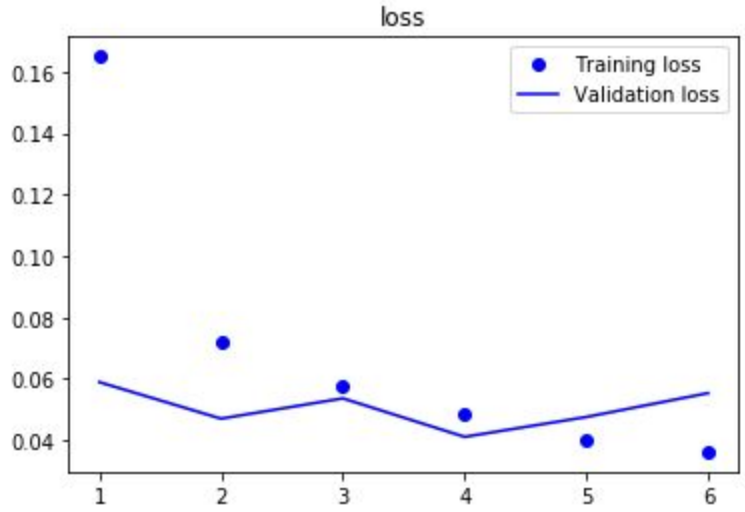
```
[[5868    0   13    2    0    0   37    0    1    2]
 [   0 6691    7    1    7    2   16   11    0    7]
 [   1    2 5932    1    2    0   14    3    3    0]
 [   1    0   53 6061    0    7    0    1    6    2]
 [   1    1    3    0 5806    0   11    1    0   19]
 [   3    0    5   20    1 5354   25    0    7    6]
 [   1    0    1    0    2    3 5911    0    0    0]
 [   0    4   64    3    5    0    0 6167    0   22]
 [   4    3   11    1   13    2   20    3 5774   20]
 [   5    1    6    3   14    3    0    4    8 5905]]
```

Learning Curves:

Accuracy:



Loss:



F1 Score:

0.9911624834913386

Variations Tried:

Model was tested for different hyperparameters like no of epochs and batch size, after several testing and observations and with aim to reduce overfitting epochs were set to 6 and batch size was set to 50.

Inferences:

As can be seen from learning curves for accuracy and loss both validation as well as training parameters remained almost same for no of epochs which suggest that model has been tuned to reduce overfitting.

Results after 6th final epoch

loss:0.0362 - acc: 0.9896 - val_loss: 0.0554 - val_acc: 0.9870

Line Dataset

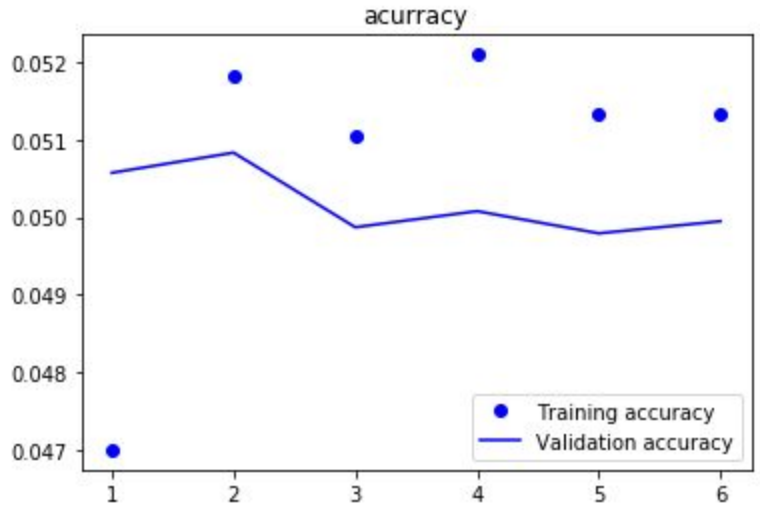
A) Predefined Model

Model Structure:

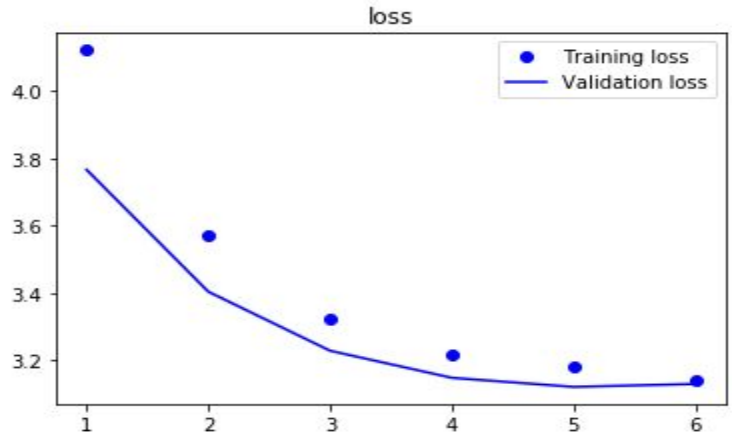
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 22, 22, 32)        4736
_________________________________________________________________
batch_normalization_1 (Batch (None, 22, 22, 32)        128
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 11, 11, 32)        0
_________________________________________________________________
flatten_1 (Flatten)          (None, 3872)              0
_________________________________________________________________
dense_1 (Dense)              (None, 1024)              3965952
_________________________________________________________________
dense_2 (Dense)              (None, 128)               131200
_________________________________________________________________
dense_3 (Dense)              (None, 96)                12384
=================================================================
Total params: 4,114,400
Trainable params: 4,114,336
Non-trainable params: 64
```

Learning Curves:

Accuracy:



Loss:



Confusion Matrix:

```
[[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 ...
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]
```

F1-Score:

0.0054682488650751844

Variations Tried:

Model was tested for different hyperparameters like no of epochs and batch size, after several testing and observations and with aim to reduce overfitting epochs were set to 6 and batch size was set to 50.

Inferences:

As can be seen from learning curves for accuracy and loss both validation as well as training parameters remained almost same for no of epochs which suggest that model has been tuned to reduce overfitting.

Results after 6th final epoch

oss: 3.1382 - acc: 0.0513 - val_loss: 3.1284 - val_acc: 0.0499

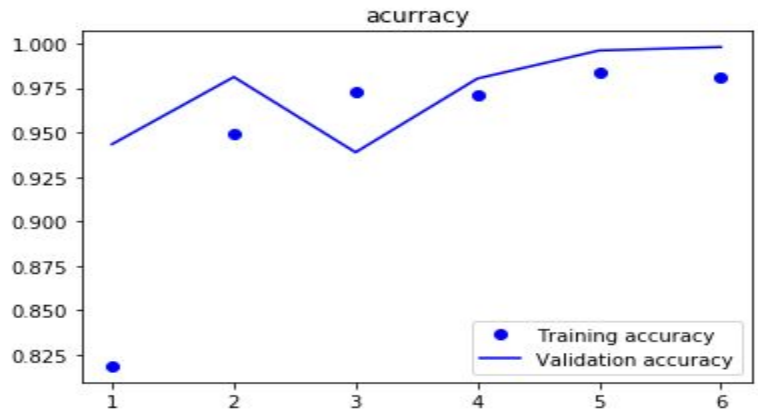
B) Optimized Model

Model Structure:

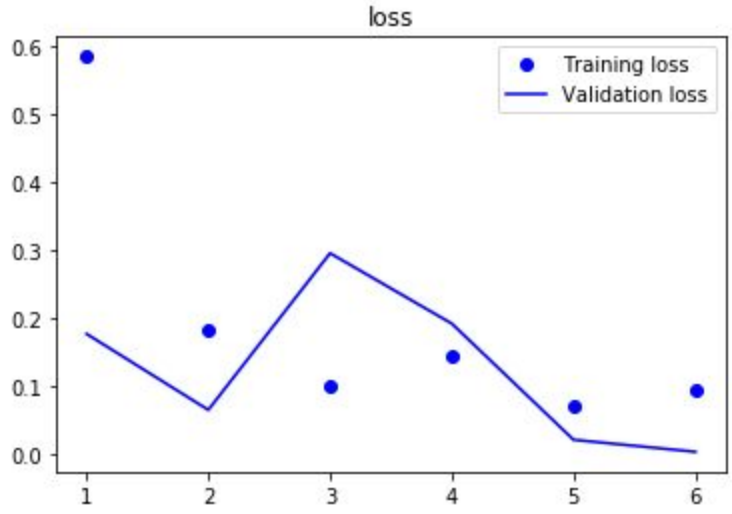
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 26, 26, 32)        896
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 24, 24, 64)        18496
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 10, 10, 128)       73856
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 5, 5, 128)         0
_________________________________________________________________
dropout_1 (Dropout)          (None, 5, 5, 128)         0
_________________________________________________________________
batch_normalization_1 (Batch (None, 5, 5, 128)         512
_________________________________________________________________
flatten_1 (Flatten)          (None, 3200)              0
_________________________________________________________________
dense_1 (Dense)              (None, 2056)              6581256
_________________________________________________________________
dense_2 (Dense)              (None, 1024)              2106368
_________________________________________________________________
dense_3 (Dense)              (None, 256)               262400
_________________________________________________________________
dense_4 (Dense)              (None, 96)                24672
=================================================================
Total params: 9,068,456
Trainable params: 9,068,200
Non-trainable params: 256
```

Learning Curves:

Accuracy:



Loss:



Confusion Matrix:

```
[[1000    0    0 ...    0    0    0]
 [   0 1000    0 ...    0    0    0]
 [   0    0 1000 ...    0    0    0]
 ...
 [   0    0    0 ... 1000    0    0]
 [   0    0    0 ...    0  169    0]
 [   0    0    0 ...    0    0 1000]]
```

F1-Score

0.9979175664829821

Variations Tried:

Model was tested for different hyperparameters like no of epochs and batch size, after several testing and observations and with aim to reduce overfitting epochs were set to 6 and batch size was set to 50.

Inferences:

As can be seen from learning curves for accuracy and loss both validation as well as training parameters remained almost same for no of epochs which suggest that model has been tuned to reduce overfitting.

Results after 6th final epoch

loss: 0.0959 - acc: 0.9810 - val_loss: 0.0043 - val_acc: 0.9980