CS551 Assignment 4 - Report

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A total of 10 experiments with different CNN models were conducted for the classification task on MNIST Database. All models have 3 hidden layers -

1. Convolutional
2. Batch Normalization
3. Dense

Input layer has shape of (28,28,1) and output layer has 10 classes with softmax activation. All hidden layers use leaky ReLU activation. All convolution kernels are of size (3,3). Cost function used - sparse_categorical_crossentropy. Number of epochs is controlled by early stopping callbacks. Maximum epochs are limited to 20. The following table summarizes the parameters used for experiments, and their results.

Exp	Conv Layer Size	Dense Layer Size	Optimizer	Learning Rate control	Batch size	Data Aug	Test Accuracy (%)	Remarks
1	32	64	adam	Not Controlled	100	none	97.24	Epoch 00007: early stopping
2	32	64	sgd	Not Controlled	200	none	**98.32**	
3	32	64	rmsprop	Not Controlled	1000	none	96.87	Epoch 00014: early stopping
4	32	64	sgd	Controlled 1	150	none	**98.34**	Epoch 00018: early stopping
5	32	128	adam	Controlled 2	100	none	97.74	Epoch 00012: early stopping
6	64	64	rmsprop	Controlled 3	400	none	**98.2**	Epoch 00016: early stopping
7	32	64	adam	Controlled 4	500	Rotation	80.42	2x data
8	32	128	rmsprop	Controlled 4	500	Shift	93.97	2x data, Epoch 00018: early stopping
9	64	128	rmsprop	Controlled 4	500	Flip	96.82	3x data, Epoch 00014: early stopping
10	64	128	sgd	Controlled 5	500	Mixed	77.42	4x data, Epoch 00015: early stopping

Table: Summary of all experiments

Details of Learning Rate Callback

Controlled 1

```
  if e<=10:
    new_lr = lr-0.00001
  else:
    new_lr = lr*0.8
```

Controlled 2

```
  if e<=10:
    new_lr=lr*1.1   # initially increase slowly
  else:
    new_lr=lr*0.75  # then decrease
```

Controlled 3

```
  if e<=5:
    new_lr=lr*1.1   # initially increase slowly
  elif e<=10:
    new_lr=lr*0.70
  else:
    new_lr=lr*0.90
```

Controlled 4

```
  if e<=7:
    new_lr = lr   #keep unchanged
  else:
    new_lr = lr*0.75 # decay
```

Controlled 5

```
  if e<=5:
    new_lr = lr   #keep unchanged
  elif e<=10:
    new_lr = lr*0.80
  else:
    new_lr = lr/e # decay
```