

CSCE 636 - DEEP LEARNING

Homework 2 Report

(Programming Part)

Implementation of Classes and Methods

Class Standard_Block -

- This block is used for implementing the Original structure of ResNet. Hence it is designed to support the same.
- The Standard block consists of 2 convolution layers both with an equal number of filters and a kernel size of 3x3.
- After the first conv layer, there is a batch normalization operation followed by ReLU. After the second conv layer, there is a batch normalization layer.
- There are 3 divisions in the ResNet model each consisting of n (resnet_size) standard blocks. After each division, the number of filters is doubled and a stride of 2 is used in the first conv layer of divisions 2 and 3.
- In the first 2 blocks of divisions 2 and 3, a 1x1 convolution is performed on input feature maps and then added to the output instead of adding input features directly, as the number of filters from the previous layer is doubled in the new block.

Class Bottleneck_Block -

- This block is used for implementing the Full-Preactivation structure in ResNet. Hence it is designed to support the same.
- The Bottleneck block consists of 3 convolution layers. The first and last conv layers use a kernel size of 1x1. The second layer uses a 3x3 kernel. The number of output feature maps of the first and second layers is the number of output feature maps of layer 3 divided by 4.
- In the Bottleneck block, before every conv layer batch normalization followed by ReLU is performed.
- The structure of divisions is similar to standard blocks.
- Since the number of input feature maps and output feature maps doesn't match in all 3 divisions, the 1x1 convolution on input feature maps is performed in all starting blocks before adding them to outputs.

Class Stack_Layer -

- This class consists of a list of blocks belonging to each division.
- If either the stride is 2 or the block used is bottleneck, set the projection shortcut for the starting block.

Class Output_Layer -

- This class consists of layers required after the convolution process.
- The first layer is the pooling layer, followed by the flattening layer.
- The last layer is a fully connected (i.e. Linear) layer, that maps the output of convolution to the number of classes in the classification problem.

Model Evaluation

Note - I have trained the model in hprc. In hprc the console outputs are redirected into a log file, where each batch while training and each sample while testing are logged separately. Hence it is difficult to attach console record in this report as the record is huge. So, I am attaching screenshots of training and testing as requested.

V1

Skeleton Code Parameters

Batch Size - 128
Resnet size - 18
Loss Function - CrossEntropy Loss
Optimizer - Stochastic Gradient Descent
Epochs - 200

Results

Training Loss - 0.012039 (After 200 epochs)
Validation Accuracy - 89.52%
Test Accuracy - 88.61%

Screenshot for Loss

```
Batch 342/351 Loss 0.002564
Batch 343/351 Loss 0.001289
Batch 344/351 Loss 0.000911
Batch 345/351 Loss 0.009846
Batch 346/351 Loss 0.005694
Batch 347/351 Loss 0.007750
Batch 348/351 Loss 0.004428
Batch 349/351 Loss 0.006855
Batch 350/351 Loss 0.012039
Epoch 200 Loss 0.012039 Duration 32.666 seconds.
Checkpoint has been created.
```

Screenshot for Validation Accuracy (5000 Samples)

```
99%|          | 4968/5000 [01:35<00:00, 52.28it/s]
99%|          | 4974/5000 [01:35<00:00, 52.22it/s]
100%|         | 4980/5000 [01:35<00:00, 52.18it/s]
100%|         | 4986/5000 [01:35<00:00, 52.14it/s]
100%|         | 4992/5000 [01:35<00:00, 52.13it/s]
100%|         | 4998/5000 [01:35<00:00, 52.13it/s]
100%|         | 5000/5000 [01:35<00:00, 52.10it/s]
/scratch/user/jawaharsainathani/TAMU_Courses/Spring_2
use sourceTensor.clone().detach() or sourceTensor.cl
y = torch.tensor(y)
Test accuracy: 0.8952
```

Screenshot for Test Accuracy (10000 Samples)

```
100%|          | 9970/10000 [03:40<00:00, 44.90it/s]
100%|          | 9975/10000 [03:40<00:00, 44.91it/s]
100%|          | 9980/10000 [03:40<00:00, 44.91it/s]
100%|          | 9985/10000 [03:41<00:00, 44.91it/s]
100%|          | 9990/10000 [03:41<00:00, 44.88it/s]
100%|          | 9995/10000 [03:41<00:00, 44.86it/s]
100%|          | 10000/10000 [03:41<00:00, 44.84it/s]
100%|          | 10000/10000 [03:41<00:00, 45.17it/s]
Test accuracy: 0.8861
```

V2

Skeleton Code Parameters

Batch Size - 128
Resnet size - 18
Loss Function - CrossEntropy Loss
Optimizer - Stochastic Gradient Descent
Epochs - 200

Results

Training Loss - 0.003701 (After 200 epochs)
Validation Accuracy - 93.87%
Test Accuracy - 93.12%

Screenshot for Loss

```
Batch 333/351 Loss 0.001857
Batch 334/351 Loss 0.007102
Batch 335/351 Loss 0.004232
Batch 336/351 Loss 0.008160
Batch 337/351 Loss 0.009314
Batch 338/351 Loss 0.002735
Batch 339/351 Loss 0.004121
Batch 340/351 Loss 0.003738
Batch 341/351 Loss 0.006924
Batch 342/351 Loss 0.000968
Batch 343/351 Loss 0.003890
Batch 344/351 Loss 0.001077
Batch 345/351 Loss 0.010549
Batch 346/351 Loss 0.003448
Batch 347/351 Loss 0.009354
Batch 348/351 Loss 0.001438
Batch 349/351 Loss 0.005554
Batch 350/351 Loss 0.003701
Epoch 200 Loss 0.003701 Duration 36.445 seconds.
Checkpoint has been created.
```

Screenshot for Validation Accuracy (5000 Samples)

```
99%|          | 4965/5000 [02:41<00:01, 32.53it/s]
99%|          | 4969/5000 [02:41<00:00, 32.44it/s]
99%|          | 4973/5000 [02:41<00:00, 32.38it/s]
100%|         | 4977/5000 [02:42<00:00, 32.34it/s]
100%|         | 4981/5000 [02:42<00:00, 32.31it/s]
100%|         | 4985/5000 [02:42<00:00, 32.28it/s]
100%|         | 4989/5000 [02:42<00:00, 32.28it/s]
100%|         | 4993/5000 [02:42<00:00, 32.26it/s]
100%|         | 4997/5000 [02:42<00:00, 32.25it/s]
100%|         | 5000/5000 [02:42<00:00, 30.72it/s]
Test accuracy: 0.9387
```

Screenshot for Test Accuracy (10000 Samples)

```
100%|          | 9968/10000 [05:06<00:00, 32.40it/s]
100%|          | 9972/10000 [05:06<00:00, 32.41it/s]
100%|          | 9976/10000 [05:06<00:00, 32.42it/s]
100%|          | 9980/10000 [05:06<00:00, 32.41it/s]
100%|          | 9984/10000 [05:07<00:00, 32.44it/s]
100%|          | 9988/10000 [05:07<00:00, 32.43it/s]
100%|          | 9992/10000 [05:07<00:00, 32.43it/s]
100%|          | 9996/10000 [05:07<00:00, 32.44it/s]
100%|          | 10000/10000 [05:07<00:00, 32.44it/s]
100%|          | 10000/10000 [05:07<00:00, 32.52it/s]
Test accuracy: 0.9312
```

Hyperparameter Tuning

Resnet Version - 2
Loss Function - CrossEntropy Loss
Optimizer - Stochastic Gradient Descent
Epochs - 60 (Learning Rate starting with 0.1, divided by 10 after every 20 epochs)

Setting 1

Batch Size - 64
Resnet size - 10
Training Loss - 0.119129
Validation Accuracy - 88.58%
Test Accuracy - 87.67%

```
Epoch 57 Loss 0.067968 Duration 35.331 seconds.  
Epoch 58 Loss 0.179611 Duration 35.393 seconds.  
Epoch 59 Loss 0.135397 Duration 35.362 seconds.  
Epoch 60 Loss 0.119129 Duration 35.361 seconds.  
Checkpoint has been created.  
### Test or Validation ###  
Restored model parameters from model_l10_b64/model-60.ckpt  
Test accuracy: 0.8858  
### Test or Validation ###  
Restored model parameters from model_l10_b64/model-60.ckpt  
Test accuracy: 0.8767
```

Setting 2

Batch Size - 64
Resnet size - 28
Training Loss - 0.047387
Validation Accuracy - 89.36%
Test Accuracy - 88.33%

```
Epoch 57 Loss 0.022737 Duration 78.235 seconds.  
Epoch 58 Loss 0.070528 Duration 78.298 seconds.  
Epoch 59 Loss 0.032589 Duration 78.234 seconds.  
Epoch 60 Loss 0.047387 Duration 79.634 seconds.  
Checkpoint has been created.  
### Test or Validation ###  
Restored model parameters from model_l28_b64/model-60.ckpt  
Test accuracy: 0.8936  
### Test or Validation ###  
Restored model parameters from model_l28_b64/model-60.ckpt  
Test accuracy: 0.8833
```

Setting 3

Batch Size - 128
Resnet size - 28
Training Loss - 0.094752
Validation Accuracy - 86.12%
Test Accuracy - 85.85%

```
Epoch 59 Loss 0.064718 Duration 61.635 seconds.  
Epoch 60 Loss 0.094752 Duration 61.639 seconds.  
Checkpoint has been created.  
### Test or Validation ###  
Restored model parameters from model_l28_b128/model-60.ckpt  
Test accuracy: 0.8612  
### Test or Validation ###  
Restored model parameters from model_l28_b128/model-60.ckpt  
Test accuracy: 0.8585
```