CMPT 412
Project 2
Image classification and PyTorch Introduction
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**Part 1: Improving BaseNet on CIFAR100**

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I developed 13 Conv layers, each of it followed with a BatchNorm and Relu. Since the instruction asked us not to having pooling in each layer, pooling is used in layers 2, 4, 7, 10, and 13. The architecture is as follow:

**Model Architecture:**

| Layer | Layer type | Kernel size | Input \| Output | Input \| Output Channel | Padding | Stride | Size |
|---|---|---|---|---|---|---|---|
| 1 | Conv2d | 3 | 32 \| 32 | 3 \| 64 | 1 | 1 | |
| | BatchNorm2d | | | 64 | | | |
| | Relu | | | | | | |
| 2 | Conv2d | 3 | 32 \| 16 | 64 \| 64 | 1 | | |
| | BatchNorm2d | | | 64 | | | |
| | Relu | | | | | | |
| | MaxPool | 2 | | | | 2 | |
| 3 | Conv2d | 3 | 16 \| 16 | 64 \| 128 | 1 | 1 | |
| | BatchNorm2d | | | 128 | | | |
| | Relu | | | | | | |
| 4 | Conv2d | 3 | 16 \| 8 | 128 \| 128 | 1 | 1 | |
| | BatchNorm2d | | | 128 | | | |
| | Relu | | | | | | |
| | MaxPool | 2 | | | | 2 | |
| 5 | Conv2d | 3 | 8 \| 8 | 128 \| 256 | 1 | 1 | |
| | BatchNorm2d | | | 256 | | | |
| | Relu | | | | | | |
| 6 | Conv2d | 3 | 8 \| 8 | 256 \| 256 | 1 | 1 | |
| | BatchNorm2d | | | 256 | | | |
| | Relu | | | | | | |
| 7 | Conv2d | 3 | 8 \| 4 | 256 \| 256 | 1 | 1 | |
| | BatchNorm2d | | | 256 | | | |
| | Relu | | | | | | |
| | MaxPool | 2 | | | | 2 | |
| 8 | Conv2d | 3 | 4 \| 4 | 256 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | Conv2d | 3 | 4 \| 4 | 512 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |
| 10 | Conv2d | 3 | 4 \| 2 | 512 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |
| | MaxPool | 2 | | | | 2 | |
| 11 | Conv2d | 3 | 2 \| 2 | 512 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |
| 12 | Conv2d | 3 | 2 \| 2 | 512 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |
| 13 | Conv2d | 3 | 2 \| 1 | 512 \| 512 | 1 | 1 | |
| | BatchNorm2d | | | 512 | | | |
| | Relu | | | | | | |
| | MaxPool | 2 | | | | 2 | |
| 14 | Dropout | | | | | | 0.5 |
| 15 | Linear | | 512 \| 256 | | | | |
| 16 | Relu | | | | | | |
| 17 | Dropout | | | | | | 0.5 |
| 18 | Linear | | 256 \| 256 | | | | |
| 19 | Relu | | | | | | |
| 20 | Linear | | 256 \| 100 | | | | |

**Model Improvement:**

To improve the model following steps were taken:

1. Calculating the dataset mean and standard deviation and applying into normalization
2. Making the Model deeper by the addition of more Convolution, MaxPooling and Batch Normalization layers
3. Increasing Epoch from 15 to 50
4. Increasing Learning rate from 0.005 to 0.01
5. Removing Momentum

**Model Evaluation:**

The model obtained a validation accuracy of almost 57%. For plot.png please see attachment in the last page.

**Part 2: Transfer Learning**

Modifications:
Load pre-traien ResNet Model
Replace fc layer in ResNet to linear layer
Epochs: 20
Batch_size: 8
Learning Rate: 0.005 (Epoch 1 to 5)
0.003 (Epoch 6,7)
0.001 (Epoch 8 to 11)
0.0002 (Epoch 12 to 20)

Last layer:

```
TRAINING Epoch 1/20 Loss 0.6476 Accuracy 0.0453
TRAINING Epoch 2/20 Loss 0.4654 Accuracy 0.1943
TRAINING Epoch 3/20 Loss 0.3753 Accuracy 0.3080
TRAINING Epoch 4/20 Loss 0.3347 Accuracy 0.3603
TRAINING Epoch 5/20 Loss 0.2968 Accuracy 0.4327
TRAINING Epoch 6/20 Loss 0.2735 Accuracy 0.4727
TRAINING Epoch 7/20 Loss 0.2263 Accuracy 0.5700
TRAINING Epoch 8/20 Loss 0.2225 Accuracy 0.5823
TRAINING Epoch 9/20 Loss 0.1959 Accuracy 0.6437
TRAINING Epoch 10/20 Loss 0.1847 Accuracy 0.6620
TRAINING Epoch 11/20 Loss 0.1880 Accuracy 0.6473
TRAINING Epoch 12/20 Loss 0.1880 Accuracy 0.6607
TRAINING Epoch 13/20 Loss 0.1781 Accuracy 0.6757
TRAINING Epoch 14/20 Loss 0.1754 Accuracy 0.6913
TRAINING Epoch 15/20 Loss 0.1806 Accuracy 0.6777
TRAINING Epoch 16/20 Loss 0.1732 Accuracy 0.6980
TRAINING Epoch 17/20 Loss 0.1776 Accuracy 0.6793
TRAINING Epoch 18/20 Loss 0.1752 Accuracy 0.7007
TRAINING Epoch 19/20 Loss 0.1745 Accuracy 0.6953
TRAINING Epoch 20/20 Loss 0.1705 Accuracy 0.6977
Finished Training
```

```
Test Loss: 0.2631 Test Accuracy 0.4721
```

Entire network:

```
TRAINING Epoch 1/20 Loss 0.6521 Accuracy 0.0327
TRAINING Epoch 2/20 Loss 0.5217 Accuracy 0.1120
TRAINING Epoch 3/20 Loss 0.4569 Accuracy 0.1813
TRAINING Epoch 4/20 Loss 0.4130 Accuracy 0.2277
TRAINING Epoch 5/20 Loss 0.3862 Accuracy 0.2627
TRAINING Epoch 6/20 Loss 0.3508 Accuracy 0.3287
TRAINING Epoch 7/20 Loss 0.2741 Accuracy 0.4510
TRAINING Epoch 8/20 Loss 0.2354 Accuracy 0.5210
TRAINING Epoch 9/20 Loss 0.1891 Accuracy 0.6337
TRAINING Epoch 10/20 Loss 0.1677 Accuracy 0.6750
TRAINING Epoch 11/20 Loss 0.1575 Accuracy 0.7023
TRAINING Epoch 12/20 Loss 0.1564 Accuracy 0.7027
TRAINING Epoch 13/20 Loss 0.1324 Accuracy 0.7513
TRAINING Epoch 14/20 Loss 0.1343 Accuracy 0.7560
TRAINING Epoch 15/20 Loss 0.1266 Accuracy 0.7717
TRAINING Epoch 16/20 Loss 0.1288 Accuracy 0.7630
TRAINING Epoch 17/20 Loss 0.1294 Accuracy 0.7743
TRAINING Epoch 18/20 Loss 0.1192 Accuracy 0.7900
TRAINING Epoch 19/20 Loss 0.1270 Accuracy 0.7687
TRAINING Epoch 20/20 Loss 0.1240 Accuracy 0.7757
Finished Training
```

```
Test Loss: 0.2191 Test Accuracy 0.5648
```

**Attachment:**
Part 1 enlarged plot.png