

Riya Roopesh
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CMPT 412

Project 2

1 Late Day used

Submitted on: 11th October 2023.

Kaggle submission ID: Riya Roopesh

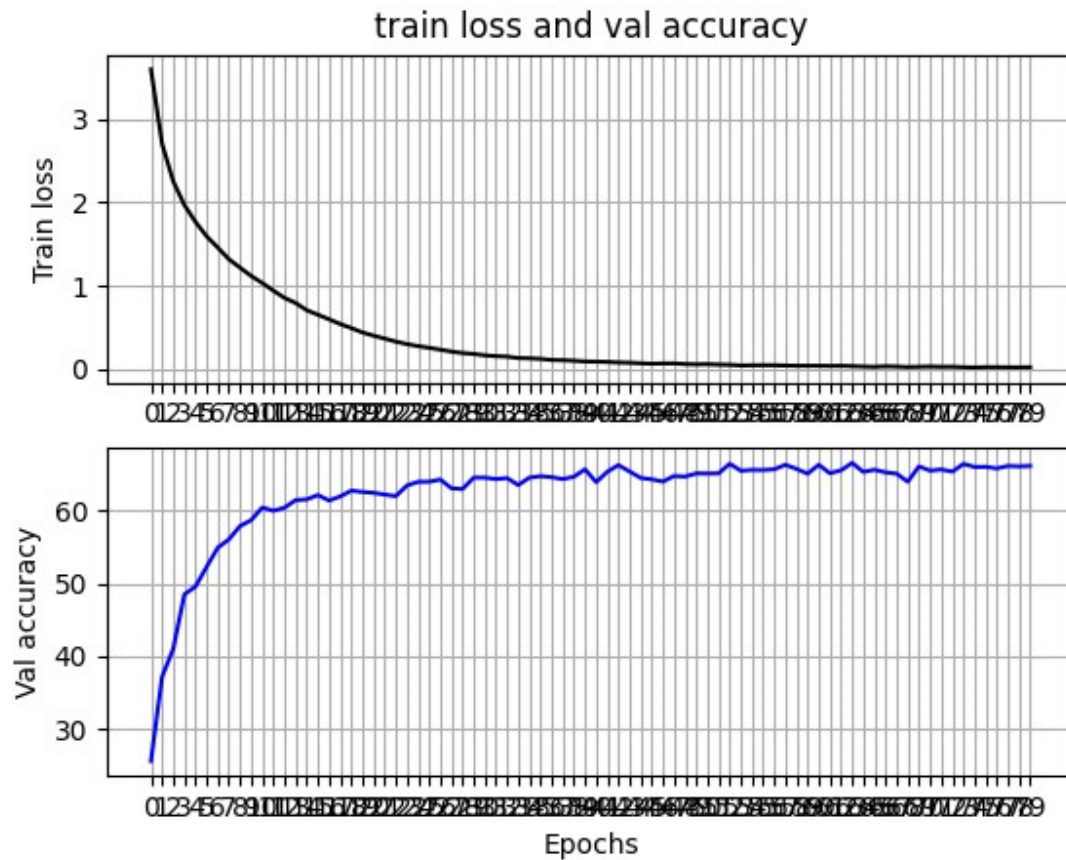
Part 1:

Table

Layer No.	Layer Type	Kernel size (for conv layers)	Input Output dimension	Input Output Channels (for conv layers)
1	Conv2d	3	32 32	3 128
2	BatchNorm2d	-	32 32	-
3	Relu	-	32 32	-
4	Conv2d	3	32 32	128 128
5	BatchNorm2d	-	32 32	-
6	Relu	-	32 32	-
7	MaxPool2d	2	32 16	-
8	Conv2d	3	16 16	128 256
9	BatchNorm2d	-	16 16	-
10	Relu	-	16 16	-
11	Conv2d	3	16 16	256 256
12	BatchNorm2d	-	16 16	-
13	Relu	-	16 16	-
14	MaxPool2d	2	16 8	-
15	Conv2d	3	8 8	256 512
16	BatchNorm2d	-	8 8	-
17	Relu	-	8 8	-
18	Conv2d	3	8 8	512 512
19	BatchNorm2d	-	8 8	-
20	Relu	-	8 8	-
21	MaxPool2d	2	8 4	-
22	Conv2d	3	4 4	512 512
23	BatchNorm2d	-	4 4	-
24	Relu	-	4 4	-
25	Conv2d	3	4 4	512 1024
26	BatchNorm2d	-	4 4	-
27	Relu	-	4 4	-
28	Linear	-	16384 2048	-
29	Relu	-	2048 2048	-
30	Linear	-	2048 2048	-
31	Linear	-	2048 100	-

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Plot:



Output:

```
[1] loss: 3.598
Accuracy of the network on the val images: 25 %
[2] loss: 2.704
Accuracy of the network on the val images: 37 %
[3] loss: 2.256
Accuracy of the network on the val images: 41 %
[4] loss: 1.972
Accuracy of the network on the val images: 48 %
[5] loss: 1.769
Accuracy of the network on the val images: 49 %
[6] loss: 1.596
Accuracy of the network on the val images: 52 %
[7] loss: 1.461
Accuracy of the network on the val images: 54 %
[8] loss: 1.321
Accuracy of the network on the val images: 56 %
[9] loss: 1.220
Accuracy of the network on the val images: 57 %
[10] loss: 1.120
Accuracy of the network on the val images: 58 %
[11] loss: 1.036
Accuracy of the network on the val images: 60 %
[12] loss: 0.944
Accuracy of the network on the val images: 59 %
```

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```
[13] loss: 0.857
Accuracy of the network on the val images: 60 %
[14] loss: 0.796
Accuracy of the network on the val images: 61 %
[15] loss: 0.709
Accuracy of the network on the val images: 61 %
[16] loss: 0.655
Accuracy of the network on the val images: 62 %
[17] loss: 0.601
Accuracy of the network on the val images: 61 %
[18] loss: 0.544
Accuracy of the network on the val images: 61 %
[19] loss: 0.495
Accuracy of the network on the val images: 62 %
[20] loss: 0.443
Accuracy of the network on the val images: 62 %
[21] loss: 0.404
Accuracy of the network on the val images: 62 %
[22] loss: 0.369
Accuracy of the network on the val images: 62 %
[23] loss: 0.333
Accuracy of the network on the val images: 61 %
[24] loss: 0.303
Accuracy of the network on the val images: 63 %
[25] loss: 0.279
Accuracy of the network on the val images: 63 %
[26] loss: 0.258
Accuracy of the network on the val images: 63 %
[27] loss: 0.236
Accuracy of the network on the val images: 64 %
[28] loss: 0.213
Accuracy of the network on the val images: 63 %
[29] loss: 0.196
Accuracy of the network on the val images: 62 %
[30] loss: 0.185
Accuracy of the network on the val images: 64 %
[31] loss: 0.168
Accuracy of the network on the val images: 64 %
[32] loss: 0.158
Accuracy of the network on the val images: 64 %
[33] loss: 0.153
Accuracy of the network on the val images: 64 %
[34] loss: 0.136
Accuracy of the network on the val images: 63 %
[35] loss: 0.133
Accuracy of the network on the val images: 64 %
[36] loss: 0.126
Accuracy of the network on the val images: 64 %
[37] loss: 0.113
Accuracy of the network on the val images: 64 %
[38] loss: 0.110
Accuracy of the network on the val images: 64 %
[39] loss: 0.104
Accuracy of the network on the val images: 64 %
[40] loss: 0.095
Accuracy of the network on the val images: 65 %
[41] loss: 0.092
Accuracy of the network on the val images: 63 %
[42] loss: 0.089
Accuracy of the network on the val images: 65 %
[43] loss: 0.083
Accuracy of the network on the val images: 66 %
[44] loss: 0.079
Accuracy of the network on the val images: 65 %
[45] loss: 0.073
Accuracy of the network on the val images: 64 %
[46] loss: 0.068
Accuracy of the network on the val images: 64 %
[47] loss: 0.071
Accuracy of the network on the val images: 63 %
[48] loss: 0.071
```

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```
Accuracy of the network on the val images: 64 %  
[49] loss: 0.064  
Accuracy of the network on the val images: 64 %  
[50] loss: 0.060  
Accuracy of the network on the val images: 65 %  
[51] loss: 0.063  
Accuracy of the network on the val images: 65 %  
[52] loss: 0.057  
Accuracy of the network on the val images: 65 %  
[53] loss: 0.055  
Accuracy of the network on the val images: 66 %  
[54] loss: 0.047  
Accuracy of the network on the val images: 65 %  
[55] loss: 0.049  
Accuracy of the network on the val images: 65 %  
[56] loss: 0.050  
Accuracy of the network on the val images: 65 %  
[57] loss: 0.049  
Accuracy of the network on the val images: 65 %  
[58] loss: 0.046  
Accuracy of the network on the val images: 66 %  
[59] loss: 0.043  
Accuracy of the network on the val images: 65 %  
[60] loss: 0.043  
Accuracy of the network on the val images: 65 %  
[61] loss: 0.043  
Accuracy of the network on the val images: 66 %  
[62] loss: 0.041  
Accuracy of the network on the val images: 65 %  
[63] loss: 0.043  
Accuracy of the network on the val images: 65 %  
[64] loss: 0.038  
Accuracy of the network on the val images: 66 %  
[65] loss: 0.034  
Accuracy of the network on the val images: 65 %  
[66] loss: 0.030  
Accuracy of the network on the val images: 65 %  
[67] loss: 0.037  
Accuracy of the network on the val images: 65 %  
[68] loss: 0.033  
Accuracy of the network on the val images: 65 %  
[69] loss: 0.027  
Accuracy of the network on the val images: 63 %  
[70] loss: 0.031  
Accuracy of the network on the val images: 66 %  
[71] loss: 0.034  
Accuracy of the network on the val images: 65 %  
[72] loss: 0.030  
Accuracy of the network on the val images: 65 %  
[73] loss: 0.031  
Accuracy of the network on the val images: 65 %  
[74] loss: 0.026  
Accuracy of the network on the val images: 66 %  
[75] loss: 0.023  
Accuracy of the network on the val images: 65 %  
[76] loss: 0.026  
Accuracy of the network on the val images: 65 %  
[77] loss: 0.026  
Accuracy of the network on the val images: 65 %  
[78] loss: 0.025  
Accuracy of the network on the val images: 66 %  
[79] loss: 0.024  
Accuracy of the network on the val images: 66 %  
[80] loss: 0.026  
Accuracy of the network on the val images: 66 %  
Finished Training
```

Best accuracy = 66%

Best Kaggle Accuracy:68.6%

Ablation Study:

Upon following some of the basic steps mentioned in the project description I was able to improve the model. These steps include data normalization, data augmentation, adding more convolution and fully connected layers, adding appropriate number of Normalization layers and tweaking the values such as the learning rate and total number of EPOCHS. By following these steps I was able to improve the accuracy of the model from approximately 25% to 66%.

1) Having done the following:

- i) Adding data normalization and data augmentation steps such as.

```
train_transform = transforms.Compose(  
    [  
        transforms.RandomHorizontalFlip(0.5),  
        transforms.RandomCrop(32),  
        transforms.ToTensor(),  
        transforms.Normalize((0.49139968, 0.48215827, 0.44653124), (0.24703233,  
0.24348505, 0.26158768)))  
test_transform = transforms.Compose(  
    [  
        transforms.ToTensor(),  
        transforms.Normalize((0.49139968, 0.48215827, 0.44653124), (0.24703233,  
0.24348505, 0.26158768)))
```

I chose these values for the mean and the standard deviation, since upon doing some research these were the values that were ideal for the CIFAR-10 dataset.

- ii) Adding more convolution layers as well normalization layers respectively, fully connected layers(linear layers) and MaxPooling layers.

I was able to reach an accuracy of 49%.

- 2) Further upon tweaking the values of the input and output channels and adding a few more convolution layers, reducing the number of linear layers and ensuring that pooling is only carried out after every two convolution layers. And lastly on increasing the number of EPOCH's to 50, I was able to improve my model and reach an accuracy of 64%.

3) Lastly, I did the following:

- i) Increased the input and output channel as shown in the table above.
- ii) Tweaked the data augmentation slightly by changing `transforms.RandomCrop(32)` to `transforms.RandomCrop(28)` and resized the images back to 32x32.
- iii) Tweaked the learning rate to 0.0015.
- iv) Removing the last Maxpool() step and the normalization steps within the fully connected layers..
- v) Increased my number of EPOCH's to 80

As a result of the above I was able to achieve my best accuracy which was 66%

PART 2:

For part two I used the same data normalization values as I did in part one and replaced transforms.CenterCrop(224) with transforms.RandomResizedCrop(224).

Hyperparameter values:

EPOCH = 50

Learning rate = 0.0015

Batch size = 64

RESNET_LAST_ONLY = False

Training Accuracy:

TRAINING	Epoch	1/50	Loss	0.0844	Accuracy	0.0070
TRAINING	Epoch	2/50	Loss	0.0785	Accuracy	0.0403
TRAINING	Epoch	3/50	Loss	0.0729	Accuracy	0.1217
TRAINING	Epoch	4/50	Loss	0.0670	Accuracy	0.2150
TRAINING	Epoch	5/50	Loss	0.0615	Accuracy	0.2907
TRAINING	Epoch	6/50	Loss	0.0568	Accuracy	0.3577
TRAINING	Epoch	7/50	Loss	0.0523	Accuracy	0.4300
TRAINING	Epoch	8/50	Loss	0.0490	Accuracy	0.4677
TRAINING	Epoch	9/50	Loss	0.0455	Accuracy	0.5177
TRAINING	Epoch	10/50	Loss	0.0425	Accuracy	0.5603
TRAINING	Epoch	11/50	Loss	0.0402	Accuracy	0.5800
TRAINING	Epoch	12/50	Loss	0.0376	Accuracy	0.6253
TRAINING	Epoch	13/50	Loss	0.0353	Accuracy	0.6437
TRAINING	Epoch	14/50	Loss	0.0333	Accuracy	0.6657
TRAINING	Epoch	15/50	Loss	0.0315	Accuracy	0.6900
TRAINING	Epoch	16/50	Loss	0.0299	Accuracy	0.6967
TRAINING	Epoch	17/50	Loss	0.0287	Accuracy	0.7160
TRAINING	Epoch	18/50	Loss	0.0272	Accuracy	0.7287
TRAINING	Epoch	19/50	Loss	0.0254	Accuracy	0.7563
TRAINING	Epoch	20/50	Loss	0.0246	Accuracy	0.7477
TRAINING	Epoch	21/50	Loss	0.0233	Accuracy	0.7690
TRAINING	Epoch	22/50	Loss	0.0220	Accuracy	0.7903
TRAINING	Epoch	23/50	Loss	0.0216	Accuracy	0.7963
TRAINING	Epoch	24/50	Loss	0.0206	Accuracy	0.8020

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```
TRAINING Epoch 25/50 Loss 0.0197 Accuracy 0.8077
TRAINING Epoch 26/50 Loss 0.0189 Accuracy 0.8163
TRAINING Epoch 27/50 Loss 0.0180 Accuracy 0.8263
TRAINING Epoch 28/50 Loss 0.0174 Accuracy 0.8377
TRAINING Epoch 29/50 Loss 0.0170 Accuracy 0.8313
TRAINING Epoch 30/50 Loss 0.0167 Accuracy 0.8357
TRAINING Epoch 31/50 Loss 0.0158 Accuracy 0.8497
TRAINING Epoch 32/50 Loss 0.0153 Accuracy 0.8487
TRAINING Epoch 33/50 Loss 0.0148 Accuracy 0.8550
TRAINING Epoch 34/50 Loss 0.0142 Accuracy 0.8637
TRAINING Epoch 35/50 Loss 0.0138 Accuracy 0.8610
TRAINING Epoch 36/50 Loss 0.0135 Accuracy 0.8660
TRAINING Epoch 37/50 Loss 0.0132 Accuracy 0.8670
TRAINING Epoch 38/50 Loss 0.0128 Accuracy 0.8743
TRAINING Epoch 39/50 Loss 0.0124 Accuracy 0.8787
TRAINING Epoch 40/50 Loss 0.0118 Accuracy 0.8810
TRAINING Epoch 41/50 Loss 0.0112 Accuracy 0.8920
TRAINING Epoch 42/50 Loss 0.0113 Accuracy 0.8837
TRAINING Epoch 43/50 Loss 0.0111 Accuracy 0.8900
TRAINING Epoch 44/50 Loss 0.0105 Accuracy 0.8990
TRAINING Epoch 45/50 Loss 0.0106 Accuracy 0.8937
TRAINING Epoch 46/50 Loss 0.0104 Accuracy 0.8967
TRAINING Epoch 47/50 Loss 0.0098 Accuracy 0.9037
TRAINING Epoch 48/50 Loss 0.0099 Accuracy 0.8977

TRAINING Epoch 49/50 Loss 0.0099 Accuracy 0.8927
TRAINING Epoch 50/50 Loss 0.0095 Accuracy 0.9007
Finished Training
-----
```

Training accuracy: 90.07%

Test Accuracy:



```
test(model, criterion)
```

```
Test Loss: 0.0280 Test Accuracy 0.5631
```

Test Accuracy: 56.31%

class: 091.Mockingbird predicted: 100.Brown_Pelican



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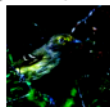
class: 114.Black_throated_Sparrow predicted: 114.Black_throated_Sparrow



class: 166.Golden_winged_Warbler predicted: 166.Golden_winged_Warbler



class: 156.White_eyed_Vireo predicted: 175.Pine_Warbler



class: 162.Canada_Warbler predicted: 162.Canada_Warbler



class: 199.Winter_Wren predicted: 199.Winter_Wren



class: 120.Fox_Sparrow predicted: 120.Fox_Sparrow



class: 160.Black_throated_Blue_Warbler predicted: 080.Green_Kingfisher

