

## Convolutional Neural Network

Submitted By:

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Question 1:

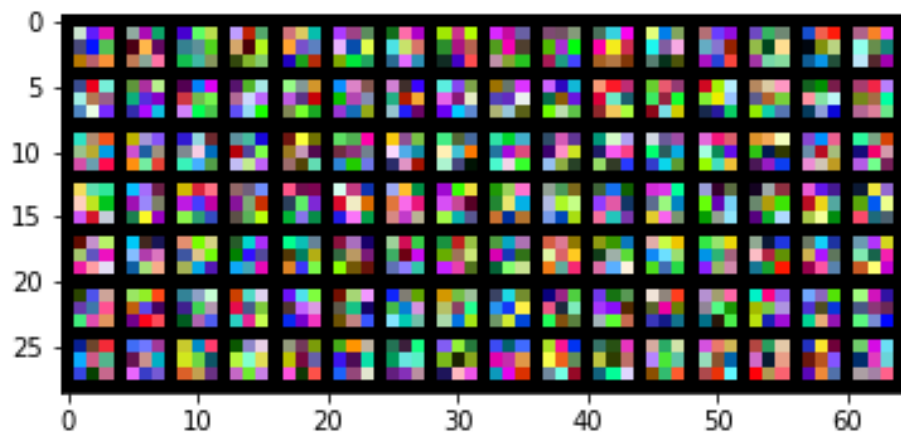
a.) After training the given convolution network we get the following result:

- Epoch [20/20], Step [200/245], Loss: 0.2432
- Validation accuracy is: 78.5 %
- Accuracy of the network on the 1000 test images: 78.2 %
- Training Accuracy is: 80%

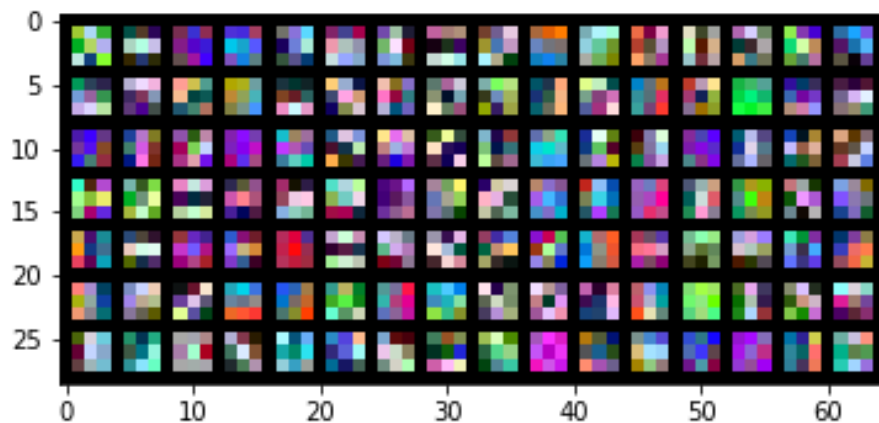
b.) Total Trainable parameters: 10038282

c.)

**Before Training**



**After Training**



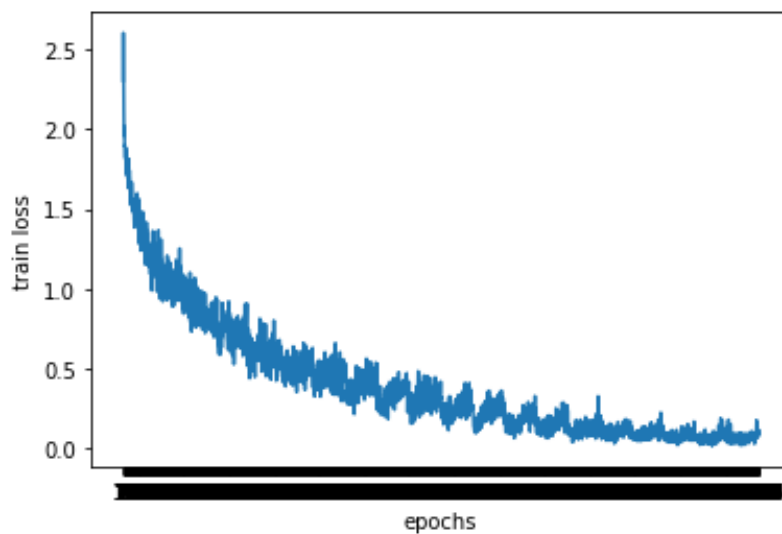
As we can observe that before the training the pattern in filter is random but after training we can see some horizontal and vertical lines which is nothing but the edges of the images.

Question 2:

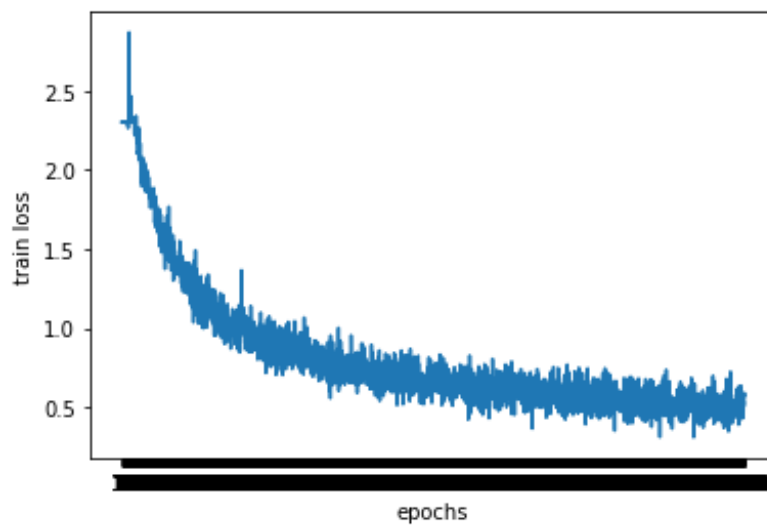
a) After Applying Batch Normalization, we get the following results:

- Epoch [20/20], Step [200/245], Loss: 0.0683
- Training accuracy is: 98.0 %
- Validation accuracy is: 82.3 %
- Accuracy of the network on the 1000 test images: 80.0 %

**With Batch Normalization**



**Without Batch Normalization**



Batch Normalization has significantly increased the speed of Convergence. From the results above, we can observe that batch normalization has also slightly improved the model's performance by more than 10% when compared with the model without batch normalization.

b.) After training the model for 50 epochs, we get the following result:

#### **Latest Model with Batch Normalization**

- Epoch [50/50], Step [200/245], Loss: 0.0231
- Training accuracy is: 100.0 %
- Validation accuracy is: 82.8 %

#### **Best Model with Batch Normalization at 30<sup>th</sup> epoch**

- Epoch [30/50], Step [200/245], Loss: 0.0183
- Training accuracy is: 100.0 %
- Validation accuracy is: 83.9 %

Accuracy of the network on the 1000 test images: 82.5 %

#### **Latest Model without Batch Normalization**

- Epoch [50/50], Step [200/245], Loss: 0.0117
- Training accuracy is: 100.0 %
- Validation accuracy is: 78.4 %

#### **Best Model without Batch Normalization at 13<sup>th</sup> epoch**

- Epoch [13/50], Step [200/245], Loss: 0.3369
- Training accuracy is: 91.5 %
- Validation accuracy is: 82.6 %

Accuracy of the network on the 1000 test images: 79.1 %

The results show that as the model with batch normalization is trained for more epochs, it becomes overfit. We can confirm that the model has overfitted with respect to the training data because the training accuracy has reached 100 % but the validation accuracy is only 82.8 %. Similar trends can also be seen with the model without batch normalization.

### Question 3:

a.) After applying ColorJitter(brightness=0.5), RandomHorizontalFlip(p=0.5), RandomVerticalFlip(p=0.05) and RandomGrayscale(p=0.2) transformations the best Augmentation is achieved, and the results are as follows. The following results are without Batch Normalization.

- Epoch [25/25], Step [200/245], Loss: 0.4968
- Training accuracy is: 81.0 %
- Validation accuracy is: 79.8 %

b.) Using the Dropout layer between the convolution blocks, the results are as follows:

#### **Dropout - 0.1**

- Epoch [20/20], Step [200/245], Loss: 0.2473
- Training accuracy is: 98.5 %
- Validation accuracy is: 84.2 %

#### **Dropout - 0.2**

- Epoch [20/20], Step [200/245], Loss: 0.5774
- Training accuracy is: 93.0 %
- Validation accuracy is: 82.4 %

#### **Dropout - 0.3**

- Epoch [20/20], Step [200/245], Loss: 0.6987
- Training accuracy is: 86.5 %
- Validation accuracy is: 80.7 %

#### **Dropout - 0.4**

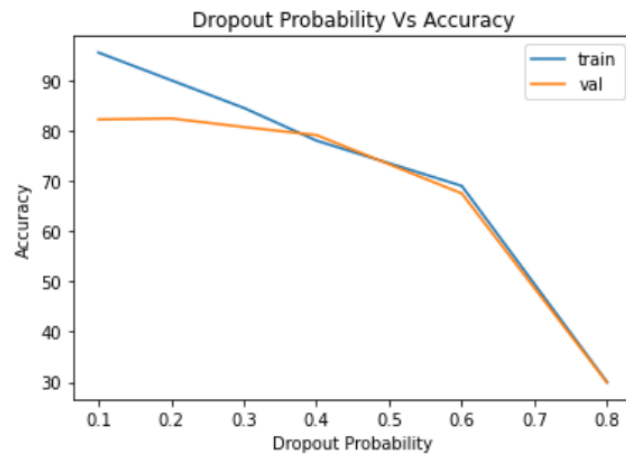
- Epoch [20/20], Step [200/245], Loss: 0.7937
- Training accuracy is: 78.0 %
- Validation accuracy is: 80.1 %

#### **Dropout - 0.6**

- Epoch [20/20], Step [200/245], Loss: 1.1383
- Training accuracy is: 64.0 %
- Validation accuracy is: 61.5 %

#### **Dropout - 0.8**

- Epoch [20/20], Step [200/245], Loss: 1.5149
- Training accuracy is: 28.7 %
- Validation accuracy is: 26.9 %

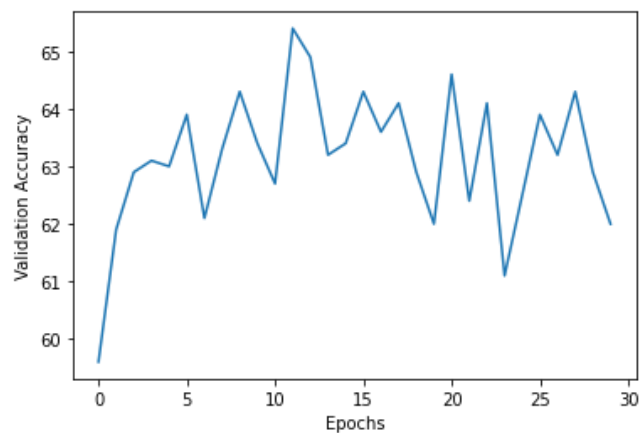


High Values of  $p$  regularized the model heavily and decreased the model capacity. At  $p = 0.2$  we got the best Validation Accuracy.

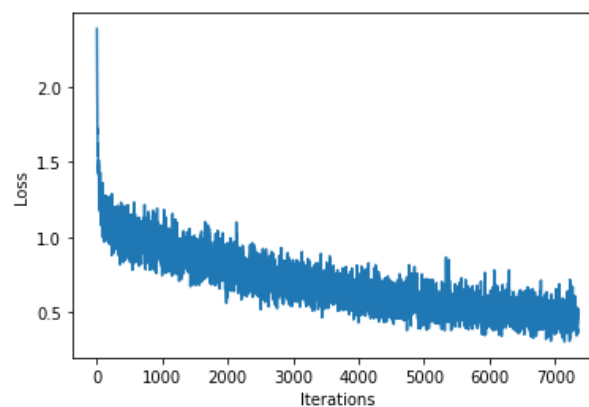
Question 4:

a.) Best Model Detected at 65.4% validation accuracy.

- Validation accuracy of model with grads of only new layers is: 65.4 %
- Accuracy of the network on the 1000 test images: 64.4 %



Graph showing the validation accuracies and best model on training only the newly added layers at 65.4



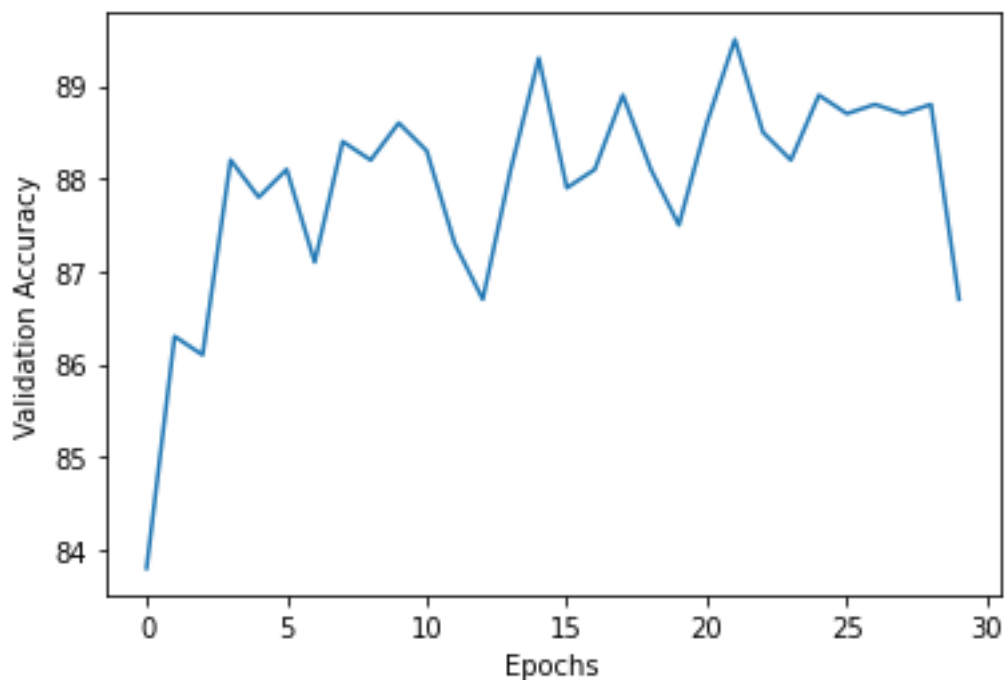
b.)

Now fine tune the complete network with pretrained weights: - finetune = False  
pretrained=True.

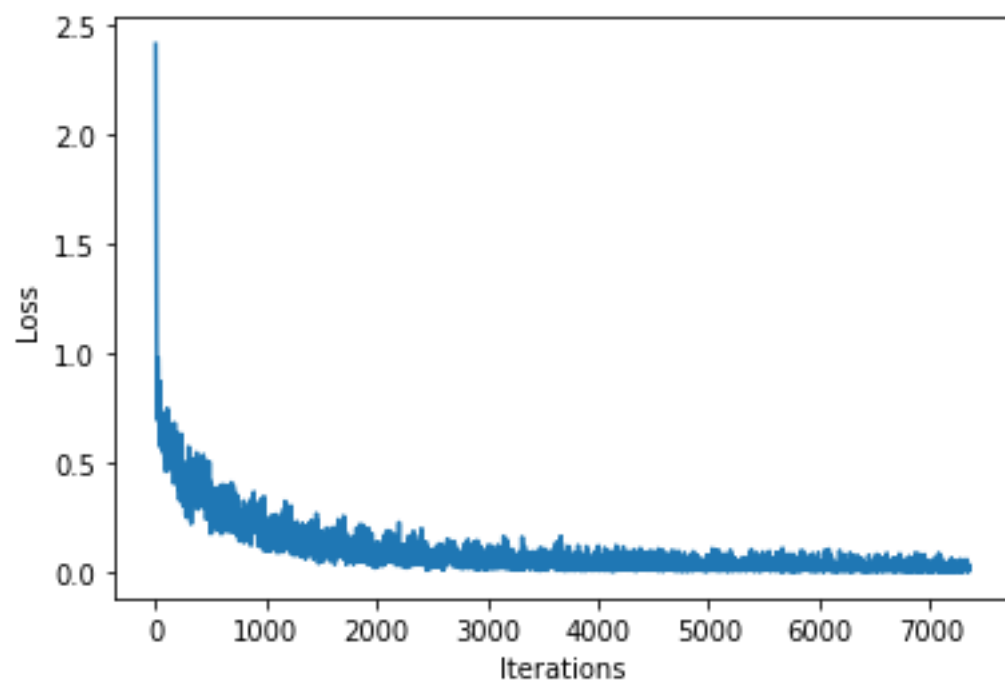
After fine tuning, i.e., setting gradients for all the parameters and not just learning those of the layers we added and modified for feature extraction and transfer learning,

**The validation accuracy of the best model is 89.5 %.**

**Accuracy of the network on the 1000 test images: 88.7 %**



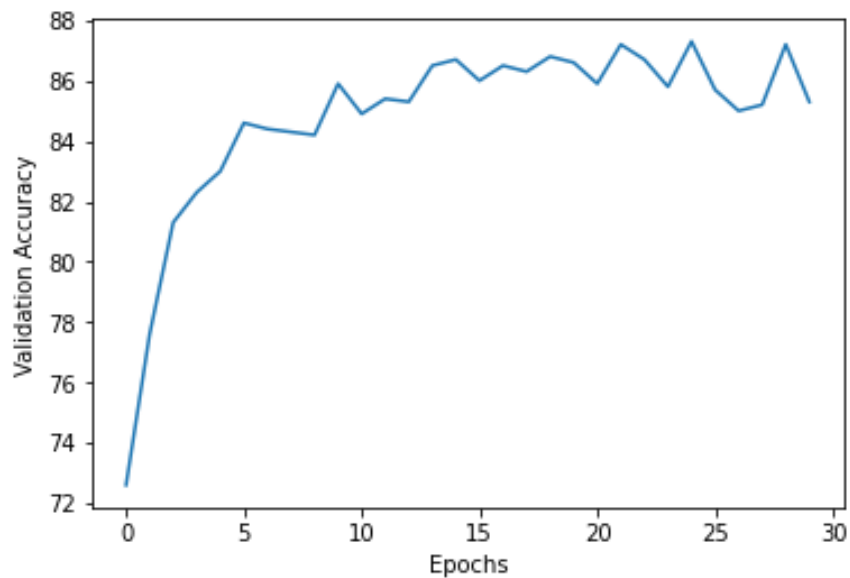
**Showing the validation accuracies and best model on training all layers (update all the model parameters) with pre-train at 89.5 %.**



Now Fine tune the complete network without pretrained weights (from scratch):-  
fine\_tune = False pretrained=False

**Validation accuracy of best\_model\_Scratch (with fine tuning and without pre trained) is: 87.3 %**

**in the testing phase of the best\_model\_Scratch (with fine tuning and without pre trained), Accuracy of the network on the 1000 test images: 86.5 %**



**Showing the validation accuracies and best model on training all layers without pre-train(scratch) at 89.5%.**

