

## Project 0: Convolutional Neural Networks

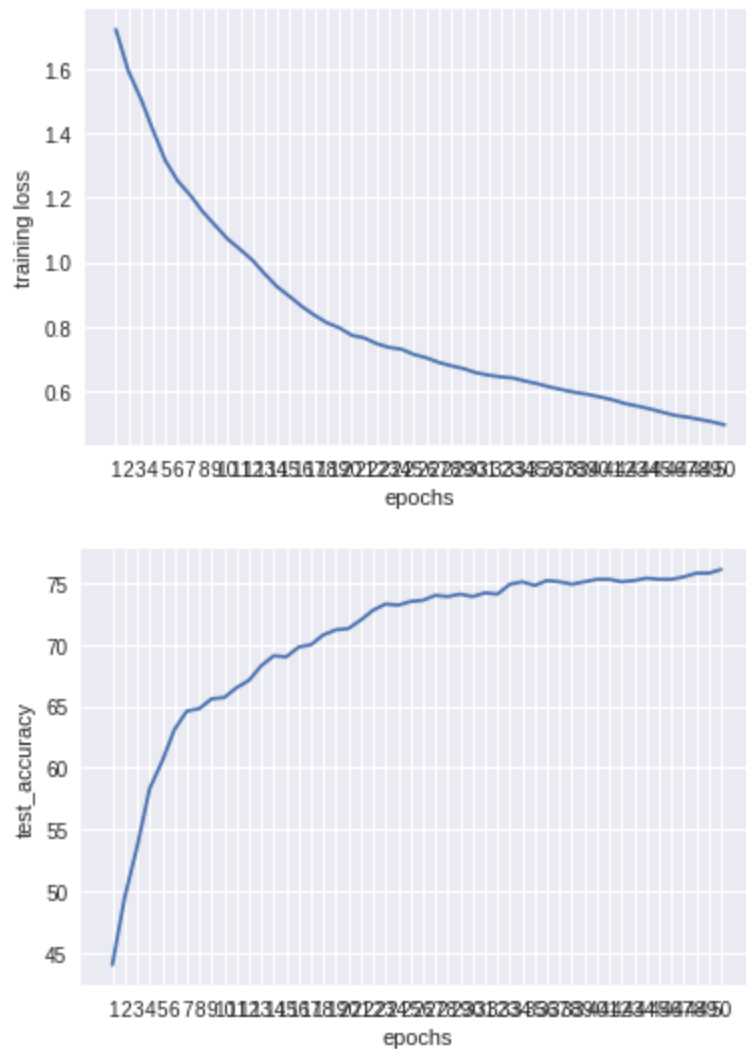
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### 1. Optimization of LeNet

After trying different values of learning\_rate and epochs (accuracy for these parameters and comparison are in Appendix.a), the best parameter I found is as below:

**learning\_rate = 0.005, epochs = 50**

Training loss and test accuracy over epochs are shown as below.



### 2. Alteration of LeNet

In this part, I kept the best parameters (learning\_rate=0.005, epoch=50) that I found in the previous question, and then learn the ConvNet only with

- Block1: the filter size of Block5 need to be change to 16x16.
- Block1 and Block2: the filter size of Block5 need to be change to 8x8.

iii. Block1, Block2 and Block3: the filter size of Block5 need to be change to 4x4.

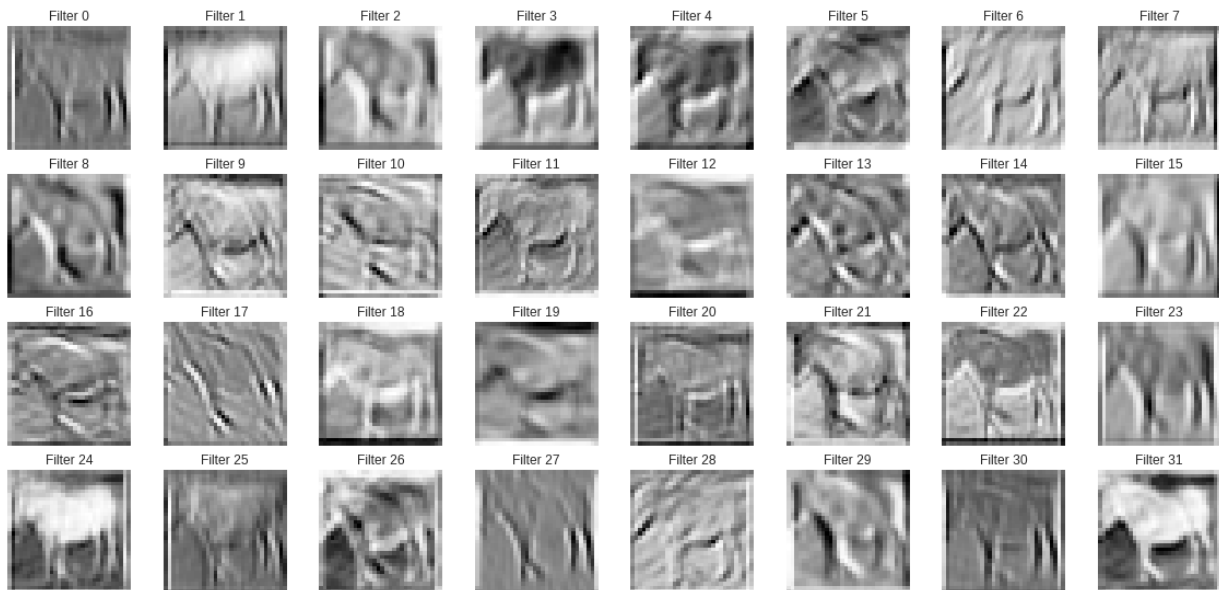
The final test accuracies for (i., ii., iii.) are shown as below. The figure of overall test accuracy over epochs are shown in Appendix.b.

Blocks	Final test accuracy
i. Block1	65.50%
ii. Block1 and Block2	74.10%
iii. Block1, Block2 and Block3	75.70%

From the above data we can see that as the number of block increases, the final test accuracy gets higher, which means deeper network has better performance.

### 3. Visualization of filters and activations

(a) the learned 32 filters of the first convolutional layer in LeNet.

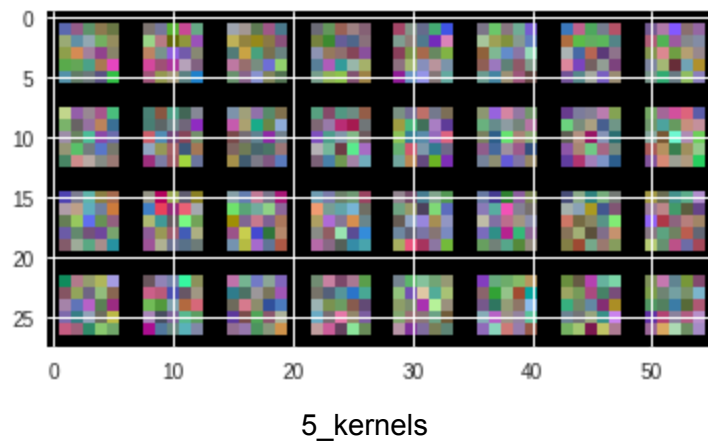


5\_activations

(b) the filter response maps for a given sample image of CIFAR-10



4\_data



## Appendix

### a. Test accuracy of different learning rates

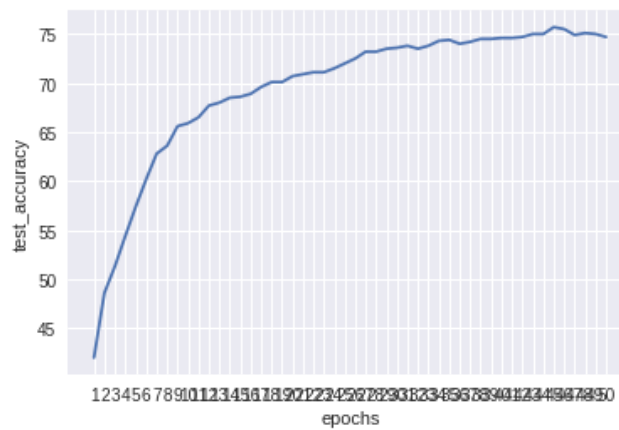


Figure 1. test\_accuracy vs epochs with learning\_rate = 0.005

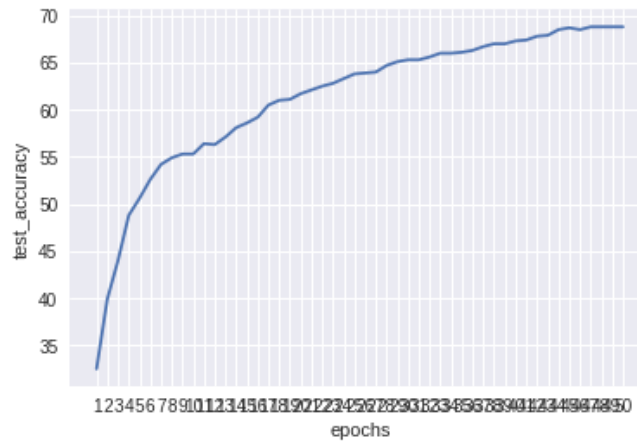


Figure 2. test\_accuracy vs epochs with learning\_rate = 0.001

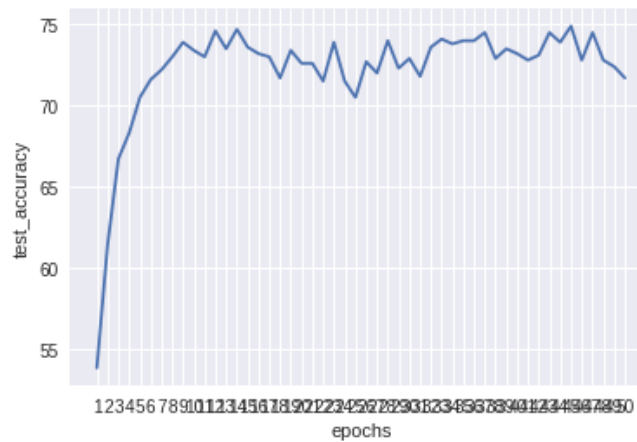


Figure 3. test\_accuracy vs epochs with learning\_rate = 0.05

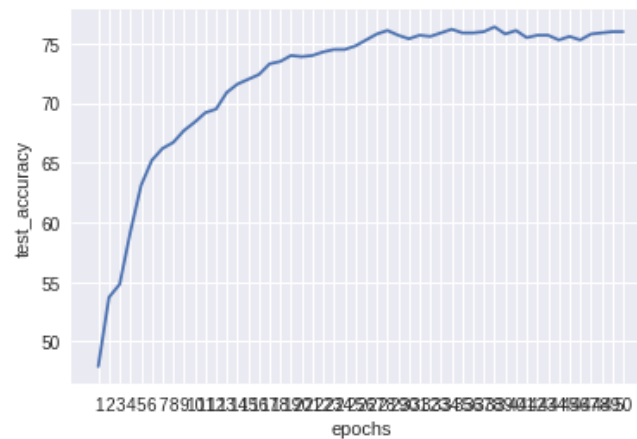


Figure 4. test\_accuracy vs epochs with learning\_rate = 0.01

From the above figures, we can see that generally the test accuracy reaches 70% at 10-20 epochs, and keep increasing and become steady as the number of epoch increases. Among the learning rates above, 0.005 and 0.01 both show good result, but 0.005 is more steady though.

b. Test accuracy over epochs with different number of blocks

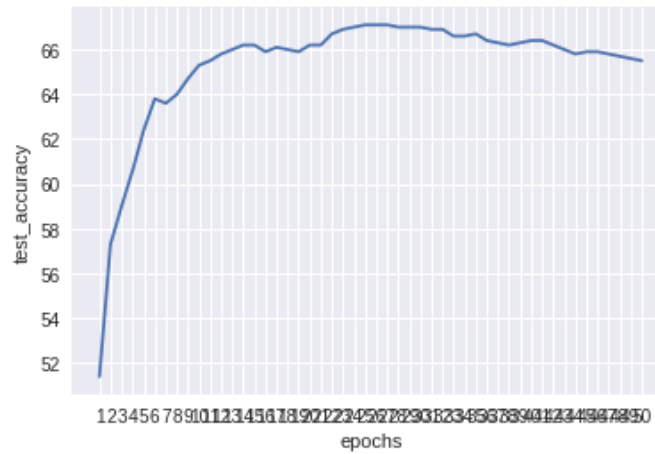


Figure 5. test\_accuracy vs epochs with 2 blocks(Block1, Block5)

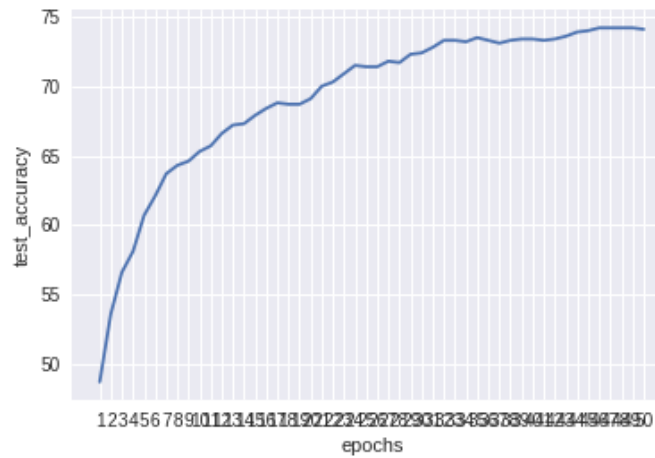


Figure 6. test\_accuracy vs epochs with 3 blocks(Block1, Block2, Block5)

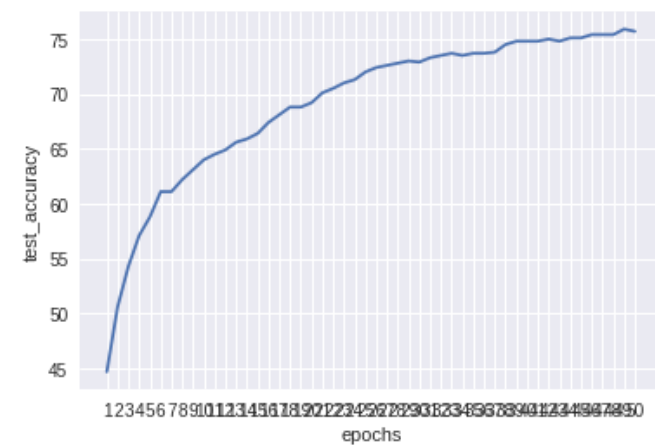


Figure 7. test\_accuracy vs epochs with 4 blocks(Block1, Block2, Block3, Block5)