

# CAP5415

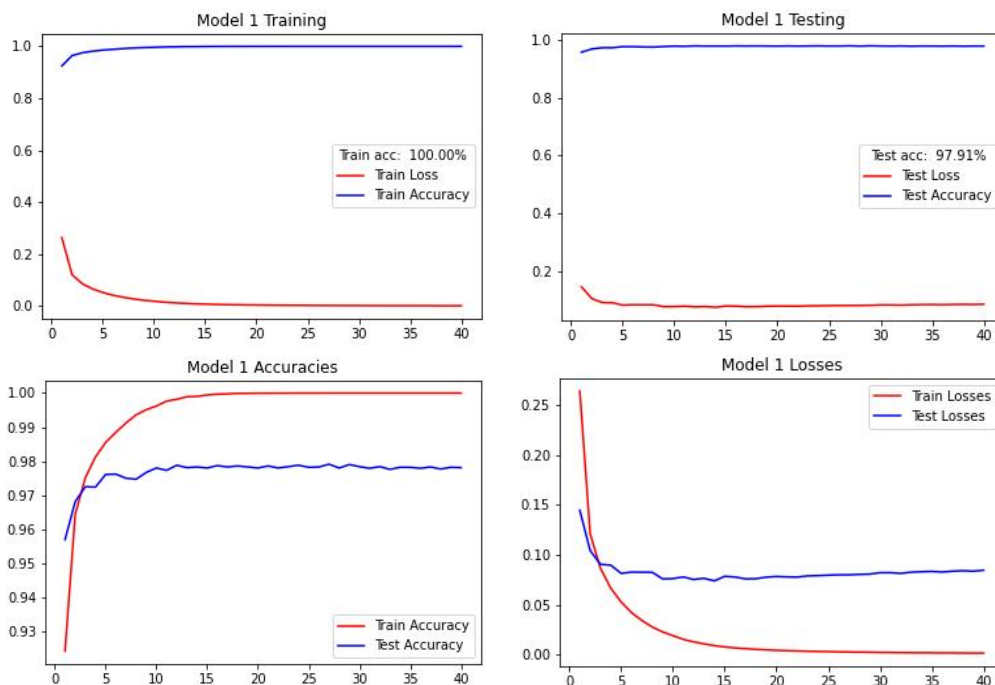
## Programming Assignment 2

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Code: <https://github.com/greysou1/ConvolutionalNN>

### Model 1

A fully connected (FC) hidden layer (with 100 neurons)



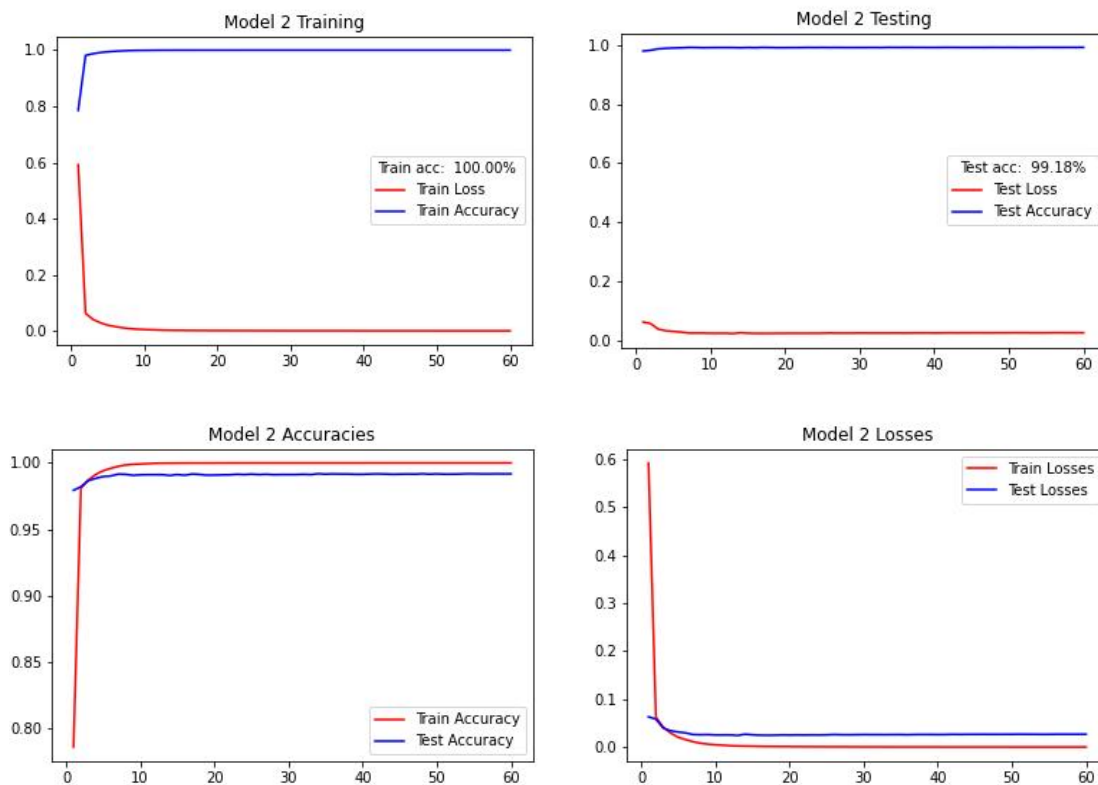
Training accuracy: 100%

Testing accuracy: 97.91%

- This model is the simplest of all the models as it has only the fully connected layers in it. Hence, it runs the fastest.
- The loss for training starts high at first but quickly declines for the first couple of epoch.
- Over the next 10-15 epochs the loss slowly reduces.
- After this point the loss is at it's lowest and completely flattens for most of the epochs.
- The Accuracy starts off pretty good at around 90% and climbs to 98-99 just after a few epochs and then completely flattens for the rest of the epochs.
- For testing the loss starts at a relatively low value and then flattens.
- The train accuracy trains until 100 while the test accuracy flattens around 98%
- The same pattern can be seen in the losses, the loss ends up 0 while the test accuracy flattens around 0.08.

## Model 2

Two convolutional layers + A fully connected (FC) hidden layer (with 100 neurons)



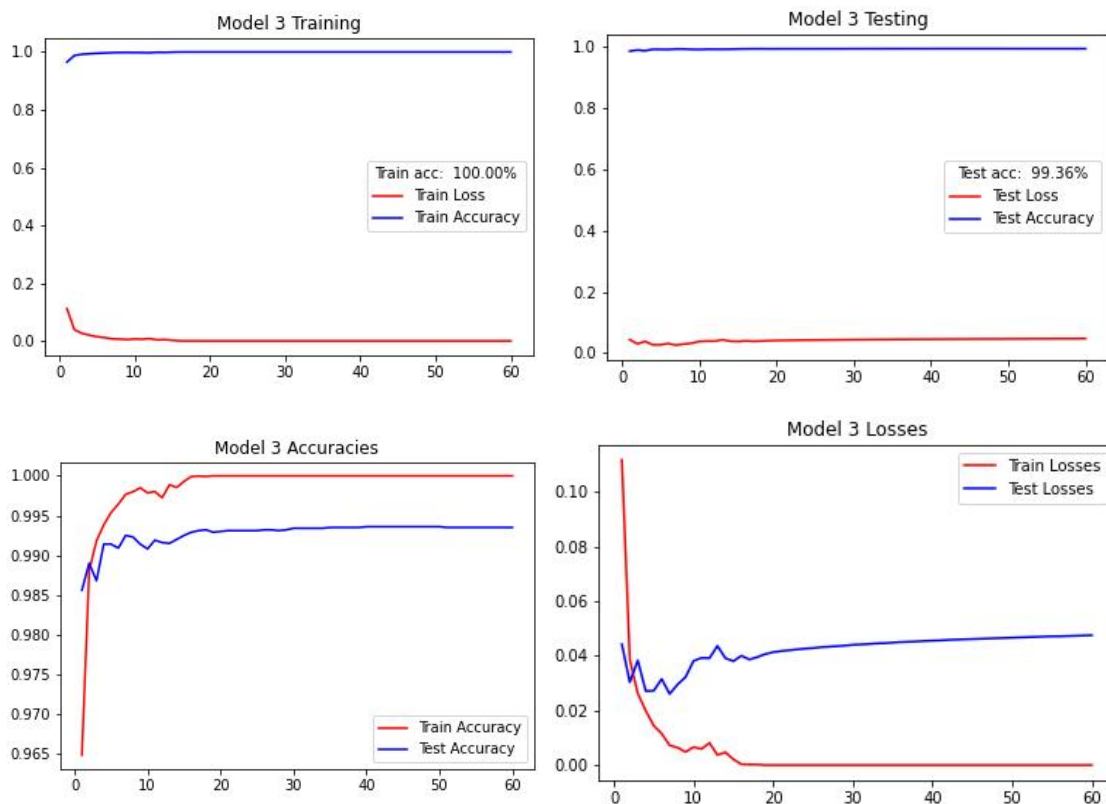
Training accuracy: 100%

Testing accuracy: 99.18%

- This model adds 2 convolutional layers to the existing fully connected model 1 thereby adding more parameters that needs to be trained, hence this model take a bit longer to complete 60 epochs than model 1.
- The loss starts pretty high at first but just after 2-3 epoch the loss sees a steep decline.
- This is because the kernels in the convolutional layers are randomly initialised and quickly gets learned after 2-3 epochs but since the learning rate is comparatively high it quickly converges.
- The same can be seen in the accuracy, starts off low around 80% but then quickly climbs to almost 98-99 and then flattens at 100% (train accuracy)
- This model has a better test accuracy than the model 1 because of the convolutional layer.
- The testing starts off at a pretty good accuracy and low loss from the 1st epoch and maintains the average
- While the Train accuracy starts off pretty high comparatively and flattens out at 1, the test accuracy already Strats pretty high and then flattens around 0.99
- Both the training and testing accuracies and losses follow the same pattern

## Model 3

Replace Sigmoid with ReLU in model 2, and update the learning rate ( $=0.03$ ).



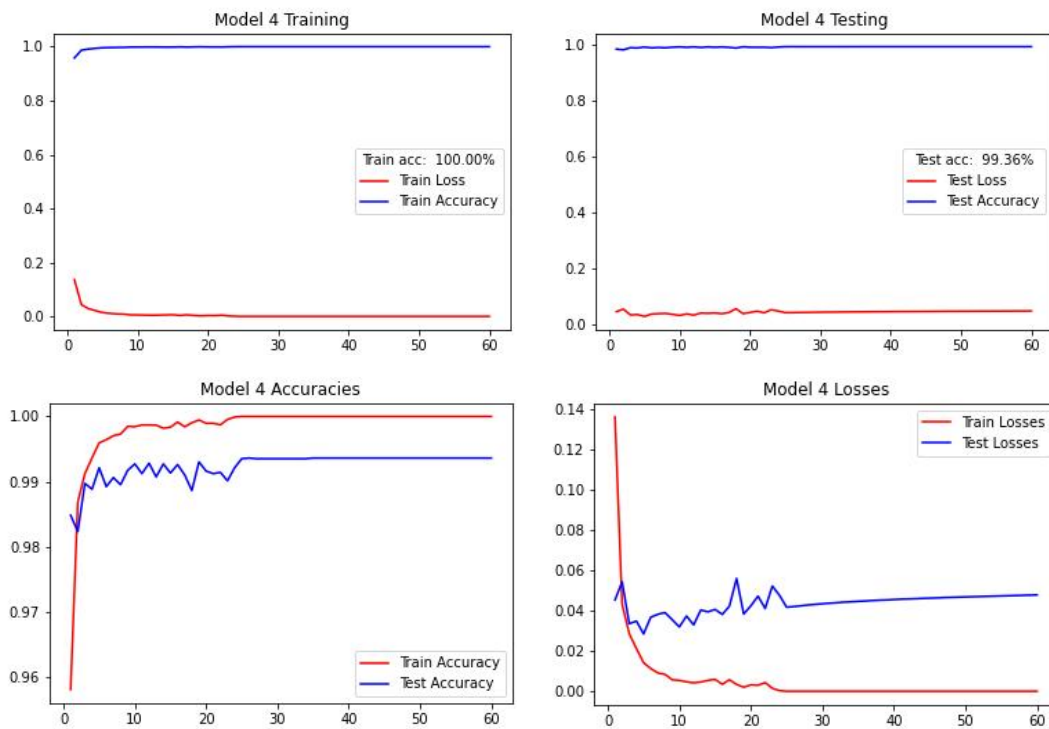
Training accuracy: 100%

Testing accuracy: 99.36%

- This model is exactly the same as the previous model with the change in activation function and learning rate.
- There isn't significant difference between model 2 and model 3's accuracy except, model 3 finished training a tad bit earlier than model 2 (~1 min difference). This could be due to the fact that ReLU is faster to compute than Sigmoid.
- The loss starts off pretty low compared to the model 2 but it takes longer to reach the lowest loss compared to the model 2 training because of the comparatively low learning rate.
- The accuracy starts off pretty high and easily flattens at 100%
- The model's slightly better accuracy can be attributed to ReLU activation function.
- Same can be said for the testing.
- When the train accuracy is much higher than the test accuracy, it is said that the model is overfitting.
- This can also be seen in the loss, the gap between the loss lines is huge indicating overfitting.

## Model 4

Add another fully connected (FC) layer (with 100 neurons) to model 3.



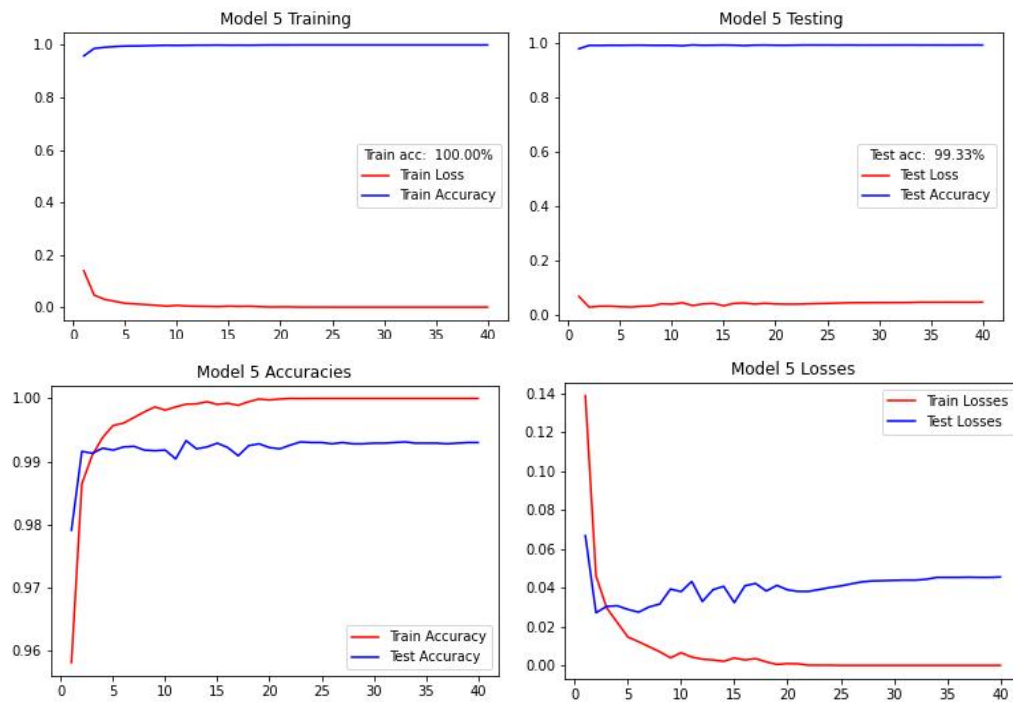
Training accuracy: 100%

Testing accuracy: 99.36%

- The only change in this model is the addition of a new hidden layer.
- We can see even after adding a new layer to the existing model the accuracy is the exact same as the previous layer.
- The loss and accuracy has the same pattern as model 3
- The accuracy starts off pretty high and easily flattens at 100%
- This model took a tad bit longer to train than model 3 (20 seconds).
- For testing, the loss value seems to have had a volatile low value for almost the first half epochs but then flattens out towards the end.
- Overfitting can be seen in this model as well.

## Model 5

Change the neurons numbers in FC layers into 1000. For Regularization, use Dropout (with a rate of 0.5). Train the whole system using 40 epochs.



Training accuracy: 100%

Testing accuracy: 99.33%

- This model's main difference is that the neurons in the layers are changed to 1000.
- We can see that even after changing the number of nodes in the FC layers in the existing model the accuracy is almost the same as the previous layer.
- The accuracy starts off pretty high and easily flattens at 100%
- Dropout is added to reduce the effects of overfitting but the accuracy (which is already high) is slightly lower than model 4. This could be because the dropout has been added right before the last layer so the effects of dropout couldn't be realised to the fullest
- Or it could just be for the fact that the model is already showing pretty good accuracy (99.36% in the last model) and that 0.03% difference could be from any other parameter or just at random.