Epoch 1/15

42000/42000 [==============================] - 786s 19ms/step - loss: 0.0898 - mean\_squared\_error: 0.0898 - acc: 0.1403 - val\_loss: 0.0896 - val\_mean\_squared\_error: 0.0896 - val\_acc: 0.1611

Epoch 2/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1727 - val\_loss: 0.0892 - val\_mean\_squared\_error: 0.0892 - val\_acc: 0.1840

Epoch 3/15

42000/42000 [==============================] - 795s 19ms/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.1899 - val\_loss: 0.0888 - val\_mean\_squared\_error: 0.0888 - val\_acc: 0.2015

Epoch 4/15

42000/42000 [==============================] - 782s 19ms/step - loss: 0.0886 - mean\_squared\_error: 0.0886 - acc: 0.2048 - val\_loss: 0.0884 - val\_mean\_squared\_error: 0.0884 - val\_acc: 0.2079

Epoch 5/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0882 - mean\_squared\_error: 0.0882 - acc: 0.2129 - val\_loss: 0.0880 - val\_mean\_squared\_error: 0.0880 - val\_acc: 0.2167

Epoch 6/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0878 - mean\_squared\_error: 0.0878 - acc: 0.2201 - val\_loss: 0.0875 - val\_mean\_squared\_error: 0.0875 - val\_acc: 0.2238

Epoch 7/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0873 - mean\_squared\_error: 0.0873 - acc: 0.2278 - val\_loss: 0.0871 - val\_mean\_squared\_error: 0.0871 - val\_acc: 0.2309

Epoch 8/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0868 - mean\_squared\_error: 0.0868 - acc: 0.2330 - val\_loss: 0.0866 - val\_mean\_squared\_error: 0.0866 - val\_acc: 0.2310

Epoch 9/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0864 - mean\_squared\_error: 0.0864 - acc: 0.2383 - val\_loss: 0.0862 - val\_mean\_squared\_error: 0.0862 - val\_acc: 0.2389

Epoch 10/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0859 - mean\_squared\_error: 0.0859 - acc: 0.2450 - val\_loss: 0.0857 - val\_mean\_squared\_error: 0.0857 - val\_acc: 0.2461

Epoch 11/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0855 - mean\_squared\_error: 0.0855 - acc: 0.2521 - val\_loss: 0.0853 - val\_mean\_squared\_error: 0.0853 - val\_acc: 0.2561

Epoch 12/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0850 - mean\_squared\_error: 0.0850 - acc: 0.2590 - val\_loss: 0.0849 - val\_mean\_squared\_error: 0.0849 - val\_acc: 0.2610

Epoch 13/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0846 - mean\_squared\_error: 0.0846 - acc: 0.2674 - val\_loss: 0.0845 - val\_mean\_squared\_error: 0.0845 - val\_acc: 0.2690

Epoch 14/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0841 - mean\_squared\_error: 0.0841 - acc: 0.2774 - val\_loss: 0.0841 - val\_mean\_squared\_error: 0.0841 - val\_acc: 0.2818

Epoch 15/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0837 - mean\_squared\_error: 0.0837 - acc: 0.2870 - val\_loss: 0.0836 - val\_mean\_squared\_error: 0.0836 - val\_acc: 0.2966

10000/10000 [==============================] - 60s 6ms/step

The testing accuracy metric for batch size 128 and lr 0.01 is [0.08345746948719025, 0.08345746948719025, 0.2899]

---------------------------------------------------

Train on 42000 samples, validate on 8000 samples

Epoch 1/15

42000/42000 [==============================] - 789s 19ms/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1612 - val\_loss: 0.0888 - val\_mean\_squared\_error: 0.0888 - val\_acc: 0.2214

Epoch 2/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0878 - mean\_squared\_error: 0.0878 - acc: 0.2235 - val\_loss: 0.0867 - val\_mean\_squared\_error: 0.0867 - val\_acc: 0.2185

Epoch 3/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0853 - mean\_squared\_error: 0.0853 - acc: 0.2631 - val\_loss: 0.0842 - val\_mean\_squared\_error: 0.0842 - val\_acc: 0.2715

Epoch 4/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0826 - mean\_squared\_error: 0.0826 - acc: 0.3053 - val\_loss: 0.0820 - val\_mean\_squared\_error: 0.0820 - val\_acc: 0.2914

Epoch 5/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0804 - mean\_squared\_error: 0.0804 - acc: 0.3350 - val\_loss: 0.0802 - val\_mean\_squared\_error: 0.0802 - val\_acc: 0.3320

Epoch 6/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0790 - mean\_squared\_error: 0.0790 - acc: 0.3502 - val\_loss: 0.0812 - val\_mean\_squared\_error: 0.0812 - val\_acc: 0.3214

Epoch 7/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0780 - mean\_squared\_error: 0.0780 - acc: 0.3592 - val\_loss: 0.0786 - val\_mean\_squared\_error: 0.0786 - val\_acc: 0.3409

Epoch 8/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0772 - mean\_squared\_error: 0.0772 - acc: 0.3703 - val\_loss: 0.0795 - val\_mean\_squared\_error: 0.0795 - val\_acc: 0.3336

Epoch 9/15

42000/42000 [==============================] - 788s 19ms/step - loss: 0.0765 - mean\_squared\_error: 0.0765 - acc: 0.3775 - val\_loss: 0.0779 - val\_mean\_squared\_error: 0.0779 - val\_acc: 0.3535

Epoch 10/15

42000/42000 [==============================] - 782s 19ms/step - loss: 0.0759 - mean\_squared\_error: 0.0759 - acc: 0.3859 - val\_loss: 0.0793 - val\_mean\_squared\_error: 0.0793 - val\_acc: 0.3429

Epoch 11/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0753 - mean\_squared\_error: 0.0753 - acc: 0.3898 - val\_loss: 0.0793 - val\_mean\_squared\_error: 0.0793 - val\_acc: 0.3391

Epoch 12/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0747 - mean\_squared\_error: 0.0747 - acc: 0.3989 - val\_loss: 0.0760 - val\_mean\_squared\_error: 0.0760 - val\_acc: 0.3811

Epoch 13/15

42000/42000 [==============================] - 781s 19ms/step - loss: 0.0741 - mean\_squared\_error: 0.0741 - acc: 0.4037 - val\_loss: 0.0746 - val\_mean\_squared\_error: 0.0746 - val\_acc: 0.4006

Epoch 14/15

42000/42000 [==============================] - 780s 19ms/step - loss: 0.0736 - mean\_squared\_error: 0.0736 - acc: 0.4071 - val\_loss: 0.0751 - val\_mean\_squared\_error: 0.0751 - val\_acc: 0.3901

Epoch 15/15

42000/42000 [==============================] - 782s 19ms/step - loss: 0.0730 - mean\_squared\_error: 0.0730 - acc: 0.4159 - val\_loss: 0.0741 - val\_mean\_squared\_error: 0.0741 - val\_acc: 0.4046

10000/10000 [==============================] - 60s 6ms/step

The testing accuracy metric for batch size 128 and lr 0.05 is [0.07344373550415038, 0.07344373550415038, 0.4155]

---------------------------------------------------

Train on 42000 samples, validate on 8000 samples

Epoch 1/15

42000/42000 [==============================] - 748s 18ms/step - loss: 0.0900 - mean\_squared\_error: 0.0900 - acc: 0.1095 - val\_loss: 0.0899 - val\_mean\_squared\_error: 0.0899 - val\_acc: 0.1229

Epoch 2/15

42000/42000 [==============================] - 745s 18ms/step - loss: 0.0899 - mean\_squared\_error: 0.0899 - acc: 0.1293 - val\_loss: 0.0898 - val\_mean\_squared\_error: 0.0898 - val\_acc: 0.1338

Epoch 3/15

42000/42000 [==============================] - 747s 18ms/step - loss: 0.0897 - mean\_squared\_error: 0.0897 - acc: 0.1301 - val\_loss: 0.0896 - val\_mean\_squared\_error: 0.0896 - val\_acc: 0.1316

Epoch 4/15

42000/42000 [==============================] - 745s 18ms/step - loss: 0.0896 - mean\_squared\_error: 0.0896 - acc: 0.1326 - val\_loss: 0.0895 - val\_mean\_squared\_error: 0.0895 - val\_acc: 0.1459

Epoch 5/15

42000/42000 [==============================] - 746s 18ms/step - loss: 0.0895 - mean\_squared\_error: 0.0895 - acc: 0.1457 - val\_loss: 0.0894 - val\_mean\_squared\_error: 0.0894 - val\_acc: 0.1501

Epoch 6/15

42000/42000 [==============================] - 746s 18ms/step - loss: 0.0894 - mean\_squared\_error: 0.0894 - acc: 0.1564 - val\_loss: 0.0893 - val\_mean\_squared\_error: 0.0893 - val\_acc: 0.1600

Epoch 7/15

42000/42000 [==============================] - 745s 18ms/step - loss: 0.0892 - mean\_squared\_error: 0.0892 - acc: 0.1643 - val\_loss: 0.0891 - val\_mean\_squared\_error: 0.0891 - val\_acc: 0.1714

Epoch 8/15

42000/42000 [==============================] - 746s 18ms/step - loss: 0.0891 - mean\_squared\_error: 0.0891 - acc: 0.1721 - val\_loss: 0.0890 - val\_mean\_squared\_error: 0.0890 - val\_acc: 0.1762

Epoch 9/15

42000/42000 [==============================] - 746s 18ms/step - loss: 0.0890 - mean\_squared\_error: 0.0890 - acc: 0.1775 - val\_loss: 0.0888 - val\_mean\_squared\_error: 0.0888 - val\_acc: 0.1832

Epoch 10/15

42000/42000 [==============================] - 747s 18ms/step - loss: 0.0888 - mean\_squared\_error: 0.0888 - acc: 0.1839 - val\_loss: 0.0887 - val\_mean\_squared\_error: 0.0887 - val\_acc: 0.1906

Epoch 11/15

42000/42000 [==============================] - 747s 18ms/step - loss: 0.0886 - mean\_squared\_error: 0.0886 - acc: 0.1910 - val\_loss: 0.0885 - val\_mean\_squared\_error: 0.0885 - val\_acc: 0.1940

Epoch 12/15

42000/42000 [==============================] - 776s 18ms/step - loss: 0.0885 - mean\_squared\_error: 0.0885 - acc: 0.1954 - val\_loss: 0.0883 - val\_mean\_squared\_error: 0.0883 - val\_acc: 0.1966

Epoch 13/15

42000/42000 [==============================] - 754s 18ms/step - loss: 0.0883 - mean\_squared\_error: 0.0883 - acc: 0.1958 - val\_loss: 0.0882 - val\_mean\_squared\_error: 0.0882 - val\_acc: 0.2003

Epoch 14/15

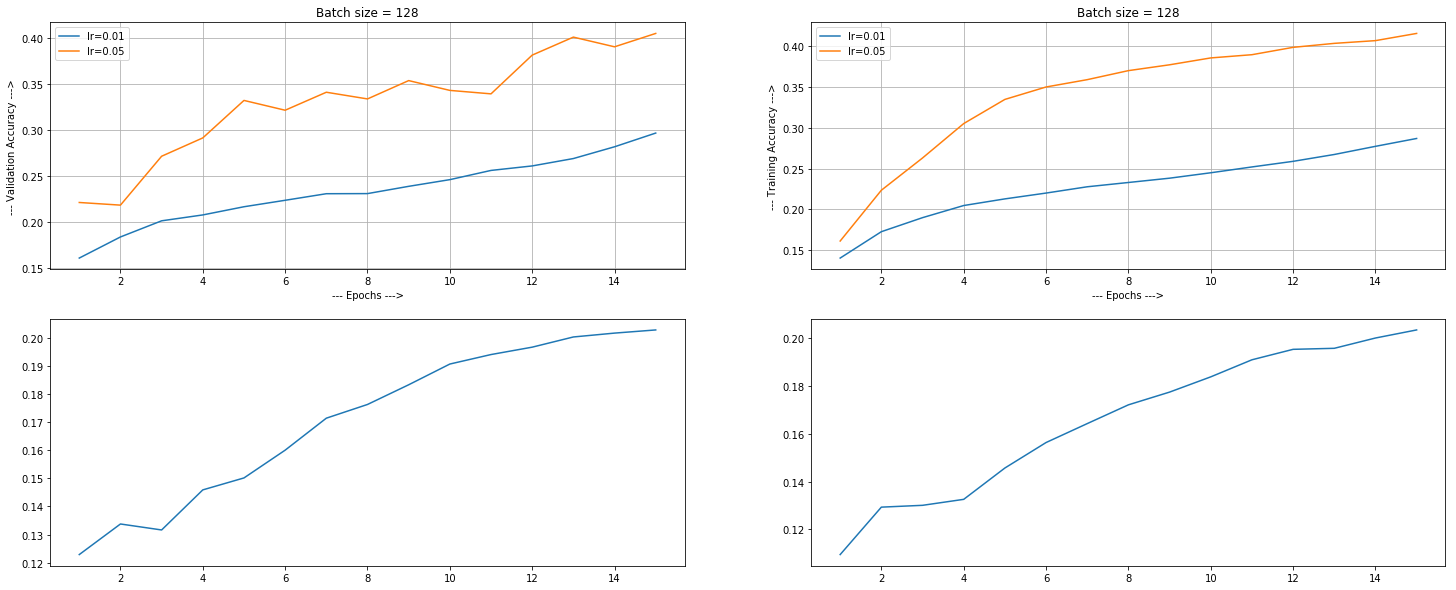
42000/42000 [==============================] - 746s 18ms/step - loss: 0.0881 - mean\_squared\_error: 0.0881 - acc: 0.2001 - val\_loss: 0.0880 - val\_mean\_squared\_error: 0.0880 - val\_acc: 0.2016

Epoch 15/15

42000/42000 [==============================] - 745s 18ms/step - loss: 0.0879 - mean\_squared\_error: 0.0879 - acc: 0.2035 - val\_loss: 0.0878 - val\_mean\_squared\_error: 0.0878 - val\_acc: 0.2028

10000/10000 [==============================] - 64s 6ms/step

The testing accuracy metric for batch size 256 and lr 0.01 is [0.08783616034984588, 0.08783616034984588, 0.2051]



**OBSERVATIONS:**

We see that more time we give to the model to train, better is the Accuracy. Specific Observation is as below:

1. **Batch Size Vs Accuracy**: More batch size means less iterations in one epoch. We observed that as we decreased the batch size, the accuracy also decreased. As we can see from above data, testing accuracy also increased. We observe that in any case the accuracy curve didn’t saturate. This might be due to less number of epochs or less number of trainable parameters which can be increased by increasing number of CNN layers.
2. **Epoch Vs Accuracy**: We can see that as the no of epochs increased, the accuracy for both training and validation. To save computational effort, we should regulate this growth and stop the training when the difference between the accuracy of last two epoch isn’t significant enough.
3. **Learning Rate vs Accuracy**:
4. N=0.01: When the learning rate was this small, it took time to gain significant accuracy. That’s why we see that training and validation accuracy is bit low in this case as compared to 0.05. But both are not saturated till 15 epochs. Choosing a greater learning rate might help, but it can decrease the testing accuracy.