Report
RBE595 Deep Learning: Homework 6-7

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Dataset:

We divided the whole dataset into 3 parts: Training (60%), Validation (20%) and Testing (20%).

Development of models:

We developed 3 different models but finally used the VGG16 model as all three of our models failed to give an accuracy above 25%.

1. Model A: Four Convolution layers with ‘tanh’ activations and two fully connected layers with one layer having ‘tanh’ activation and the last one having ‘softmax’ activation.
2. Model B: Four Convolution layers with ‘relu’ activations and two fully connected layers with one layer having ‘relu’ activation and the last one having ‘softmax’ activation.
3. Model C: Six Convolution layers with ‘relu’ activations and two fully connected layers with one layer having ‘relu’ activation and the last one having ‘softmax’ activation.
4. VGG16 Model: Thirteen Convolution layers with ‘relu’ activations and three fully connected layers with two layers having ‘relu’ activations and the last one having ‘softmax’ activation.

Performance of models:

1. **Model A:**
   It gives about 20% validation accuracy. We thought the reason might be the ‘tanh’ activation functions and thus replace them by ‘relu’ in Model B.

2. **Model B:**

This model also gives an accuracy of about 20% which led us to think that maybe we need to increase the number of convolution layers which we do in Model C.

3. Model C:

This model also gives an accuracy of around 20% which then got us to think if there is some problem in the way we are loading our data and that is why we decided to try the exact same code by just replacing our model by the VGG16 model.

```
Epoch 1/50
2000/2000 [==============================] - 196s - loss: 12.5373 - acc: 0.2175 - val_loss: 12.7937 - val_acc: 0.2062
Epoch 2/50
2000/2000 [==============================] - 194s - loss: 12.9831 - acc: 0.1945 - val_loss: 13.0557 - val_acc: 0.1900
Epoch 3/50
2000/2000 [==============================] - 195s - loss: 12.7252 - acc: 0.2105 - val_loss: 12.7131 - val_acc: 0.2112
Epoch 4/50
2000/2000 [==============================] - 195s - loss: 12.7414 - acc: 0.2095 - val_loss: 12.6527 - val_acc: 0.2150
Epoch 5/50
2000/2000 [==============================] - 194s - loss: 12.9912 - acc: 0.1940 - val_loss: 12.6527 - val_acc: 0.2150
Epoch 6/50
2000/2000 [==============================] - 194s - loss: 12.6366 - acc: 0.2160 - val_loss: 12.9549 - val_acc: 0.1962
Epoch 7/50
2000/2000 [==============================] - 194s - loss: 12.9428 - acc: 0.1970 - val_loss: 12.7534 - val_acc: 0.2087
Epoch 8/50
2000/2000 [==============================] - 194s - loss: 12.8139 - acc: 0.2050 - val_loss: 12.6729 - val_acc: 0.2137
Epoch 9/50
2000/2000 [==============================] - 195s - loss: 12.6930 - acc: 0.2125 - val_loss: 12.6930 - val_acc: 0.2125
Epoch 10/50
2000/2000 [==============================] - 194s - loss: 13.0476 - acc: 0.1905 - val_loss: 12.4915 - val_acc: 0.2250
Epoch 11/50
2000/2000 [==============================] - 194s - loss: 13.0476 - acc: 0.1905 - val_loss: 12.7333 - val_acc: 0.2100
Epoch 12/50
2000/2000 [==============================] - 195s - loss: 12.7414 - acc: 0.2095 - val_loss: 13.1564 - val_acc: 0.1837
Epoch 13/50
2000/2000 [==============================] - 194s - loss: 12.8139 - acc: 0.2050 - val_loss: 12.9348 - val_acc: 0.1975
Epoch 14/50
2000/2000 [==============================] - 194s - loss: 12.5399 - acc: 0.2220 - val_loss: 13.0557 - val_acc: 0.1900
Epoch 15/50
2000/2000 [==============================] - 194s - loss: 12.8461 - acc: 0.2030 - val_loss: 12.7534 - val_acc: 0.2087
Epoch 16/50
2000/2000 [==============================] - 194s - loss: 12.9267 - acc: 0.1980 - val_loss: 13.1564 - val_acc: 0.1837
Epoch 17/50
2000/2000 [==============================] - 195s - loss: 12.8542 - acc: 0.2025 - val_loss: 13.2168 - val_acc: 0.1800
Epoch 18/50
2000/2000 [==============================] - 194s - loss: 12.5076 - acc: 0.2240 - val_loss: 12.8542 - val_acc: 0.2025
Epoch 19/50
2000/2000 [==============================] - 194s - loss: 12.7172 - acc: 0.2110 - val_loss: 13.1967 - val_acc: 0.1812
Epoch 20/50
2000/2000 [==============================] - 194s - loss: 12.7736 - acc: 0.2075 - val_loss: 12.7937 - val_acc: 0.2062
Epoch 21/50
2000/2000 [==============================] - 194s - loss: 12.6608 - acc: 0.2145 - val_loss: 12.5721 - val_acc: 0.2200
Epoch 22/50
2000/2000 [==============================] - 194s - loss: 12.8139 - acc: 0.2050 - val_loss: 12.8139 - val_acc: 0.2050
Epoch 23/50
2000/2000 [==============================] - 194s - loss: 12.6124 - acc: 0.2175 - val_loss: 12.6124 - val_acc: 0.2175
```

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Epoch 24/50
2000/2000 [==============================] - 195s - loss: 12.8622 - acc: 0.2020 - val_loss: 12.8743 - val_acc: 0.2012
Epoch 25/50
2000/2000 [==============================] - 194s - loss: 12.8622 - acc: 0.2020 - val_loss: 12.5721 - val_acc: 0.2200
Epoch 26/50
2000/2000 [==============================] - 195s - loss: 12.5399 - acc: 0.2220 - val_loss: 13.0355 - val_acc: 0.1912
Epoch 27/50
2000/2000 [==============================] - 194s - loss: 13.1604 - acc: 0.1835 - val_loss: 12.7937 - val_acc: 0.2062
Epoch 28/50
2000/2000 [==============================] - 195s - loss: 12.7091 - acc: 0.2115 - val_loss: 13.0355 - val_acc: 0.1912
Epoch 29/50
2000/2000 [==============================] - 195s - loss: 12.7897 - acc: 0.2065 - val_loss: 12.8945 - val_acc: 0.2000
Epoch 30/50
2000/2000 [==============================] - 194s - loss: 12.6769 - acc: 0.2135 - val_loss: 12.7736 - val_acc: 0.2075
Epoch 31/50
2000/2000 [==============================] - 195s - loss: 12.7655 - acc: 0.2080 - val_loss: 12.5520 - val_acc: 0.2212
Epoch 32/50
2000/2000 [==============================] - 195s - loss: 12.9025 - acc: 0.1995 - val_loss: 12.6930 - val_acc: 0.2125
Epoch 33/50
2000/2000 [==============================] - 195s - loss: 12.9428 - acc: 0.1970 - val_loss: 12.7736 - val_acc: 0.2075
Epoch 34/50
2000/2000 [==============================] - 195s - loss: 13.0960 - acc: 0.1875 - val_loss: 12.6930 - val_acc: 0.2125
Epoch 35/50
2000/2000 [==============================] - 206s - loss: 12.8622 - acc: 0.2020 - val_loss: 13.1161 - val_acc: 0.1862
Epoch 36/50
2000/2000 [==============================] - 195s - loss: 12.7494 - acc: 0.2090 - val_loss: 13.1362 - val_acc: 0.1850
Epoch 37/50
2000/2000 [==============================] - 195s - loss: 13.1524 - acc: 0.1840 - val_loss: 12.6124 - val_acc: 0.2175
Epoch 38/50
2000/2000 [==============================] - 194s - loss: 13.0154 - acc: 0.1925 - val_loss: 12.8945 - val_acc: 0.2000
Epoch 39/50
2000/2000 [==============================] - 194s - loss: 12.8139 - acc: 0.2050 - val_loss: 12.9348 - val_acc: 0.1975
Epoch 40/50
2000/2000 [==============================] - 204s - loss: 12.8542 - acc: 0.2025 - val_loss: 12.7333 - val_acc: 0.2100
Epoch 41/50
2000/2000 [==============================] - 194s - loss: 12.7655 - acc: 0.2080 - val_loss: 12.8340 - val_acc: 0.2037
Epoch 42/50
2000/2000 [==============================] - 194s - loss: 12.7091 - acc: 0.2115 - val_loss: 12.9348 - val_acc: 0.1975
Epoch 43/50
2000/2000 [==============================] - 194s - loss: 12.8820 - acc: 0.2005 - val_loss: 12.7131 - val_acc: 0.2112
Epoch 44/50
2000/2000 [==============================] - 194s - loss: 12.4271 - acc: 0.2290 - val_loss: 12.7937 - val_acc: 0.2063
Epoch 45/50
2000/2000 [==============================] - 194s - loss: 13.1362 - acc: 0.1850 - val_loss: 12.9549 - val_acc: 0.1962
Epoch 46/50
2000/2000 [==============================] - 194s - loss: 12.6688 - acc: 0.2140 - val_loss: 12.7131 - val_acc: 0.2112
Epoch 47/50
2000/2000 [==============================] - 195s - loss: 12.9428 - acc: 0.1970 - val_loss: 12.9751 - val_acc: 0.1950
Epoch 48/50
2000/2000 [==============================] - 194s - loss: 12.7575 - acc: 0.2085 - val_loss: 13.0355 - val_acc: 0.1912
Epoch 49/50
2000/2000 [==============================] - 195s - loss: 12.7252 - acc: 0.2105 - val_loss: 12.4512 - val_acc: 0.2275
Epoch 50/50
2000/2000 [==============================] - 194s - loss: 12.8622 - acc: 0.2020 - val_loss: 12.8139 - val_acc: 0.2050
Saved model to disk
```

Figure 1. Shows epochs 1-50 for Model C

4. VGG16 Model:

The VGG16 model, to our surprise, gave us shocking results with about 97.5% validation accuracy in the first 30 epochs. The figure below shows only 10 epochs because training was resumed by loading weights upto 20 epochs and then run for 10 epochs.

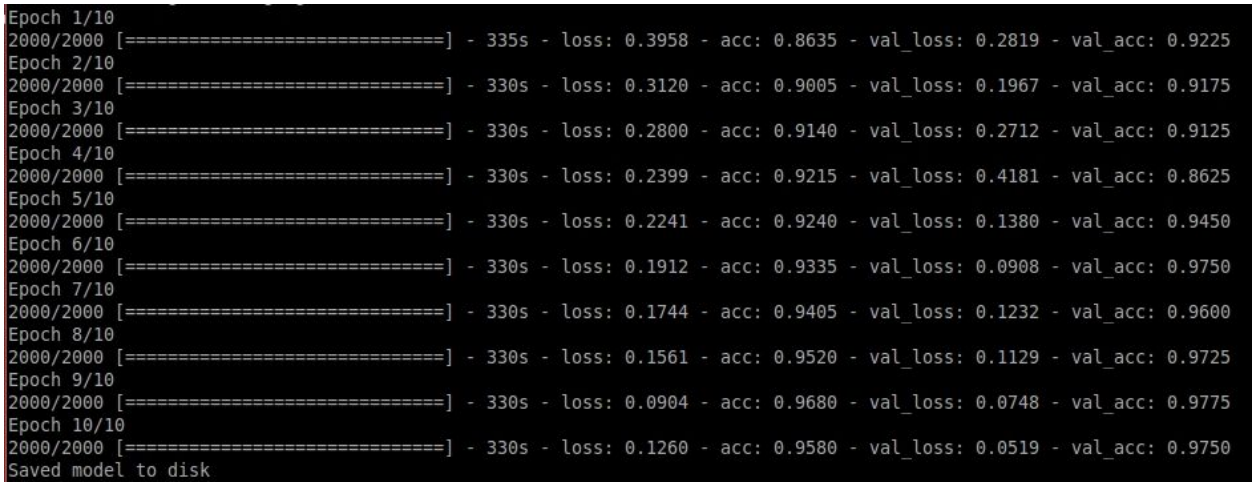

Figure 2: Shows epochs 21-30 for the VGG16 Model

We also tested this model using the testing dataset (that we divided earlier) and there we got an accuracy of 96.15%.