Data processing: Pictures are rescaled to 224 x 224; Data augmentation on train set (rescale, rotation, shift, shear, zoom, horizontal flip)

CNN architecture: Use the ImageNet pre-trained VGG16 as feature extractor (remove the top layer), We add a dense layer with 512 unit with dropout 0.5 and a dense layer with 4 units and softmaxloss function on top of conv_base.

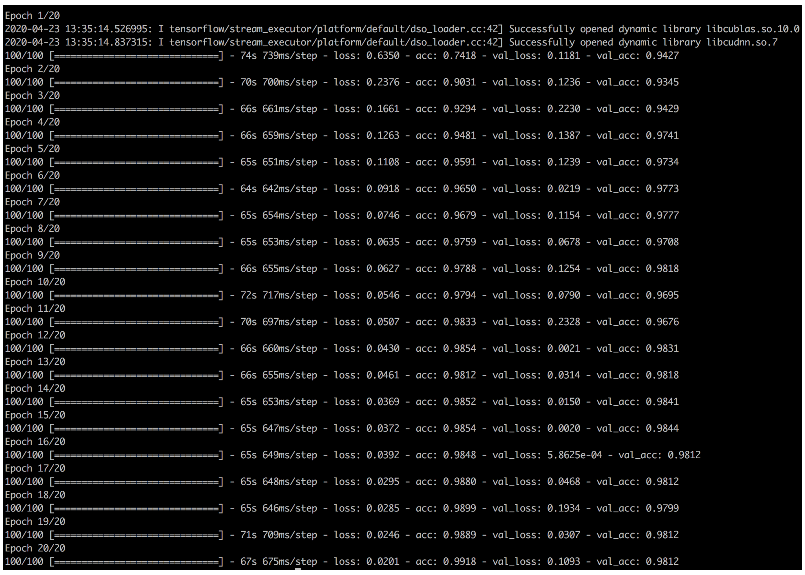
Fine tuning: Freeze all the layers of the VGGnet before block5_conv1

Batch size (for the training/validation generators) = 32

Optimizer RMSprop with **learning rate** = 1e-5

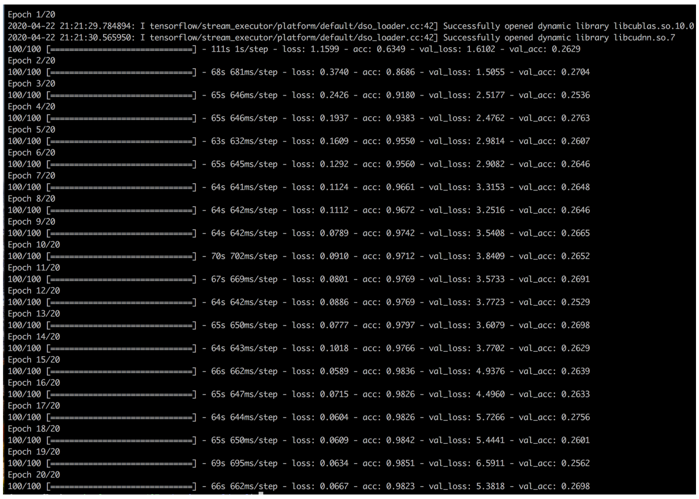
Epochs = 20

The train and validation process is as following. And the accuracy on test dataset is 0.9850.

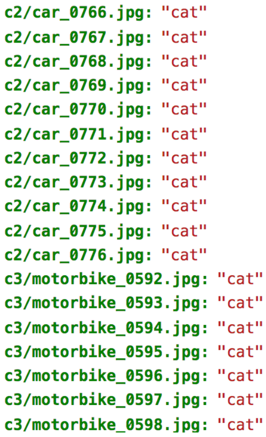


```
Epoch 1/20
2020-04-23 13:35:14.526995: I tensorflow/stream_executor/platform/default/dso_loader.cc:42] Successfully opened dynamic library libcublas.so.10.0
2020-04-23 13:35:14.837315: I tensorflow/stream_executor/platform/default/dso_loader.cc:42] Successfully opened dynamic library libcudnn.so.7
100/100 [==============================] - 74s 739ms/step - loss: 0.6350 - acc: 0.7418 - val_loss: 0.1181 - val_acc: 0.9427
Epoch 2/20
100/100 [==============================] - 70s 700ms/step - loss: 0.2376 - acc: 0.9031 - val_loss: 0.1236 - val_acc: 0.9345
Epoch 3/20
100/100 [==============================] - 66s 661ms/step - loss: 0.1661 - acc: 0.9294 - val_loss: 0.2230 - val_acc: 0.9429
Epoch 4/20
100/100 [==============================] - 66s 659ms/step - loss: 0.1263 - acc: 0.9481 - val_loss: 0.1387 - val_acc: 0.9741
Epoch 5/20
100/100 [==============================] - 65s 651ms/step - loss: 0.1108 - acc: 0.9591 - val_loss: 0.1239 - val_acc: 0.9734
Epoch 6/20
100/100 [==============================] - 64s 642ms/step - loss: 0.0918 - acc: 0.9650 - val_loss: 0.0219 - val_acc: 0.9773
Epoch 7/20
100/100 [==============================] - 65s 654ms/step - loss: 0.0746 - acc: 0.9679 - val_loss: 0.1154 - val_acc: 0.9777
Epoch 8/20
100/100 [==============================] - 65s 653ms/step - loss: 0.0635 - acc: 0.9759 - val_loss: 0.0678 - val_acc: 0.9708
Epoch 9/20
100/100 [==============================] - 66s 655ms/step - loss: 0.0627 - acc: 0.9788 - val_loss: 0.1254 - val_acc: 0.9818
Epoch 10/20
100/100 [==============================] - 72s 717ms/step - loss: 0.0546 - acc: 0.9794 - val_loss: 0.0790 - val_acc: 0.9695
Epoch 11/20
100/100 [==============================] - 70s 697ms/step - loss: 0.0507 - acc: 0.9833 - val_loss: 0.2328 - val_acc: 0.9676
Epoch 12/20
100/100 [==============================] - 66s 660ms/step - loss: 0.0430 - acc: 0.9854 - val_loss: 0.0021 - val_acc: 0.9831
Epoch 13/20
100/100 [==============================] - 66s 655ms/step - loss: 0.0461 - acc: 0.9812 - val_loss: 0.0314 - val_acc: 0.9818
Epoch 14/20
100/100 [==============================] - 65s 653ms/step - loss: 0.0369 - acc: 0.9852 - val_loss: 0.0150 - val_acc: 0.9841
Epoch 15/20
100/100 [==============================] - 65s 647ms/step - loss: 0.0372 - acc: 0.9854 - val_loss: 0.0020 - val_acc: 0.9844
Epoch 16/20
100/100 [==============================] - 65s 649ms/step - loss: 0.0392 - acc: 0.9848 - val_loss: 5.8625e-04 - val_acc: 0.9812
Epoch 17/20
100/100 [==============================] - 65s 648ms/step - loss: 0.0295 - acc: 0.9880 - val_loss: 0.0468 - val_acc: 0.9812
Epoch 18/20
100/100 [==============================] - 65s 646ms/step - loss: 0.0285 - acc: 0.9899 - val_loss: 0.1934 - val_acc: 0.9799
Epoch 19/20
100/100 [==============================] - 71s 709ms/step - loss: 0.0246 - acc: 0.9889 - val_loss: 0.0307 - val_acc: 0.9812
Epoch 20/20
100/100 [==============================] - 67s 675ms/step - loss: 0.0201 - acc: 0.9918 - val_loss: 0.1093 - val_acc: 0.9812
```

(Failed exercise) What's more, I tried to use ImageNet pre-trained Resnet50 with fine-tuning before. The result is as following.



```
Epoch 1/20
2020-04-22 21:21:29.784894: I tensorflow/stream_executor/platform/default/dso_loader.cc:42] Successfully opened dynamic library libcublas.so.10.0
2020-04-22 21:21:30.565950: I tensorflow/stream_executor/platform/default/dso_loader.cc:42] Successfully opened dynamic library libcudnn.so.7
100/100 [==============================] - 111s 1s/step - loss: 1.1599 - acc: 0.6349 - val_loss: 1.6102 - val_acc: 0.2629
Epoch 2/20
100/100 [==============================] - 68s 681ms/step - loss: 0.3740 - acc: 0.8686 - val_loss: 1.5055 - val_acc: 0.2704
Epoch 3/20
100/100 [==============================] - 65s 646ms/step - loss: 0.2426 - acc: 0.9180 - val_loss: 2.5177 - val_acc: 0.2536
Epoch 4/20
100/100 [==============================] - 65s 646ms/step - loss: 0.1937 - acc: 0.9383 - val_loss: 2.4762 - val_acc: 0.2763
Epoch 5/20
100/100 [==============================] - 63s 632ms/step - loss: 0.1609 - acc: 0.9550 - val_loss: 2.9814 - val_acc: 0.2607
Epoch 6/20
100/100 [==============================] - 65s 645ms/step - loss: 0.1292 - acc: 0.9560 - val_loss: 2.9082 - val_acc: 0.2646
Epoch 7/20
100/100 [==============================] - 64s 641ms/step - loss: 0.1124 - acc: 0.9661 - val_loss: 3.3153 - val_acc: 0.2648
Epoch 8/20
100/100 [==============================] - 64s 642ms/step - loss: 0.1112 - acc: 0.9672 - val_loss: 3.2516 - val_acc: 0.2646
Epoch 9/20
100/100 [==============================] - 64s 642ms/step - loss: 0.0789 - acc: 0.9742 - val_loss: 3.5408 - val_acc: 0.2665
Epoch 10/20
100/100 [==============================] - 70s 702ms/step - loss: 0.0910 - acc: 0.9712 - val_loss: 3.8409 - val_acc: 0.2652
Epoch 11/20
100/100 [==============================] - 67s 669ms/step - loss: 0.0801 - acc: 0.9769 - val_loss: 3.5733 - val_acc: 0.2691
Epoch 12/20
100/100 [==============================] - 64s 642ms/step - loss: 0.0886 - acc: 0.9769 - val_loss: 3.7723 - val_acc: 0.2529
Epoch 13/20
100/100 [==============================] - 65s 650ms/step - loss: 0.0777 - acc: 0.9797 - val_loss: 3.6079 - val_acc: 0.2698
Epoch 14/20
100/100 [==============================] - 64s 643ms/step - loss: 0.1018 - acc: 0.9766 - val_loss: 3.7702 - val_acc: 0.2629
Epoch 15/20
100/100 [==============================] - 66s 662ms/step - loss: 0.0589 - acc: 0.9836 - val_loss: 4.9376 - val_acc: 0.2639
Epoch 16/20
100/100 [==============================] - 65s 647ms/step - loss: 0.0715 - acc: 0.9826 - val_loss: 4.4960 - val_acc: 0.2633
Epoch 17/20
100/100 [==============================] - 64s 644ms/step - loss: 0.0604 - acc: 0.9826 - val_loss: 5.7266 - val_acc: 0.2756
Epoch 18/20
100/100 [==============================] - 65s 650ms/step - loss: 0.0609 - acc: 0.9842 - val_loss: 5.4441 - val_acc: 0.2601
Epoch 19/20
100/100 [==============================] - 69s 695ms/step - loss: 0.0634 - acc: 0.9851 - val_loss: 6.5911 - val_acc: 0.2562
Epoch 20/20
100/100 [==============================] - 66s 662ms/step - loss: 0.0667 - acc: 0.9823 - val_loss: 5.3818 - val_acc: 0.2698
```



```
c2/car_0766.jpg: "cat"
c2/car_0767.jpg: "cat"
c2/car_0768.jpg: "cat"
c2/car_0769.jpg: "cat"
c2/car_0770.jpg: "cat"
c2/car_0771.jpg: "cat"
c2/car_0772.jpg: "cat"
c2/car_0773.jpg: "cat"
c2/car_0774.jpg: "cat"
c2/car_0775.jpg: "cat"
c2/car_0776.jpg: "cat"
c3/motorbike_0592.jpg: "cat"
c3/motorbike_0593.jpg: "cat"
c3/motorbike_0594.jpg: "cat"
c3/motorbike_0595.jpg: "cat"
c3/motorbike_0596.jpg: "cat"
c3/motorbike_0597.jpg: "cat"
c3/motorbike_0598.jpg: "cat"
```

The train loss keeps decreasing while the validation loss keeps increasing, which indicates an overfitting situation. The test result of this model also proves that because this model recognized everything as the cat label.

After all of this, I find VGG structure is good enough for this small dataset.