Homework 3 Report

1.

Result = [0. 0. 1.2319232 0. 0.04842055 0.39851195

1.703964 0.32821387]

2.

Result = [0. 1.3407363 1.4184607 0. 0. 2.2878466 0.8547394

0.5266884]

3.

Epoch 1/50

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow\_backend.py:197: The name tf.ConfigProto is deprecated. Please use tf.compat.v1.ConfigProto instead.

25/25 [==============================] - 82s 3s/step - loss: 2.5152 - acc: 0.2245 - val\_loss: 3.2390 - val\_acc: 0.1406

Epoch 2/50

25/25 [==============================] - 21s 823ms/step - loss: 1.7607 - acc: 0.3537 - val\_loss: 2.1377 - val\_acc: 0.2651

Epoch 3/50

25/25 [==============================] - 25s 997ms/step - loss: 1.7049 - acc: 0.3944 - val\_loss: 13.6726 - val\_acc: 0.0924

Epoch 4/50

25/25 [==============================] - 25s 1s/step - loss: 1.5850 - acc: 0.4264 - val\_loss: 4.0149 - val\_acc: 0.2583

Epoch 5/50

25/25 [==============================] - 24s 976ms/step - loss: 1.4818 - acc: 0.4608 - val\_loss: 1.6892 - val\_acc: 0.4063

Epoch 6/50

25/25 [==============================] - 25s 992ms/step - loss: 1.4333 - acc: 0.4842 - val\_loss: 1.6360 - val\_acc: 0.4264

Epoch 7/50

25/25 [==============================] - 25s 999ms/step - loss: 1.3624 - acc: 0.5084 - val\_loss: 1.5904 - val\_acc: 0.4527

Epoch 8/50

25/25 [==============================] - 26s 1s/step - loss: 1.3092 - acc: 0.5304 - val\_loss: 1.9813 - val\_acc: 0.3607

Epoch 9/50

25/25 [==============================] - 26s 1s/step - loss: 1.2701 - acc: 0.5478 - val\_loss: 1.6163 - val\_acc: 0.4368

Epoch 10/50

25/25 [==============================] - 25s 1s/step - loss: 1.2480 - acc: 0.5557 - val\_loss: 2.0217 - val\_acc: 0.3152

Epoch 11/50

25/25 [==============================] - 25s 1s/step - loss: 1.2380 - acc: 0.5580 - val\_loss: 6.4824 - val\_acc: 0.2383

Epoch 12/50

25/25 [==============================] - 25s 1s/step - loss: 1.2004 - acc: 0.5716 - val\_loss: 1.3012 - val\_acc: 0.5397

Epoch 13/50

25/25 [==============================] - 25s 994ms/step - loss: 1.1651 - acc: 0.5857 - val\_loss: 1.9653 - val\_acc: 0.4393

Epoch 14/50

25/25 [==============================] - 25s 994ms/step - loss: 1.1555 - acc: 0.5895 - val\_loss: 14.5046 - val\_acc: 0.1000

Epoch 15/50

25/25 [==============================] - 25s 988ms/step - loss: 1.1295 - acc: 0.6017 - val\_loss: 12.0721 - val\_acc: 0.1062

Epoch 16/50

25/25 [==============================] - 25s 982ms/step - loss: 1.0846 - acc: 0.6145 - val\_loss: 1.4809 - val\_acc: 0.5187

Epoch 17/50

25/25 [==============================] - 25s 989ms/step - loss: 1.0538 - acc: 0.6262 - val\_loss: 1.9058 - val\_acc: 0.4064

Epoch 18/50

25/25 [==============================] - 25s 992ms/step - loss: 1.0566 - acc: 0.6233 - val\_loss: 1.4597 - val\_acc: 0.5468

Epoch 19/50

25/25 [==============================] - 24s 966ms/step - loss: 1.0485 - acc: 0.6285 - val\_loss: 5.5161 - val\_acc: 0.3071

Epoch 20/50

25/25 [==============================] - 24s 975ms/step - loss: 1.0532 - acc: 0.6269 - val\_loss: 1.7572 - val\_acc: 0.4646

Epoch 21/50

25/25 [==============================] - 25s 986ms/step - loss: 1.0289 - acc: 0.6351 - val\_loss: 2.1132 - val\_acc: 0.3516

Epoch 22/50

25/25 [==============================] - 24s 967ms/step - loss: 1.0328 - acc: 0.6334 - val\_loss: 2.9228 - val\_acc: 0.3740

Epoch 23/50

25/25 [==============================] - 24s 970ms/step - loss: 0.9587 - acc: 0.6595 - val\_loss: 1.7267 - val\_acc: 0.4741

Epoch 24/50

25/25 [==============================] - 24s 969ms/step - loss: 0.9430 - acc: 0.6630 - val\_loss: 1.3450 - val\_acc: 0.5507

Epoch 25/50

25/25 [==============================] - 24s 964ms/step - loss: 0.9290 - acc: 0.6726 - val\_loss: 7.3152 - val\_acc: 0.2155

Epoch 26/50

25/25 [==============================] - 24s 969ms/step - loss: 0.9148 - acc: 0.6763 - val\_loss: 1.1954 - val\_acc: 0.5929

Epoch 27/50

25/25 [==============================] - 27s 1s/step - loss: 0.8875 - acc: 0.6849 - val\_loss: 1.4865 - val\_acc: 0.5280

Epoch 28/50

25/25 [==============================] - 23s 909ms/step - loss: 0.9176 - acc: 0.6719 - val\_loss: 1.7294 - val\_acc: 0.4696

Epoch 29/50

25/25 [==============================] - 24s 966ms/step - loss: 0.8731 - acc: 0.6887 - val\_loss: 1.1610 - val\_acc: 0.6022

Epoch 30/50

25/25 [==============================] - 24s 963ms/step - loss: 0.8309 - acc: 0.7021 - val\_loss: 1.0669 - val\_acc: 0.6334

Epoch 31/50

25/25 [==============================] - 24s 962ms/step - loss: 0.8455 - acc: 0.6975 - val\_loss: 2.5341 - val\_acc: 0.3118

Epoch 32/50

25/25 [==============================] - 24s 953ms/step - loss: 0.9551 - acc: 0.6702 - val\_loss: 3.4621 - val\_acc: 0.3099

Epoch 33/50

25/25 [==============================] - 24s 965ms/step - loss: 0.9215 - acc: 0.6775 - val\_loss: 2.8447 - val\_acc: 0.3848

Epoch 34/50

25/25 [==============================] - 24s 956ms/step - loss: 0.8629 - acc: 0.6973 - val\_loss: 1.4200 - val\_acc: 0.5440

Epoch 35/50

25/25 [==============================] - 24s 966ms/step - loss: 0.8091 - acc: 0.7143 - val\_loss: 1.1069 - val\_acc: 0.6231

Epoch 36/50

25/25 [==============================] - 26s 1s/step - loss: 0.7806 - acc: 0.7238 - val\_loss: 1.0572 - val\_acc: 0.6444

Epoch 37/50

25/25 [==============================] - 25s 1s/step - loss: 0.7689 - acc: 0.7297 - val\_loss: 1.0010 - val\_acc: 0.6593

Epoch 38/50

25/25 [==============================] - 25s 990ms/step - loss: 0.7548 - acc: 0.7332 - val\_loss: 0.9427 - val\_acc: 0.6699

Epoch 39/50

25/25 [==============================] - 25s 984ms/step - loss: 0.7404 - acc: 0.7382 - val\_loss: 0.9969 - val\_acc: 0.6536

Epoch 40/50

25/25 [==============================] - 25s 981ms/step - loss: 0.7259 - acc: 0.7437 - val\_loss: 1.0750 - val\_acc: 0.6525

Epoch 41/50

25/25 [==============================] - 25s 984ms/step - loss: 0.7153 - acc: 0.7481 - val\_loss: 1.0768 - val\_acc: 0.6463

Epoch 42/50

25/25 [==============================] - 25s 984ms/step - loss: 0.7479 - acc: 0.7377 - val\_loss: 6.3463 - val\_acc: 0.2139

Epoch 43/50

25/25 [==============================] - 25s 984ms/step - loss: 0.8395 - acc: 0.7034 - val\_loss: 1.9075 - val\_acc: 0.5445

Epoch 44/50

25/25 [==============================] - 24s 969ms/step - loss: 0.7502 - acc: 0.7344 - val\_loss: 1.1719 - val\_acc: 0.6295

Epoch 45/50

25/25 [==============================] - 25s 986ms/step - loss: 0.7031 - acc: 0.7491 - val\_loss: 1.0146 - val\_acc: 0.6681

Epoch 46/50

25/25 [==============================] - 24s 972ms/step - loss: 0.6888 - acc: 0.7553 - val\_loss: 0.9670 - val\_acc: 0.6727

Epoch 47/50

25/25 [==============================] - 25s 997ms/step - loss: 0.6728 - acc: 0.7618 - val\_loss: 0.8682 - val\_acc: 0.7017

Epoch 48/50

25/25 [==============================] - 25s 993ms/step - loss: 0.6708 - acc: 0.7627 - val\_loss: 0.8660 - val\_acc: 0.7073

Epoch 49/50

25/25 [==============================] - 24s 976ms/step - loss: 0.6489 - acc: 0.7688 - val\_loss: 0.9632 - val\_acc: 0.6767

Epoch 50/50

25/25 [==============================] - 25s 984ms/step - loss: 0.6384 - acc: 0.7737 - val\_loss: 0.8673 - val\_acc: 0.7046

Training time is 1292.207596063614 s

Saved trained model at /model/resnet/resnet

Test loss: 0.8672622466087341

Test accuracy: 0.7046

Epoch 1/50

25/25 [==============================] - 68s 3s/step - loss: 1.1071 - acc: 0.6271 - val\_loss: 1.8856 - val\_acc: 0.4279

Epoch 2/50

25/25 [==============================] - 43s 2s/step - loss: 0.9382 - acc: 0.6651 - val\_loss: 1.9508 - val\_acc: 0.3990

Epoch 3/50

25/25 [==============================] - 45s 2s/step - loss: 0.8716 - acc: 0.6897 - val\_loss: 1.5860 - val\_acc: 0.4786

Epoch 4/50

25/25 [==============================] - 44s 2s/step - loss: 0.8320 - acc: 0.7036 - val\_loss: 1.2517 - val\_acc: 0.5617

Epoch 5/50

25/25 [==============================] - 44s 2s/step - loss: 0.8084 - acc: 0.7118 - val\_loss: 1.1487 - val\_acc: 0.6055

Epoch 6/50

25/25 [==============================] - 44s 2s/step - loss: 0.7855 - acc: 0.7192 - val\_loss: 0.9482 - val\_acc: 0.6733

Epoch 7/50

25/25 [==============================] - 45s 2s/step - loss: 0.7621 - acc: 0.7286 - val\_loss: 1.0870 - val\_acc: 0.6334

Epoch 8/50

25/25 [==============================] - 44s 2s/step - loss: 0.7490 - acc: 0.7331 - val\_loss: 1.0608 - val\_acc: 0.6452

Epoch 9/50

25/25 [==============================] - 45s 2s/step - loss: 0.7332 - acc: 0.7385 - val\_loss: 1.1558 - val\_acc: 0.6200

Epoch 10/50

25/25 [==============================] - 45s 2s/step - loss: 0.7235 - acc: 0.7432 - val\_loss: 1.2704 - val\_acc: 0.6042

Epoch 11/50

25/25 [==============================] - 43s 2s/step - loss: 0.7018 - acc: 0.7504 - val\_loss: 0.9177 - val\_acc: 0.6875

Epoch 12/50

25/25 [==============================] - 45s 2s/step - loss: 0.6956 - acc: 0.7514 - val\_loss: 0.8309 - val\_acc: 0.7189

Epoch 13/50

25/25 [==============================] - 44s 2s/step - loss: 0.6841 - acc: 0.7549 - val\_loss: 0.9201 - val\_acc: 0.7003

Epoch 14/50

25/25 [==============================] - 45s 2s/step - loss: 0.6671 - acc: 0.7631 - val\_loss: 0.9288 - val\_acc: 0.6870

Epoch 15/50

25/25 [==============================] - 44s 2s/step - loss: 0.6532 - acc: 0.7676 - val\_loss: 1.0452 - val\_acc: 0.6619

Epoch 16/50

25/25 [==============================] - 44s 2s/step - loss: 0.6527 - acc: 0.7686 - val\_loss: 0.9337 - val\_acc: 0.6851

Epoch 17/50

25/25 [==============================] - 44s 2s/step - loss: 0.6341 - acc: 0.7740 - val\_loss: 1.0000 - val\_acc: 0.6819

Epoch 18/50

25/25 [==============================] - 44s 2s/step - loss: 0.6307 - acc: 0.7767 - val\_loss: 1.1019 - val\_acc: 0.6506

Epoch 19/50

25/25 [==============================] - 44s 2s/step - loss: 0.6182 - acc: 0.7804 - val\_loss: 0.9868 - val\_acc: 0.6737

Epoch 20/50

25/25 [==============================] - 44s 2s/step - loss: 0.5993 - acc: 0.7866 - val\_loss: 0.9335 - val\_acc: 0.6892

Epoch 21/50

25/25 [==============================] - 44s 2s/step - loss: 0.5990 - acc: 0.7849 - val\_loss: 0.8221 - val\_acc: 0.7206

Epoch 22/50

25/25 [==============================] - 44s 2s/step - loss: 0.5864 - acc: 0.7931 - val\_loss: 0.8719 - val\_acc: 0.7217

Epoch 23/50

25/25 [==============================] - 44s 2s/step - loss: 0.5722 - acc: 0.7973 - val\_loss: 0.8863 - val\_acc: 0.7224

Epoch 24/50

25/25 [==============================] - 45s 2s/step - loss: 0.5649 - acc: 0.7991 - val\_loss: 0.8133 - val\_acc: 0.7301

Epoch 25/50

25/25 [==============================] - 44s 2s/step - loss: 0.5622 - acc: 0.7993 - val\_loss: 0.9171 - val\_acc: 0.7180

Epoch 26/50

25/25 [==============================] - 44s 2s/step - loss: 0.5554 - acc: 0.8043 - val\_loss: 0.8055 - val\_acc: 0.7327

Epoch 27/50

25/25 [==============================] - 44s 2s/step - loss: 0.5448 - acc: 0.8074 - val\_loss: 0.7778 - val\_acc: 0.7393

Epoch 28/50

25/25 [==============================] - 44s 2s/step - loss: 0.5363 - acc: 0.8100 - val\_loss: 0.7905 - val\_acc: 0.7426

Epoch 29/50

25/25 [==============================] - 44s 2s/step - loss: 0.5292 - acc: 0.8120 - val\_loss: 0.9269 - val\_acc: 0.6961

Epoch 30/50

25/25 [==============================] - 44s 2s/step - loss: 0.5258 - acc: 0.8132 - val\_loss: 0.8954 - val\_acc: 0.7177

Epoch 31/50

25/25 [==============================] - 44s 2s/step - loss: 0.5124 - acc: 0.8182 - val\_loss: 0.8602 - val\_acc: 0.7147

Epoch 32/50

25/25 [==============================] - 44s 2s/step - loss: 0.5038 - acc: 0.8205 - val\_loss: 0.7977 - val\_acc: 0.7351

Epoch 33/50

25/25 [==============================] - 44s 2s/step - loss: 0.5120 - acc: 0.8188 - val\_loss: 0.8406 - val\_acc: 0.7365

Epoch 34/50

25/25 [==============================] - 44s 2s/step - loss: 0.4970 - acc: 0.8247 - val\_loss: 0.8958 - val\_acc: 0.7187

Epoch 35/50

25/25 [==============================] - 44s 2s/step - loss: 0.4957 - acc: 0.8236 - val\_loss: 1.0402 - val\_acc: 0.6885

Epoch 36/50

25/25 [==============================] - 44s 2s/step - loss: 0.4844 - acc: 0.8306 - val\_loss: 0.9225 - val\_acc: 0.7158

Epoch 37/50

25/25 [==============================] - 45s 2s/step - loss: 0.4709 - acc: 0.8336 - val\_loss: 0.8258 - val\_acc: 0.7286

Epoch 38/50

25/25 [==============================] - 44s 2s/step - loss: 0.4686 - acc: 0.8334 - val\_loss: 0.9026 - val\_acc: 0.7229

Epoch 39/50

25/25 [==============================] - 44s 2s/step - loss: 0.5893 - acc: 0.7954 - val\_loss: 2.2384 - val\_acc: 0.4441

Epoch 40/50

25/25 [==============================] - 44s 2s/step - loss: 0.5832 - acc: 0.7924 - val\_loss: 13.2013 - val\_acc: 0.1306

Epoch 41/50

25/25 [==============================] - 44s 2s/step - loss: 0.5040 - acc: 0.8217 - val\_loss: 1.9886 - val\_acc: 0.6124

Epoch 42/50

25/25 [==============================] - 44s 2s/step - loss: 0.4721 - acc: 0.8322 - val\_loss: 0.8696 - val\_acc: 0.7246

Epoch 43/50

25/25 [==============================] - 44s 2s/step - loss: 0.4661 - acc: 0.8354 - val\_loss: 0.8427 - val\_acc: 0.7343

Epoch 44/50

25/25 [==============================] - 44s 2s/step - loss: 0.4545 - acc: 0.8380 - val\_loss: 0.7745 - val\_acc: 0.7532

Epoch 45/50

25/25 [==============================] - 45s 2s/step - loss: 0.4343 - acc: 0.8458 - val\_loss: 0.7667 - val\_acc: 0.7550

Epoch 46/50

25/25 [==============================] - 44s 2s/step - loss: 0.4446 - acc: 0.8412 - val\_loss: 0.8323 - val\_acc: 0.7343

Epoch 47/50

25/25 [==============================] - 44s 2s/step - loss: 0.4250 - acc: 0.8476 - val\_loss: 0.7983 - val\_acc: 0.7406

Epoch 48/50

25/25 [==============================] - 44s 2s/step - loss: 0.4227 - acc: 0.8494 - val\_loss: 0.8418 - val\_acc: 0.7449

Epoch 49/50

25/25 [==============================] - 44s 2s/step - loss: 0.4222 - acc: 0.8516 - val\_loss: 0.7964 - val\_acc: 0.7504

Epoch 50/50

25/25 [==============================] - 44s 2s/step - loss: 0.4150 - acc: 0.8523 - val\_loss: 0.9184 - val\_acc: 0.7265

Training time is 2239.8856904506683 s

Saved trained model at /model/resnet/resnet

10000/10000 [==============================] - 10s 1ms/step

Test loss: 0.9184365228652954

Test accuracy: 0.7265

4.

A close up of a map

Description automatically generated

A screenshot of a cell phone

Description automatically generated

A close up of a map

Description automatically generated

A screenshot of a cell phone

Description automatically generated

5.

The overall trend of training accuracy is increasing with larger epoch size, which means that the model fits the training dataset very well in the end. The overall trend of testing accuracy is not very stable, but still shows a generally increasing trend until reaching the epoch size of 40. In the beginning, the model is underfitting because the epoch is too small to explain the variance of the dataset. We only have a ~40% testing accuracy. Then the testing accuracy gradually increases with larger epoch size. The model is overfitting the training set at epoch size of 40 because the testing accuracy dropped significantly at this point. The model is not flexible enough to explain the variance of the testing dataset. In order to prevent underfitting and overfitting, we need to choose an appropriate epoch size. The testing accuracy displays a relatively stable increasing trend from epoch size 18 to 28.