q3

November 8, 2020

```python
[1]: import numpy as np
     import pandas as pd
     import matplotlib.pyplot as plt
     from sklearn.model_selection import train_test_split
     import tensorflow as tf
     # import tensorflow.contrib.keras as keras
     from tensorflow import keras
```

```python
[2]: #use saved data from problem 2a
     dataset = pd.read_csv('output_data.csv')
     X = dataset.iloc[:,[1,2]].values
     y = dataset.iloc[:,3].values
     assert(X.shape[0] == 2000)
     assert(X.shape[1] == 2)
     assert(y.shape[0] == 2000)

     #The train-test split to be used for the dataset is 80%-20%
     X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20)
     #Mean centering and normalization
     mean = np.mean(X_train, axis=0)
     std = np.std(X_train)

     X_trainc = (X_train - mean)/std
     X_testc = (X_test - mean)/std
```

```python
[4]: np.random.seed(123)
     tf.random.set_seed(123)
     #convert the labels into the one-hot format
     y_train_onehot = keras.utils.to_categorical(y_train)

     #initialize model
     model = keras.models.Sequential()

     #add input layer
     #the first two layers will each have 80 units with the tanh activation
     #the last layer (output layer) will have 20 ayers for the 20 class labels
     #uses softmax to give probability of each class.
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```python
model.add(keras.layers.Dense(units=80, input_dim=X_trainc.shape[1],
                             kernel_initializer='glorot_uniform',
                             bias_initializer='zeros',
                             activation='relu'))
model.add(keras.layers.Dense(units=80, input_dim=80,
                             kernel_initializer='glorot_uniform',
                             bias_initializer='zeros',
                             activation='relu'))
#add output layer
model.add(keras.layers.Dense(units=20, input_dim=y_train_onehot.shape[1],
                             kernel_initializer='glorot_uniform',
                             bias_initializer='zeros',
                             activation='softmax'))
#stochastic gradient optimizer
sgd_optimizer = keras.optimizers.SGD(lr=0.001, decay=1e-7, momentum=0.9)

model.compile(optimizer=sgd_optimizer, loss='categorical_crossentropy',␣
 →metrics=['accuracy'])

#train model
history = model.fit(X_trainc, y_train_onehot, batch_size=40,
                    epochs=300, verbose=1, validation_split=0.1)


#Goal: test accuracy of 85% achieved
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Train on 1440 samples, validate on 160 samples
Epoch 1/300
1440/1440 [==============================] - 1s 917us/sample - loss: 2.9668 -
accuracy: 0.0826 - val_loss: 2.9720 - val_accuracy: 0.0750
Epoch 2/300
1440/1440 [==============================] - 0s 125us/sample - loss: 2.9380 -
accuracy: 0.1000 - val_loss: 2.9482 - val_accuracy: 0.0750
Epoch 3/300
1440/1440 [==============================] - 0s 121us/sample - loss: 2.9110 -
accuracy: 0.1007 - val_loss: 2.9255 - val_accuracy: 0.0938
Epoch 4/300
1440/1440 [==============================] - 0s 122us/sample - loss: 2.8852 -
accuracy: 0.1056 - val_loss: 2.9035 - val_accuracy: 0.1063
Epoch 5/300
1440/1440 [==============================] - 0s 127us/sample - loss: 2.8592 -
accuracy: 0.1160 - val_loss: 2.8817 - val_accuracy: 0.1187
Epoch 6/300
1440/1440 [==============================] - 0s 119us/sample - loss: 2.8344 -
accuracy: 0.1250 - val_loss: 2.8603 - val_accuracy: 0.1187
Epoch 7/300
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1440/1440 [==============================] - 0s 118us/sample - loss: 2.8095 -
accuracy: 0.1257 - val_loss: 2.8394 - val_accuracy: 0.1187
Epoch 8/300
1440/1440 [==============================] - 0s 113us/sample - loss: 2.7845 -
accuracy: 0.1278 - val_loss: 2.8164 - val_accuracy: 0.1187
Epoch 9/300
1440/1440 [==============================] - 0s 115us/sample - loss: 2.7587 -
accuracy: 0.1306 - val_loss: 2.7935 - val_accuracy: 0.1187
Epoch 10/300
1440/1440 [==============================] - 0s 150us/sample - loss: 2.7326 -
accuracy: 0.1312 - val_loss: 2.7703 - val_accuracy: 0.1250
Epoch 11/300
1440/1440 [==============================] - 0s 135us/sample - loss: 2.7063 -
accuracy: 0.1361 - val_loss: 2.7464 - val_accuracy: 0.1250
Epoch 12/300
1440/1440 [==============================] - 0s 119us/sample - loss: 2.6800 -
accuracy: 0.1382 - val_loss: 2.7220 - val_accuracy: 0.1250
Epoch 13/300
1440/1440 [==============================] - 0s 126us/sample - loss: 2.6539 -
accuracy: 0.1403 - val_loss: 2.6973 - val_accuracy: 0.1250
Epoch 14/300
1440/1440 [==============================] - 0s 123us/sample - loss: 2.6275 -
accuracy: 0.1424 - val_loss: 2.6723 - val_accuracy: 0.1312
Epoch 15/300
1440/1440 [==============================] - 0s 124us/sample - loss: 2.6011 -
accuracy: 0.1444 - val_loss: 2.6460 - val_accuracy: 0.1375
Epoch 16/300
1440/1440 [==============================] - 0s 146us/sample - loss: 2.5746 -
accuracy: 0.1472 - val_loss: 2.6208 - val_accuracy: 0.1375
Epoch 17/300
1440/1440 [==============================] - 0s 128us/sample - loss: 2.5485 -
accuracy: 0.1486 - val_loss: 2.5936 - val_accuracy: 0.1375
Epoch 18/300
1440/1440 [==============================] - 0s 134us/sample - loss: 2.5222 -
accuracy: 0.1500 - val_loss: 2.5671 - val_accuracy: 0.1375
Epoch 19/300
1440/1440 [==============================] - 0s 138us/sample - loss: 2.4964 -
accuracy: 0.1514 - val_loss: 2.5398 - val_accuracy: 0.1437
Epoch 20/300
1440/1440 [==============================] - 0s 137us/sample - loss: 2.4710 -
accuracy: 0.1514 - val_loss: 2.5129 - val_accuracy: 0.1437
Epoch 21/300
1440/1440 [==============================] - 0s 126us/sample - loss: 2.4464 -
accuracy: 0.1514 - val_loss: 2.4872 - val_accuracy: 0.1375
Epoch 22/300
1440/1440 [==============================] - 0s 123us/sample - loss: 2.4224 -
accuracy: 0.1514 - val_loss: 2.4607 - val_accuracy: 0.1375
Epoch 23/300
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1440/1440 [==============================] - 0s 120us/sample - loss: 2.3989 -
accuracy: 0.1514 - val_loss: 2.4358 - val_accuracy: 0.1375
Epoch 24/300
1440/1440 [==============================] - 0s 121us/sample - loss: 2.3765 -
accuracy: 0.1500 - val_loss: 2.4102 - val_accuracy: 0.1375
Epoch 25/300
1440/1440 [==============================] - 0s 117us/sample - loss: 2.3545 -
accuracy: 0.1514 - val_loss: 2.3858 - val_accuracy: 0.1375
Epoch 26/300
1440/1440 [==============================] - 0s 119us/sample - loss: 2.3334 -
accuracy: 0.1583 - val_loss: 2.3621 - val_accuracy: 0.1562
Epoch 27/300
1440/1440 [==============================] - 0s 123us/sample - loss: 2.3131 -
accuracy: 0.1507 - val_loss: 2.3398 - val_accuracy: 0.1625
Epoch 28/300
1440/1440 [==============================] - 0s 123us/sample - loss: 2.2936 -
accuracy: 0.1562 - val_loss: 2.3182 - val_accuracy: 0.1375
Epoch 29/300
1440/1440 [==============================] - 0s 118us/sample - loss: 2.2749 -
accuracy: 0.1472 - val_loss: 2.2955 - val_accuracy: 0.1625
Epoch 30/300
1440/1440 [==============================] - 0s 120us/sample - loss: 2.2566 -
accuracy: 0.1549 - val_loss: 2.2753 - val_accuracy: 0.1375
Epoch 31/300
1440/1440 [==============================] - 0s 115us/sample - loss: 2.2384 -
accuracy: 0.1562 - val_loss: 2.2549 - val_accuracy: 0.1375
Epoch 32/300
1440/1440 [==============================] - 0s 119us/sample - loss: 2.2212 -
accuracy: 0.1562 - val_loss: 2.2350 - val_accuracy: 0.1375
Epoch 33/300
1440/1440 [==============================] - 0s 119us/sample - loss: 2.2035 -
accuracy: 0.1576 - val_loss: 2.2158 - val_accuracy: 0.1375
Epoch 34/300
1440/1440 [==============================] - 0s 117us/sample - loss: 2.1868 -
accuracy: 0.1632 - val_loss: 2.1966 - val_accuracy: 0.1500
Epoch 35/300
1440/1440 [==============================] - 0s 174us/sample - loss: 2.1705 -
accuracy: 0.1653 - val_loss: 2.1776 - val_accuracy: 0.1500
Epoch 36/300
1440/1440 [==============================] - 0s 167us/sample - loss: 2.1539 -
accuracy: 0.1688 - val_loss: 2.1589 - val_accuracy: 0.1562
Epoch 37/300
1440/1440 [==============================] - 0s 150us/sample - loss: 2.1382 -
accuracy: 0.1813 - val_loss: 2.1421 - val_accuracy: 0.1813
Epoch 38/300
1440/1440 [==============================] - 0s 115us/sample - loss: 2.1225 -
accuracy: 0.1944 - val_loss: 2.1238 - val_accuracy: 0.2188
Epoch 39/300
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1440/1440 [==============================] - 0s 117us/sample - loss: 2.1068 -
accuracy: 0.2125 - val_loss: 2.1055 - val_accuracy: 0.2438
Epoch 40/300
1440/1440 [==============================] - 0s 114us/sample - loss: 2.0921 -
accuracy: 0.2597 - val_loss: 2.0887 - val_accuracy: 0.2500
Epoch 41/300
1440/1440 [==============================] - 0s 114us/sample - loss: 2.0769 -
accuracy: 0.2319 - val_loss: 2.0740 - val_accuracy: 0.2625
Epoch 42/300
1440/1440 [==============================] - 0s 114us/sample - loss: 2.0621 -
accuracy: 0.2986 - val_loss: 2.0572 - val_accuracy: 0.2750
Epoch 43/300
1440/1440 [==============================] - 0s 122us/sample - loss: 2.0475 -
accuracy: 0.2806 - val_loss: 2.0397 - val_accuracy: 0.3375
Epoch 44/300
1440/1440 [==============================] - 0s 114us/sample - loss: 2.0324 -
accuracy: 0.2944 - val_loss: 2.0233 - val_accuracy: 0.3125
Epoch 45/300
1440/1440 [==============================] - 0s 116us/sample - loss: 2.0179 -
accuracy: 0.3208 - val_loss: 2.0079 - val_accuracy: 0.3438
Epoch 46/300
1440/1440 [==============================] - 0s 121us/sample - loss: 2.0040 -
accuracy: 0.3278 - val_loss: 1.9912 - val_accuracy: 0.2937
Epoch 47/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.9888 -
accuracy: 0.3285 - val_loss: 1.9764 - val_accuracy: 0.3812
Epoch 48/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.9740 -
accuracy: 0.3722 - val_loss: 1.9610 - val_accuracy: 0.3875
Epoch 49/300
1440/1440 [==============================] - 0s 117us/sample - loss: 1.9600 -
accuracy: 0.3667 - val_loss: 1.9446 - val_accuracy: 0.3812
Epoch 50/300
1440/1440 [==============================] - 0s 111us/sample - loss: 1.9453 -
accuracy: 0.3528 - val_loss: 1.9282 - val_accuracy: 0.3875
Epoch 51/300
1440/1440 [==============================] - 0s 116us/sample - loss: 1.9301 -
accuracy: 0.3903 - val_loss: 1.9115 - val_accuracy: 0.4062
Epoch 52/300
1440/1440 [==============================] - 0s 113us/sample - loss: 1.9157 -
accuracy: 0.3535 - val_loss: 1.8962 - val_accuracy: 0.3812
Epoch 53/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.9011 -
accuracy: 0.3889 - val_loss: 1.8809 - val_accuracy: 0.3875
Epoch 54/300
1440/1440 [==============================] - 0s 112us/sample - loss: 1.8872 -
accuracy: 0.3729 - val_loss: 1.8654 - val_accuracy: 0.4000
Epoch 55/300
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1440/1440 [==============================] - 0s 119us/sample - loss: 1.8731 -
accuracy: 0.4007 - val_loss: 1.8509 - val_accuracy: 0.4125
Epoch 56/300
1440/1440 [==============================] - 0s 112us/sample - loss: 1.8588 -
accuracy: 0.3924 - val_loss: 1.8359 - val_accuracy: 0.3625
Epoch 57/300
1440/1440 [==============================] - 0s 171us/sample - loss: 1.8446 -
accuracy: 0.3799 - val_loss: 1.8234 - val_accuracy: 0.4313
Epoch 58/300
1440/1440 [==============================] - 0s 151us/sample - loss: 1.8315 -
accuracy: 0.3812 - val_loss: 1.8066 - val_accuracy: 0.4250
Epoch 59/300
1440/1440 [==============================] - 0s 116us/sample - loss: 1.8170 -
accuracy: 0.3958 - val_loss: 1.7924 - val_accuracy: 0.4125
Epoch 60/300
1440/1440 [==============================] - 0s 135us/sample - loss: 1.8043 -
accuracy: 0.4167 - val_loss: 1.7802 - val_accuracy: 0.4437
Epoch 61/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.7925 -
accuracy: 0.4437 - val_loss: 1.7655 - val_accuracy: 0.4375
Epoch 62/300
1440/1440 [==============================] - 0s 161us/sample - loss: 1.7765 -
accuracy: 0.4583 - val_loss: 1.7500 - val_accuracy: 0.4250
Epoch 63/300
1440/1440 [==============================] - 0s 113us/sample - loss: 1.7638 -
accuracy: 0.4444 - val_loss: 1.7383 - val_accuracy: 0.4313
Epoch 64/300
1440/1440 [==============================] - 0s 116us/sample - loss: 1.7513 -
accuracy: 0.4778 - val_loss: 1.7232 - val_accuracy: 0.4938
Epoch 65/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.7375 -
accuracy: 0.4444 - val_loss: 1.7104 - val_accuracy: 0.4187
Epoch 66/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.7250 -
accuracy: 0.4500 - val_loss: 1.6966 - val_accuracy: 0.4750
Epoch 67/300
1440/1440 [==============================] - 0s 112us/sample - loss: 1.7118 -
accuracy: 0.4910 - val_loss: 1.6822 - val_accuracy: 0.4938
Epoch 68/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.7006 -
accuracy: 0.5063 - val_loss: 1.6689 - val_accuracy: 0.4375
Epoch 69/300
1440/1440 [==============================] - 0s 109us/sample - loss: 1.6875 -
accuracy: 0.4882 - val_loss: 1.6579 - val_accuracy: 0.4875
Epoch 70/300
1440/1440 [==============================] - 0s 110us/sample - loss: 1.6748 -
accuracy: 0.4639 - val_loss: 1.6448 - val_accuracy: 0.5312
Epoch 71/300
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1440/1440 [==============================] - 0s 119us/sample - loss: 1.6635 -
accuracy: 0.4965 - val_loss: 1.6306 - val_accuracy: 0.5000
Epoch 72/300
1440/1440 [==============================] - 0s 162us/sample - loss: 1.6519 -
accuracy: 0.5500 - val_loss: 1.6201 - val_accuracy: 0.5188
Epoch 73/300
1440/1440 [==============================] - 0s 128us/sample - loss: 1.6392 -
accuracy: 0.5431 - val_loss: 1.6100 - val_accuracy: 0.4938
Epoch 74/300
1440/1440 [==============================] - 0s 111us/sample - loss: 1.6270 -
accuracy: 0.5285 - val_loss: 1.5949 - val_accuracy: 0.5000
Epoch 75/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.6168 -
accuracy: 0.5271 - val_loss: 1.5847 - val_accuracy: 0.5625
Epoch 76/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.6049 -
accuracy: 0.5312 - val_loss: 1.5727 - val_accuracy: 0.5063
Epoch 77/300
1440/1440 [==============================] - ETA: 0s - loss: 1.5912 - accuracy:
0.58 - 0s 131us/sample - loss: 1.5927 - accuracy: 0.5840 - val_loss: 1.5631 -
val_accuracy: 0.5375
Epoch 78/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.5807 -
accuracy: 0.6028 - val_loss: 1.5484 - val_accuracy: 0.5688
Epoch 79/300
1440/1440 [==============================] - 0s 129us/sample - loss: 1.5701 -
accuracy: 0.5472 - val_loss: 1.5362 - val_accuracy: 0.5437
Epoch 80/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.5579 -
accuracy: 0.5965 - val_loss: 1.5281 - val_accuracy: 0.5188
Epoch 81/300
1440/1440 [==============================] - 0s 112us/sample - loss: 1.5491 -
accuracy: 0.5819 - val_loss: 1.5178 - val_accuracy: 0.6187
Epoch 82/300
1440/1440 [==============================] - 0s 112us/sample - loss: 1.5364 -
accuracy: 0.5583 - val_loss: 1.5052 - val_accuracy: 0.5875
Epoch 83/300
1440/1440 [==============================] - 0s 137us/sample - loss: 1.5265 -
accuracy: 0.5951 - val_loss: 1.4939 - val_accuracy: 0.5562
Epoch 84/300
1440/1440 [==============================] - 0s 130us/sample - loss: 1.5167 -
accuracy: 0.6014 - val_loss: 1.4848 - val_accuracy: 0.6187
Epoch 85/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.5053 -
accuracy: 0.6285 - val_loss: 1.4741 - val_accuracy: 0.5562
Epoch 86/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.4945 -
accuracy: 0.5986 - val_loss: 1.4631 - val_accuracy: 0.5312
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Epoch 87/300
1440/1440 [==============================] - 0s 162us/sample - loss: 1.4847 -
accuracy: 0.5938 - val_loss: 1.4551 - val_accuracy: 0.6062
Epoch 88/300
1440/1440 [==============================] - 0s 141us/sample - loss: 1.4765 -
accuracy: 0.6083 - val_loss: 1.4452 - val_accuracy: 0.5875
Epoch 89/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.4656 -
accuracy: 0.6375 - val_loss: 1.4320 - val_accuracy: 0.5813
Epoch 90/300
1440/1440 [==============================] - 0s 126us/sample - loss: 1.4559 -
accuracy: 0.6111 - val_loss: 1.4248 - val_accuracy: 0.6500
Epoch 91/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.4452 -
accuracy: 0.6056 - val_loss: 1.4143 - val_accuracy: 0.6187
Epoch 92/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.4372 -
accuracy: 0.6840 - val_loss: 1.3996 - val_accuracy: 0.6250
Epoch 93/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.4273 -
accuracy: 0.5986 - val_loss: 1.3944 - val_accuracy: 0.6438
Epoch 94/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.4187 -
accuracy: 0.6542 - val_loss: 1.3825 - val_accuracy: 0.6438
Epoch 95/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.4091 -
accuracy: 0.6313 - val_loss: 1.3791 - val_accuracy: 0.6062
Epoch 96/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.3997 -
accuracy: 0.6694 - val_loss: 1.3680 - val_accuracy: 0.6438
Epoch 97/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.3908 -
accuracy: 0.6653 - val_loss: 1.3579 - val_accuracy: 0.6500
Epoch 98/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.3814 -
accuracy: 0.6438 - val_loss: 1.3504 - val_accuracy: 0.5813
Epoch 99/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.3720 -
accuracy: 0.6306 - val_loss: 1.3415 - val_accuracy: 0.6313
Epoch 100/300
1440/1440 [==============================] - 0s 140us/sample - loss: 1.3629 -
accuracy: 0.7000 - val_loss: 1.3294 - val_accuracy: 0.6187
Epoch 101/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.3555 -
accuracy: 0.6292 - val_loss: 1.3249 - val_accuracy: 0.6812
Epoch 102/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.3476 -
accuracy: 0.6736 - val_loss: 1.3131 - val_accuracy: 0.6313
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Epoch 103/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.3386 -
accuracy: 0.6562 - val_loss: 1.3060 - val_accuracy: 0.6625
Epoch 104/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.3300 -
accuracy: 0.6632 - val_loss: 1.2977 - val_accuracy: 0.6938
Epoch 105/300
1440/1440 [==============================] - 0s 128us/sample - loss: 1.3226 -
accuracy: 0.7028 - val_loss: 1.2873 - val_accuracy: 0.7250
Epoch 106/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.3132 -
accuracy: 0.6847 - val_loss: 1.2808 - val_accuracy: 0.6687
Epoch 107/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.3062 -
accuracy: 0.6569 - val_loss: 1.2778 - val_accuracy: 0.6938
Epoch 108/300
1440/1440 [==============================] - 0s 113us/sample - loss: 1.2992 -
accuracy: 0.6722 - val_loss: 1.2643 - val_accuracy: 0.6625
Epoch 109/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.2894 -
accuracy: 0.6743 - val_loss: 1.2602 - val_accuracy: 0.6187
Epoch 110/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.2827 -
accuracy: 0.6924 - val_loss: 1.2535 - val_accuracy: 0.6750
Epoch 111/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.2758 -
accuracy: 0.6715 - val_loss: 1.2430 - val_accuracy: 0.7188
Epoch 112/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.2655 -
accuracy: 0.7139 - val_loss: 1.2318 - val_accuracy: 0.6438
Epoch 113/300
1440/1440 [==============================] - 0s 126us/sample - loss: 1.2587 -
accuracy: 0.6944 - val_loss: 1.2272 - val_accuracy: 0.6938
Epoch 114/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.2521 -
accuracy: 0.7167 - val_loss: 1.2168 - val_accuracy: 0.7250
Epoch 115/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.2446 -
accuracy: 0.7076 - val_loss: 1.2135 - val_accuracy: 0.6438
Epoch 116/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.2377 -
accuracy: 0.7097 - val_loss: 1.2019 - val_accuracy: 0.6875
Epoch 117/300
1440/1440 [==============================] - 0s 129us/sample - loss: 1.2317 -
accuracy: 0.6986 - val_loss: 1.1968 - val_accuracy: 0.7125
Epoch 118/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.2238 -
accuracy: 0.7479 - val_loss: 1.1936 - val_accuracy: 0.6875
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Epoch 119/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.2169 -
accuracy: 0.7021 - val_loss: 1.1839 - val_accuracy: 0.6750
Epoch 120/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.2080 -
accuracy: 0.7118 - val_loss: 1.1746 - val_accuracy: 0.7000
Epoch 121/300
1440/1440 [==============================] - 0s 117us/sample - loss: 1.2015 -
accuracy: 0.7264 - val_loss: 1.1731 - val_accuracy: 0.7250
Epoch 122/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.1946 -
accuracy: 0.7465 - val_loss: 1.1619 - val_accuracy: 0.6812
Epoch 123/300
1440/1440 [==============================] - 0s 155us/sample - loss: 1.1899 -
accuracy: 0.7125 - val_loss: 1.1539 - val_accuracy: 0.7125
Epoch 124/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.1811 -
accuracy: 0.7160 - val_loss: 1.1476 - val_accuracy: 0.7188
Epoch 125/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.1757 -
accuracy: 0.7333 - val_loss: 1.1412 - val_accuracy: 0.6875
Epoch 126/300
1440/1440 [==============================] - 0s 117us/sample - loss: 1.1689 -
accuracy: 0.7035 - val_loss: 1.1342 - val_accuracy: 0.7125
Epoch 127/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.1627 -
accuracy: 0.7104 - val_loss: 1.1310 - val_accuracy: 0.7750
Epoch 128/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.1575 -
accuracy: 0.7174 - val_loss: 1.1223 - val_accuracy: 0.7000
Epoch 129/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.1524 -
accuracy: 0.6812 - val_loss: 1.1135 - val_accuracy: 0.7375
Epoch 130/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.1450 -
accuracy: 0.7132 - val_loss: 1.1138 - val_accuracy: 0.7625
Epoch 131/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.1385 -
accuracy: 0.7472 - val_loss: 1.1044 - val_accuracy: 0.7500
Epoch 132/300
1440/1440 [==============================] - 0s 119us/sample - loss: 1.1320 -
accuracy: 0.7153 - val_loss: 1.0947 - val_accuracy: 0.7875
Epoch 133/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.1250 -
accuracy: 0.7410 - val_loss: 1.0887 - val_accuracy: 0.7500
Epoch 134/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.1177 -
accuracy: 0.7382 - val_loss: 1.0909 - val_accuracy: 0.7250
```

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Epoch 135/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.1117 -
accuracy: 0.7389 - val_loss: 1.0767 - val_accuracy: 0.7437
Epoch 136/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.1070 -
accuracy: 0.7042 - val_loss: 1.0768 - val_accuracy: 0.7563
Epoch 137/300
1440/1440 [==============================] - 0s 132us/sample - loss: 1.1000 -
accuracy: 0.7479 - val_loss: 1.0698 - val_accuracy: 0.7375
Epoch 138/300
1440/1440 [==============================] - 0s 122us/sample - loss: 1.0943 -
accuracy: 0.7194 - val_loss: 1.0653 - val_accuracy: 0.7437
Epoch 139/300
1440/1440 [==============================] - 0s 128us/sample - loss: 1.0899 -
accuracy: 0.7104 - val_loss: 1.0589 - val_accuracy: 0.7437
Epoch 140/300
1440/1440 [==============================] - 0s 127us/sample - loss: 1.0849 -
accuracy: 0.7361 - val_loss: 1.0533 - val_accuracy: 0.7437
Epoch 141/300
1440/1440 [==============================] - 0s 129us/sample - loss: 1.0768 -
accuracy: 0.7424 - val_loss: 1.0432 - val_accuracy: 0.7812
Epoch 142/300
1440/1440 [==============================] - 0s 126us/sample - loss: 1.0715 -
accuracy: 0.7736 - val_loss: 1.0397 - val_accuracy: 0.7375
Epoch 143/300
1440/1440 [==============================] - 0s 125us/sample - loss: 1.0671 -
accuracy: 0.7771 - val_loss: 1.0338 - val_accuracy: 0.8188
Epoch 144/300
1440/1440 [==============================] - 0s 120us/sample - loss: 1.0602 -
accuracy: 0.7819 - val_loss: 1.0296 - val_accuracy: 0.8000
Epoch 145/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.0571 -
accuracy: 0.7563 - val_loss: 1.0244 - val_accuracy: 0.7437
Epoch 146/300
1440/1440 [==============================] - 0s 115us/sample - loss: 1.0508 -
accuracy: 0.7576 - val_loss: 1.0156 - val_accuracy: 0.7500
Epoch 147/300
1440/1440 [==============================] - 0s 113us/sample - loss: 1.0444 -
accuracy: 0.7382 - val_loss: 1.0141 - val_accuracy: 0.7625
Epoch 148/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.0398 -
accuracy: 0.7604 - val_loss: 1.0070 - val_accuracy: 0.7437
Epoch 149/300
1440/1440 [==============================] - 0s 116us/sample - loss: 1.0326 -
accuracy: 0.7382 - val_loss: 1.0030 - val_accuracy: 0.7625
Epoch 150/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.0301 -
accuracy: 0.7417 - val_loss: 0.9987 - val_accuracy: 0.7688
```

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Epoch 151/300
1440/1440 [==============================] - 0s 118us/sample - loss: 1.0234 -
accuracy: 0.7660 - val_loss: 0.9945 - val_accuracy: 0.7750
Epoch 152/300
1440/1440 [==============================] - 0s 122us/sample - loss: 1.0175 -
accuracy: 0.8014 - val_loss: 0.9846 - val_accuracy: 0.7875
Epoch 153/300
1440/1440 [==============================] - 0s 124us/sample - loss: 1.0115 -
accuracy: 0.7437 - val_loss: 0.9844 - val_accuracy: 0.7563
Epoch 154/300
1440/1440 [==============================] - 0s 123us/sample - loss: 1.0052 -
accuracy: 0.7576 - val_loss: 0.9725 - val_accuracy: 0.6938
Epoch 155/300
1440/1440 [==============================] - 0s 121us/sample - loss: 1.0028 -
accuracy: 0.7625 - val_loss: 0.9741 - val_accuracy: 0.7812
Epoch 156/300
1440/1440 [==============================] - 0s 125us/sample - loss: 0.9963 -
accuracy: 0.7847 - val_loss: 0.9606 - val_accuracy: 0.7937
Epoch 157/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.9907 -
accuracy: 0.7937 - val_loss: 0.9621 - val_accuracy: 0.7563
Epoch 158/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.9890 -
accuracy: 0.7667 - val_loss: 0.9524 - val_accuracy: 0.8062
Epoch 159/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.9805 -
accuracy: 0.7924 - val_loss: 0.9470 - val_accuracy: 0.7937
Epoch 160/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.9747 -
accuracy: 0.7736 - val_loss: 0.9496 - val_accuracy: 0.7937
Epoch 161/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.9735 -
accuracy: 0.7535 - val_loss: 0.9393 - val_accuracy: 0.7188
Epoch 162/300
1440/1440 [==============================] - 0s 123us/sample - loss: 0.9662 -
accuracy: 0.7604 - val_loss: 0.9328 - val_accuracy: 0.7375
Epoch 163/300
1440/1440 [==============================] - 0s 151us/sample - loss: 0.9618 -
accuracy: 0.7674 - val_loss: 0.9227 - val_accuracy: 0.8125
Epoch 164/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.9560 -
accuracy: 0.7785 - val_loss: 0.9254 - val_accuracy: 0.7688
Epoch 165/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.9515 -
accuracy: 0.7799 - val_loss: 0.9204 - val_accuracy: 0.7937
Epoch 166/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.9473 -
accuracy: 0.7819 - val_loss: 0.9198 - val_accuracy: 0.7375
```

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Epoch 167/300
1440/1440 [==============================] - 0s 126us/sample - loss: 0.9402 -
accuracy: 0.7924 - val_loss: 0.9098 - val_accuracy: 0.7750
Epoch 168/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.9380 -
accuracy: 0.7667 - val_loss: 0.9059 - val_accuracy: 0.8188
Epoch 169/300
1440/1440 [==============================] - 0s 120us/sample - loss: 0.9315 -
accuracy: 0.8056 - val_loss: 0.9015 - val_accuracy: 0.7750
Epoch 170/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.9284 -
accuracy: 0.7799 - val_loss: 0.8966 - val_accuracy: 0.8062
Epoch 171/300
1440/1440 [==============================] - 0s 113us/sample - loss: 0.9203 -
accuracy: 0.7903 - val_loss: 0.8914 - val_accuracy: 0.7625
Epoch 172/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.9204 -
accuracy: 0.7812 - val_loss: 0.8880 - val_accuracy: 0.7437
Epoch 173/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.9125 -
accuracy: 0.7931 - val_loss: 0.8843 - val_accuracy: 0.8062
Epoch 174/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.9075 -
accuracy: 0.7757 - val_loss: 0.8802 - val_accuracy: 0.7750
Epoch 175/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.9060 -
accuracy: 0.7514 - val_loss: 0.8725 - val_accuracy: 0.8000
Epoch 176/300
1440/1440 [==============================] - 0s 111us/sample - loss: 0.9002 -
accuracy: 0.7924 - val_loss: 0.8692 - val_accuracy: 0.8062
Epoch 177/300
1440/1440 [==============================] - 0s 111us/sample - loss: 0.8941 -
accuracy: 0.8153 - val_loss: 0.8632 - val_accuracy: 0.7937
Epoch 178/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.8879 -
accuracy: 0.7840 - val_loss: 0.8593 - val_accuracy: 0.7750
Epoch 179/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.8815 -
accuracy: 0.7958 - val_loss: 0.8602 - val_accuracy: 0.8188
Epoch 180/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.8809 -
accuracy: 0.8111 - val_loss: 0.8573 - val_accuracy: 0.7937
Epoch 181/300
1440/1440 [==============================] - 0s 146us/sample - loss: 0.8773 -
accuracy: 0.7646 - val_loss: 0.8455 - val_accuracy: 0.8313
Epoch 182/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.8725 -
accuracy: 0.8014 - val_loss: 0.8410 - val_accuracy: 0.7688
```

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Epoch 183/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.8673 -
accuracy: 0.8139 - val_loss: 0.8467 - val_accuracy: 0.8125
Epoch 184/300
1440/1440 [==============================] - 0s 125us/sample - loss: 0.8598 -
accuracy: 0.8333 - val_loss: 0.8313 - val_accuracy: 0.8500
Epoch 185/300
1440/1440 [==============================] - 0s 128us/sample - loss: 0.8552 -
accuracy: 0.7993 - val_loss: 0.8255 - val_accuracy: 0.8062
Epoch 186/300
1440/1440 [==============================] - 0s 122us/sample - loss: 0.8507 -
accuracy: 0.8000 - val_loss: 0.8254 - val_accuracy: 0.7750
Epoch 187/300
1440/1440 [==============================] - 0s 142us/sample - loss: 0.8468 -
accuracy: 0.7972 - val_loss: 0.8201 - val_accuracy: 0.7750
Epoch 188/300
1440/1440 [==============================] - 0s 142us/sample - loss: 0.8474 -
accuracy: 0.7778 - val_loss: 0.8158 - val_accuracy: 0.7250
Epoch 189/300
1440/1440 [==============================] - 0s 129us/sample - loss: 0.8421 -
accuracy: 0.7701 - val_loss: 0.8103 - val_accuracy: 0.8375
Epoch 190/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.8365 -
accuracy: 0.8021 - val_loss: 0.8016 - val_accuracy: 0.8438
Epoch 191/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.8278 -
accuracy: 0.8021 - val_loss: 0.8005 - val_accuracy: 0.7937
Epoch 192/300
1440/1440 [==============================] - 0s 110us/sample - loss: 0.8245 -
accuracy: 0.8007 - val_loss: 0.7979 - val_accuracy: 0.8313
Epoch 193/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.8234 -
accuracy: 0.8083 - val_loss: 0.8016 - val_accuracy: 0.7625
Epoch 194/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.8178 -
accuracy: 0.7944 - val_loss: 0.7957 - val_accuracy: 0.8188
Epoch 195/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.8176 -
accuracy: 0.8062 - val_loss: 0.7929 - val_accuracy: 0.8000
Epoch 196/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.8061 -
accuracy: 0.8153 - val_loss: 0.7857 - val_accuracy: 0.7625
Epoch 197/300
1440/1440 [==============================] - 0s 130us/sample - loss: 0.8067 -
accuracy: 0.7979 - val_loss: 0.7744 - val_accuracy: 0.8125
Epoch 198/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.7988 -
accuracy: 0.8069 - val_loss: 0.7705 - val_accuracy: 0.8188
```

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Epoch 199/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.7930 -
accuracy: 0.8021 - val_loss: 0.7736 - val_accuracy: 0.8438
Epoch 200/300
1440/1440 [==============================] - 0s 119us/sample - loss: 0.7885 -
accuracy: 0.8201 - val_loss: 0.7590 - val_accuracy: 0.8438
Epoch 201/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.7860 -
accuracy: 0.8028 - val_loss: 0.7614 - val_accuracy: 0.7875
Epoch 202/300
1440/1440 [==============================] - 0s 127us/sample - loss: 0.7823 -
accuracy: 0.8174 - val_loss: 0.7574 - val_accuracy: 0.7937
Epoch 203/300
1440/1440 [==============================] - 0s 123us/sample - loss: 0.7796 -
accuracy: 0.8049 - val_loss: 0.7477 - val_accuracy: 0.7937
Epoch 204/300
1440/1440 [==============================] - 0s 125us/sample - loss: 0.7795 -
accuracy: 0.7889 - val_loss: 0.7437 - val_accuracy: 0.8188
Epoch 205/300
1440/1440 [==============================] - ETA: 0s - loss: 0.7698 - accuracy:
0.80 - 0s 133us/sample - loss: 0.7712 - accuracy: 0.8083 - val_loss: 0.7456 -
val_accuracy: 0.8250
Epoch 206/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.7664 -
accuracy: 0.7931 - val_loss: 0.7455 - val_accuracy: 0.8000
Epoch 207/300
1440/1440 [==============================] - 0s 130us/sample - loss: 0.7607 -
accuracy: 0.8153 - val_loss: 0.7389 - val_accuracy: 0.8000
Epoch 208/300
1440/1440 [==============================] - 0s 124us/sample - loss: 0.7551 -
accuracy: 0.8264 - val_loss: 0.7347 - val_accuracy: 0.8438
Epoch 209/300
1440/1440 [==============================] - 0s 128us/sample - loss: 0.7510 -
accuracy: 0.8194 - val_loss: 0.7288 - val_accuracy: 0.8188
Epoch 210/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.7514 -
accuracy: 0.8194 - val_loss: 0.7355 - val_accuracy: 0.7812
Epoch 211/300
1440/1440 [==============================] - 0s 111us/sample - loss: 0.7429 -
accuracy: 0.8326 - val_loss: 0.7205 - val_accuracy: 0.8687
Epoch 212/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.7419 -
accuracy: 0.8090 - val_loss: 0.7254 - val_accuracy: 0.8250
Epoch 213/300
1440/1440 [==============================] - 0s 127us/sample - loss: 0.7401 -
accuracy: 0.8076 - val_loss: 0.7161 - val_accuracy: 0.8125
Epoch 214/300
1440/1440 [==============================] - 0s 126us/sample - loss: 0.7308 -
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accuracy: 0.8257 - val_loss: 0.7106 - val_accuracy: 0.8500
Epoch 215/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.7279 -
accuracy: 0.8146 - val_loss: 0.7064 - val_accuracy: 0.8313
Epoch 216/300
1440/1440 [==============================] - 0s 124us/sample - loss: 0.7259 -
accuracy: 0.8139 - val_loss: 0.7116 - val_accuracy: 0.7563
Epoch 217/300
1440/1440 [==============================] - 0s 142us/sample - loss: 0.7201 -
accuracy: 0.8181 - val_loss: 0.6910 - val_accuracy: 0.8438
Epoch 218/300
1440/1440 [==============================] - 0s 128us/sample - loss: 0.7128 -
accuracy: 0.8326 - val_loss: 0.7009 - val_accuracy: 0.8250
Epoch 219/300
1440/1440 [==============================] - 0s 135us/sample - loss: 0.7124 -
accuracy: 0.8313 - val_loss: 0.6863 - val_accuracy: 0.8375
Epoch 220/300
1440/1440 [==============================] - 0s 122us/sample - loss: 0.7091 -
accuracy: 0.8167 - val_loss: 0.6786 - val_accuracy: 0.8188
Epoch 221/300
1440/1440 [==============================] - 0s 137us/sample - loss: 0.7131 -
accuracy: 0.8000 - val_loss: 0.6864 - val_accuracy: 0.8375
Epoch 222/300
1440/1440 [==============================] - 0s 127us/sample - loss: 0.7031 -
accuracy: 0.8181 - val_loss: 0.6828 - val_accuracy: 0.8687
Epoch 223/300
1440/1440 [==============================] - 0s 126us/sample - loss: 0.7035 -
accuracy: 0.8153 - val_loss: 0.6773 - val_accuracy: 0.7875
Epoch 224/300
1440/1440 [==============================] - 0s 142us/sample - loss: 0.6934 -
accuracy: 0.8285 - val_loss: 0.6655 - val_accuracy: 0.8813
Epoch 225/300
1440/1440 [==============================] - 0s 157us/sample - loss: 0.6891 -
accuracy: 0.8604 - val_loss: 0.6684 - val_accuracy: 0.8250
Epoch 226/300
1440/1440 [==============================] - 0s 147us/sample - loss: 0.6868 -
accuracy: 0.8299 - val_loss: 0.6599 - val_accuracy: 0.8625
Epoch 227/300
1440/1440 [==============================] - 0s 155us/sample - loss: 0.6816 -
accuracy: 0.8278 - val_loss: 0.6679 - val_accuracy: 0.8062
Epoch 228/300
1440/1440 [==============================] - 0s 136us/sample - loss: 0.6781 -
accuracy: 0.8438 - val_loss: 0.6630 - val_accuracy: 0.8687
Epoch 229/300
1440/1440 [==============================] - 0s 155us/sample - loss: 0.6745 -
accuracy: 0.8625 - val_loss: 0.6611 - val_accuracy: 0.8500
Epoch 230/300
1440/1440 [==============================] - 0s 165us/sample - loss: 0.6698 -
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accuracy: 0.8215 - val_loss: 0.6524 - val_accuracy: 0.8062
Epoch 231/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.6674 -
accuracy: 0.8222 - val_loss: 0.6472 - val_accuracy: 0.8438
Epoch 232/300
1440/1440 [==============================] - 0s 112us/sample - loss: 0.6678 -
accuracy: 0.8181 - val_loss: 0.6436 - val_accuracy: 0.8562
Epoch 233/300
1440/1440 [==============================] - 0s 113us/sample - loss: 0.6636 -
accuracy: 0.8139 - val_loss: 0.6443 - val_accuracy: 0.8062
Epoch 234/300
1440/1440 [==============================] - 0s 120us/sample - loss: 0.6539 -
accuracy: 0.8382 - val_loss: 0.6490 - val_accuracy: 0.8500
Epoch 235/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.6548 -
accuracy: 0.8424 - val_loss: 0.6310 - val_accuracy: 0.8625
Epoch 236/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.6518 -
accuracy: 0.8264 - val_loss: 0.6337 - val_accuracy: 0.8500
Epoch 237/300
1440/1440 [==============================] - 0s 115us/sample - loss: 0.6448 -
accuracy: 0.8438 - val_loss: 0.6243 - val_accuracy: 0.9062
Epoch 238/300
1440/1440 [==============================] - 0s 117us/sample - loss: 0.6424 -
accuracy: 0.8458 - val_loss: 0.6320 - val_accuracy: 0.7875
Epoch 239/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.6366 -
accuracy: 0.8382 - val_loss: 0.6215 - val_accuracy: 0.8938
Epoch 240/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.6346 -
accuracy: 0.8347 - val_loss: 0.6306 - val_accuracy: 0.8375
Epoch 241/300
1440/1440 [==============================] - 0s 122us/sample - loss: 0.6344 -
accuracy: 0.8299 - val_loss: 0.6131 - val_accuracy: 0.8438
Epoch 242/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.6286 -
accuracy: 0.8194 - val_loss: 0.6063 - val_accuracy: 0.8625
Epoch 243/300
1440/1440 [==============================] - 0s 111us/sample - loss: 0.6247 -
accuracy: 0.8556 - val_loss: 0.6080 - val_accuracy: 0.8562
Epoch 244/300
1440/1440 [==============================] - 0s 109us/sample - loss: 0.6211 -
accuracy: 0.8514 - val_loss: 0.6114 - val_accuracy: 0.8562
Epoch 245/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.6185 -
accuracy: 0.8340 - val_loss: 0.6019 - val_accuracy: 0.8375
Epoch 246/300
1440/1440 [==============================] - 0s 112us/sample - loss: 0.6135 -

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accuracy: 0.8354 - val_loss: 0.6162 - val_accuracy: 0.8000
Epoch 247/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.6153 -
accuracy: 0.8382 - val_loss: 0.5977 - val_accuracy: 0.8375
Epoch 248/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.6102 -
accuracy: 0.8451 - val_loss: 0.5924 - val_accuracy: 0.8313
Epoch 249/300
1440/1440 [==============================] - 0s 107us/sample - loss: 0.6045 -
accuracy: 0.8632 - val_loss: 0.5907 - val_accuracy: 0.8438
Epoch 250/300
1440/1440 [==============================] - 0s 103us/sample - loss: 0.6038 -
accuracy: 0.8361 - val_loss: 0.5834 - val_accuracy: 0.8375
Epoch 251/300
1440/1440 [==============================] - 0s 123us/sample - loss: 0.6065 -
accuracy: 0.8354 - val_loss: 0.5964 - val_accuracy: 0.8500
Epoch 252/300
1440/1440 [==============================] - 0s 135us/sample - loss: 0.6000 -
accuracy: 0.8576 - val_loss: 0.5854 - val_accuracy: 0.8250
Epoch 253/300
1440/1440 [==============================] - 0s 123us/sample - loss: 0.5950 -
accuracy: 0.8444 - val_loss: 0.5836 - val_accuracy: 0.8500
Epoch 254/300
1440/1440 [==============================] - 0s 153us/sample - loss: 0.5886 -
accuracy: 0.8576 - val_loss: 0.5654 - val_accuracy: 0.8750
Epoch 255/300
1440/1440 [==============================] - 0s 150us/sample - loss: 0.5903 -
accuracy: 0.8403 - val_loss: 0.5734 - val_accuracy: 0.8500
Epoch 256/300
1440/1440 [==============================] - 0s 155us/sample - loss: 0.5851 -
accuracy: 0.8639 - val_loss: 0.5669 - val_accuracy: 0.8562
Epoch 257/300
1440/1440 [==============================] - 0s 158us/sample - loss: 0.5794 -
accuracy: 0.8653 - val_loss: 0.5818 - val_accuracy: 0.8375
Epoch 258/300
1440/1440 [==============================] - 0s 166us/sample - loss: 0.5782 -
accuracy: 0.8299 - val_loss: 0.5685 - val_accuracy: 0.8375
Epoch 259/300
1440/1440 [==============================] - 0s 136us/sample - loss: 0.5761 -
accuracy: 0.8528 - val_loss: 0.5571 - val_accuracy: 0.8313
Epoch 260/300
1440/1440 [==============================] - 0s 146us/sample - loss: 0.5754 -
accuracy: 0.8604 - val_loss: 0.5543 - val_accuracy: 0.8375
Epoch 261/300
1440/1440 [==============================] - 0s 146us/sample - loss: 0.5703 -
accuracy: 0.8625 - val_loss: 0.5604 - val_accuracy: 0.8500
Epoch 262/300
1440/1440 [==============================] - 0s 138us/sample - loss: 0.5691 -
```

```
accuracy: 0.8542 - val_loss: 0.5496 - val_accuracy: 0.8562
Epoch 263/300
1440/1440 [==============================] - 0s 118us/sample - loss: 0.5682 -
accuracy: 0.8514 - val_loss: 0.5441 - val_accuracy: 0.8438
Epoch 264/300
1440/1440 [==============================] - 0s 138us/sample - loss: 0.5657 -
accuracy: 0.8542 - val_loss: 0.5481 - val_accuracy: 0.8625
Epoch 265/300
1440/1440 [==============================] - 0s 140us/sample - loss: 0.5601 -
accuracy: 0.8590 - val_loss: 0.5451 - val_accuracy: 0.8813
Epoch 266/300
1440/1440 [==============================] - 0s 145us/sample - loss: 0.5587 -
accuracy: 0.8375 - val_loss: 0.5324 - val_accuracy: 0.8625
Epoch 267/300
1440/1440 [==============================] - 0s 156us/sample - loss: 0.5545 -
accuracy: 0.8458 - val_loss: 0.5407 - val_accuracy: 0.8562
Epoch 268/300
1440/1440 [==============================] - 0s 161us/sample - loss: 0.5506 -
accuracy: 0.8639 - val_loss: 0.5256 - val_accuracy: 0.8500
Epoch 269/300
1440/1440 [==============================] - 0s 112us/sample - loss: 0.5509 -
accuracy: 0.8361 - val_loss: 0.5409 - val_accuracy: 0.8438
Epoch 270/300
1440/1440 [==============================] - 0s 124us/sample - loss: 0.5485 -
accuracy: 0.8472 - val_loss: 0.5249 - val_accuracy: 0.8938
Epoch 271/300
1440/1440 [==============================] - 0s 120us/sample - loss: 0.5461 -
accuracy: 0.8368 - val_loss: 0.5287 - val_accuracy: 0.8938
Epoch 272/300
1440/1440 [==============================] - 0s 138us/sample - loss: 0.5455 -
accuracy: 0.8347 - val_loss: 0.5311 - val_accuracy: 0.8188
Epoch 273/300
1440/1440 [==============================] - 0s 138us/sample - loss: 0.5377 -
accuracy: 0.8618 - val_loss: 0.5330 - val_accuracy: 0.8062
Epoch 274/300
1440/1440 [==============================] - 0s 142us/sample - loss: 0.5357 -
accuracy: 0.8514 - val_loss: 0.5402 - val_accuracy: 0.8438
Epoch 275/300
1440/1440 [==============================] - 0s 156us/sample - loss: 0.5344 -
accuracy: 0.8681 - val_loss: 0.5199 - val_accuracy: 0.8813
Epoch 276/300
1440/1440 [==============================] - 0s 164us/sample - loss: 0.5320 -
accuracy: 0.8569 - val_loss: 0.5133 - val_accuracy: 0.8875
Epoch 277/300
1440/1440 [==============================] - 0s 160us/sample - loss: 0.5292 -
accuracy: 0.8792 - val_loss: 0.5115 - val_accuracy: 0.8375
Epoch 278/300
1440/1440 [==============================] - 0s 149us/sample - loss: 0.5266 -
```

```
accuracy: 0.8507 - val_loss: 0.5220 - val_accuracy: 0.8625
Epoch 279/300
1440/1440 [==============================] - 0s 150us/sample - loss: 0.5323 -
accuracy: 0.8479 - val_loss: 0.5176 - val_accuracy: 0.8375
Epoch 280/300
1440/1440 [==============================] - 0s 153us/sample - loss: 0.5241 -
accuracy: 0.8458 - val_loss: 0.5142 - val_accuracy: 0.8938
Epoch 281/300
1440/1440 [==============================] - 0s 150us/sample - loss: 0.5198 -
accuracy: 0.8813 - val_loss: 0.5030 - val_accuracy: 0.8813
Epoch 282/300
1440/1440 [==============================] - 0s 140us/sample - loss: 0.5192 -
accuracy: 0.8528 - val_loss: 0.4999 - val_accuracy: 0.8625
Epoch 283/300
1440/1440 [==============================] - 0s 139us/sample - loss: 0.5121 -
accuracy: 0.8847 - val_loss: 0.5117 - val_accuracy: 0.8375
Epoch 284/300
1440/1440 [==============================] - 0s 125us/sample - loss: 0.5106 -
accuracy: 0.8618 - val_loss: 0.4951 - val_accuracy: 0.8687
Epoch 285/300
1440/1440 [==============================] - 0s 144us/sample - loss: 0.5109 -
accuracy: 0.8722 - val_loss: 0.5014 - val_accuracy: 0.9062
Epoch 286/300
1440/1440 [==============================] - 0s 121us/sample - loss: 0.5098 -
accuracy: 0.8542 - val_loss: 0.4943 - val_accuracy: 0.8750
Epoch 287/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.5045 -
accuracy: 0.8708 - val_loss: 0.4953 - val_accuracy: 0.8813
Epoch 288/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.5121 -
accuracy: 0.8597 - val_loss: 0.4887 - val_accuracy: 0.8813
Epoch 289/300
1440/1440 [==============================] - 0s 107us/sample - loss: 0.5007 -
accuracy: 0.8729 - val_loss: 0.4877 - val_accuracy: 0.8562
Epoch 290/300
1440/1440 [==============================] - 0s 106us/sample - loss: 0.5019 -
accuracy: 0.8521 - val_loss: 0.4856 - val_accuracy: 0.8938
Epoch 291/300
1440/1440 [==============================] - 0s 108us/sample - loss: 0.4978 -
accuracy: 0.8681 - val_loss: 0.4901 - val_accuracy: 0.8375
Epoch 292/300
1440/1440 [==============================] - 0s 113us/sample - loss: 0.4924 -
accuracy: 0.8868 - val_loss: 0.4817 - val_accuracy: 0.8625
Epoch 293/300
1440/1440 [==============================] - 0s 108us/sample - loss: 0.4946 -
accuracy: 0.8639 - val_loss: 0.4850 - val_accuracy: 0.9000
Epoch 294/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.4915 -
```

```
accuracy: 0.8799 - val_loss: 0.4775 - val_accuracy: 0.8562
Epoch 295/300
1440/1440 [==============================] - 0s 116us/sample - loss: 0.4873 -
accuracy: 0.8854 - val_loss: 0.4789 - val_accuracy: 0.8687
Epoch 296/300
1440/1440 [==============================] - 0s 105us/sample - loss: 0.4909 -
accuracy: 0.8715 - val_loss: 0.4815 - val_accuracy: 0.8375
Epoch 297/300
1440/1440 [==============================] - 0s 98us/sample - loss: 0.4804 -
accuracy: 0.8681 - val_loss: 0.4813 - val_accuracy: 0.8438
Epoch 298/300
1440/1440 [==============================] - 0s 114us/sample - loss: 0.4868 -
accuracy: 0.8674 - val_loss: 0.4677 - val_accuracy: 0.9187
Epoch 299/300
1440/1440 [==============================] - 0s 112us/sample - loss: 0.4787 -
accuracy: 0.8965 - val_loss: 0.4684 - val_accuracy: 0.8562
Epoch 300/300
1440/1440 [==============================] - 0s 100us/sample - loss: 0.4825 -
accuracy: 0.8701 - val_loss: 0.4732 - val_accuracy: 0.8813
```

[5]:
```python
#Calculating the training accuracy
y_train_pred = model.predict_classes(X_trainc, verbose=0)
count_pred = np.sum(y_train == y_train_pred, axis=0)
accuracy_train = (count_pred/y_train.shape[0])*100
print('Training accuracy: ', accuracy_train)

#Calculating the testing accuracy
y_test_pred = model.predict_classes(X_testc, verbose=0)
count_pred = np.sum(y_test == y_test_pred, axis=0)
accuracy_test = (count_pred/y_test.shape[0])*100
print('Test accuracy: ', accuracy_test)
```

```
Training accuracy:  89.75
Test accuracy:  88.0
```

[ ]: