

VIT-Vellore, SCOPE

CSE6037 - Deep Learning and its Applications

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Assessment 5

GitHub Link: https://github.com/manansuthar55/CSE6037_20MAI0016/tree/main/Assessment_5

Problem 1: Vanilla RNN.

In [1]:

```
import numpy as np
from sklearn.metrics import accuracy_score
from keras.datasets import reuters
from keras.preprocessing.sequence import pad_sequences
from keras.utils import to_categorical
from keras.models import Sequential
from keras.layers import Dense, SimpleRNN, Activation
from keras import optimizers
from keras.wrappers.scikit_learn import KerasClassifier

num_words = 30000
maxlen = 50
test_split = 0.3

(X_train, y_train), (X_test, y_test) = reuters.load_data(num_words = num_words, maxlen =
maxlen, test_split = test_split)
X_train = pad_sequences(X_train, padding = 'post')
X_test = pad_sequences(X_test, padding = 'post')
X_train = np.array(X_train).reshape((X_train.shape[0], X_train.shape[1], 1))
X_test = np.array(X_test).reshape((X_test.shape[0], X_test.shape[1], 1))
y_data = np.concatenate((y_train, y_test))
y_data = to_categorical(y_data)
y_train = y_data[:1395]
y_test = y_data[1395:]

def vanilla_rnn():
    model = Sequential()
    model.add(SimpleRNN(50, input_shape = (49,1), return_sequences = False))
    model.add(Dense(46))
    model.add(Activation('softmax'))
    adam = optimizers.Adam(lr = 0.001)
    model.compile(loss = 'categorical_crossentropy', optimizer = adam, metrics = ['accu
acy'])
    return model

model = KerasClassifier(build_fn = vanilla_rnn, epochs = 200, batch_size = 50, verbose =
1)
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
y_test_ = np.argmax(y_test, axis = 1)
print(accuracy_score(y_pred, y_test_))
```

Downloading data from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/reuters.npz>
2113536/2110848 [=====] - 0s 0us/step

/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/datasets/reuters.py:148: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray
x_train, y_train = np.array(xs[idx]), np.array(labels[idx])

```
x_train, y_train = np.array(xs[idx:]), np.array(labels[idx:]),  
/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/datasets/reuters.py:149: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant to do this, you must specify 'dtype=object' when creating the ndarray  
x_test, y_test = np.array(xs[idx:]), np.array(labels[idx:])
```

```
Epoch 1/200  
28/28 [=====] - 1s 10ms/step - loss: 3.2570 - accuracy: 0.2723  
Epoch 2/200  
28/28 [=====] - 0s 10ms/step - loss: 1.3573 - accuracy: 0.7074  
Epoch 3/200  
28/28 [=====] - 0s 10ms/step - loss: 1.2419 - accuracy: 0.6976  
Epoch 4/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1771 - accuracy: 0.7066  
Epoch 5/200  
28/28 [=====] - 0s 10ms/step - loss: 1.2220 - accuracy: 0.6985  
Epoch 6/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1966 - accuracy: 0.7055  
Epoch 7/200  
28/28 [=====] - 0s 10ms/step - loss: 1.2120 - accuracy: 0.6933  
Epoch 8/200  
28/28 [=====] - 0s 10ms/step - loss: 1.0856 - accuracy: 0.7275  
Epoch 9/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1530 - accuracy: 0.7091  
Epoch 10/200  
28/28 [=====] - 0s 10ms/step - loss: 1.2208 - accuracy: 0.6951  
Epoch 11/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1334 - accuracy: 0.7158  
Epoch 12/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1213 - accuracy: 0.7314  
Epoch 13/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1725 - accuracy: 0.7084  
Epoch 14/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1624 - accuracy: 0.7100  
Epoch 15/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1513 - accuracy: 0.7130  
Epoch 16/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1596 - accuracy: 0.7156  
Epoch 17/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1194 - accuracy: 0.7258  
Epoch 18/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1024 - accuracy: 0.7188  
Epoch 19/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1304 - accuracy: 0.7113  
Epoch 20/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1263 - accuracy: 0.7160  
Epoch 21/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1488 - accuracy: 0.7044  
Epoch 22/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1778 - accuracy: 0.6987  
Epoch 23/200  
28/28 [=====] - 0s 10ms/step - loss: 1.0729 - accuracy: 0.7311  
Epoch 24/200  
28/28 [=====] - 0s 11ms/step - loss: 1.1301 - accuracy: 0.7089  
Epoch 25/200  
28/28 [=====] - 0s 11ms/step - loss: 1.2205 - accuracy: 0.6943  
Epoch 26/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1437 - accuracy: 0.7191  
Epoch 27/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1685 - accuracy: 0.6985  
Epoch 28/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1402 - accuracy: 0.6987  
Epoch 29/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1781 - accuracy: 0.6923  
Epoch 30/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1194 - accuracy: 0.7129  
Epoch 31/200  
28/28 [=====] - 0s 10ms/step - loss: 1.0868 - accuracy: 0.7217  
Epoch 32/200  
28/28 [=====] - 0s 10ms/step - loss: 1.1153 - accuracy: 0.7016  
Epoch 33/200  
28/28 [=====] - 0s 10ms/step - loss: 1.0571 - accuracy: 0.7189
```

Epoch 34/200
28/28 [=====] - 0s 10ms/step - loss: 1.1026 - accuracy: 0.7137
Epoch 35/200
28/28 [=====] - 0s 10ms/step - loss: 1.0466 - accuracy: 0.7282
Epoch 36/200
28/28 [=====] - 0s 10ms/step - loss: 0.9737 - accuracy: 0.7482
Epoch 37/200
28/28 [=====] - 0s 10ms/step - loss: 1.0428 - accuracy: 0.7168
Epoch 38/200
28/28 [=====] - 0s 10ms/step - loss: 1.0465 - accuracy: 0.7201
Epoch 39/200
28/28 [=====] - 0s 10ms/step - loss: 1.0553 - accuracy: 0.7154
Epoch 40/200
28/28 [=====] - 0s 10ms/step - loss: 1.1192 - accuracy: 0.7027
Epoch 41/200
28/28 [=====] - 0s 10ms/step - loss: 1.2325 - accuracy: 0.6942
Epoch 42/200
28/28 [=====] - 0s 10ms/step - loss: 1.1276 - accuracy: 0.7106
Epoch 43/200
28/28 [=====] - 0s 10ms/step - loss: 1.1103 - accuracy: 0.7161
Epoch 44/200
28/28 [=====] - 0s 10ms/step - loss: 1.0825 - accuracy: 0.7107
Epoch 45/200
28/28 [=====] - 0s 10ms/step - loss: 1.1140 - accuracy: 0.7135
Epoch 46/200
28/28 [=====] - 0s 10ms/step - loss: 1.0818 - accuracy: 0.7147
Epoch 47/200
28/28 [=====] - 0s 10ms/step - loss: 1.0928 - accuracy: 0.7144
Epoch 48/200
28/28 [=====] - 0s 10ms/step - loss: 1.0815 - accuracy: 0.7144
Epoch 49/200
28/28 [=====] - 0s 10ms/step - loss: 1.0962 - accuracy: 0.6997
Epoch 50/200
28/28 [=====] - 0s 10ms/step - loss: 1.0705 - accuracy: 0.7184
Epoch 51/200
28/28 [=====] - 0s 10ms/step - loss: 1.1487 - accuracy: 0.6961
Epoch 52/200
28/28 [=====] - 0s 10ms/step - loss: 1.1244 - accuracy: 0.7076
Epoch 53/200
28/28 [=====] - 0s 10ms/step - loss: 1.0408 - accuracy: 0.7149
Epoch 54/200
28/28 [=====] - 0s 10ms/step - loss: 1.1144 - accuracy: 0.6912
Epoch 55/200
28/28 [=====] - 0s 10ms/step - loss: 1.1291 - accuracy: 0.6917
Epoch 56/200
28/28 [=====] - 0s 10ms/step - loss: 1.0492 - accuracy: 0.7028
Epoch 57/200
28/28 [=====] - 0s 10ms/step - loss: 0.9994 - accuracy: 0.7267
Epoch 58/200
28/28 [=====] - 0s 10ms/step - loss: 1.0542 - accuracy: 0.7266
Epoch 59/200
28/28 [=====] - 0s 10ms/step - loss: 1.0206 - accuracy: 0.7087
Epoch 60/200
28/28 [=====] - 0s 10ms/step - loss: 1.0896 - accuracy: 0.7046
Epoch 61/200
28/28 [=====] - 0s 10ms/step - loss: 1.0880 - accuracy: 0.7152
Epoch 62/200
28/28 [=====] - 0s 10ms/step - loss: 1.0578 - accuracy: 0.7134
Epoch 63/200
28/28 [=====] - 0s 10ms/step - loss: 1.0569 - accuracy: 0.7194
Epoch 64/200
28/28 [=====] - 0s 11ms/step - loss: 1.0459 - accuracy: 0.7093
Epoch 65/200
28/28 [=====] - 0s 10ms/step - loss: 1.1039 - accuracy: 0.7050
Epoch 66/200
28/28 [=====] - 0s 10ms/step - loss: 1.0062 - accuracy: 0.7235
Epoch 67/200
28/28 [=====] - 0s 10ms/step - loss: 1.0310 - accuracy: 0.7062
Epoch 68/200
28/28 [=====] - 0s 10ms/step - loss: 1.0740 - accuracy: 0.7135
Epoch 69/200
28/28 [=====] - 0s 10ms/step - loss: 1.1003 - accuracy: 0.7034

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Epoch 70/200
28/28 [=====] - 0s 10ms/step - loss: 1.0270 - accuracy: 0.7282
Epoch 71/200
28/28 [=====] - 0s 9ms/step - loss: 1.0911 - accuracy: 0.7012
Epoch 72/200
28/28 [=====] - 0s 10ms/step - loss: 1.0531 - accuracy: 0.7162
Epoch 73/200
28/28 [=====] - 0s 10ms/step - loss: 1.0795 - accuracy: 0.7157
Epoch 74/200
28/28 [=====] - 0s 9ms/step - loss: 1.0571 - accuracy: 0.7114
Epoch 75/200
28/28 [=====] - 0s 10ms/step - loss: 1.0915 - accuracy: 0.6996
Epoch 76/200
28/28 [=====] - 0s 10ms/step - loss: 1.0320 - accuracy: 0.7202
Epoch 77/200
28/28 [=====] - 0s 10ms/step - loss: 1.0314 - accuracy: 0.7251
Epoch 78/200
28/28 [=====] - 0s 10ms/step - loss: 1.0147 - accuracy: 0.7173
Epoch 79/200
28/28 [=====] - 0s 10ms/step - loss: 1.0822 - accuracy: 0.7065
Epoch 80/200
28/28 [=====] - 0s 10ms/step - loss: 0.9986 - accuracy: 0.7304
Epoch 81/200
28/28 [=====] - 0s 10ms/step - loss: 1.0253 - accuracy: 0.7161
Epoch 82/200
28/28 [=====] - 0s 10ms/step - loss: 1.0482 - accuracy: 0.7206
Epoch 83/200
28/28 [=====] - 0s 10ms/step - loss: 1.0062 - accuracy: 0.7261
Epoch 84/200
28/28 [=====] - 0s 12ms/step - loss: 1.0046 - accuracy: 0.7292
Epoch 85/200
28/28 [=====] - 0s 12ms/step - loss: 1.0751 - accuracy: 0.7083
Epoch 86/200
28/28 [=====] - 0s 11ms/step - loss: 1.0635 - accuracy: 0.6935
Epoch 87/200
28/28 [=====] - 0s 11ms/step - loss: 1.0843 - accuracy: 0.7131
Epoch 88/200
28/28 [=====] - 0s 10ms/step - loss: 1.0312 - accuracy: 0.7237
Epoch 89/200
28/28 [=====] - 0s 10ms/step - loss: 0.9976 - accuracy: 0.7215
Epoch 90/200
28/28 [=====] - 0s 10ms/step - loss: 1.0229 - accuracy: 0.7189
Epoch 91/200
28/28 [=====] - 0s 10ms/step - loss: 1.0934 - accuracy: 0.6988
Epoch 92/200
28/28 [=====] - 0s 10ms/step - loss: 1.0421 - accuracy: 0.7129
Epoch 93/200
28/28 [=====] - 0s 10ms/step - loss: 1.0252 - accuracy: 0.7186
Epoch 94/200
28/28 [=====] - 0s 10ms/step - loss: 0.9928 - accuracy: 0.7193
Epoch 95/200
28/28 [=====] - 0s 10ms/step - loss: 0.9928 - accuracy: 0.7276
Epoch 96/200
28/28 [=====] - 0s 10ms/step - loss: 1.0276 - accuracy: 0.7301
Epoch 97/200
28/28 [=====] - 0s 10ms/step - loss: 1.0595 - accuracy: 0.7159
Epoch 98/200
28/28 [=====] - 0s 10ms/step - loss: 1.0025 - accuracy: 0.7319
Epoch 99/200
28/28 [=====] - 0s 10ms/step - loss: 1.0174 - accuracy: 0.7162
Epoch 100/200
28/28 [=====] - 0s 10ms/step - loss: 1.0931 - accuracy: 0.7035
Epoch 101/200
28/28 [=====] - 0s 10ms/step - loss: 0.9780 - accuracy: 0.7372
Epoch 102/200
28/28 [=====] - 0s 10ms/step - loss: 1.0297 - accuracy: 0.7264
Epoch 103/200
28/28 [=====] - 0s 11ms/step - loss: 1.0096 - accuracy: 0.7275
Epoch 104/200
28/28 [=====] - 0s 10ms/step - loss: 1.0343 - accuracy: 0.7142
Epoch 105/200
28/28 [=====] - 0s 10ms/step - loss: 1.0203 - accuracy: 0.7221
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Epoch 106/200
28/28 [=====] - 0s 10ms/step - loss: 1.0550 - accuracy: 0.7099
Epoch 107/200
28/28 [=====] - 0s 10ms/step - loss: 1.0166 - accuracy: 0.7147
Epoch 108/200
28/28 [=====] - 0s 10ms/step - loss: 1.0700 - accuracy: 0.7131
Epoch 109/200
28/28 [=====] - 0s 9ms/step - loss: 0.9809 - accuracy: 0.7288
Epoch 110/200
28/28 [=====] - 0s 10ms/step - loss: 0.9770 - accuracy: 0.7172
Epoch 111/200
28/28 [=====] - 0s 10ms/step - loss: 0.9981 - accuracy: 0.7218
Epoch 112/200
28/28 [=====] - 0s 10ms/step - loss: 1.0367 - accuracy: 0.7148
Epoch 113/200
28/28 [=====] - 0s 10ms/step - loss: 1.0129 - accuracy: 0.7226
Epoch 114/200
28/28 [=====] - 0s 10ms/step - loss: 1.0385 - accuracy: 0.7143
Epoch 115/200
28/28 [=====] - 0s 10ms/step - loss: 1.1156 - accuracy: 0.6951
Epoch 116/200
28/28 [=====] - 0s 10ms/step - loss: 1.0320 - accuracy: 0.7126
Epoch 117/200
28/28 [=====] - 0s 10ms/step - loss: 1.0516 - accuracy: 0.7021
Epoch 118/200
28/28 [=====] - 0s 10ms/step - loss: 1.0136 - accuracy: 0.7161
Epoch 119/200
28/28 [=====] - 0s 10ms/step - loss: 0.9688 - accuracy: 0.7188
Epoch 120/200
28/28 [=====] - 0s 10ms/step - loss: 1.0378 - accuracy: 0.7131
Epoch 121/200
28/28 [=====] - 0s 9ms/step - loss: 1.0092 - accuracy: 0.7328
Epoch 122/200
28/28 [=====] - 0s 10ms/step - loss: 0.9888 - accuracy: 0.7356
Epoch 123/200
28/28 [=====] - 0s 10ms/step - loss: 0.9878 - accuracy: 0.7254
Epoch 124/200
28/28 [=====] - 0s 10ms/step - loss: 0.9200 - accuracy: 0.7432
Epoch 125/200
28/28 [=====] - 0s 10ms/step - loss: 1.0509 - accuracy: 0.7152
Epoch 126/200
28/28 [=====] - 0s 10ms/step - loss: 1.0007 - accuracy: 0.7306
Epoch 127/200
28/28 [=====] - 0s 10ms/step - loss: 1.0782 - accuracy: 0.6985
Epoch 128/200
28/28 [=====] - 0s 10ms/step - loss: 0.9829 - accuracy: 0.7161
Epoch 129/200
28/28 [=====] - 0s 10ms/step - loss: 1.0514 - accuracy: 0.7051
Epoch 130/200
28/28 [=====] - 0s 10ms/step - loss: 1.0301 - accuracy: 0.7071
Epoch 131/200
28/28 [=====] - 0s 10ms/step - loss: 1.0056 - accuracy: 0.7231
Epoch 132/200
28/28 [=====] - 0s 10ms/step - loss: 1.0153 - accuracy: 0.7178
Epoch 133/200
28/28 [=====] - 0s 10ms/step - loss: 0.9673 - accuracy: 0.7317
Epoch 134/200
28/28 [=====] - 0s 10ms/step - loss: 0.9911 - accuracy: 0.7305
Epoch 135/200
28/28 [=====] - 0s 10ms/step - loss: 1.0351 - accuracy: 0.6979
Epoch 136/200
28/28 [=====] - 0s 10ms/step - loss: 0.9968 - accuracy: 0.7232
Epoch 137/200
28/28 [=====] - 0s 10ms/step - loss: 0.9412 - accuracy: 0.7338
Epoch 138/200
28/28 [=====] - 0s 10ms/step - loss: 0.9918 - accuracy: 0.7143
Epoch 139/200
28/28 [=====] - 0s 10ms/step - loss: 0.9827 - accuracy: 0.7209
Epoch 140/200
28/28 [=====] - 0s 10ms/step - loss: 0.9792 - accuracy: 0.7262
Epoch 141/200
28/28 [=====] - 0s 10ms/step - loss: 1.0471 - accuracy: 0.6969

```
Epoch 142/200
28/28 [=====] - 0s 11ms/step - loss: 0.9784 - accuracy: 0.7259
Epoch 143/200
28/28 [=====] - 0s 10ms/step - loss: 0.9746 - accuracy: 0.7244
Epoch 144/200
28/28 [=====] - 0s 10ms/step - loss: 1.0529 - accuracy: 0.7038
Epoch 145/200
28/28 [=====] - 0s 10ms/step - loss: 1.0439 - accuracy: 0.6974
Epoch 146/200
28/28 [=====] - 0s 10ms/step - loss: 0.9638 - accuracy: 0.7288
Epoch 147/200
28/28 [=====] - 0s 10ms/step - loss: 0.9458 - accuracy: 0.7370
Epoch 148/200
28/28 [=====] - 0s 10ms/step - loss: 0.9631 - accuracy: 0.7314
Epoch 149/200
28/28 [=====] - 0s 10ms/step - loss: 0.9334 - accuracy: 0.7369
Epoch 150/200
28/28 [=====] - 0s 9ms/step - loss: 0.8958 - accuracy: 0.7443
Epoch 151/200
28/28 [=====] - 0s 10ms/step - loss: 0.9571 - accuracy: 0.7319
Epoch 152/200
28/28 [=====] - 0s 10ms/step - loss: 0.9601 - accuracy: 0.7234
Epoch 153/200
28/28 [=====] - 0s 10ms/step - loss: 0.9971 - accuracy: 0.7151
Epoch 154/200
28/28 [=====] - 0s 10ms/step - loss: 0.9539 - accuracy: 0.7315
Epoch 155/200
28/28 [=====] - 0s 10ms/step - loss: 0.9670 - accuracy: 0.7239
Epoch 156/200
28/28 [=====] - 0s 10ms/step - loss: 0.9917 - accuracy: 0.7252
Epoch 157/200
28/28 [=====] - 0s 10ms/step - loss: 1.1638 - accuracy: 0.6944
Epoch 158/200
28/28 [=====] - 0s 10ms/step - loss: 0.9988 - accuracy: 0.7149
Epoch 159/200
28/28 [=====] - 0s 10ms/step - loss: 0.9806 - accuracy: 0.7302
Epoch 160/200
28/28 [=====] - 0s 10ms/step - loss: 1.0079 - accuracy: 0.7156
Epoch 161/200
28/28 [=====] - 0s 10ms/step - loss: 1.0259 - accuracy: 0.7005
Epoch 162/200
28/28 [=====] - 0s 10ms/step - loss: 0.9868 - accuracy: 0.7168
Epoch 163/200
28/28 [=====] - 0s 10ms/step - loss: 0.9614 - accuracy: 0.7345
Epoch 164/200
28/28 [=====] - 0s 9ms/step - loss: 0.9765 - accuracy: 0.7204
Epoch 165/200
28/28 [=====] - 0s 10ms/step - loss: 0.9580 - accuracy: 0.7234
Epoch 166/200
28/28 [=====] - 0s 10ms/step - loss: 0.9713 - accuracy: 0.7167
Epoch 167/200
28/28 [=====] - 0s 10ms/step - loss: 1.0149 - accuracy: 0.7171
Epoch 168/200
28/28 [=====] - 0s 10ms/step - loss: 1.0438 - accuracy: 0.7062
Epoch 169/200
28/28 [=====] - 0s 10ms/step - loss: 0.9577 - accuracy: 0.7241
Epoch 170/200
28/28 [=====] - 0s 9ms/step - loss: 1.0106 - accuracy: 0.7106
Epoch 171/200
28/28 [=====] - 0s 10ms/step - loss: 0.9974 - accuracy: 0.7157
Epoch 172/200
28/28 [=====] - 0s 10ms/step - loss: 0.9655 - accuracy: 0.7108
Epoch 173/200
28/28 [=====] - 0s 10ms/step - loss: 0.9986 - accuracy: 0.7132
Epoch 174/200
28/28 [=====] - 0s 10ms/step - loss: 0.9801 - accuracy: 0.7142
Epoch 175/200
28/28 [=====] - 0s 10ms/step - loss: 0.9721 - accuracy: 0.7304
Epoch 176/200
28/28 [=====] - 0s 10ms/step - loss: 0.8847 - accuracy: 0.7512
Epoch 177/200
28/28 [=====] - 0s 10ms/step - loss: 0.9745 - accuracy: 0.7296
```

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Epoch 178/200
28/28 [=====] - 0s 10ms/step - loss: 1.0236 - accuracy: 0.6995
Epoch 179/200
28/28 [=====] - 0s 10ms/step - loss: 0.9751 - accuracy: 0.7277
Epoch 180/200
28/28 [=====] - 0s 10ms/step - loss: 1.0056 - accuracy: 0.7175
Epoch 181/200
28/28 [=====] - 0s 10ms/step - loss: 0.9455 - accuracy: 0.7221
Epoch 182/200
28/28 [=====] - 0s 12ms/step - loss: 0.8936 - accuracy: 0.7424
Epoch 183/200
28/28 [=====] - 0s 10ms/step - loss: 0.9338 - accuracy: 0.7286
Epoch 184/200
28/28 [=====] - 0s 10ms/step - loss: 1.0115 - accuracy: 0.7218
Epoch 185/200
28/28 [=====] - 0s 10ms/step - loss: 0.9038 - accuracy: 0.7347
Epoch 186/200
28/28 [=====] - 0s 10ms/step - loss: 0.9014 - accuracy: 0.7317
Epoch 187/200
28/28 [=====] - 0s 10ms/step - loss: 1.0032 - accuracy: 0.7049
Epoch 188/200
28/28 [=====] - 0s 10ms/step - loss: 0.9931 - accuracy: 0.7220
Epoch 189/200
28/28 [=====] - 0s 10ms/step - loss: 0.9817 - accuracy: 0.7205
Epoch 190/200
28/28 [=====] - 0s 10ms/step - loss: 0.9539 - accuracy: 0.7343
Epoch 191/200
28/28 [=====] - 0s 10ms/step - loss: 0.9839 - accuracy: 0.7077
Epoch 192/200
28/28 [=====] - 0s 10ms/step - loss: 0.9662 - accuracy: 0.7259
Epoch 193/200
28/28 [=====] - 0s 10ms/step - loss: 1.0064 - accuracy: 0.7144
Epoch 194/200
28/28 [=====] - 0s 10ms/step - loss: 0.9175 - accuracy: 0.7401
Epoch 195/200
28/28 [=====] - 0s 10ms/step - loss: 0.9779 - accuracy: 0.7140
Epoch 196/200
28/28 [=====] - 0s 10ms/step - loss: 0.9872 - accuracy: 0.7020
Epoch 197/200
28/28 [=====] - 0s 10ms/step - loss: 0.9179 - accuracy: 0.7271
Epoch 198/200
28/28 [=====] - 0s 10ms/step - loss: 0.8815 - accuracy: 0.7478
Epoch 199/200
28/28 [=====] - 0s 9ms/step - loss: 0.9013 - accuracy: 0.7295
Epoch 200/200
28/28 [=====] - 0s 10ms/step - loss: 0.9075 - accuracy: 0.7381

```

```

/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after 2021-01-01
. Please use instead: * `np.argmax(model.predict(x), axis=-1)`, if your model does multi
-class classification (e.g. if it uses a `softmax` last-layer activation). * `(model.pre
dict(x) > 0.5).astype("int32")`, if your model does binary classification (e.g. if it
uses a `sigmoid` last-layer activation).
  warnings.warn("`model.predict_classes()` is deprecated and '

```

```

12/12 [=====] - 0s 5ms/step
0.7495826377295493

```

Problem 2: LSTM.

In [2]:

```

import numpy as np
from sklearn.metrics import accuracy_score
from keras.datasets import reuters
from keras.preprocessing.sequence import pad_sequences
from keras.utils import to_categorical
from keras.models import Sequential
from keras.layers import Dense, LSTM, Activation
from keras import optimizers

```

```

from keras.wrappers.scikit_learn import KerasClassifier

num_words = 30000
maxlen = 50
test_split = 0.3
(X_train, y_train), (X_test, y_test) = reuters.load_data(num_words = num_words, maxlen =
maxlen, test_split = test_split)
X_train = pad_sequences(X_train, padding = 'post')
X_test = pad_sequences(X_test, padding = 'post')
X_train = np.array(X_train).reshape((X_train.shape[0], X_train.shape[1], 1))
X_test = np.array(X_test).reshape((X_test.shape[0], X_test.shape[1], 1))
y_data = np.concatenate((y_train, y_test))
y_data = to_categorical(y_data)
y_train = y_data[:1395]
y_test = y_data[1395:]

def lstm():
    model = Sequential()
    model.add(LSTM(50, input_shape = (49,1), return_sequences = False))
    model.add(Dense(46))
    model.add(Activation('softmax'))
    adam = optimizers.Adam(lr = 0.001)
    model.compile(loss = 'categorical_crossentropy', optimizer = adam, metrics = ['accur
acy'])
    return model

model = KerasClassifier(build_fn = lstm, epochs = 200, batch_size = 50, verbose = 1)
model.fit(X_train, y_train)
y_pred = model.predict(X_test)
y_test_ = np.argmax(y_test, axis = 1)
print(accuracy_score(y_pred, y_test_))

```

```

/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/datasets/reuters.py:148: V
isibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a li
st-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecate
d. If you meant to do this, you must specify 'dtype=object' when creating the ndarray
    x_train, y_train = np.array(xs[:idx]), np.array(labels[:idx])
/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/datasets/reuters.py:149: V
isibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a li
st-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecate
d. If you meant to do this, you must specify 'dtype=object' when creating the ndarray
    x_test, y_test = np.array(xs[idx:]), np.array(labels[idx:])

```

```

Epoch 1/200
28/28 [=====] - 2s 23ms/step - loss: 3.5812 - accuracy: 0.3967
Epoch 2/200
28/28 [=====] - 1s 24ms/step - loss: 1.4365 - accuracy: 0.7232
Epoch 3/200
28/28 [=====] - 1s 24ms/step - loss: 1.1865 - accuracy: 0.7246
Epoch 4/200
28/28 [=====] - 1s 24ms/step - loss: 1.3119 - accuracy: 0.6912
Epoch 5/200
28/28 [=====] - 1s 26ms/step - loss: 1.1047 - accuracy: 0.7252
Epoch 6/200
28/28 [=====] - 1s 25ms/step - loss: 1.1215 - accuracy: 0.7231
Epoch 7/200
28/28 [=====] - 1s 25ms/step - loss: 1.1157 - accuracy: 0.7169
Epoch 8/200
28/28 [=====] - 1s 25ms/step - loss: 1.0667 - accuracy: 0.7259
Epoch 9/200
28/28 [=====] - 1s 25ms/step - loss: 1.0607 - accuracy: 0.7197
Epoch 10/200
28/28 [=====] - 1s 24ms/step - loss: 0.9781 - accuracy: 0.7337
Epoch 11/200
28/28 [=====] - 1s 25ms/step - loss: 0.9754 - accuracy: 0.7372
Epoch 12/200
28/28 [=====] - 1s 25ms/step - loss: 0.8783 - accuracy: 0.8070
Epoch 13/200
28/28 [=====] - 1s 26ms/step - loss: 0.8732 - accuracy: 0.7920
Epoch 14/200
28/28 [=====] - 1s 24ms/step - loss: 0.8906 - accuracy: 0.7897
Epoch 15/200
28/28 [=====] - 1s 22ms/step - loss: 0.8607 - accuracy: 0.7850

```



```
28/28 [=====] - 1s 23ms/step - loss: 0.8607 - accuracy: 0.7950
Epoch 16/200
28/28 [=====] - 1s 23ms/step - loss: 0.8627 - accuracy: 0.8083
Epoch 17/200
28/28 [=====] - 1s 23ms/step - loss: 0.7985 - accuracy: 0.8192
Epoch 18/200
28/28 [=====] - 1s 23ms/step - loss: 0.7906 - accuracy: 0.8124
Epoch 19/200
28/28 [=====] - 1s 23ms/step - loss: 0.8163 - accuracy: 0.7958
Epoch 20/200
28/28 [=====] - 1s 23ms/step - loss: 0.8227 - accuracy: 0.8094
Epoch 21/200
28/28 [=====] - 1s 24ms/step - loss: 0.7227 - accuracy: 0.8372
Epoch 22/200
28/28 [=====] - 1s 24ms/step - loss: 0.7608 - accuracy: 0.8182
Epoch 23/200
28/28 [=====] - 1s 23ms/step - loss: 0.7613 - accuracy: 0.8220
Epoch 24/200
28/28 [=====] - 1s 23ms/step - loss: 0.7303 - accuracy: 0.8246
Epoch 25/200
28/28 [=====] - 1s 24ms/step - loss: 0.7652 - accuracy: 0.8242
Epoch 26/200
28/28 [=====] - 1s 22ms/step - loss: 0.8589 - accuracy: 0.8031
Epoch 27/200
28/28 [=====] - 1s 23ms/step - loss: 0.7205 - accuracy: 0.8268
Epoch 28/200
28/28 [=====] - 1s 22ms/step - loss: 0.8501 - accuracy: 0.8069
Epoch 29/200
28/28 [=====] - 1s 23ms/step - loss: 0.7671 - accuracy: 0.8253
Epoch 30/200
28/28 [=====] - 1s 23ms/step - loss: 0.7197 - accuracy: 0.8259
Epoch 31/200
28/28 [=====] - 1s 23ms/step - loss: 0.7172 - accuracy: 0.8327
Epoch 32/200
28/28 [=====] - 1s 24ms/step - loss: 0.7401 - accuracy: 0.8293
Epoch 33/200
28/28 [=====] - 1s 23ms/step - loss: 0.6767 - accuracy: 0.8328
Epoch 34/200
28/28 [=====] - 1s 23ms/step - loss: 0.7129 - accuracy: 0.8291
Epoch 35/200
28/28 [=====] - 1s 23ms/step - loss: 0.7206 - accuracy: 0.8390
Epoch 36/200
28/28 [=====] - 1s 23ms/step - loss: 0.7288 - accuracy: 0.8266
Epoch 37/200
28/28 [=====] - 1s 23ms/step - loss: 0.7293 - accuracy: 0.8195
Epoch 38/200
28/28 [=====] - 1s 25ms/step - loss: 0.7101 - accuracy: 0.8251
Epoch 39/200
28/28 [=====] - 1s 23ms/step - loss: 0.7443 - accuracy: 0.8240
Epoch 40/200
28/28 [=====] - 1s 23ms/step - loss: 0.6852 - accuracy: 0.8338
Epoch 41/200
28/28 [=====] - 1s 23ms/step - loss: 0.7407 - accuracy: 0.8215
Epoch 42/200
28/28 [=====] - 1s 22ms/step - loss: 0.7030 - accuracy: 0.8246
Epoch 43/200
28/28 [=====] - 1s 23ms/step - loss: 0.6946 - accuracy: 0.8298
Epoch 44/200
28/28 [=====] - 1s 23ms/step - loss: 0.6245 - accuracy: 0.8524
Epoch 45/200
28/28 [=====] - 1s 22ms/step - loss: 0.6892 - accuracy: 0.8304
Epoch 46/200
28/28 [=====] - 1s 26ms/step - loss: 0.7872 - accuracy: 0.8119
Epoch 47/200
28/28 [=====] - 1s 27ms/step - loss: 0.7470 - accuracy: 0.8204
Epoch 48/200
28/28 [=====] - 1s 23ms/step - loss: 0.7011 - accuracy: 0.8276
Epoch 49/200
28/28 [=====] - 1s 24ms/step - loss: 0.6743 - accuracy: 0.8404
Epoch 50/200
28/28 [=====] - 1s 23ms/step - loss: 0.7173 - accuracy: 0.8219
Epoch 51/200
28/28 [=====] - 1s 23ms/step - loss: 0.7406 - accuracy: 0.8181
```

```
28/28 [=====] - 1s 23ms/step - loss: 0.7496 - accuracy: 0.8181
Epoch 52/200
28/28 [=====] - 1s 23ms/step - loss: 0.6771 - accuracy: 0.8315
Epoch 53/200
28/28 [=====] - 1s 24ms/step - loss: 0.6672 - accuracy: 0.8416
Epoch 54/200
28/28 [=====] - 1s 23ms/step - loss: 0.7011 - accuracy: 0.8286
Epoch 55/200
28/28 [=====] - 1s 25ms/step - loss: 0.6374 - accuracy: 0.8439
Epoch 56/200
28/28 [=====] - 1s 23ms/step - loss: 0.6783 - accuracy: 0.8330
Epoch 57/200
28/28 [=====] - 1s 23ms/step - loss: 0.6600 - accuracy: 0.8362
Epoch 58/200
28/28 [=====] - 1s 23ms/step - loss: 0.6818 - accuracy: 0.8407
Epoch 59/200
28/28 [=====] - 1s 23ms/step - loss: 0.6840 - accuracy: 0.8388
Epoch 60/200
28/28 [=====] - 1s 23ms/step - loss: 0.6599 - accuracy: 0.8425
Epoch 61/200
28/28 [=====] - 1s 24ms/step - loss: 0.6636 - accuracy: 0.8333
Epoch 62/200
28/28 [=====] - 1s 22ms/step - loss: 0.6572 - accuracy: 0.8422
Epoch 63/200
28/28 [=====] - 1s 24ms/step - loss: 0.6516 - accuracy: 0.8506
Epoch 64/200
28/28 [=====] - 1s 23ms/step - loss: 0.6406 - accuracy: 0.8459
Epoch 65/200
28/28 [=====] - 1s 23ms/step - loss: 0.6582 - accuracy: 0.8401
Epoch 66/200
28/28 [=====] - 1s 23ms/step - loss: 0.5887 - accuracy: 0.8544
Epoch 67/200
28/28 [=====] - 1s 22ms/step - loss: 0.6197 - accuracy: 0.8509
Epoch 68/200
28/28 [=====] - 1s 22ms/step - loss: 0.6376 - accuracy: 0.8493
Epoch 69/200
28/28 [=====] - 1s 22ms/step - loss: 0.6717 - accuracy: 0.8299
Epoch 70/200
28/28 [=====] - 1s 23ms/step - loss: 0.7025 - accuracy: 0.8278
Epoch 71/200
28/28 [=====] - 1s 23ms/step - loss: 0.5910 - accuracy: 0.8578
Epoch 72/200
28/28 [=====] - 1s 25ms/step - loss: 0.6108 - accuracy: 0.8462
Epoch 73/200
28/28 [=====] - 1s 23ms/step - loss: 0.6616 - accuracy: 0.8415
Epoch 74/200
28/28 [=====] - 1s 24ms/step - loss: 0.6774 - accuracy: 0.8284
Epoch 75/200
28/28 [=====] - 1s 24ms/step - loss: 0.6095 - accuracy: 0.8548
Epoch 76/200
28/28 [=====] - 1s 24ms/step - loss: 0.6605 - accuracy: 0.8416
Epoch 77/200
28/28 [=====] - 1s 23ms/step - loss: 0.6038 - accuracy: 0.8492
Epoch 78/200
28/28 [=====] - 1s 24ms/step - loss: 0.6516 - accuracy: 0.8366
Epoch 79/200
28/28 [=====] - 1s 24ms/step - loss: 0.5617 - accuracy: 0.8563
Epoch 80/200
28/28 [=====] - 1s 24ms/step - loss: 0.6268 - accuracy: 0.8483
Epoch 81/200
28/28 [=====] - 1s 22ms/step - loss: 0.6424 - accuracy: 0.8323
Epoch 82/200
28/28 [=====] - 1s 23ms/step - loss: 0.5646 - accuracy: 0.8567
Epoch 83/200
28/28 [=====] - 1s 23ms/step - loss: 0.6319 - accuracy: 0.8407
Epoch 84/200
28/28 [=====] - 1s 23ms/step - loss: 0.5727 - accuracy: 0.8536
Epoch 85/200
28/28 [=====] - 1s 23ms/step - loss: 0.5876 - accuracy: 0.8500
Epoch 86/200
28/28 [=====] - 1s 23ms/step - loss: 0.5608 - accuracy: 0.8600
Epoch 87/200
28/28 [=====] - 1s 23ms/step - loss: 0.6000 - accuracy: 0.8345
```

```
28/28 [=====] - 1s 22ms/step - loss: 0.6202 - accuracy: 0.8349
Epoch 88/200
28/28 [=====] - 1s 23ms/step - loss: 0.5810 - accuracy: 0.8532
Epoch 89/200
28/28 [=====] - 1s 23ms/step - loss: 0.5527 - accuracy: 0.8589
Epoch 90/200
28/28 [=====] - 1s 22ms/step - loss: 0.6202 - accuracy: 0.8303
Epoch 91/200
28/28 [=====] - 1s 23ms/step - loss: 0.5413 - accuracy: 0.8571
Epoch 92/200
28/28 [=====] - 1s 23ms/step - loss: 0.6060 - accuracy: 0.8442
Epoch 93/200
28/28 [=====] - 1s 23ms/step - loss: 0.6150 - accuracy: 0.8364
Epoch 94/200
28/28 [=====] - 1s 23ms/step - loss: 0.5959 - accuracy: 0.8413
Epoch 95/200
28/28 [=====] - 1s 24ms/step - loss: 0.6832 - accuracy: 0.8237
Epoch 96/200
28/28 [=====] - 1s 26ms/step - loss: 0.5607 - accuracy: 0.8522
Epoch 97/200
28/28 [=====] - 1s 26ms/step - loss: 0.6410 - accuracy: 0.8336
Epoch 98/200
28/28 [=====] - 1s 23ms/step - loss: 0.5626 - accuracy: 0.8562
Epoch 99/200
28/28 [=====] - 1s 23ms/step - loss: 0.5880 - accuracy: 0.8492
Epoch 100/200
28/28 [=====] - 1s 23ms/step - loss: 0.5449 - accuracy: 0.8534
Epoch 101/200
28/28 [=====] - 1s 23ms/step - loss: 0.5397 - accuracy: 0.8536
Epoch 102/200
28/28 [=====] - 1s 23ms/step - loss: 0.5703 - accuracy: 0.8564
Epoch 103/200
28/28 [=====] - 1s 23ms/step - loss: 0.4803 - accuracy: 0.8679
Epoch 104/200
28/28 [=====] - 1s 22ms/step - loss: 0.5373 - accuracy: 0.8587
Epoch 105/200
28/28 [=====] - 1s 25ms/step - loss: 0.5525 - accuracy: 0.8589
Epoch 106/200
28/28 [=====] - 1s 24ms/step - loss: 0.5530 - accuracy: 0.8550
Epoch 107/200
28/28 [=====] - 1s 23ms/step - loss: 0.5752 - accuracy: 0.8391
Epoch 108/200
28/28 [=====] - 1s 23ms/step - loss: 0.5245 - accuracy: 0.8591
Epoch 109/200
28/28 [=====] - 1s 23ms/step - loss: 0.6286 - accuracy: 0.8301
Epoch 110/200
28/28 [=====] - 1s 23ms/step - loss: 0.6042 - accuracy: 0.8348
Epoch 111/200
28/28 [=====] - 1s 23ms/step - loss: 0.5784 - accuracy: 0.8455
Epoch 112/200
28/28 [=====] - 1s 23ms/step - loss: 0.5706 - accuracy: 0.8485
Epoch 113/200
28/28 [=====] - 1s 23ms/step - loss: 0.5931 - accuracy: 0.8388
Epoch 114/200
28/28 [=====] - 1s 23ms/step - loss: 0.5165 - accuracy: 0.8648
Epoch 115/200
28/28 [=====] - 1s 23ms/step - loss: 0.6047 - accuracy: 0.8376
Epoch 116/200
28/28 [=====] - 1s 24ms/step - loss: 0.5611 - accuracy: 0.8441
Epoch 117/200
28/28 [=====] - 1s 23ms/step - loss: 0.5399 - accuracy: 0.8544
Epoch 118/200
28/28 [=====] - 1s 24ms/step - loss: 0.5264 - accuracy: 0.8619
Epoch 119/200
28/28 [=====] - 1s 23ms/step - loss: 0.5162 - accuracy: 0.8633
Epoch 120/200
28/28 [=====] - 1s 23ms/step - loss: 0.4966 - accuracy: 0.8707
Epoch 121/200
28/28 [=====] - 1s 23ms/step - loss: 0.5331 - accuracy: 0.8538
Epoch 122/200
28/28 [=====] - 1s 25ms/step - loss: 0.4990 - accuracy: 0.8588
Epoch 123/200
28/28 [=====] - 1s 23ms/step - loss: 0.5425 - accuracy: 0.8571
```

```
28/28 [=====] - 1s 23ms/step - loss: 0.5435 - accuracy: 0.8571
Epoch 124/200
28/28 [=====] - 1s 23ms/step - loss: 0.5356 - accuracy: 0.8525
Epoch 125/200
28/28 [=====] - 1s 24ms/step - loss: 0.5223 - accuracy: 0.8570
Epoch 126/200
28/28 [=====] - 1s 23ms/step - loss: 0.5192 - accuracy: 0.8546
Epoch 127/200
28/28 [=====] - 1s 24ms/step - loss: 0.4832 - accuracy: 0.8594
Epoch 128/200
28/28 [=====] - 1s 23ms/step - loss: 0.5022 - accuracy: 0.8658
Epoch 129/200
28/28 [=====] - 1s 23ms/step - loss: 0.5516 - accuracy: 0.8483
Epoch 130/200
28/28 [=====] - 1s 22ms/step - loss: 0.4809 - accuracy: 0.8682
Epoch 131/200
28/28 [=====] - 1s 24ms/step - loss: 0.5023 - accuracy: 0.8618
Epoch 132/200
28/28 [=====] - 1s 23ms/step - loss: 0.5550 - accuracy: 0.8469
Epoch 133/200
28/28 [=====] - 1s 23ms/step - loss: 0.4979 - accuracy: 0.8594
Epoch 134/200
28/28 [=====] - 1s 23ms/step - loss: 0.4920 - accuracy: 0.8583
Epoch 135/200
28/28 [=====] - 1s 23ms/step - loss: 0.4548 - accuracy: 0.8765
Epoch 136/200
28/28 [=====] - 1s 23ms/step - loss: 0.5459 - accuracy: 0.8470
Epoch 137/200
28/28 [=====] - 1s 23ms/step - loss: 0.4394 - accuracy: 0.8697
Epoch 138/200
28/28 [=====] - 1s 23ms/step - loss: 0.5046 - accuracy: 0.8640
Epoch 139/200
28/28 [=====] - 1s 25ms/step - loss: 0.4638 - accuracy: 0.8798
Epoch 140/200
28/28 [=====] - 1s 23ms/step - loss: 0.4887 - accuracy: 0.8652
Epoch 141/200
28/28 [=====] - 1s 23ms/step - loss: 0.5335 - accuracy: 0.8602
Epoch 142/200
28/28 [=====] - 1s 23ms/step - loss: 0.5711 - accuracy: 0.8396
Epoch 143/200
28/28 [=====] - 1s 23ms/step - loss: 0.5139 - accuracy: 0.8512
Epoch 144/200
28/28 [=====] - 1s 23ms/step - loss: 0.4753 - accuracy: 0.8676
Epoch 145/200
28/28 [=====] - 1s 24ms/step - loss: 0.4654 - accuracy: 0.8682
Epoch 146/200
28/28 [=====] - 1s 26ms/step - loss: 0.4770 - accuracy: 0.8616
Epoch 147/200
28/28 [=====] - 1s 26ms/step - loss: 0.4800 - accuracy: 0.8568
Epoch 148/200
28/28 [=====] - 1s 23ms/step - loss: 0.4413 - accuracy: 0.8677
Epoch 149/200
28/28 [=====] - 1s 22ms/step - loss: 0.5011 - accuracy: 0.8561
Epoch 150/200
28/28 [=====] - 1s 22ms/step - loss: 0.5166 - accuracy: 0.8581
Epoch 151/200
28/28 [=====] - 1s 23ms/step - loss: 0.4774 - accuracy: 0.8653
Epoch 152/200
28/28 [=====] - 1s 23ms/step - loss: 0.4766 - accuracy: 0.8688
Epoch 153/200
28/28 [=====] - 1s 23ms/step - loss: 0.4323 - accuracy: 0.8750
Epoch 154/200
28/28 [=====] - 1s 24ms/step - loss: 0.4178 - accuracy: 0.8805
Epoch 155/200
28/28 [=====] - 1s 23ms/step - loss: 0.4380 - accuracy: 0.8808
Epoch 156/200
28/28 [=====] - 1s 25ms/step - loss: 0.4455 - accuracy: 0.8758
Epoch 157/200
28/28 [=====] - 1s 23ms/step - loss: 0.4602 - accuracy: 0.8705
Epoch 158/200
28/28 [=====] - 1s 23ms/step - loss: 0.4734 - accuracy: 0.8686
Epoch 159/200
28/28 [=====] - 1s 24ms/step - loss: 0.4502 - accuracy: 0.8764
```

```
28/28 [=====] - 1s 24ms/step - loss: 0.4503 - accuracy: 0.8764
Epoch 160/200
28/28 [=====] - 1s 24ms/step - loss: 0.4490 - accuracy: 0.8650
Epoch 161/200
28/28 [=====] - 1s 23ms/step - loss: 0.4757 - accuracy: 0.8636
Epoch 162/200
28/28 [=====] - 1s 24ms/step - loss: 0.4753 - accuracy: 0.8577
Epoch 163/200
28/28 [=====] - 1s 23ms/step - loss: 0.4359 - accuracy: 0.8685
Epoch 164/200
28/28 [=====] - 1s 23ms/step - loss: 0.4313 - accuracy: 0.8876
Epoch 165/200
28/28 [=====] - 1s 23ms/step - loss: 0.4286 - accuracy: 0.8761
Epoch 166/200
28/28 [=====] - 1s 23ms/step - loss: 0.4589 - accuracy: 0.8684
Epoch 167/200
28/28 [=====] - 1s 23ms/step - loss: 0.4923 - accuracy: 0.8604
Epoch 168/200
28/28 [=====] - 1s 23ms/step - loss: 0.5455 - accuracy: 0.8461
Epoch 169/200
28/28 [=====] - 1s 22ms/step - loss: 0.4552 - accuracy: 0.8741
Epoch 170/200
28/28 [=====] - 1s 23ms/step - loss: 0.4590 - accuracy: 0.8640
Epoch 171/200
28/28 [=====] - 1s 23ms/step - loss: 0.4520 - accuracy: 0.8595
Epoch 172/200
28/28 [=====] - 1s 24ms/step - loss: 0.4985 - accuracy: 0.8573
Epoch 173/200
28/28 [=====] - 1s 23ms/step - loss: 0.4894 - accuracy: 0.8607
Epoch 174/200
28/28 [=====] - 1s 23ms/step - loss: 0.4169 - accuracy: 0.8824
Epoch 175/200
28/28 [=====] - 1s 23ms/step - loss: 0.4748 - accuracy: 0.8636
Epoch 176/200
28/28 [=====] - 1s 22ms/step - loss: 0.4331 - accuracy: 0.8743
Epoch 177/200
28/28 [=====] - 1s 24ms/step - loss: 0.3944 - accuracy: 0.8822
Epoch 178/200
28/28 [=====] - 1s 24ms/step - loss: 0.4290 - accuracy: 0.8797
Epoch 179/200
28/28 [=====] - 1s 24ms/step - loss: 0.4281 - accuracy: 0.8805
Epoch 180/200
28/28 [=====] - 1s 24ms/step - loss: 0.4462 - accuracy: 0.8729
Epoch 181/200
28/28 [=====] - 1s 23ms/step - loss: 0.3879 - accuracy: 0.8871
Epoch 182/200
28/28 [=====] - 1s 25ms/step - loss: 0.4500 - accuracy: 0.8787
Epoch 183/200
28/28 [=====] - 1s 25ms/step - loss: 0.4718 - accuracy: 0.8702
Epoch 184/200
28/28 [=====] - 1s 24ms/step - loss: 0.4299 - accuracy: 0.8795
Epoch 185/200
28/28 [=====] - 1s 24ms/step - loss: 0.3857 - accuracy: 0.8925
Epoch 186/200
28/28 [=====] - 1s 23ms/step - loss: 0.3674 - accuracy: 0.8969
Epoch 187/200
28/28 [=====] - 1s 23ms/step - loss: 0.4223 - accuracy: 0.8792
Epoch 188/200
28/28 [=====] - 1s 23ms/step - loss: 0.4430 - accuracy: 0.8677
Epoch 189/200
28/28 [=====] - 1s 25ms/step - loss: 0.4217 - accuracy: 0.8767
Epoch 190/200
28/28 [=====] - 1s 23ms/step - loss: 0.3904 - accuracy: 0.8891
Epoch 191/200
28/28 [=====] - 1s 23ms/step - loss: 0.4495 - accuracy: 0.8759
Epoch 192/200
28/28 [=====] - 1s 23ms/step - loss: 0.3847 - accuracy: 0.8966
Epoch 193/200
28/28 [=====] - 1s 23ms/step - loss: 0.4136 - accuracy: 0.8872
Epoch 194/200
28/28 [=====] - 1s 23ms/step - loss: 0.3549 - accuracy: 0.8997
Epoch 195/200
28/28 [=====] - 1s 23ms/step - loss: 0.3570 - accuracy: 0.8992
```

```
28/28 [=====] - 1s 23ms/step - loss: 0.3570 - accuracy: 0.9002
Epoch 196/200
28/28 [=====] - 1s 24ms/step - loss: 0.4011 - accuracy: 0.8908
Epoch 197/200
28/28 [=====] - 1s 28ms/step - loss: 0.3574 - accuracy: 0.9068
Epoch 198/200
28/28 [=====] - 1s 25ms/step - loss: 0.3668 - accuracy: 0.9037
Epoch 199/200
28/28 [=====] - 1s 23ms/step - loss: 0.3968 - accuracy: 0.8974
Epoch 200/200
28/28 [=====] - 1s 24ms/step - loss: 0.3824 - accuracy: 0.8978
```

```
/opt/conda/lib/python3.7/site-packages/tensorflow/python/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after 2021-01-01
. Please use instead: * `np.argmax(model.predict(x), axis=-1)`, if your model does multi
-class classification (e.g. if it uses a `softmax` last-layer activation). * `(model.pre
dict(x) > 0.5).astype("int32")`, if your model does binary classification (e.g. if it
uses a `sigmoid` last-layer activation).
  warnings.warn("`model.predict_classes()` is deprecated and '
```

```
12/12 [=====] - 0s 9ms/step
0.8430717863105175
```