In [1]:

```
import pandas as pd
import numpy as np
import random
```

In [69]:

```
# Activities are the class labels
# It is a 6 class classification
ACTIVITIES = {
    0: 'WALKING',
    1: 'WALKING_UPSTAIRS',
    2: 'WALKING_DOWNSTAIRS',
    3: 'SITTING',
    4: 'STANDING',
    5: 'LAYING',
}

% matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns
# Utility function to print the confusion matrix
def confusion_matrix(Y_true, Y_pred):
    Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_true, axis=1)])
    Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_pred, axis=1)])

    return pd.crosstab(Y_true, Y_pred, rownames=['True'], colnames=['Pred'])
def heap_map_confusion_matrix(y_test,y_predict):

  confu_matrix=confusion_matrix(y_test, y_predict)
  plt.figure(figsize=(12, 10))
  sns.heatmap(confu_matrix,xticklabels= list(ACTIVITIES.values()),
              yticklabels=list(ACTIVITIES.values()),
              annot=True, fmt="d");
  plt.title("Confusion matrix")
  plt.ylabel('True label')
  plt.xlabel('Predicted label')
  plt.show()
```

Data

In [70]:

```
DATADIR = 'UCI_HAR_Dataset'
```

In [71]:

```
# Raw data signals
# Signals are from Accelerometer and Gyroscope
# The signals are in x,y,z directions
# Sensor signals are filtered to have only body acceleration
# excluding the acceleration due to gravity
# Triaxial acceleration from the accelerometer is total acceleration
SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"
]
```

In [72]:

```
# Utility function to read the data from csv file
```

```
def _read_csv(filename):
    return pd.read_csv(filename, delim_whitespace=True, header=None)

# Utility function to load the load
def load_signals(subset):
    signals_data = []

    for signal in SIGNALS:
        filename = f'UCI_HAR_Dataset/{subset}/Inertial Signals/{signal}_{subset}.txt'
        signals_data.append(
            _read_csv(filename).as_matrix()
        )

    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 signals)
    return np.transpose(signals_data, (1, 2, 0))
```

In [73]:

```
def load_y(subset):
    """
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
    """
    filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]

    return pd.get_dummies(y).as_matrix()
```

In [74]:

```
def load_y_raw(subset):
    """
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
    """
    filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]

    return y
```

In [75]:

```
def load_data():
    """
    Obtain the dataset from multiple files.
    Returns: X_train, X_test, y_train, y_test
    """
    X_train, X_test = load_signals('train'), load_signals('test')
    y_train, y_test = load_y('train'), load_y('test')

    return X_train, X_test, y_train, y_test
```

In [76]:

```
# Importing tensorflow
np.random.seed(42)
import tensorflow as tf
tf.set_random_seed(42)
```

In [36]:

```
# Configuring a session
session_conf = tf.ConfigProto(
    intra_op_parallelism_threads=0,
    inter_op_parallelism_threads=0
)
```

In [37]:

```
# Import Keras
from keras import backend as K
sess = tf.Session(graph=tf.get_default_graph(), config=session_conf)
K.set_session(sess)
```

In [77]:

```
# Importing libraries
import tensorflow as tf
from keras import backend as K
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
```

In [78]:

```
# Initializing parameters
epochs = 30
batch_size = 16
n_hidden = 32
```

In [79]:

```
# Utility function to count the number of classes
def _count_classes(y):
    return len(set([tuple(category) for category in y]))
```

In [80]:

```
# Loading the train and test data
X_train, X_test, Y_train, Y_test = load_data()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:12: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
  if sys.path[0] == '':
```

In [81]:

```
timesteps = len(X_train_dy[0])
input_dim = len(X_train_dy[0][0])
n_classes = _count_classes(y_train_dy)

print(timesteps)
print(input_dim)
print(len(X_train_dy))
```

```
128
9
3285
```

- Defining the Architecture of LSTM

In [42]:

```
tf.keras.backend.clear_session()
# Initiliazing the sequential model
model = Sequential()
# Configuring the parameters
model.add(LSTM(32, input_shape=(timesteps, input_dim)))
# Adding a dropout layer
model.add(Dropout(0.5))
# Adding a dense output layer with sigmoid activation
model.add(Dense(n_classes, activation='sigmoid'))
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 32)                5376
_________________________________________________________________
dropout_1 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 198
=================================================================
Total params: 5,574
Trainable params: 5,574
Non-trainable params: 0
_________________________________________________________________
```

In [43]:

```
# Compiling the model
model.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
```

In [44]:

```
# Training the model 75,0.25
model.fit(X_train,
          Y_train,
          batch_size=batch_size,
          validation_data=(X_test, Y_test),
          epochs=epochs)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 75s 10ms/step - loss: 0.1018 - acc: 0.9591 - val_loss
: 0.4606 - val_acc: 0.9155
Epoch 2/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1012 - acc: 0.9596 - val_loss
: 0.4761 - val_acc: 0.9114
Epoch 3/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1076 - acc: 0.9550 - val_loss
: 0.3617 - val_acc: 0.9114
Epoch 4/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1050 - acc: 0.9570 - val_loss
: 0.4742 - val_acc: 0.8955
Epoch 5/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.0997 - acc: 0.9592 - val_loss
: 0.4303 - val_acc: 0.9111
Epoch 6/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1176 - acc: 0.9544 - val_loss
: 0.4276 - val_acc: 0.8938
Epoch 7/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1169 - acc: 0.9516 - val_loss
: 0.4459 - val_acc: 0.9070
Epoch 8/30
7352/7352 [==============================] - 75s 10ms/step - loss: 0.1021 - acc: 0.9592 - val_loss
: 0.4281 - val_acc: 0.9206
Epoch 9/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1012 - acc: 0.9611 - val_loss
: 0.5742 - val_acc: 0.9097
Epoch 10/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1077 - acc: 0.9619 - val_loss
: 0.5670 - val_acc: 0.9050
Epoch 11/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1057 - acc: 0.9576 - val_loss
: 0.5541 - val_acc: 0.9002
Epoch 12/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1141 - acc: 0.9559 - val_loss
: 0.5719 - val_acc: 0.9131
Epoch 13/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1088 - acc: 0.9631 - val_loss
: 0.6379 - val_acc: 0.9013
Epoch 14/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1142 - acc: 0.9559 - val_loss
: 0.6408 - val_acc: 0.9162
Epoch 15/30
```

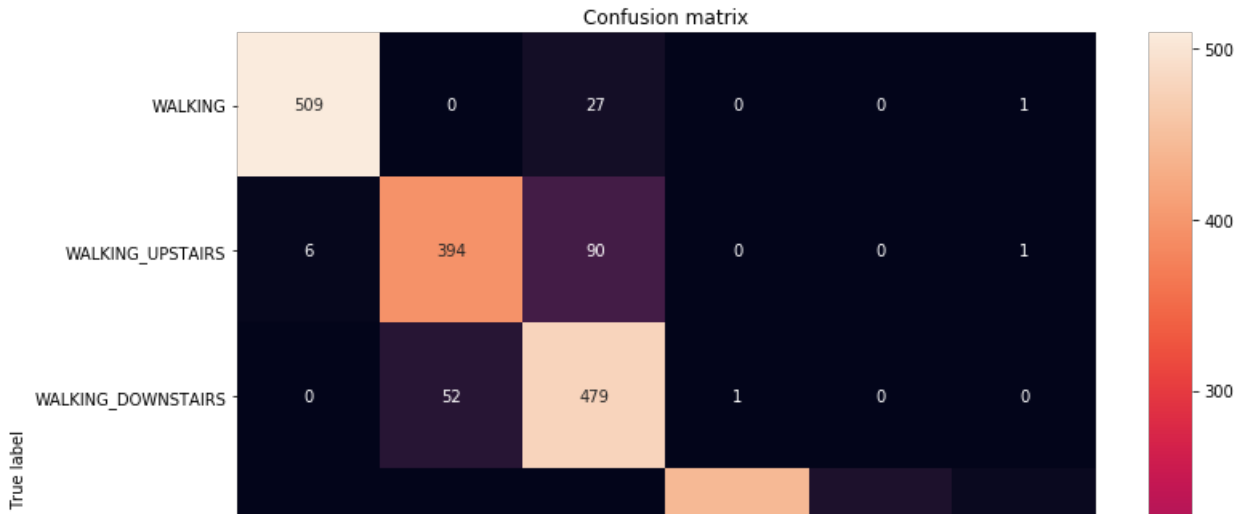
```
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1142 - acc: 0.9595 - val_loss
: 0.5587 - val_acc: 0.9148
Epoch 16/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.0905 - acc: 0.9650 - val_loss
: 0.5907 - val_acc: 0.9097
Epoch 17/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1055 - acc: 0.9608 - val_loss
: 0.5192 - val_acc: 0.9179
Epoch 18/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1028 - acc: 0.9652 - val_loss
: 0.4253 - val_acc: 0.9138
Epoch 19/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1002 - acc: 0.9622 - val_loss
: 0.5382 - val_acc: 0.9094
Epoch 20/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1085 - acc: 0.9621 - val_loss
: 0.5908 - val_acc: 0.9094
Epoch 21/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1185 - acc: 0.9555 - val_loss
: 0.6699 - val_acc: 0.8962
Epoch 22/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1098 - acc: 0.9587 - val_loss
: 0.5204 - val_acc: 0.9179
Epoch 23/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1091 - acc: 0.9581 - val_loss
: 0.4513 - val_acc: 0.9057
Epoch 24/30
7352/7352 [==============================] - 74s 10ms/step - loss: 0.0974 - acc: 0.9650 - val_loss
: 0.5351 - val_acc: 0.9128
Epoch 25/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1458 - acc: 0.9582 - val_loss
: 0.4656 - val_acc: 0.9175
Epoch 26/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1003 - acc: 0.9612 - val_loss
: 0.5602 - val_acc: 0.9104
Epoch 27/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.0972 - acc: 0.9657 - val_loss
: 0.4577 - val_acc: 0.9172
Epoch 28/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1064 - acc: 0.9645 - val_loss
: 0.4900 - val_acc: 0.9026
Epoch 29/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.0940 - acc: 0.9652 - val_loss
: 0.6132 - val_acc: 0.8979
Epoch 30/30
7352/7352 [==============================] - 73s 10ms/step - loss: 0.1014 - acc: 0.9625 - val_loss
: 0.5238 - val_acc: 0.9108
```

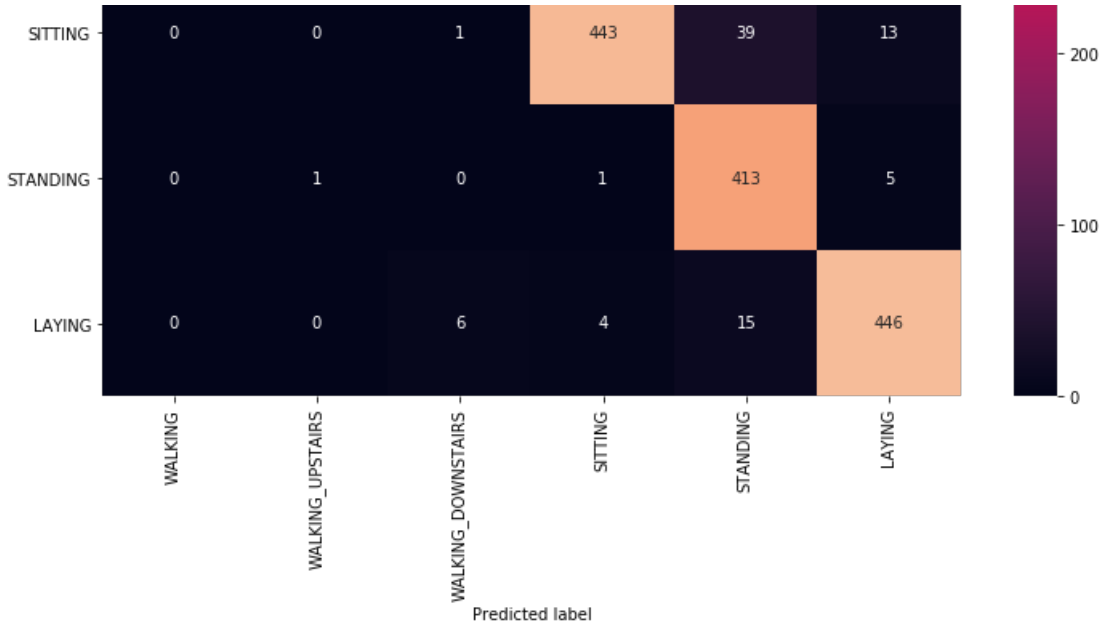
Out[44]:

```
<keras.callbacks.History at 0x88d3201b70>
```

In [45]:

```
heap_map_confusion_matrix(Y_test, model.predict(X_test))
```





In [15]:

```
def lstm_model(rate,units):
  # Initiliazing the sequential model
  model = Sequential()
  # Configuring the parameters
  model.add(LSTM(units, input_shape=(timesteps, input_dim)))
  # Adding a dropout layer
  model.add(Dropout(rate))
  # Adding a dense output layer with sigmoid activation
  model.add(Dense(n_classes, activation='sigmoid'))
  # Compiling the model
  model.compile(loss='categorical_crossentropy',optimizer='rmsprop',metrics=['accuracy'])
  return model
```

In [16]:

```
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import GridSearchCV
parameter={'units':[32,50,75,120],'rate':[0.25,0.5,0.75]}
model1=KerasClassifier(build_fn=lstm_model)
gs=GridSearchCV(estimator =model1,param_grid=parameter,return_train_score=True,verbose=1)
gs.fit(X_train,Y_train,epochs=30)
```

```
Fitting 3 folds for each of 12 candidates, totalling 36 fits
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\framework\op_def_library.py:263: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:1978: FutureWarning:
The default value of cv will change from 3 to 5 in version 0.22. Specify it explicitly to silence
this warning.
  warnings.warn(CV_WARNING, FutureWarning)
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.

WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\keras\backend\tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Epoch 1/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.4265 - acc: 0.4181
```

```
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.1626 - acc: 0.5107
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9929 - acc: 0.5262
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8734 - acc: 0.6289
Epoch 5/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8140 - acc: 0.6384
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7311 - acc: 0.6539
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6708 - acc: 0.6784
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6504 - acc: 0.6725
Epoch 9/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6114 - acc: 0.7131
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7457 - acc: 0.6780
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5986 - acc: 0.7431
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5435 - acc: 0.7849
Epoch 13/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5342 - acc: 0.7831
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4634 - acc: 0.8049
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4532 - acc: 0.8037
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4496 - acc: 0.8088
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4167 - acc: 0.8331
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4165 - acc: 0.8294
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3840 - acc: 0.8698
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3004 - acc: 0.8994
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2723 - acc: 0.9129
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2855 - acc: 0.9133
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2385 - acc: 0.9274
Epoch 24/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2116 - acc: 0.9325
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1997 - acc: 0.9323
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1857 - acc: 0.9372
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1926 - acc: 0.9357
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2012 - acc: 0.9392
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1988 - acc: 0.9353
Epoch 30/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2064 - acc: 0.9382
2451/2451 [==============================] - 1s 462us/step
4901/4901 [==============================] - 2s 392us/step
Epoch 1/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.4739 - acc: 0.3840
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.2164 - acc: 0.4870
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.0951 - acc: 0.5274
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.1269 - acc: 0.5766
Epoch 5/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9269 - acc: 0.6176
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8926 - acc: 0.6174
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8840 - acc: 0.6011
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8073 - acc: 0.6427
Epoch 9/30
```

```
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8595 - acc: 0.6395
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7533 - acc: 0.6911
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7172 - acc: 0.7111
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6988 - acc: 0.7229
Epoch 13/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6698 - acc: 0.7437
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6187 - acc: 0.7741
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6244 - acc: 0.7784
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5729 - acc: 0.7962
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5469 - acc: 0.8121
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5457 - acc: 0.8182
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5129 - acc: 0.8380
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4474 - acc: 0.8496
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4234 - acc: 0.8688
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3905 - acc: 0.8827
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3600 - acc: 0.8955
Epoch 24/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3271 - acc: 0.8970
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3124 - acc: 0.9035
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2781 - acc: 0.9135
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2506 - acc: 0.9206
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2328 - acc: 0.9212
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2240 - acc: 0.9272
Epoch 30/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1959 - acc: 0.9388
2451/2451 [==============================] - 1s 482us/step
4901/4901 [==============================] - 2s 397us/step
Epoch 1/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.4022 - acc: 0.4521
Epoch 2/30
4902/4902 [==============================] - 11s 2ms/step - loss: 1.1489 - acc: 0.4880
Epoch 3/30
4902/4902 [==============================] - 11s 2ms/step - loss: 1.0838 - acc: 0.5082
Epoch 4/30
4902/4902 [==============================] - 11s 2ms/step - loss: 1.0256 - acc: 0.5343
Epoch 5/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.9505 - acc: 0.5749
Epoch 6/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.8371 - acc: 0.6344
Epoch 7/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.7453 - acc: 0.6610
Epoch 8/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6948 - acc: 0.6689
Epoch 9/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6420 - acc: 0.6867
Epoch 10/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6040 - acc: 0.7040
Epoch 11/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.5920 - acc: 0.7252
Epoch 12/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.5576 - acc: 0.7560
Epoch 13/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5351 - acc: 0.7709
Epoch 14/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4913 - acc: 0.7864
Epoch 15/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.4641 - acc: 0.7923
Epoch 16/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.4477 - acc: 0.8023
```

```
Epoch 17/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.3944 - acc: 0.8086
Epoch 18/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.3889 - acc: 0.8205
Epoch 19/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.3530 - acc: 0.8401
Epoch 20/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.3412 - acc: 0.8507
Epoch 21/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.2969 - acc: 0.8945
Epoch 22/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.2393 - acc: 0.9186
Epoch 23/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.2361 - acc: 0.9174
Epoch 24/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.2048 - acc: 0.9282
Epoch 25/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1953 - acc: 0.9255
Epoch 26/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1912 - acc: 0.9333
Epoch 27/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1767 - acc: 0.9317
Epoch 28/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1653 - acc: 0.9361
Epoch 29/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1601 - acc: 0.9329
Epoch 30/30
4902/4902 [==============================] - 10s 2ms/step - loss: 0.1637 - acc: 0.9366
2450/2450 [==============================] - 1s 490us/step
4902/4902 [==============================] - 2s 393us/step
Epoch 1/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.3267 - acc: 0.4489
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.0161 - acc: 0.5281
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.0622 - acc: 0.5291
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9784 - acc: 0.5634
Epoch 5/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8825 - acc: 0.6076
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7515 - acc: 0.6578
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6663 - acc: 0.6819
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6341 - acc: 0.7133
Epoch 9/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5743 - acc: 0.7545
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5236 - acc: 0.7817
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4740 - acc: 0.8249
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4201 - acc: 0.8625
Epoch 13/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3738 - acc: 0.8794
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3485 - acc: 0.8753
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3134 - acc: 0.8927
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2853 - acc: 0.9008
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2728 - acc: 0.9025
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2499 - acc: 0.9108
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2286 - acc: 0.9214
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2245 - acc: 0.9190
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2260 - acc: 0.9168
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2142 - acc: 0.9208
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1911 - acc: 0.9316
Epoch 24/30
```

```
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1695 - acc: 0.9431
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1722 - acc: 0.9404
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1767 - acc: 0.9386
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1853 - acc: 0.9292
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1699 - acc: 0.9433
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1556 - acc: 0.9455
Epoch 30/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1529 - acc: 0.9412
2451/2451 [==============================] - 1s 564us/step
4901/4901 [==============================] - 2s 439us/step
Epoch 1/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.4050 - acc: 0.3640
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.1721 - acc: 0.4699
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.0749 - acc: 0.5140
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9122 - acc: 0.6156
Epoch 5/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8709 - acc: 0.6215
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7205 - acc: 0.6952
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6711 - acc: 0.7382
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5759 - acc: 0.7909
Epoch 9/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5628 - acc: 0.8076
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4493 - acc: 0.8606
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4060 - acc: 0.8745
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3345 - acc: 0.9004
Epoch 13/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2958 - acc: 0.9119
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2552 - acc: 0.9237
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2607 - acc: 0.9221
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2194 - acc: 0.9290
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1929 - acc: 0.9423
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1791 - acc: 0.9425
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1651 - acc: 0.9492
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1540 - acc: 0.9494
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1765 - acc: 0.9398
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1652 - acc: 0.9455
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1485 - acc: 0.9461
Epoch 24/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1262 - acc: 0.9535
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1354 - acc: 0.9514
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1272 - acc: 0.9525
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1217 - acc: 0.9533
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1345 - acc: 0.9525
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.1193 - acc: 0.9557
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1117 - acc: 0.9580
2451/2451 [==============================] - 2s 616us/step
4901/4901 [==============================] - 2s 455us/step
```

```
Epoch 1/30
4902/4902 [==============================] - 13s 3ms/step - loss: 1.3303 - acc: 0.4439
Epoch 2/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.0431 - acc: 0.5345
Epoch 3/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.9966 - acc: 0.5728
Epoch 4/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.8935 - acc: 0.6269
Epoch 5/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.8217 - acc: 0.6393
Epoch 6/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.7354 - acc: 0.6767
Epoch 7/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6563 - acc: 0.7295
Epoch 8/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5927 - acc: 0.7485
Epoch 9/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5506 - acc: 0.8005
Epoch 10/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4536 - acc: 0.8515
Epoch 11/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3819 - acc: 0.8835
Epoch 12/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3435 - acc: 0.8882
Epoch 13/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2888 - acc: 0.9031
Epoch 14/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2525 - acc: 0.9062
Epoch 15/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2197 - acc: 0.9127
Epoch 16/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2081 - acc: 0.9115
Epoch 17/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2035 - acc: 0.9188
Epoch 18/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1936 - acc: 0.9253
Epoch 19/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1662 - acc: 0.9351
Epoch 20/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1738 - acc: 0.9380
Epoch 21/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1586 - acc: 0.9427
Epoch 22/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1793 - acc: 0.9347
Epoch 23/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1750 - acc: 0.9274
Epoch 24/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1382 - acc: 0.9459
Epoch 25/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1302 - acc: 0.9484
Epoch 26/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1567 - acc: 0.9429
Epoch 27/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1506 - acc: 0.9421
Epoch 28/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1488 - acc: 0.9435
Epoch 29/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1298 - acc: 0.9494
Epoch 30/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.1264 - acc: 0.9476
2450/2450 [==============================] - 1s 609us/step
4902/4902 [==============================] - 2s 458us/step
Epoch 1/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.2930 - acc: 0.4495
Epoch 2/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.9459 - acc: 0.5991
Epoch 3/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.9259 - acc: 0.5846
Epoch 4/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.8311 - acc: 0.6201
Epoch 5/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.8442 - acc: 0.6033
Epoch 6/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6888 - acc: 0.6954
Epoch 7/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6912 - acc: 0.7121
Epoch 8/30
```

```
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6457 - acc: 0.7301
Epoch 9/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6097 - acc: 0.7456
Epoch 10/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.5054 - acc: 0.7831
Epoch 11/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.4603 - acc: 0.8084
Epoch 12/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.4353 - acc: 0.8353
Epoch 13/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3319 - acc: 0.8823
Epoch 14/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3040 - acc: 0.8941
Epoch 15/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2641 - acc: 0.9068
Epoch 16/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3617 - acc: 0.8786
Epoch 17/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2469 - acc: 0.9155
Epoch 18/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2073 - acc: 0.9296
Epoch 19/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1872 - acc: 0.9361
Epoch 20/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1667 - acc: 0.9367
Epoch 21/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1785 - acc: 0.9376
Epoch 22/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1710 - acc: 0.9345
Epoch 23/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1616 - acc: 0.9400
Epoch 24/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1852 - acc: 0.9370
Epoch 25/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1558 - acc: 0.9437
Epoch 26/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1470 - acc: 0.9476
Epoch 27/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1537 - acc: 0.9410
Epoch 28/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1492 - acc: 0.9431: 1s - loss:
0.1486
Epoch 29/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1400 - acc: 0.9465
Epoch 30/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1561 - acc: 0.9431
2451/2451 [==============================] - 2s 830us/step
4901/4901 [==============================] - 3s 626us/step
Epoch 1/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.3076 - acc: 0.4385
Epoch 2/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.0976 - acc: 0.5303
Epoch 3/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.9003 - acc: 0.6164
Epoch 4/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.9739 - acc: 0.5607
Epoch 5/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.7794 - acc: 0.6348
Epoch 6/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.7055 - acc: 0.6935
Epoch 7/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.5881 - acc: 0.7870
Epoch 8/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4863 - acc: 0.8206
Epoch 9/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3964 - acc: 0.8600
Epoch 10/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2993 - acc: 0.8966
Epoch 11/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2932 - acc: 0.9074
Epoch 12/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2312 - acc: 0.9267
Epoch 13/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2171 - acc: 0.9302
Epoch 14/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1757 - acc: 0.9459
Epoch 15/30
```

```
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1940 - acc: 0.9276
Epoch 16/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1503 - acc: 0.9435
Epoch 17/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1524 - acc: 0.9443: 0s - loss:
0.1481 - a
Epoch 18/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2064 - acc: 0.9216
Epoch 19/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1571 - acc: 0.9423
Epoch 20/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1398 - acc: 0.9449
Epoch 21/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1434 - acc: 0.9467
Epoch 22/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1507 - acc: 0.9433
Epoch 23/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1413 - acc: 0.9459
Epoch 24/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1311 - acc: 0.9527
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1236 - acc: 0.9525
Epoch 26/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1355 - acc: 0.9525
Epoch 27/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1323 - acc: 0.9496
Epoch 28/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1164 - acc: 0.9533
Epoch 29/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1350 - acc: 0.9535
Epoch 30/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.1188 - acc: 0.9555
2451/2451 [==============================] - 2s 864us/step
4901/4901 [==============================] - 3s 646us/step
Epoch 1/30
4902/4902 [==============================] - 14s 3ms/step - loss: 1.3371 - acc: 0.4080
Epoch 2/30
4902/4902 [==============================] - 13s 3ms/step - loss: 1.1724 - acc: 0.4625
Epoch 3/30
4902/4902 [==============================] - 13s 3ms/step - loss: 1.0943 - acc: 0.5324
Epoch 4/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8413 - acc: 0.6244
Epoch 5/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8294 - acc: 0.6550
Epoch 6/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.7159 - acc: 0.6895
Epoch 7/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.6915 - acc: 0.6863
Epoch 8/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.6549 - acc: 0.7081: 2s  - ETA:
0s - loss: 0.6585 - acc: 0.
Epoch 9/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.5645 - acc: 0.7511
Epoch 10/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.5104 - acc: 0.7880
Epoch 11/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4605 - acc: 0.8278
Epoch 12/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4455 - acc: 0.8317
Epoch 13/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4996 - acc: 0.8323
Epoch 14/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.3291 - acc: 0.8758
Epoch 15/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2813 - acc: 0.8931
Epoch 16/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2463 - acc: 0.9053
Epoch 17/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2254 - acc: 0.9115
Epoch 18/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2004 - acc: 0.9213
Epoch 19/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1863 - acc: 0.9272
Epoch 20/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1670 - acc: 0.9333
Epoch 21/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1680 - acc: 0.9325
```

```
Epoch 22/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1506 - acc: 0.9394
Epoch 23/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1442 - acc: 0.9423
Epoch 24/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1452 - acc: 0.9396
Epoch 25/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1436 - acc: 0.9384
Epoch 26/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1415 - acc: 0.9417
Epoch 27/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1441 - acc: 0.9388
Epoch 28/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1276 - acc: 0.9466
Epoch 29/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1425 - acc: 0.9410
Epoch 30/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1273 - acc: 0.9453
2450/2450 [==============================] - 2s 880us/step
4902/4902 [==============================] - 3s 620us/step
Epoch 1/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.3132 - acc: 0.4358
Epoch 2/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.1019 - acc: 0.5156
Epoch 3/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.8534 - acc: 0.6376
Epoch 4/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.6752 - acc: 0.7058
Epoch 5/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.5880 - acc: 0.7733
Epoch 6/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.5003 - acc: 0.8168
Epoch 7/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.4063 - acc: 0.8613
Epoch 8/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2917 - acc: 0.8992
Epoch 9/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2418 - acc: 0.9112
Epoch 10/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2244 - acc: 0.9165
Epoch 11/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2065 - acc: 0.9241
Epoch 12/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2180 - acc: 0.9192
Epoch 13/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1788 - acc: 0.9345
Epoch 14/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1662 - acc: 0.9374
Epoch 15/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1675 - acc: 0.9370
Epoch 16/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1642 - acc: 0.9323
Epoch 17/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1683 - acc: 0.9378
Epoch 18/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1519 - acc: 0.9365
Epoch 19/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1519 - acc: 0.9423
Epoch 20/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1391 - acc: 0.9453
Epoch 21/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1271 - acc: 0.9504
Epoch 22/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1394 - acc: 0.9492
Epoch 23/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1306 - acc: 0.9500
Epoch 24/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1348 - acc: 0.9484
Epoch 25/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1324 - acc: 0.9516
Epoch 26/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1396 - acc: 0.9525
Epoch 27/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1337 - acc: 0.9492
Epoch 28/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1313 - acc: 0.9502
Epoch 29/30
```

```
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1234 - acc: 0.9523
Epoch 30/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1343 - acc: 0.9539
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 5s 982us/step
Epoch 1/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.2781 - acc: 0.4362
Epoch 2/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.1246 - acc: 0.4954
Epoch 3/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.9721 - acc: 0.5838
Epoch 4/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.8330 - acc: 0.6223
Epoch 5/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.7595 - acc: 0.6729
Epoch 6/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.8726 - acc: 0.6372
Epoch 7/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.8069 - acc: 0.6862
Epoch 8/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.5534 - acc: 0.8098
Epoch 9/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.4673 - acc: 0.8417
Epoch 10/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.3686 - acc: 0.8804
Epoch 11/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.3355 - acc: 0.8933
Epoch 12/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2621 - acc: 0.9125
Epoch 13/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2180 - acc: 0.9288
Epoch 14/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2023 - acc: 0.9314
Epoch 15/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2007 - acc: 0.9314
Epoch 16/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1730 - acc: 0.9455
Epoch 17/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1671 - acc: 0.9416
Epoch 18/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1402 - acc: 0.9504
Epoch 19/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1381 - acc: 0.9508
Epoch 20/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1492 - acc: 0.9457
Epoch 21/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1415 - acc: 0.9482
Epoch 22/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1292 - acc: 0.9480
Epoch 23/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1362 - acc: 0.9523
Epoch 24/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1247 - acc: 0.9518
Epoch 25/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1206 - acc: 0.9539
Epoch 26/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1340 - acc: 0.9506
Epoch 27/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1135 - acc: 0.9549
Epoch 28/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1395 - acc: 0.9486
Epoch 29/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1146 - acc: 0.9541
Epoch 30/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1253 - acc: 0.9553
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 5s 972us/step
Epoch 1/30
4902/4902 [==============================] - 19s 4ms/step - loss: 1.3243 - acc: 0.4308
Epoch 2/30
4902/4902 [==============================] - 17s 3ms/step - loss: 1.1539 - acc: 0.4743
Epoch 3/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.9889 - acc: 0.5486
Epoch 4/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.9846 - acc: 0.5447
Epoch 5/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.7769 - acc: 0.6679
```

```
Epoch 6/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.6961 - acc: 0.7099
Epoch 7/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.6359 - acc: 0.7485
Epoch 8/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.4999 - acc: 0.8137
Epoch 9/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.4744 - acc: 0.8227
Epoch 10/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.3454 - acc: 0.8843
Epoch 11/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.2918 - acc: 0.9011
Epoch 12/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.2370 - acc: 0.9135
Epoch 13/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.2044 - acc: 0.9237
Epoch 14/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.2008 - acc: 0.9255
Epoch 15/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1781 - acc: 0.9357
Epoch 16/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1675 - acc: 0.9329
Epoch 17/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1595 - acc: 0.9410
Epoch 18/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1437 - acc: 0.9439
Epoch 19/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1419 - acc: 0.9412
Epoch 20/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1344 - acc: 0.9449
Epoch 21/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1425 - acc: 0.9449
Epoch 22/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.2038 - acc: 0.9223
Epoch 23/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1319 - acc: 0.9435
Epoch 24/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1360 - acc: 0.9453
Epoch 25/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1264 - acc: 0.9488
Epoch 26/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1324 - acc: 0.9457
Epoch 27/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1328 - acc: 0.9476
Epoch 28/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1262 - acc: 0.9551
Epoch 29/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1217 - acc: 0.9523
Epoch 30/30
4902/4902 [==============================] - 17s 3ms/step - loss: 0.1213 - acc: 0.9478
2450/2450 [==============================] - 3s 1ms/step
4902/4902 [==============================] - 5s 1ms/step
Epoch 1/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.5456 - acc: 0.3952
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.1905 - acc: 0.5219
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9886 - acc: 0.6019
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8627 - acc: 0.6497
Epoch 5/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8065 - acc: 0.6709
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8164 - acc: 0.6588
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7554 - acc: 0.6660
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6861 - acc: 0.7113
Epoch 9/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6634 - acc: 0.7233
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6067 - acc: 0.7568
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5853 - acc: 0.7756
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5907 - acc: 0.7709
Epoch 13/30
```

```
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5442 - acc: 0.7947
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5169 - acc: 0.8007
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4975 - acc: 0.8162
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5120 - acc: 0.8176
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4836 - acc: 0.8298
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4242 - acc: 0.8643
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4073 - acc: 0.8751
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3562 - acc: 0.8925
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3191 - acc: 0.9033
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3313 - acc: 0.9068
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3133 - acc: 0.9094
Epoch 24/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3177 - acc: 0.9035
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3391 - acc: 0.9017
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2897 - acc: 0.9202
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6360 - acc: 0.8406
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6219 - acc: 0.8313
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2648 - acc: 0.9198
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2794 - acc: 0.9143
2451/2451 [==============================] - 2s 775us/step
4901/4901 [==============================] - 2s 492us/step
Epoch 1/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.4871 - acc: 0.3469
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.2704 - acc: 0.3913
Epoch 3/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1408 - acc: 0.4866
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9971 - acc: 0.5852
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8766 - acc: 0.6415
Epoch 6/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.8011 - acc: 0.6511
Epoch 7/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.7223 - acc: 0.6848
Epoch 8/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6782 - acc: 0.6999
Epoch 9/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6529 - acc: 0.7143
Epoch 10/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6123 - acc: 0.7329
Epoch 11/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6020 - acc: 0.7413
Epoch 12/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5962 - acc: 0.7623
Epoch 13/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5539 - acc: 0.8137
Epoch 14/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5703 - acc: 0.8119
Epoch 15/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4898 - acc: 0.8533
Epoch 16/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.5713 - acc: 0.8086
Epoch 17/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.6687 - acc: 0.7635
Epoch 18/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4817 - acc: 0.8584
Epoch 19/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.4130 - acc: 0.8853
Epoch 20/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3694 - acc: 0.8988
```

```
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3091 - acc: 0.8966
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3585 - acc: 0.8929
Epoch 22/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3287 - acc: 0.9092
Epoch 23/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3234 - acc: 0.9080
Epoch 24/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3309 - acc: 0.9065
Epoch 25/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2836 - acc: 0.9190
Epoch 26/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2751 - acc: 0.9229
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3222 - acc: 0.9084
Epoch 28/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.3102 - acc: 0.9157
Epoch 29/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2412 - acc: 0.9321
Epoch 30/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2376 - acc: 0.9310
2451/2451 [==============================] - 2s 795us/step
4901/4901 [==============================] - 2s 417us/step
Epoch 1/30
4902/4902 [==============================] - 14s 3ms/step - loss: 1.4702 - acc: 0.3813
Epoch 2/30
4902/4902 [==============================] - 11s 2ms/step - loss: 1.1648 - acc: 0.5418
Epoch 3/30
4902/4902 [==============================] - 11s 2ms/step - loss: 1.0215 - acc: 0.5800
Epoch 4/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.9712 - acc: 0.5887
Epoch 5/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.8093 - acc: 0.6616
Epoch 6/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.7459 - acc: 0.6820
Epoch 7/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6866 - acc: 0.7099
Epoch 8/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6426 - acc: 0.7428
Epoch 9/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5885 - acc: 0.7623
Epoch 10/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.5829 - acc: 0.7697
Epoch 11/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5621 - acc: 0.7789
Epoch 12/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.5097 - acc: 0.7982
Epoch 13/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4887 - acc: 0.7958
Epoch 14/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.6207 - acc: 0.7750
Epoch 15/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4610 - acc: 0.8044
Epoch 16/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4483 - acc: 0.8058
Epoch 17/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4260 - acc: 0.8123
Epoch 18/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.4254 - acc: 0.8256
Epoch 19/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3849 - acc: 0.8450
Epoch 20/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3593 - acc: 0.8605
Epoch 21/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3363 - acc: 0.8780
Epoch 22/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3305 - acc: 0.8958
Epoch 23/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3687 - acc: 0.9011
Epoch 24/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.3013 - acc: 0.9035
Epoch 25/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2734 - acc: 0.9223
Epoch 26/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2496 - acc: 0.9221
Epoch 27/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2340 - acc: 0.9270
Epoch 28/30
```

```
Epoch 28/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2166 - acc: 0.9276
Epoch 29/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.1983 - acc: 0.9339
Epoch 30/30
4902/4902 [==============================] - 11s 2ms/step - loss: 0.2373 - acc: 0.9351
2450/2450 [==============================] - 2s 828us/step
4902/4902 [==============================] - 2s 447us/step
Epoch 1/30
4901/4901 [==============================] - 15s 3ms/step - loss: 1.3916 - acc: 0.4297
Epoch 2/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.2035 - acc: 0.4742
Epoch 3/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1509 - acc: 0.5003
Epoch 4/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0140 - acc: 0.5697
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8858 - acc: 0.6307
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7840 - acc: 0.6491
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7383 - acc: 0.6607
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7093 - acc: 0.6754
Epoch 9/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6492 - acc: 0.7125
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5713 - acc: 0.7584
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5236 - acc: 0.7754
Epoch 12/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4686 - acc: 0.7902
Epoch 13/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4897 - acc: 0.7862
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5002 - acc: 0.7882
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4249 - acc: 0.8149
Epoch 16/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4362 - acc: 0.8229
Epoch 17/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3686 - acc: 0.8708
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3123 - acc: 0.9027
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2846 - acc: 0.9092
Epoch 20/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2551 - acc: 0.9178
Epoch 21/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2227 - acc: 0.9284
Epoch 22/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.2995 - acc: 0.9082
Epoch 23/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2095 - acc: 0.9263
Epoch 24/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1962 - acc: 0.9355
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1833 - acc: 0.9363
Epoch 26/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1903 - acc: 0.9339
Epoch 27/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2292 - acc: 0.9243
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1742 - acc: 0.9402
Epoch 29/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1855 - acc: 0.9351
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.1568 - acc: 0.9441
2451/2451 [==============================] - 2s 933us/step
4901/4901 [==============================] - 2s 498us/step
Epoch 1/30
4901/4901 [==============================] - 15s 3ms/step - loss: 1.4099 - acc: 0.4040
Epoch 2/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.1628 - acc: 0.4938
Epoch 3/30
4901/4901 [==============================] - 11s 2ms/step - loss: 1.0763 - acc: 0.5119
Epoch 4/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9887 - acc: 0.5658
```

```
4901/4901 [==============================] - 11s 2ms/step - loss: 0.9667 - acc: 0.5656
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8741 - acc: 0.6140
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9964 - acc: 0.5636
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9633 - acc: 0.5787
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8634 - acc: 0.6203
Epoch 9/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8052 - acc: 0.6238
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7217 - acc: 0.6697
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.2338 - acc: 0.4989
Epoch 12/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8029 - acc: 0.6605
Epoch 13/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6639 - acc: 0.7356
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5765 - acc: 0.7925
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5277 - acc: 0.8229
Epoch 16/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4910 - acc: 0.8368
Epoch 17/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4132 - acc: 0.8715
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3601 - acc: 0.8878
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3224 - acc: 0.9057
Epoch 20/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2919 - acc: 0.9104
Epoch 21/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2636 - acc: 0.9153
Epoch 22/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2883 - acc: 0.9106
Epoch 23/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3776 - acc: 0.8821
Epoch 24/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2487 - acc: 0.9221
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2286 - acc: 0.9239
Epoch 26/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2183 - acc: 0.9316
Epoch 27/30
4901/4901 [==============================] - 11s 2ms/step - loss: 0.2221 - acc: 0.9329
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2160 - acc: 0.9341
Epoch 29/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2386 - acc: 0.9249
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2970 - acc: 0.9090
2451/2451 [==============================] - 2s 964us/step
4901/4901 [==============================] - 2s 474us/step
Epoch 1/30
4902/4902 [==============================] - 15s 3ms/step - loss: 1.4028 - acc: 0.3949
Epoch 2/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.2430 - acc: 0.4390
Epoch 3/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.0827 - acc: 0.5000
Epoch 4/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.9907 - acc: 0.5475
Epoch 5/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.8636 - acc: 0.6108
Epoch 6/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7752 - acc: 0.6401
Epoch 7/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.7803 - acc: 0.6320
Epoch 8/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6839 - acc: 0.6673
Epoch 9/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6860 - acc: 0.6803
Epoch 10/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6397 - acc: 0.7046
Epoch 11/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6149 - acc: 0.7128
Epoch 12/30
```

```
Epoch 12/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6547 - acc: 0.6781
Epoch 13/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6566 - acc: 0.6914
Epoch 14/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.5750 - acc: 0.7264
Epoch 15/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.5366 - acc: 0.7542
Epoch 16/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.4924 - acc: 0.7919
Epoch 17/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.5148 - acc: 0.7689
Epoch 18/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.4746 - acc: 0.8054
Epoch 19/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.4160 - acc: 0.8482
Epoch 20/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.3588 - acc: 0.8729
Epoch 21/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.3168 - acc: 0.8915
Epoch 22/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.3041 - acc: 0.8968
Epoch 23/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.2647 - acc: 0.9145
Epoch 24/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.2700 - acc: 0.9092
Epoch 25/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.2070 - acc: 0.9282
Epoch 26/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.1968 - acc: 0.9304
Epoch 27/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.2460 - acc: 0.9247
Epoch 28/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.2189 - acc: 0.9225
Epoch 29/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.1860 - acc: 0.9380
Epoch 30/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.1644 - acc: 0.9372
2450/2450 [==============================] - 2s 977us/step
4902/4902 [==============================] - 3s 512us/step
Epoch 1/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.3577 - acc: 0.4248
Epoch 2/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.1931 - acc: 0.4762
Epoch 3/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.1139 - acc: 0.5101
Epoch 4/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.9581 - acc: 0.5940
Epoch 5/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.7905 - acc: 0.6566
Epoch 6/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.7112 - acc: 0.6825
Epoch 7/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6886 - acc: 0.7068
Epoch 8/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6122 - acc: 0.7600
Epoch 9/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.5525 - acc: 0.8078
Epoch 10/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4677 - acc: 0.8437
Epoch 11/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4595 - acc: 0.8545
Epoch 12/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4333 - acc: 0.8582
Epoch 13/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3720 - acc: 0.8778
Epoch 14/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3231 - acc: 0.8947
Epoch 15/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2665 - acc: 0.9055
Epoch 16/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2785 - acc: 0.9068: 1s - loss:
0.2
Epoch 17/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2687 - acc: 0.9063
Epoch 18/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3061 - acc: 0.8925
Epoch 19/30
```

```
Epoch 19/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2339 - acc: 0.9161
Epoch 20/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2381 - acc: 0.9172
Epoch 21/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2483 - acc: 0.9198
Epoch 22/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2540 - acc: 0.9123: 1s - loss:
0.
Epoch 23/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2939 - acc: 0.8949
Epoch 24/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2263 - acc: 0.9247
Epoch 25/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2033 - acc: 0.9296
Epoch 26/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1919 - acc: 0.9282
Epoch 27/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1793 - acc: 0.9325: 0s - loss:
0.1780 - a
Epoch 28/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.1852 - acc: 0.9374
Epoch 29/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1812 - acc: 0.9355
Epoch 30/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1684 - acc: 0.9361
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 3s 665us/step
Epoch 1/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.3744 - acc: 0.3724
Epoch 2/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.2134 - acc: 0.4511
Epoch 3/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.0952 - acc: 0.5091
Epoch 4/30
4901/4901 [==============================] - 13s 3ms/step - loss: 1.0291 - acc: 0.5372
Epoch 5/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.9408 - acc: 0.5780
Epoch 6/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.8069 - acc: 0.6550
Epoch 7/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.7969 - acc: 0.6707
Epoch 8/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.7721 - acc: 0.6366
Epoch 9/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.7536 - acc: 0.6772
Epoch 10/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6539 - acc: 0.7274
Epoch 11/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.6088 - acc: 0.7625
Epoch 12/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.5833 - acc: 0.7849
Epoch 13/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4794 - acc: 0.8255
Epoch 14/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.4063 - acc: 0.8606: 2s - l
Epoch 15/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3925 - acc: 0.8784
Epoch 16/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.3644 - acc: 0.8925
Epoch 17/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2782 - acc: 0.9143
Epoch 18/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2664 - acc: 0.9304: 4s - ETA:
1s - loss
Epoch 19/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2571 - acc: 0.9225
Epoch 20/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2272 - acc: 0.9310
Epoch 21/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1927 - acc: 0.9398
Epoch 22/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1704 - acc: 0.9457
Epoch 23/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1692 - acc: 0.9469
Epoch 24/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1588 - acc: 0.9480
Epoch 25/30
```

```
Epoch 25/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1825 - acc: 0.9414
Epoch 26/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1746 - acc: 0.9465
Epoch 27/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1466 - acc: 0.9494: 2
Epoch 28/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1617 - acc: 0.9465
Epoch 29/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1439 - acc: 0.9504
Epoch 30/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.1394 - acc: 0.9516
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 3s 660us/step
Epoch 1/30
4902/4902 [==============================] - 17s 3ms/step - loss: 1.3584 - acc: 0.3752
Epoch 2/30
4902/4902 [==============================] - 13s 3ms/step - loss: 1.1485 - acc: 0.4869
Epoch 3/30
4902/4902 [==============================] - 13s 3ms/step - loss: 1.0453 - acc: 0.5259
Epoch 4/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8942 - acc: 0.5732
Epoch 5/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8299 - acc: 0.6144
Epoch 6/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.7269 - acc: 0.6442
Epoch 7/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8570 - acc: 0.6087
Epoch 8/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.7882 - acc: 0.6230
Epoch 9/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8263 - acc: 0.6795: 0s - loss:
0.8321 - acc:
Epoch 10/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.6030 - acc: 0.7475: 0s - loss:
0.6023 - acc: 0
Epoch 11/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.5410 - acc: 0.7852
Epoch 12/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4371 - acc: 0.8231
Epoch 13/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.3873 - acc: 0.8623
Epoch 14/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.3396 - acc: 0.8796
Epoch 15/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2747 - acc: 0.8988
Epoch 16/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2481 - acc: 0.9076
Epoch 17/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2133 - acc: 0.9233
Epoch 18/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2119 - acc: 0.9245
Epoch 19/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.2016 - acc: 0.9286: 2s
Epoch 20/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1731 - acc: 0.9343
Epoch 21/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1626 - acc: 0.9359
Epoch 22/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1740 - acc: 0.9323
Epoch 23/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1481 - acc: 0.9390
Epoch 24/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1403 - acc: 0.9457
Epoch 25/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1696 - acc: 0.9317
Epoch 26/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1823 - acc: 0.9345
Epoch 27/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1595 - acc: 0.9410
Epoch 28/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1435 - acc: 0.9419
Epoch 29/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1919 - acc: 0.9359
Epoch 30/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.1261 - acc: 0.9461: 0s - loss:
0.1269 - acc: 0.94
```

```
2450/2450 [==============================] - 3s 1ms/step
4902/4902 [==============================] - 3s 681us/step
Epoch 1/30
4901/4901 [==============================] - 21s 4ms/step - loss: 1.3418 - acc: 0.4273
Epoch 2/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.0938 - acc: 0.5193
Epoch 3/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.0448 - acc: 0.5546
Epoch 4/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.0509 - acc: 0.5134
Epoch 5/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.9704 - acc: 0.5754: 0s - loss:
0.9717 - acc: 0.5
Epoch 6/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.7481 - acc: 0.6719
Epoch 7/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.6786 - acc: 0.7129
Epoch 8/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.6225 - acc: 0.7629
Epoch 9/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.5587 - acc: 0.8004
Epoch 10/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.4496 - acc: 0.8408
Epoch 11/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.3864 - acc: 0.8684
Epoch 12/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.3431 - acc: 0.8837
Epoch 13/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.3009 - acc: 0.8898
Epoch 14/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.2534 - acc: 0.9102
Epoch 15/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.2168 - acc: 0.9227
Epoch 16/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1998 - acc: 0.9276
Epoch 17/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1821 - acc: 0.9349
Epoch 18/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1754 - acc: 0.9380
Epoch 19/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.2031 - acc: 0.9296
Epoch 20/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1697 - acc: 0.9367
Epoch 21/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1697 - acc: 0.9372
Epoch 22/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1768 - acc: 0.9355
Epoch 23/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1504 - acc: 0.9394
Epoch 24/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1744 - acc: 0.9333
Epoch 25/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1487 - acc: 0.9394
Epoch 26/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1561 - acc: 0.9416
Epoch 27/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1518 - acc: 0.9459
Epoch 28/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1328 - acc: 0.9494
Epoch 29/30
4901/4901 [==============================] - 18s 4ms/step - loss: 0.1514 - acc: 0.9435
Epoch 30/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1373 - acc: 0.9414
2451/2451 [==============================] - 4s 2ms/step
4901/4901 [==============================] - 5s 1ms/step
Epoch 1/30
4901/4901 [==============================] - 22s 4ms/step - loss: 1.3360 - acc: 0.4058
Epoch 2/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.1907 - acc: 0.4628
Epoch 3/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.1870 - acc: 0.4850
Epoch 4/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.0308 - acc: 0.5321
Epoch 5/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.9164 - acc: 0.5872
Epoch 6/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.7285 - acc: 0.6678
```

```
Epoch 7/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.7856 - acc: 0.6913
Epoch 8/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.6270 - acc: 0.7590
Epoch 9/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.4539 - acc: 0.8429
Epoch 10/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.3596 - acc: 0.8866
Epoch 11/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.3302 - acc: 0.8898
Epoch 12/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2537 - acc: 0.9206
Epoch 13/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.2195 - acc: 0.9296
Epoch 14/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1945 - acc: 0.9398
Epoch 15/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1705 - acc: 0.9376
Epoch 16/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1549 - acc: 0.9418
Epoch 17/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1661 - acc: 0.9455
Epoch 18/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.2461 - acc: 0.9259
Epoch 19/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1699 - acc: 0.9410
Epoch 20/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1396 - acc: 0.9480
Epoch 21/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1323 - acc: 0.9510
Epoch 22/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1352 - acc: 0.9504
Epoch 23/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1355 - acc: 0.9494
Epoch 24/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1284 - acc: 0.9512
Epoch 25/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1273 - acc: 0.9508
Epoch 26/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1389 - acc: 0.9527
Epoch 27/30
4901/4901 [==============================] - 17s 3ms/step - loss: 0.1114 - acc: 0.9545
Epoch 28/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1243 - acc: 0.9559
Epoch 29/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1105 - acc: 0.9565
Epoch 30/30
4901/4901 [==============================] - 17s 4ms/step - loss: 0.1236 - acc: 0.9567
2451/2451 [==============================] - 4s 2ms/step
4901/4901 [==============================] - 5s 1ms/step
Epoch 1/30
4902/4902 [==============================] - 22s 4ms/step - loss: 1.3397 - acc: 0.3925
Epoch 2/30
4902/4902 [==============================] - 18s 4ms/step - loss: 1.2106 - acc: 0.4517
Epoch 3/30
4902/4902 [==============================] - 18s 4ms/step - loss: 1.0882 - acc: 0.4931
Epoch 4/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.9896 - acc: 0.5641
Epoch 5/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.8262 - acc: 0.6138
Epoch 6/30
4902/4902 [==============================] - 18s 4ms/step - loss: 1.0674 - acc: 0.5365
Epoch 7/30
4902/4902 [==============================] - 18s 4ms/step - loss: 1.1626 - acc: 0.4590
Epoch 8/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.8042 - acc: 0.6267
Epoch 9/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.6782 - acc: 0.6393
Epoch 10/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.6748 - acc: 0.6638
Epoch 11/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.6260 - acc: 0.6842
Epoch 12/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.6295 - acc: 0.7301
Epoch 13/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.5774 - acc: 0.7489
Epoch 14/30
```

```
4902/4902 [==============================] - 18s 4ms/step - loss: 0.4165 - acc: 0.8454
Epoch 15/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.3289 - acc: 0.8872
Epoch 16/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.2892 - acc: 0.8970
Epoch 17/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.2430 - acc: 0.9104
Epoch 18/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1952 - acc: 0.9255
Epoch 19/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1897 - acc: 0.9343
Epoch 20/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1827 - acc: 0.9349
Epoch 21/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1678 - acc: 0.9382
Epoch 22/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1877 - acc: 0.9286
Epoch 23/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1695 - acc: 0.9378
Epoch 24/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1697 - acc: 0.9404
Epoch 25/30
4902/4902 [==============================] - 17s 4ms/step - loss: 0.1880 - acc: 0.9292
Epoch 26/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1587 - acc: 0.9433
Epoch 27/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1285 - acc: 0.9484
Epoch 28/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1434 - acc: 0.9423
Epoch 29/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1680 - acc: 0.9421
Epoch 30/30
4902/4902 [==============================] - 18s 4ms/step - loss: 0.1269 - acc: 0.9478
2450/2450 [==============================] - 4s 2ms/step
4902/4902 [==============================] - 5s 1ms/step
Epoch 1/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.5097 - acc: 0.3591
Epoch 2/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.2994 - acc: 0.4483
Epoch 3/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1842 - acc: 0.5007
Epoch 4/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0748 - acc: 0.5462
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0335 - acc: 0.5448
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1851 - acc: 0.4658
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1613 - acc: 0.4764
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9444 - acc: 0.5731
Epoch 9/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8770 - acc: 0.6107
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8669 - acc: 0.6097
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8008 - acc: 0.6356
Epoch 12/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8972 - acc: 0.5954
Epoch 13/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8470 - acc: 0.6142
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9033 - acc: 0.5821
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8481 - acc: 0.6089
Epoch 16/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7946 - acc: 0.6340
Epoch 17/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8404 - acc: 0.6207
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7939 - acc: 0.6364
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7842 - acc: 0.6366
Epoch 20/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7554 - acc: 0.6423
Epoch 21/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8172 - acc: 0.6282
```

```
Epoch 22/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7890 - acc: 0.6576
Epoch 23/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7631 - acc: 0.6560
Epoch 24/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7081 - acc: 0.6517
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7071 - acc: 0.6582
Epoch 26/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6961 - acc: 0.6615
Epoch 27/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6927 - acc: 0.6717
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7154 - acc: 0.6558
Epoch 29/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7073 - acc: 0.6715
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7095 - acc: 0.6817
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 2s 453us/step
Epoch 1/30
4901/4901 [==============================] - 17s 3ms/step - loss: 1.6164 - acc: 0.3618
Epoch 2/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.3198 - acc: 0.5150
Epoch 3/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.1822 - acc: 0.5446
Epoch 4/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0779 - acc: 0.5611
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9732 - acc: 0.5870
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9105 - acc: 0.6074
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8725 - acc: 0.6160
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8375 - acc: 0.6370
Epoch 9/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7995 - acc: 0.6595
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7992 - acc: 0.6609
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7771 - acc: 0.6756
Epoch 12/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7530 - acc: 0.6760
Epoch 13/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7314 - acc: 0.6960
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7285 - acc: 0.7088
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7153 - acc: 0.7117
Epoch 16/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7009 - acc: 0.7294
Epoch 17/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6550 - acc: 0.7507
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6522 - acc: 0.7737
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6003 - acc: 0.7970
Epoch 20/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5808 - acc: 0.8151
Epoch 21/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5311 - acc: 0.8253
Epoch 22/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5234 - acc: 0.8408
Epoch 23/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4817 - acc: 0.8594
Epoch 24/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4717 - acc: 0.8553
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4356 - acc: 0.8698
Epoch 26/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4339 - acc: 0.8729
Epoch 27/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3983 - acc: 0.8827
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4069 - acc: 0.8806
Epoch 29/30
```

```
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3824 - acc: 0.8935
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3725 - acc: 0.8925
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 2s 494us/step
Epoch 1/30
4902/4902 [==============================] - 17s 3ms/step - loss: 1.5002 - acc: 0.3592
Epoch 2/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.3321 - acc: 0.4329
Epoch 3/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.2492 - acc: 0.4672
Epoch 4/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.2085 - acc: 0.4684
Epoch 5/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.1420 - acc: 0.4833
Epoch 6/30
4902/4902 [==============================] - 12s 2ms/step - loss: 1.0698 - acc: 0.5053
Epoch 7/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.9798 - acc: 0.5492
Epoch 8/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.9343 - acc: 0.5928
Epoch 9/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.8942 - acc: 0.6134
Epoch 10/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.8682 - acc: 0.6173
Epoch 11/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.8062 - acc: 0.6273
Epoch 12/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7917 - acc: 0.6448
Epoch 13/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7550 - acc: 0.6473
Epoch 14/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7929 - acc: 0.6357
Epoch 15/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7303 - acc: 0.6567
Epoch 16/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7577 - acc: 0.6493
Epoch 17/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7295 - acc: 0.6481
Epoch 18/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7247 - acc: 0.6485
Epoch 19/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7031 - acc: 0.6597
Epoch 20/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6812 - acc: 0.6689
Epoch 21/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.7208 - acc: 0.6552
Epoch 22/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6984 - acc: 0.6585
Epoch 23/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6656 - acc: 0.6695
Epoch 24/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6930 - acc: 0.6591
Epoch 25/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6590 - acc: 0.6699
Epoch 26/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6864 - acc: 0.6583
Epoch 27/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6489 - acc: 0.6712
Epoch 28/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6572 - acc: 0.6616
Epoch 29/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6720 - acc: 0.6646
Epoch 30/30
4902/4902 [==============================] - 12s 2ms/step - loss: 0.6517 - acc: 0.6659
2450/2450 [==============================] - 3s 1ms/step
4902/4902 [==============================] - 2s 452us/step
Epoch 1/30
4901/4901 [==============================] - 17s 4ms/step - loss: 1.4687 - acc: 0.3881
Epoch 2/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.2432 - acc: 0.4793
Epoch 3/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.1278 - acc: 0.5023
Epoch 4/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0327 - acc: 0.5625
Epoch 5/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9589 - acc: 0.5713
```

```
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8847 - acc: 0.5919
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.3326 - acc: 0.4366
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9097 - acc: 0.5866
Epoch 9/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7805 - acc: 0.6393
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7493 - acc: 0.6442
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7200 - acc: 0.6495
Epoch 12/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7322 - acc: 0.6519
Epoch 13/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.7130 - acc: 0.6386
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6741 - acc: 0.6593
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7081 - acc: 0.6497
Epoch 16/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7419 - acc: 0.6429
Epoch 17/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7304 - acc: 0.6523
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7142 - acc: 0.6586
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7174 - acc: 0.6613
Epoch 20/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6884 - acc: 0.6564
Epoch 21/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6790 - acc: 0.6637
Epoch 22/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6760 - acc: 0.6625
Epoch 23/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6584 - acc: 0.6644
Epoch 24/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6616 - acc: 0.6644
Epoch 25/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7353 - acc: 0.6625
Epoch 26/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6749 - acc: 0.6623
Epoch 27/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6700 - acc: 0.6666
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7207 - acc: 0.6607
Epoch 29/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6831 - acc: 0.6619
Epoch 30/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6944 - acc: 0.6635
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 2s 510us/step
Epoch 1/30
4901/4901 [==============================] - 18s 4ms/step - loss: 1.5134 - acc: 0.3507
Epoch 2/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.2513 - acc: 0.4817
Epoch 3/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.0765 - acc: 0.5676
Epoch 4/30
4901/4901 [==============================] - 12s 2ms/step - loss: 1.0834 - acc: 0.5260
Epoch 5/30
4901/4901 [==============================] - 12s 3ms/step - loss: 1.0263 - acc: 0.5444
Epoch 6/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.9233 - acc: 0.6023
Epoch 7/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8875 - acc: 0.6156
Epoch 8/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.8314 - acc: 0.6221
Epoch 9/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.8056 - acc: 0.6486
Epoch 10/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7987 - acc: 0.6556
Epoch 11/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.7262 - acc: 0.6668
Epoch 12/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.7228 - acc: 0.6766
Epoch 13/30
```

```
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6685 - acc: 0.7129
Epoch 14/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.6296 - acc: 0.7417
Epoch 15/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5775 - acc: 0.7917
Epoch 16/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.6751 - acc: 0.7743
Epoch 17/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.5981 - acc: 0.8102
Epoch 18/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5612 - acc: 0.8351
Epoch 19/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.5164 - acc: 0.8435
Epoch 20/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4639 - acc: 0.8655
Epoch 21/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.4229 - acc: 0.8782
Epoch 22/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.3823 - acc: 0.8980
Epoch 23/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3244 - acc: 0.9068
Epoch 24/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3642 - acc: 0.9045
Epoch 25/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3449 - acc: 0.9092
Epoch 26/30
4901/4901 [==============================] - 12s 3ms/step - loss: 0.3005 - acc: 0.9155
Epoch 27/30
4901/4901 [==============================] - 13s 3ms/step - loss: 0.2713 - acc: 0.9253
Epoch 28/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2374 - acc: 0.9353
Epoch 29/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2488 - acc: 0.9302
Epoch 30/30
4901/4901 [==============================] - 12s 2ms/step - loss: 0.2411 - acc: 0.9345
2451/2451 [==============================] - 3s 1ms/step
4901/4901 [==============================] - 2s 497us/step
Epoch 1/30
4902/4902 [==============================] - 18s 4ms/step - loss: 1.4234 - acc: 0.3900
Epoch 2/30
4902/4902 [==============================] - 12s 3ms/step - loss: 1.2556 - acc: 0.4621
Epoch 3/30
4902/4902 [==============================] - 12s 3ms/step - loss: 1.1571 - acc: 0.4792
Epoch 4/30
4902/4902 [==============================] - 12s 3ms/step - loss: 1.1203 - acc: 0.4843
Epoch 5/30
4902/4902 [==============================] - 12s 3ms/step - loss: 1.0627 - acc: 0.5014
Epoch 6/30
4902/4902 [==============================] - 12s 3ms/step - loss: 1.0073 - acc: 0.5182
Epoch 7/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.9263 - acc: 0.5730
Epoch 8/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.9227 - acc: 0.5843
Epoch 9/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.8430 - acc: 0.6155
Epoch 10/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8303 - acc: 0.6206
Epoch 11/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.8892 - acc: 0.5761
Epoch 12/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.8389 - acc: 0.6087
Epoch 13/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.7123 - acc: 0.6503
Epoch 14/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.6775 - acc: 0.6618
Epoch 15/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.7253 - acc: 0.6589
Epoch 16/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.6797 - acc: 0.6693
Epoch 17/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.6766 - acc: 0.6791
Epoch 18/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.6285 - acc: 0.6975
Epoch 19/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.5922 - acc: 0.7260
Epoch 20/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.9968 - acc: 0.6597
```

```
Epoch 21/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.6287 - acc: 0.7385
Epoch 22/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.5255 - acc: 0.7734
Epoch 23/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4835 - acc: 0.7972
Epoch 24/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.5089 - acc: 0.7923
Epoch 25/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4667 - acc: 0.7989
Epoch 26/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.4395 - acc: 0.8152
Epoch 27/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.4189 - acc: 0.8335
Epoch 28/30
4902/4902 [==============================] - 13s 3ms/step - loss: 0.4274 - acc: 0.8425
Epoch 29/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.4273 - acc: 0.8454
Epoch 30/30
4902/4902 [==============================] - 12s 3ms/step - loss: 0.3619 - acc: 0.8756
2450/2450 [==============================] - 3s 1ms/step
4902/4902 [==============================] - 2s 509us/step
Epoch 1/30
4901/4901 [==============================] - 20s 4ms/step - loss: 1.4295 - acc: 0.3583: 1s - loss:
1.4394 - ac
Epoch 2/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.2175 - acc: 0.4579: 5s
Epoch 3/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.1781 - acc: 0.4899: 1s - loss:
Epoch 4/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.9981 - acc: 0.5617
Epoch 5/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.9460 - acc: 0.5809
Epoch 6/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.8280 - acc: 0.6333
Epoch 7/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7803 - acc: 0.6427
Epoch 8/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7526 - acc: 0.6546
Epoch 9/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7541 - acc: 0.6582
Epoch 10/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7900 - acc: 0.6376
Epoch 11/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7271 - acc: 0.6550
Epoch 12/30
4901/4901 [==============================] - ETA: 0s - loss: 0.7168 - acc: 0.6673- ETA: 0s - loss:
0.7174 - acc: 0.66 - 14s 3ms/step - loss: 0.7167 - acc: 0.6670
Epoch 13/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7277 - acc: 0.6625
Epoch 14/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6582 - acc: 0.6766
Epoch 15/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6286 - acc: 0.7082: 1s - loss:

Epoch 16/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.5709 - acc: 0.7605
Epoch 17/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.5502 - acc: 0.8017
Epoch 18/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.4519 - acc: 0.8531
Epoch 19/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.4939 - acc: 0.8490: 1s - loss:
0
Epoch 20/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.3745 - acc: 0.8878
Epoch 21/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.3230 - acc: 0.9012
Epoch 22/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.3200 - acc: 0.9072
Epoch 23/30
4901/4901 [==============================] - ETA: 0s - loss: 0.2694 - acc: 0.918 - 14s 3ms/step -
loss: 0.2692 - acc: 0.9190
Epoch 24/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2505 - acc: 0.9172
Epoch 25/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2793 - acc: 0.9159
```

```
Epoch 26/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2676 - acc: 0.9114
Epoch 27/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2317 - acc: 0.9267
Epoch 28/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2879 - acc: 0.9155
Epoch 29/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2134 - acc: 0.9312
Epoch 30/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2606 - acc: 0.9182
2451/2451 [==============================] - 4s 2ms/step
4901/4901 [==============================] - 3s 694us/step
Epoch 1/30
4901/4901 [==============================] - 20s 4ms/step - loss: 1.4611 - acc: 0.3281: 2s - loss:
1.47
Epoch 2/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.2503 - acc: 0.4589: 9s - loss:
1.31 -  - ETA: - ETA: 1s - loss: 1
Epoch 3/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.1653 - acc: 0.4721
Epoch 4/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.1520 - acc: 0.4754
Epoch 5/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.0366 - acc: 0.5236
Epoch 6/30
4901/4901 [==============================] - 14s 3ms/step - loss: 1.0350 - acc: 0.5215
Epoch 7/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.9545 - acc: 0.5660
Epoch 8/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.8034 - acc: 0.6282: 2s -
Epoch 9/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.8545 - acc: 0.6131: 2s -
Epoch 10/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7616 - acc: 0.6442
Epoch 11/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6881 - acc: 0.6521: 0s - loss:
0.6919 -
Epoch 12/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.7434 - acc: 0.6454: 0s - loss:
0.7442 - a
Epoch 13/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6671 - acc: 0.6646: 1s - loss:
0.6705
Epoch 14/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6774 - acc: 0.6627
Epoch 15/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.6856 - acc: 0.6741
Epoch 16/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.5934 - acc: 0.6966
Epoch 17/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.5586 - acc: 0.7339
Epoch 18/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.5412 - acc: 0.7668
Epoch 19/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.4748 - acc: 0.8004
Epoch 20/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.4829 - acc: 0.8137: 7s - loss:
0.5251 - - ETA: 6s - loss - ETA: 4s - loss: 0.5039  -
Epoch 21/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.4329 - acc: 0.8484
Epoch 22/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.3642 - acc: 0.8821
Epoch 23/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.3023 - acc: 0.9047
Epoch 24/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2674 - acc: 0.9194: 1s - loss:

Epoch 25/30
4901/4901 [==============================] - 14s 3ms/step - loss: 0.2570 - acc: 0.9237
Epoch 26/30
4901/4901 [==============================] - 14s 3ms/step - loss: nan - acc: 0.4568
Epoch 27/30
4901/4901 [==============================] - 14s 3ms/step - loss: nan - acc: 0.1736
Epoch 28/30
4901/4901 [==============================] - 14s 3ms/step - loss: nan - acc: 0.1736
Epoch 29/30
4901/4901 [==============================] - 14s 3ms/step - loss: nan - acc: 0.1736
```

```
Epoch 30/30
4901/4901 [==============================] - 14s 3ms/step - loss: nan - acc: 0.1736
2451/2451 [==============================] - 4s 2ms/step
4901/4901 [==============================] - 3s 690us/step
Epoch 1/30
4902/4902 [==============================] - 20s 4ms/step - loss: 1.3788 - acc: 0.3829
Epoch 2/30
4902/4902 [==============================] - 14s 3ms/step - loss: 1.1810 - acc: 0.4871: 6s - loss:
1.1885 - acc: 0. - ETA
Epoch 3/30
4902/4902 [==============================] - 14s 3ms/step - loss: 1.0363 - acc: 0.5530
Epoch 4/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.9193 - acc: 0.6018
Epoch 5/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.8192 - acc: 0.6167
Epoch 6/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.7937 - acc: 0.6350: 1s - loss:
0.7
Epoch 7/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.7423 - acc: 0.6599
Epoch 8/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.7047 - acc: 0.6814
Epoch 9/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.7129 - acc: 0.6885
Epoch 10/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6859 - acc: 0.6989
Epoch 11/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.7406 - acc: 0.6430
Epoch 12/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6546 - acc: 0.7016
Epoch 13/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6632 - acc: 0.6930: 8s - lo -
ETA: 5s - - ETA: 0s - loss: 0.6628 - acc: 0.693
Epoch 14/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6116 - acc: 0.7309: 8s - ETA:
2s
Epoch 15/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6036 - acc: 0.7275: 1s - loss:
0.
Epoch 16/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.5752 - acc: 0.7379
Epoch 17/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.6320 - acc: 0.7303
Epoch 18/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.5860 - acc: 0.7652
Epoch 19/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4588 - acc: 0.8199
Epoch 20/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4761 - acc: 0.8295: 2s - loss:
0. - ETA: 0s - loss: 0.4767 - acc
Epoch 21/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4281 - acc: 0.8474: 0s - loss:
0.4346 - acc
Epoch 22/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4526 - acc: 0.8368: 9s - loss:
0.4 - ETA: 7s - loss: 0.4550  - ETA:
Epoch 23/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4429 - acc: 0.8488
Epoch 24/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.3741 - acc: 0.8752: 5s -
Epoch 25/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.4014 - acc: 0.8556
Epoch 26/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.3136 - acc: 0.8958: 3s - loss:
0 - ETA: 2s - lo
Epoch 27/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.3535 - acc: 0.8892
Epoch 28/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.3619 - acc: 0.8902
Epoch 29/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.2784 - acc: 0.9086: 5s -
Epoch 30/30
4902/4902 [==============================] - 14s 3ms/step - loss: 0.2919 - acc: 0.9115
2450/2450 [==============================] - 4s 2ms/step
4902/4902 [==============================] - 3s 704us/step
Epoch 1/30
4901/4901 [==============================] - 25s 5ms/step - loss: 1.3760 - acc: 0.3975
```

```
Epoch 2/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.1944 - acc: 0.4911
Epoch 3/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.0869 - acc: 0.4977
Epoch 4/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.0110 - acc: 0.5607
Epoch 5/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.8440 - acc: 0.6170
Epoch 6/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.9864 - acc: 0.5717
Epoch 7/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7880 - acc: 0.6344
Epoch 8/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7095 - acc: 0.6613
Epoch 9/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7550 - acc: 0.6486
Epoch 10/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7130 - acc: 0.6764
Epoch 11/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.6338 - acc: 0.7158
Epoch 12/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.6165 - acc: 0.7484
Epoch 13/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.5845 - acc: 0.7837
Epoch 14/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.4561 - acc: 0.8468
Epoch 15/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.4019 - acc: 0.8755
Epoch 16/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.3406 - acc: 0.8951
Epoch 17/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2657 - acc: 0.9086
Epoch 18/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2417 - acc: 0.9188
Epoch 19/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2435 - acc: 0.9200
Epoch 20/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2654 - acc: 0.9198
Epoch 21/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2346 - acc: 0.9270
Epoch 22/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2081 - acc: 0.9265
Epoch 23/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2242 - acc: 0.9298
Epoch 24/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2398 - acc: 0.9288
Epoch 25/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2266 - acc: 0.9190
Epoch 26/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2088 - acc: 0.9272
Epoch 27/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1868 - acc: 0.9341
Epoch 28/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2172 - acc: 0.9200
Epoch 29/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1696 - acc: 0.9404
Epoch 30/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2089 - acc: 0.9343
2451/2451 [==============================] - 5s 2ms/step
4901/4901 [==============================] - 6s 1ms/step
Epoch 1/30
4901/4901 [==============================] - 25s 5ms/step - loss: 1.4024 - acc: 0.3926
Epoch 2/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.2368 - acc: 0.4422
Epoch 3/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.1199 - acc: 0.5042
Epoch 4/30
4901/4901 [==============================] - 19s 4ms/step - loss: 1.0105 - acc: 0.5578
Epoch 5/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.8677 - acc: 0.5970
Epoch 6/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.8248 - acc: 0.6142
Epoch 7/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7465 - acc: 0.6303
Epoch 8/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7123 - acc: 0.6572
Epoch 9/30
```

```
Epoch 9/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7893 - acc: 0.6597
Epoch 10/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7343 - acc: 0.6917
Epoch 11/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.7061 - acc: 0.7115
Epoch 12/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.5872 - acc: 0.7600
Epoch 13/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.5489 - acc: 0.8102
Epoch 14/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.4590 - acc: 0.8537
Epoch 15/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.3844 - acc: 0.8868
Epoch 16/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.3234 - acc: 0.9094
Epoch 17/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2630 - acc: 0.9216
Epoch 18/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2774 - acc: 0.9190
Epoch 19/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2324 - acc: 0.9274
Epoch 20/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2266 - acc: 0.9329
Epoch 21/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2271 - acc: 0.9380
Epoch 22/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2868 - acc: 0.9255
Epoch 23/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1992 - acc: 0.9351
Epoch 24/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2381 - acc: 0.9325
Epoch 25/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2345 - acc: 0.9337
Epoch 26/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2000 - acc: 0.9441
Epoch 27/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1754 - acc: 0.9457
Epoch 28/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1577 - acc: 0.9476
Epoch 29/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.1861 - acc: 0.9482
Epoch 30/30
4901/4901 [==============================] - 19s 4ms/step - loss: 0.2021 - acc: 0.9425
2451/2451 [==============================] - 5s 2ms/step
4901/4901 [==============================] - 6s 1ms/step
Epoch 1/30
4902/4902 [==============================] - 26s 5ms/step - loss: 1.4158 - acc: 0.3945
Epoch 2/30
4902/4902 [==============================] - 19s 4ms/step - loss: 1.3176 - acc: 0.4074
Epoch 3/30
4902/4902 [==============================] - 19s 4ms/step - loss: 1.1227 - acc: 0.4945
Epoch 4/30
4902/4902 [==============================] - 19s 4ms/step - loss: 1.0690 - acc: 0.5198
Epoch 5/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.9012 - acc: 0.5830
Epoch 6/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.7288 - acc: 0.6399
Epoch 7/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.7181 - acc: 0.6442
Epoch 8/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.7817 - acc: 0.6328
Epoch 9/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.8452 - acc: 0.5987
Epoch 10/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.7236 - acc: 0.6522
Epoch 11/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.6894 - acc: 0.6536
Epoch 12/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.7318 - acc: 0.6455
Epoch 13/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.6445 - acc: 0.6952
Epoch 14/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.5901 - acc: 0.7289
Epoch 15/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.5132 - acc: 0.7766
Epoch 16/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.5019 - acc: 0.7909
```

```
4902/4902 [==============================] - 19s 4ms/step - loss: 0.5019 - acc: 0.7909
Epoch 17/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.4123 - acc: 0.8346
Epoch 18/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.3811 - acc: 0.8578
Epoch 19/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.3201 - acc: 0.8825
Epoch 20/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2905 - acc: 0.8984
Epoch 21/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2961 - acc: 0.8949
Epoch 22/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2653 - acc: 0.9035
Epoch 23/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2354 - acc: 0.9268
Epoch 24/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2013 - acc: 0.9286
Epoch 25/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2040 - acc: 0.9233
Epoch 26/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.4191 - acc: 0.8894
Epoch 27/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2417 - acc: 0.9188
Epoch 28/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.1678 - acc: 0.9351
Epoch 29/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.2839 - acc: 0.9221
Epoch 30/30
4902/4902 [==============================] - 19s 4ms/step - loss: 0.1425 - acc: 0.9412
2450/2450 [==============================] - 6s 2ms/step
4902/4902 [==============================] - 6s 1ms/step

[Parallel(n_jobs=1)]: Done  36 out of  36 | elapsed: 248.8min finished

Epoch 1/30
7352/7352 [==============================] - 36s 5ms/step - loss: 1.3193 - acc: 0.4177
Epoch 2/30
7352/7352 [==============================] - 29s 4ms/step - loss: 1.0762 - acc: 0.5007
Epoch 3/30
7352/7352 [==============================] - 29s 4ms/step - loss: 1.0878 - acc: 0.5275
Epoch 4/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.8150 - acc: 0.5981
Epoch 5/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.6970 - acc: 0.6396
Epoch 6/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.6286 - acc: 0.7040
Epoch 7/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.5214 - acc: 0.7867
Epoch 8/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.3840 - acc: 0.8700
Epoch 9/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.3223 - acc: 0.8953
Epoch 10/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.2747 - acc: 0.8977
Epoch 11/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.2139 - acc: 0.9227
Epoch 12/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1823 - acc: 0.9357
Epoch 13/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1796 - acc: 0.9332
Epoch 14/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1670 - acc: 0.9384
Epoch 15/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1608 - acc: 0.9423
Epoch 16/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1581 - acc: 0.9438
Epoch 17/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1566 - acc: 0.9404
Epoch 18/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1452 - acc: 0.9456
Epoch 19/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1453 - acc: 0.9436
Epoch 20/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1376 - acc: 0.9478
Epoch 21/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1467 - acc: 0.9464
Epoch 22/30
```

```
Epoch 22/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1433 - acc: 0.9442
Epoch 23/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1452 - acc: 0.9434
Epoch 24/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1320 - acc: 0.9474
Epoch 25/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1328 - acc: 0.9494
Epoch 26/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1360 - acc: 0.9510
Epoch 27/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1346 - acc: 0.9505
Epoch 28/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1276 - acc: 0.9509
Epoch 29/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1329 - acc: 0.9493
Epoch 30/30
7352/7352 [==============================] - 29s 4ms/step - loss: 0.1247 - acc: 0.9513
```

Out[16]:

```
GridSearchCV(cv='warn', error_score='raise-deprecating',
             estimator=<keras.wrappers.scikit_learn.KerasClassifier object at 0x000000102F2217F0>,
             iid='warn', n_jobs=None,
             param_grid={'rate': [0.25, 0.5, 0.75], 'units': [32, 50, 75, 120]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
             scoring=None, verbose=1)
```

In [17]:

```
results2=pd.DataFrame(gs.cv_results_).sort_values(by='rank_test_score')
results2
```

Out[17]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_rate	param_units	params	split0_test_score	sp
7	527.647625	6.007313	4.234099	0.108445	0.5	120	{'rate': 0.5, 'units': 120}	0.940840	0.9
11	575.242887	4.367187	5.435952	0.105066	0.75	120	{'rate': 0.75, 'units': 120}	0.931457	0.9
3	505.279724	2.539347	3.154789	0.078219	0.25	120	{'rate': 0.25, 'units': 120}	0.944512	0.8
0	321.903135	3.703575	1.174702	0.029534	0.25	32	{'rate': 0.25, 'units': 32}	0.940432	0.8
6	399.889164	1.962008	3.039253	0.063813	0.5	75	{'rate': 0.5, 'units': 75}	0.931865	0.8
1	340.882094	3.834282	1.465524	0.056561	0.25	50	{'rate': 0.25, 'units': 50}	0.911873	0.8
5	358.696543	3.870178	2.351838	0.045211	0.5	50	{'rate': 0.5, 'units': 50}	0.926969	0.8
							{'rate':		

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_rate	param_units	params	split0_test_score	sp
4	333.774160	1.760434	1.961462	0.055249	0.5	32	0.5, 'units': 32}	0.906161	0.8
2	379.636419	2.948856	2.107200	0.050675	0.25	75	{'rate': 0.25, 'units': 75}	0.935537	0.7
9	376.254098	4.405062	3.302417	0.075248	0.75	50	{'rate': 0.75, 'units': 50}	0.655243	0.8
8	359.093956	0.845472	2.993633	0.070305	0.75	32	{'rate': 0.75, 'units': 32}	0.676051	0.8
10	422.288964	2.377860	3.989702	0.077297	0.75	75	{'rate': 0.75, 'units': 75}	0.872297	0.1

In [24]:

```
tf.keras.backend.clear_session()
# Initiliazing the sequential model
model = Sequential()
# Configuring the parameters
model.add(LSTM(75, input_shape=(timesteps, input_dim)))
# Adding a dropout layer
model.add(Dropout(0.25))
# Adding a dense output layer with sigmoid activation
model.add(Dense(n_classes, activation='sigmoid'))
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 75)                25500
_________________________________________________________________
dropout_1 (Dropout)          (None, 75)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 456
=================================================================
Total params: 25,956
Trainable params: 25,956
Non-trainable params: 0
_________________________________________________________________
```

In [25]:

```
# Compiling the model
model.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
```

In [23]:

```
model.fit(X_train,
          Y_train,
          batch_size=batch_size,
          validation_data=(X_test, Y_test),
          epochs=epochs)
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 7352 samples, validate on 2947 samples
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 46s 6ms/step - loss: 1.2742 - acc: 0.4457 - val_loss:
1.0340 - val_acc: 0.5779
Epoch 2/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.9959 - acc: 0.5635 - val_loss:
0.8613 - val_acc: 0.6189
Epoch 3/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.8477 - acc: 0.6212 - val_loss:
0.8045 - val_acc: 0.6284
Epoch 4/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.6366 - acc: 0.7225 - val_loss:
0.6710 - val_acc: 0.7835
Epoch 5/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.4576 - acc: 0.8338 - val_loss:
0.7840 - val_acc: 0.7808
Epoch 6/30
7352/7352 [==============================] - 45s 6ms/step - loss: 0.3271 - acc: 0.8864 - val_loss:
0.4474 - val_acc: 0.8541
Epoch 7/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.2709 - acc: 0.9104 - val_loss:
0.3720 - val_acc: 0.8633
Epoch 8/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.2180 - acc: 0.9244 - val_loss:
0.2824 - val_acc: 0.8972
Epoch 9/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1840 - acc: 0.9321 - val_loss:
0.3335 - val_acc: 0.8996
Epoch 10/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1715 - acc: 0.9361 - val_loss:
0.4097 - val_acc: 0.8863
Epoch 11/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1847 - acc: 0.9346 - val_loss:
0.3546 - val_acc: 0.9053
Epoch 12/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1620 - acc: 0.9421 - val_loss:
0.2867 - val_acc: 0.9013
Epoch 13/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1523 - acc: 0.9430 - val_loss:
0.3227 - val_acc: 0.9091
Epoch 14/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1499 - acc: 0.9482 - val_loss:
0.2414 - val_acc: 0.9182
Epoch 15/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1420 - acc: 0.9482 - val_loss:
0.3737 - val_acc: 0.9189
Epoch 16/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1437 - acc: 0.9487 - val_loss:
0.2709 - val_acc: 0.9162
Epoch 17/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1411 - acc: 0.9484 - val_loss:
0.3797 - val_acc: 0.9104
Epoch 18/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1469 - acc: 0.9499 - val_loss:
0.3500 - val_acc: 0.9036
Epoch 19/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1435 - acc: 0.9465 - val_loss:
0.3696 - val_acc: 0.9104
Epoch 20/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1292 - acc: 0.9484 - val_loss:
0.3610 - val_acc: 0.9162
Epoch 21/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1291 - acc: 0.9514 - val_loss:
0.3301 - val_acc: 0.9267
Epoch 22/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1260 - acc: 0.9509 - val_loss:
0.2382 - val_acc: 0.9213
Epoch 23/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1313 - acc: 0.9487 - val_loss:
0.3531 - val_acc: 0.9182
Epoch 24/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1283 - acc: 0.9520 - val_loss:
0.4482 - val_acc: 0.9046
Epoch 25/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1290 - acc: 0.9509 - val_loss:
0.4083 - val_acc: 0.9091
Epoch 26/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1222 - acc: 0.9521 - val_loss:
```

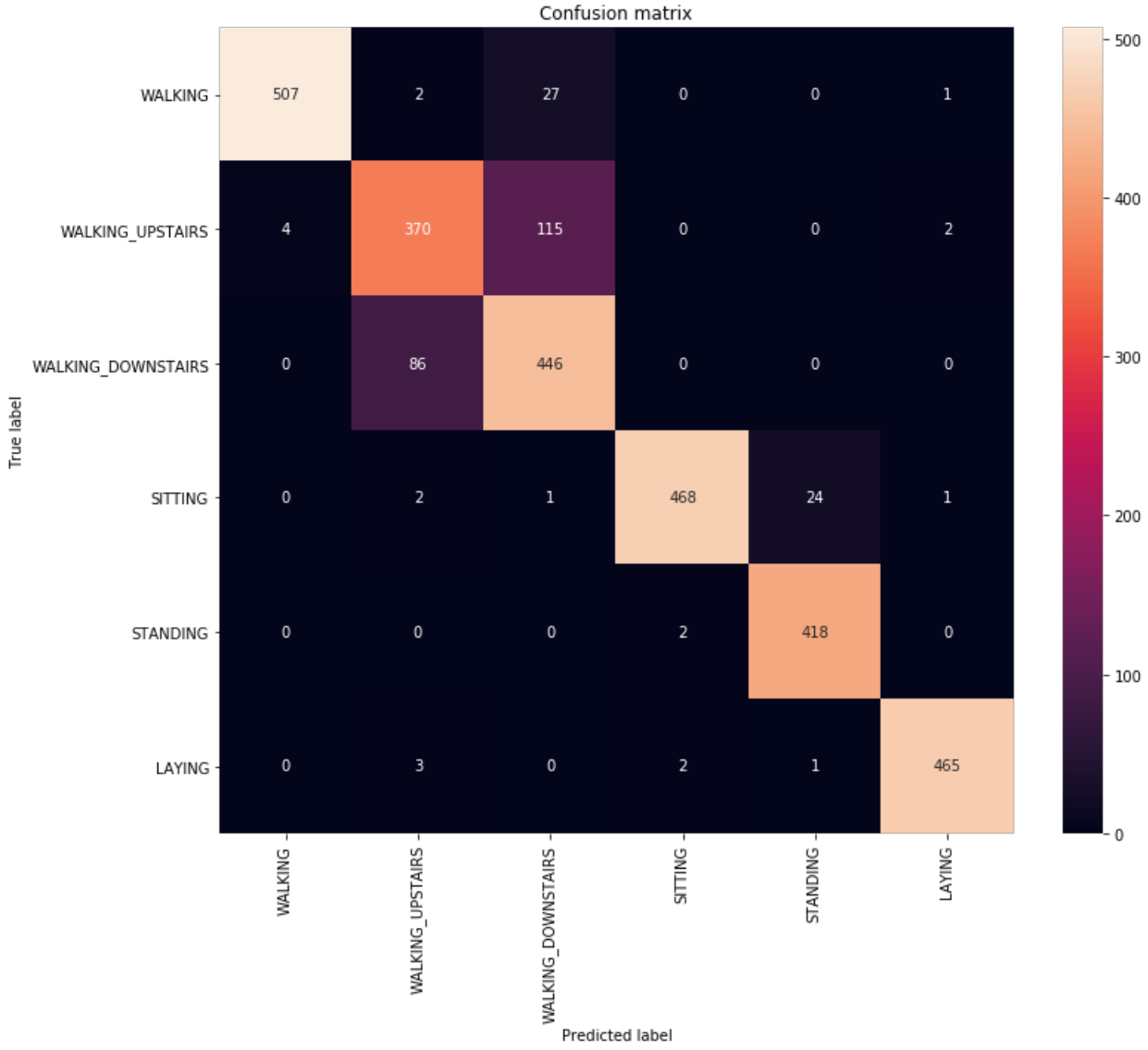
```
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1222 - acc: 0.9521 - val_loss:
0.3914 - val_acc: 0.9145
Epoch 27/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1303 - acc: 0.9523 - val_loss:
0.3176 - val_acc: 0.9179
Epoch 28/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1258 - acc: 0.9539 - val_loss:
0.7749 - val_acc: 0.8514
Epoch 29/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1375 - acc: 0.9516 - val_loss:
0.3887 - val_acc: 0.9087
Epoch 30/30
7352/7352 [==============================] - 46s 6ms/step - loss: 0.1392 - acc: 0.9527 - val_loss:
0.4432 - val_acc: 0.9128
```

Out[23]:

```
<keras.callbacks.History at 0xe0e1269ac8>
```

In [48]:

```
heap_map_confusion_matrix(Y_test, model.predict(X_test))
```



In [51]:

```
score = model.evaluate(X_test, Y_test)
```

```
2947/2947 [==============================] - 2s 606us/step
```

In [52]:

```
score
```

Out[52]:

```
[0.4251796115343771, 0.9073634204275535]
```

1. Even after doing hyper parameter tuning, could not get accuracy more than 96%.
2. 91.69% accuracy got if I choose 72 LSTM units and dropout rate=0.25,because we have less data point model is over fining.
3. Train accuracy is 95.23% and test accuracy is 97.69% there is huge gap between train and test accuracy we can conclude that model is overfitting.

Model with 2 LSTM layers

LSTM(75)->dropout(0.1)->LSTM(32)->dropout(0.1)->dense(6)

In [28]:

```
tf.keras.backend.clear_session()
model1 = Sequential()
# Configuring the parameters
model1.add(LSTM(75,return_sequences=True, input_shape=(timesteps, input_dim)))
# Adding a dropout layer
model1.add(Dropout(0.1))
model1.add(LSTM(32, input_shape=(timesteps, input_dim)))
model1.add(Dropout(0.1))
# Adding a dense output layer with sigmoid activation
model1.add(Dense(n_classes, activation='sigmoid'))
model1.summary()
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\framework\op_def_library.py:263: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\keras\backend\tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 75)           25500
_________________________________________________________________
dropout_1 (Dropout)          (None, 128, 75)           0
_________________________________________________________________
lstm_2 (LSTM)                (None, 32)                13824
_________________________________________________________________
dropout_2 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 198
=================================================================
Total params: 39,522
Trainable params: 39,522
Non-trainable params: 0
_________________________________________________________________
```

In [29]:

```
# Compiling the model
model1.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
```

In [30]:

```
# Training the model 75,0.1,32,.01
model1.fit(X_train,Y_train, batch_size=22, validation_data=(X_test, Y_test), epochs=epochs)
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 59s 8ms/step - loss: 1.2147 - acc: 0.4781 - val_loss:
1.0385 - val_acc: 0.5582
Epoch 2/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.8280 - acc: 0.6336 - val_loss:
0.8380 - val_acc: 0.6624
Epoch 3/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.7065 - acc: 0.6813 - val_loss:
0.9908 - val_acc: 0.6532
Epoch 4/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.6230 - acc: 0.7452 - val_loss:
0.6537 - val_acc: 0.7577
Epoch 5/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.4110 - acc: 0.8715 - val_loss:
0.4141 - val_acc: 0.8558
Epoch 6/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.2679 - acc: 0.9161 - val_loss:
0.3714 - val_acc: 0.8738
Epoch 7/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.2258 - acc: 0.9227 - val_loss:
0.4352 - val_acc: 0.8609
Epoch 8/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1849 - acc: 0.9354 - val_loss:
0.3841 - val_acc: 0.8789
Epoch 9/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1749 - acc: 0.9358 - val_loss:
0.3227 - val_acc: 0.9036
Epoch 10/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1663 - acc: 0.9389 - val_loss:
0.5342 - val_acc: 0.8235
Epoch 11/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1591 - acc: 0.9410 - val_loss:
0.4589 - val_acc: 0.8714
Epoch 12/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1536 - acc: 0.9444 - val_loss:
0.3675 - val_acc: 0.8907
Epoch 13/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1475 - acc: 0.9448 - val_loss:
0.4026 - val_acc: 0.8921
Epoch 14/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1401 - acc: 0.9486 - val_loss:
0.4331 - val_acc: 0.8921
Epoch 15/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1398 - acc: 0.9517 - val_loss:
0.4159 - val_acc: 0.8890
Epoch 16/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1388 - acc: 0.9495 - val_loss:
0.4476 - val_acc: 0.8839
Epoch 17/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1257 - acc: 0.9508 - val_loss:
0.4238 - val_acc: 0.8918
Epoch 18/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1326 - acc: 0.9501 - val_loss:
0.4838 - val_acc: 0.8931
Epoch 19/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1321 - acc: 0.9513 - val_loss:
0.4445 - val_acc: 0.8924
Epoch 20/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1323 - acc: 0.9509 - val_loss:
0.4934 - val_acc: 0.8880
Epoch 21/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1340 - acc: 0.9495 - val_loss:
0.4624 - val_acc: 0.8955
Epoch 22/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1358 - acc: 0.9514 - val_loss:
0.4746 - val_acc: 0.8873
Epoch 23/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1417 - acc: 0.9505 - val_loss:
0.4713 - val_acc: 0.8982
Epoch 24/30
```

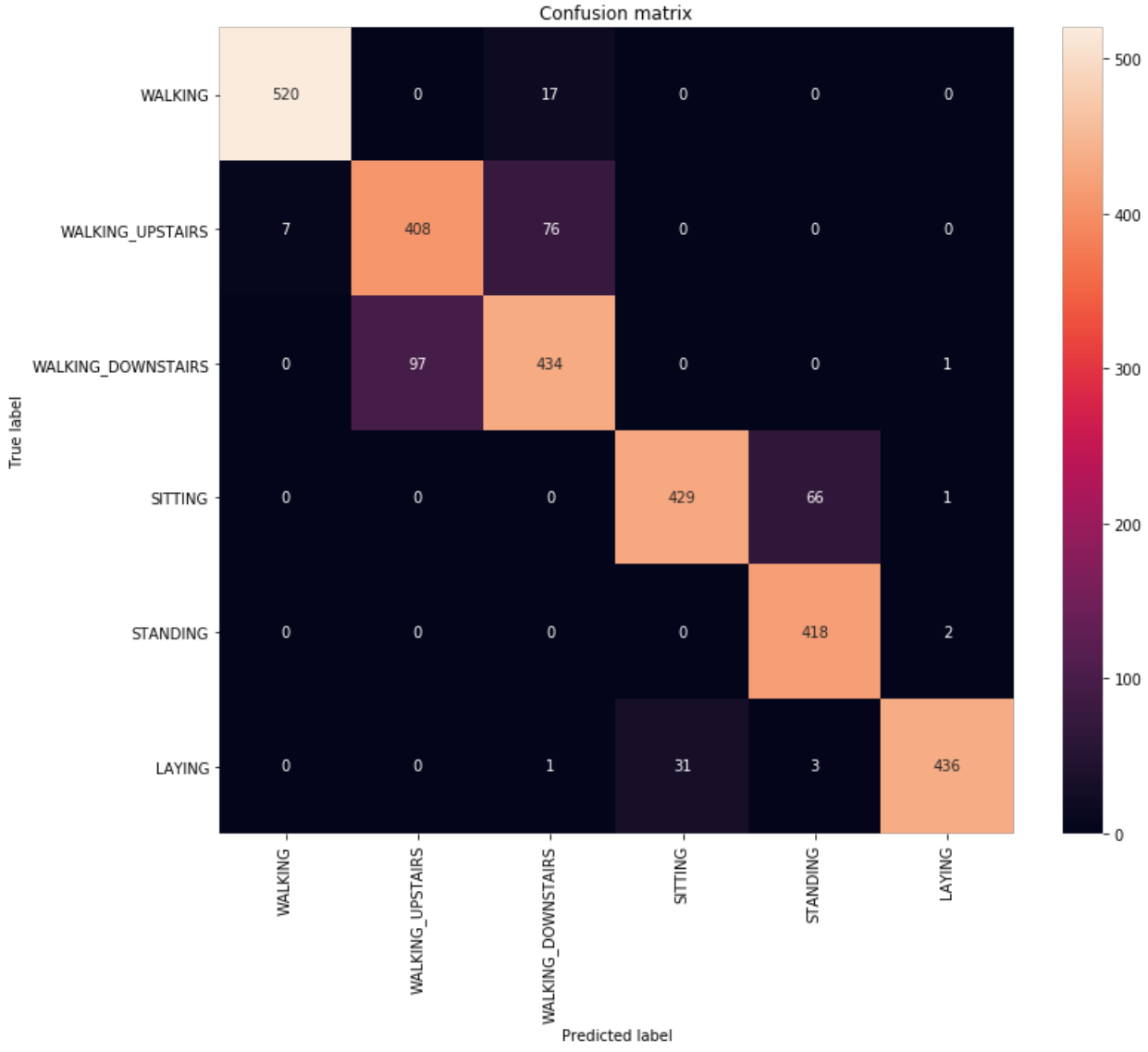
```
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1163 - acc: 0.9542 - val_loss:
0.4397 - val_acc: 0.8951
Epoch 25/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1279 - acc: 0.9514 - val_loss:
0.5471 - val_acc: 0.8853
Epoch 26/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1203 - acc: 0.9538 - val_loss:
0.4612 - val_acc: 0.9019
Epoch 27/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1235 - acc: 0.9538 - val_loss:
0.5305 - val_acc: 0.8768
Epoch 28/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1135 - acc: 0.9543 - val_loss:
0.4420 - val_acc: 0.8924
Epoch 29/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1199 - acc: 0.9542 - val_loss:
0.4775 - val_acc: 0.9050
Epoch 30/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1137 - acc: 0.9536 - val_loss:
0.4802 - val_acc: 0.8975
```

Out[30]:

```
<keras.callbacks.History at 0x88bbffca58>
```

In [31]:

```
heap_map_confusion_matrix(Y_test, model1.predict(X_test))
```



LSTM(50)->dropout(0.1)->LSTM(32)->dropout(0.1)->dense(6)

In [32]:

```
tf.keras.backend.clear_session()
model1 = Sequential()
# Configuring the parameters
model1.add(LSTM(50,return_sequences=True, input_shape=(timesteps, input_dim)))
# Adding a dropout layer
model1.add(Dropout(0.1))
model1.add(LSTM(32, input_shape=(timesteps, input_dim)))
model1.add(Dropout(0.1))
# Adding a dense output layer with sigmoid activation
model1.add(Dense(n_classes, activation='sigmoid'))
model1.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 50)           12000
_________________________________________________________________
dropout_1 (Dropout)          (None, 128, 50)           0
_________________________________________________________________
lstm_2 (LSTM)                (None, 32)                10624
_________________________________________________________________
dropout_2 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 198
=================================================================
Total params: 22,822
Trainable params: 22,822
Non-trainable params: 0
_________________________________________________________________
```

In [34]:

```
# Compiling the model
model1.compile(loss='categorical_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
```

In [35]:

```
#model 50,32
model1.fit(X_train,Y_train, batch_size=22, validation_data=(X_test, Y_test), epochs=epochs)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1114 - acc: 0.9570 - val_loss:
0.4864 - val_acc: 0.8989
Epoch 2/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1101 - acc: 0.9563 - val_loss:
0.5089 - val_acc: 0.8890
Epoch 3/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1352 - acc: 0.9532 - val_loss:
0.5561 - val_acc: 0.8700
Epoch 4/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1140 - acc: 0.9554 - val_loss:
0.4189 - val_acc: 0.9131
Epoch 5/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1220 - acc: 0.9543 - val_loss:
0.4250 - val_acc: 0.9172
Epoch 6/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1156 - acc: 0.9558 - val_loss:
0.4545 - val_acc: 0.9002
Epoch 7/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1219 - acc: 0.9554 - val_loss:
0.4923 - val_acc: 0.9046
Epoch 8/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1380 - acc: 0.9523 - val_loss:
0.4753 - val_acc: 0.9070
Epoch 9/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1150 - acc: 0.9554 - val_loss:
0.3934 - val_acc: 0.8982
Epoch 10/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1104 - acc: 0.9567 - val_loss:
```

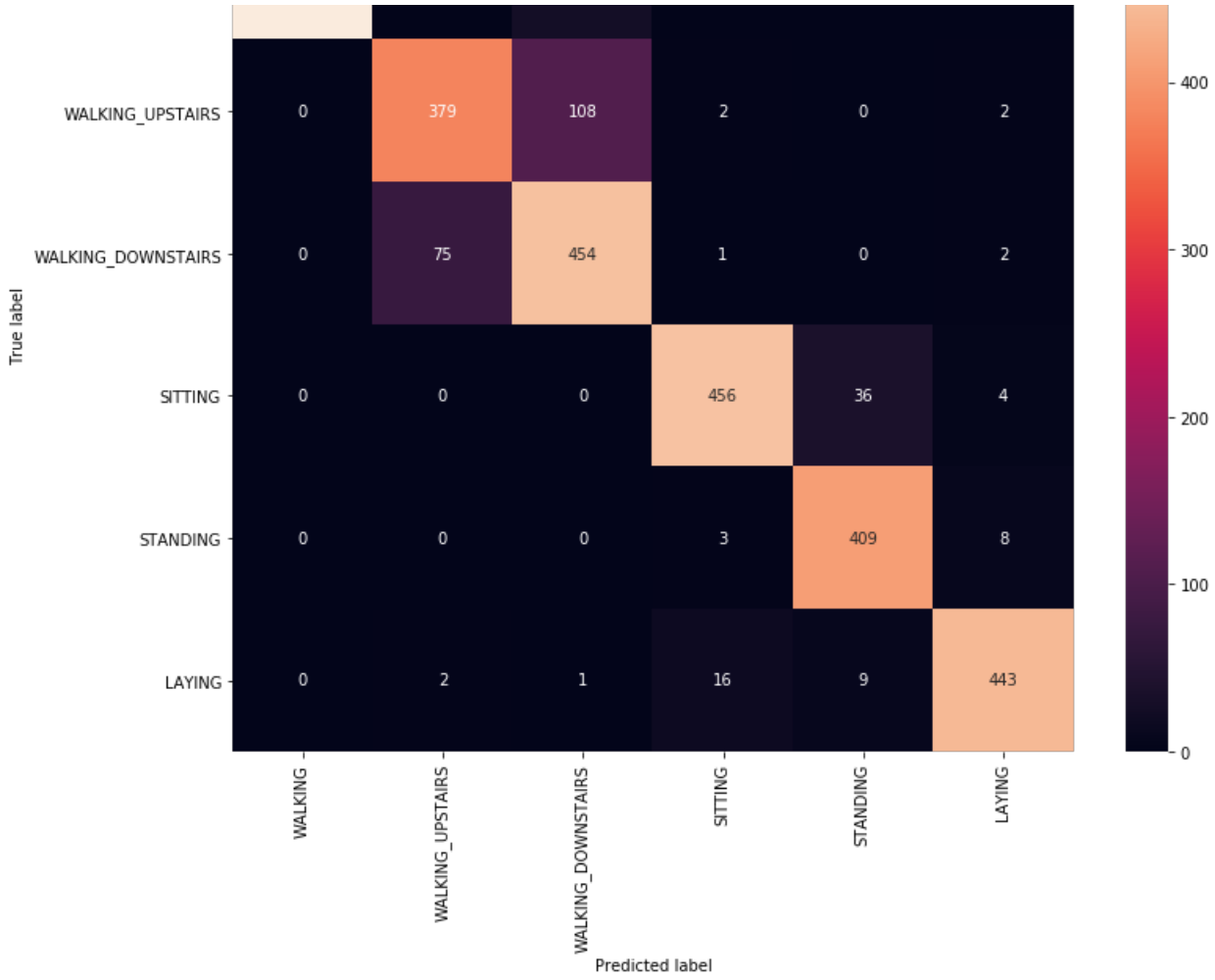
```
0.5520 - val_acc: 0.8992
Epoch 11/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1173 - acc: 0.9563 - val_loss:
0.4702 - val_acc: 0.9030
Epoch 12/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1064 - acc: 0.9577 - val_loss:
0.5056 - val_acc: 0.9046
Epoch 13/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1186 - acc: 0.9572 - val_loss:
0.5635 - val_acc: 0.8982
Epoch 14/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0983 - acc: 0.9592 - val_loss:
0.4878 - val_acc: 0.9135
Epoch 15/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1052 - acc: 0.9585 - val_loss:
0.4848 - val_acc: 0.9128
Epoch 16/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1130 - acc: 0.9570 - val_loss:
0.5635 - val_acc: 0.9084
Epoch 17/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1037 - acc: 0.9582 - val_loss:
0.5061 - val_acc: 0.9091
Epoch 18/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1104 - acc: 0.9565 - val_loss:
0.5019 - val_acc: 0.9050
Epoch 19/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1078 - acc: 0.9578 - val_loss:
0.5556 - val_acc: 0.9026
Epoch 20/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1000 - acc: 0.9608 - val_loss:
0.5249 - val_acc: 0.9013
Epoch 21/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1125 - acc: 0.9528 - val_loss:
0.5122 - val_acc: 0.9033
Epoch 22/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1093 - acc: 0.9553 - val_loss:
0.5585 - val_acc: 0.9101
Epoch 23/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1166 - acc: 0.9557 - val_loss:
0.6241 - val_acc: 0.8904
Epoch 24/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1103 - acc: 0.9554 - val_loss:
0.6138 - val_acc: 0.8951
Epoch 25/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1081 - acc: 0.9569 - val_loss:
0.4478 - val_acc: 0.9046
Epoch 26/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1149 - acc: 0.9565 - val_loss:
0.4310 - val_acc: 0.9114
Epoch 27/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1087 - acc: 0.9596 - val_loss:
0.4833 - val_acc: 0.9108
Epoch 28/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1077 - acc: 0.9578 - val_loss:
0.4829 - val_acc: 0.9046
Epoch 29/30
7352/7352 [==============================] - 55s 8ms/step - loss: 0.0972 - acc: 0.9599 - val_loss:
0.4997 - val_acc: 0.9128
Epoch 30/30
7352/7352 [==============================] - 55s 8ms/step - loss: 0.1260 - acc: 0.9539 - val_loss:
0.5190 - val_acc: 0.8996
```

Out[35]:

```
<keras.callbacks.History at 0x88bd840320>
```

In [36]:

```
heap_map_confusion_matrix(Y_test, model1.predict(X_test))
```



LSTM(32)->dropout(0.1)->LSTM(15)->dropout(0.1)->dense(6)

In [37]:

```
tf.keras.backend.clear_session()
model1 = Sequential()
# Configuring the parameters
model1.add(LSTM(32,return_sequences=True, input_shape=(timesteps, input_dim)))
# Adding a dropout layer
model1.add(Dropout(0.1))
model1.add(LSTM(15, input_shape=(timesteps, input_dim)))
model1.add(Dropout(0.1))
# Adding a dense output layer with sigmoid activation
model1.add(Dense(n_classes, activation='sigmoid'))
model1.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 32)           5376
_________________________________________________________________
dropout_1 (Dropout)          (None, 128, 32)           0
_________________________________________________________________
lstm_2 (LSTM)                (None, 15)                2880
_________________________________________________________________
dropout_2 (Dropout)          (None, 15)                0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 96
=================================================================
Total params: 8,352
Trainable params: 8,352
Non-trainable params: 0
_________________________________________________________________
```

In [38]:

```
# Compiling the model
```

```
model1.compile(loss='categorical_crossentropy',
               optimizer='rmsprop',
               metrics=['accuracy'])
```

In [39]:

```
#model 32,15
model1.fit(X_train,Y_train, batch_size=22, validation_data=(X_test, Y_test), epochs=epochs)
```

```
Train on 7352 samples, validate on 2947 samples
Epoch 1/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1158 - acc: 0.9546 - val_loss:
0.5083 - val_acc: 0.9023
Epoch 2/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1086 - acc: 0.9584 - val_loss:
0.4791 - val_acc: 0.9063
Epoch 3/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1115 - acc: 0.9557 - val_loss:
0.4457 - val_acc: 0.9145
Epoch 4/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1062 - acc: 0.9588 - val_loss:
0.4386 - val_acc: 0.9203
Epoch 5/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.0980 - acc: 0.9612 - val_loss:
0.4654 - val_acc: 0.9203
Epoch 6/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.0988 - acc: 0.9600 - val_loss:
0.5513 - val_acc: 0.9077
Epoch 7/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.0996 - acc: 0.9600 - val_loss:
0.4583 - val_acc: 0.9175
Epoch 8/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.1098 - acc: 0.9577 - val_loss:
0.5453 - val_acc: 0.8928
Epoch 9/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.0990 - acc: 0.9597 - val_loss:
0.4261 - val_acc: 0.9169
Epoch 10/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1118 - acc: 0.9581 - val_loss:
0.4027 - val_acc: 0.9223
Epoch 11/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1062 - acc: 0.9544 - val_loss:
0.4825 - val_acc: 0.9131
Epoch 12/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.1211 - acc: 0.9544 - val_loss:
0.4654 - val_acc: 0.9104
Epoch 13/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1055 - acc: 0.9581 - val_loss:
0.4406 - val_acc: 0.9155
Epoch 14/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.1189 - acc: 0.9563 - val_loss:
0.5098 - val_acc: 0.9030
Epoch 15/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.1058 - acc: 0.9567 - val_loss:
0.4717 - val_acc: 0.9196
Epoch 16/30
7352/7352 [==============================] - 58s 8ms/step - loss: 0.0938 - acc: 0.9596 - val_loss:
0.5049 - val_acc: 0.9186
Epoch 17/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.0970 - acc: 0.9614 - val_loss:
0.4469 - val_acc: 0.9216
Epoch 18/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1023 - acc: 0.9608 - val_loss:
0.6023 - val_acc: 0.9077
Epoch 19/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1197 - acc: 0.9551 - val_loss:
0.5232 - val_acc: 0.9050
Epoch 20/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1059 - acc: 0.9569 - val_loss:
0.5257 - val_acc: 0.8989
Epoch 21/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0958 - acc: 0.9616 - val_loss:
0.4447 - val_acc: 0.9108
Epoch 22/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1000 - acc: 0.9603 - val_loss:
```

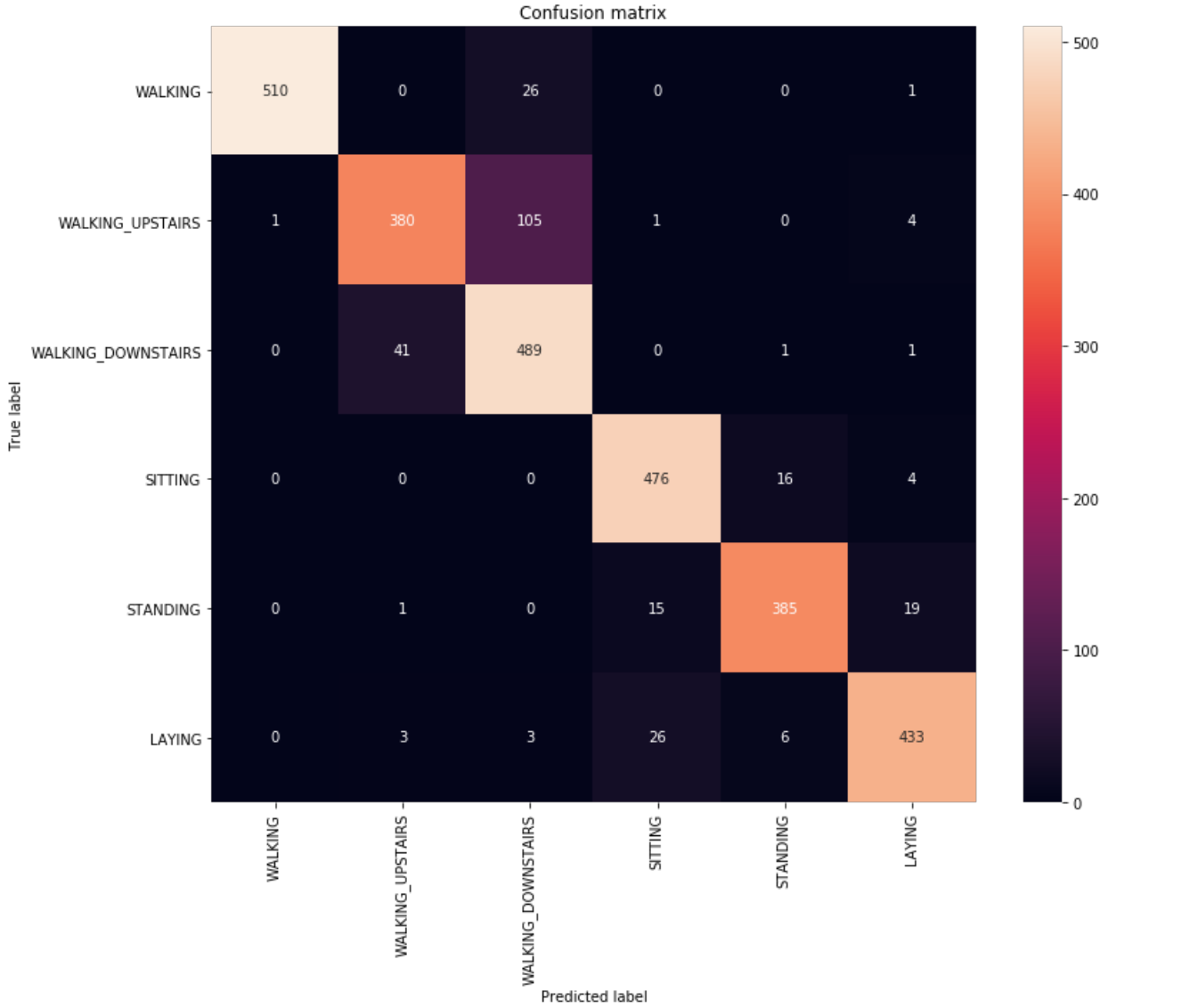
```
0.4947 - val_acc: 0.9104
Epoch 23/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0879 - acc: 0.9641 - val_loss:
0.4261 - val_acc: 0.9118
Epoch 24/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0897 - acc: 0.9634 - val_loss:
0.4317 - val_acc: 0.9209
Epoch 25/30
7352/7352 [==============================] - 57s 8ms/step - loss: 0.0981 - acc: 0.9603 - val_loss:
0.3942 - val_acc: 0.9196
Epoch 26/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0918 - acc: 0.9622 - val_loss:
0.5553 - val_acc: 0.9189
Epoch 27/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.0980 - acc: 0.9604 - val_loss:
0.4588 - val_acc: 0.9118
Epoch 28/30
7352/7352 [==============================] - 59s 8ms/step - loss: 0.0950 - acc: 0.9621 - val_loss:
0.4009 - val_acc: 0.9091
Epoch 29/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1186 - acc: 0.9475 - val_loss:
0.4643 - val_acc: 0.9009
Epoch 30/30
7352/7352 [==============================] - 56s 8ms/step - loss: 0.1031 - acc: 0.9572 - val_loss:
0.5430 - val_acc: 0.9070
```

Out[39]:

```
<keras.callbacks.History at 0x88bbffce48>
```

In [40]:

```
heap_map_confusion_matrix(Y_test, model1.predict(X_test))
```



In [1]:

```
import prettytable

table=prettytable.PrettyTable()

table.field_names=['Model','Layer 1 units','Layer 2 units','keepprob','accuracy']

table.add_row(['1 layer','32','_','0.5','91.08'])
table.add_row(['1 layer','72','_','0.25','91.28'])
table.add_row(['2 layer','75','32','0.1','89.75'])
table.add_row(['2 layer','50','32','0.1','89.96'])
table.add_row(['2 layer','32','15','0.1','90.70'])


print(table)
```

```
+---------+---------------+---------------+----------+----------+
|  Model  | Layer 1 units | Layer 2 units | keepprob | accuracy |
+---------+---------------+---------------+----------+----------+
| 1 layer |       32      |       _       |   0.5    |  91.08   |
| 1 layer |       72      |       _       |   0.25   |  91.28   |
| 2 layer |       75      |       32      |   0.1    |  89.75   |
| 2 layer |       50      |       32      |   0.1    |  89.96   |
| 2 layer |       32      |       15      |   0.1    |  90.70   |
+---------+---------------+---------------+----------+----------+
```

1. Even after doing hyper parameter tuning, could not get accuracy more than 96%.
2. 91.69% accuracy got if I choose 72 LSTM units and dropout rate=0.25,because we have less data point model is over fining.
3. Train accuracy is 95.23% and test accuracy is 97.69% there is huge gap between train and test accuracy we can conclude that model is overfitting.
4. For two layer model again accuracy is low because we have less data point and more number of wieghts to be adjust

divide and conquer cnn

In [2]:

```
# Importing libraries
from keras.regularizers import l2
import tensorflow as tf
# Importing libraries
from matplotlib import pyplot
from sklearn.preprocessing import StandardScaler
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Flatten
from keras.layers import Dropout
from keras.layers.convolutional import Conv1D
from keras.layers.convolutional import MaxPooling1D
from keras.utils import to_categorical
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
import keras

# Importing libraries
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers.core import Dense, Dropout
from hyperopt import Trials, STATUS_OK, tpe
from hyperas import optim
from hyperas.distributions import choice, uniform
from hyperas.utils import eval_hyperopt_space
import pandas as pd
import numpy as np
import random
```

```
C:\ProgramData\Anaconda3\lib\site-packages\h5py\__init__.py:36: FutureWarning: Conversion of the s
econd argument of issubdtype from `float` to `np.floating` is deprecated. In future, it will be
treated as `np.float64 == np.dtype(float).type`.
```

```
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:526:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:527:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:528:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:529:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:530:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:535:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
```

In [3]:

```
%matplotlib notebook
import matplotlib.pyplot as plt
import numpy as np
import time
# https://gist.github.com/greydanus/f6eee59eaf1d90fcb3b534a25362cea4
# https://stackoverflow.com/a/14434334
# this function is used to update the plots for each epoch and error
def plt_dynamic(x, vy, ty, ax,tit, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation")
    ax.plot(x, ty, 'r', label="Train")
    plt.legend()
    plt.grid()
    plt.title(tit)
    plt.show()
    #fig.canvas.draw()
```

classifying the data into static actives and dynamic actives

In [3]:

```
import pickle
from sklearn.preprocessing import StandardScaler
def data_data_2():
    # Data directory
    DATADIR = 'UCI_HAR_Dataset'
    SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"]
    # Utility function to read the data from csv file
    def _read_csv(filename):
        return pd.read_csv(filename, delim_whitespace=True, header=None)

    # Utility function to load the load
    def load_signals(subset):
        signals_data = []
        for signal in SIGNALS:
            filename = f'UCI_HAR_Dataset/{subset}/Inertial_Signals/{signal}_{subset}.txt'
```

```
            signals_data.append(_read_csv(filename).as_matrix())
    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 signals)
        return np.transpose(signals_data, (1, 2, 0))
    def load_data():

        """
        Obtain the dataset from multiple files.
         Returns: X_train, X_test, y_train, y_test
         """
        X_train, X_test = load_signals('train'), load_signals('test')
        y_train, y_test = load_y_raw('train'), load_y_raw('test')
        return X_train, X_test, y_train, y_test
    from sklearn.base import BaseEstimator, TransformerMixin
    class scaling_tseries_data(BaseEstimator, TransformerMixin):
        from sklearn.preprocessing import StandardScaler
        def __init__(self):
            self.scale = None

        def transform(self, X):
            temp_X1 = X.reshape((X.shape[0] * X.shape[1], X.shape[2]))
            temp_X1 = self.scale.transform(temp_X1)
            return temp_X1.reshape(X.shape)

        def fit(self, X):
            # remove overlaping
            remove = int(X.shape[1] / 2)
            temp_X = X[:, -remove:, :]
            # flatten data
            temp_X = temp_X.reshape((temp_X.shape[0] * temp_X.shape[1], temp_X.shape[2]))
            scale = StandardScaler()
            scale.fit(temp_X)
            pickle.dump(scale,open('act.p','wb'))
            self.scale = scale
            return self
    def load_y_2(subset):

        """
        The objective that we are trying to predict is a integer, from 1 to 6,
         that represents a human activity. We return a binary representation of
         every sample objective as a 6 bits vector using One Hot Encoding
        (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
         """
        filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
        y = _read_csv(filename)[0]
        y[y<=3] = 0
        y[y>3] = 1
        return pd.get_dummies(y).as_matrix()

    Y_train_2 = load_y_2('train')
    Y_test_2 = load_y_2('test')
    X_train_2, X_test_2 = load_signals('train'), load_signals('test')

    Scale = scaling_tseries_data()
    Scale.fit(X_train_2)
    X_train_2 = Scale.transform(X_train_2)
    X_test_2 = Scale.transform(X_test_2)
    return X_train_2,Y_train_2,X_test_2,Y_test_2
```

In [4]:

```
X_train_2, Y_train_2, X_test_2,  Y_test_2 = data_data_2()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:73: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:25: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
```

In [5]:

```
print(X_train_2.shape, Y_train_2.shape, X_test_2.shape,  Y_test_2.shape)
```

```
(7352, 128, 9) (7352, 2) (2947, 128, 9) (2947, 2)
```

(7352, 128, 9) (7352, 2) (2947, 128, 9) (2947, 2)

In [6]:

```
tf.keras.backend.clear_session()
model = Sequential()
model.add(LSTM(32,return_sequences=True, input_shape=(128,9)))
model.add(Conv1D(filters=32, kernel_size=3, activation='relu',kernel_initializer='he_uniform'))
model.add(Conv1D(filters=32, kernel_size=3, activation='relu',kernel_initializer='he_uniform'))
model.add(Dropout(0.6))
model.add(MaxPooling1D(pool_size=2))
model.add(Flatten())
model.add(Dense(50, activation='relu'))
model.add(Dense(2, activation='softmax'))
model.summary()
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\framework\op_def_library.py:263: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\keras\backend\tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 32)           5376
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 126, 32)           3104
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 124, 32)           3104
_________________________________________________________________
dropout_1 (Dropout)          (None, 124, 32)           0
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 62, 32)            0
_________________________________________________________________
flatten_1 (Flatten)          (None, 1984)              0
_________________________________________________________________
dense_1 (Dense)              (None, 50)                99250
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 102
=================================================================
Total params: 110,936
Trainable params: 110,936
Non-trainable params: 0
_________________________________________________________________
```

In [7]:

```
adam = keras.optimizers.Adam(lr=0.001)
model.compile(loss='categorical_crossentropy', optimizer=adam, metrics=['accuracy'])
model.fit(X_train_2, Y_train_2, epochs=20, batch_size=16,validation_data=(X_test_2,  Y_test_2), ver
bose=2)
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 7352 samples, validate on 2947 samples
Epoch 1/20
 - 37s - loss: 0.0234 - acc: 0.9909 - val_loss: 0.0015 - val_acc: 1.0000
Epoch 2/20
 - 37s - loss: 5.7630e-05 - acc: 1.0000 - val_loss: 4.6614e-04 - val_acc: 1.0000
Epoch 3/20
 - 36s - loss: 2.0547e-05 - acc: 1.0000 - val_loss: 2.0638e-04 - val_acc: 1.0000
Epoch 4/20
 - 36s - loss: 5.2724e-06 - acc: 1.0000 - val_loss: 2.2171e-04 - val_acc: 1.0000
Epoch 5/20
 - 35s - loss: 0.0044 - acc: 0.9992 - val_loss: 0.0039 - val_acc: 0.9993
Epoch 6/20
```

```
Epoch 6/20
 - 35s - loss: 0.0018 - acc: 0.9999 - val_loss: 6.1709e-04 - val_acc: 1.0000
Epoch 7/20
 - 35s - loss: 5.9105e-05 - acc: 1.0000 - val_loss: 5.2428e-04 - val_acc: 1.0000
Epoch 8/20
 - 35s - loss: 0.0064 - acc: 0.9990 - val_loss: 0.0937 - val_acc: 0.9915
Epoch 9/20
 - 35s - loss: 0.0059 - acc: 0.9992 - val_loss: 0.0021 - val_acc: 0.9993
Epoch 10/20
 - 35s - loss: 0.0025 - acc: 0.9997 - val_loss: 0.0023 - val_acc: 0.9990
Epoch 11/20
 - 35s - loss: 2.9938e-04 - acc: 0.9999 - val_loss: 0.0025 - val_acc: 0.9986
Epoch 12/20
 - 35s - loss: 3.3289e-07 - acc: 1.0000 - val_loss: 0.0025 - val_acc: 0.9986
Epoch 13/20
 - 35s - loss: 3.7919e-07 - acc: 1.0000 - val_loss: 0.0024 - val_acc: 0.9986
Epoch 14/20
 - 36s - loss: 3.0101e-07 - acc: 1.0000 - val_loss: 0.0024 - val_acc: 0.9986
Epoch 15/20
 - 36s - loss: 2.0328e-07 - acc: 1.0000 - val_loss: 0.0024 - val_acc: 0.9986
Epoch 16/20
 - 36s - loss: 2.2465e-07 - acc: 1.0000 - val_loss: 0.0024 - val_acc: 0.9986
Epoch 17/20
 - 36s - loss: 2.0037e-07 - acc: 1.0000 - val_loss: 0.0023 - val_acc: 0.9986
Epoch 18/20
 - 36s - loss: 2.2793e-07 - acc: 1.0000 - val_loss: 0.0023 - val_acc: 0.9986
Epoch 19/20
 - 36s - loss: 2.5151e-07 - acc: 1.0000 - val_loss: 0.0024 - val_acc: 0.9986
Epoch 20/20
 - 36s - loss: 1.7472e-07 - acc: 1.0000 - val_loss: 0.0023 - val_acc: 0.9986
```

Out[7]:

```
<keras.callbacks.History at 0xc8005c45f8>
```

In [8]:

```
model.evaluate(X_test_2,  Y_test_2)
```

```
2947/2947 [==============================] - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:
- ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  -
ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - 2s
585us/step
```

Out[8]:

```
[0.002347592716254783, 0.998642687478792]
```

In [9]:

```
model.save('model_class_2_lstm.h5')
```

In [10]:

```
from keras.models import load_model
model=load_model('model_class_2.h5')
model.evaluate(X_test_2,  Y_test_2)
```

```
2947/2947 [==============================] - ETA: 13 - ETA: 1 - ETA:  - ETA:  - ETA:  - ETA:  - ET
A:  - ETA:  - 1s 188us/step
```

Out[10]:

```
[0.008060890691714543, 0.9989820156090939]
```

ccn to classify static activities

In [16]:

```
import pickle
```

```
from sklearn.preprocessing import StandardScaler

def data_data_st():
    # Data directory
    DATADIR = 'UCI_HAR_Dataset'
    SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"]
    # Utility function to read the data from csv file
    def _read_csv(filename):
        return pd.read_csv(filename, delim_whitespace=True, header=None)

    # Utility function to load the load
    def load_signals(subset):
        signals_data = []
        for signal in SIGNALS:
            filename = f'UCI_HAR_Dataset/{subset}/Inertial Signals/{signal}_{subset}.txt'
            signals_data.append(_read_csv(filename).as_matrix())
    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 signals)
        return np.transpose(signals_data, (1, 2, 0))
    def load_data():

        """
        Obtain the dataset from multiple files.
         Returns: X_train, X_test, y_train, y_test
         """
        X_train, X_test = load_signals('train'), load_signals('test')
        y_train, y_test = load_y_raw('train'), load_y_raw('test')
        return X_train, X_test, y_train, y_test
    def load_y_st(subset):


        """
        The objective that we are trying to predict is a integer, from 1 to 6,
         that represents a human activity. We return a binary representation of
         every sample objective as a 6 bits vector using One Hot Encoding
        (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
         """
        filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
        y = _read_csv(filename)[0]
        y_subset = y>3
        y = y[y_subset]
        return pd.get_dummies(y).as_matrix(),y_subset
    from sklearn.base import BaseEstimator, TransformerMixin
    class scaling_tseries_data(BaseEstimator, TransformerMixin):
        from sklearn.preprocessing import StandardScaler
        def __init__(self):
            self.scale = None

        def transform(self, X):
            temp_X1 = X.reshape((X.shape[0] * X.shape[1], X.shape[2]))
            temp_X1 = self.scale.transform(temp_X1)
            return temp_X1.reshape(X.shape)

        def fit(self, X):
            # remove overlaping
            remove = int(X.shape[1] / 2)
            temp_X = X[:, -remove:, :]
            # flatten data
            temp_X = temp_X.reshape((temp_X.shape[0] * temp_X.shape[1], temp_X.shape[2]))
            scale = StandardScaler()
            scale.fit(temp_X)
            pickle.dump(scale,open('static.p','wb'))
            self.scale = scale
            return self
    Y_train_st,y_train_sub = load_y_st('train')
    Y_test_st,y_test_sub = load_y_st('test')
    X_train_st, X_test_st = load_signals('train'), load_signals('test')
```

```
    X_train_st = X_train_st[y_train_sub]
    X_test_st = X_test_st[y_test_sub]

    Scale = scaling_tseries_data()
    Scale.fit(X_train_st)
    X_train_st = Scale.transform(X_train_st)
    X_test_st = Scale.transform(X_test_st)

    return X_train_st,Y_train_st,X_test_st,Y_test_st
```

In [17]:

```
X_train_st,Y_train_st,X_test_st,Y_test_st= data_data_st()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:53: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:26: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
```

In [6]:

```
tf.keras.backend.clear_session()
model_st = Sequential()
model_st.add(LSTM(32,return_sequences=True, input_shape=(128,9)))
model_st.add(Conv1D(filters=64, kernel_size=7, activation='relu',kernel_initializer='he_uniform'))
model_st.add(Conv1D(filters=64, kernel_size=3, activation='relu',kernel_initializer='he_uniform'))
model_st.add(Dropout(0.6))
model_st.add(MaxPooling1D(pool_size=3))
model_st.add(Flatten())
model_st.add(Dense(16, activation='relu'))
model_st.add(Dense(3, activation='softmax'))
model_st.summary()
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\framework\op_def_library.py:263: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\keras\backend\tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 32)           5376
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 122, 64)           14400
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 120, 64)           12352
_________________________________________________________________
dropout_1 (Dropout)          (None, 120, 64)           0
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 40, 64)            0
_________________________________________________________________
flatten_1 (Flatten)          (None, 2560)              0
_________________________________________________________________
dense_1 (Dense)              (None, 16)                40976
_________________________________________________________________
dense_2 (Dense)              (None, 3)                 51
=================================================================
Total params: 73,155
Trainable params: 73,155
Non-trainable params: 0
_________________________________________________________________
```

In [7]:

```
adam = keras.optimizers.Adam(lr=0.004)
model_st.compile(loss='categorical_crossentropy', optimizer=adam, metrics=['accuracy'])
result = model_st.fit(X_train_st, Y_train_st,
```

```
            batch_size=64,
            nb_epoch=30,
            verbose=2,
            validation_data=(X_test_st,  Y_test_st))
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:7: UserWarning: The `nb_epoch` ar
gument in `fit` has been renamed `epochs`.
  import sys
```

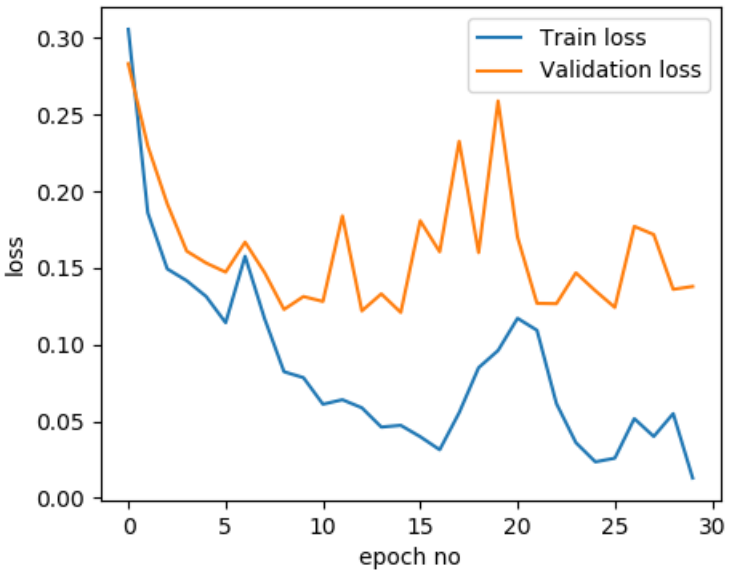
```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 4067 samples, validate on 1560 samples
Epoch 1/30
 - 10s - loss: 0.3057 - acc: 0.8692 - val_loss: 0.2833 - val_acc: 0.8904
Epoch 2/30
 - 9s - loss: 0.1861 - acc: 0.9248 - val_loss: 0.2297 - val_acc: 0.9224
Epoch 3/30
 - 9s - loss: 0.1495 - acc: 0.9412 - val_loss: 0.1920 - val_acc: 0.9385
Epoch 4/30
 - 9s - loss: 0.1418 - acc: 0.9471 - val_loss: 0.1611 - val_acc: 0.9455
Epoch 5/30
 - 9s - loss: 0.1315 - acc: 0.9457 - val_loss: 0.1533 - val_acc: 0.9340
Epoch 6/30
 - 9s - loss: 0.1144 - acc: 0.9575 - val_loss: 0.1474 - val_acc: 0.9526
Epoch 7/30
 - 9s - loss: 0.1577 - acc: 0.9521 - val_loss: 0.1669 - val_acc: 0.9256
Epoch 8/30
 - 9s - loss: 0.1171 - acc: 0.9575 - val_loss: 0.1471 - val_acc: 0.9404
Epoch 9/30
 - 9s - loss: 0.0824 - acc: 0.9683 - val_loss: 0.1230 - val_acc: 0.9538
Epoch 10/30
 - 9s - loss: 0.0785 - acc: 0.9688 - val_loss: 0.1315 - val_acc: 0.9558
Epoch 11/30
 - 9s - loss: 0.0612 - acc: 0.9766 - val_loss: 0.1283 - val_acc: 0.9449
Epoch 12/30
 - 9s - loss: 0.0641 - acc: 0.9771 - val_loss: 0.1841 - val_acc: 0.9359
Epoch 13/30
 - 9s - loss: 0.0589 - acc: 0.9781 - val_loss: 0.1221 - val_acc: 0.9513
Epoch 14/30
 - 9s - loss: 0.0463 - acc: 0.9811 - val_loss: 0.1332 - val_acc: 0.9468
Epoch 15/30
 - 9s - loss: 0.0474 - acc: 0.9801 - val_loss: 0.1211 - val_acc: 0.9551
Epoch 16/30
 - 9s - loss: 0.0400 - acc: 0.9862 - val_loss: 0.1809 - val_acc: 0.9519
Epoch 17/30
 - 9s - loss: 0.0315 - acc: 0.9882 - val_loss: 0.1606 - val_acc: 0.9577
Epoch 18/30
 - 9s - loss: 0.0557 - acc: 0.9796 - val_loss: 0.2327 - val_acc: 0.9103
Epoch 19/30
 - 9s - loss: 0.0850 - acc: 0.9759 - val_loss: 0.1601 - val_acc: 0.9462
Epoch 20/30
 - 9s - loss: 0.0962 - acc: 0.9793 - val_loss: 0.2590 - val_acc: 0.9404
Epoch 21/30
 - 9s - loss: 0.1173 - acc: 0.9715 - val_loss: 0.1702 - val_acc: 0.9308
Epoch 22/30
 - 9s - loss: 0.1094 - acc: 0.9722 - val_loss: 0.1270 - val_acc: 0.9571
Epoch 23/30
 - 9s - loss: 0.0616 - acc: 0.9808 - val_loss: 0.1268 - val_acc: 0.9487
Epoch 24/30
 - 9s - loss: 0.0361 - acc: 0.9889 - val_loss: 0.1469 - val_acc: 0.9506
Epoch 25/30
 - 9s - loss: 0.0236 - acc: 0.9914 - val_loss: 0.1352 - val_acc: 0.9538
Epoch 26/30
 - 9s - loss: 0.0260 - acc: 0.9911 - val_loss: 0.1244 - val_acc: 0.9545
Epoch 27/30
 - 9s - loss: 0.0518 - acc: 0.9823 - val_loss: 0.1772 - val_acc: 0.9288
Epoch 28/30
 - 9s - loss: 0.0402 - acc: 0.9852 - val_loss: 0.1719 - val_acc: 0.9436
Epoch 29/30
 - 9s - loss: 0.0551 - acc: 0.9828 - val_loss: 0.1361 - val_acc: 0.9532
Epoch 30/30
 - 9s - loss: 0.0131 - acc: 0.9958 - val_loss: 0.1380 - val_acc: 0.9551
```

In [8]:

```
#saving model
model_st.save('model_class_static_best_lstm.h5')
```

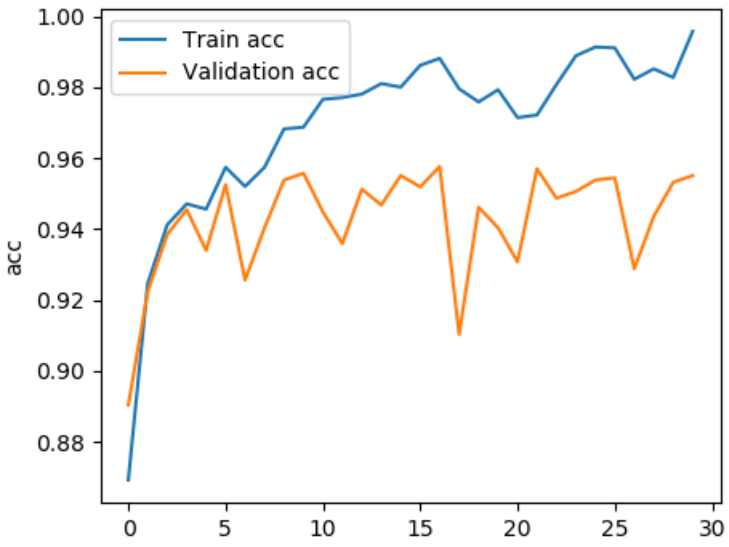
In [9]:

```
plt.figure(figsize=(5,4))
plt.plot(result.history['loss'],label='Train loss')
plt.plot(result.history['val_loss'],label = 'Validation loss')
plt.xlabel('epoch no')
plt.ylabel('loss')
plt.legend()
plt.show()
```



In [10]:

```
plt.figure(figsize=(5,4))
plt.plot(result.history['acc'],label='Train acc')
plt.plot(result.history['val_acc'],label = 'Validation acc')
plt.xlabel('epoch no')
plt.ylabel('acc')
plt.legend()
plt.show()
```



epoch no

In [19]:

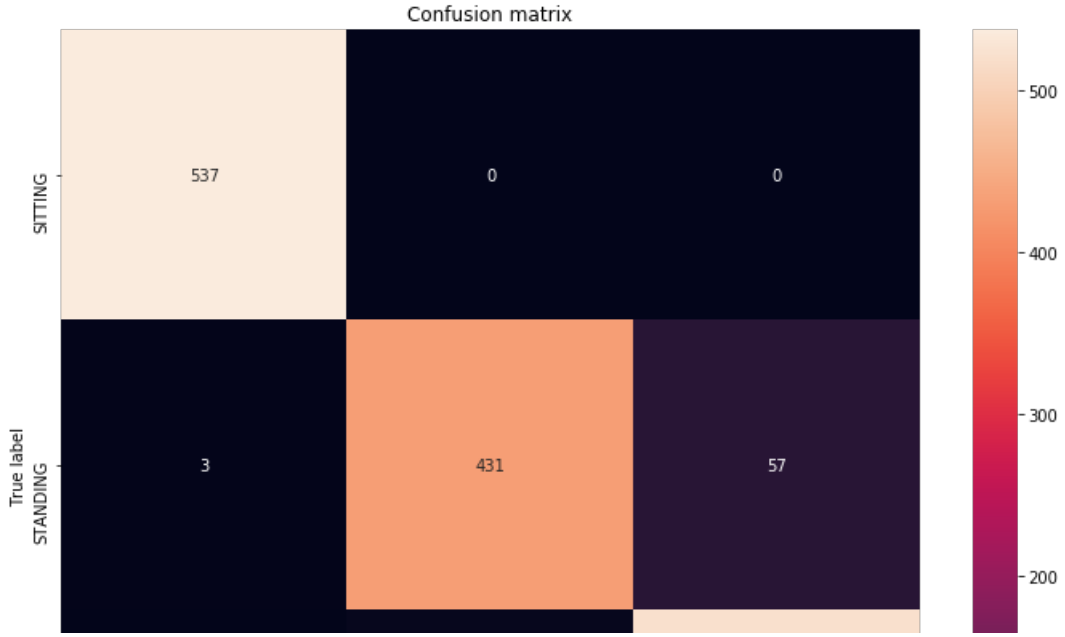
```
from keras.models import load_model
from tensorflow import Graph, Session
graph1 = Graph()
with graph1.as_default():
    session1 = Session()
    with session1.as_default():
        # load model
        model1 = load_model("model_class_static_best_lstm.h5")
        output1 = model1.predict(X_test_st)
        session1.close()
```

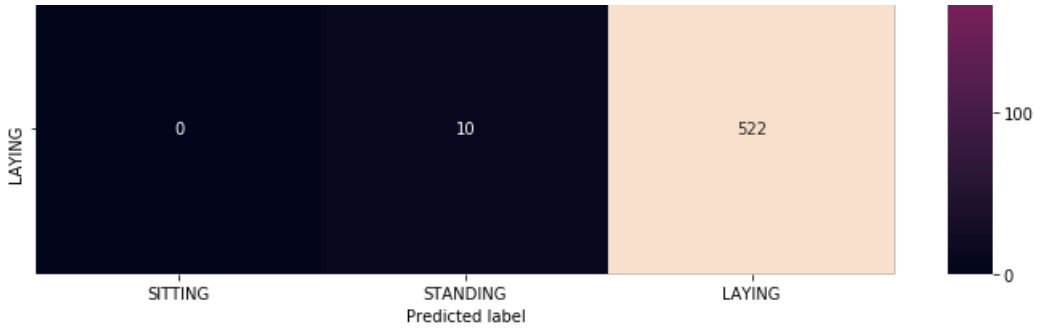
In [20]:

```
# Activities are the class labels
# It is a 6 class classification
ACTIVITIES = {

    0: 'SITTING',
    1: 'STANDING',
    2: 'LAYING',
}

% matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns
# Utility function to print the confusion matrix
def confusion_matrix(Y_true, Y_pred):
    Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_true, axis=1)])
    Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_pred, axis=1)])

    return pd.crosstab(Y_true, Y_pred, rownames=['True'], colnames=['Pred'])
def heap_map_confusion_matrix(y_test,y_predict):

  confu_matrix=confusion_matrix(y_test, y_predict)
  plt.figure(figsize=(12, 10))
  sns.heatmap(confu_matrix,xticklabels= list(ACTIVITIES.values()),
                yticklabels=list(ACTIVITIES.values()),
                annot=True, fmt="d");
  plt.title("Confusion matrix")
  plt.ylabel('True label')
  plt.xlabel('Predicted label')
  plt.show()
```

In [21]:

```
heap_map_confusion_matrix(Y_test_st,output1)
```





ccn to classify dynamic activities

In [17]:

```
import pickle
def data_data_dy():
    # Data directory
    DATADIR = 'UCI_HAR_Dataset'
    SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"]
    # Utility function to read the data from csv file
    def _read_csv(filename):
        return pd.read_csv(filename, delim_whitespace=True, header=None)

    # Utility function to load the load
    def load_signals(subset):
        signals_data = []
        for signal in SIGNALS:
            filename = f'UCI_HAR_Dataset/{subset}/Inertial Signals/{signal}_{subset}.txt'
            signals_data.append(_read_csv(filename).as_matrix())
    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 signals)
        return np.transpose(signals_data, (1, 2, 0))
    def load_data():

        """
        Obtain the dataset from multiple files.
         Returns: X_train, X_test, y_train, y_test
         """
        X_train, X_test = load_signals('train'), load_signals('test')
        y_train, y_test = load_y_raw('train'), load_y_raw('test')
        return X_train, X_test, y_train, y_test
    def load_y_dy(subset):

        """
        The objective that we are trying to predict is a integer, from 1 to 6,
         that represents a human activity. We return a binary representation of
         every sample objective as a 6 bits vector using One Hot Encoding
        (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
         """
        filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
        y = _read_csv(filename)[0]
        y_subset = y<=3
        y = y[y_subset]
        return pd.get_dummies(y).as_matrix(),y_subset
    from sklearn.base import BaseEstimator, TransformerMixin
    class scaling_tseries_data(BaseEstimator, TransformerMixin):
        from sklearn.preprocessing import StandardScaler
        def __init__(self):
            self.scale = None

        def transform(self, X):
            temp_X1 = X.reshape((X.shape[0] * X.shape[1], X.shape[2]))
```

```
            temp_X1 = self.scale.transform(temp_X1)
            return temp_X1.reshape(X.shape)

        def fit(self, X):
            # remove overlaping
            remove = int(X.shape[1] / 2)
            temp_X = X[:, -remove:, :]
            # flatten data
            temp_X = temp_X.reshape((temp_X.shape[0] * temp_X.shape[1], temp_X.shape[2]))
            scale = StandardScaler()
            scale.fit(temp_X)
            pickle.dump(scale,open('dynamic.p','wb'))
            self.scale = scale
            return self
    Y_train_dy,y_train_sub = load_y_dy('train')
    Y_test_dy,y_test_sub = load_y_dy('test')
    X_train_dy, X_test_dy = load_signals('train'), load_signals('test')
    X_train_dy = X_train_dy[y_train_sub]
    X_test_dy = X_test_dy[y_test_sub]

    Scale = scaling_tseries_data()
    Scale.fit(X_train_dy)
    X_train_dy = Scale.transform(X_train_dy)
    X_test_dy = Scale.transform(X_test_dy)

    return X_train_dy,Y_train_dy,X_test_dy,Y_test_dy
    #return X_train_s, Y_train_s, X_val_s, Y_val_s
```

In [18]:

```
X_train_dy,Y_train_dy,X_test_dy,Y_test_dy= data_data_dy()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:50: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:24: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
```

In [19]:

```
tf.keras.backend.clear_session()
model_dy = Sequential()
model_dy.add(LSTM(32,return_sequences=True, input_shape=(128,9)))
model_dy.add(Conv1D(filters=64, kernel_size=7, activation='relu',kernel_initializer='he_uniform'))
model_dy.add(Conv1D(filters=64, kernel_size=3, activation='relu',kernel_initializer='he_uniform'))
model_dy.add(Dropout(0.6))
model_dy.add(MaxPooling1D(pool_size=3))
model_dy.add(Flatten())
model_dy.add(Dense(16, activation='relu'))
model_dy.add(Dense(3, activation='softmax'))
model_dy.summary()
adam = keras.optimizers.Adam(lr=0.004)
model_dy.compile(loss='categorical_crossentropy', optimizer=adam, metrics=['accuracy'])


result = model_dy.fit(X_train_dy, Y_train_dy,batch_size=64,nb_epoch=30,verbose=2, validation_data=(
X_test_dy,  Y_test_dy))
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 128, 32)           5376
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 122, 64)           14400
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 120, 64)           12352
_________________________________________________________________
dropout_1 (Dropout)          (None, 120, 64)           0
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 40, 64)            0
_________________________________________________________________
flatten_1 (Flatten)          (None, 2560)              0
_________________________________________________________________
dense_1 (Dense)              (None, 16)                40976
```

```
_________________________________________________________________
dense_2 (Dense)              (None, 3)                 51
=================================================================
Total params: 73,155
Trainable params: 73,155
Non-trainable params: 0
_________________________________________________________________
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:16: UserWarning: The `nb_epoch` a
rgument in `fit` has been renamed `epochs`.
  app.launch_new_instance()
```

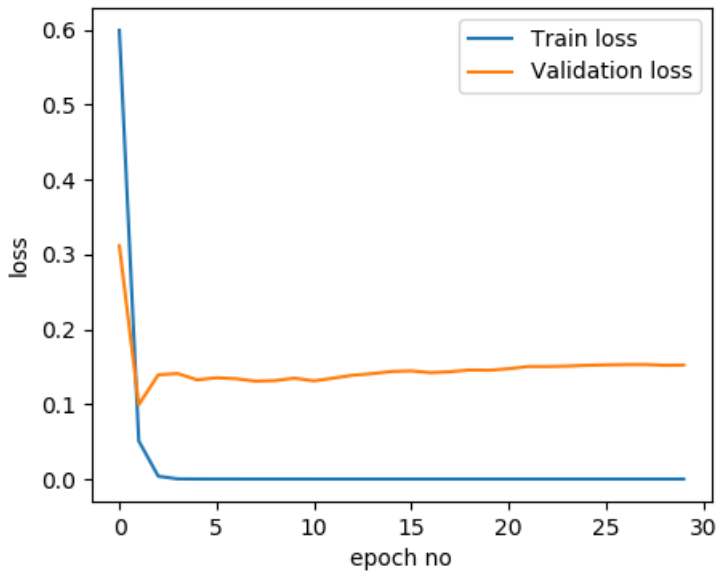
```
Train on 3285 samples, validate on 1387 samples
Epoch 1/30
 - 8s - loss: 0.3192 - acc: 0.8648 - val_loss: 0.2154 - val_acc: 0.9409
Epoch 2/30
 - 7s - loss: 0.0174 - acc: 0.9957 - val_loss: 0.2742 - val_acc: 0.9301
Epoch 3/30
 - 7s - loss: 0.0100 - acc: 0.9957 - val_loss: 0.2412 - val_acc: 0.9438
Epoch 4/30
 - 7s - loss: 0.0266 - acc: 0.9930 - val_loss: 0.2679 - val_acc: 0.9099
Epoch 5/30
 - 7s - loss: 0.0125 - acc: 0.9967 - val_loss: 0.1938 - val_acc: 0.9524
Epoch 6/30
 - 7s - loss: 3.8851e-04 - acc: 1.0000 - val_loss: 0.1399 - val_acc: 0.9704
Epoch 7/30
 - 7s - loss: 0.0053 - acc: 0.9988 - val_loss: 0.5357 - val_acc: 0.9387
Epoch 8/30
 - 7s - loss: 0.0020 - acc: 0.9994 - val_loss: 0.4475 - val_acc: 0.9366
Epoch 9/30
 - 7s - loss: 2.5728e-04 - acc: 1.0000 - val_loss: 0.3211 - val_acc: 0.9531
Epoch 10/30
 - 7s - loss: 4.4730e-05 - acc: 1.0000 - val_loss: 0.3453 - val_acc: 0.9531
Epoch 11/30
 - 7s - loss: 1.0486e-05 - acc: 1.0000 - val_loss: 0.3519 - val_acc: 0.9524
Epoch 12/30
 - 7s - loss: 6.5997e-06 - acc: 1.0000 - val_loss: 0.3556 - val_acc: 0.9517
Epoch 13/30
 - 7s - loss: 5.6932e-06 - acc: 1.0000 - val_loss: 0.3574 - val_acc: 0.9517
Epoch 14/30
 - 7s - loss: 6.3921e-06 - acc: 1.0000 - val_loss: 0.3604 - val_acc: 0.9524
Epoch 15/30
 - 7s - loss: 4.7810e-06 - acc: 1.0000 - val_loss: 0.3615 - val_acc: 0.9524
Epoch 16/30
 - 7s - loss: 6.3196e-06 - acc: 1.0000 - val_loss: 0.3641 - val_acc: 0.9517
Epoch 17/30
 - 7s - loss: 5.4391e-06 - acc: 1.0000 - val_loss: 0.3668 - val_acc: 0.9517
Epoch 18/30
 - 7s - loss: 4.5206e-06 - acc: 1.0000 - val_loss: 0.3668 - val_acc: 0.9517
Epoch 19/30
 - 7s - loss: 5.2934e-06 - acc: 1.0000 - val_loss: 0.3666 - val_acc: 0.9517
Epoch 20/30
 - 7s - loss: 3.6604e-06 - acc: 1.0000 - val_loss: 0.3660 - val_acc: 0.9517
Epoch 21/30
 - 7s - loss: 4.1288e-06 - acc: 1.0000 - val_loss: 0.3665 - val_acc: 0.9517
Epoch 22/30
 - 7s - loss: 4.2706e-06 - acc: 1.0000 - val_loss: 0.3666 - val_acc: 0.9517
Epoch 23/30
 - 7s - loss: 3.1368e-06 - acc: 1.0000 - val_loss: 0.3691 - val_acc: 0.9517
Epoch 24/30
 - 7s - loss: 2.8721e-06 - acc: 1.0000 - val_loss: 0.3693 - val_acc: 0.9517
Epoch 25/30
 - 7s - loss: 2.7706e-06 - acc: 1.0000 - val_loss: 0.3695 - val_acc: 0.9517
Epoch 26/30
 - 7s - loss: 2.9257e-06 - acc: 1.0000 - val_loss: 0.3694 - val_acc: 0.9517
Epoch 27/30
 - 7s - loss: 2.4835e-06 - acc: 1.0000 - val_loss: 0.3708 - val_acc: 0.9517
Epoch 28/30
 - 7s - loss: 3.9086e-06 - acc: 1.0000 - val_loss: 0.3745 - val_acc: 0.9517
Epoch 29/30
 - 7s - loss: 2.3971e-06 - acc: 1.0000 - val_loss: 0.3769 - val_acc: 0.9517
Epoch 30/30
 - 7s - loss: 2.4321e-06 - acc: 1.0000 - val_loss: 0.3767 - val_acc: 0.9517
```

In [10]:

```
#saving model
model_dy.save('model_class_dynamic_best_lstm.h5')
```

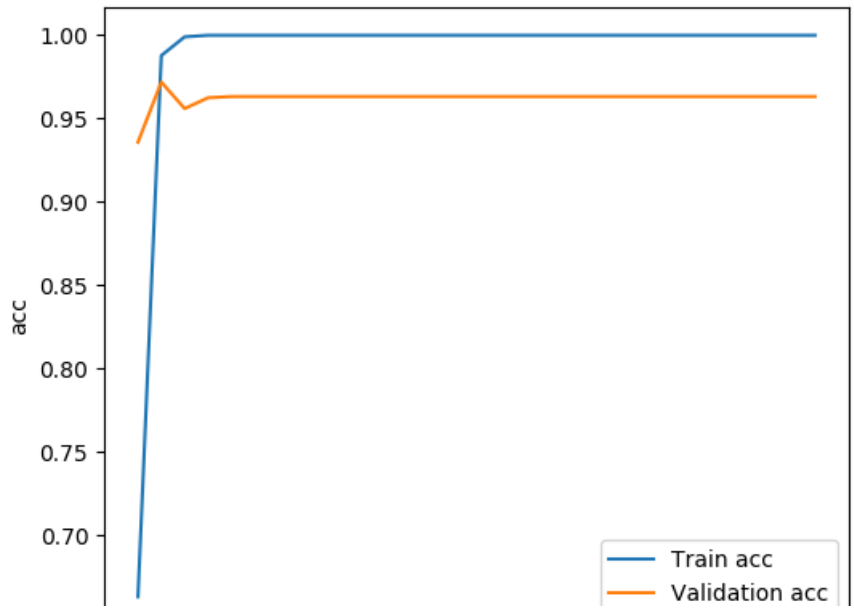
In [11]:

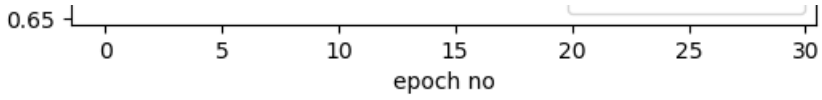
```
plt.figure(figsize=(5,4))
plt.plot(result.history['loss'],label='Train loss')
plt.plot(result.history['val_loss'],label = 'Validation loss')
plt.xlabel('epoch no')
plt.ylabel('loss')
plt.legend()
plt.show()
```



In [12]:

```
plt.figure(figsize=(6,5))
plt.plot(result.history['acc'],label='Train acc')
plt.plot(result.history['val_acc'],label = 'Validation acc')
plt.xlabel('epoch no')
plt.ylabel('acc')
plt.legend()
plt.show()
```





In [24]:

```
# Activities are the class labels
# It is a 6 class classification
ACTIVITIES = {
    0: 'WALKING',
    1: 'WALKING_UPSTAIRS',
    2: 'WALKING_DOWNSTAIRS',
}

% matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns
# Utility function to print the confusion matrix
def confusion_matrix(Y_true, Y_pred):
    Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_true, axis=1)])
    Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_pred, axis=1)])

    return pd.crosstab(Y_true, Y_pred, rownames=['True'], colnames=['Pred'])
def heap_map_confusion_matrix(y_test,y_predict):

  confu_matrix=confusion_matrix(y_test, y_predict)
  plt.figure(figsize=(12, 10))
  sns.heatmap(confu_matrix,xticklabels= list(ACTIVITIES.values()),
              yticklabels=list(ACTIVITIES.values()),
              annot=True, fmt="d");
  plt.title("Confusion matrix")
  plt.ylabel('True label')
  plt.xlabel('Predicted label')
  plt.show()
```

In [25]:

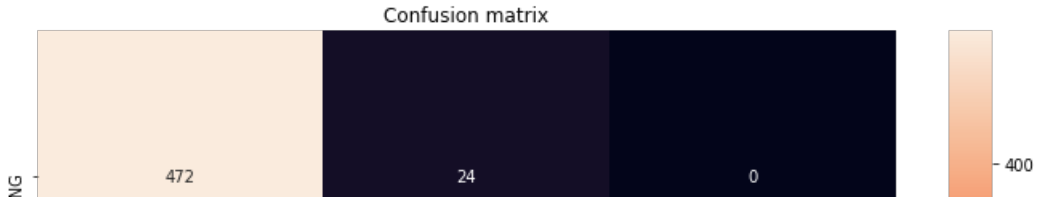
```
graph2 = Graph()
with graph2.as_default():
    session2 = Session()
    with session2.as_default():
        # load model
        model2 = load_model("model_class_dynamic_best_lstm.h5")
        output2 = model2.predict(X_test_dy)
        model2.evaluate(X_test_dy,Y_test_dy)
    session2.close()
```

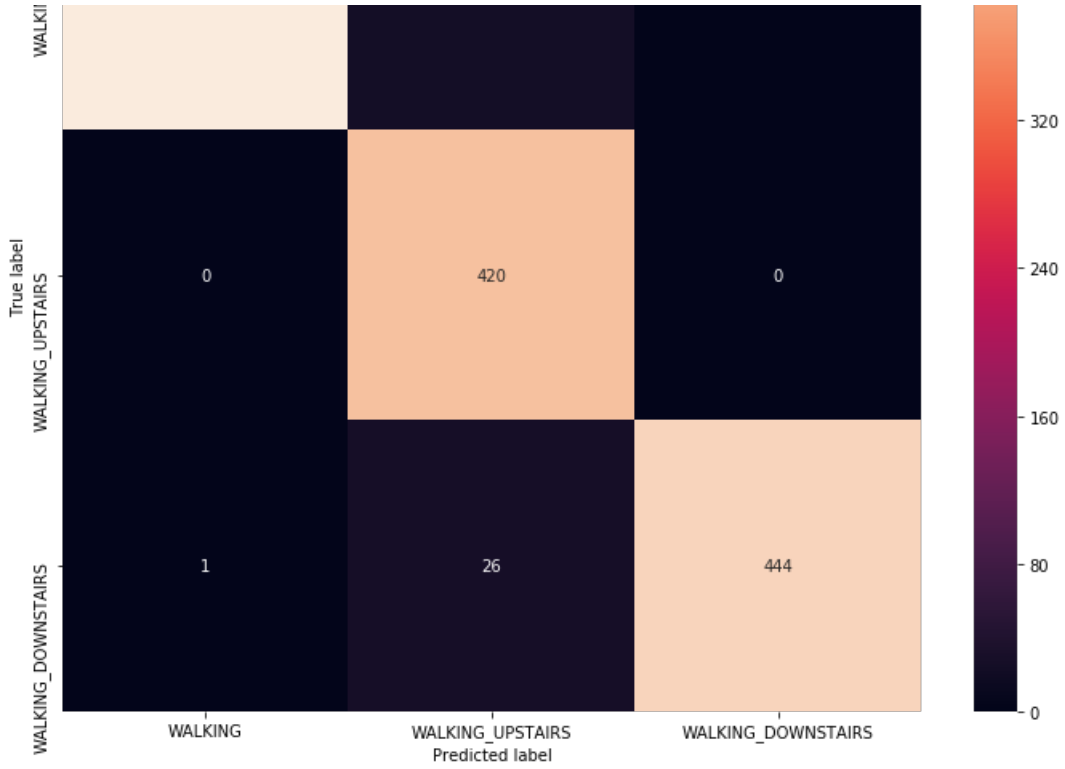
```
Exception ignored in: <bound method BaseSession._Callable.__del__ of
<tensorflow.python.client.session.BaseSession._Callable object at 0x000000D52D9BD320>>
Traceback (most recent call last):
  File "C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\client\session.py", line
1455, in __del__
    self._session._session, self._handle, status)
  File "C:\ProgramData\Anaconda3\lib\site-packages\tensorflow\python\framework\errors_impl.py", li
ne 528, in __exit__
    c_api.TF_GetCode(self.status.status))
tensorflow.python.framework.errors_impl.CancelledError: Session has been closed.
```

```
1387/1387 [==============================] - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:
- ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - ETA:  - 1s 814us/step
```

In [26]:

```
heap_map_confusion_matrix(Y_test_dy,output2)
```





In [12]:

```
# Activities are the class labels
# It is a 6 class classification
ACTIVITIES = {
    0: 'WALKING',
    1: 'WALKING_UPSTAIRS',
    2: 'WALKING_DOWNSTAIRS',
    3: 'SITTING',
    4: 'STANDING',
    5: 'LAYING',
}

% matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns
# Utility function to print the confusion matrix
def confusion_matrix(Y_true, Y_pred):
    Y_true = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_true, axis=1)])
    Y_pred = pd.Series([ACTIVITIES[y] for y in np.argmax(Y_pred, axis=1)])

    return pd.crosstab(Y_true, Y_pred, rownames=['True'], colnames=['Pred'])
def heap_map_confusion_matrix(y_test,y_predict):

  confu_matrix=confusion_matrix(y_test, y_predict)
  plt.figure(figsize=(12, 10))
  sns.heatmap(confu_matrix,xticklabels= list(ACTIVITIES.values()),
                yticklabels=list(ACTIVITIES.values()),
                annot=True, fmt="d");
  plt.title("Confusion matrix")
  plt.ylabel('True label')
  plt.xlabel('Predicted label')
  plt.show()
```

In [4]:

```
DATADIR = 'UCI_HAR_Dataset'
def load_data():
    """
    Obtain the dataset from multiple files.
    Returns: X_train, X_test, y_train, y_test
    """
    X_train, X_test = load_signals('train'), load_signals('test')
    y_train, y_test = load_y('train'), load_y('test')

    return X_train, X_test, y_train, y_test
```

```
def load_y(subset):
    """
    The objective that we are trying to predict is a integer, from 1 to 6,
    that represents a human activity. We return a binary representation of
    every sample objective as a 6 bits vector using One Hot Encoding
    (https://pandas.pydata.org/pandas-docs/stable/generated/pandas.get_dummies.html)
    """
    filename = f'UCI_HAR_Dataset/{subset}/y_{subset}.txt'
    y = _read_csv(filename)[0]

    return y
# Utility function to read the data from csv file
def _read_csv(filename):
    return pd.read_csv(filename, delim_whitespace=True, header=None)

# Utility function to load the load
def load_signals(subset):
    signals_data = []

    for signal in SIGNALS:
        filename = f'UCI_HAR_Dataset/{subset}/Inertial Signals/{signal}_{subset}.txt'
        signals_data.append(
            _read_csv(filename).as_matrix()
        )

    # Transpose is used to change the dimensionality of the output,
    # aggregating the signals by combination of sample/timestep.
    # Resultant shape is (7352 train/2947 test samples, 128 timesteps, 9 signals)
    return np.transpose(signals_data, (1, 2, 0))
# Raw data signals
# Signals are from Accelerometer and Gyroscope
# The signals are in x,y,z directions
# Sensor signals are filtered to have only body acceleration
# excluding the acceleration due to gravity
# Triaxial acceleration from the accelerometer is total acceleration
SIGNALS = [
    "body_acc_x",
    "body_acc_y",
    "body_acc_z",
    "body_gyro_x",
    "body_gyro_y",
    "body_gyro_z",
    "total_acc_x",
    "total_acc_y",
    "total_acc_z"
]
# Loading the train and test data
X_train, X_test, Y_train, Y_test = load_data()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:34: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
```

In [5]:

```
def transform(scale, X):
    temp_X1 = X.reshape((X.shape[0] * X.shape[1], X.shape[2]))
    temp_X1 = scale.transform(temp_X1)
    return temp_X1.reshape(X.shape)
```

In [6]:

```
import numpy as np
import pickle
act = pickle.load(open('act.p','rb'))
static = pickle.load(open('static.p','rb'))
dynamic = pickle.load(open('dynamic.p','rb'))
from keras.models import load_model
from tensorflow import Graph, Session
def predict(X):

    temp=transform(act,X)
    graph = Graph()
    with graph.as_default():
        session = Session()
```

```
        with session.as_default():
            # load model
            model = load_model("model_class_2_best_lstm.h5")
            output= model.predict(temp)
        session.close()
    prd1=np.argmax(output,axis=1)
    X_st=X[np.where(prd1==1)]
    X_dy=X[np.where(prd1==0)]
    X_st=transform(static,X_st)
    X_dy=transform(dynamic,X_dy)
    graph1 = Graph()
    with graph1.as_default():
        session1 = Session()
        with session1.as_default():
            # load model
            model1 = load_model("model_class_static_best_lstm.h5")
            output1 = model1.predict(X_st)
        session1.close()
    prd2=np.argmax(output1,axis=1)
    prd2=prd2+4
    graph2 = Graph()
    with graph2.as_default():
        session2 = Session()
        with session2.as_default():
            # load model
            model2 = load_model("model_class_dynamic_best_lstm.h5")
            output2 = model2.predict(X_dy)
        session2.close()
    prd3=np.argmax(output2,axis=1)
    prd3=prd3+1
    #merging two list
    final_prd=[]
    i=0
    j=0
    for predection in prd1:
        if predection==1:
            final_prd.append(prd2[i])
            i=i+1
        else:
            final_prd.append(prd3[j])
            j=j+1
    return final_prd
```

In [7]:

```
prdict_train=predict(X_train)
prdict_test=predict(X_test)
```

```
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\framework\op_def_library.py:263: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\keras\backend\tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
WARNING:tensorflow:From C:\ProgramData\Anaconda3\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
```

In [10]:

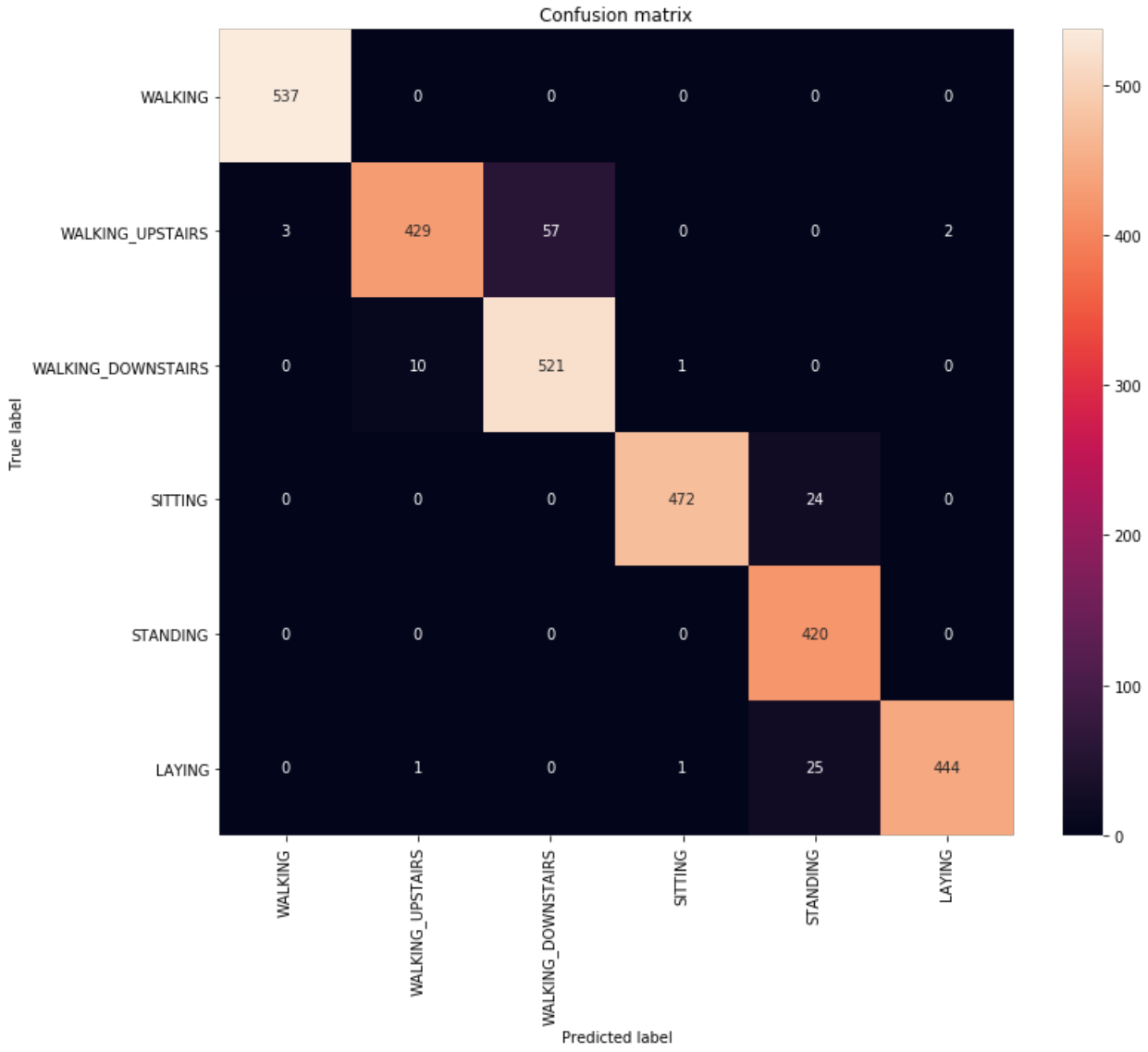
```
##accuracy of cnn model
from sklearn.metrics import accuracy_score
print('Accuracy of train data',accuracy_score(Y_train,prdict_train))
print('Accuracy of test data',accuracy_score(Y_test,prdict_test))
Y_test=pd.get_dummies(Y_test).as_matrix()
prdict_test=pd.get_dummies(prdict_test).as_matrix()
```

```
Accuracy of train data 0.999183895538629
Accuracy of validation data 0.9579233118425518
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:5: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
  """
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:6: FutureWarning: Method
.as_matrix will be removed in a future version. Use .values instead.
```

In [13]:

```
heap_map_confusion_matrix(Y_test,prdict_test)
```



Accuracy of train data 0.999183895538629
Accuracy of test data 0.9579233118425518