Part A Question 3

In [ ]:
```
import time
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import tensorflow as tf
import shap
shap.initjs()


import IPython.display as ipd

from scipy.io import wavfile as wav

from sklearn import preprocessing
from sklearn.model_selection import KFold
from sklearn.model_selection import train_test_split
from sklearn.metrics import f1_score, precision_score, recall_score, confusion_matrix


import tensorflow.keras as keras
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense, Flatten
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import *
from tensorflow.keras.regularizers import l2
from tensorflow.keras.callbacks import ReduceLROnPlateau,EarlyStopping,ModelCheckpoint,
from sklearn import datasets
from sklearn.model_selection import KFold
```

```
c:\Users\JoeTe\AppData\Local\Programs\Python\Python310\lib\site-packages\tqdm\auto.py:2
2: TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See https://
ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
```

In [ ]:
```
SEED = 42
import os
os.environ['TF_CUDNN_DETERMINISTIC'] = '1'

import random
random.seed(SEED)

import numpy as np
np.random.seed(SEED)

import tensorflow as tf
tf.random.set_seed(SEED)
```

In [ ]:
```
df = pd.read_csv('./full.csv')
df.head()
```

Out[ ]:

	filename	tempo	total_beats	average_beats	chroma_stft_mean	chroma
0	app_3001_4001_phnd_neg_0000.wav	184.570312	623	69.222222	0.515281	
1	app_3001_4001_phnd_neg_0001.wav	151.999081	521	74.428571	0.487201	
2	app_3001_4001_phnd_neg_0002.wav	112.347147	1614	146.727273	0.444244	
3	app_3001_4001_phnd_neg_0003.wav	107.666016	2060	158.461538	0.454156	
4	app_3001_4001_phnd_neg_0004.wav	75.999540	66	33.000000	0.478780	

5 rows × 78 columns

In [ ]:
```
df['label'] = df['filename'].str.split('_').str[-2]
df['label'].value_counts()
```

Out[ ]:
```
pos    92826
neg    89428
Name: label, dtype: int64
```

In [ ]:
```
columns_to_drop = ['label','filename']

def split_dataset(df, columns_to_drop, test_size, random_state):
  label_encoder = preprocessing.LabelEncoder()

  df['label'] = label_encoder.fit_transform(df['label'])

  df_train, df_test = train_test_split(df, test_size=test_size, random_state=random_sta

  df_train2 = df_train.drop(columns_to_drop,axis=1)
  y_train2 = df_train['label'].to_numpy()

  df_test2 = df_test.drop(columns_to_drop,axis=1)
  y_test2 = df_test['label'].to_numpy()

  return df_train2, y_train2, df_test2, y_test2

def preprocess_dataset(df_train, df_test):

  standard_scaler = preprocessing.StandardScaler()
  df_train_scaled = standard_scaler.fit_transform(df_train)

  df_test_scaled = standard_scaler.transform(df_test)

  return df_train_scaled, df_test_scaled

X_train, y_train, X_test, y_test = split_dataset(df, columns_to_drop, test_size=0.3, ra

X_train_scaled, X_test_scaled = preprocess_dataset(X_train, X_test)
```

In [ ]:
```
num_neurons = 128
learning_rate = 0.001
batch_size = 256
no_epochs = 100
```

Timing callback for every epoch

In [ ]:
```
# TimingCallBack class for Q2b

class TimingCallback(keras.callbacks.Callback):
    def on_train_begin(self, logs={}):
        self.times = []

    def on_epoch_begin(self, epoch, logs={}):
        self.epoch_time_start = time.time()

    def on_epoch_end(self, epoch, logs={}):
        self.times.append(time.time() - self.epoch_time_start)
```

Callback for early stopping

In [ ]:
```
callback = tf.keras.callbacks.EarlyStopping(monitor='val_accuracy', patience=3)
```

Number of folds

In [ ]:
```
no_folds = 5
cv = KFold(n_splits=no_folds, shuffle=True, random_state=0)
```

In [ ]:
```
model_neurons_list = ["model_neurons_64", "model_neurons_128", "model_neurons_256"]
num_neurons_list = [64,128,256]

Q3_X, Q3_Y = X_train_scaled, y_train
neurons_idx = 0
```

In [ ]:
```
model_neurons_list = ["model_neurons_64", "model_neurons_128", "model_neurons_256"]
num_neurons_list = [64,128,256]
model_fold = ["_0", "_1", "_2", "_3" ,"_4"]
optimal_batch_size = 512 #From Question 2

Q3_X, Q3_Y = X_train, y_train
neurons_idx = 0
```

Find the optimal number of hidden neurons for the first hidden layer

In [ ]:
```
Q3_time_taken_dict = {}
Q3_model_acc = {}
Q3_model_train_acc = {}
Q3_model_loss = {}
Q3_history = {}
for model_neurons in model_neurons_list:
    fold = 0
    val_acc = []
    train_acc = []
    val_loss = []
    time_taken_list = []
    for train_idx, test_idx in cv.split(Q3_X, Q3_Y):
        Q3_cb = TimingCallback()
        Q3_X_train, Q3_y_train  = Q3_X.iloc[train_idx], Q3_Y[train_idx]
        Q3_X_test, Q3_y_test = Q3_X.iloc[test_idx], Q3_Y[test_idx]

        # Rescale the data, so we do the scaling after splitting
        Q3_X_train, Q3_X_test = preprocess_dataset(Q3_X_train, Q3_X_test)
```

```
        Q3_model = Sequential([Dense(num_neurons_list[neurons_idx], activation='relu'),
                        Dropout(0.2), Dense(num_neurons, activation ='relu'),
                        Dropout(0.2), Dense(num_neurons, activation='relu'),
                        Dropout(0.2), Dense(1, activation='sigmoid')])

        Q3_model.compile(optimizer='adam',
                    loss='binary_crossentropy',
                    metrics=['accuracy'])

        Q3_history[model_neurons + model_fold[fold]] = Q3_model.fit(Q3_X_train, Q3_y_tra
                        batch_size = optimal_batch_size,
                        epochs=no_epochs,
                        verbose=1,
                        use_multiprocessing=True,
                        validation_data=(Q3_X_test, Q3_y_test), callbacks=[callback, Q3_

        #Time taken of final epoch for each fold
        time_taken_list.append(Q3_cb.times[-1])
        #print("Time Taken for final epoch " + model_neurons + model_fold[fold] + ": {}

        #Val accuracy of final epoch of each fold
        val_acc.append(Q3_history[model_neurons + model_fold[fold]].history['val_accura

        #Train accuracy of final epoch of each fold
        train_acc.append(Q3_history[model_neurons + model_fold[fold]].history['accuracy

        #Val loss of final epoch of each fold
        val_loss.append(Q3_history[model_neurons + model_fold[fold]].history['val_loss'

        #print(model_neurons +' fold %d test accuracy %g'%(fold, val_acc[fold]))
        fold += 1

    Q3_model_acc[model_neurons] = val_acc
    Q3_model_train_acc[model_neurons] = train_acc
    Q3_time_taken_dict[model_neurons]= time_taken_list
    Q3_model_loss[model_neurons] = val_loss
    print(model_neurons + '* mean accuracy = %g *'% np.mean(val_acc))
    neurons_idx+=1
```

```
Epoch 1/100
200/200 [==============================] - 2s 5ms/step - loss: 0.6923 - accuracy: 0.527
3 - val_loss: 0.6856 - val_accuracy: 0.5462
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6864 - accuracy: 0.544
6 - val_loss: 0.6829 - val_accuracy: 0.5512
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6838 - accuracy: 0.549
7 - val_loss: 0.6816 - val_accuracy: 0.5573
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6825 - accuracy: 0.553
8 - val_loss: 0.6813 - val_accuracy: 0.5562
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6807 - accuracy: 0.557
3 - val_loss: 0.6793 - val_accuracy: 0.5607
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6793 - accuracy: 0.561
9 - val_loss: 0.6783 - val_accuracy: 0.5658
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6771 - accuracy: 0.567
1 - val_loss: 0.6765 - val_accuracy: 0.5660
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6756 - accuracy: 0.569
0 - val_loss: 0.6753 - val_accuracy: 0.5722
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6744 - accuracy: 0.573
1 - val_loss: 0.6735 - val_accuracy: 0.5741
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6725 - accuracy: 0.575
1 - val_loss: 0.6720 - val_accuracy: 0.5758
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6709 - accuracy: 0.580
9 - val_loss: 0.6705 - val_accuracy: 0.5807
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6687 - accuracy: 0.583
5 - val_loss: 0.6697 - val_accuracy: 0.5827
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6679 - accuracy: 0.583
8 - val_loss: 0.6686 - val_accuracy: 0.5850
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6660 - accuracy: 0.586
8 - val_loss: 0.6673 - val_accuracy: 0.5857
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6641 - accuracy: 0.590
1 - val_loss: 0.6665 - val_accuracy: 0.5870
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6633 - accuracy: 0.592
2 - val_loss: 0.6647 - val_accuracy: 0.5935
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6621 - accuracy: 0.593
0 - val_loss: 0.6647 - val_accuracy: 0.5933
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6588 - accuracy: 0.599
6 - val_loss: 0.6628 - val_accuracy: 0.5904
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6587 - accuracy: 0.600
2 - val_loss: 0.6611 - val_accuracy: 0.5968
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6564 - accuracy: 0.602
6 - val_loss: 0.6594 - val_accuracy: 0.6017
```

```
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6551 - accuracy: 0.605
2 - val_loss: 0.6583 - val_accuracy: 0.6018
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6537 - accuracy: 0.607
1 - val_loss: 0.6590 - val_accuracy: 0.6004
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6534 - accuracy: 0.606
9 - val_loss: 0.6577 - val_accuracy: 0.6019
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6515 - accuracy: 0.608
3 - val_loss: 0.6567 - val_accuracy: 0.6023
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6511 - accuracy: 0.608
7 - val_loss: 0.6559 - val_accuracy: 0.6032
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6497 - accuracy: 0.612
4 - val_loss: 0.6541 - val_accuracy: 0.6091
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6478 - accuracy: 0.612
1 - val_loss: 0.6533 - val_accuracy: 0.6072
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6472 - accuracy: 0.614
9 - val_loss: 0.6527 - val_accuracy: 0.6099
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6469 - accuracy: 0.615
9 - val_loss: 0.6514 - val_accuracy: 0.6103
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6464 - accuracy: 0.617
7 - val_loss: 0.6524 - val_accuracy: 0.6088
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6445 - accuracy: 0.618
8 - val_loss: 0.6501 - val_accuracy: 0.6144
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6435 - accuracy: 0.621
4 - val_loss: 0.6508 - val_accuracy: 0.6123
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6429 - accuracy: 0.620
2 - val_loss: 0.6503 - val_accuracy: 0.6107
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6415 - accuracy: 0.622
9 - val_loss: 0.6489 - val_accuracy: 0.6108
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6923 - accuracy: 0.529
7 - val_loss: 0.6855 - val_accuracy: 0.5468
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6861 - accuracy: 0.543
0 - val_loss: 0.6831 - val_accuracy: 0.5544
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6839 - accuracy: 0.550
6 - val_loss: 0.6814 - val_accuracy: 0.5584
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6818 - accuracy: 0.555
7 - val_loss: 0.6817 - val_accuracy: 0.5596
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6801 - accuracy: 0.560
9 - val_loss: 0.6796 - val_accuracy: 0.5578
Epoch 6/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6788 - accuracy: 0.563
1 - val_loss: 0.6777 - val_accuracy: 0.5671
```

```
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6767 - accuracy: 0.567
9 - val_loss: 0.6768 - val_accuracy: 0.5669
Epoch 8/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6752 - accuracy: 0.570
8 - val_loss: 0.6761 - val_accuracy: 0.5716
Epoch 9/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6729 - accuracy: 0.575
1 - val_loss: 0.6739 - val_accuracy: 0.5729
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6714 - accuracy: 0.580
2 - val_loss: 0.6734 - val_accuracy: 0.5744
Epoch 11/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6701 - accuracy: 0.581
7 - val_loss: 0.6715 - val_accuracy: 0.5752
Epoch 12/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6682 - accuracy: 0.584
5 - val_loss: 0.6699 - val_accuracy: 0.5808
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6667 - accuracy: 0.587
1 - val_loss: 0.6684 - val_accuracy: 0.5824
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6649 - accuracy: 0.589
5 - val_loss: 0.6666 - val_accuracy: 0.5883
Epoch 15/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6630 - accuracy: 0.592
2 - val_loss: 0.6651 - val_accuracy: 0.5890
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6618 - accuracy: 0.596
3 - val_loss: 0.6635 - val_accuracy: 0.5892
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6604 - accuracy: 0.597
2 - val_loss: 0.6632 - val_accuracy: 0.5925
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6587 - accuracy: 0.598
5 - val_loss: 0.6615 - val_accuracy: 0.5950
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6566 - accuracy: 0.603
6 - val_loss: 0.6602 - val_accuracy: 0.5963
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6565 - accuracy: 0.604
3 - val_loss: 0.6601 - val_accuracy: 0.5982
Epoch 21/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6541 - accuracy: 0.607
1 - val_loss: 0.6591 - val_accuracy: 0.5984
Epoch 22/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6537 - accuracy: 0.604
7 - val_loss: 0.6580 - val_accuracy: 0.6023
Epoch 23/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6522 - accuracy: 0.609
4 - val_loss: 0.6556 - val_accuracy: 0.6036
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6506 - accuracy: 0.611
2 - val_loss: 0.6545 - val_accuracy: 0.6050
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6488 - accuracy: 0.613
7 - val_loss: 0.6549 - val_accuracy: 0.6041
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6490 - accuracy: 0.613
5 - val_loss: 0.6542 - val_accuracy: 0.6062
```

```
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6476 - accuracy: 0.616
0 - val_loss: 0.6535 - val_accuracy: 0.6038
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6473 - accuracy: 0.615
4 - val_loss: 0.6529 - val_accuracy: 0.6057
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6455 - accuracy: 0.614
5 - val_loss: 0.6526 - val_accuracy: 0.6094
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6444 - accuracy: 0.619
5 - val_loss: 0.6526 - val_accuracy: 0.6077
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6451 - accuracy: 0.618
5 - val_loss: 0.6522 - val_accuracy: 0.6088
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6429 - accuracy: 0.620
1 - val_loss: 0.6505 - val_accuracy: 0.6106
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6426 - accuracy: 0.622
0 - val_loss: 0.6490 - val_accuracy: 0.6099
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6422 - accuracy: 0.621
9 - val_loss: 0.6491 - val_accuracy: 0.6110
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6401 - accuracy: 0.624
6 - val_loss: 0.6487 - val_accuracy: 0.6106
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6405 - accuracy: 0.623
4 - val_loss: 0.6479 - val_accuracy: 0.6119
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6381 - accuracy: 0.627
6 - val_loss: 0.6473 - val_accuracy: 0.6115
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6395 - accuracy: 0.624
5 - val_loss: 0.6468 - val_accuracy: 0.6143
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6370 - accuracy: 0.629
3 - val_loss: 0.6451 - val_accuracy: 0.6199
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6367 - accuracy: 0.627
7 - val_loss: 0.6450 - val_accuracy: 0.6167
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6363 - accuracy: 0.629
4 - val_loss: 0.6449 - val_accuracy: 0.6175
Epoch 42/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6355 - accuracy: 0.628
9 - val_loss: 0.6447 - val_accuracy: 0.6155
Epoch 1/100
200/200 [==============================] - 2s 5ms/step - loss: 0.6921 - accuracy: 0.530
5 - val_loss: 0.6860 - val_accuracy: 0.5442
Epoch 2/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6863 - accuracy: 0.545
9 - val_loss: 0.6846 - val_accuracy: 0.5537
Epoch 3/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6840 - accuracy: 0.552
3 - val_loss: 0.6828 - val_accuracy: 0.5565
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6818 - accuracy: 0.556
1 - val_loss: 0.6806 - val_accuracy: 0.5592
```

```
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6800 - accuracy: 0.560
8 - val_loss: 0.6794 - val_accuracy: 0.5631
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6787 - accuracy: 0.563
9 - val_loss: 0.6783 - val_accuracy: 0.5618
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6772 - accuracy: 0.566
6 - val_loss: 0.6769 - val_accuracy: 0.5692
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6753 - accuracy: 0.568
1 - val_loss: 0.6754 - val_accuracy: 0.5712
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6738 - accuracy: 0.574
4 - val_loss: 0.6747 - val_accuracy: 0.5681
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6723 - accuracy: 0.577
0 - val_loss: 0.6732 - val_accuracy: 0.5748
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6707 - accuracy: 0.579
5 - val_loss: 0.6719 - val_accuracy: 0.5769
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6692 - accuracy: 0.582
1 - val_loss: 0.6707 - val_accuracy: 0.5773
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6677 - accuracy: 0.584
3 - val_loss: 0.6690 - val_accuracy: 0.5815
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6660 - accuracy: 0.587
3 - val_loss: 0.6672 - val_accuracy: 0.5841
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6645 - accuracy: 0.588
8 - val_loss: 0.6662 - val_accuracy: 0.5894
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6630 - accuracy: 0.592
6 - val_loss: 0.6648 - val_accuracy: 0.5884
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6613 - accuracy: 0.594
7 - val_loss: 0.6634 - val_accuracy: 0.5935
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6602 - accuracy: 0.595
2 - val_loss: 0.6629 - val_accuracy: 0.5937
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6586 - accuracy: 0.598
2 - val_loss: 0.6615 - val_accuracy: 0.5953
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6574 - accuracy: 0.601
0 - val_loss: 0.6595 - val_accuracy: 0.5989
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6564 - accuracy: 0.602
8 - val_loss: 0.6588 - val_accuracy: 0.6017
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6546 - accuracy: 0.603
8 - val_loss: 0.6583 - val_accuracy: 0.5984
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6534 - accuracy: 0.605
9 - val_loss: 0.6572 - val_accuracy: 0.6007
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6521 - accuracy: 0.608
3 - val_loss: 0.6566 - val_accuracy: 0.6034
```

```
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6528 - accuracy: 0.606
2 - val_loss: 0.6545 - val_accuracy: 0.6044
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6501 - accuracy: 0.608
9 - val_loss: 0.6547 - val_accuracy: 0.6076
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6503 - accuracy: 0.611
3 - val_loss: 0.6534 - val_accuracy: 0.6102
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6481 - accuracy: 0.614
4 - val_loss: 0.6519 - val_accuracy: 0.6117
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6485 - accuracy: 0.613
5 - val_loss: 0.6514 - val_accuracy: 0.6114
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6466 - accuracy: 0.614
3 - val_loss: 0.6503 - val_accuracy: 0.6118
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6467 - accuracy: 0.614
9 - val_loss: 0.6510 - val_accuracy: 0.6105
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6445 - accuracy: 0.617
6 - val_loss: 0.6495 - val_accuracy: 0.6111
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6443 - accuracy: 0.617
7 - val_loss: 0.6491 - val_accuracy: 0.6142
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6431 - accuracy: 0.619
1 - val_loss: 0.6481 - val_accuracy: 0.6159
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6418 - accuracy: 0.619
5 - val_loss: 0.6472 - val_accuracy: 0.6146
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6406 - accuracy: 0.622
0 - val_loss: 0.6464 - val_accuracy: 0.6196
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6406 - accuracy: 0.621
2 - val_loss: 0.6460 - val_accuracy: 0.6189
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6388 - accuracy: 0.624
8 - val_loss: 0.6451 - val_accuracy: 0.6164
Epoch 39/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6402 - accuracy: 0.621
2 - val_loss: 0.6456 - val_accuracy: 0.6182
Epoch 1/100
200/200 [==============================] - 2s 6ms/step - loss: 0.6935 - accuracy: 0.527
1 - val_loss: 0.6856 - val_accuracy: 0.5485
Epoch 2/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6867 - accuracy: 0.543
8 - val_loss: 0.6832 - val_accuracy: 0.5539
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6838 - accuracy: 0.550
4 - val_loss: 0.6817 - val_accuracy: 0.5614
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6818 - accuracy: 0.554
6 - val_loss: 0.6803 - val_accuracy: 0.5659
Epoch 5/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6798 - accuracy: 0.560
7 - val_loss: 0.6799 - val_accuracy: 0.5672
```

```
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6791 - accuracy: 0.562
5 - val_loss: 0.6780 - val_accuracy: 0.5700
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6765 - accuracy: 0.566
2 - val_loss: 0.6774 - val_accuracy: 0.5707
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6757 - accuracy: 0.569
5 - val_loss: 0.6760 - val_accuracy: 0.5740
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6739 - accuracy: 0.571
7 - val_loss: 0.6740 - val_accuracy: 0.5769
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6720 - accuracy: 0.576
0 - val_loss: 0.6740 - val_accuracy: 0.5793
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6700 - accuracy: 0.579
2 - val_loss: 0.6726 - val_accuracy: 0.5790
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6693 - accuracy: 0.579
9 - val_loss: 0.6710 - val_accuracy: 0.5805
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6672 - accuracy: 0.584
2 - val_loss: 0.6700 - val_accuracy: 0.5846
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6654 - accuracy: 0.587
2 - val_loss: 0.6694 - val_accuracy: 0.5862
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6644 - accuracy: 0.588
7 - val_loss: 0.6676 - val_accuracy: 0.5884
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6623 - accuracy: 0.592
1 - val_loss: 0.6659 - val_accuracy: 0.5913
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6617 - accuracy: 0.593
4 - val_loss: 0.6651 - val_accuracy: 0.5920
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6600 - accuracy: 0.594
2 - val_loss: 0.6632 - val_accuracy: 0.5948
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6596 - accuracy: 0.597
7 - val_loss: 0.6637 - val_accuracy: 0.5951
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6574 - accuracy: 0.600
5 - val_loss: 0.6616 - val_accuracy: 0.5994
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6556 - accuracy: 0.598
6 - val_loss: 0.6602 - val_accuracy: 0.5993
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6560 - accuracy: 0.601
7 - val_loss: 0.6609 - val_accuracy: 0.5986
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6539 - accuracy: 0.605
0 - val_loss: 0.6606 - val_accuracy: 0.5971
Epoch 1/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6930 - accuracy: 0.529
6 - val_loss: 0.6863 - val_accuracy: 0.5428
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6864 - accuracy: 0.544
3 - val_loss: 0.6839 - val_accuracy: 0.5490
```

```
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6839 - accuracy: 0.552
3 - val_loss: 0.6823 - val_accuracy: 0.5522
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6824 - accuracy: 0.555
5 - val_loss: 0.6808 - val_accuracy: 0.5570
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6804 - accuracy: 0.559
2 - val_loss: 0.6798 - val_accuracy: 0.5592
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6790 - accuracy: 0.563
3 - val_loss: 0.6784 - val_accuracy: 0.5628
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6770 - accuracy: 0.567
0 - val_loss: 0.6771 - val_accuracy: 0.5686
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6757 - accuracy: 0.569
3 - val_loss: 0.6762 - val_accuracy: 0.5715
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6741 - accuracy: 0.574
0 - val_loss: 0.6747 - val_accuracy: 0.5712
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6729 - accuracy: 0.575
1 - val_loss: 0.6724 - val_accuracy: 0.5745
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6715 - accuracy: 0.579
3 - val_loss: 0.6717 - val_accuracy: 0.5790
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6696 - accuracy: 0.584
1 - val_loss: 0.6698 - val_accuracy: 0.5788
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6675 - accuracy: 0.584
4 - val_loss: 0.6689 - val_accuracy: 0.5796
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6667 - accuracy: 0.587
5 - val_loss: 0.6681 - val_accuracy: 0.5812
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6652 - accuracy: 0.586
8 - val_loss: 0.6669 - val_accuracy: 0.5859
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6628 - accuracy: 0.591
7 - val_loss: 0.6648 - val_accuracy: 0.5878
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6607 - accuracy: 0.595
3 - val_loss: 0.6640 - val_accuracy: 0.5932
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6600 - accuracy: 0.596
4 - val_loss: 0.6635 - val_accuracy: 0.5917
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6584 - accuracy: 0.600
2 - val_loss: 0.6619 - val_accuracy: 0.5929
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6583 - accuracy: 0.599
9 - val_loss: 0.6611 - val_accuracy: 0.5956
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6569 - accuracy: 0.600
7 - val_loss: 0.6600 - val_accuracy: 0.5972
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6550 - accuracy: 0.605
4 - val_loss: 0.6591 - val_accuracy: 0.5962
```

```
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6544 - accuracy: 0.605
7 - val_loss: 0.6584 - val_accuracy: 0.5998
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6526 - accuracy: 0.607
3 - val_loss: 0.6577 - val_accuracy: 0.5996
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6529 - accuracy: 0.606
4 - val_loss: 0.6567 - val_accuracy: 0.6038
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6496 - accuracy: 0.611
7 - val_loss: 0.6555 - val_accuracy: 0.6030
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6492 - accuracy: 0.611
9 - val_loss: 0.6542 - val_accuracy: 0.6043
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6478 - accuracy: 0.613
2 - val_loss: 0.6538 - val_accuracy: 0.6044
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6485 - accuracy: 0.611
2 - val_loss: 0.6532 - val_accuracy: 0.6081
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6471 - accuracy: 0.614
9 - val_loss: 0.6534 - val_accuracy: 0.6051
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6457 - accuracy: 0.617
0 - val_loss: 0.6523 - val_accuracy: 0.6065
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6441 - accuracy: 0.619
3 - val_loss: 0.6515 - val_accuracy: 0.6098
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6429 - accuracy: 0.620
5 - val_loss: 0.6500 - val_accuracy: 0.6129
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6416 - accuracy: 0.622
4 - val_loss: 0.6493 - val_accuracy: 0.6109
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6411 - accuracy: 0.622
7 - val_loss: 0.6493 - val_accuracy: 0.6107
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6416 - accuracy: 0.622
1 - val_loss: 0.6490 - val_accuracy: 0.6134
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6408 - accuracy: 0.622
3 - val_loss: 0.6485 - val_accuracy: 0.6150
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6392 - accuracy: 0.626
1 - val_loss: 0.6479 - val_accuracy: 0.6188
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6374 - accuracy: 0.626
8 - val_loss: 0.6468 - val_accuracy: 0.6163
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6381 - accuracy: 0.627
9 - val_loss: 0.6456 - val_accuracy: 0.6187
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6372 - accuracy: 0.626
7 - val_loss: 0.6470 - val_accuracy: 0.6169
model_neurons_64* mean accuracy = 0.611701 *
Epoch 1/100
200/200 [==============================] - 2s 5ms/step - loss: 0.6933 - accuracy: 0.531
```

```
6 - val_loss: 0.6842 - val_accuracy: 0.5492
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6852 - accuracy: 0.550
3 - val_loss: 0.6815 - val_accuracy: 0.5555
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6824 - accuracy: 0.555
8 - val_loss: 0.6796 - val_accuracy: 0.5647
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6804 - accuracy: 0.559
3 - val_loss: 0.6788 - val_accuracy: 0.5667
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6782 - accuracy: 0.567
5 - val_loss: 0.6760 - val_accuracy: 0.5678
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6755 - accuracy: 0.571
6 - val_loss: 0.6745 - val_accuracy: 0.5732
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6733 - accuracy: 0.575
0 - val_loss: 0.6719 - val_accuracy: 0.5759
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6705 - accuracy: 0.580
1 - val_loss: 0.6710 - val_accuracy: 0.5810
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6681 - accuracy: 0.582
9 - val_loss: 0.6683 - val_accuracy: 0.5823
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6653 - accuracy: 0.589
8 - val_loss: 0.6665 - val_accuracy: 0.5886
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6621 - accuracy: 0.593
6 - val_loss: 0.6636 - val_accuracy: 0.5923
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6585 - accuracy: 0.599
2 - val_loss: 0.6620 - val_accuracy: 0.5941
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6569 - accuracy: 0.604
7 - val_loss: 0.6592 - val_accuracy: 0.6012
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6539 - accuracy: 0.607
3 - val_loss: 0.6564 - val_accuracy: 0.6040
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6496 - accuracy: 0.612
6 - val_loss: 0.6559 - val_accuracy: 0.6053
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6478 - accuracy: 0.616
3 - val_loss: 0.6536 - val_accuracy: 0.6075
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6449 - accuracy: 0.617
2 - val_loss: 0.6517 - val_accuracy: 0.6104
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6407 - accuracy: 0.623
8 - val_loss: 0.6505 - val_accuracy: 0.6073
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6398 - accuracy: 0.626
2 - val_loss: 0.6462 - val_accuracy: 0.6172
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6370 - accuracy: 0.628
7 - val_loss: 0.6459 - val_accuracy: 0.6168
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6344 - accuracy: 0.629
```

```
8 - val_loss: 0.6417 - val_accuracy: 0.6240
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6314 - accuracy: 0.635
9 - val_loss: 0.6420 - val_accuracy: 0.6204
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6296 - accuracy: 0.636
0 - val_loss: 0.6403 - val_accuracy: 0.6279
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6268 - accuracy: 0.639
7 - val_loss: 0.6383 - val_accuracy: 0.6278
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6261 - accuracy: 0.641
0 - val_loss: 0.6369 - val_accuracy: 0.6278
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6229 - accuracy: 0.644
2 - val_loss: 0.6358 - val_accuracy: 0.6305
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6214 - accuracy: 0.646
8 - val_loss: 0.6334 - val_accuracy: 0.6318
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6209 - accuracy: 0.645
7 - val_loss: 0.6322 - val_accuracy: 0.6331
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6182 - accuracy: 0.649
3 - val_loss: 0.6297 - val_accuracy: 0.6340
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6154 - accuracy: 0.653
4 - val_loss: 0.6309 - val_accuracy: 0.6351
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6140 - accuracy: 0.654
3 - val_loss: 0.6296 - val_accuracy: 0.6352
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6147 - accuracy: 0.653
6 - val_loss: 0.6272 - val_accuracy: 0.6409
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6120 - accuracy: 0.654
1 - val_loss: 0.6251 - val_accuracy: 0.6391
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6114 - accuracy: 0.656
5 - val_loss: 0.6266 - val_accuracy: 0.6363
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6083 - accuracy: 0.658
9 - val_loss: 0.6232 - val_accuracy: 0.6440
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6083 - accuracy: 0.659
3 - val_loss: 0.6212 - val_accuracy: 0.6452
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6060 - accuracy: 0.660
8 - val_loss: 0.6211 - val_accuracy: 0.6428
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6055 - accuracy: 0.661
9 - val_loss: 0.6207 - val_accuracy: 0.6452
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6045 - accuracy: 0.662
6 - val_loss: 0.6191 - val_accuracy: 0.6440
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6020 - accuracy: 0.664
7 - val_loss: 0.6197 - val_accuracy: 0.6436
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6017 - accuracy: 0.663
```

```
7 - val_loss: 0.6174 - val_accuracy: 0.6474
Epoch 42/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6020 - accuracy: 0.665
8 - val_loss: 0.6179 - val_accuracy: 0.6440
Epoch 43/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5988 - accuracy: 0.668
9 - val_loss: 0.6167 - val_accuracy: 0.6499
Epoch 44/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5972 - accuracy: 0.670
8 - val_loss: 0.6154 - val_accuracy: 0.6514
Epoch 45/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5960 - accuracy: 0.671
4 - val_loss: 0.6152 - val_accuracy: 0.6501
Epoch 46/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5953 - accuracy: 0.672
5 - val_loss: 0.6138 - val_accuracy: 0.6514
Epoch 47/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5947 - accuracy: 0.672
3 - val_loss: 0.6127 - val_accuracy: 0.6529
Epoch 48/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5928 - accuracy: 0.675
9 - val_loss: 0.6137 - val_accuracy: 0.6554
Epoch 49/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5910 - accuracy: 0.673
7 - val_loss: 0.6112 - val_accuracy: 0.6571
Epoch 50/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5916 - accuracy: 0.674
4 - val_loss: 0.6120 - val_accuracy: 0.6545
Epoch 51/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5920 - accuracy: 0.674
3 - val_loss: 0.6109 - val_accuracy: 0.6532
Epoch 52/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5909 - accuracy: 0.675
3 - val_loss: 0.6103 - val_accuracy: 0.6522
Epoch 1/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6922 - accuracy: 0.533
5 - val_loss: 0.6847 - val_accuracy: 0.5484
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6850 - accuracy: 0.548
4 - val_loss: 0.6822 - val_accuracy: 0.5571
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6821 - accuracy: 0.556
5 - val_loss: 0.6802 - val_accuracy: 0.5594
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6795 - accuracy: 0.561
8 - val_loss: 0.6796 - val_accuracy: 0.5665
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6773 - accuracy: 0.567
4 - val_loss: 0.6774 - val_accuracy: 0.5681
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6749 - accuracy: 0.571
7 - val_loss: 0.6750 - val_accuracy: 0.5723
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6731 - accuracy: 0.573
9 - val_loss: 0.6737 - val_accuracy: 0.5745
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6693 - accuracy: 0.583
4 - val_loss: 0.6713 - val_accuracy: 0.5780
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6658 - accuracy: 0.585
```

```
4 - val_loss: 0.6689 - val_accuracy: 0.5830
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6635 - accuracy: 0.590
8 - val_loss: 0.6665 - val_accuracy: 0.5851
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6601 - accuracy: 0.598
0 - val_loss: 0.6652 - val_accuracy: 0.5858
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6566 - accuracy: 0.601
2 - val_loss: 0.6633 - val_accuracy: 0.5908
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6538 - accuracy: 0.606
2 - val_loss: 0.6587 - val_accuracy: 0.5995
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6511 - accuracy: 0.608
8 - val_loss: 0.6592 - val_accuracy: 0.5959
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6478 - accuracy: 0.613
1 - val_loss: 0.6551 - val_accuracy: 0.6037
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6459 - accuracy: 0.617
1 - val_loss: 0.6517 - val_accuracy: 0.6100
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6430 - accuracy: 0.617
9 - val_loss: 0.6530 - val_accuracy: 0.6056
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6404 - accuracy: 0.622
7 - val_loss: 0.6509 - val_accuracy: 0.6078
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6368 - accuracy: 0.626
6 - val_loss: 0.6472 - val_accuracy: 0.6155
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6333 - accuracy: 0.630
5 - val_loss: 0.6454 - val_accuracy: 0.6186
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6326 - accuracy: 0.630
7 - val_loss: 0.6433 - val_accuracy: 0.6184
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6312 - accuracy: 0.632
4 - val_loss: 0.6440 - val_accuracy: 0.6182
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6279 - accuracy: 0.636
1 - val_loss: 0.6414 - val_accuracy: 0.6233
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6269 - accuracy: 0.637
5 - val_loss: 0.6386 - val_accuracy: 0.6275
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6250 - accuracy: 0.640
8 - val_loss: 0.6380 - val_accuracy: 0.6268
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6225 - accuracy: 0.641
1 - val_loss: 0.6381 - val_accuracy: 0.6241
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6207 - accuracy: 0.643
9 - val_loss: 0.6367 - val_accuracy: 0.6265
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6913 - accuracy: 0.531
9 - val_loss: 0.6850 - val_accuracy: 0.5471
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6849 - accuracy: 0.549
```

```
3 - val_loss: 0.6834 - val_accuracy: 0.5572
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6818 - accuracy: 0.557
5 - val_loss: 0.6800 - val_accuracy: 0.5625
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6794 - accuracy: 0.562
0 - val_loss: 0.6790 - val_accuracy: 0.5643
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6776 - accuracy: 0.565
5 - val_loss: 0.6766 - val_accuracy: 0.5714
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6750 - accuracy: 0.570
6 - val_loss: 0.6752 - val_accuracy: 0.5709
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6725 - accuracy: 0.575
6 - val_loss: 0.6729 - val_accuracy: 0.5762
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6695 - accuracy: 0.580
3 - val_loss: 0.6704 - val_accuracy: 0.5792
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6673 - accuracy: 0.585
0 - val_loss: 0.6711 - val_accuracy: 0.5790
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6645 - accuracy: 0.590
8 - val_loss: 0.6679 - val_accuracy: 0.5836
Epoch 11/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6612 - accuracy: 0.593
6 - val_loss: 0.6648 - val_accuracy: 0.5907
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6594 - accuracy: 0.597
6 - val_loss: 0.6617 - val_accuracy: 0.5955
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6564 - accuracy: 0.601
8 - val_loss: 0.6599 - val_accuracy: 0.5979
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6533 - accuracy: 0.606
1 - val_loss: 0.6566 - val_accuracy: 0.6011
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6503 - accuracy: 0.609
5 - val_loss: 0.6554 - val_accuracy: 0.6058
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6496 - accuracy: 0.611
6 - val_loss: 0.6537 - val_accuracy: 0.6047
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6460 - accuracy: 0.615
3 - val_loss: 0.6512 - val_accuracy: 0.6091
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6425 - accuracy: 0.621
4 - val_loss: 0.6501 - val_accuracy: 0.6129
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6409 - accuracy: 0.621
4 - val_loss: 0.6470 - val_accuracy: 0.6174
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6389 - accuracy: 0.625
7 - val_loss: 0.6467 - val_accuracy: 0.6161
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6361 - accuracy: 0.627
5 - val_loss: 0.6445 - val_accuracy: 0.6179
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6332 - accuracy: 0.630
```

```
0 - val_loss: 0.6421 - val_accuracy: 0.6201
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6319 - accuracy: 0.633
5 - val_loss: 0.6416 - val_accuracy: 0.6221
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6293 - accuracy: 0.635
2 - val_loss: 0.6400 - val_accuracy: 0.6219
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6274 - accuracy: 0.639
1 - val_loss: 0.6370 - val_accuracy: 0.6286
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6268 - accuracy: 0.637
9 - val_loss: 0.6362 - val_accuracy: 0.6271
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6238 - accuracy: 0.641
5 - val_loss: 0.6368 - val_accuracy: 0.6286
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6231 - accuracy: 0.641
7 - val_loss: 0.6341 - val_accuracy: 0.6288
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6202 - accuracy: 0.643
7 - val_loss: 0.6322 - val_accuracy: 0.6328
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6199 - accuracy: 0.644
6 - val_loss: 0.6324 - val_accuracy: 0.6288
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6177 - accuracy: 0.648
4 - val_loss: 0.6316 - val_accuracy: 0.6312
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6155 - accuracy: 0.651
2 - val_loss: 0.6303 - val_accuracy: 0.6319
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6935 - accuracy: 0.529
5 - val_loss: 0.6847 - val_accuracy: 0.5509
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6853 - accuracy: 0.546
1 - val_loss: 0.6821 - val_accuracy: 0.5577
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6827 - accuracy: 0.554
0 - val_loss: 0.6803 - val_accuracy: 0.5655
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6794 - accuracy: 0.559
6 - val_loss: 0.6782 - val_accuracy: 0.5702
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6777 - accuracy: 0.565
1 - val_loss: 0.6772 - val_accuracy: 0.5707
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6751 - accuracy: 0.570
1 - val_loss: 0.6747 - val_accuracy: 0.5747
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6725 - accuracy: 0.574
4 - val_loss: 0.6737 - val_accuracy: 0.5801
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6702 - accuracy: 0.579
5 - val_loss: 0.6707 - val_accuracy: 0.5820
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6670 - accuracy: 0.584
8 - val_loss: 0.6685 - val_accuracy: 0.5896
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6648 - accuracy: 0.589
```

```
1 - val_loss: 0.6666 - val_accuracy: 0.5906
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6606 - accuracy: 0.593
8 - val_loss: 0.6645 - val_accuracy: 0.5928
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6580 - accuracy: 0.599
2 - val_loss: 0.6615 - val_accuracy: 0.5955
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6557 - accuracy: 0.603
9 - val_loss: 0.6611 - val_accuracy: 0.5956
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6524 - accuracy: 0.607
3 - val_loss: 0.6575 - val_accuracy: 0.6000
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6499 - accuracy: 0.610
2 - val_loss: 0.6550 - val_accuracy: 0.6045
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6455 - accuracy: 0.615
3 - val_loss: 0.6523 - val_accuracy: 0.6078
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6422 - accuracy: 0.619
8 - val_loss: 0.6516 - val_accuracy: 0.6093
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6405 - accuracy: 0.621
2 - val_loss: 0.6505 - val_accuracy: 0.6089
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6365 - accuracy: 0.626
7 - val_loss: 0.6463 - val_accuracy: 0.6140
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6353 - accuracy: 0.628
9 - val_loss: 0.6466 - val_accuracy: 0.6138
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6329 - accuracy: 0.630
5 - val_loss: 0.6442 - val_accuracy: 0.6204
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6315 - accuracy: 0.632
4 - val_loss: 0.6436 - val_accuracy: 0.6198
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6276 - accuracy: 0.636
3 - val_loss: 0.6410 - val_accuracy: 0.6203
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6263 - accuracy: 0.639
4 - val_loss: 0.6400 - val_accuracy: 0.6227
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6250 - accuracy: 0.639
2 - val_loss: 0.6385 - val_accuracy: 0.6270
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6223 - accuracy: 0.643
8 - val_loss: 0.6374 - val_accuracy: 0.6233
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6201 - accuracy: 0.644
1 - val_loss: 0.6361 - val_accuracy: 0.6292
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6190 - accuracy: 0.645
3 - val_loss: 0.6360 - val_accuracy: 0.6302
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6170 - accuracy: 0.646
7 - val_loss: 0.6334 - val_accuracy: 0.6306
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6165 - accuracy: 0.647
```

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4 - val_loss: 0.6322 - val_accuracy: 0.6309
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6128 - accuracy: 0.654
4 - val_loss: 0.6315 - val_accuracy: 0.6301
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6112 - accuracy: 0.654
8 - val_loss: 0.6303 - val_accuracy: 0.6337
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6108 - accuracy: 0.654
1 - val_loss: 0.6297 - val_accuracy: 0.6336
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6079 - accuracy: 0.657
7 - val_loss: 0.6276 - val_accuracy: 0.6383
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6074 - accuracy: 0.657
5 - val_loss: 0.6279 - val_accuracy: 0.6395
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6062 - accuracy: 0.659
1 - val_loss: 0.6272 - val_accuracy: 0.6346
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6050 - accuracy: 0.660
4 - val_loss: 0.6262 - val_accuracy: 0.6383
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6036 - accuracy: 0.661
7 - val_loss: 0.6245 - val_accuracy: 0.6362
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6921 - accuracy: 0.531
8 - val_loss: 0.6843 - val_accuracy: 0.5523
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6845 - accuracy: 0.550
8 - val_loss: 0.6816 - val_accuracy: 0.5553
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6817 - accuracy: 0.557
1 - val_loss: 0.6802 - val_accuracy: 0.5616
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6795 - accuracy: 0.561
1 - val_loss: 0.6782 - val_accuracy: 0.5619
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6772 - accuracy: 0.566
8 - val_loss: 0.6770 - val_accuracy: 0.5635
Epoch 6/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6742 - accuracy: 0.571
2 - val_loss: 0.6752 - val_accuracy: 0.5744
Epoch 7/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6712 - accuracy: 0.577
0 - val_loss: 0.6735 - val_accuracy: 0.5751
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6691 - accuracy: 0.580
1 - val_loss: 0.6705 - val_accuracy: 0.5803
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6652 - accuracy: 0.587
4 - val_loss: 0.6683 - val_accuracy: 0.5829
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6626 - accuracy: 0.590
2 - val_loss: 0.6660 - val_accuracy: 0.5899
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6593 - accuracy: 0.597
5 - val_loss: 0.6631 - val_accuracy: 0.5937
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6568 - accuracy: 0.599
```

```
2 - val_loss: 0.6611 - val_accuracy: 0.5947
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6533 - accuracy: 0.606
7 - val_loss: 0.6598 - val_accuracy: 0.5950
Epoch 14/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6519 - accuracy: 0.606
9 - val_loss: 0.6579 - val_accuracy: 0.5990
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6488 - accuracy: 0.608
6 - val_loss: 0.6554 - val_accuracy: 0.6042
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6465 - accuracy: 0.614
5 - val_loss: 0.6529 - val_accuracy: 0.6070
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6435 - accuracy: 0.616
1 - val_loss: 0.6510 - val_accuracy: 0.6065
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6406 - accuracy: 0.620
4 - val_loss: 0.6496 - val_accuracy: 0.6120
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6379 - accuracy: 0.622
9 - val_loss: 0.6485 - val_accuracy: 0.6145
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6363 - accuracy: 0.627
0 - val_loss: 0.6458 - val_accuracy: 0.6156
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6342 - accuracy: 0.628
7 - val_loss: 0.6462 - val_accuracy: 0.6164
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6309 - accuracy: 0.630
7 - val_loss: 0.6437 - val_accuracy: 0.6178
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6295 - accuracy: 0.633
5 - val_loss: 0.6425 - val_accuracy: 0.6189
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6277 - accuracy: 0.636
2 - val_loss: 0.6408 - val_accuracy: 0.6225
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6249 - accuracy: 0.637
9 - val_loss: 0.6390 - val_accuracy: 0.6231
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6237 - accuracy: 0.640
9 - val_loss: 0.6374 - val_accuracy: 0.6257
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6208 - accuracy: 0.644
2 - val_loss: 0.6366 - val_accuracy: 0.6248
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6188 - accuracy: 0.643
9 - val_loss: 0.6347 - val_accuracy: 0.6267
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6185 - accuracy: 0.646
3 - val_loss: 0.6343 - val_accuracy: 0.6288
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6159 - accuracy: 0.649
3 - val_loss: 0.6342 - val_accuracy: 0.6303
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6145 - accuracy: 0.650
1 - val_loss: 0.6330 - val_accuracy: 0.6304
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6132 - accuracy: 0.653
```

```
0 - val_loss: 0.6311 - val_accuracy: 0.6318
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6113 - accuracy: 0.653
9 - val_loss: 0.6309 - val_accuracy: 0.6284
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6098 - accuracy: 0.654
4 - val_loss: 0.6290 - val_accuracy: 0.6351
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6096 - accuracy: 0.655
5 - val_loss: 0.6292 - val_accuracy: 0.6343
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6082 - accuracy: 0.655
9 - val_loss: 0.6270 - val_accuracy: 0.6369
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6055 - accuracy: 0.658
5 - val_loss: 0.6259 - val_accuracy: 0.6412
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6053 - accuracy: 0.660
3 - val_loss: 0.6271 - val_accuracy: 0.6370
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6051 - accuracy: 0.660
5 - val_loss: 0.6246 - val_accuracy: 0.6412
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6024 - accuracy: 0.661
0 - val_loss: 0.6252 - val_accuracy: 0.6389
model_neurons_128* mean accuracy = 0.637145 *
Epoch 1/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6904 - accuracy: 0.534
2 - val_loss: 0.6836 - val_accuracy: 0.5506
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6841 - accuracy: 0.551
9 - val_loss: 0.6803 - val_accuracy: 0.5564
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6800 - accuracy: 0.558
7 - val_loss: 0.6780 - val_accuracy: 0.5662
Epoch 4/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6772 - accuracy: 0.568
8 - val_loss: 0.6754 - val_accuracy: 0.5711
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6731 - accuracy: 0.574
8 - val_loss: 0.6718 - val_accuracy: 0.5763
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6697 - accuracy: 0.580
3 - val_loss: 0.6697 - val_accuracy: 0.5805
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6658 - accuracy: 0.586
1 - val_loss: 0.6658 - val_accuracy: 0.5908
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6608 - accuracy: 0.595
3 - val_loss: 0.6639 - val_accuracy: 0.5911
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6569 - accuracy: 0.600
5 - val_loss: 0.6606 - val_accuracy: 0.5955
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6521 - accuracy: 0.607
0 - val_loss: 0.6540 - val_accuracy: 0.6067
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6466 - accuracy: 0.614
0 - val_loss: 0.6521 - val_accuracy: 0.6076
Epoch 12/100
```

```
200/200 [==============================] - 1s 4ms/step - loss: 0.6401 - accuracy: 0.622
0 - val_loss: 0.6488 - val_accuracy: 0.6122
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6362 - accuracy: 0.625
2 - val_loss: 0.6442 - val_accuracy: 0.6142
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6307 - accuracy: 0.633
7 - val_loss: 0.6403 - val_accuracy: 0.6206
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6255 - accuracy: 0.639
2 - val_loss: 0.6377 - val_accuracy: 0.6235
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6220 - accuracy: 0.642
5 - val_loss: 0.6336 - val_accuracy: 0.6283
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6166 - accuracy: 0.647
9 - val_loss: 0.6312 - val_accuracy: 0.6324
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6125 - accuracy: 0.654
2 - val_loss: 0.6284 - val_accuracy: 0.6336
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6085 - accuracy: 0.656
0 - val_loss: 0.6265 - val_accuracy: 0.6398
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6032 - accuracy: 0.662
1 - val_loss: 0.6224 - val_accuracy: 0.6418
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6003 - accuracy: 0.664
3 - val_loss: 0.6203 - val_accuracy: 0.6437
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5968 - accuracy: 0.667
2 - val_loss: 0.6171 - val_accuracy: 0.6526
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5915 - accuracy: 0.670
8 - val_loss: 0.6175 - val_accuracy: 0.6488
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5890 - accuracy: 0.674
1 - val_loss: 0.6152 - val_accuracy: 0.6489
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5859 - accuracy: 0.678
6 - val_loss: 0.6123 - val_accuracy: 0.6543
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5836 - accuracy: 0.681
2 - val_loss: 0.6104 - val_accuracy: 0.6504
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5788 - accuracy: 0.683
3 - val_loss: 0.6079 - val_accuracy: 0.6556
Epoch 28/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5769 - accuracy: 0.684
4 - val_loss: 0.6076 - val_accuracy: 0.6562
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5727 - accuracy: 0.688
6 - val_loss: 0.6067 - val_accuracy: 0.6541
Epoch 30/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5709 - accuracy: 0.690
1 - val_loss: 0.6062 - val_accuracy: 0.6536
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5693 - accuracy: 0.691
5 - val_loss: 0.6012 - val_accuracy: 0.6624
Epoch 32/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.5655 - accuracy: 0.694
4 - val_loss: 0.6021 - val_accuracy: 0.6592
Epoch 33/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5629 - accuracy: 0.698
6 - val_loss: 0.6024 - val_accuracy: 0.6645
Epoch 34/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5607 - accuracy: 0.698
3 - val_loss: 0.6010 - val_accuracy: 0.6621
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5579 - accuracy: 0.701
1 - val_loss: 0.5980 - val_accuracy: 0.6650
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5567 - accuracy: 0.702
6 - val_loss: 0.5978 - val_accuracy: 0.6652
Epoch 37/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5550 - accuracy: 0.702
1 - val_loss: 0.5958 - val_accuracy: 0.6653
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5521 - accuracy: 0.704
8 - val_loss: 0.5943 - val_accuracy: 0.6683
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5506 - accuracy: 0.706
3 - val_loss: 0.5925 - val_accuracy: 0.6686
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5488 - accuracy: 0.710
1 - val_loss: 0.5920 - val_accuracy: 0.6700
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5484 - accuracy: 0.708
7 - val_loss: 0.5924 - val_accuracy: 0.6694
Epoch 42/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5465 - accuracy: 0.710
5 - val_loss: 0.5905 - val_accuracy: 0.6726
Epoch 43/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5445 - accuracy: 0.712
9 - val_loss: 0.5913 - val_accuracy: 0.6722
Epoch 44/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5431 - accuracy: 0.714
8 - val_loss: 0.5910 - val_accuracy: 0.6722
Epoch 45/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5407 - accuracy: 0.714
2 - val_loss: 0.5891 - val_accuracy: 0.6748
Epoch 46/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5386 - accuracy: 0.715
9 - val_loss: 0.5890 - val_accuracy: 0.6749
Epoch 47/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5376 - accuracy: 0.716
7 - val_loss: 0.5906 - val_accuracy: 0.6716
Epoch 48/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5359 - accuracy: 0.717
9 - val_loss: 0.5876 - val_accuracy: 0.6740
Epoch 49/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5360 - accuracy: 0.718
0 - val_loss: 0.5874 - val_accuracy: 0.6771
Epoch 50/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5339 - accuracy: 0.721
0 - val_loss: 0.5854 - val_accuracy: 0.6762
Epoch 51/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5339 - accuracy: 0.721
3 - val_loss: 0.5852 - val_accuracy: 0.6798
Epoch 52/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.5305 - accuracy: 0.723
2 - val_loss: 0.5845 - val_accuracy: 0.6778
Epoch 53/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5311 - accuracy: 0.721
7 - val_loss: 0.5841 - val_accuracy: 0.6773
Epoch 54/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5284 - accuracy: 0.724
6 - val_loss: 0.5841 - val_accuracy: 0.6793
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6904 - accuracy: 0.535
9 - val_loss: 0.6829 - val_accuracy: 0.5557
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6832 - accuracy: 0.552
7 - val_loss: 0.6802 - val_accuracy: 0.5612
Epoch 3/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6801 - accuracy: 0.558
1 - val_loss: 0.6780 - val_accuracy: 0.5680
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6761 - accuracy: 0.568
5 - val_loss: 0.6769 - val_accuracy: 0.5719
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6731 - accuracy: 0.576
2 - val_loss: 0.6729 - val_accuracy: 0.5756
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6688 - accuracy: 0.582
5 - val_loss: 0.6691 - val_accuracy: 0.5848
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6643 - accuracy: 0.590
1 - val_loss: 0.6665 - val_accuracy: 0.5907
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6598 - accuracy: 0.596
7 - val_loss: 0.6639 - val_accuracy: 0.5946
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6549 - accuracy: 0.604
3 - val_loss: 0.6595 - val_accuracy: 0.5987
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6506 - accuracy: 0.611
1 - val_loss: 0.6567 - val_accuracy: 0.6026
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6450 - accuracy: 0.617
5 - val_loss: 0.6537 - val_accuracy: 0.6066
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6403 - accuracy: 0.624
5 - val_loss: 0.6508 - val_accuracy: 0.6103
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6357 - accuracy: 0.628
0 - val_loss: 0.6462 - val_accuracy: 0.6191
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6300 - accuracy: 0.634
5 - val_loss: 0.6452 - val_accuracy: 0.6189
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6268 - accuracy: 0.637
8 - val_loss: 0.6410 - val_accuracy: 0.6217
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6207 - accuracy: 0.646
1 - val_loss: 0.6351 - val_accuracy: 0.6296
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6161 - accuracy: 0.650
8 - val_loss: 0.6356 - val_accuracy: 0.6272
Epoch 18/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.6109 - accuracy: 0.654
3 - val_loss: 0.6322 - val_accuracy: 0.6336
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6083 - accuracy: 0.655
9 - val_loss: 0.6303 - val_accuracy: 0.6347
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6029 - accuracy: 0.663
3 - val_loss: 0.6289 - val_accuracy: 0.6369
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5994 - accuracy: 0.666
3 - val_loss: 0.6251 - val_accuracy: 0.6392
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5970 - accuracy: 0.666
1 - val_loss: 0.6251 - val_accuracy: 0.6409
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5928 - accuracy: 0.672
1 - val_loss: 0.6211 - val_accuracy: 0.6445
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5880 - accuracy: 0.675
3 - val_loss: 0.6194 - val_accuracy: 0.6441
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5850 - accuracy: 0.678
0 - val_loss: 0.6182 - val_accuracy: 0.6492
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5829 - accuracy: 0.680
3 - val_loss: 0.6182 - val_accuracy: 0.6475
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5807 - accuracy: 0.681
2 - val_loss: 0.6150 - val_accuracy: 0.6542
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5762 - accuracy: 0.685
5 - val_loss: 0.6115 - val_accuracy: 0.6575
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5743 - accuracy: 0.687
6 - val_loss: 0.6111 - val_accuracy: 0.6560
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5695 - accuracy: 0.692
9 - val_loss: 0.6100 - val_accuracy: 0.6603
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5684 - accuracy: 0.692
8 - val_loss: 0.6104 - val_accuracy: 0.6581
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5657 - accuracy: 0.694
6 - val_loss: 0.6063 - val_accuracy: 0.6631
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5637 - accuracy: 0.695
9 - val_loss: 0.6026 - val_accuracy: 0.6672
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5599 - accuracy: 0.699
2 - val_loss: 0.6035 - val_accuracy: 0.6632
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5584 - accuracy: 0.701
5 - val_loss: 0.6035 - val_accuracy: 0.6654
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5578 - accuracy: 0.704
1 - val_loss: 0.6008 - val_accuracy: 0.6697
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5563 - accuracy: 0.703
1 - val_loss: 0.6026 - val_accuracy: 0.6672
Epoch 38/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.5502 - accuracy: 0.709
7 - val_loss: 0.6006 - val_accuracy: 0.6690
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5505 - accuracy: 0.706
1 - val_loss: 0.6004 - val_accuracy: 0.6676
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6897 - accuracy: 0.538
0 - val_loss: 0.6838 - val_accuracy: 0.5508
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6839 - accuracy: 0.552
4 - val_loss: 0.6818 - val_accuracy: 0.5564
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6809 - accuracy: 0.557
8 - val_loss: 0.6777 - val_accuracy: 0.5625
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6770 - accuracy: 0.569
4 - val_loss: 0.6757 - val_accuracy: 0.5722
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6733 - accuracy: 0.575
8 - val_loss: 0.6723 - val_accuracy: 0.5746
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6695 - accuracy: 0.582
3 - val_loss: 0.6697 - val_accuracy: 0.5804
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6649 - accuracy: 0.589
4 - val_loss: 0.6661 - val_accuracy: 0.5866
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6609 - accuracy: 0.597
4 - val_loss: 0.6630 - val_accuracy: 0.5940
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6556 - accuracy: 0.604
3 - val_loss: 0.6597 - val_accuracy: 0.5988
Epoch 10/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6512 - accuracy: 0.608
6 - val_loss: 0.6552 - val_accuracy: 0.6021
Epoch 11/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6465 - accuracy: 0.616
2 - val_loss: 0.6522 - val_accuracy: 0.6078
Epoch 12/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6413 - accuracy: 0.622
4 - val_loss: 0.6466 - val_accuracy: 0.6160
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6361 - accuracy: 0.627
4 - val_loss: 0.6450 - val_accuracy: 0.6141
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6322 - accuracy: 0.632
8 - val_loss: 0.6404 - val_accuracy: 0.6196
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6257 - accuracy: 0.639
5 - val_loss: 0.6360 - val_accuracy: 0.6261
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6223 - accuracy: 0.643
0 - val_loss: 0.6332 - val_accuracy: 0.6270
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6171 - accuracy: 0.647
2 - val_loss: 0.6315 - val_accuracy: 0.6303
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6121 - accuracy: 0.654
0 - val_loss: 0.6292 - val_accuracy: 0.6341
Epoch 19/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.6084 - accuracy: 0.657
1 - val_loss: 0.6250 - val_accuracy: 0.6384
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6044 - accuracy: 0.659
6 - val_loss: 0.6235 - val_accuracy: 0.6390
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6004 - accuracy: 0.664
4 - val_loss: 0.6191 - val_accuracy: 0.6450
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5967 - accuracy: 0.667
0 - val_loss: 0.6175 - val_accuracy: 0.6437
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5939 - accuracy: 0.670
0 - val_loss: 0.6161 - val_accuracy: 0.6513
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5913 - accuracy: 0.671
3 - val_loss: 0.6139 - val_accuracy: 0.6473
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5852 - accuracy: 0.678
8 - val_loss: 0.6120 - val_accuracy: 0.6504
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5849 - accuracy: 0.678
7 - val_loss: 0.6103 - val_accuracy: 0.6574
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5822 - accuracy: 0.681
3 - val_loss: 0.6093 - val_accuracy: 0.6553
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5793 - accuracy: 0.684
2 - val_loss: 0.6094 - val_accuracy: 0.6547
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5770 - accuracy: 0.685
3 - val_loss: 0.6057 - val_accuracy: 0.6582
Epoch 30/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5744 - accuracy: 0.688
4 - val_loss: 0.6030 - val_accuracy: 0.6595
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5713 - accuracy: 0.690
5 - val_loss: 0.6046 - val_accuracy: 0.6573
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5679 - accuracy: 0.691
6 - val_loss: 0.6020 - val_accuracy: 0.6615
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5662 - accuracy: 0.694
9 - val_loss: 0.5995 - val_accuracy: 0.6627
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5631 - accuracy: 0.697
6 - val_loss: 0.6003 - val_accuracy: 0.6631
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5617 - accuracy: 0.697
1 - val_loss: 0.5993 - val_accuracy: 0.6643
Epoch 36/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5593 - accuracy: 0.700
1 - val_loss: 0.5979 - val_accuracy: 0.6650
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5566 - accuracy: 0.702
7 - val_loss: 0.5967 - val_accuracy: 0.6653
Epoch 38/100
200/200 [==============================] - 1s 3ms/step - loss: 0.5550 - accuracy: 0.703
4 - val_loss: 0.5981 - val_accuracy: 0.6675
Epoch 39/100
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200/200 [==============================] - 1s 3ms/step - loss: 0.5514 - accuracy: 0.705
7 - val_loss: 0.5970 - val_accuracy: 0.6643
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5515 - accuracy: 0.706
9 - val_loss: 0.5949 - val_accuracy: 0.6667
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5491 - accuracy: 0.708
7 - val_loss: 0.5942 - val_accuracy: 0.6642
Epoch 1/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6909 - accuracy: 0.534
2 - val_loss: 0.6848 - val_accuracy: 0.5553
Epoch 2/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6832 - accuracy: 0.553
0 - val_loss: 0.6803 - val_accuracy: 0.5634
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6804 - accuracy: 0.559
7 - val_loss: 0.6783 - val_accuracy: 0.5676
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6767 - accuracy: 0.566
6 - val_loss: 0.6764 - val_accuracy: 0.5694
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6728 - accuracy: 0.577
2 - val_loss: 0.6727 - val_accuracy: 0.5782
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6691 - accuracy: 0.581
5 - val_loss: 0.6681 - val_accuracy: 0.5840
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6647 - accuracy: 0.589
7 - val_loss: 0.6666 - val_accuracy: 0.5885
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6598 - accuracy: 0.596
3 - val_loss: 0.6624 - val_accuracy: 0.5932
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6547 - accuracy: 0.603
4 - val_loss: 0.6583 - val_accuracy: 0.5955
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6512 - accuracy: 0.609
6 - val_loss: 0.6542 - val_accuracy: 0.6045
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6455 - accuracy: 0.614
6 - val_loss: 0.6513 - val_accuracy: 0.6110
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6399 - accuracy: 0.623
7 - val_loss: 0.6482 - val_accuracy: 0.6157
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6350 - accuracy: 0.628
1 - val_loss: 0.6463 - val_accuracy: 0.6158
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6293 - accuracy: 0.635
7 - val_loss: 0.6406 - val_accuracy: 0.6195
Epoch 15/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6263 - accuracy: 0.639
4 - val_loss: 0.6385 - val_accuracy: 0.6227
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6213 - accuracy: 0.645
4 - val_loss: 0.6345 - val_accuracy: 0.6290
Epoch 17/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6180 - accuracy: 0.648
7 - val_loss: 0.6337 - val_accuracy: 0.6312
Epoch 18/100
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200/200 [==============================] - 1s 4ms/step - loss: 0.6122 - accuracy: 0.652
5 - val_loss: 0.6289 - val_accuracy: 0.6386
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6065 - accuracy: 0.658
2 - val_loss: 0.6297 - val_accuracy: 0.6361
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6048 - accuracy: 0.658
9 - val_loss: 0.6268 - val_accuracy: 0.6394
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6007 - accuracy: 0.664
4 - val_loss: 0.6237 - val_accuracy: 0.6420
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5975 - accuracy: 0.667
6 - val_loss: 0.6225 - val_accuracy: 0.6430
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5950 - accuracy: 0.668
6 - val_loss: 0.6187 - val_accuracy: 0.6446
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5909 - accuracy: 0.672
7 - val_loss: 0.6172 - val_accuracy: 0.6475
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5875 - accuracy: 0.677
4 - val_loss: 0.6165 - val_accuracy: 0.6479
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5867 - accuracy: 0.675
8 - val_loss: 0.6146 - val_accuracy: 0.6525
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5817 - accuracy: 0.681
8 - val_loss: 0.6122 - val_accuracy: 0.6547
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5787 - accuracy: 0.682
9 - val_loss: 0.6116 - val_accuracy: 0.6539
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5767 - accuracy: 0.685
4 - val_loss: 0.6104 - val_accuracy: 0.6511
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5742 - accuracy: 0.688
1 - val_loss: 0.6074 - val_accuracy: 0.6553
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5726 - accuracy: 0.690
4 - val_loss: 0.6065 - val_accuracy: 0.6555
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5690 - accuracy: 0.693
7 - val_loss: 0.6072 - val_accuracy: 0.6567
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5677 - accuracy: 0.695
7 - val_loss: 0.6079 - val_accuracy: 0.6585
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5649 - accuracy: 0.695
8 - val_loss: 0.6041 - val_accuracy: 0.6581
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5627 - accuracy: 0.698
1 - val_loss: 0.6041 - val_accuracy: 0.6603
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5611 - accuracy: 0.699
3 - val_loss: 0.6027 - val_accuracy: 0.6622
Epoch 37/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5568 - accuracy: 0.701
6 - val_loss: 0.6001 - val_accuracy: 0.6621
Epoch 38/100
```

```
200/200 [==============================] - 1s 4ms/step - loss: 0.5563 - accuracy: 0.702
6 - val_loss: 0.6010 - val_accuracy: 0.6640
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5531 - accuracy: 0.706
1 - val_loss: 0.6014 - val_accuracy: 0.6627
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5507 - accuracy: 0.707
2 - val_loss: 0.6024 - val_accuracy: 0.6635
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5500 - accuracy: 0.708
4 - val_loss: 0.6000 - val_accuracy: 0.6639
Epoch 1/100
200/200 [==============================] - 1s 5ms/step - loss: 0.6909 - accuracy: 0.535
5 - val_loss: 0.6836 - val_accuracy: 0.5513
Epoch 2/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6832 - accuracy: 0.553
9 - val_loss: 0.6813 - val_accuracy: 0.5595
Epoch 3/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6799 - accuracy: 0.561
9 - val_loss: 0.6781 - val_accuracy: 0.5650
Epoch 4/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6765 - accuracy: 0.570
0 - val_loss: 0.6755 - val_accuracy: 0.5670
Epoch 5/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6732 - accuracy: 0.575
2 - val_loss: 0.6724 - val_accuracy: 0.5748
Epoch 6/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6685 - accuracy: 0.582
9 - val_loss: 0.6699 - val_accuracy: 0.5809
Epoch 7/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6650 - accuracy: 0.592
5 - val_loss: 0.6671 - val_accuracy: 0.5873
Epoch 8/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6594 - accuracy: 0.599
2 - val_loss: 0.6649 - val_accuracy: 0.5903
Epoch 9/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6563 - accuracy: 0.603
7 - val_loss: 0.6588 - val_accuracy: 0.5987
Epoch 10/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6494 - accuracy: 0.612
0 - val_loss: 0.6550 - val_accuracy: 0.6037
Epoch 11/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6451 - accuracy: 0.617
3 - val_loss: 0.6517 - val_accuracy: 0.6106
Epoch 12/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6401 - accuracy: 0.623
3 - val_loss: 0.6483 - val_accuracy: 0.6138
Epoch 13/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6348 - accuracy: 0.628
9 - val_loss: 0.6471 - val_accuracy: 0.6141
Epoch 14/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6321 - accuracy: 0.631
1 - val_loss: 0.6420 - val_accuracy: 0.6167
Epoch 15/100
200/200 [==============================] - 1s 3ms/step - loss: 0.6247 - accuracy: 0.639
0 - val_loss: 0.6369 - val_accuracy: 0.6250
Epoch 16/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6211 - accuracy: 0.645
3 - val_loss: 0.6342 - val_accuracy: 0.6266
Epoch 17/100
```

```
200/200 [==============================] - 1s 4ms/step - loss: 0.6169 - accuracy: 0.647
7 - val_loss: 0.6317 - val_accuracy: 0.6311
Epoch 18/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6116 - accuracy: 0.652
0 - val_loss: 0.6320 - val_accuracy: 0.6323
Epoch 19/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6081 - accuracy: 0.656
8 - val_loss: 0.6267 - val_accuracy: 0.6360
Epoch 20/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6050 - accuracy: 0.659
8 - val_loss: 0.6239 - val_accuracy: 0.6409
Epoch 21/100
200/200 [==============================] - 1s 4ms/step - loss: 0.6003 - accuracy: 0.663
2 - val_loss: 0.6233 - val_accuracy: 0.6386
Epoch 22/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5973 - accuracy: 0.667
2 - val_loss: 0.6221 - val_accuracy: 0.6424
Epoch 23/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5943 - accuracy: 0.671
6 - val_loss: 0.6210 - val_accuracy: 0.6406
Epoch 24/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5887 - accuracy: 0.676
6 - val_loss: 0.6187 - val_accuracy: 0.6446
Epoch 25/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5855 - accuracy: 0.679
0 - val_loss: 0.6151 - val_accuracy: 0.6494
Epoch 26/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5821 - accuracy: 0.680
5 - val_loss: 0.6137 - val_accuracy: 0.6519
Epoch 27/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5803 - accuracy: 0.682
0 - val_loss: 0.6125 - val_accuracy: 0.6494
Epoch 28/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5788 - accuracy: 0.683
7 - val_loss: 0.6094 - val_accuracy: 0.6549
Epoch 29/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5765 - accuracy: 0.684
4 - val_loss: 0.6097 - val_accuracy: 0.6548
Epoch 30/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5692 - accuracy: 0.692
5 - val_loss: 0.6088 - val_accuracy: 0.6530
Epoch 31/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5686 - accuracy: 0.691
6 - val_loss: 0.6062 - val_accuracy: 0.6551
Epoch 32/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5652 - accuracy: 0.695
4 - val_loss: 0.6033 - val_accuracy: 0.6613
Epoch 33/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5641 - accuracy: 0.695
3 - val_loss: 0.6040 - val_accuracy: 0.6605
Epoch 34/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5626 - accuracy: 0.697
8 - val_loss: 0.6019 - val_accuracy: 0.6620
Epoch 35/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5589 - accuracy: 0.698
8 - val_loss: 0.6008 - val_accuracy: 0.6643
Epoch 36/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5571 - accuracy: 0.702
8 - val_loss: 0.6003 - val_accuracy: 0.6653
Epoch 37/100
```

```
200/200 [==============================] - 1s 4ms/step - loss: 0.5549 - accuracy: 0.703
3 - val_loss: 0.5996 - val_accuracy: 0.6667
Epoch 38/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5526 - accuracy: 0.705
3 - val_loss: 0.5988 - val_accuracy: 0.6667
Epoch 39/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5500 - accuracy: 0.707
6 - val_loss: 0.5995 - val_accuracy: 0.6650
Epoch 40/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5510 - accuracy: 0.707
0 - val_loss: 0.5967 - val_accuracy: 0.6701
Epoch 41/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5468 - accuracy: 0.710
1 - val_loss: 0.5977 - val_accuracy: 0.6656
Epoch 42/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5466 - accuracy: 0.708
8 - val_loss: 0.5956 - val_accuracy: 0.6703
Epoch 43/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5426 - accuracy: 0.713
5 - val_loss: 0.5960 - val_accuracy: 0.6695
Epoch 44/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5429 - accuracy: 0.714
0 - val_loss: 0.5964 - val_accuracy: 0.6688
Epoch 45/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5409 - accuracy: 0.714
9 - val_loss: 0.5950 - val_accuracy: 0.6726
Epoch 46/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5391 - accuracy: 0.716
8 - val_loss: 0.5929 - val_accuracy: 0.6714
Epoch 47/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5363 - accuracy: 0.717
8 - val_loss: 0.5918 - val_accuracy: 0.6743
Epoch 48/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5357 - accuracy: 0.718
9 - val_loss: 0.5938 - val_accuracy: 0.6735
Epoch 49/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5351 - accuracy: 0.719
5 - val_loss: 0.5907 - val_accuracy: 0.6738
Epoch 50/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5331 - accuracy: 0.720
5 - val_loss: 0.5915 - val_accuracy: 0.6753
Epoch 51/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5329 - accuracy: 0.720
8 - val_loss: 0.5911 - val_accuracy: 0.6774
Epoch 52/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5308 - accuracy: 0.723
7 - val_loss: 0.5913 - val_accuracy: 0.6727
Epoch 53/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5291 - accuracy: 0.724
5 - val_loss: 0.5892 - val_accuracy: 0.6756
Epoch 54/100
200/200 [==============================] - 1s 4ms/step - loss: 0.5294 - accuracy: 0.724
5 - val_loss: 0.5910 - val_accuracy: 0.6767
model_neurons_256* mean accuracy = 0.67034 *
```

Question 3A

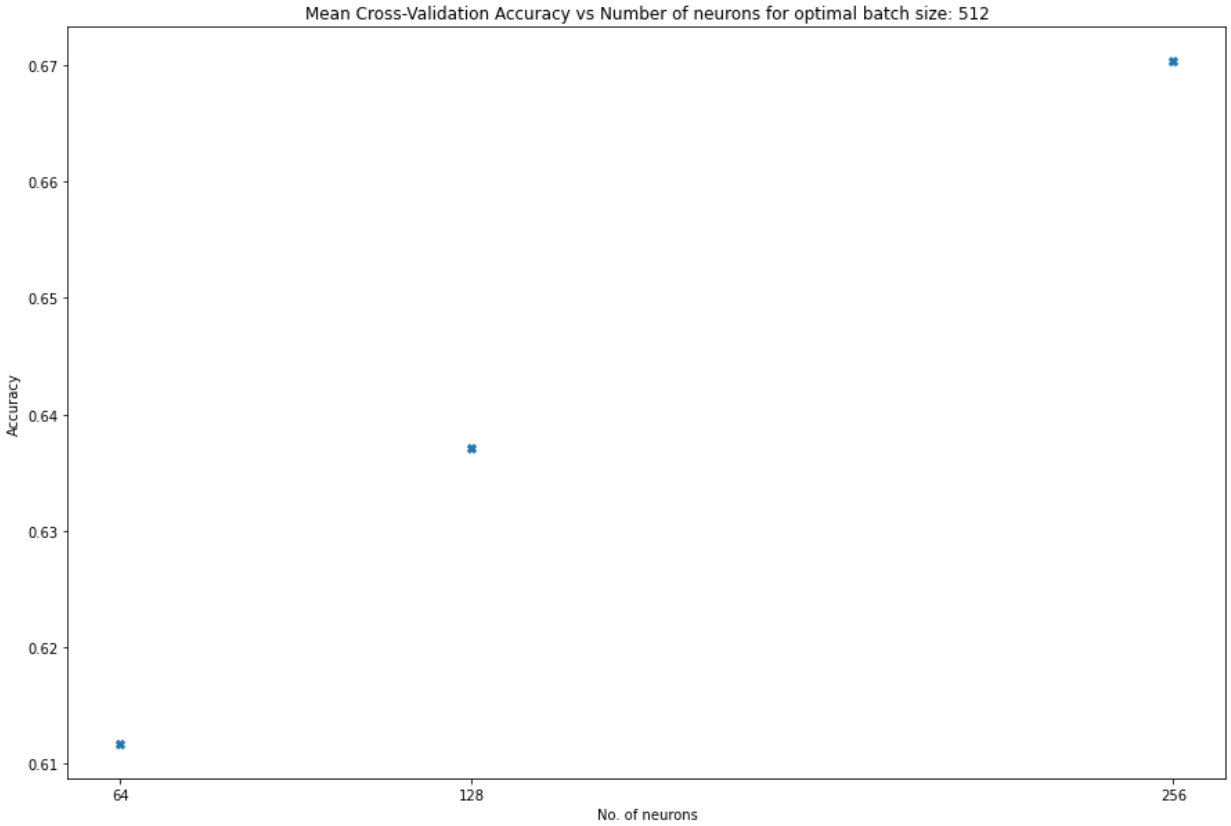
Mean cross-validation accuracies on the final epoch for different numbers of

hidden-layer neurons

In [ ]:
```
Q3_mean_val_acc = []
for key, value in Q3_model_acc.items():
    Q3_mean_val_acc.append(np.mean(value))

Q3_mean_val_loss = []
for key, value in Q3_model_loss.items():
    Q3_mean_val_loss.append(np.mean(value))

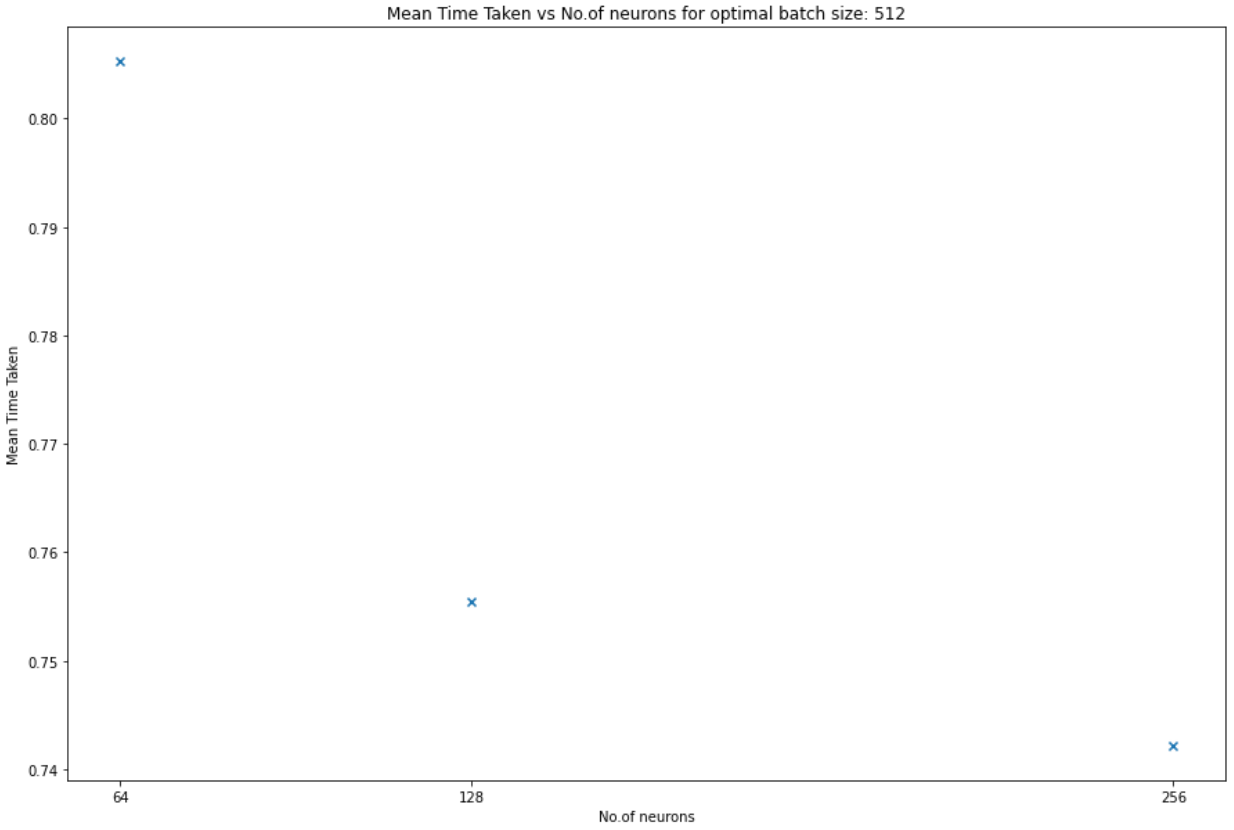
plt_1 = plt.figure(figsize=(15, 10))
plt.scatter(num_neurons_list, Q3_mean_val_acc, marker = 'X')
plt.title('Mean Cross-Validation Accuracy vs Number of neurons for optimal batch size: 
plt.ylabel('Accuracy')
plt.xlabel('No. of neurons')
plt.xticks(num_neurons_list)
plt.show()
```



In [ ]:
```
Q3_mean_time_taken = []
for key, value in Q3_time_taken_dict.items():
    Q3_mean_time_taken.append(np.mean(value))
```

Mean Time Taken on the final epoch for different numbers of hidden-layer neurons

In [ ]:
```
plt_1 = plt.figure(figsize=(15, 10))
plt.scatter(num_neurons_list, Q3_mean_time_taken, marker = 'x')
plt.title('Mean Time Taken vs No.of neurons for optimal batch size: {}'.format(optimal_
plt.ylabel('Mean Time Taken')
plt.xlabel('No.of neurons')
plt.xticks(num_neurons_list)
plt.show()
```



Question 3B

Select the optimal number of neurons for the hidden layer

In [ ]:
```
table_df = pd.DataFrame.from_dict(Q3_model_acc,orient='index', columns=["fold_0", "fold_
table_dict = {
              "Mean Val Acc": Q3_mean_val_acc,
              "Mean Val Loss": Q3_mean_val_loss,
              "Mean Time Taken": Q3_mean_time_taken,
              "Model Neurons list": model_neurons_list,
              "Number of neurons": num_neurons_list}
data_df = pd.DataFrame.from_dict(table_dict)

table_df.reset_index(drop=True, inplace=True)
data_df.reset_index(drop=True, inplace=True)

table_df = pd.concat([table_df, data_df], axis=1)
table_df.set_index('Number of neurons', inplace = True)
table_df
```

Out[ ]:

Number of neurons	fold_0	fold_1	fold_2	fold_3	fold_4	Mean Val Acc	Mean Val Loss	Mean Time Taken	Model Neurons lis
64	0.610832	0.615535	0.618225	0.597061	0.616853	0.611701	0.649358	0.805312	model_neurons_6
128	0.652179	0.626548	0.631903	0.636175	0.638918	0.637145	0.625384	0.755477	model_neurons_12
256	0.679299	0.667620	0.664237	0.663884	0.676661	0.670340	0.593939	0.742146	model_neurons_25

In [ ]:
```
optimal_no_neurons = int(table_df['Mean Val Acc'].idxmax())

data = {"Optimal Batch": [optimal_batch_size], "Optimal No.of neurons": [optimal_no_neu

data_df = pd.DataFrame.from_dict(data)
data_df
```

Out[ ]:

	Optimal Batch	Optimal No.of neurons
0	512	256

The selected optimal number of neurons in the hidden layer is 256. The rationale is that it yields the highest mean validation accuracy. It is possible that with the increase in number of neurons in the hidden layer, it allows the train model to be more adaptive and higher capacity to learn.

In terms of time taken, when there is a increase number of neurons and the mean time taken for the final epoch does not change significantly nor any obvious relationship was observed thus time taken was not taken into consideration.

Question 3C

Train & Test accuracies against training epochs with the optimal number of neurons for different folds

In [ ]:
```
plt_1 = plt.figure(figsize=(15, 10))
fold = 0
optimal_neuron_model = str(table_df.loc[optimal_no_neurons, "Model Neurons list"])

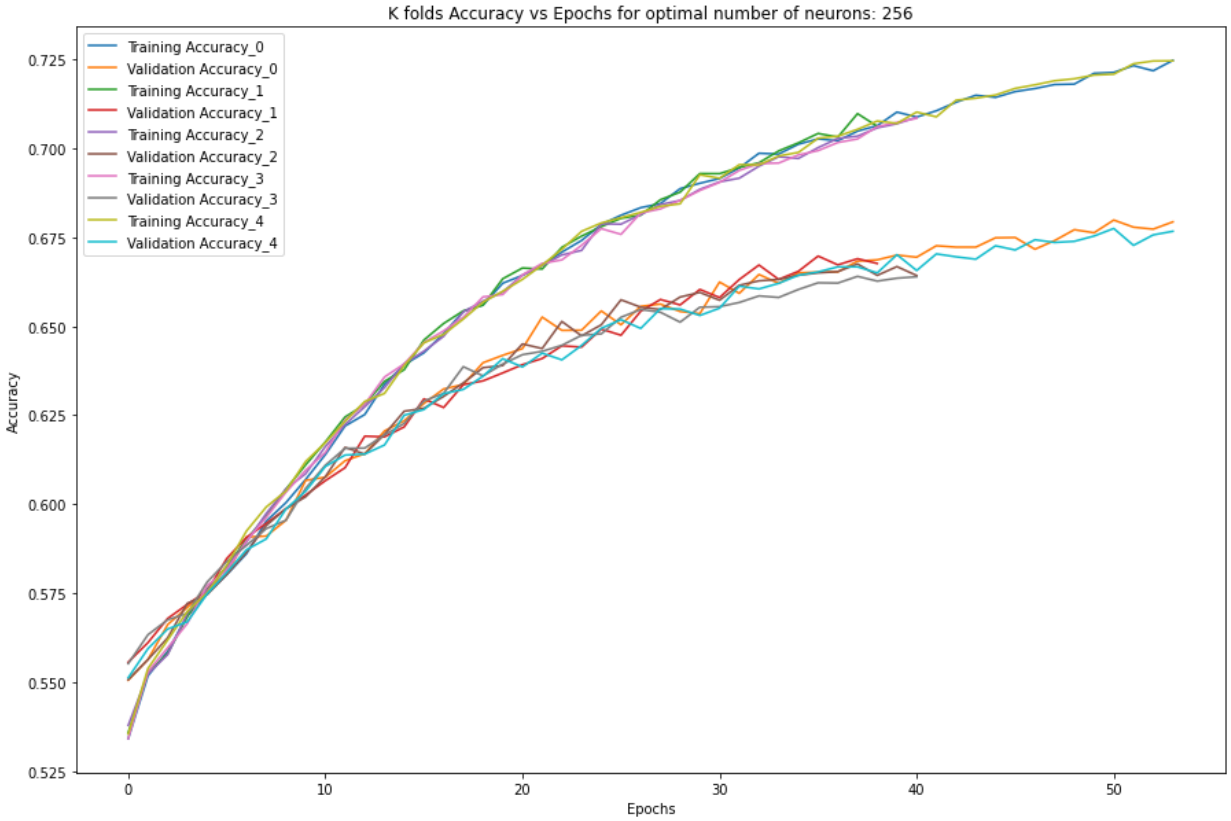
Q3_legend_list = []

while(fold<no_folds):

    plt.plot(Q3_history[optimal_neuron_model + model_fold[fold]].history["accuracy"])
    Q3_legend_list.append("Training Accuracy" + model_fold[fold])

    plt.plot(Q3_history[optimal_neuron_model + model_fold[fold]].history["val_accuracy"
    Q3_legend_list.append("Validation Accuracy" + model_fold[fold])
    fold+=1
```

```
plt.legend(Q3_legend_list)
plt.title('K folds Accuracy vs Epochs for optimal number of neurons: ' + str(optimal_no
plt.ylabel('Accuracy')
plt.xlabel('Epochs')
plt.show()
```



Training of model with optimal batch size and optimal number of neurons

In [ ]:
```
Q3C_model = Sequential([Dense(optimal_no_neurons, activation='relu'),
                Dropout(0.2), Dense(128, activation ='relu'),
                Dropout(0.2), Dense(128, activation='relu'),
                Dropout(0.2), Dense(1, activation='sigmoid')])

Q3C_model.compile(optimizer='adam',
            loss='binary_crossentropy',
            metrics=['accuracy'])

Q3C_cb = TimingCallback()

Q3C_history = {}
Q3C_history["Q3C_model"] = Q3C_model.fit(X_train_scaled, y_train,
                batch_size = optimal_batch_size,
                epochs=no_epochs,
                verbose=1,
                use_multiprocessing=True,
                validation_data=(X_test_scaled, y_test), callbacks=[callback,  Q3C_cb])
```

```
Epoch 1/100
250/250 [==============================] - 2s 5ms/step - loss: 0.6902 - accuracy: 0.538
1 - val_loss: 0.6846 - val_accuracy: 0.5493
Epoch 2/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6830 - accuracy: 0.555
9 - val_loss: 0.6809 - val_accuracy: 0.5575
Epoch 3/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6790 - accuracy: 0.564
0 - val_loss: 0.6799 - val_accuracy: 0.5618
Epoch 4/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6753 - accuracy: 0.571
1 - val_loss: 0.6744 - val_accuracy: 0.5709
Epoch 5/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6721 - accuracy: 0.576
1 - val_loss: 0.6711 - val_accuracy: 0.5765
Epoch 6/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6676 - accuracy: 0.584
3 - val_loss: 0.6683 - val_accuracy: 0.5818
Epoch 7/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6626 - accuracy: 0.593
6 - val_loss: 0.6619 - val_accuracy: 0.5898
Epoch 8/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6570 - accuracy: 0.599
5 - val_loss: 0.6572 - val_accuracy: 0.5975
Epoch 9/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6517 - accuracy: 0.608
8 - val_loss: 0.6546 - val_accuracy: 0.6042
Epoch 10/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6472 - accuracy: 0.613
5 - val_loss: 0.6501 - val_accuracy: 0.6098
Epoch 11/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6407 - accuracy: 0.622
1 - val_loss: 0.6459 - val_accuracy: 0.6151
Epoch 12/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6355 - accuracy: 0.627
1 - val_loss: 0.6408 - val_accuracy: 0.6164
Epoch 13/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6309 - accuracy: 0.632
6 - val_loss: 0.6367 - val_accuracy: 0.6220
Epoch 14/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6256 - accuracy: 0.638
4 - val_loss: 0.6309 - val_accuracy: 0.6312
Epoch 15/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6205 - accuracy: 0.642
7 - val_loss: 0.6291 - val_accuracy: 0.6356
Epoch 16/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6163 - accuracy: 0.648
9 - val_loss: 0.6254 - val_accuracy: 0.6367
Epoch 17/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6134 - accuracy: 0.650
0 - val_loss: 0.6229 - val_accuracy: 0.6426
Epoch 18/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6082 - accuracy: 0.655
8 - val_loss: 0.6197 - val_accuracy: 0.6414
Epoch 19/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6048 - accuracy: 0.659
5 - val_loss: 0.6164 - val_accuracy: 0.6449
Epoch 20/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6005 - accuracy: 0.661
8 - val_loss: 0.6163 - val_accuracy: 0.6494
```

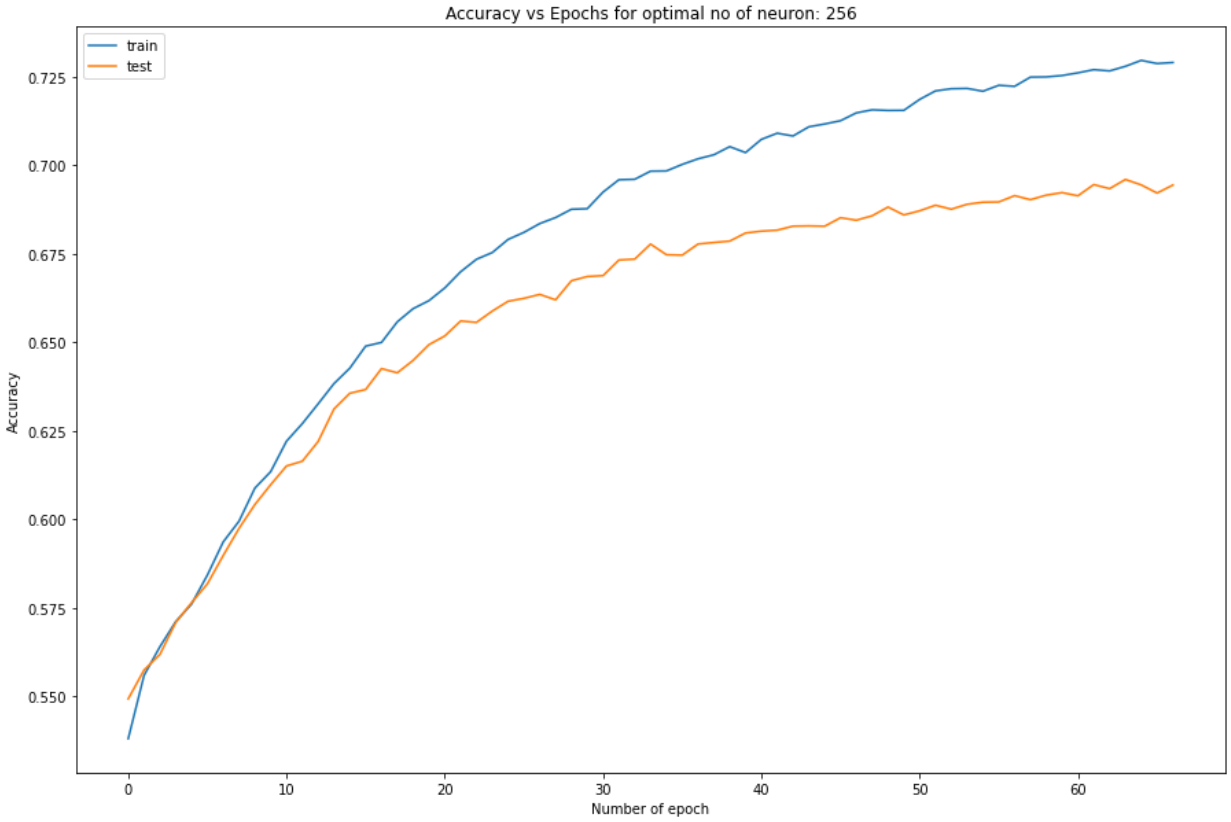
```
Epoch 21/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5970 - accuracy: 0.665
4 - val_loss: 0.6117 - val_accuracy: 0.6518
Epoch 22/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5948 - accuracy: 0.669
9 - val_loss: 0.6081 - val_accuracy: 0.6560
Epoch 23/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5905 - accuracy: 0.673
5 - val_loss: 0.6059 - val_accuracy: 0.6557
Epoch 24/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5867 - accuracy: 0.675
4 - val_loss: 0.6047 - val_accuracy: 0.6588
Epoch 25/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5835 - accuracy: 0.679
1 - val_loss: 0.6014 - val_accuracy: 0.6616
Epoch 26/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5818 - accuracy: 0.681
1 - val_loss: 0.6011 - val_accuracy: 0.6624
Epoch 27/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5780 - accuracy: 0.683
6 - val_loss: 0.5989 - val_accuracy: 0.6636
Epoch 28/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5768 - accuracy: 0.685
3 - val_loss: 0.5987 - val_accuracy: 0.6620
Epoch 29/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5726 - accuracy: 0.687
6 - val_loss: 0.5951 - val_accuracy: 0.6674
Epoch 30/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5730 - accuracy: 0.687
8 - val_loss: 0.5942 - val_accuracy: 0.6686
Epoch 31/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5690 - accuracy: 0.692
5 - val_loss: 0.5927 - val_accuracy: 0.6689
Epoch 32/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5657 - accuracy: 0.695
9 - val_loss: 0.5905 - val_accuracy: 0.6733
Epoch 33/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5646 - accuracy: 0.696
1 - val_loss: 0.5897 - val_accuracy: 0.6735
Epoch 34/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5616 - accuracy: 0.698
4 - val_loss: 0.5874 - val_accuracy: 0.6778
Epoch 35/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5615 - accuracy: 0.698
4 - val_loss: 0.5862 - val_accuracy: 0.6748
Epoch 36/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5591 - accuracy: 0.700
3 - val_loss: 0.5864 - val_accuracy: 0.6746
Epoch 37/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5571 - accuracy: 0.701
9 - val_loss: 0.5837 - val_accuracy: 0.6778
Epoch 38/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5554 - accuracy: 0.703
0 - val_loss: 0.5848 - val_accuracy: 0.6782
Epoch 39/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5530 - accuracy: 0.705
3 - val_loss: 0.5826 - val_accuracy: 0.6786
Epoch 40/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5522 - accuracy: 0.703
6 - val_loss: 0.5824 - val_accuracy: 0.6809
```

```
Epoch 41/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5504 - accuracy: 0.707
3 - val_loss: 0.5799 - val_accuracy: 0.6814
Epoch 42/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5490 - accuracy: 0.709
1 - val_loss: 0.5814 - val_accuracy: 0.6817
Epoch 43/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5475 - accuracy: 0.708
3 - val_loss: 0.5788 - val_accuracy: 0.6828
Epoch 44/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5456 - accuracy: 0.710
9 - val_loss: 0.5779 - val_accuracy: 0.6829
Epoch 45/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5443 - accuracy: 0.711
7 - val_loss: 0.5775 - val_accuracy: 0.6828
Epoch 46/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5437 - accuracy: 0.712
6 - val_loss: 0.5769 - val_accuracy: 0.6852
Epoch 47/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5408 - accuracy: 0.714
8 - val_loss: 0.5765 - val_accuracy: 0.6845
Epoch 48/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5400 - accuracy: 0.715
7 - val_loss: 0.5762 - val_accuracy: 0.6858
Epoch 49/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5389 - accuracy: 0.715
5 - val_loss: 0.5746 - val_accuracy: 0.6882
Epoch 50/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5397 - accuracy: 0.715
5 - val_loss: 0.5734 - val_accuracy: 0.6860
Epoch 51/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5365 - accuracy: 0.718
6 - val_loss: 0.5746 - val_accuracy: 0.6872
Epoch 52/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5345 - accuracy: 0.721
0 - val_loss: 0.5728 - val_accuracy: 0.6887
Epoch 53/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5336 - accuracy: 0.721
6 - val_loss: 0.5716 - val_accuracy: 0.6876
Epoch 54/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5321 - accuracy: 0.721
7 - val_loss: 0.5724 - val_accuracy: 0.6890
Epoch 55/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5325 - accuracy: 0.720
9 - val_loss: 0.5701 - val_accuracy: 0.6896
Epoch 56/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5319 - accuracy: 0.722
6 - val_loss: 0.5705 - val_accuracy: 0.6897
Epoch 57/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5304 - accuracy: 0.722
3 - val_loss: 0.5699 - val_accuracy: 0.6914
Epoch 58/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5277 - accuracy: 0.724
9 - val_loss: 0.5704 - val_accuracy: 0.6903
Epoch 59/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5275 - accuracy: 0.725
0 - val_loss: 0.5688 - val_accuracy: 0.6916
Epoch 60/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5265 - accuracy: 0.725
4 - val_loss: 0.5675 - val_accuracy: 0.6923
```

```
Epoch 61/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5268 - accuracy: 0.726
1 - val_loss: 0.5685 - val_accuracy: 0.6914
Epoch 62/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5247 - accuracy: 0.727
0 - val_loss: 0.5663 - val_accuracy: 0.6946
Epoch 63/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5243 - accuracy: 0.726
7 - val_loss: 0.5668 - val_accuracy: 0.6934
Epoch 64/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5242 - accuracy: 0.728
0 - val_loss: 0.5649 - val_accuracy: 0.6960
Epoch 65/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5216 - accuracy: 0.729
7 - val_loss: 0.5648 - val_accuracy: 0.6945
Epoch 66/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5218 - accuracy: 0.728
8 - val_loss: 0.5660 - val_accuracy: 0.6922
Epoch 67/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5215 - accuracy: 0.729
0 - val_loss: 0.5647 - val_accuracy: 0.6944
```

Train & Test accuracy against training epochs with the optimal number of neurons

In [ ]:
```
plt_1 = plt.figure(figsize=(15, 10))
plt.plot(Q3C_history['Q3C_model'].history['accuracy'])
plt.plot(Q3C_history['Q3C_model'].history['val_accuracy'])
plt.title('Accuracy vs Epochs for optimal no of neuron: ' + str(optimal_no_neurons))
plt.ylabel('Accuracy')
plt.xlabel('Number of epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```



Question 3D

How does dropout works, and what is the purpose of dropouts?

Dropout is a technique where randomly selected neurons are ignored during training to avoid overfitting. The neurons are presented with a probability p and presented to the next layer with weight W to the next layer at the training time. At test time, the weights are always present and presented to the network with weights multipled by probability p (dropout rate = 0.2). The output at the test time is same as the expected output at the training time

Dropout prevents all neurons in a layer from syncrhonously optimizing their weights. It prevents all the neurons from converging to the same goal, thus decorrelating the weights. As such, it removes the simple dependencies between the neurons and increases the robustness of the model.

Question 3E

Besides early stopping and dropout, what is another approach that you could take to address overfitting in the model, and how does it work? Implement the approach

Weight regularization. Weight regularization ensures that the weights of the network as large network weights indicates that the model is overfitting. The learning algorithm would encourage the network towards using small weights by penalizing the model with a larger loss score.

Through experimenting with the values, L2 = 0.000001 yields a higher val accuracy score.

I have used the model with the implementation of weight regularizations for the entirety of Question 4.

In [ ]:
```
# Implementation of weight regularization with optimal batch size and number of neurons
from tensorflow.keras import regularizers

optimized_model = Sequential([Dense(optimal_no_neurons, activation='relu', kernel_regula
                        Dropout(0.2), Dense(128, activation ='relu', kernel_regularizer
                        Dropout(0.2), Dense(128, activation='relu', kernel_regularizer =
                        Dropout(0.2), Dense(1, activation='sigmoid')])

# Default values for l1 and l2 are 0.01

optimized_model.compile(optimizer='adam',
                    loss='binary_crossentropy',
                    metrics=['accuracy'])

history = {}
history['optimized_model'] = optimized_model.fit(X_train_scaled, y_train,
```

```
                                epochs = no_epochs, verbose = 1,
                                batch_size = optimal_batch_size, validation_data = (X_test_
```

```
Epoch 1/100
250/250 [==============================] - 2s 5ms/step - loss: 0.6897 - accuracy: 0.537
7 - val_loss: 0.6851 - val_accuracy: 0.5498
Epoch 2/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6828 - accuracy: 0.556
2 - val_loss: 0.6807 - val_accuracy: 0.5591
Epoch 3/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6790 - accuracy: 0.562
2 - val_loss: 0.6801 - val_accuracy: 0.5590
Epoch 4/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6756 - accuracy: 0.571
2 - val_loss: 0.6747 - val_accuracy: 0.5722
Epoch 5/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6715 - accuracy: 0.579
0 - val_loss: 0.6711 - val_accuracy: 0.5798
Epoch 6/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6672 - accuracy: 0.584
7 - val_loss: 0.6678 - val_accuracy: 0.5849
Epoch 7/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6623 - accuracy: 0.594
9 - val_loss: 0.6627 - val_accuracy: 0.5928
Epoch 8/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6574 - accuracy: 0.601
0 - val_loss: 0.6584 - val_accuracy: 0.6003
Epoch 9/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6519 - accuracy: 0.608
5 - val_loss: 0.6542 - val_accuracy: 0.6058
Epoch 10/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6463 - accuracy: 0.616
9 - val_loss: 0.6504 - val_accuracy: 0.6129
Epoch 11/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6421 - accuracy: 0.620
8 - val_loss: 0.6463 - val_accuracy: 0.6191
Epoch 12/100
250/250 [==============================] - 1s 4ms/step - loss: 0.6365 - accuracy: 0.627
4 - val_loss: 0.6413 - val_accuracy: 0.6197
Epoch 13/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6306 - accuracy: 0.633
3 - val_loss: 0.6369 - val_accuracy: 0.6252
Epoch 14/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6259 - accuracy: 0.638
2 - val_loss: 0.6329 - val_accuracy: 0.6306
Epoch 15/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6210 - accuracy: 0.644
2 - val_loss: 0.6291 - val_accuracy: 0.6344
Epoch 16/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6176 - accuracy: 0.647
2 - val_loss: 0.6265 - val_accuracy: 0.6385
Epoch 17/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6107 - accuracy: 0.654
9 - val_loss: 0.6221 - val_accuracy: 0.6433
Epoch 18/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6087 - accuracy: 0.657
1 - val_loss: 0.6170 - val_accuracy: 0.6448
Epoch 19/100
250/250 [==============================] - 1s 5ms/step - loss: 0.6047 - accuracy: 0.661
2 - val_loss: 0.6164 - val_accuracy: 0.6493
Epoch 20/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5995 - accuracy: 0.665
4 - val_loss: 0.6149 - val_accuracy: 0.6516
```

```
Epoch 21/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5973 - accuracy: 0.666
7 - val_loss: 0.6104 - val_accuracy: 0.6555
Epoch 22/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5919 - accuracy: 0.673
5 - val_loss: 0.6093 - val_accuracy: 0.6574
Epoch 23/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5903 - accuracy: 0.674
6 - val_loss: 0.6060 - val_accuracy: 0.6597
Epoch 24/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5864 - accuracy: 0.679
2 - val_loss: 0.6052 - val_accuracy: 0.6608
Epoch 25/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5828 - accuracy: 0.680
4 - val_loss: 0.6019 - val_accuracy: 0.6638
Epoch 26/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5796 - accuracy: 0.680
8 - val_loss: 0.5999 - val_accuracy: 0.6643
Epoch 27/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5785 - accuracy: 0.684
3 - val_loss: 0.6004 - val_accuracy: 0.6623
Epoch 28/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5760 - accuracy: 0.686
7 - val_loss: 0.5984 - val_accuracy: 0.6656
Epoch 29/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5732 - accuracy: 0.689
1 - val_loss: 0.5935 - val_accuracy: 0.6699
Epoch 30/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5697 - accuracy: 0.693
0 - val_loss: 0.5935 - val_accuracy: 0.6715
Epoch 31/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5689 - accuracy: 0.692
6 - val_loss: 0.5931 - val_accuracy: 0.6711
Epoch 32/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5650 - accuracy: 0.697
0 - val_loss: 0.5889 - val_accuracy: 0.6748
Epoch 33/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5632 - accuracy: 0.698
7 - val_loss: 0.5888 - val_accuracy: 0.6736
Epoch 34/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5616 - accuracy: 0.697
8 - val_loss: 0.5906 - val_accuracy: 0.6741
Epoch 35/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5608 - accuracy: 0.698
8 - val_loss: 0.5870 - val_accuracy: 0.6751
Epoch 36/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5580 - accuracy: 0.703
1 - val_loss: 0.5860 - val_accuracy: 0.6762
Epoch 37/100
250/250 [==============================] - 1s 6ms/step - loss: 0.5564 - accuracy: 0.702
1 - val_loss: 0.5836 - val_accuracy: 0.6797
Epoch 38/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5545 - accuracy: 0.705
4 - val_loss: 0.5837 - val_accuracy: 0.6805
Epoch 39/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5534 - accuracy: 0.707
1 - val_loss: 0.5819 - val_accuracy: 0.6814
Epoch 40/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5520 - accuracy: 0.707
7 - val_loss: 0.5833 - val_accuracy: 0.6786
```

```
Epoch 41/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5498 - accuracy: 0.709
5 - val_loss: 0.5807 - val_accuracy: 0.6847
Epoch 42/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5465 - accuracy: 0.712
2 - val_loss: 0.5798 - val_accuracy: 0.6839
Epoch 43/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5475 - accuracy: 0.710
8 - val_loss: 0.5796 - val_accuracy: 0.6845
Epoch 44/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5435 - accuracy: 0.712
7 - val_loss: 0.5794 - val_accuracy: 0.6852
Epoch 45/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5444 - accuracy: 0.712
5 - val_loss: 0.5768 - val_accuracy: 0.6866
Epoch 46/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5421 - accuracy: 0.715
7 - val_loss: 0.5763 - val_accuracy: 0.6868
Epoch 47/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5407 - accuracy: 0.716
5 - val_loss: 0.5762 - val_accuracy: 0.6865
Epoch 48/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5406 - accuracy: 0.715
9 - val_loss: 0.5762 - val_accuracy: 0.6848
Epoch 49/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5375 - accuracy: 0.719
1 - val_loss: 0.5739 - val_accuracy: 0.6892
Epoch 50/100
250/250 [==============================] - 1s 4ms/step - loss: 0.5364 - accuracy: 0.719
6 - val_loss: 0.5724 - val_accuracy: 0.6885
Epoch 51/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5359 - accuracy: 0.719
9 - val_loss: 0.5747 - val_accuracy: 0.6884
Epoch 52/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5353 - accuracy: 0.718
9 - val_loss: 0.5709 - val_accuracy: 0.6900
Epoch 53/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5343 - accuracy: 0.720
7 - val_loss: 0.5731 - val_accuracy: 0.6896
Epoch 54/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5344 - accuracy: 0.721
0 - val_loss: 0.5722 - val_accuracy: 0.6887
Epoch 55/100
250/250 [==============================] - 1s 6ms/step - loss: 0.5313 - accuracy: 0.723
5 - val_loss: 0.5714 - val_accuracy: 0.6931
Epoch 56/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5314 - accuracy: 0.723
3 - val_loss: 0.5707 - val_accuracy: 0.6913
Epoch 57/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5294 - accuracy: 0.724
1 - val_loss: 0.5678 - val_accuracy: 0.6942
Epoch 58/100
250/250 [==============================] - 1s 6ms/step - loss: 0.5282 - accuracy: 0.725
6 - val_loss: 0.5699 - val_accuracy: 0.6913
Epoch 59/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5273 - accuracy: 0.727
1 - val_loss: 0.5687 - val_accuracy: 0.6941
Epoch 60/100
250/250 [==============================] - 1s 5ms/step - loss: 0.5258 - accuracy: 0.727
9 - val_loss: 0.5670 - val_accuracy: 0.6922
```

In [ ]:
```
optimized_model.save('optimized_model/')
```

```
INFO:tensorflow:Assets written to: optimized_model/assets
```

Plot of optimized model train test accuracies against epochs

In [ ]:
```
plt_1 = plt.figure(figsize=(15, 10))
plt.plot(history['optimized_model'].history['accuracy'])
plt.plot(history['optimized_model'].history['val_accuracy'])
plt.title('Optimized model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Number of epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```