Dsc Machine Learning Task

Importing Libraries

```
#import libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import tensorflow as tf
import seaborn as sns
```

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.callbacks import EarlyStopping, LambdaCallback
```

```
from keras.wrappers.scikit_learn import KerasClassifier
from keras.utils import np_utils
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import KFold
from sklearn.preprocessing import LabelEncoder
from sklearn.pipeline import Pipeline
```

```
from sklearn import preprocessing
```

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
from sklearn.metrics import f1_score
from sklearn.metrics import cohen_kappa_score
from sklearn.metrics import roc_auc_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve
```

Loading dataset

```
#store data into a dataframe from csv
dataframe = pd.read_csv('DSC_Task.csv')
dataframe.head()
```

	Unnamed: 0	userId	tier	gender	following_rate	followers_avg_age	following_avg_age	max_repetitive_punc	num_of_hashtags_per_action	emoji_count_per_action	punctuations_per_action	number_of_words_per_action	avgC
0	265153	48958844	2	1	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	
1	405231	51100441	2	2	0.0	0.0	0.0	0	0.0	0.0	0.076923	0.153846	
2	57867	6887426	2	1	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	
3	272618	50742404	2	1	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	
4	251123	45589200	2	2	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	

Exploratory Data Analysis

```
#shape and size of the dataframe
dataframe.shape
```

```
(488877, 27)
```

```
#data type of the features
dataframe.dtypes
```

```
Unnamed: 0                        int64
userId                            int64
tier                              int64
gender                            int64
following_rate                  float64
followers_avg_age               float64
following_avg_age               float64
max_repetitive_punc               int64
num_of_hashtags_per_action      float64
emoji_count_per_action          float64
punctuations_per_action         float64
number_of_words_per_action      float64
avgCompletion                   float64
avgTimeSpent                    float64
avgDuration                     float64
avgComments                       int64
creations                       float64
content_views                   float64
num_of_comments                 float64
weekends_trails_watched_per_day float64
weekdays_trails_watched_per_day float64
slot1_trails_watched_per_day    float64
slot2_trails_watched_per_day    float64
slot3_trails_watched_per_day    float64
slot4_trails_watched_per_day    float64
avgt2                           float64
age_group                         int64
dtype: object
```

```
#statistical inference
dataframe.describe()
```

	Unnamed: 0	userId	tier	gender	following_rate	followers_avg_age	following_avg_age	max_repetitive_punc	num_of_hashtags_per_action	emoji_count_per_action	punctuations_per_action	number_c
count	488877.000000	4.888770e+05	488877.000000	488877.000000	488877.000000	488877.000000	488877.000000	488877.000000	488877.000000	488877.000000	488877.000000	
mean	271605.981815	4.236096e+07	1.975382	1.213037	0.082233	0.347520	0.403049	0.739748	0.000277	0.000981	0.012805	
std	156808.138002	1.821664e+07	0.430707	0.409454	2.467781	0.816334	0.925291	3.075954	0.012221	0.020381	0.159553	
min	0.000000	2.700000e+01	1.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	135779.000000	3.537599e+07	2.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
50%	271560.000000	4.336270e+07	2.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
75%	407431.000000	5.370523e+07	2.000000	1.000000	0.008621	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
max	543196.000000	7.904203e+07	3.000000	2.000000	895.304000	4.000000	4.000000	624.000000	2.333333	3.000000	27.333333	

```
#null values in the dataset
dataframe.isnull().sum()
```

```
following_rate                  0
followers_avg_age               0
following_avg_age               0
max_repetitive_punc             0
num_of_hashtags_per_action      0
emoji_count_per_action          0
punctuations_per_action         0
number_of_words_per_action      0
avgCompletion                   0
avgTimeSpent                    0
avgDuration                     0
avgComments                     0
creations                       0
content_views                   0
num_of_comments                 0
weekends_trails_watched_per_day 0
weekdays_trails_watched_per_day 0
slot1_trails_watched_per_day    0
slot2_trails_watched_per_day    0
slot3_trails_watched_per_day    0
```

```
slot4_trails_watched_per_day       0
avgt2                              0
age_group                          0
dtype: int64
```

```
#name of the features
dataframe.columns
```

```
Index(['Unnamed: 0', 'userId', 'tier', 'gender', 'following_rate',
       'followers_avg_age', 'following_avg_age', 'max_repetitive_punc',
       'num_of_hashtags_per_action', 'emoji_count_per_action',
       'punctuations_per_action', 'number_of_words_per_action',
       'avgCompletion', 'avgTimeSpent', 'avgDuration', 'avgComments',
       'creations', 'content_views', 'num_of_comments',
       'weekends_trails_watched_per_day', 'weekdays_trails_watched_per_day',
       'slot1_trails_watched_per_day', 'slot2_trails_watched_per_day',
       'slot3_trails_watched_per_day', 'slot4_trails_watched_per_day', 'avgt2',
       'age_group'],
      dtype='object')
```

```
#removing redundant features
dataframe = dataframe.drop(['Unnamed: 0', 'userId', 'tier', 'gender'], axis=1)
dataframe.head()
```

	following_rate	followers_avg_age	following_avg_age	max_repetitive_punc	num_of_hashtags_per_action	emoji_count_per_action	punctuations_per_action	number_of_words_per_action	avgCompletion	avgTimeSpent	avgDura
0	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.463330	34.160000	53.99
1	0.0	0.0	0.0	0	0.0	0.0	0.076923	0.153846	0.429468	15.285714	96.23
2	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.341657	22.000000	83.05
3	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.005735	3.000000	523.08
4	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.456549	12.333333	53.76

```
#updated shape
dataframe.shape
```

```
(488877, 23)
```

```
#finding duplicate data
duplicate_rows_df = dataframe[dataframe.duplicated()]
print("number of duplicate rows: ", duplicate_rows_df.shape)
```

```
number of duplicate rows:  (4697, 23)
```

```
dataframe.count()
```

```
following_rate                    488877
followers_avg_age                 488877
following_avg_age                 488877
max_repetitive_punc               488877
num_of_hashtags_per_action        488877
emoji_count_per_action            488877
punctuations_per_action           488877
number_of_words_per_action        488877
avgCompletion                     488877
avgTimeSpent                      488877
avgDuration                       488877
avgComments                       488877
creations                         488877
content_views                     488877
num_of_comments                   488877
weekends_trails_watched_per_day   488877
weekdays_trails_watched_per_day   488877
slot1_trails_watched_per_day      488877
slot2_trails_watched_per_day      488877
slot3_trails_watched_per_day      488877
slot4_trails_watched_per_day      488877
avgt2                             488877
age_group                         488877
dtype: int64
```

```
#removing duplicate data
dataframe = dataframe.drop_duplicates()
dataframe.head(5)
```

	following_rate	followers_avg_age	following_avg_age	max_repetitive_punc	num_of_hashtags_per_action	emoji_count_per_action	punctuations_per_action	number_of_words_per_action	avgCompletion	avgTimeSpent	avgDura
0	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.463330	34.160000	53.99
1	0.0	0.0	0.0	0	0.0	0.0	0.076923	0.153846	0.429468	15.285714	96.23
2	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.341657	22.000000	83.05
3	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.005735	3.000000	523.08
4	0.0	0.0	0.0	0	0.0	0.0	0.000000	0.000000	0.456549	12.333333	53.76

```
#plotting heatmap to estimate correlation
plt.figure(figsize=(20,10))
c= dataframe.corr()
sns.heatmap(c,cmap="BrBG",annot=True)
c
```

following_avg_age	0.060661	0.939531	1.000000	0.164260	0.007321	0.002994	0.012344	0.123634	-0.01
max_repetitive_punc	0.041980	0.171550	0.164260	1.000000	0.013153	0.036527	0.107390	0.113329	0.01
num_of_hashtags_per_action	-0.000274	0.007064	0.007321	0.013153	1.000000	0.082207	0.246667	0.063880	-0.0
emoji_count_per_action	-0.000110	0.002770	0.002994	0.036527	0.082207	1.000000	0.268522	0.091354	0.0
punctuations_per_action	0.000411	0.012022	0.012344	0.107390	0.246667	0.268522	1.000000	0.178515	0.0
number_of_words_per_action	0.013450	0.122155	0.123634	0.113329	0.063880	0.091354	0.178515	1.000000	-0.0
avgCompletion	-0.002220	-0.006192	-0.010080	0.015527	-0.000721	0.006488	0.005640	-0.007281	1.0
avgTimeSpent	-0.000042	0.003223	0.003128	0.001446	-0.000028	-0.000079	-0.000131	0.000408	-0.0
avgDuration	0.002608	0.070717	0.076087	0.012854	0.006733	0.000638	0.011597	0.094934	-0.5
avgComments	0.048708	0.066604	0.063899	0.085125	0.000042	-0.000750	-0.000408	0.084354	-0.0
creations	0.068396	0.096358	0.089151	0.128086	0.000199	-0.000175	0.000381	0.090588	-0.0
content_views	0.068030	0.130748	0.115404	0.103561	-0.007352	-0.015141	-0.025386	-0.052488	0.1
num_of_comments	0.097303	0.091183	0.086155	0.134346	-0.000680	-0.001215	-0.001485	0.105745	0.0
weekends_trails_watched_per_day	0.069358	0.141807	0.128692	0.124273	-0.005134	-0.010463	-0.017807	-0.024688	0.1
weekdays_trails_watched_per_day	0.078690	0.148516	0.132141	0.131502	-0.006094	-0.012807	-0.021284	-0.029912	0.0

```
#finding target classes
pd.unique(dataframe['age_group'])
```

```
array([1, 2, 3, 4])
```

slot4_trails_watched_per_day	0.067468	0.129670	0.116268	0.111418	-0.004853	-0.010428	-0.017244	-0.024039	0.0

```
#excluding target column before normalization
data = dataframe.drop(['age_group'], axis=1)
```

Normalization

```
preprocessed_data = preprocessing.normalize(data)
normalized_dataframe = pd.DataFrame(preprocessed_data)
normalized_dataframe.head()
```

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0	0.0	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	0.007251	0.534614	0.845055	0.0	0.000000	0.003130	0.0	0.000652	0.000391	0.0	0.000000	0.002739	0.000522	0.000000
1	0.0	0.0	0.0	0.0	0.0	0.0	0.000602	0.001205	0.003364	0.119725	0.753729	0.0	0.000066	0.000730	0.0	0.000100	0.000146	0.0	0.000664	0.000000	0.000266	0.646177
2	0.0	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	0.003977	0.256062	0.966652	0.0	0.000000	0.000032	0.0	0.000000	0.000006	0.0	0.000032	0.000000	0.000000	0.000000
3	0.0	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	0.000011	0.005735	0.999984	0.0	0.000000	0.000016	0.0	0.000000	0.000003	0.0	0.000000	0.000000	0.000016	0.000000
4	0.0	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	0.008276	0.223569	0.974639	0.0	0.000000	0.003715	0.0	0.000000	0.000892	0.0	0.000149	0.001040	0.003269	0.000000

Feature Engineering


```
dataset = dataframe.values
```



```
norm_dataset = normalized_dataframe.values
X = norm_dataset[:,0:-1].astype(float)
```



```
Y = dataset[:,-1]
```


Train-Validation-Test Split


```
from sklearn.model_selection import train_test_split

#splitting data into train: test in 80:20 ratio
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.2, random_state=1)
print(X_train.shape)
print(X_test.shape)
print(Y_train.shape)
print(Y_test.shape)
```

```
(387344, 21)
(96836, 21)
(387344,)
(96836,)
```

One Hot Encoding

```
#one hot encoding the training labels
encoder = LabelEncoder()
encoder.fit(Y_train)
encoded_Y = encoder.transform(Y_train)
# convert integers to dummy variables (i.e. one hot encoded)
Y_train = np_utils.to_categorical(encoded_Y)
```

Building Model

```
def get_model():
  #define model
  model = Sequential()
  model.add(Dense(8, input_dim=21, activation='relu'))
  model.add(Dense(32, activation='relu'))
  model.add(Dense(4, activation='softmax'))
  # Compile model
  model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
  return model

model = get_model()
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense (Dense)                (None, 8)                 176       
_________________________________________________________________
dense_1 (Dense)              (None, 32)                288       
_________________________________________________________________
dense_2 (Dense)              (None, 4)                 132       
=================================================================
Total params: 596
Trainable params: 596
Non-trainable params: 0
_________________________________________________________________
```

/

```
#estimator = KerasClassifier(build_fn=get_model, epochs=200, batch_size=5, verbose=0)
```

```
#kfold = KFold(n_splits=10, shuffle=True)
```

```
#results = cross_val_score(estimator, X, dummy_y, cv=kfold)
#print("Baseline: %.2f%% (%.2f%%)" % (results.mean()*100, results.std()*100))
```

Training Model

```
early_stopping = EarlyStopping(monitor='val_loss', patience = 5)

model = get_model()

#Prediction on untrained model for comparision.
preds_on_untrained = model.predict(X_test, verbose=0)

#Fitting the model for given data
history = model.fit(
    X_train, Y_train,
    validation_split = 0.125, #7:1 ratio for train-val split
    epochs = 100,
    callbacks = [early_stopping]
)
```

```
Epoch 1/100
10592/10592 [==============================] - 12s 1ms/step - loss: 0.8216 - accuracy: 0.6296 - val_loss: 0.7498 - val_accuracy: 0.6349
Epoch 2/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7430 - accuracy: 0.6375 - val_loss: 0.7293 - val_accuracy: 0.6474
Epoch 3/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7264 - accuracy: 0.6504 - val_loss: 0.7195 - val_accuracy: 0.6523
Epoch 4/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7145 - accuracy: 0.6582 - val_loss: 0.7123 - val_accuracy: 0.6541
Epoch 5/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7094 - accuracy: 0.6593 - val_loss: 0.7121 - val_accuracy: 0.6607
Epoch 6/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7067 - accuracy: 0.6616 - val_loss: 0.7115 - val_accuracy: 0.6587
Epoch 7/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7049 - accuracy: 0.6615 - val_loss: 0.7110 - val_accuracy: 0.6617
Epoch 8/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7038 - accuracy: 0.6628 - val_loss: 0.7056 - val_accuracy: 0.6636
Epoch 9/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7033 - accuracy: 0.6620 - val_loss: 0.7067 - val_accuracy: 0.6661
Epoch 10/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.7024 - accuracy: 0.6637 - val_loss: 0.7112 - val_accuracy: 0.6632
Epoch 11/100
10592/10592 [==============================] - 12s 1ms/step - loss: 0.7004 - accuracy: 0.6638 - val_loss: 0.7066 - val_accuracy: 0.6619
Epoch 12/100
10592/10592 [==============================] - 12s 1ms/step - loss: 0.7010 - accuracy: 0.6644 - val_loss: 0.7050 - val_accuracy: 0.6666
Epoch 13/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.6974 - accuracy: 0.6650 - val_loss: 0.7059 - val_accuracy: 0.6695
Epoch 14/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.6967 - accuracy: 0.6660 - val_loss: 0.7075 - val_accuracy: 0.6667
Epoch 15/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.6945 - accuracy: 0.6662 - val_loss: 0.7074 - val_accuracy: 0.6667
Epoch 16/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.6976 - accuracy: 0.6661 - val_loss: 0.7074 - val_accuracy: 0.6689
Epoch 17/100
10592/10592 [==============================] - 11s 1ms/step - loss: 0.6938 - accuracy: 0.6676 - val_loss: 0.7064 - val_accuracy: 0.6685
```

Model Evaluation

```
#predicted probabilites
yhat_probs = model.predict(X_test, verbose=0)
```

```
#yhat_classes = model.predict_classes(X_test, verbose=0)
```

```
#predicted classes
yhat = np.argmax(model.predict(X_test), axis=-1)
```

```
Y_test
```

```
array([1., 4., 1., ..., 1., 2., 1.])
```

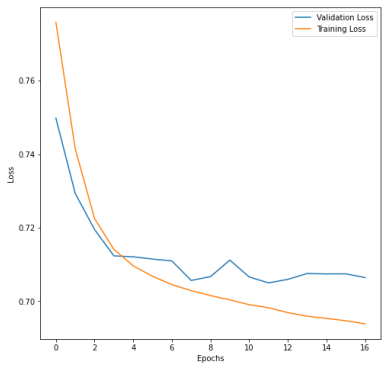
```
for i in range(len(yhat)):
  yhat[i] += 1 #since yhat is in range 0-3
```

```
np.unique(yhat)
```

```
array([1, 2, 3, 4])
```

Training and Val loss - Graph

```
def plot_loss(history):
    h = history.history
    x_lim = len(h['loss'])
    plt.figure(figsize=(8, 8))
    plt.plot(range(x_lim), h['val_loss'], label = 'Validation Loss')
    plt.plot(range(x_lim), h['loss'], label = 'Training Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()
    plt.show()
    return
plot_loss(history)
```



Metrics

```
# accuracy: (tp + tn) / (p + n)
accuracy = accuracy_score(Y_test, yhat)
print('Accuracy: %f' % accuracy)
```

```
Accuracy: 0.668481
```

```
# precision tp / (tp + fp)
precision = precision_score(Y_test, yhat,average='micro')
print('Precision: %f' % precision)
```

```
Precision: 0.668481
```

```
# recall: tp / (tp + fn)
recall = recall_score(Y_test, yhat,average='micro')
print('Recall: %f' % recall)
```

```
Recall: 0.668481
```

```
# f1: 2 tp / (2 tp + fp + fn)
f1 = f1_score(Y_test, yhat,average='micro')
```

```
print('F1 score: %f' % f1)
```

```
F1 score: 0.668481
```

```
auc = roc_auc_score(Y_test, yhat_probs,average='macro',multi_class='ovr')
print('ROC AUC: %f' % auc)
```

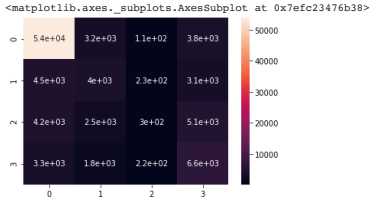
```
ROC AUC: 0.851364
```

```
# confusion matrix
matrix = confusion_matrix(Y_test, yhat)
print(matrix)
```

```
[[53851  3181   110  3803]
 [ 4541  3997   231  3057]
 [ 4225  2511   296  5102]
 [ 3345  1775   222  6589]]
```

```
#Confusion matrix visualization
import seaborn as sns
sns.heatmap(matrix, annot=True)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7efc23476b38>
```



ROC Curve

Double-click (or enter) to edit