DSE3002 - Project 3

May 1, 2023

[ ]:

```
#DSE3002 - Project 3 - Patrick Norcross
```

[ ]:

```
import pandas as pd
import numpy as np
from sklearn.metrics import accuracy_score, confusion_matrix,␣
 ↪ConfusionMatrixDisplay

def AccConMax(y_test, y_pred):
    print(accuracy_score(y_test, y_pred))
    cm = confusion_matrix(y_test, y_pred)
    ConfusionMatrixDisplay(cm, display_labels=['Low','Normal','High']).plot()
```

[ ]:

```
#1 - Importing data from
data18 = pd.read_csv('ATUS18_3.csv')
data19 = pd.read_csv('ATUS19_3.csv')
data21 = pd.read_csv('ATUS21_3.csv')
```

[ ]:

```
#Data set up (all precrossing done in project 2 code)
X_18 = data18.iloc[:,:len(data18.columns)-1].values
y_18 = data18.iloc[:,len(data18.columns)-1:].values

y_18 = y_18.reshape(len(y_18),)
```

[ ]:

```
X_19 = data19.iloc[:,:len(data19.columns)-1].values
y_19 = data19.iloc[:,len(data19.columns)-1:].values

y_19 = y_19.reshape(len(y_19),)
```

[ ]:

```
X_21 = data21.iloc[:,:len(data21.columns)-1].values
y_21 = data21.iloc[:,len(data21.columns)-1:].values

y_21 = y_21.reshape(len(y_21),)
```

PART 1

Question 2

[ ]:

```python
from sklearn.ensemble import BaggingClassifier, AdaBoostClassifier, RandomForestClassifier
from tabulate import tabulate
```

[ ]:

```python
#Bagging

#Lower max features were not performing as well usually in the .50 range for the score.
#Below are some examples of parameters I tested.
scoreBag = 0
list = []
maxs = [.75,.25,.25,.5,.75]
maxf = [.75,.75,1.,1.,1.]
for s, f in zip(maxs,maxf):
    for est in [50,100,200]:
        bagx = BaggingClassifier(n_estimators=est, max_samples= s, max_features= f, oob_score=True, random_state=1)
        bagx.fit(X_18, y_18)
        list.append([s,f,est, bagx.oob_score_])
        if bagx.oob_score_ > scoreBag:
            scoreBag = bagx.oob_score_
            bag = bagx

print(tabulate(list, headers=['sample prop','feature prop','estimators', 'scoreBag']))
print('\nBest Bagging Model:\n', bag)
```

```
  sample prop    feature prop    estimators    scoreBag
-------------  --------------  ------------  ----------
         0.75            0.75            50    0.613579
         0.75            0.75           100    0.616723
         0.75            0.75           200    0.625105
         0.25            0.75            50    0.609388
         0.25            0.75           100    0.617351
         0.25            0.75           200    0.613998
         0.25            1               50    0.627619
         0.25            1              100    0.637678
         0.25            1              200    0.638935
         0.5             1               50    0.633697
         0.5             1              100    0.647318
         0.5             1              200    0.650042
         0.75            1               50    0.633068
         0.75            1              100    0.639355
         0.75            1              200    0.639774

Best Bagging Model:
 BaggingClassifier(max_samples=0.5, n_estimators=200, oob_score=True,
                    random_state=1)
```

[ ]:
```
#Random Forest
import warnings
warnings.filterwarnings('ignore')

scoreRF = 0
list = []
for maxf in ['auto', None]:
    for est in [10,50,100,200]:
        rfx = RandomForestClassifier(n_estimators= est, max_features= maxf,␣
 ↪oob_score=True, random_state=1)
        rfx.fit(X_18, y_18)
        list.append([maxf,est, rfx.oob_score_])
        if rfx.oob_score_ > scoreRF:
            scoreRF = rfx.oob_score_
            rf = rfx

print(tabulate(list, headers=['max feat setting','num of feat', 'score']))
print('\nBest RF Model:\n', rf)
```

```
max feat setting      num of feat     score
------------------  -------------  --------
auto                           10  0.495599
auto                           50  0.595138
auto                          100  0.604359
auto                          200  0.615884
                               10  0.539816
                               50  0.629925
                              100  0.637888
                              200  0.640821

Best RF Model:
 RandomForestClassifier(max_features=None, n_estimators=200, oob_score=True,
                       random_state=1)
```

[ ]:
```
#AdaBoost
scoreBoost = 0
list = []
for est in [50,100,200]:
    for lr in [0.01,0.1,0.5,1,2]:
        boostx = AdaBoostClassifier(n_estimators=est, learning_rate=lr,␣
 ↪random_state=1)
        boostx.fit(X_18, y_18)
        list.append([est, lr, boostx.score(X_18,y_18)])
        if boostx.score(X_18, y_18) > scoreBoost:
            scoreBoost = boostx.score(X_18, y_18)
            boost = boostx
```

```
print(tabulate(list, headers=['estimator','learning rate','score']))
print('\nBest Adaboost Model:\n', boost)
```

```
  estimator    learning rate     score
-----------  ---------------  --------
         50             0.01  0.503982
         50             0.1   0.549874
         50             0.5   0.606873
         50             1     0.651718
         50             2     0.333822
        100             0.01  0.503982
        100             0.1   0.567687
        100             0.5   0.644174
        100             1     0.682733
        100             2     0.333822
        200             0.01  0.503982
        200             0.1   0.593043
        200             0.5   0.667854
        200             1     0.723177
        200             2     0.333822

Best Adaboost Model:
 AdaBoostClassifier(learning_rate=1, n_estimators=200, random_state=1)
```

Question 3

[ ]:

```
print('RF:      ',scoreRF)
print('Bagging:',scoreBag)
print('Boost:   ',scoreBoost)

#Based on the out-of-bag score/score, I would expect the Boosting classifer to predict the best since it is higher than bost bagging and boosting.
#This may be becuause it is using a different scoring method.
```

```
RF:      0.6408214585079631
Bagging: 0.6500419111483655
Boost:   0.7231768650461022
```

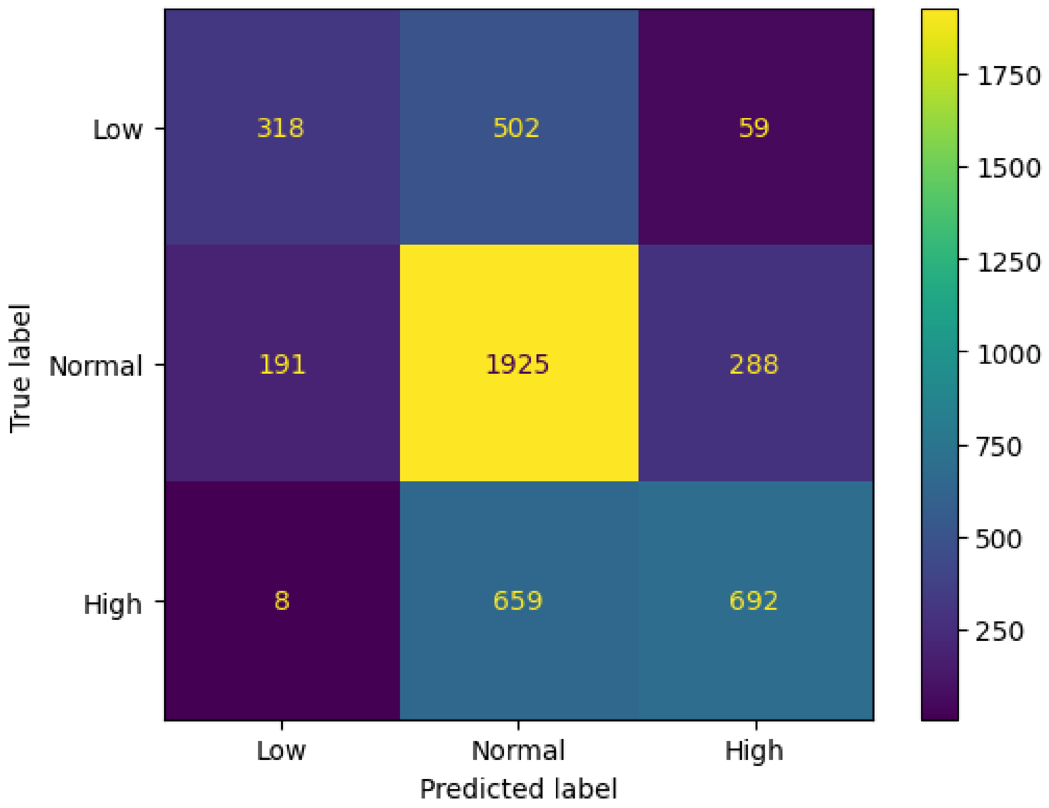
Question 4

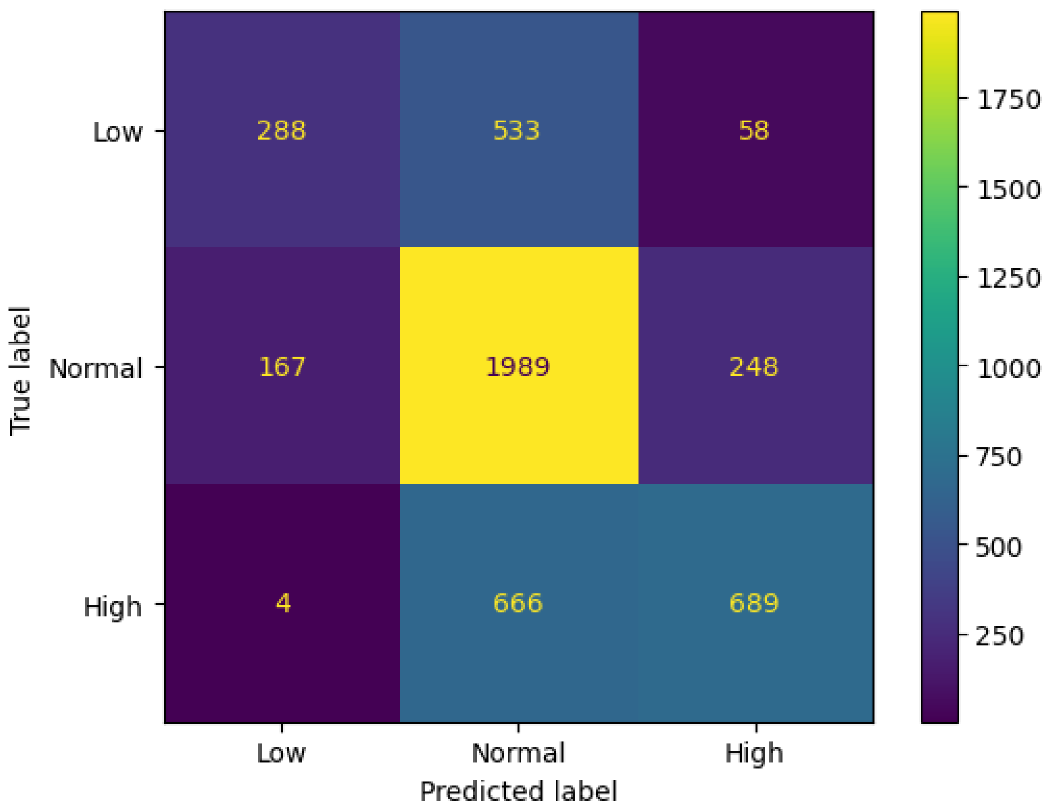
[ ]:

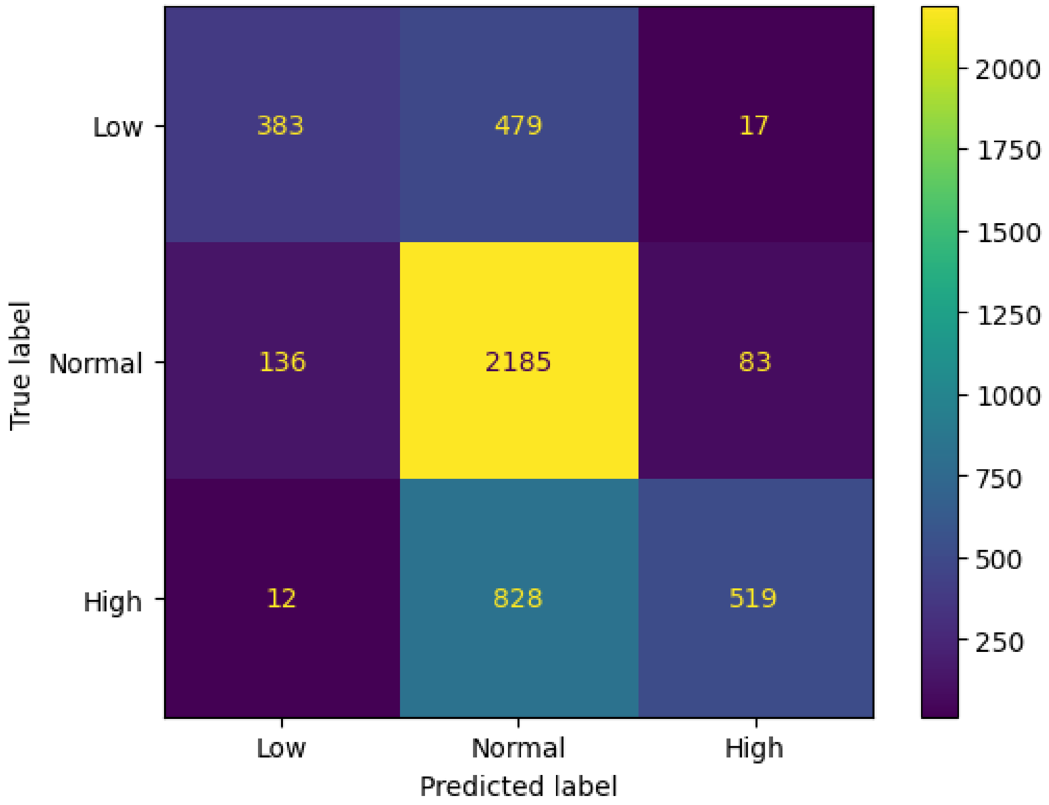
```
#2019 CONFUSION MATRICES

y_19_pred_bag = bag.predict(X_19)
y_19_pred_rf = rf.predict(X_19)
y_19_pred_ada = boost.predict(X_19)

print('Random Forest')
AccConMax(y_19, y_19_pred_rf)
```

```
print('Bagging')
AccConMax(y_19, y_19_pred_bag)
print('ADA Boosting')
AccConMax(y_19, y_19_pred_ada)
```

```
Random Forest
0.6322705730288669
Bagging
0.6389487289961223
ADA Boosting
0.6650150797070228
```




288
533
58
167
1989
248
4
666
689
Low
Normal
High
True label
Low
Normal
High
Predicted label
1750
1500
1250
1000
750
500
250

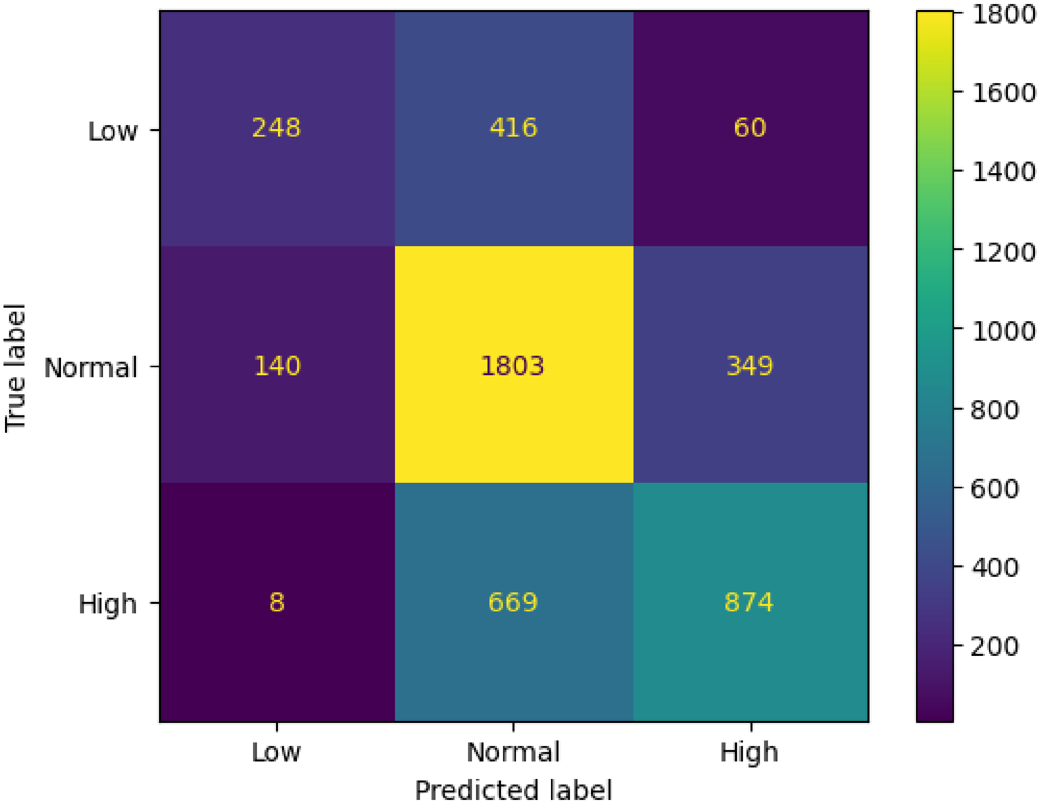


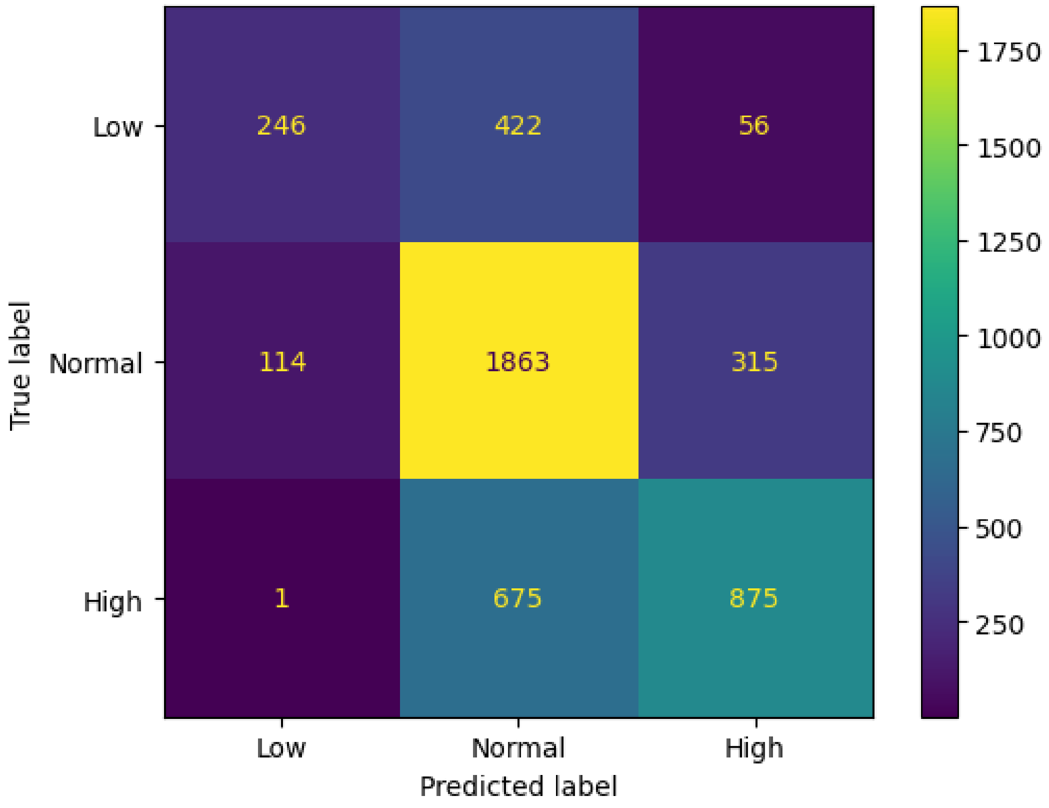
```
[ ]: #The ADABoost did the best for 2019, which did match my hypothesis from step 3.
     #ADABoost was biased toward Normal Sleep whereas the other 2 were focused more toward higher sleep levels.
```

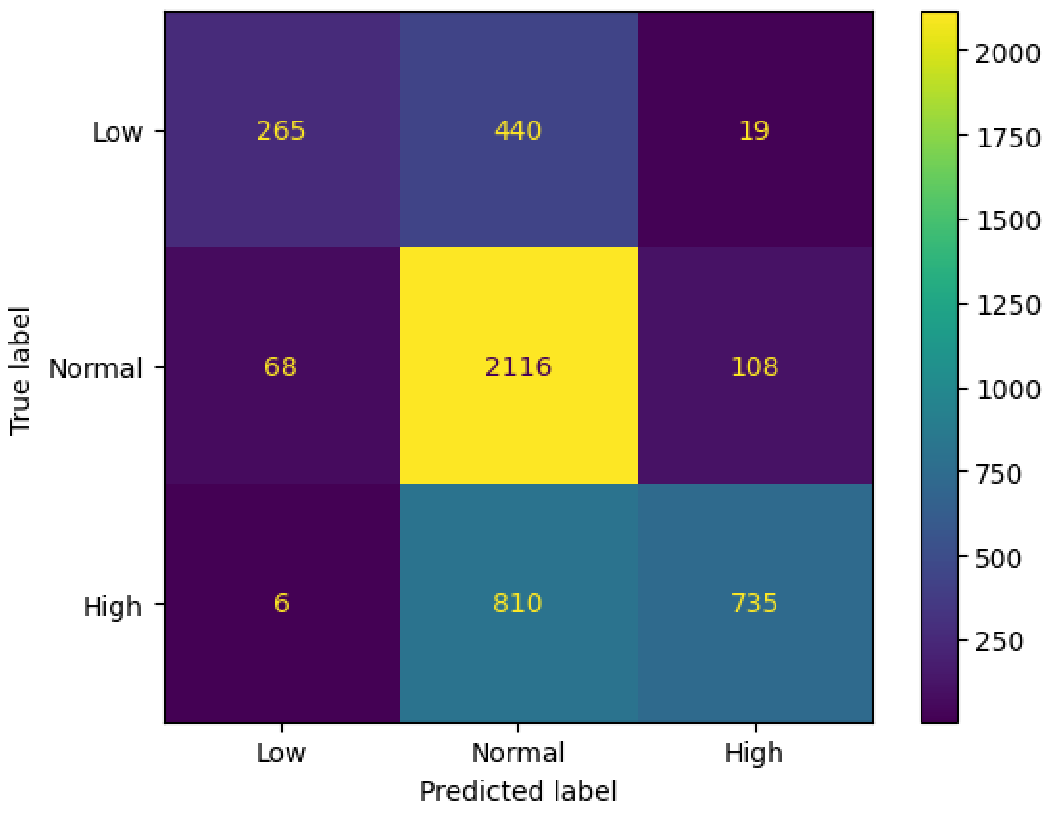
```
[ ]: #2021 CONFUSION MATRICES

     y_21_pred_bag = bag.predict(X_21)
     y_21_pred_rf = rf.predict(X_21)
     y_21_pred_ada = boost.predict(X_21)

     print('Random Forest')
     AccConMax(y_21, y_21_pred_rf)
     print('Bagging')
     AccConMax(y_21, y_21_pred_bag)
     print('ADA Boosting')
     AccConMax(y_21, y_21_pred_ada)
```

```
Random Forest
0.640464199693453
Bagging
0.6533829647470988
```

```
ADA Boosting
0.6822859645281366
```




Low
Normal
High
True label
246
422
56
114
1863
315
1
675
875
Low
Normal
High
Predicted label
1750
1500
1250
1000
750
500
250



[ ]:
```
#The same things held in the 2021 data as the 2019 data.
#The ADABoost did the best for 2021, which did match my hypothesis from step 3.
#ADABoost was biased toward Normal Sleep whereas the other 2 were focused more␣
↪toward higher sleep levels.
```

PART 2

Question 5

[ ]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.naive_bayes import GaussianNB
from sklearn.ensemble import VotingClassifier
from sklearn.model_selection import GridSearchCV
```

[ ]:
```
tuple(range(1,11))
```

[ ]:
```
(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
```

[ ]:
```
#Decision Tree GridSearch
parameters = {'max_depth': (1,2,3,4,5,6,7,8,9,10)}
```

```
GS = GridSearchCV(DecisionTreeClassifier(), parameters)
GS.fit(X_18, y_18)
dt = GS.best_estimator_
print(dt)
print(dt.score(X_18, y_18))

#kNN GridSearch
parameters = {'n_neighbors': (9, 13, 17, 19, 21, 23, 25, 27)} #not always the␣
  ↪best result
GS = GridSearchCV(KNeighborsClassifier(), parameters)
GS.fit(X_18, y_18)
knn = GS.best_estimator_
print(knn)
print(knn.score(X_18, y_18))

#SVC GridSearch
parameters = {'kernel': ('linear', 'rbf'), 'C': [10]} #I checked 1-10 but to␣
  ↪save on run time I set it to 10
svc = SVC(probability=True)
GS = GridSearchCV(svc, parameters)
GS.fit(X_18, y_18)
svm = GS.best_estimator_
print(svm)
print(svm.score(X_18, y_18))

#Naive Bayes (No GridSearch)
nb = GaussianNB()
nb.fit(X_18, y_18)
print(nb)
print(nb.score(X_18, y_18))

#SVM is the highest score at .87 while naivebayes is the lowest with .51
```

```
DecisionTreeClassifier(max_depth=8)
0.6823134953897737
KNeighborsClassifier(n_neighbors=21)
0.5752305113160101
SVC(C=10, kernel='linear', probability=True)
0.875314333612741
GaussianNB()
0.5132020117351216
```

[ ]:

```
Vclf = VotingClassifier(estimators=[('dt',dt),('knn',knn),('svm',svm),␣
  ↪('nb',nb)],
                        voting='soft', weights=[1,1,1,1])

Vclf.fit(X_18, y_18)
Vclf.score(X_18, y_18)
```

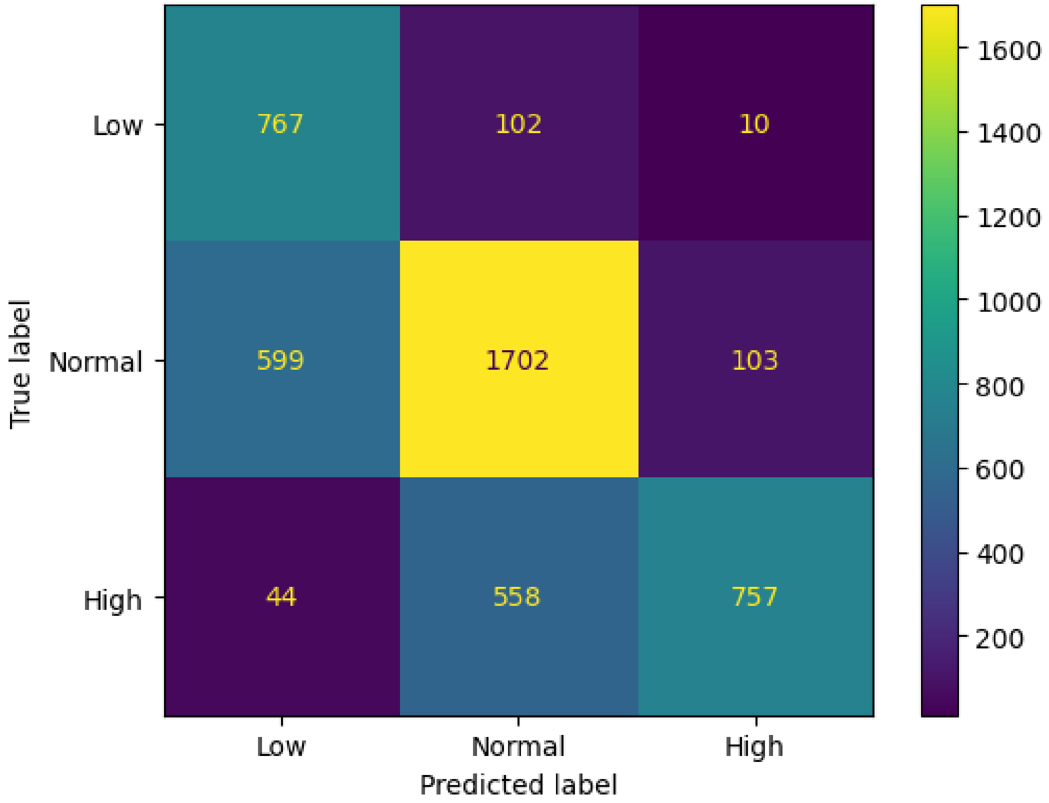
[ ]: 0.7518860016764459

[ ]:
```
Vclfw = VotingClassifier(estimators=[('dt',dt),('knn',knn),('svm',svm),('nb',␣
 ↪nb)],
                        voting='soft',weights=[3,1,6,0.5])

Vclfw.fit(X_18, y_18)
Vclfw.score(X_18, y_18)
#This score is unsurpisingly higher than the one with equal weights since I␣
 ↪prioritized the better performing models.
```

[ ]: 0.8883067896060352

[ ]:
```
#2019 CONFUSION MATRIX
y_19_pred_vote = Vclfw.predict(X_19)
AccConMax(y_19, y_19_pred_vote)
```

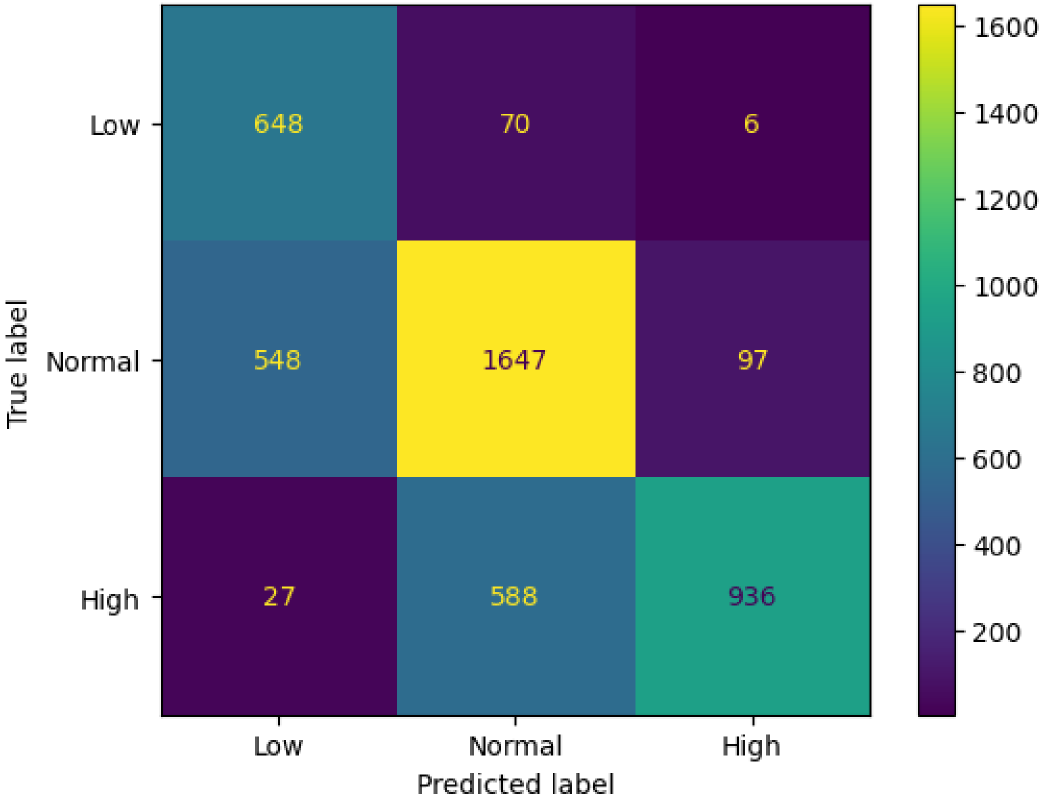
```
0.6949590693666523
```



[ ]:

```
#2021 CONFUSION MATRIX
y_21_pred_vote = Vclfw.predict(X_21)
AccConMax(y_21, y_21_pred_vote)
```

```
0.7074666082767681
```



[ ]:

```
#Best 2019 - Voting Classifier
#The voting classifier does lower the accuracy of normal sleep but puts more priority into both low and high sleep making it better for overall accuracy.
```

[ ]:

```
#Best 2021 - Voting Classifier
#The voting classifier again lowers the accuracy of normal sleep but allows low sleep and high sleep to have higher accuracy as well.
```