driving_behavior_XGBoost_v2

August 31, 2022

[ ]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

[ ]:
```
df_training = pd.read_csv("../data_mod/train_motion_data.csv")
df_test = pd.read_csv("../data_mod/test_motion_data.csv")

df_training
```

[ ]:
```
          AccX      AccY   Class  DiffAccX  DiffAccY      VelX      VelY
0     0.000000  0.000000  NORMAL  0.000000  0.000000  0.000000  0.000000
1    -1.624864 -1.082492  NORMAL -1.624864 -1.082492 -0.812432 -0.541246
2    -0.594660 -0.122410  NORMAL  1.030204  0.960082 -0.297330 -0.061205
3     0.738478 -0.228456  NORMAL  1.333138 -0.106046  0.369239 -0.114228
4     0.101741  0.777568  NORMAL -0.636737  1.006023  0.050871  0.388784
…          …         …       …         …         …         …         …
3639  0.915688 -2.017489    SLOW  2.374675 -1.824629  0.457844 -1.008745
3640 -1.934203  0.914925    SLOW -2.849891  2.932414 -0.967102  0.457462
3641 -0.222845  0.747304    SLOW  1.711359 -0.167621 -0.111422  0.373652
3642 -0.349423  0.067261    SLOW -0.126579 -0.680043 -0.174712  0.033630
3643 -0.402428  0.406218    SLOW -0.053005  0.338957 -0.201214  0.203109

[3644 rows x 7 columns]
```

[ ]:
```
df_training.isna().sum()
```

[ ]:
```
AccX        0
AccY        0
Class       0
DiffAccX    0
DiffAccY    0
VelX        0
VelY        0
dtype: int64
```

0.1 Change categories to numbers

```
[ ]: df_training = df_training.replace(
         {"Class": {"NORMAL": 0, "AGGRESSIVE": 1, "SLOW": 2}})
     df_test = df_test.replace(
         {"Class": {"NORMAL": 0, "AGGRESSIVE": 1, "SLOW": 2}})
     df_training
```

```
[ ]:          AccX      AccY  Class   DiffAccX  DiffAccY      VelX      VelY
     0     0.000000  0.000000      0  0.000000  0.000000  0.000000  0.000000
     1    -1.624864 -1.082492      0 -1.624864 -1.082492 -0.812432 -0.541246
     2    -0.594660 -0.122410      0  1.030204  0.960082 -0.297330 -0.061205
     3     0.738478 -0.228456      0  1.333138 -0.106046  0.369239 -0.114228
     4     0.101741  0.777568      0 -0.636737  1.006023  0.050871  0.388784
     …          …       …    …      …        …        …        …
     3639  0.915688 -2.017489      2  2.374675 -1.824629  0.457844 -1.008745
     3640 -1.934203  0.914925      2 -2.849891  2.932414 -0.967102  0.457462
     3641 -0.222845  0.747304      2  1.711359 -0.167621 -0.111422  0.373652
     3642 -0.349423  0.067261      2 -0.126579 -0.680043 -0.174712  0.033630
     3643 -0.402428  0.406218      2 -0.053005  0.338957 -0.201214  0.203109

     [3644 rows x 7 columns]
```

0.2 Normalize the data

```
[ ]: X_training = df_training.drop(columns=["Class"])
     X_training = (X_training - X_training.mean()) / X_training.std() * 100

     X_training["Class"] = df_training["Class"]
     X_training
```

```
[ ]:            AccX        AccY    DiffAccX    DiffAccY        VelX        VelY  \
     0     -4.105593    8.126800    0.010300   -0.010421   -4.105593    8.126800
     1   -168.957027 -111.696347 -151.542377 -101.201825 -168.957027 -111.696347
     2    -64.437130   -5.422989   96.098456   89.738101  -64.437130   -5.422989
     3     70.817107  -17.161393  124.353421   -9.923577   70.817107  -17.161393
     4      6.216602   94.197287  -59.378806   94.032688    6.216602   94.197287
     …           …          …          …          …          …          …
     3639  88.795978 -215.193071  221.498566 -170.576840   88.795978 -215.193071
     3640 -200.341232  109.401604 -265.801873  274.111831 -200.341232  109.401604
     3641 -26.714411   90.847295  159.630443  -15.679652  -26.714411   90.847295
     3642 -39.556507   15.572024  -11.795809  -63.580862  -39.556507   15.572024
     3643 -44.934120   53.091875   -4.933494   31.675331  -44.934120   53.091875

           Class
     0         0
     1         0
```

```
2          0
3          0
4          0
…      …
3639       2
3640       2
3641       2
3642       2
3643       2

[3644 rows x 7 columns]
```

```
[ ]: X_testing = df_test.drop(columns="Class")
     X_testing = (X_testing - X_testing.mean()) / X_testing.std() * 100

     X_testing["Class"] = df_test["Class"]
     X_testing
```

```
[ ]:            AccX        AccY    DiffAccX    DiffAccY        VelX        VelY  \
     0      67.345100   -9.509000   -0.021340   -0.012385  -10.948927   14.564454
     1      57.982946   10.303100   -8.494392   16.758078   58.012497   10.295271
     2     270.452050 -824.010358  192.270076 -706.238535  270.496822 -824.016540
     3     229.805029 -828.171460  -36.808209   -3.534656  229.846889 -828.177633
     4     283.133326 -732.402479   48.242495   81.053740  283.179007 -732.408842
     …            …           …           …           …           …           …
     3079  -84.712435  -57.627689  -73.609489   -1.097380  -84.693107  -57.635384
     3080  145.444037   51.068429  208.277716   91.996249  145.479853   51.060520
     3081  121.268079 -177.287100  -21.901364 -193.309813  121.302164 -177.294558
     3082   83.265000   79.069807  -34.415357  216.987532   83.296362   79.061842
     3083  140.063424   35.612446   51.383072  -36.797989  140.098855   35.604567

            Class
     0          1
     1          1
     2          1
     3          1
     4          1
     …      …
     3079       2
     3080       2
     3081       2
     3082       2
     3083       2

     [3084 rows x 7 columns]
```

[ ]:
```
X_train = X_training.drop(columns="Class")
y_train = X_training.Class

X_test = X_testing.drop(columns="Class")
y_test = X_testing.Class
```

[ ]:
```
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.model_selection import RandomizedSearchCV
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
```

[ ]:
```
xgb = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0,␣
 ↪max_depth=1, random_state=0)

param_grid = {'n_estimators': np.arange(30, 80), 'learning_rate': np.linspace(0.
 ↪01, 0.2, 15), 'max_depth': np.arange(1, 10)}

xgb_gscv = RandomizedSearchCV(xgb, param_grid, n_iter=20, cv=5, verbose=10,␣
 ↪n_jobs=10, random_state=0)
xgb_gscv.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 20 candidates, totalling 100 fits
[CV 1/5; 1/20] START learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62
[CV 2/5; 1/20] START learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62
[CV 3/5; 1/20] START learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62
[CV 4/5; 1/20] START learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62
[CV 5/5; 1/20] START learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62
[CV 1/5; 2/20] START learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37
[CV 2/5; 2/20] START learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37
[CV 3/5; 2/20] START learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37
[CV 4/5; 2/20] START learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37
[CV 5/5; 2/20] START learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37
[CV 4/5; 1/20] END learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62;, score=0.410 total time=   0.5s
[CV 5/5; 1/20] END learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62;, score=0.442 total time=   0.5s
[CV 3/5; 1/20] END learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62;, score=0.406 total time=   0.5s
```

```
[CV 1/5; 3/20] START learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33
[CV 2/5; 3/20] START learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33
[CV 3/5; 3/20] START learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33
[CV 1/5; 1/20] END learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62;, score=0.418 total time=   0.5s
[CV 4/5; 3/20] START learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33
[CV 2/5; 1/20] END learning_rate=0.09142857142857143, max_depth=1,
n_estimators=62;, score=0.383 total time=   0.5s
[CV 5/5; 3/20] START learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33
[CV 4/5; 3/20] END learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33;, score=0.422 total time=   1.4s
[CV 1/5; 4/20] START learning_rate=0.105, max_depth=3, n_estimators=44…
[CV 1/5; 2/20] END learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37;, score=0.403 total time=   2.0s
[CV 2/5; 4/20] START learning_rate=0.105, max_depth=3, n_estimators=44…
[CV 2/5; 3/20] END learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33;, score=0.385 total time=   1.6s
[CV 3/5; 4/20] START learning_rate=0.105, max_depth=3, n_estimators=44…
[CV 2/5; 2/20] END learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37;, score=0.396 total time=   2.1s
[CV 4/5; 4/20] START learning_rate=0.105, max_depth=3, n_estimators=44…
[CV 1/5; 3/20] END learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33;, score=0.403 total time=   1.6s
[CV 5/5; 4/20] START learning_rate=0.105, max_depth=3, n_estimators=44…
[CV 5/5; 2/20] END learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37;, score=0.405 total time=   2.1s
[CV 4/5; 2/20] END learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37;, score=0.420 total time=   2.1s
[CV 1/5; 5/20] START learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61
[CV 2/5; 5/20] START learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61
[CV 3/5; 3/20] END learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33;, score=0.418 total time=   1.7s
[CV 3/5; 5/20] START learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61
[CV 5/5; 3/20] END learning_rate=0.05071428571428572, max_depth=7,
n_estimators=33;, score=0.422 total time=   1.7s
[CV 4/5; 5/20] START learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61
[CV 3/5; 2/20] END learning_rate=0.07785714285714285, max_depth=8,
n_estimators=37;, score=0.405 total time=   2.3s
[CV 5/5; 5/20] START learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61
[CV 1/5; 4/20] END learning_rate=0.105, max_depth=3, n_estimators=44;,
score=0.432 total time=   0.9s
[CV 1/5; 6/20] START learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39
[CV 3/5; 4/20] END learning_rate=0.105, max_depth=3, n_estimators=44;,
score=0.420 total time=   0.8s
[CV 2/5; 6/20] START learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39
[CV 2/5; 4/20] END learning_rate=0.105, max_depth=3, n_estimators=44;,
score=0.412 total time=   1.0s
[CV 3/5; 6/20] START learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39
[CV 5/5; 4/20] END learning_rate=0.105, max_depth=3, n_estimators=44;,
score=0.455 total time=   0.9s
[CV 4/5; 6/20] START learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39
[CV 4/5; 4/20] END learning_rate=0.105, max_depth=3, n_estimators=44;,
score=0.421 total time=   1.0s
[CV 5/5; 6/20] START learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39
[CV 2/5; 6/20] END learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39;, score=0.388 total time=   1.9s
[CV 1/5; 7/20] START learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57
[CV 1/5; 6/20] END learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39;, score=0.405 total time=   2.1s
[CV 2/5; 7/20] START learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57
[CV 4/5; 6/20] END learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39;, score=0.421 total time=   2.0s
[CV 3/5; 7/20] START learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57
[CV 3/5; 6/20] END learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39;, score=0.405 total time=   2.1s
[CV 4/5; 7/20] START learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57
[CV 5/5; 6/20] END learning_rate=0.1457142857142857, max_depth=8,
n_estimators=39;, score=0.401 total time=   2.2s
[CV 5/5; 7/20] START learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57
[CV 1/5; 5/20] END learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61;, score=0.422 total time=   3.5s
[CV 1/5; 8/20] START learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63
[CV 4/5; 5/20] END learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61;, score=0.417 total time=   3.7s
[CV 2/5; 8/20] START learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63
[CV 2/5; 5/20] END learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61;, score=0.380 total time=   3.9s
[CV 3/5; 8/20] START learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63
[CV 3/5; 5/20] END learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61;, score=0.392 total time=   3.9s
[CV 4/5; 8/20] START learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63
[CV 5/5; 5/20] END learning_rate=0.1457142857142857, max_depth=9,
n_estimators=61;, score=0.393 total time=   3.8s
[CV 5/5; 8/20] START learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63
[CV 1/5; 8/20] END learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63;, score=0.416 total time=   1.3s
[CV 1/5; 9/20] START learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53
[CV 3/5; 8/20] END learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63;, score=0.416 total time=   1.2s
[CV 2/5; 9/20] START learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53
[CV 2/5; 8/20] END learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63;, score=0.390 total time=   1.3s
[CV 3/5; 9/20] START learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53
[CV 5/5; 8/20] END learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63;, score=0.456 total time=   1.1s
[CV 4/5; 9/20] START learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53
[CV 4/5; 8/20] END learning_rate=0.037142857142857144, max_depth=3,
n_estimators=63;, score=0.418 total time=   1.3s
[CV 5/5; 9/20] START learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53
[CV 1/5; 7/20] END learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57;, score=0.407 total time=   3.4s
[CV 1/5; 10/20] START learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54
[CV 3/5; 7/20] END learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57;, score=0.395 total time=   3.5s
[CV 2/5; 10/20] START learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54
[CV 4/5; 7/20] END learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57;, score=0.402 total time=   3.5s
[CV 3/5; 10/20] START learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54
[CV 2/5; 7/20] END learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57;, score=0.366 total time=   3.7s
[CV 4/5; 10/20] START learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54
[CV 1/5; 10/20] END learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54;, score=0.418 total time=   0.5s
[CV 5/5; 10/20] START learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54
[CV 5/5; 7/20] END learning_rate=0.17285714285714288, max_depth=9,
n_estimators=57;, score=0.400 total time=   3.7s
[CV 1/5; 11/20] START learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54
[CV 2/5; 10/20] END learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54;, score=0.388 total time=   0.6s
[CV 2/5; 11/20] START learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54
[CV 4/5; 10/20] END learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54;, score=0.433 total time=   0.5s
[CV 3/5; 11/20] START learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54
[CV 3/5; 10/20] END learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54;, score=0.418 total time=   0.5s
[CV 4/5; 11/20] START learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54
[CV 5/5; 10/20] END learning_rate=0.18642857142857144, max_depth=1,
n_estimators=54;, score=0.440 total time=   0.5s
[CV 5/5; 11/20] START learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54
[CV 1/5; 9/20] END learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53;, score=0.429 total time=   2.3s
[CV 1/5; 12/20] START learning_rate=0.2, max_depth=9, n_estimators=73…
[CV 4/5; 9/20] END learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53;, score=0.405 total time=   2.3s
[CV 2/5; 12/20] START learning_rate=0.2, max_depth=9, n_estimators=73…
[CV 2/5; 9/20] END learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53;, score=0.387 total time=   2.4s
[CV 3/5; 12/20] START learning_rate=0.2, max_depth=9, n_estimators=73…
[CV 5/5; 9/20] END learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53;, score=0.412 total time=   2.3s
[CV 1/5; 11/20] END learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54;, score=0.442 total time=   0.8s
[CV 4/5; 12/20] START learning_rate=0.2, max_depth=9, n_estimators=73…
[CV 5/5; 12/20] START learning_rate=0.2, max_depth=9, n_estimators=73…
[CV 2/5; 11/20] END learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54;, score=0.410 total time=   0.7s
[CV 1/5; 13/20] START learning_rate=0.2, max_depth=9, n_estimators=74…
[CV 3/5; 9/20] END learning_rate=0.13214285714285715, max_depth=7,
n_estimators=53;, score=0.420 total time=   2.5s
[CV 2/5; 13/20] START learning_rate=0.2, max_depth=9, n_estimators=74…
[CV 3/5; 11/20] END learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54;, score=0.416 total time=   0.8s
```

```
[CV 3/5; 13/20] START learning_rate=0.2, max_depth=9, n_estimators=74…
[CV 5/5; 11/20] END learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54;, score=0.449 total time=   0.7s
[CV 4/5; 13/20] START learning_rate=0.2, max_depth=9, n_estimators=74…
[CV 4/5; 11/20] END learning_rate=0.18642857142857144, max_depth=2,
n_estimators=54;, score=0.435 total time=   0.8s
[CV 5/5; 13/20] START learning_rate=0.2, max_depth=9, n_estimators=74…
[CV 1/5; 12/20] END learning_rate=0.2, max_depth=9, n_estimators=73;,
score=0.424 total time=   4.1s
[CV 1/5; 14/20] START learning_rate=0.105, max_depth=7, n_estimators=48…
[CV 3/5; 12/20] END learning_rate=0.2, max_depth=9, n_estimators=73;,
score=0.401 total time=   4.1s
[CV 2/5; 14/20] START learning_rate=0.105, max_depth=7, n_estimators=48…
[CV 2/5; 12/20] END learning_rate=0.2, max_depth=9, n_estimators=73;,
score=0.405 total time=   4.3s
[CV 3/5; 14/20] START learning_rate=0.105, max_depth=7, n_estimators=48…
[CV 4/5; 12/20] END learning_rate=0.2, max_depth=9, n_estimators=73;,
score=0.402 total time=   4.1s
[CV 4/5; 14/20] START learning_rate=0.105, max_depth=7, n_estimators=48…
[CV 5/5; 12/20] END learning_rate=0.2, max_depth=9, n_estimators=73;,
score=0.413 total time=   4.2s
[CV 5/5; 14/20] START learning_rate=0.105, max_depth=7, n_estimators=48…
[CV 2/5; 13/20] END learning_rate=0.2, max_depth=9, n_estimators=74;,
score=0.402 total time=   4.3s
[CV 1/5; 15/20] START learning_rate=0.2, max_depth=4, n_estimators=38…
[CV 4/5; 13/20] END learning_rate=0.2, max_depth=9, n_estimators=74;,
score=0.405 total time=   4.2s
[CV 2/5; 15/20] START learning_rate=0.2, max_depth=4, n_estimators=38…
[CV 1/5; 13/20] END learning_rate=0.2, max_depth=9, n_estimators=74;,
score=0.420 total time=   4.3s
[CV 3/5; 15/20] START learning_rate=0.2, max_depth=4, n_estimators=38…
[CV 3/5; 13/20] END learning_rate=0.2, max_depth=9, n_estimators=74;,
score=0.399 total time=   4.3s
[CV 4/5; 15/20] START learning_rate=0.2, max_depth=4, n_estimators=38…
[CV 5/5; 13/20] END learning_rate=0.2, max_depth=9, n_estimators=74;,
score=0.413 total time=   4.5s
[CV 5/5; 15/20] START learning_rate=0.2, max_depth=4, n_estimators=38…
[CV 2/5; 15/20] END learning_rate=0.2, max_depth=4, n_estimators=38;,
score=0.399 total time=   0.9s
[CV 3/5; 15/20] END learning_rate=0.2, max_depth=4, n_estimators=38;,
score=0.420 total time=   0.9s
[CV 1/5; 16/20] START learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35
[CV 2/5; 16/20] START learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35
[CV 1/5; 15/20] END learning_rate=0.2, max_depth=4, n_estimators=38;,
score=0.440 total time=   0.9s
[CV 3/5; 16/20] START learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35
[CV 4/5; 15/20] END learning_rate=0.2, max_depth=4, n_estimators=38;,
score=0.442 total time=   0.9s
[CV 4/5; 16/20] START learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35
[CV 5/5; 15/20] END learning_rate=0.2, max_depth=4, n_estimators=38;,
score=0.445 total time=   0.9s
[CV 5/5; 16/20] START learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35
[CV 1/5; 14/20] END learning_rate=0.105, max_depth=7, n_estimators=48;,
score=0.416 total time=   2.0s
[CV 1/5; 17/20] START learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79
[CV 2/5; 14/20] END learning_rate=0.105, max_depth=7, n_estimators=48;,
score=0.390 total time=   2.0s
[CV 2/5; 17/20] START learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79
[CV 3/5; 14/20] END learning_rate=0.105, max_depth=7, n_estimators=48;,
score=0.410 total time=   2.0s
[CV 3/5; 17/20] START learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79
[CV 5/5; 14/20] END learning_rate=0.105, max_depth=7, n_estimators=48;,
score=0.412 total time=   2.0s
[CV 4/5; 17/20] START learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79
[CV 4/5; 14/20] END learning_rate=0.105, max_depth=7, n_estimators=48;,
score=0.425 total time=   2.0s
[CV 5/5; 17/20] START learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79
[CV 2/5; 16/20] END learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35;, score=0.392 total time=   1.3s
[CV 1/5; 18/20] START learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65
[CV 4/5; 16/20] END learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35;, score=0.395 total time=   1.3s
[CV 3/5; 16/20] END learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35;, score=0.421 total time=   1.3s
[CV 2/5; 18/20] START learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65
[CV 3/5; 18/20] START learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65
[CV 1/5; 16/20] END learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35;, score=0.402 total time=   1.3s
[CV 4/5; 18/20] START learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65
[CV 5/5; 16/20] END learning_rate=0.02357142857142857, max_depth=6,
n_estimators=35;, score=0.449 total time=   1.2s
[CV 5/5; 18/20] START learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65
[CV 1/5; 17/20] END learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79;, score=0.422 total time=   3.2s
[CV 1/5; 19/20] START learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52
[CV 1/5; 18/20] END learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65;, score=0.409 total time=   2.7s
[CV 2/5; 19/20] START learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52
[CV 4/5; 18/20] END learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65;, score=0.424 total time=   2.8s
[CV 3/5; 19/20] START learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52
[CV 2/5; 18/20] END learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65;, score=0.396 total time=   2.8s
[CV 4/5; 19/20] START learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52
[CV 2/5; 17/20] END learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79;, score=0.398 total time=   3.3s
[CV 5/5; 19/20] START learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52
[CV 4/5; 17/20] END learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79;, score=0.427 total time=   3.2s
[CV 1/5; 20/20] START learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77
[CV 3/5; 18/20] END learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65;, score=0.414 total time=   2.9s
[CV 2/5; 20/20] START learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77
[CV 5/5; 17/20] END learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79;, score=0.408 total time=   3.2s
[CV 3/5; 20/20] START learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77
[CV 5/5; 18/20] END learning_rate=0.06428571428571428, max_depth=7,
n_estimators=65;, score=0.409 total time=   2.7s
[CV 4/5; 20/20] START learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77
[CV 3/5; 17/20] END learning_rate=0.07785714285714285, max_depth=7,
n_estimators=79;, score=0.396 total time=   3.4s
[CV 5/5; 20/20] START learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77
[CV 1/5; 20/20] END learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77;, score=0.439 total time=   1.8s
[CV 4/5; 20/20] END learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77;, score=0.424 total time=   1.8s
[CV 3/5; 20/20] END learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77;, score=0.420 total time=   1.8s
[CV 2/5; 20/20] END learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77;, score=0.407 total time=   1.8s
[CV 5/5; 20/20] END learning_rate=0.09142857142857143, max_depth=4,
n_estimators=77;, score=0.446 total time=   1.8s
[CV 1/5; 19/20] END learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52;, score=0.402 total time=   2.9s
[CV 2/5; 19/20] END learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52;, score=0.385 total time=   2.8s
[CV 3/5; 19/20] END learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52;, score=0.398 total time=   2.9s
[CV 5/5; 19/20] END learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52;, score=0.426 total time=   2.8s
[CV 4/5; 19/20] END learning_rate=0.06428571428571428, max_depth=9,
n_estimators=52;, score=0.417 total time=   2.9s
```

```
[ ]: RandomizedSearchCV(cv=5,
                        estimator=GradientBoostingClassifier(learning_rate=1.0,
                                                             max_depth=1,
                                                             random_state=0),
                        n_iter=20, n_jobs=10,
                        param_distributions={'learning_rate': array([0.01      ,
     0.02357143, 0.03714286, 0.05071429, 0.06428571,
            0.07785714, 0.09142857, 0.105     , 0.11857143, 0.13214286,
            0.14571429, 0.15928571, 0.17285714, 0.18642857, 0.2       ]),
                                             'max_depth': array([1, 2, 3, 4, 5, 6, 7,
     8, 9]),
                                             'n_estimators': array([30, 31, 32, 33,
     34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46,
            47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63,
            64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79])},
                        random_state=0, verbose=10)
```

```
[ ]: best_params = xgb_gscv.best_params_
     best_params
```

```
[ ]: {'n_estimators': 54, 'max_depth': 2, 'learning_rate': 0.18642857142857144}
```

```
[ ]: xgb_gscv.best_score_
```

```
[ ]: 0.43030155715340906
```

0.2.1 Check for overfitting

```
[ ]: xgb_gscv.score(X_train, y_train)
```

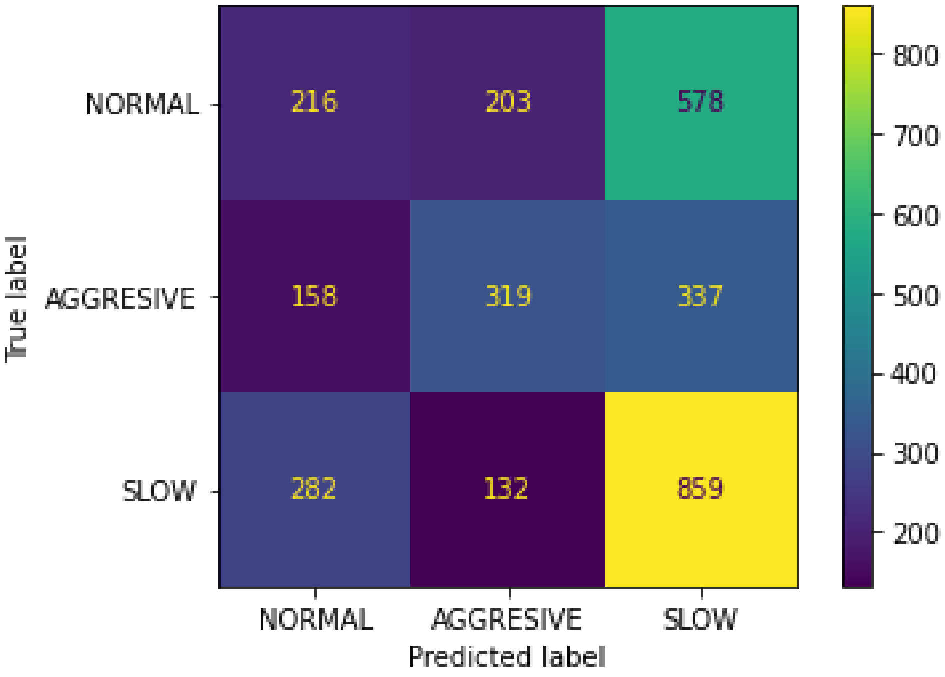
```
[ ]: 0.524423710208562
```

```
[ ]: xgb_gscv.score(X_test, y_test)
[ ]: 0.45201037613488976
```

```
[ ]: classes = ["NORMAL", "AGGRESIVE", "SLOW"]
```

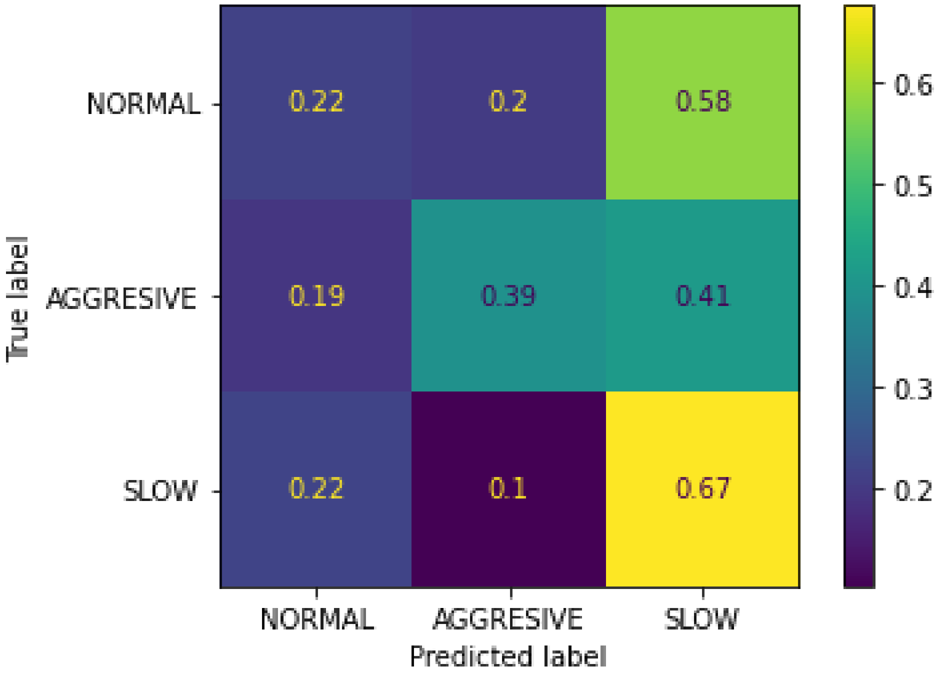
```
[ ]: y_pred = xgb_gscv.predict(X_test)

     CM = confusion_matrix(y_test, y_pred)
     display = ConfusionMatrixDisplay(confusion_matrix=CM,
                                      display_labels=classes)
     display.plot()
```

```
[ ]: <sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
     0x7f725c2ca340>
```



```
[ ]: CM_norm = confusion_matrix(y_test, y_pred, normalize="true")
     display = ConfusionMatrixDisplay(confusion_matrix=CM_norm,
                                      display_labels=classes)
     display.plot()
```

```
[ ]: <sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
     0x7f725c4df910>
```



[ ]:

```
def evaluate(model, test_features, test_labels):
    accuracy = model.score(test_features, test_labels)
    print('Model Performance')
    print('Accuracy = {:0.3f}%.'.format(accuracy))

    return accuracy

base_model = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0,␣
 ↪max_depth=1, random_state=0)
base_model.fit(X_train, y_train)
base_accuracy = evaluate(base_model, X_test, y_test)

best_random = xgb_gscv.best_estimator_
random_accuracy = evaluate(best_random, X_test, y_test)

print(f'Improvement of {100 * (random_accuracy - base_accuracy) / base_accuracy:
 ↪.3f}%.')
```

```
Model Performance
Accuracy = 0.432%.
Model Performance
Accuracy = 0.452%.
Improvement of 4.576%.
```

[ ]:

```
```