PD Tremor Severity Prediction: Both State
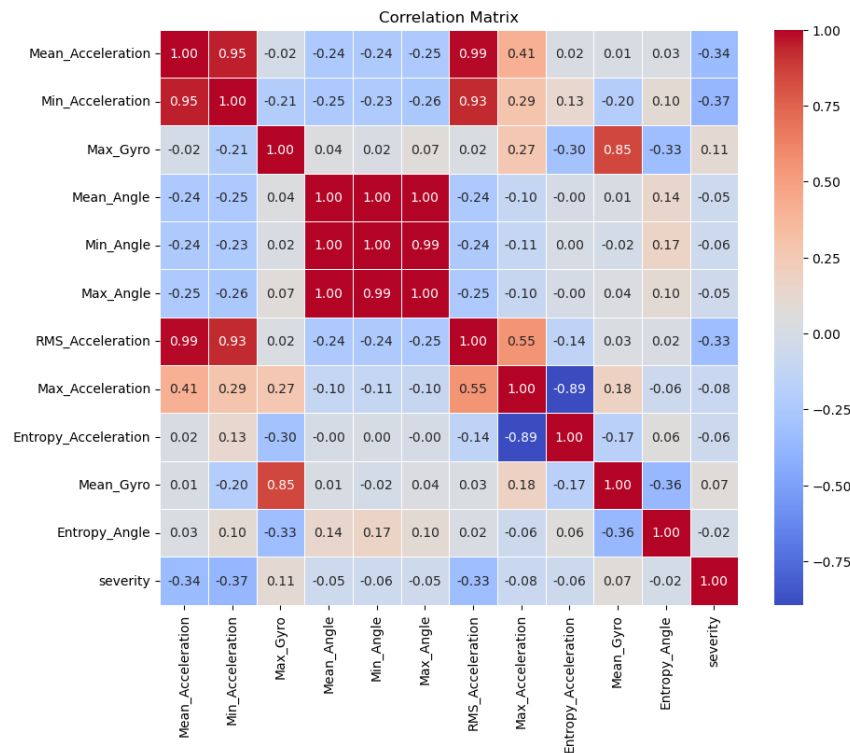
Selected Features from the refined list.

S.No.	All IMU Features	Selected IMU Features
1	Mean_Acceleration	Mean_Acceleration
2	Std_Acceleration	
3	Min_Acceleration	Min_Acceleration
4	Max_Acceleration	Max_Acceleration
5	Skew_Acceleration	
6	Kurtosis_Acceleration	
7	Entropy_Acceleration	Entropy_Acceleration
8	Mean_Gyro	Mean_Gyro
9	Std_Gyro	
10	Min_Gyro	
11	Max_Gyro	Max_Gyro
12	Skew_Gyro	
13	Kurtosis_Gyro	
14	Entropy_Gyro	
15	Mean_Angle	Mean_Angle
16	Std_Angle	
17	Min_Angle	Min_Angle
18	Max_Angle	Max_Angle
19	Skew_Angle	
20	Kurtosis_Angle	
21	Entropy_Angle	Entropy_Angle
22	RMS_Acceleration	RMS_Acceleration
23	Peaks_Acceleration	
24	Autocorr_Acceleration	
25	Dominant_Frequency	
26	Peak_Power	
27	Tremor_Stability_Index	
28	FuzzyEn_Acceleration	

Corelation of IMU features

Correlation Matrix

1.RF

Accuracy: 0.8722 ± 0.0200
F1-Score: 0.8695 ± 0.0200
Kappa: 0.7752 ± 0.0339
MCC: 0.7772 ± 0.0343
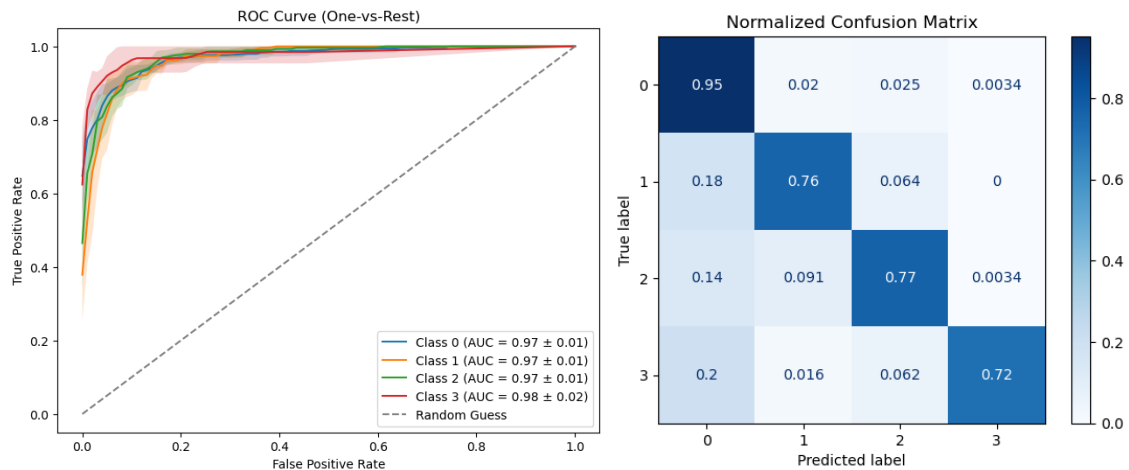Precision: 0.8714 ± 0.0218
Recall: 0.8722 ± 0.0200
Mean Training Time: 5.3209 seconds
Mean Testing Time: 0.1400 seconds
Mean Prediction Speed: 2183.19 predictions/second
Model Size: 7294.29 KB
ROC Curve and confusion matrix

2. XGBClassifier

Accuracy: 0.8630 ± 0.0109
F1-Score: 0.8603 ± 0.0099
Kappa: 0.7600 ± 0.0161
MCC: 0.7620 ± 0.0164
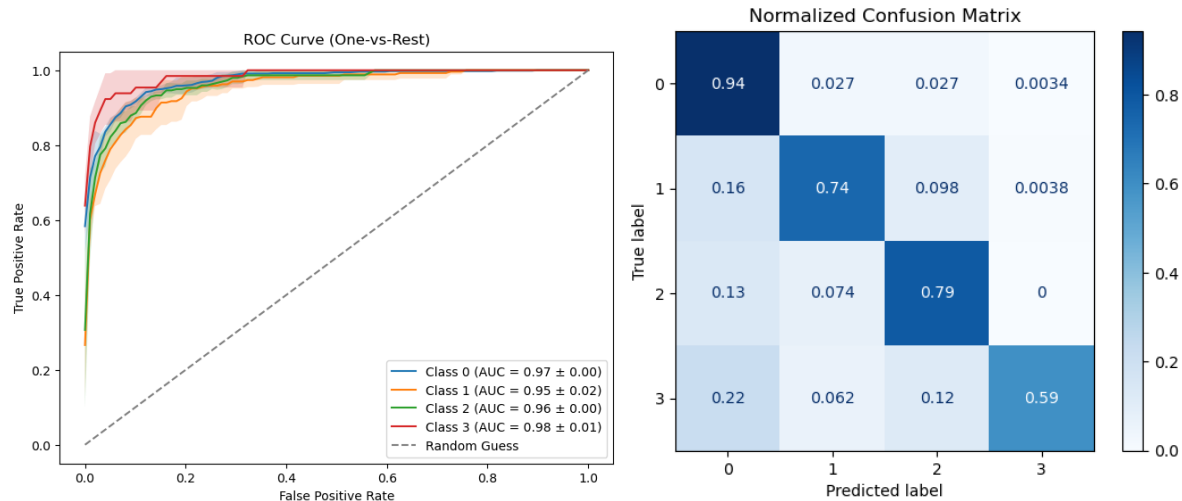Precision: 0.8635 ± 0.0101
Recall: 0.8630 ± 0.0109
Mean Training Time: 5.6931 seconds
Mean Testing Time: 0.0108 seconds
Mean Prediction Speed: 29677.57 predictions/second
Model Size: 1783.36 KB
ROC Curve and confusion matrix

3. KNeighborsClassifier

Accuracy: 0.8986 ± 0.0149
F1-Score: 0.8987 ± 0.0149
Kappa: 0.8270 ± 0.0256
MCC: 0.8274 ± 0.0256
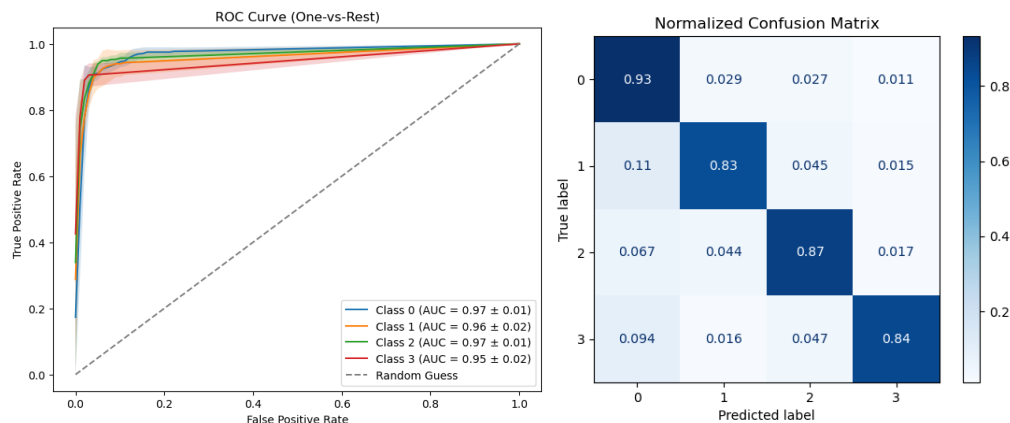Precision: 0.9003 ± 0.0145
Recall: 0.8986 ± 0.0149
Mean Training Time: 0.0021 seconds
Mean Testing Time: 0.0075 seconds
Mean Prediction Speed: 41843.87 predictions/second
Model Size: 137.31 KB
ROC Curve and confusion matrix

4. AdaBoostClassifier

Accuracy: 0.6337 ± 0.0162
F1-Score: 0.5838 ± 0.0294
Kappa: 0.2668 ± 0.0583
MCC: 0.2939 ± 0.0483
Precision: 0.6100 ± 0.0323
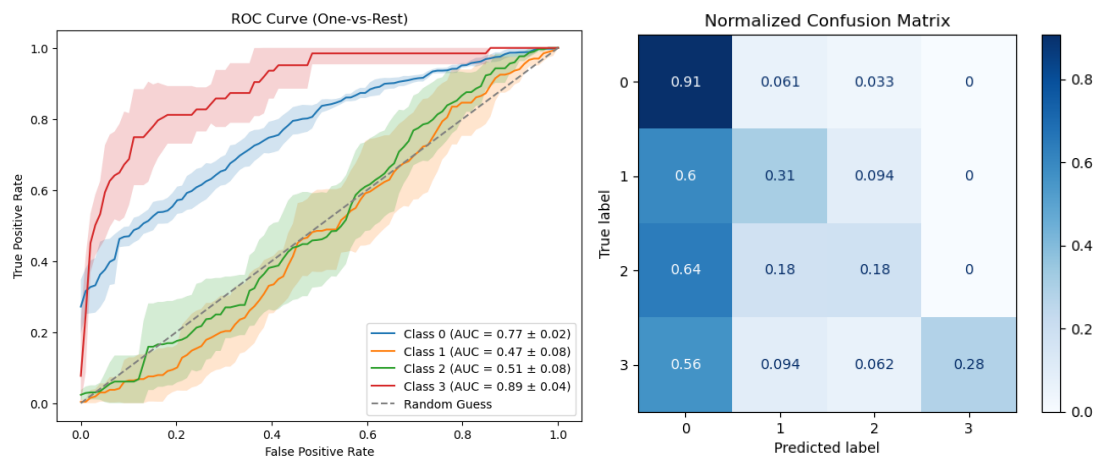Recall: 0.6337 ± 0.0162
Mean Training Time: 1.7583 seconds
Mean Testing Time: 0.0980 seconds
Mean Prediction Speed: 3133.44 predictions/second
Model Size: 121.32 KB
ROC Curve and confusion matrix

5. SVC

Accuracy: 0.6726 ± 0.0054
F1-Score: 0.6342 ± 0.0126
Kappa: 0.3695 ± 0.0271
MCC: 0.3900 ± 0.0203
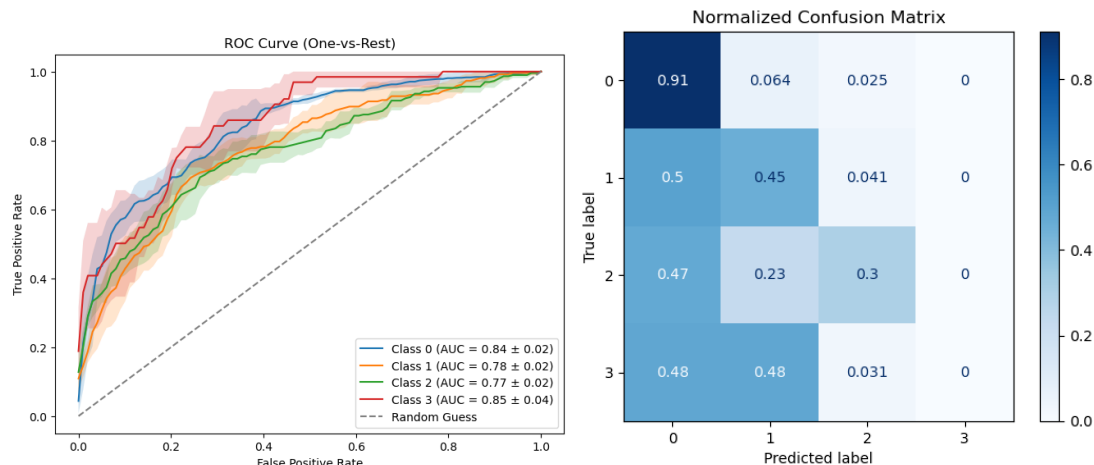Precision: 0.6483 ± 0.0131
Recall: 0.6726 ± 0.0054
Mean Training Time: 0.6434 seconds
Mean Testing Time: 0.0879 seconds
Mean Prediction Speed: 3768.49 predictions/second
Model Size: 81.75 KB
ROC Curve and confusion matrix

6. Voting classifier

Accuracy: 0.9078 ± 0.0072
F1-Score: 0.9062 ± 0.0073
Kappa: 0.8385 ± 0.0124
MCC: 0.8402 ± 0.0122
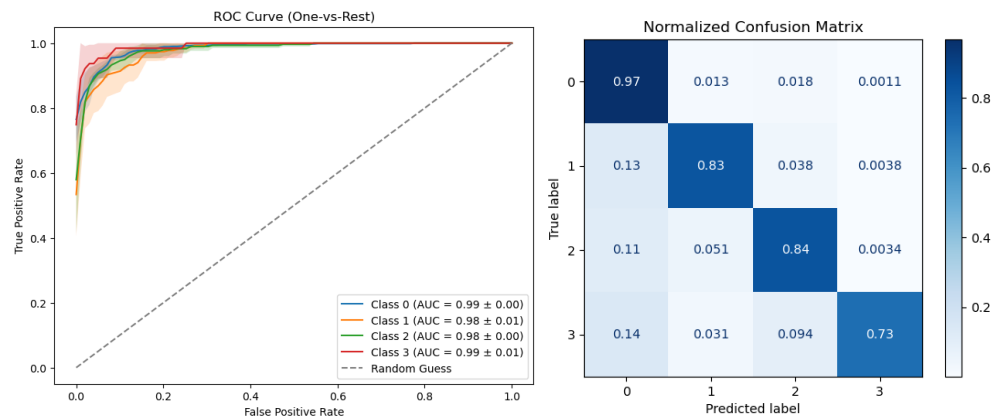Precision: 0.9084 ± 0.0076
Recall: 0.9078 ± 0.0072
Mean Training Time: 2.4692 seconds
Mean Testing Time: 0.0696 seconds
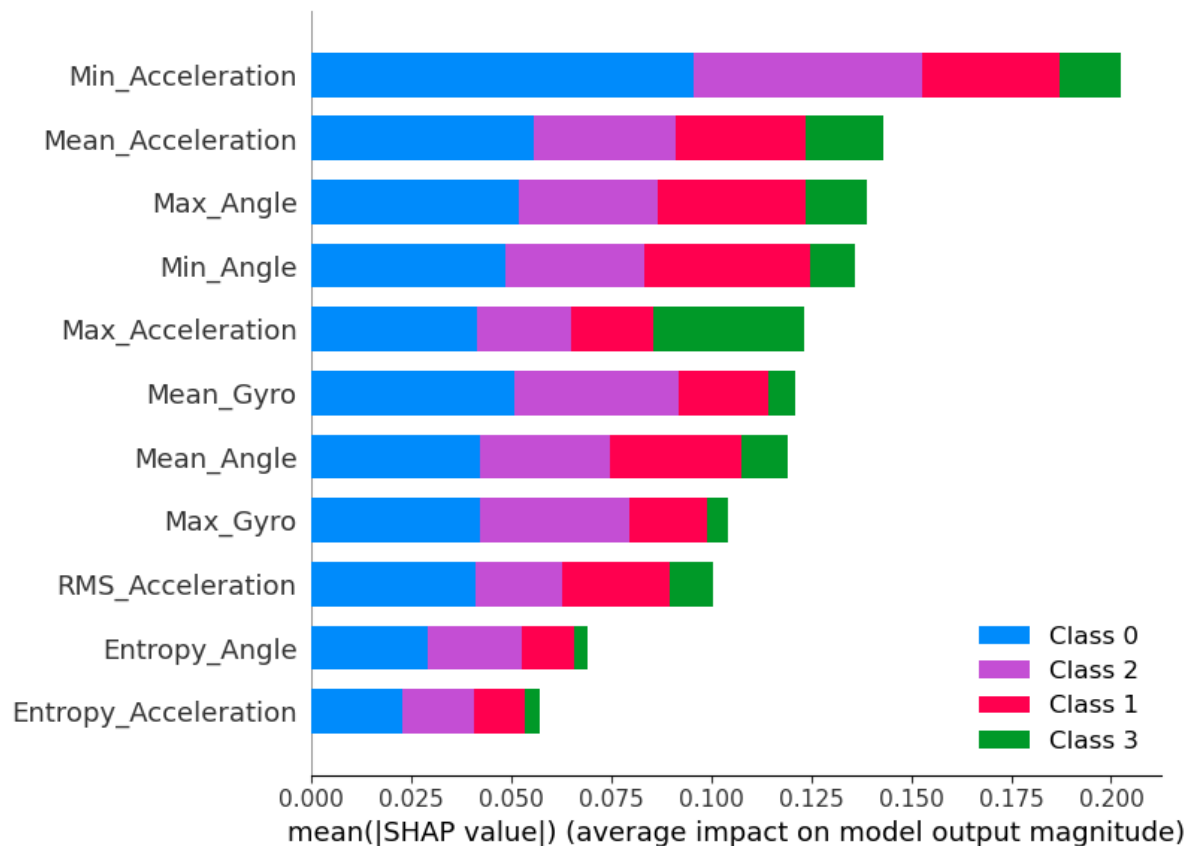Mean Prediction Speed: 4378.75 predictions/second
Model Size: 8786.35 KB
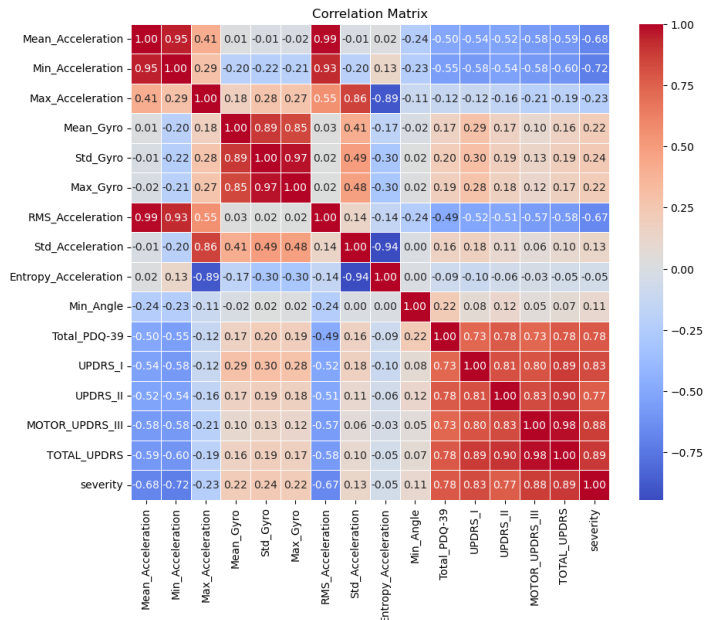**ROC Curve and confusion matrix**

Model	Given Parameters	Selected Parameter	Accuracy (%)	F1-Score (%)	Kappa (%)	MCC (%)	Precision (%)	Recall (%)	Mean Training Time (s)	Mean Testing Time (s)	Mean Prediction Speed (predictions/sec)	Model Size (KB)
RF	n_estimators: [100, 200, 300] max_depth: [None, 10, 20, 30] min_samples_split: [2, 5, 10] min_samples_leaf: [1, 2, 4] max_features: ['sqrt', 'log2']	{'max_depth': 20, 'max_features': 'sqrt', 'min_samples_leaf': 1, 'min_samples_split': 2, 'n_estimators': 200}	87.22 ± 0.0200	86.95 ± 0.0200	77.52 ± 0.0339	77.72 ± 0.0343	87.14 ± 0.0218	87.22 ± 0.0200	5.3209	0.1400	2183.19	7294.29
XGBClassifier	n_estimators: [100, 200, 300] max_depth: [3, 6, 9] learning_rate: [0.01, 0.1, 0.2] subsample: [0.8, 0.9, 1.0] colsample_bytree: [0.8, 0.9, 1.0] gamma: [0, 0.1, 0.2]	{'colsample_bytree': 0.8, 'gamma': 0, 'learning_rate': 0.1, 'max_depth': 9, 'n_estimators': 200, 'subsample': 0.9}	86.30 ± 0.0109	86.03 ± 0.0099	76.00 ± 0.0161	76.20 ± 0.0164	86.35 ± 0.0101	86.30 ± 0.0109	5.6931	0.0108	29677.57	1783.36
KNeighborsClassifier	n_neighbors: [3, 5, 7, 9, 11] weights: ['uniform', 'distance'] metric: ['euclidean', 'manhattan', 'minkowski']	{'metric': 'manhattan', 'n_neighbors': 3, 'weights': 'distance'}	89.86 ± 0.0149	89.87 ± 0.0149	82.70 ± 0.0256	82.74 ± 0.0256	90.03 ± 0.0145	89.86 ± 0.0149	0.0021	0.0075	41843.87	137.31
AdaBoostClassifier	n_estimators: [50, 100, 200] learning_rate: [0.01, 0.1, 1.0] algorithm: ['SAMME', 'SAMME.R']	{'algorithm': 'SAMME.R', 'learning_rate': 0.1, 'n_estimators': 200}	63.37 ± 0.0162	58.38 ± 0.0294	26.68 ± 0.0583	29.39 ± 0.0483	61.00 ± 0.0323	63.37 ± 0.0162	1.7583	0.0980	3133.44	121.32
SVC	C: [0.1, 1, 10] kernel: ['linear', 'rbf', 'poly'] gamma: ['scale', 'auto'] degree: [2, 3, 4]	{'C': 10, 'degree': 2, 'gamma': 'scale', 'kernel': 'rbf'}	67.26 ± 0.0054	63.42 ± 0.0126	36.95 ± 0.0271	39.00 ± 0.0203	64.83 ± 0.0131	67.26 ± 0.0054	0.6434	0.0879	3768.49	81.75
Voting Classifier	**Combines KNN, RF, and XGBoost**		90.78 ± 0.0072	90.62 ± 0.0073	83.85 ± 0.0124	84.02 ± 0.0122	90.84 ± 0.0076	90.78 ± 0.0072	2.4692	0.0696	4378.75	8786.35

Interpretability: PD Tremor severity

mean(|SHAP value|) (average impact on model output magnitude)

| Class 0 |
| Class 2 |
| Class 1 |
| Class 3 |

higher ⇄ lower

f(x)

base value

| −0.2096 | −0.009589 **0.07** | 0.1904 | 0.3904 | 0.5904 | 0.7904 | 0.9904 | 1.19 | 1.39 |

Entropy_Angle = −0.4606 Mean_Gyro = 2.926 Max_Gyro = 2.46 Min_Acceleration = −1.369 Mean_Acceleration = −0.7784 RMS_Acceleration = −0.71 Min_Angle = 0.8289

Feature	Value
Min_Acceleration	-1.37
Max_Angle	1.33
Max_Acceleration	0.40
Mean_Angle	1.28
Mean_Acceleration	-0.78
Min_Angle	0.83
Entropy_Acceleration	-0.97
RMS_Acceleration	-0.71
Entropy_Angle	-0.46
Mean_Gyro	2.93

Prediction probabilities

0	0.07
1	0.01
2	0.92
3	0.00

NOT 1   1

Min_Acceleration <= ...
0.05

Max_Angle > 1.03
0.04

Max_Acceleration > ...
0.03

Mean_Angle > 1.05
0.02

-0.84 < Mean_Accelera...
0.02

-0.16 < Min_Angle <= ...
0.02

Entropy_Acceleration ...
0.01

-0.75 < RMS_Acceler...
0.01

Entropy_Angle <= 0.14
0.00

Mean_Gyro > -0.18
0.00

II. PD Severity prediction: Both State

Holistic Multimodal Features: Corelation of IMU features+MDS-UPDRS+PDQ-39

Correlation Matrix

1. RandomForestClassifier

Accuracy: 0.9717 ± 0.0128
F1-Score: 0.9715 ± 0.0129
Kappa: 0.9517 ± 0.0216
MCC: 0.9521 ± 0.0215
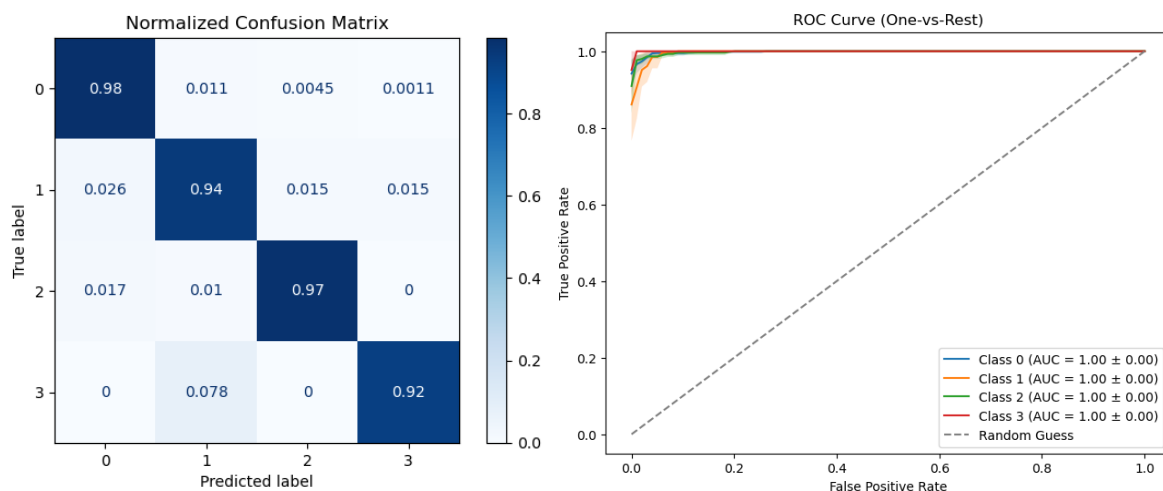Precision: 0.9726 ± 0.0126
Recall: 0.9717 ± 0.0128
Mean Training Time: 1.4595 seconds
Mean Testing Time: 0.0324 seconds
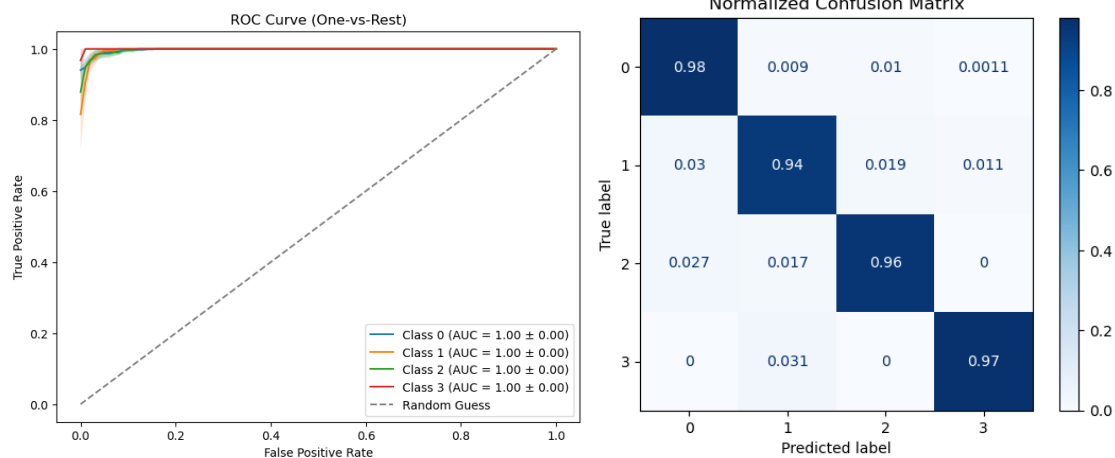Mean Prediction Speed: 9541.47 predictions/second
Model Size: 4586.59 KB
ROC Curve and confusion matrix

2. XGBClassifier

Accuracy: 0.9677 ± 0.0136
F1-Score: 0.9677 ± 0.0136
Kappa: 0.9449 ± 0.0231
MCC: 0.9453 ± 0.0230
Precision: 0.9688 ± 0.0134
Recall: 0.9677 ± 0.0136
Mean Training Time: 0.5097 seconds
Mean Testing Time: 0.0045 seconds
Mean Prediction Speed: 68388.26 predictions/second
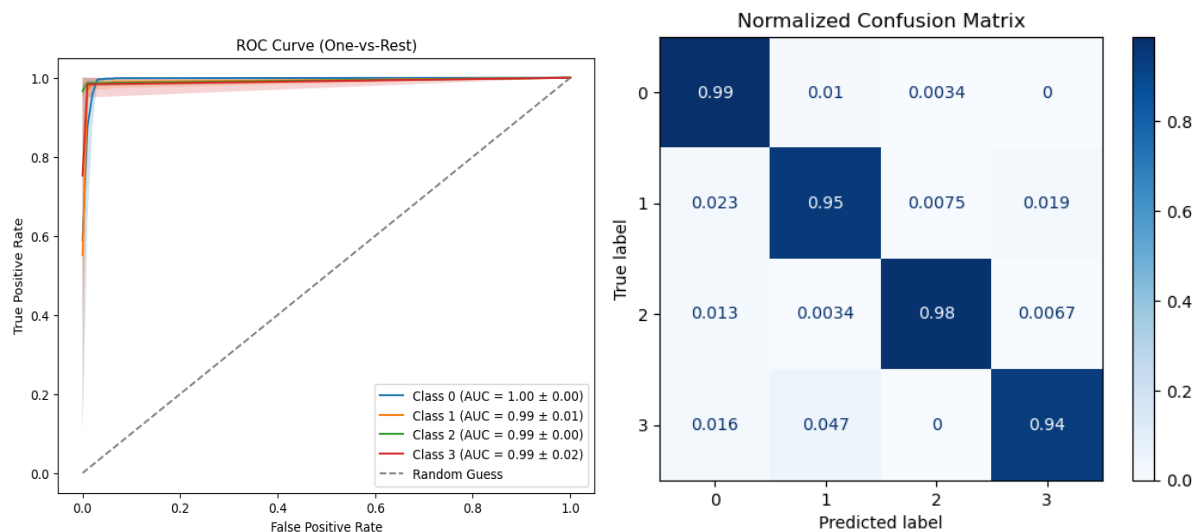Model Size: 1008.57 KB
ROC Curve and confusion matrix

3. KNeighborsClassifier

Accuracy: 0.9763 ± 0.0082
F1-Score: 0.9763 ± 0.0083
Kappa: 0.9594 ± 0.0141
MCC: 0.9597 ± 0.0140
Precision: 0.9773 ± 0.0084
Recall: 0.9763 ± 0.0082
Mean Training Time: 0.0004 seconds
Mean Testing Time: 0.0532 seconds
Mean Prediction Speed: 22631.01 predictions/second
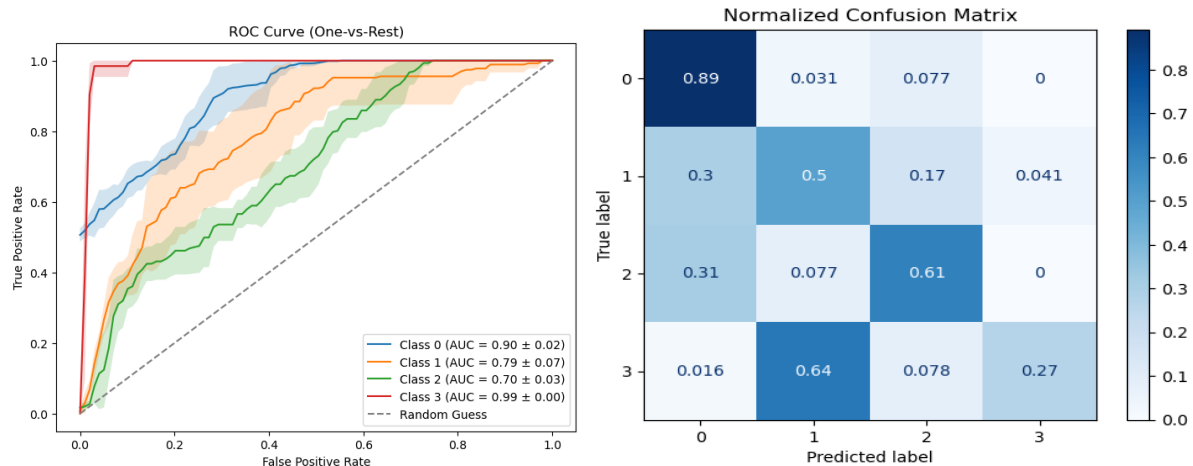Model Size: 171.53 KB
ROC Curve and confusion matrix

4. AdaBoostClassifier

Accuracy: 0.7405 ± 0.0253
F1-Score: 0.7300 ± 0.0291
Kappa: 0.5366 ± 0.0519
MCC: 0.5399 ± 0.0501
Precision: 0.7307 ± 0.0319
Recall: 0.7405 ± 0.0253
Mean Training Time: 1.1382 seconds
Mean Testing Time: 0.0463 seconds
Mean Prediction Speed: 6555.25 predictions/second
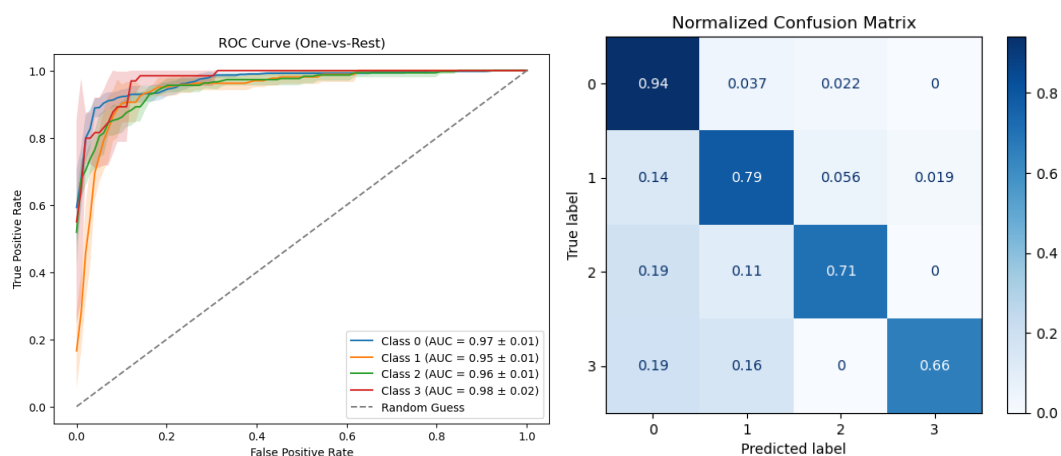Model Size: 121.32 KB
ROC Curve and confusion matrix

5. SVC

Accuracy: 0.8564 ± 0.0259
F1-Score: 0.8538 ± 0.0272
Kappa: 0.7475 ± 0.0486
MCC: 0.7503 ± 0.0472
Precision: 0.8587 ± 0.0256
Recall: 0.8564 ± 0.0259
Mean Training Time: 0.2622 seconds
Mean Testing Time: 0.0349 seconds
Mean Prediction Speed: 8739.58 predictions/second
Model Size: 88.24 KB
ROC Curve and confusion matrix

6. Voting

Accuracy: 0.9942 ± 0.0063
F1-Score: 0.9942 ± 0.0064
Kappa: 0.9902 ± 0.0108
MCC: 0.9903 ± 0.0106
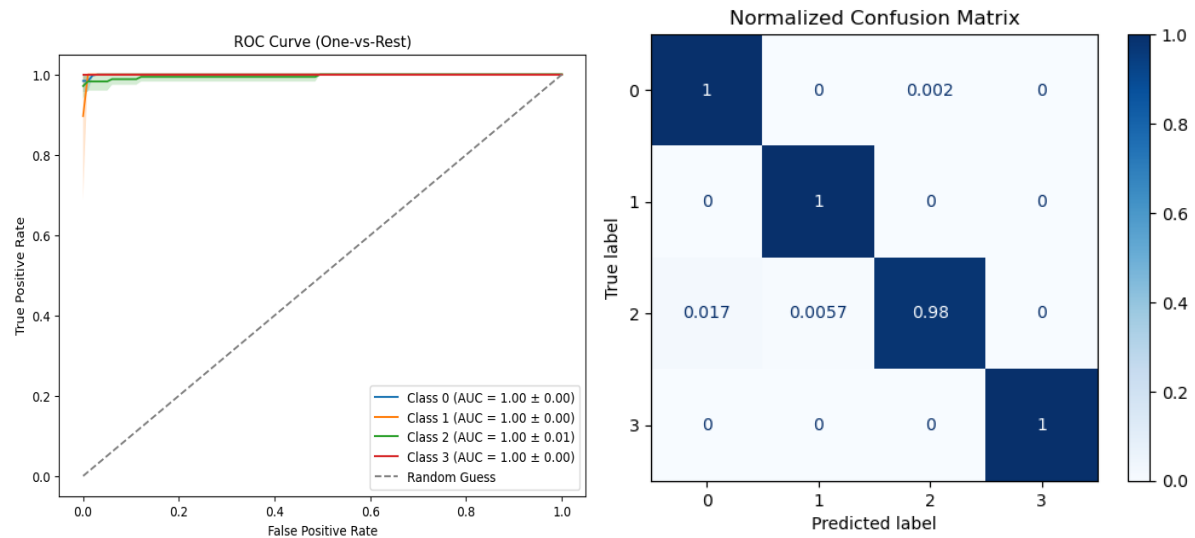Precision: 0.9944 ± 0.0061
Recall: 0.9942 ± 0.0063
Mean Training Time: 0.9227 seconds
Mean Testing Time: 0.0354 seconds
Mean Prediction Speed: 4899.48 predictions/second
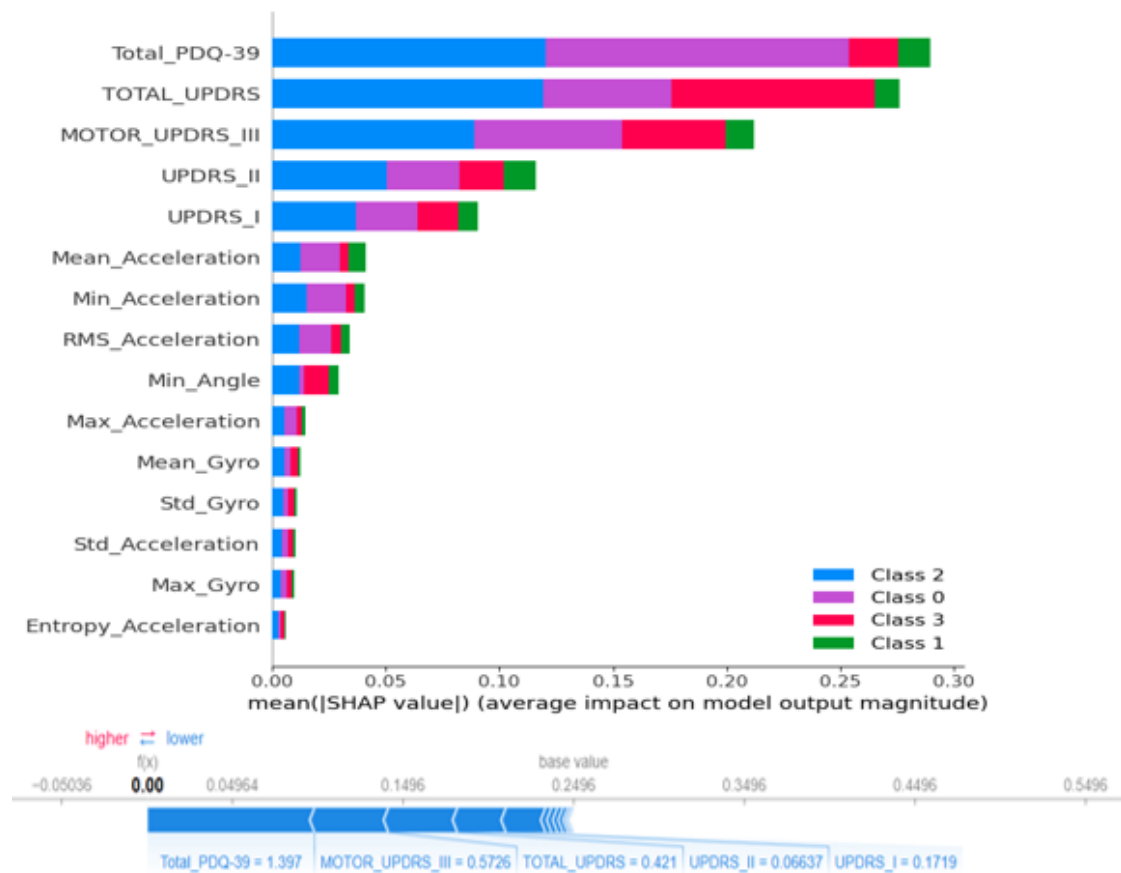Model Size: 3567.81 KB
ROC Curve and confusion matrix

Tabular Representation of Results for Both States (Postural + Rest): All Features

Classifier	Given Parameters	Selected Parameters	Accuracy	F1-Score	Kappa	MCC	Precision	Recall	Mean Training Time (s)	Mean Testing Time (s)	Mean Prediction Speed	Model Size (KB)
RandomForest	n_estimators: [100, 200, 300] max_depth: [None, 10, 20, 30] min_samples_split: [2, 5, 10] min_samples_leaf: [1, 2, 4] max_features: ['sqrt', 'log2']	n_estimators: 200 max_depth: None min_samples_split: 2 min_samples_leaf: 1 max_features: 'sqrt'	0.9717 ± 0.0128	0.9715 ± 0.0129	0.9517 ± 0.0216	0.9521 ± 0.0215	0.9726 ± 0.0126	0.9717 ± 0.0128	1.4595	0.0324	9541.47	4586.59
XGBClassifier	n_estimators: [100, 200, 300] max_depth: [3, 6, 9] learning_rate: [0.01, 0.1, 0.2] subsample: [0.8, 0.9, 1.0] colsample_bytree: [0.8, 0.9, 1.0] gamma: [0, 0.1, 0.2]	n_estimators: 200 max_depth: 9 learning_rate: 0.2 subsample: 1.0 colsample_bytree: 0.8 gamma: 0	0.9677 ± 0.0136	0.9677 ± 0.0136	0.9449 ± 0.0231	0.9453 ± 0.0230	0.9688 ± 0.0134	0.9677 ± 0.0136	0.5097	0.0045	68388.26	1008.57
KNeighborsClassifier	n_neighbors: [3, 5, 7, 9, 11] weights: ['uniform', 'distance'] metric: ['euclidean', 'manhattan', 'minkowski']	n_neighbors: 3 weights: 'distance' metric: 'manhattan'	0.9763 ± 0.0082	0.9763 ± 0.0083	0.9594 ± 0.0141	0.9597 ± 0.0140	0.9773 ± 0.0084	0.9763 ± 0.0082	0.0004	0.0532	22631.01	171.53
AdaBoostClassifier	n_estimators: [50, 100, 200] learning_rate: [0.01, 0.1, 1.0] algorithm: ['SAMME', 'SAMME.R']	n_estimators: 200 learning_rate: 1.0 algorithm: 'SAMME'	0.7405 ± 0.0253	0.7300 ± 0.0291	0.5366 ± 0.0519	0.5399 ± 0.0501	0.7307 ± 0.0319	0.7405 ± 0.0253	1.1382	0.0463	6555.25	121.32
SVC	C: [0.1, 1, 10] kernel: ['linear', 'rbf', 'poly'] gamma: ['scale', 'auto'] degree: [2, 3, 4]	C: 10 kernel: 'rbf' gamma: 'scale' degree: 2	0.8564 ± 0.0259	0.8538 ± 0.0272	0.7475 ± 0.0486	0.7503 ± 0.0472	0.8587 ± 0.0256	0.8564 ± 0.0259	0.2622	0.0349	8739.58	88.24
Voting Classifier	**Combines KNN, RF, and XGBoost**	Final Voting Model (details not provided)	**0.9942 ± 0.0063**	**0.9942 ± 0.0064**	**0.9902 ± 0.0108**	**0.9903 ± 0.0106**	**0.9944 ± 0.0061**	**0.9942 ± 0.0063**	**0.9227**	**0.0354**	**4899.48**	**3567.81**

Interpretability: PD severity