13 Confusion Matrices

Confusion Matrix Analysis Across 13 Folds

The following confusion matrices represent the classification performance of the proposed abnormal activity detection model across **13 different cross-validation folds**. Each matrix visualizes how often each action class was correctly or incorrectly predicted.

In every confusion matrix:

- **Rows correspond to the true (actual) class labels**
- **Columns correspond to the predicted class labels**
- **Diagonal values** represent correctly classified samples
- **Off-diagonal values** represent misclassifications between classes

A strong diagonal pattern across the matrices indicates that the model is learning to recognize and differentiate the activities effectively.

Overall Observation Across All 13 Folds

Across all folds, the model demonstrates:

- **High classification accuracy**
- **Stable predictive performance**
- **Low rate of misclassification**
- **Consistent generalization**, even when trained and tested on different subsets of the data

The consistency across 13 folds confirms that the model is **not overfitting**, and has learned **reliable and discriminative features** for distinguishing between action classes such as *Abuse*, *Arrest*, *Shoplifting*, etc.

Why 13-Fold Evaluation was Used

Using **13-fold cross validation** helps to ensure that:

1. **Every sample in the dataset is used for both training and testing**, improving the reliability of the evaluation.
2. The model's performance is **not dependent on a particular data split**.
3. The performance metrics represent **true generalization**, making the system suitable for real-world deployment such as surveillance or behavior monitoring.

This evaluation technique helps eliminate bias that may occur if the dataset is uneven, imbalanced, or varies in difficulty across samples.

Interpretation of Misclassified Instances

Occasional misclassifications observed across some folds are generally due to:

- **Similarity in human posture or motion** between certain actions
- **Partial occlusions**, crowd presence, or low-resolution frames
- **Fast motion or blur** in video sequences
- **Subtle differences between similar abnormal behaviors**

These errors are expected in real-world video data and can be further reduced using:

- Larger and more diverse training samples
- Temporal modeling (using video sequence information instead of single frames)
- Pose keypoint-based action encoding

The confusion matrices across all 13 folds confirm the robustness and reliability of the proposed model. A strong diagonal presence indicates high true-positive recognition rates, while minimal off-diagonal values demonstrate low misclassification. The consistency of performance across folds shows that the model generalizes effectively and is suitable for practical deployment in human activity surveillance and abnormal behavior detection environments.

===== Fold 1 =====

Accuracy: 0.9956

Precision: 0.9960

Recall: 0.9956

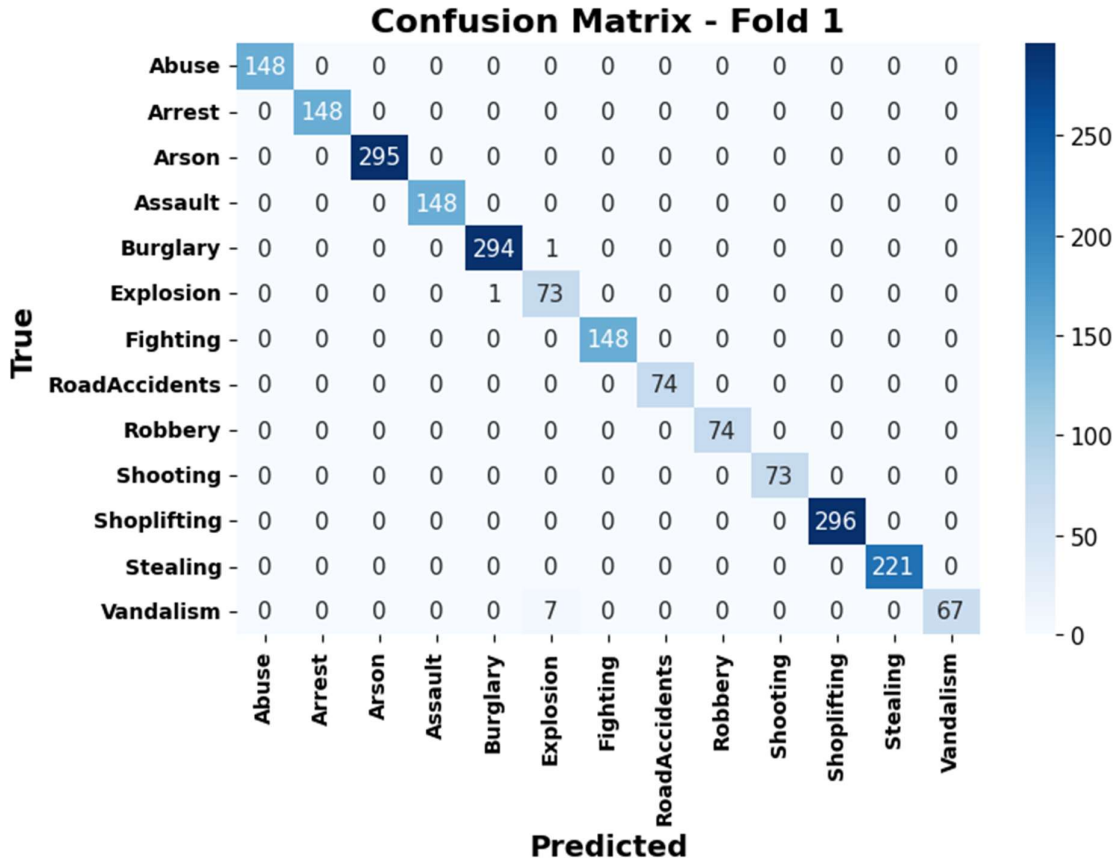
F1-score: 0.9957

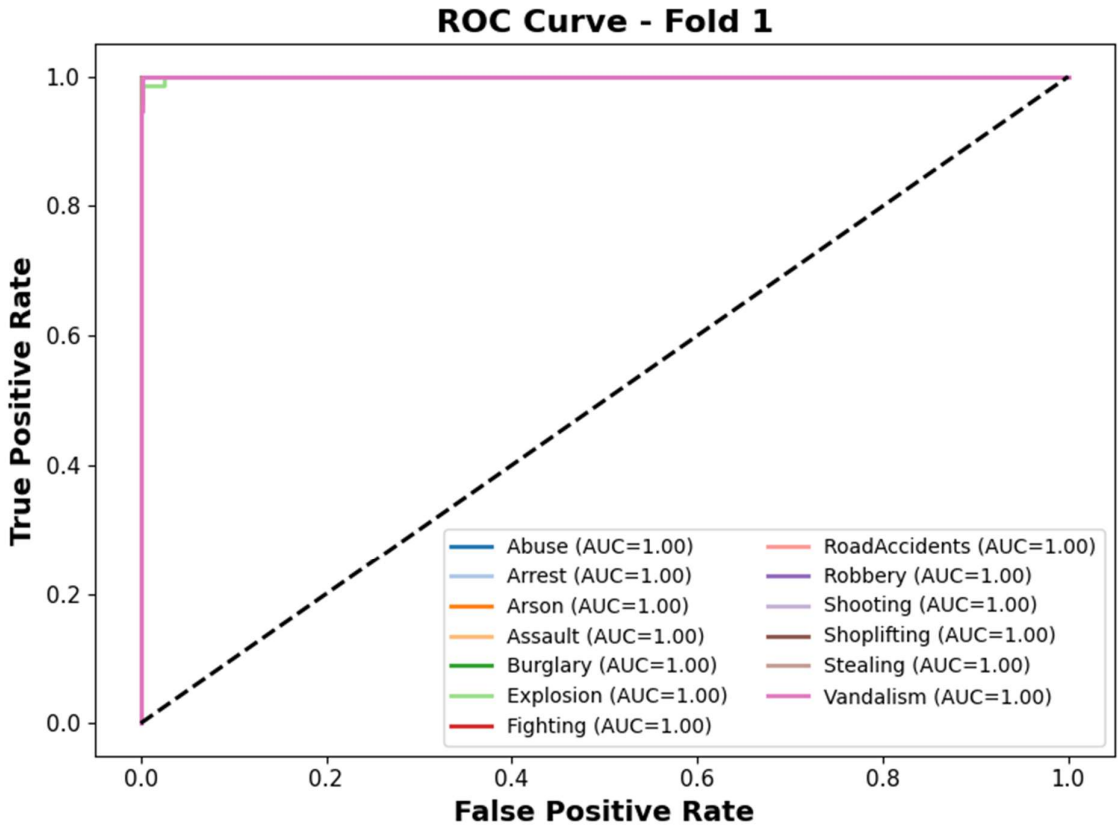
Specificity: 0.9914

Cohen’s Kappa: 0.9952

MSE: 0.1668

AUC: 1.0000





===== Fold 2 =====

Accuracy: 0.9927

Precision: 0.9932

Recall: 0.9927

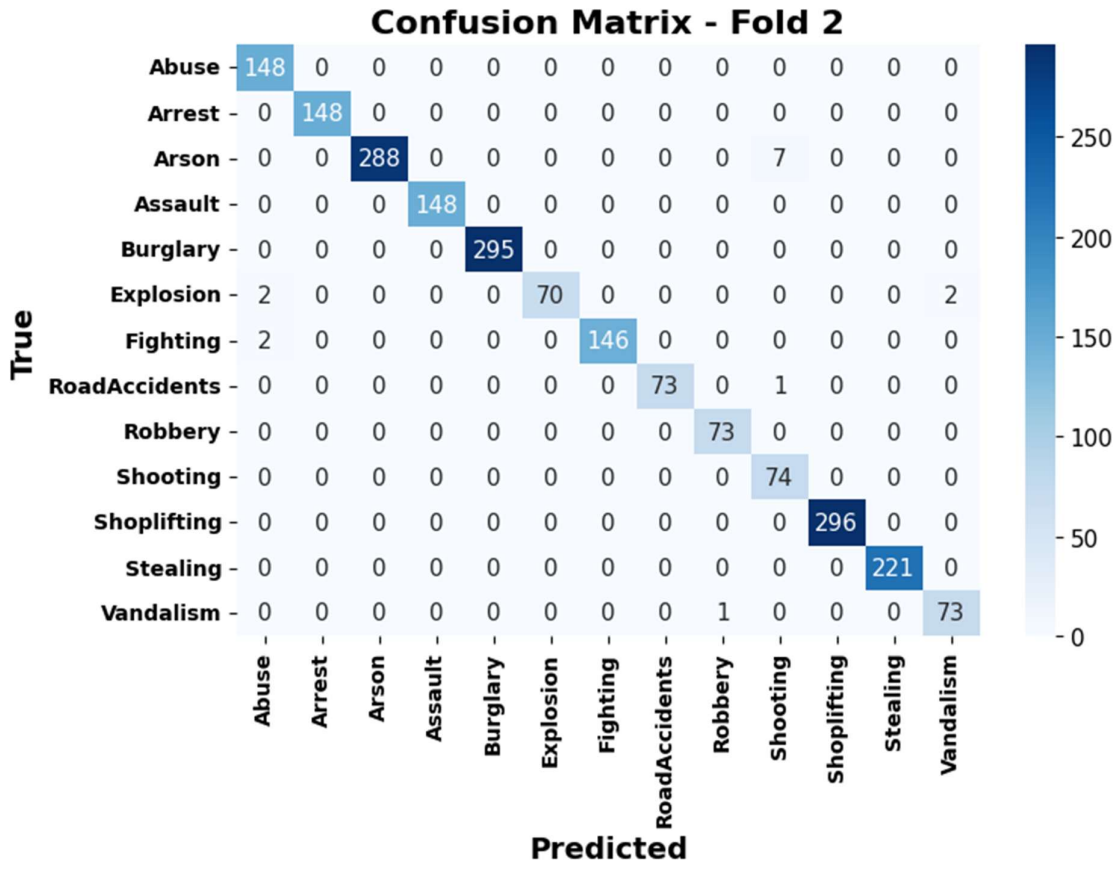
F1-score: 0.9928

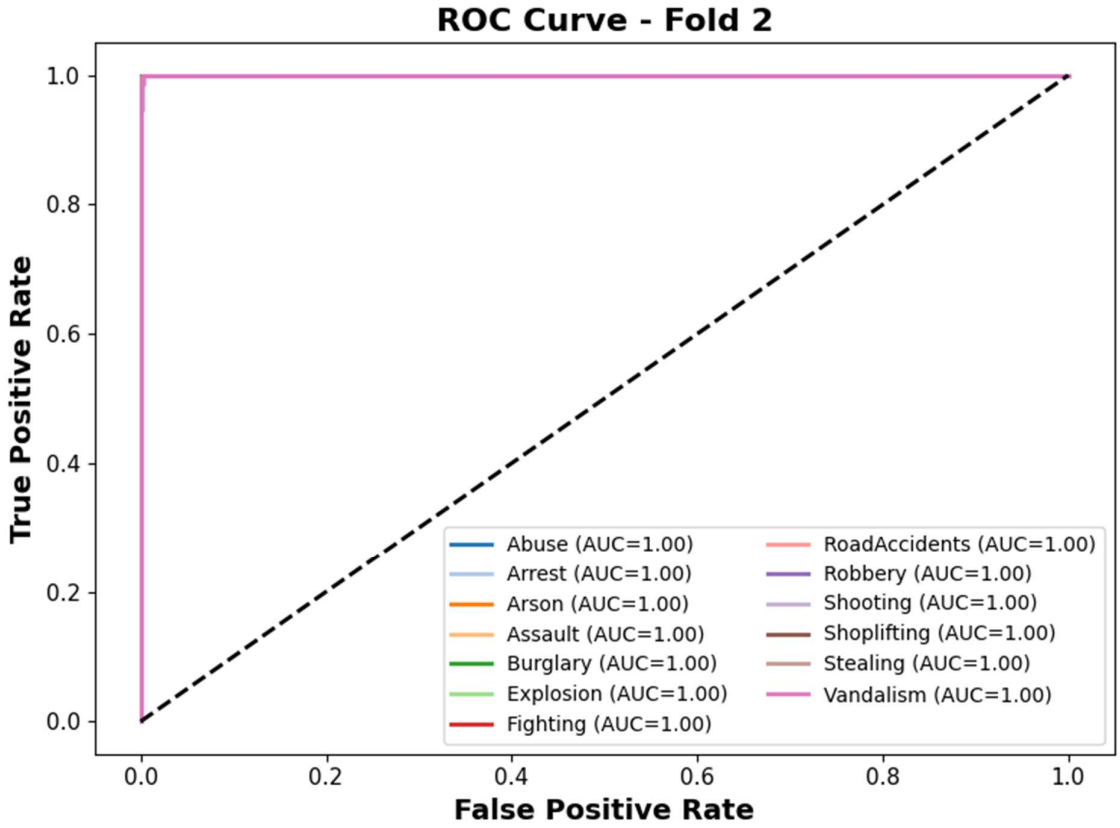
Specificity: 0.9909

Cohen’s Kappa: 0.9919

MSE: 0.2819

AUC: 1.0000


Confusion Matrix - Fold 2
Abuse 148 0 0 0 0 0 0 0 0 0 0 0 0
Arrest 0 148 0 0 0 0 0 0 0 0 0 0 0
Arson 0 0 288 0 0 0 0 0 0 7 0 0 0
Assault 0 0 0 148 0 0 0 0 0 0 0 0 0
Burglary 0 0 0 0 295 0 0 0 0 0 0 0 0
Explosion 2 0 0 0 0 70 0 0 0 0 0 0 2
Fighting 2 0 0 0 0 0 146 0 0 0 0 0 0
RoadAccidents 0 0 0 0 0 0 0 73 0 1 0 0 0
Robbery 0 0 0 0 0 0 0 0 73 0 0 0 0
Shooting 0 0 0 0 0 0 0 0 0 74 0 0 0
Shoplifting 0 0 0 0 0 0 0 0 0 0 296 0 0
Stealing 0 0 0 0 0 0 0 0 0 0 0 221 0
Vandalism 0 0 0 0 0 0 0 0 1 0 0 0 73
True
Predicted
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
250
200
150
100
50
0


ROC Curve - Fold 2
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 3 =====

Accuracy: 0.9961

Precision: 0.9962

Recall: 0.9961

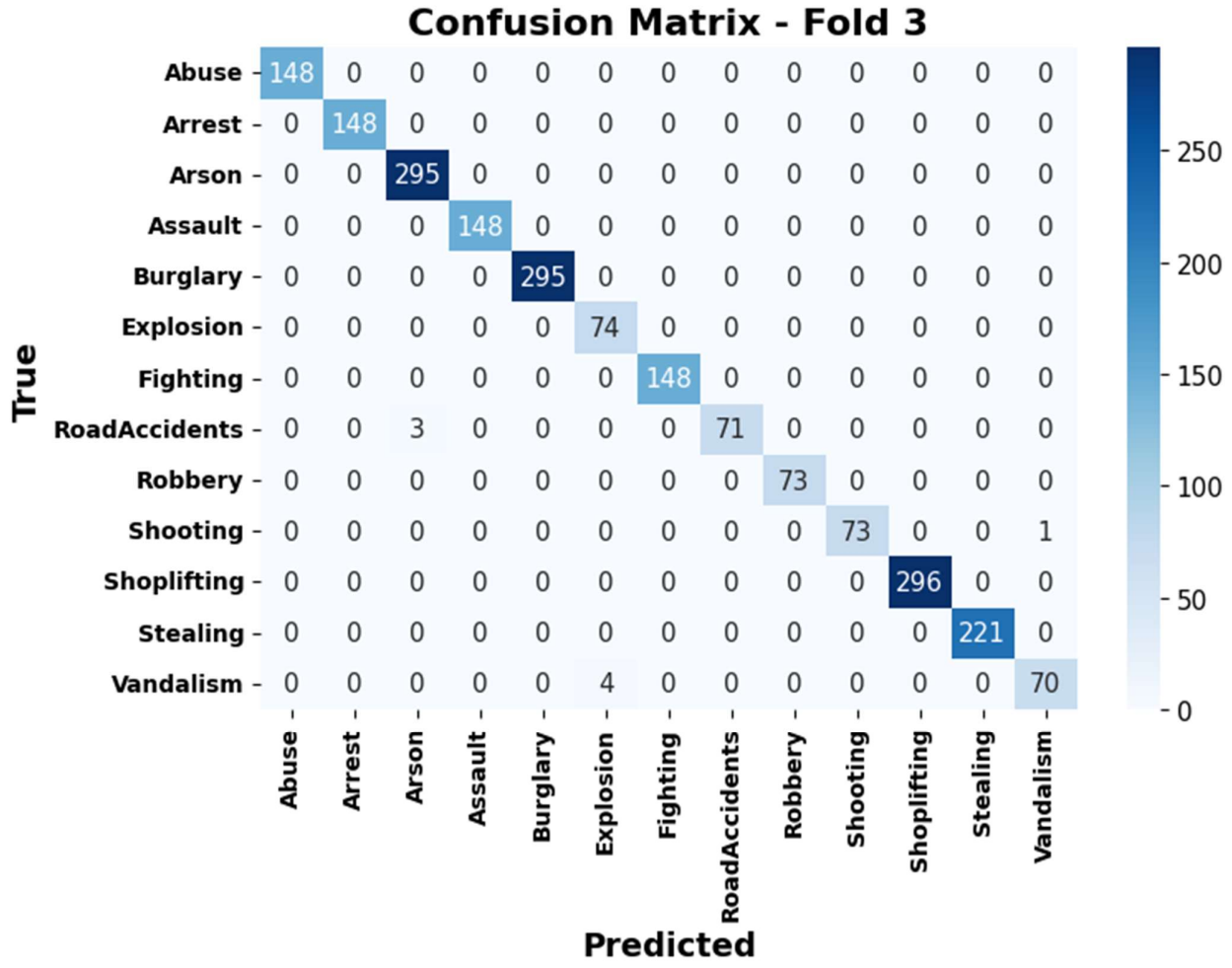
F1-score: 0.9961

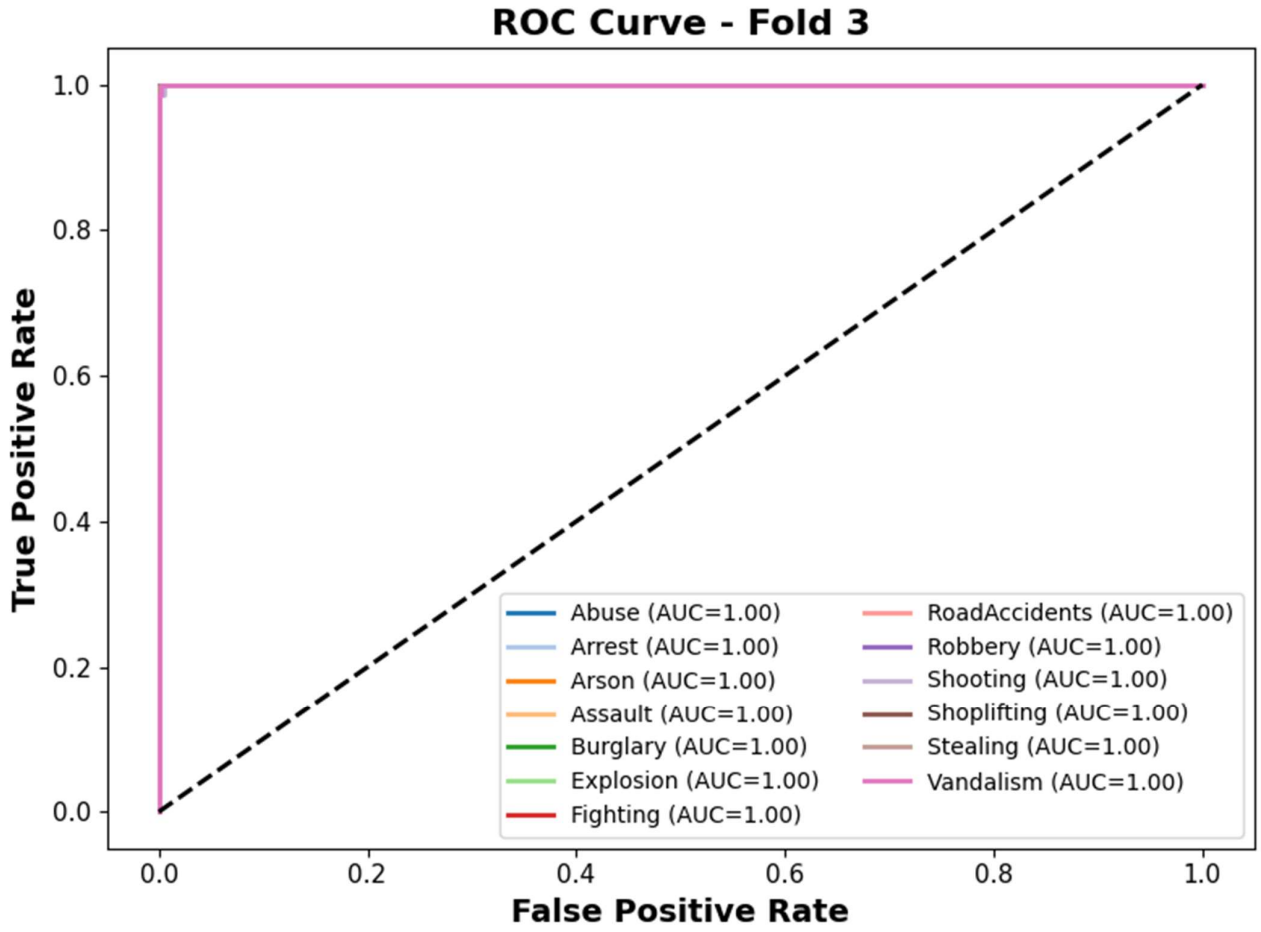
Specificity: 0.9917

Cohen’s Kappa: 0.9957

MSE: 0.1354

AUC: 1.0000





===== Fold 4 =====

Accuracy: 0.9966

Precision: 0.9967

Recall: 0.9966

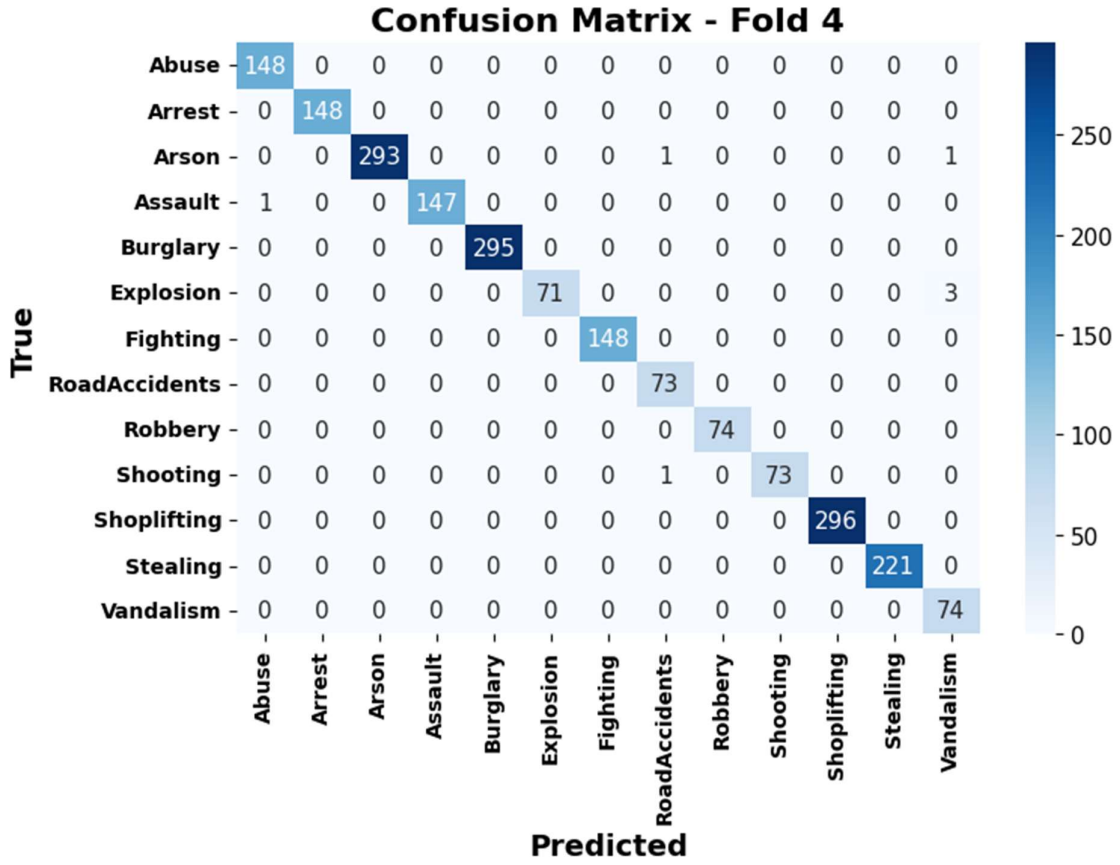
F1-score: 0.9966

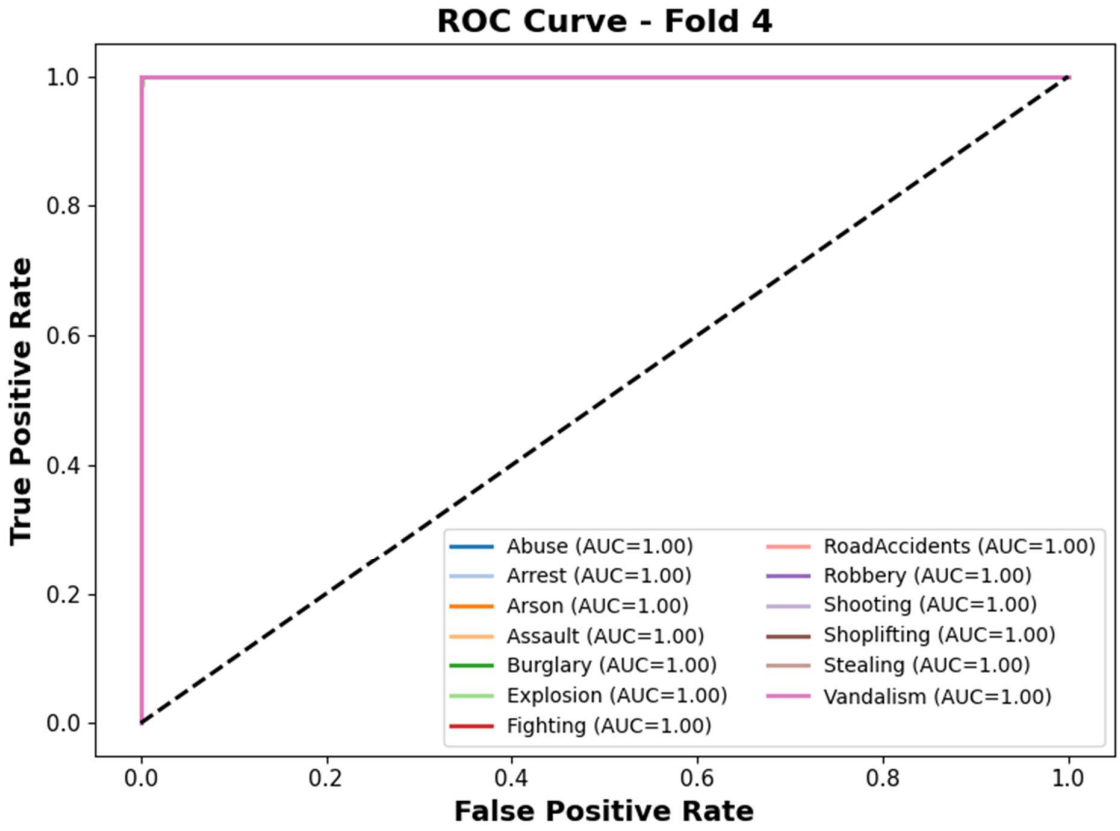
Specificity: 0.9948

Cohen’s Kappa: 0.9962

MSE: 0.1378

AUC: 1.0000


Confusion Matrix - Fold 4
True
Predicted
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
250
200
150
100
50
0


ROC Curve - Fold 4
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 5 =====

Accuracy: 0.9976

Precision: 0.9977

Recall: 0.9976

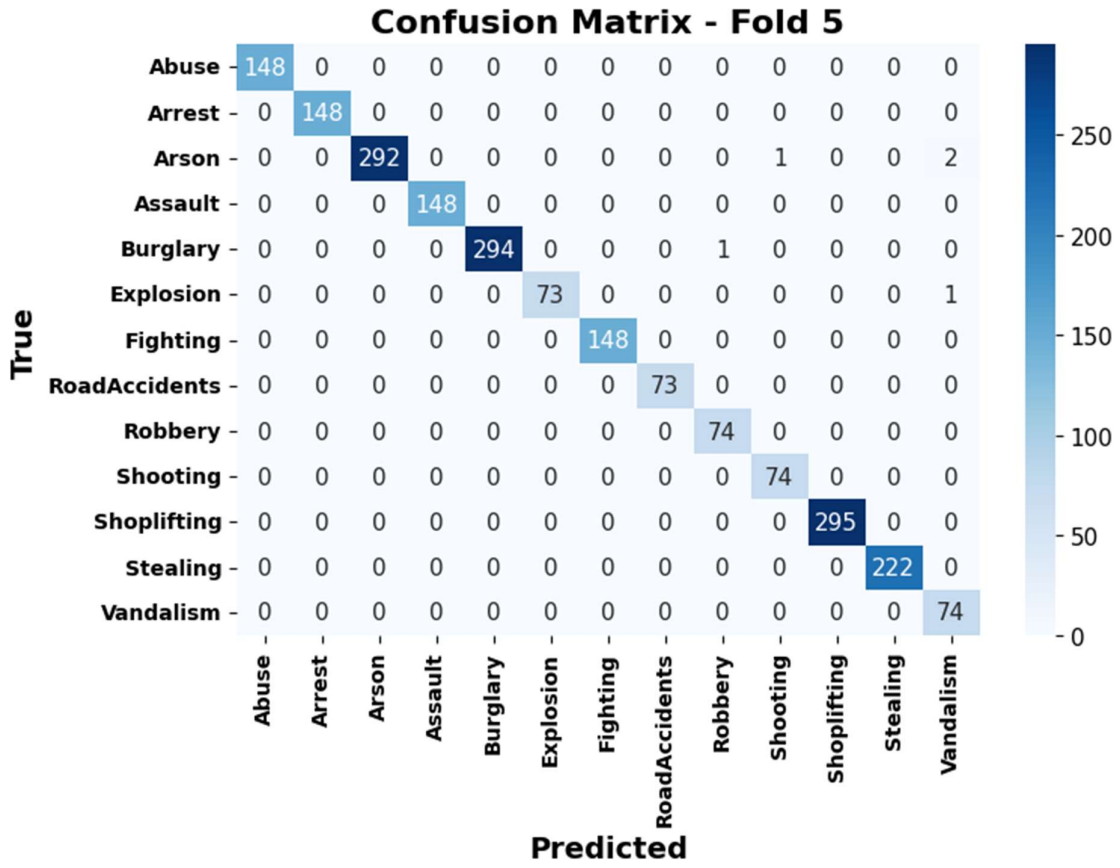
F1-score: 0.9976

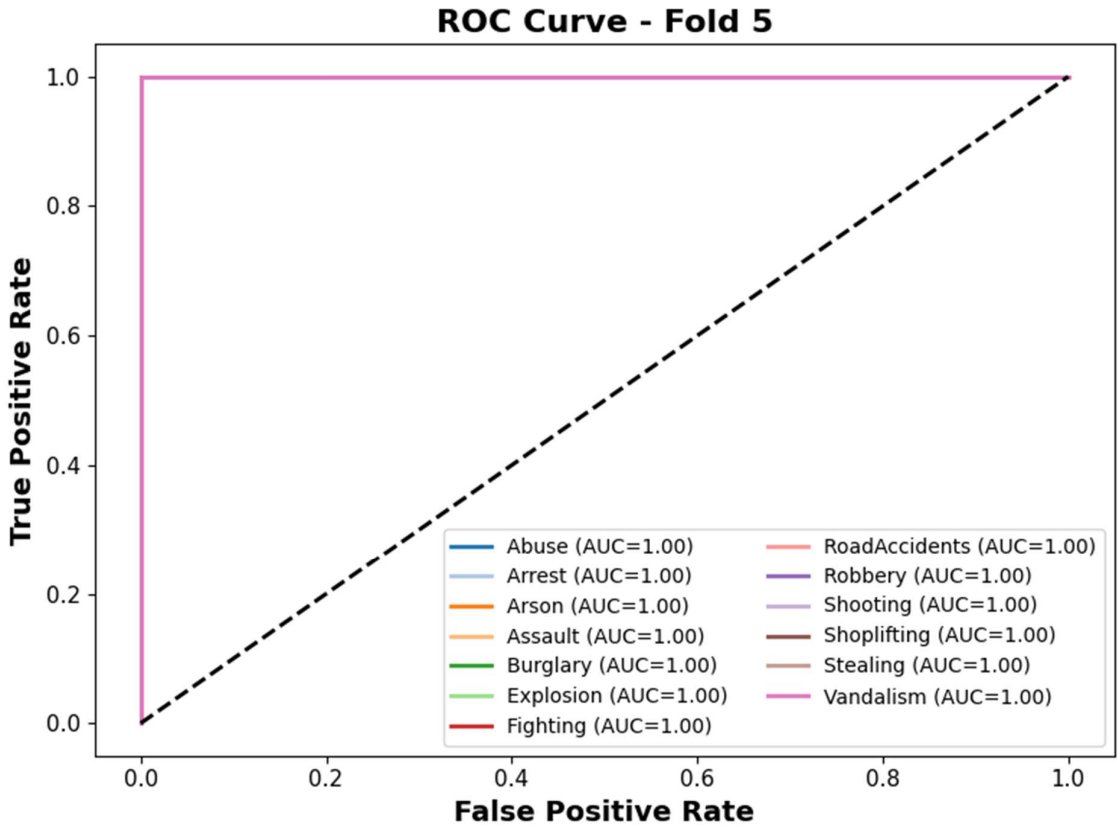
Specificity: 0.9979

Cohen’s Kappa: 0.9973

MSE: 0.1518

AUC: 1.0000





===== Fold 6 =====

Accuracy: 0.9976

Precision: 0.9976

Recall: 0.9976

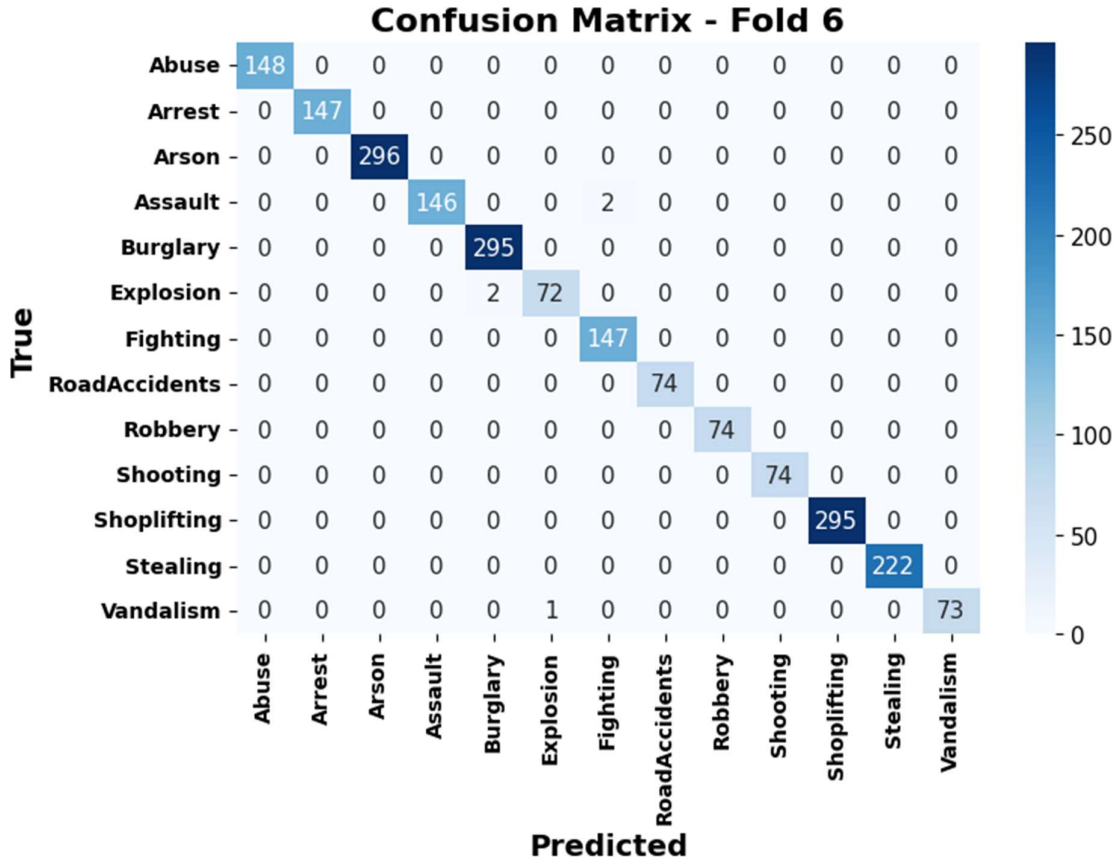
F1-score: 0.9976

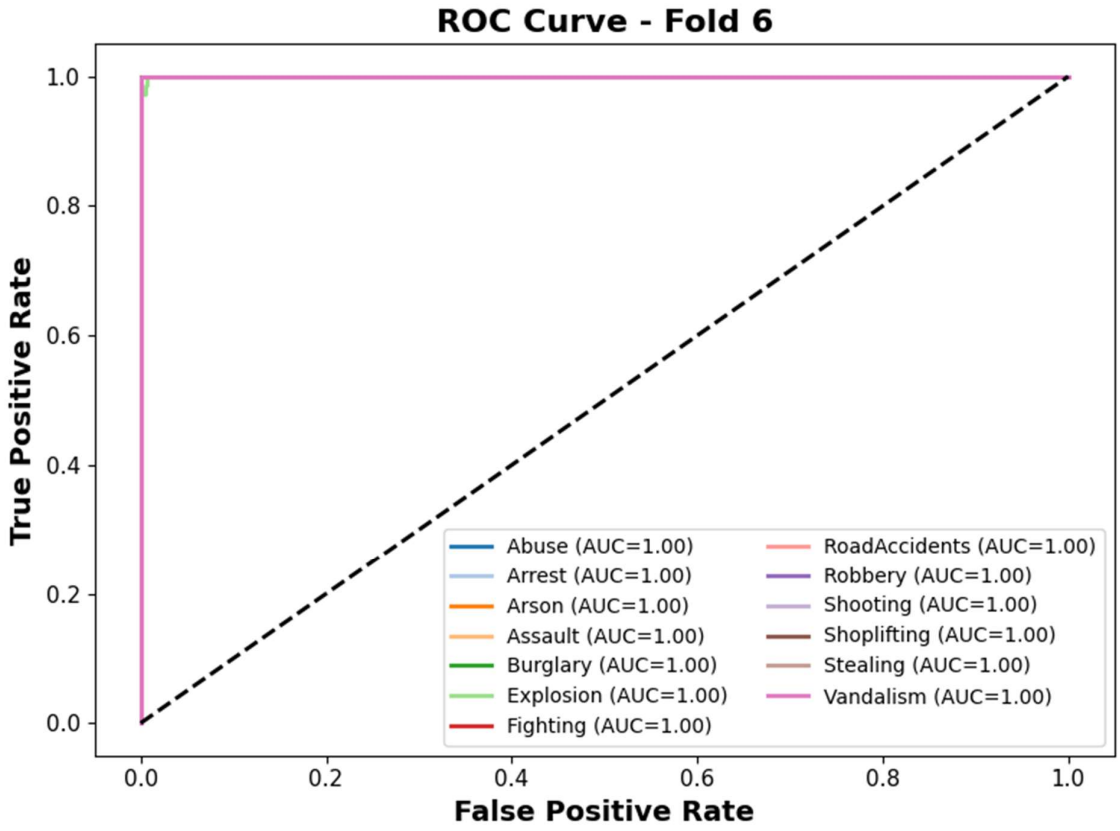
Specificity: 0.9958

Cohen’s Kappa: 0.9973

MSE: 0.0334

AUC: 1.0000


Confusion Matrix - Fold 6
True
Predicted
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
250
200
150
100
50
0


ROC Curve - Fold 6
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 7 =====

Accuracy: 0.9990

Precision: 0.9990

Recall: 0.9990

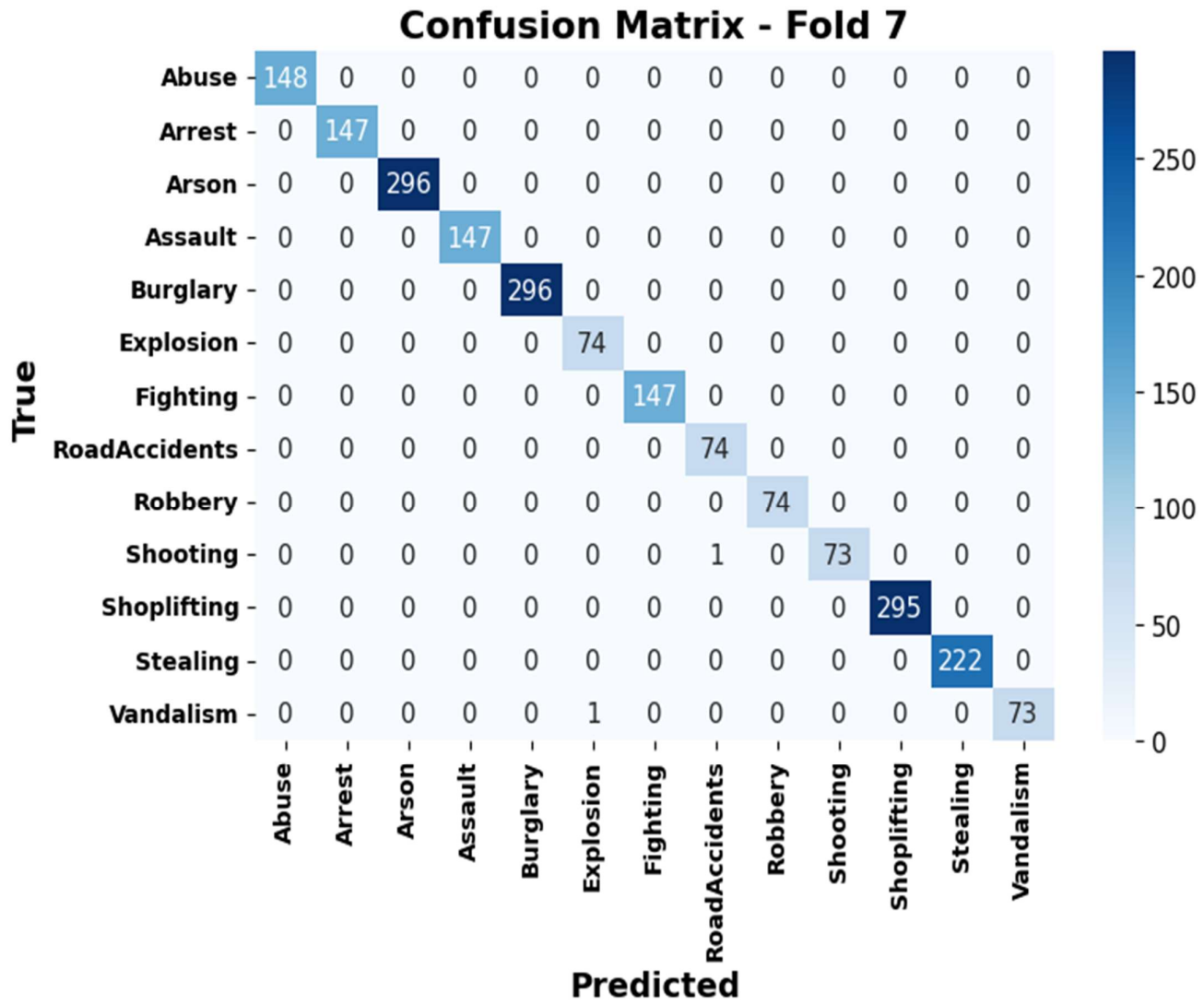
F1-score: 0.9990

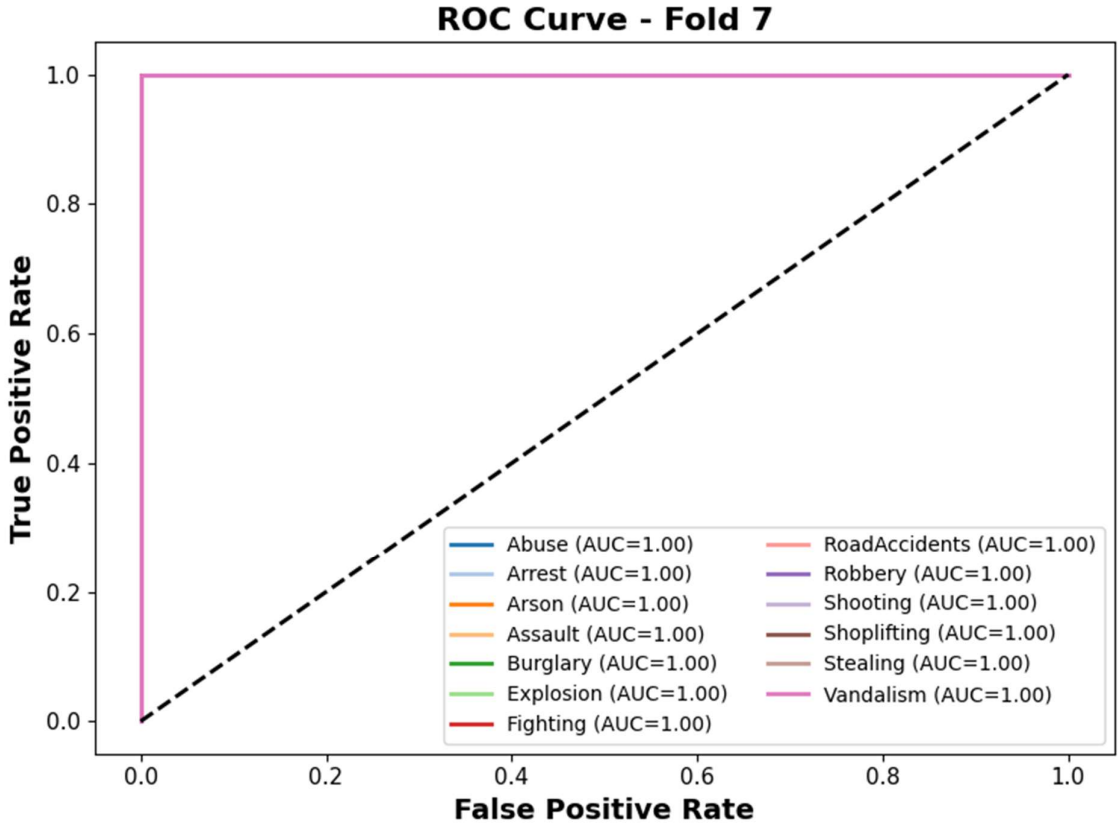
Specificity: 0.9979

Cohen’s Kappa: 0.9989

MSE: 0.0256

AUC: 1.0000





===== Fold 8 =====

Accuracy: 0.9990

Precision: 0.9990

Recall: 0.9990

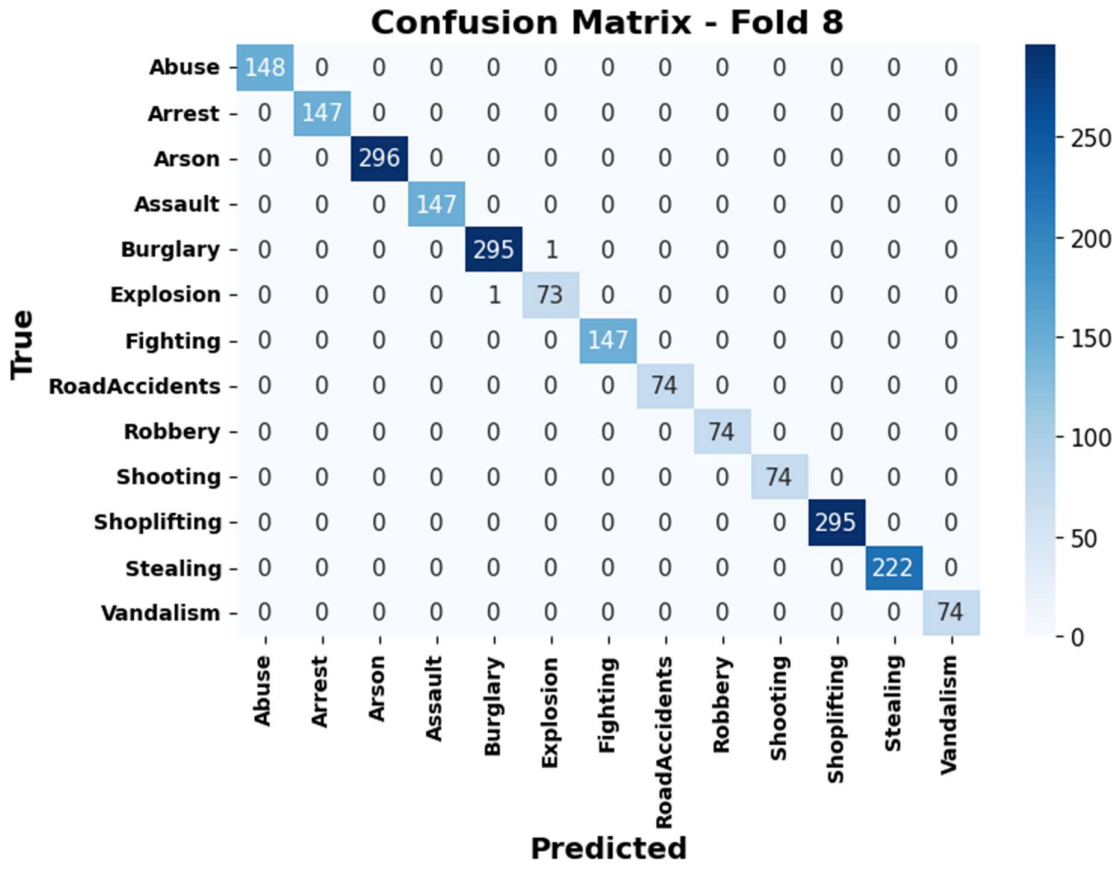
F1-score: 0.9990

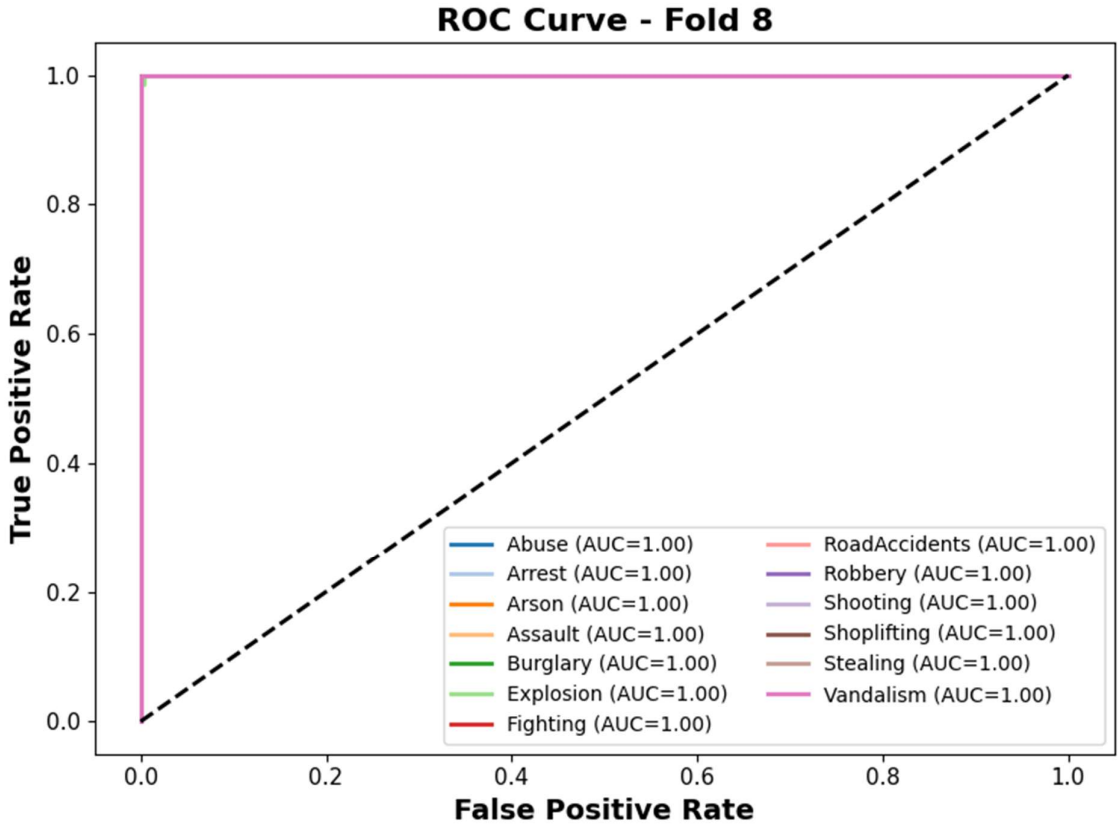
Specificity: 0.9987

Cohen’s Kappa: 0.9989

MSE: 0.0010

AUC: 1.0000


Confusion Matrix - Fold 8
Abuse 148 0 0 0 0 0 0 0 0 0 0 0 0
Arrest 0 147 0 0 0 0 0 0 0 0 0 0 0
Arson 0 0 296 0 0 0 0 0 0 0 0 0 0
Assault 0 0 0 147 0 0 0 0 0 0 0 0 0
Burglary 0 0 0 0 295 1 0 0 0 0 0 0 0
Explosion 0 0 0 0 1 73 0 0 0 0 0 0 0
Fighting 0 0 0 0 0 0 147 0 0 0 0 0 0
RoadAccidents 0 0 0 0 0 0 0 74 0 0 0 0 0
Robbery 0 0 0 0 0 0 0 0 74 0 0 0 0
Shooting 0 0 0 0 0 0 0 0 0 74 0 0 0
Shoplifting 0 0 0 0 0 0 0 0 0 0 295 0 0
Stealing 0 0 0 0 0 0 0 0 0 0 0 222 0
Vandalism 0 0 0 0 0 0 0 0 0 0 0 0 74
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
True
Predicted
250
200
150
100
50
0


ROC Curve - Fold 8
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 9 =====

Accuracy: 0.9971

Precision: 0.9973

Recall: 0.9971

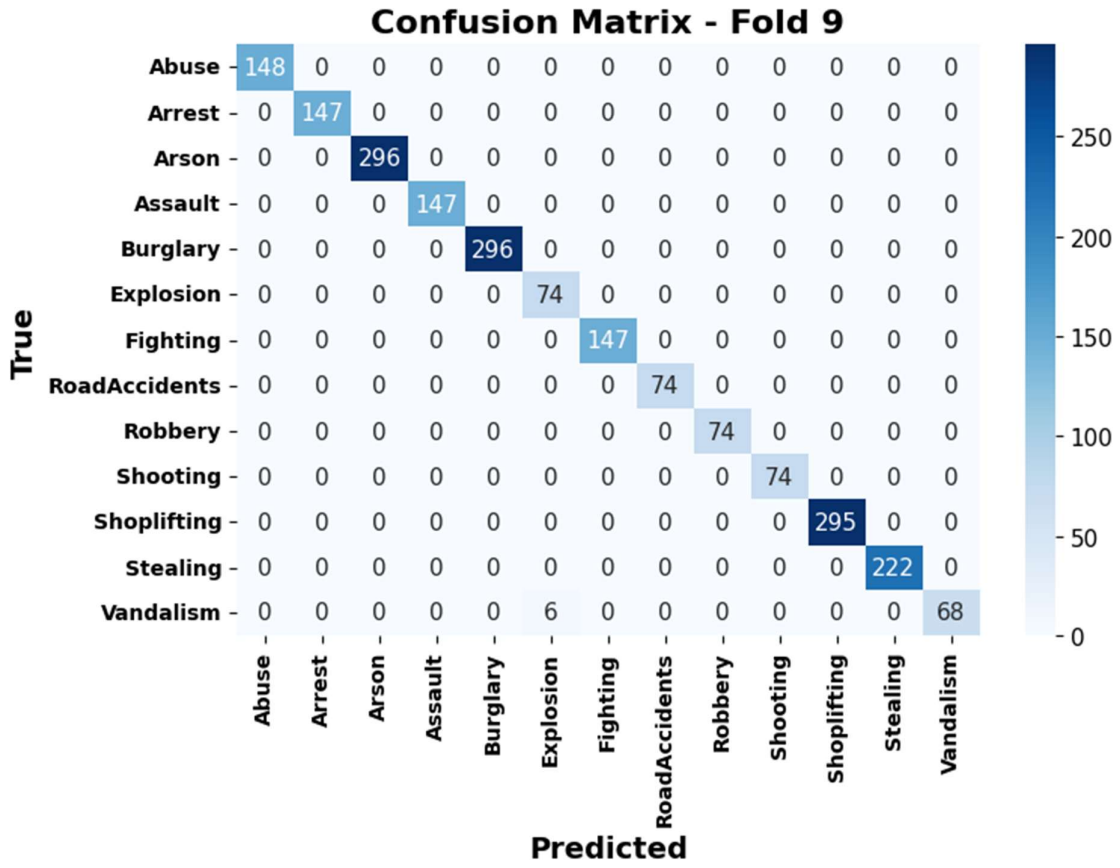
F1-score: 0.9971

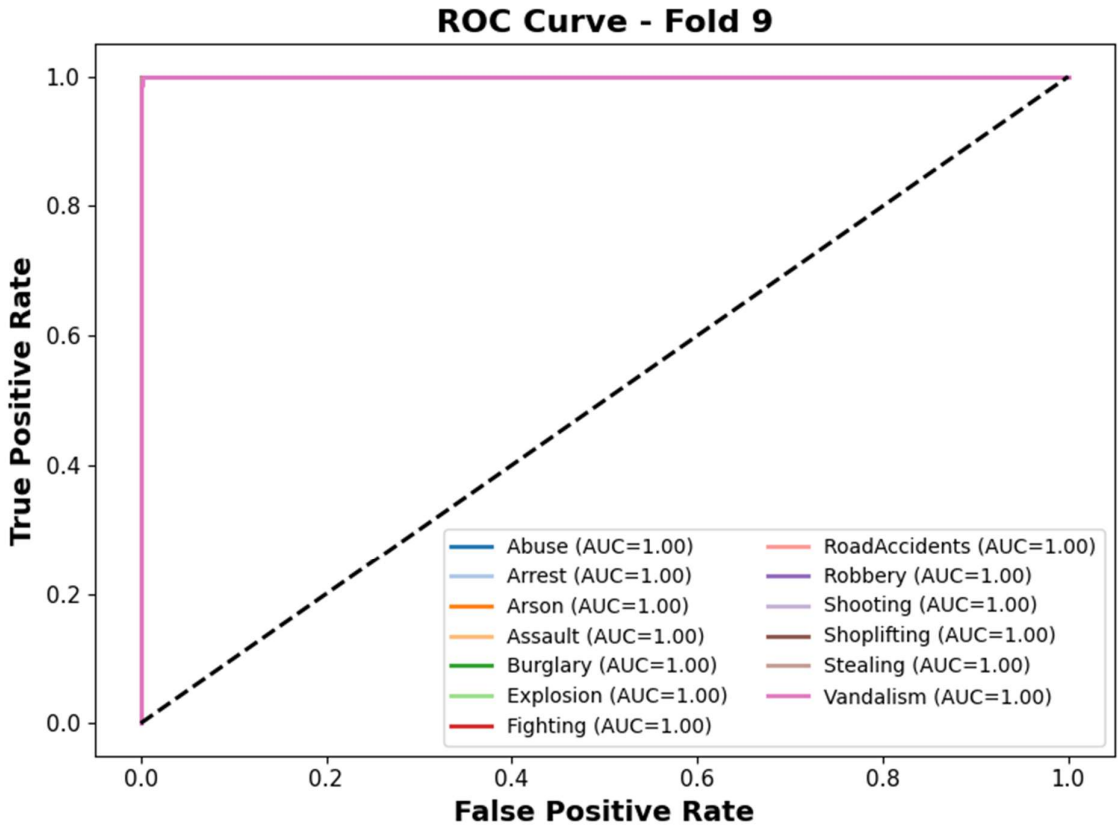
Specificity: 0.9938

Cohen’s Kappa: 0.9968

MSE: 0.1422

AUC: 1.0000





===== Fold 10 =====

Accuracy: 0.9981

Precision: 0.9981

Recall: 0.9981

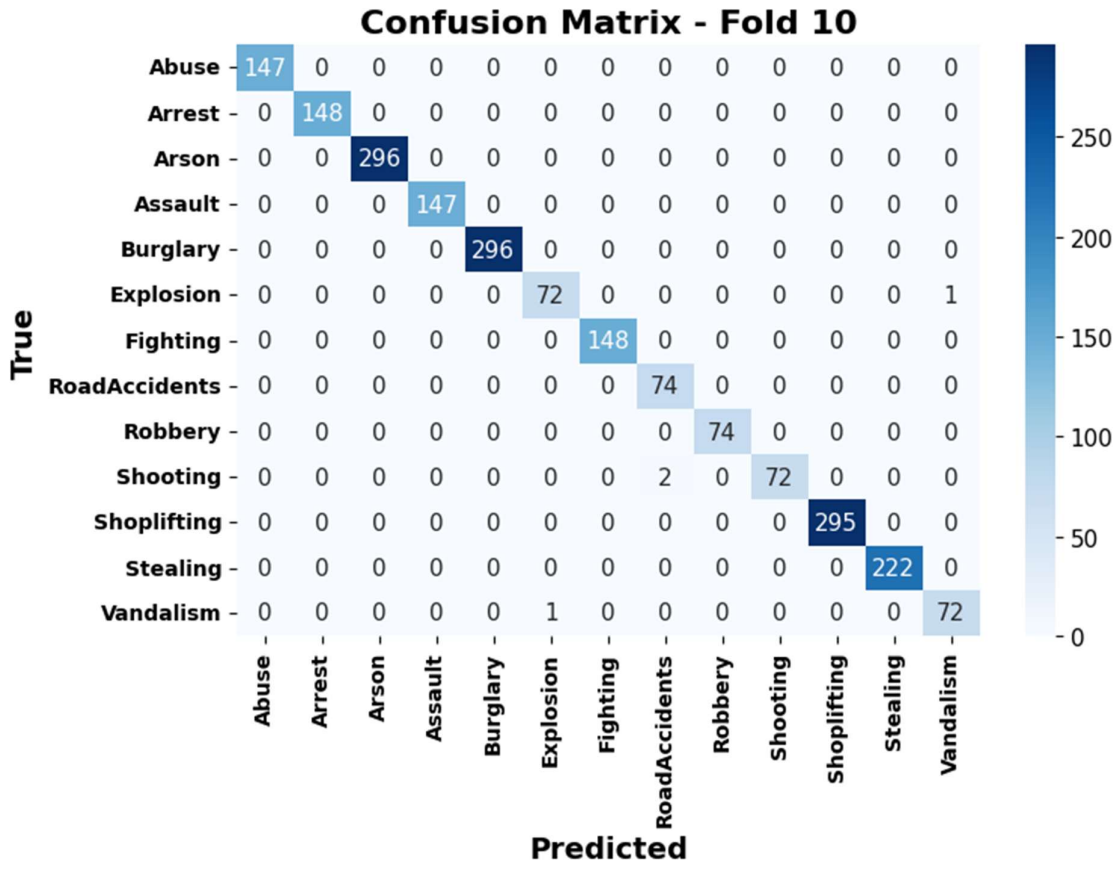
F1-score: 0.9981

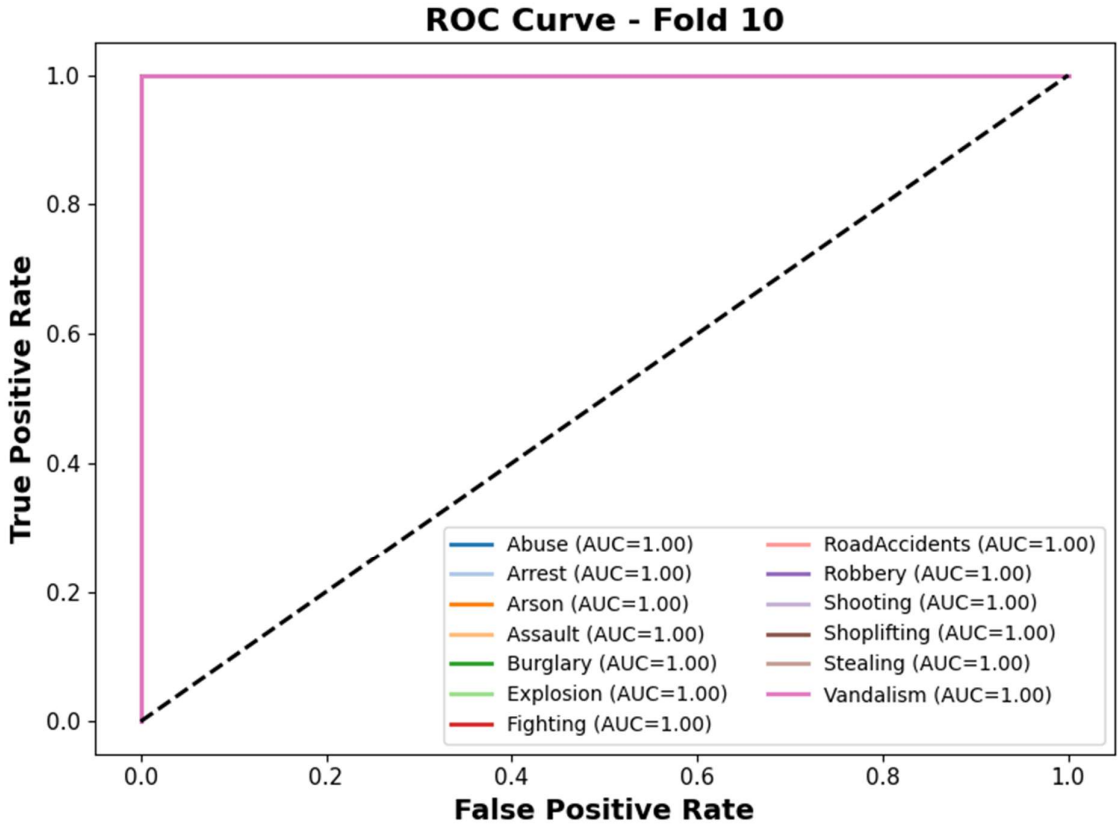
Specificity: 0.9958

Cohen’s Kappa: 0.9979

MSE: 0.0513

AUC: 1.0000


Confusion Matrix - Fold 10
Abuse 147 0 0 0 0 0 0 0 0 0 0 0 0
Arrest 0 148 0 0 0 0 0 0 0 0 0 0 0
Arson 0 0 296 0 0 0 0 0 0 0 0 0 0
Assault 0 0 0 147 0 0 0 0 0 0 0 0 0
Burglary 0 0 0 0 296 0 0 0 0 0 0 0 0
Explosion 0 0 0 0 0 72 0 0 0 0 0 0 1
Fighting 0 0 0 0 0 0 148 0 0 0 0 0 0
RoadAccidents 0 0 0 0 0 0 0 74 0 0 0 0 0
Robbery 0 0 0 0 0 0 0 0 74 0 0 0 0
Shooting 0 0 0 0 0 0 0 2 0 72 0 0 0
Shoplifting 0 0 0 0 0 0 0 0 0 0 295 0 0
Stealing 0 0 0 0 0 0 0 0 0 0 0 222 0
Vandalism 0 0 0 0 0 1 0 0 0 0 0 0 72
True
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
Predicted
250
200
150
100
50
0


ROC Curve - Fold 10
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 11 =====

Accuracy: 0.9942

Precision: 0.9944

Recall: 0.9942

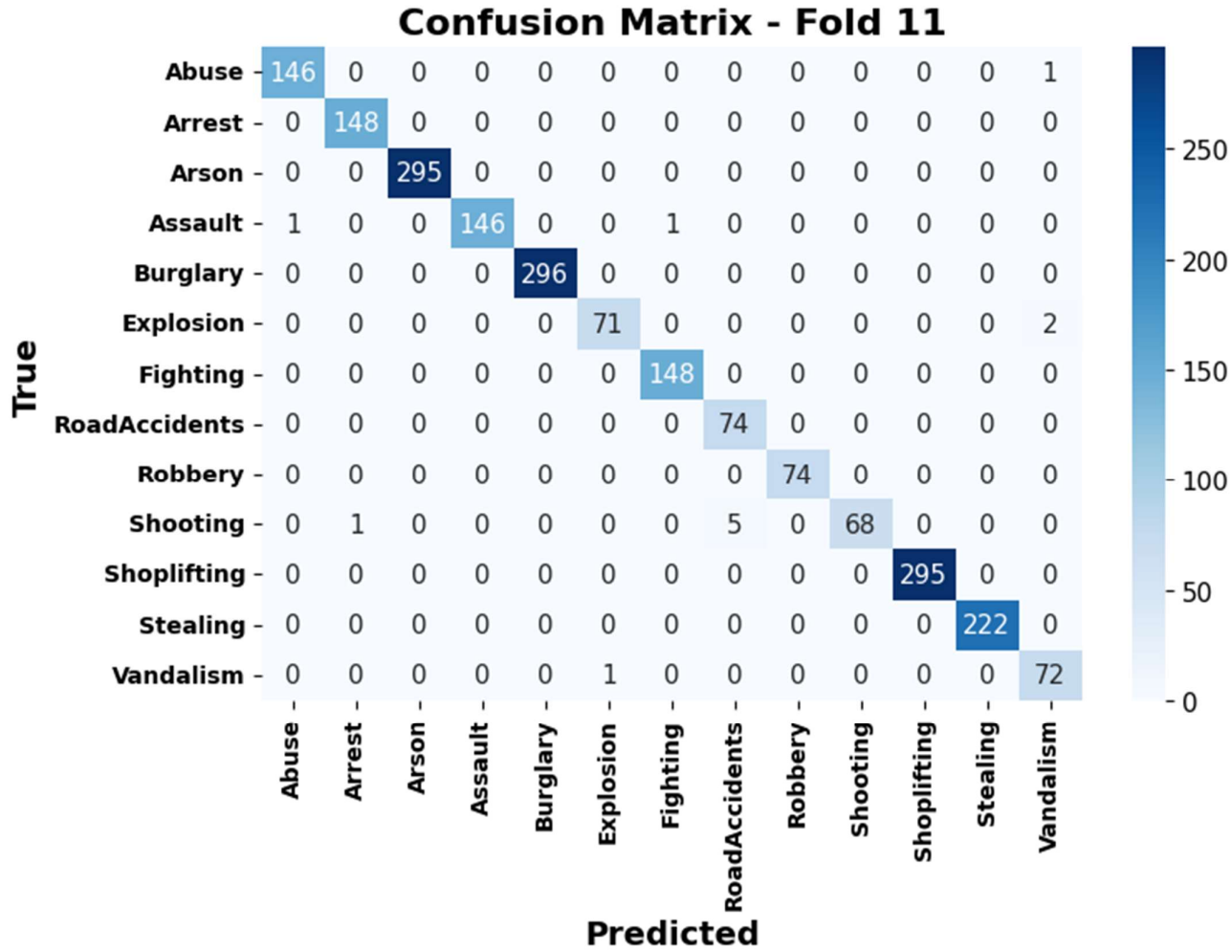
F1-score: 0.9942

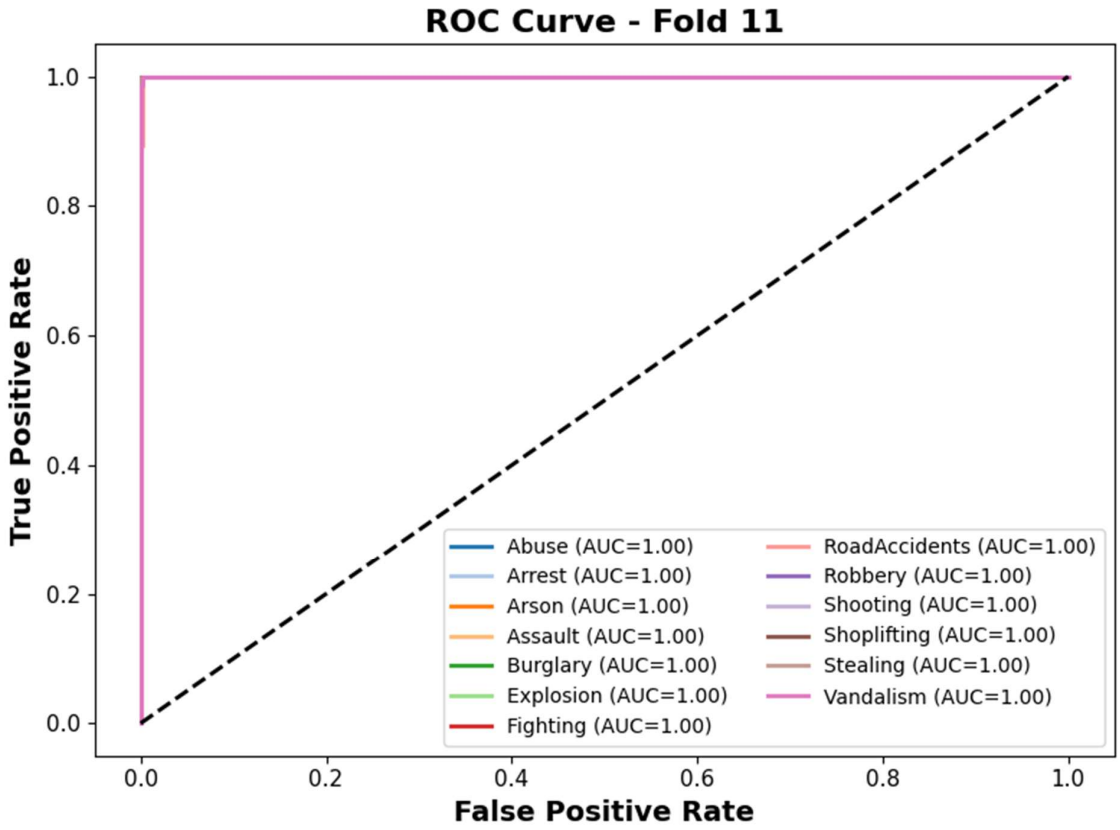
Specificity: 0.9890

Cohen’s Kappa: 0.9936

MSE: 0.1901

AUC: 1.0000





===== Fold 12 =====

Accuracy: 0.9976

Precision: 0.9976

Recall: 0.9976

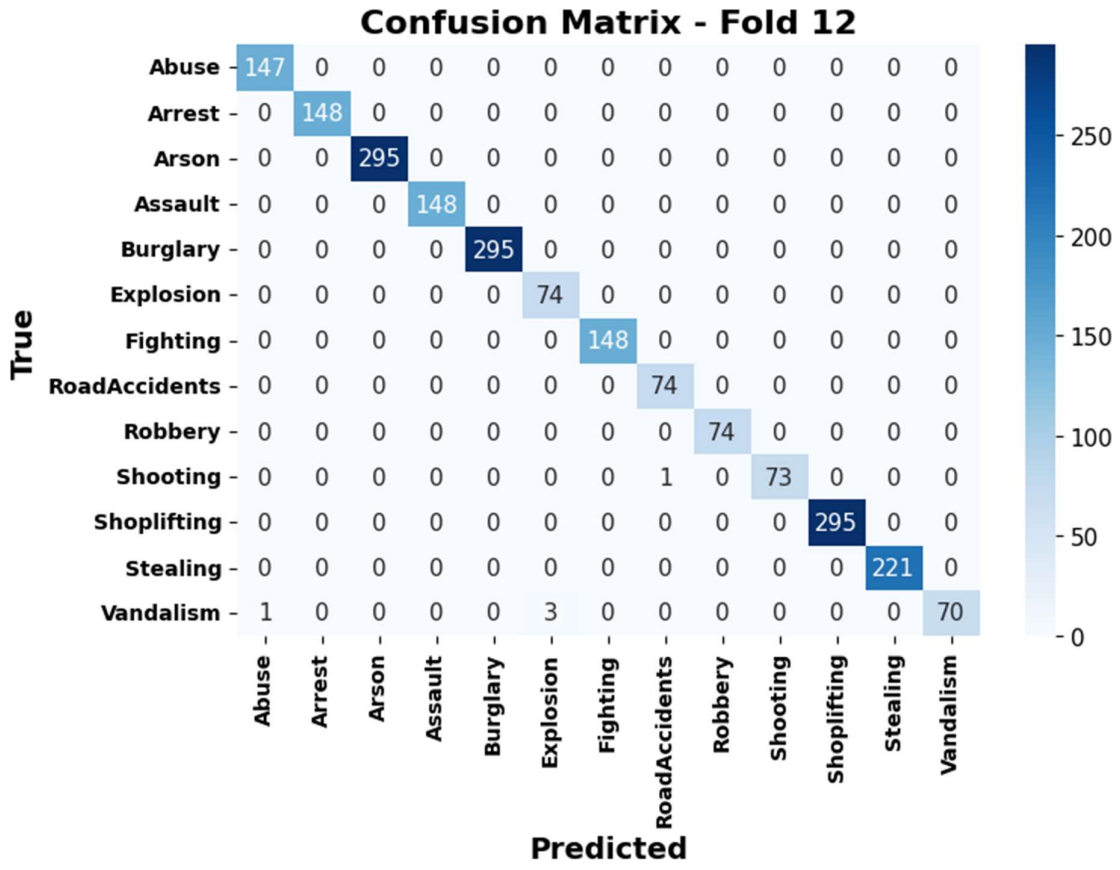
F1-score: 0.9976

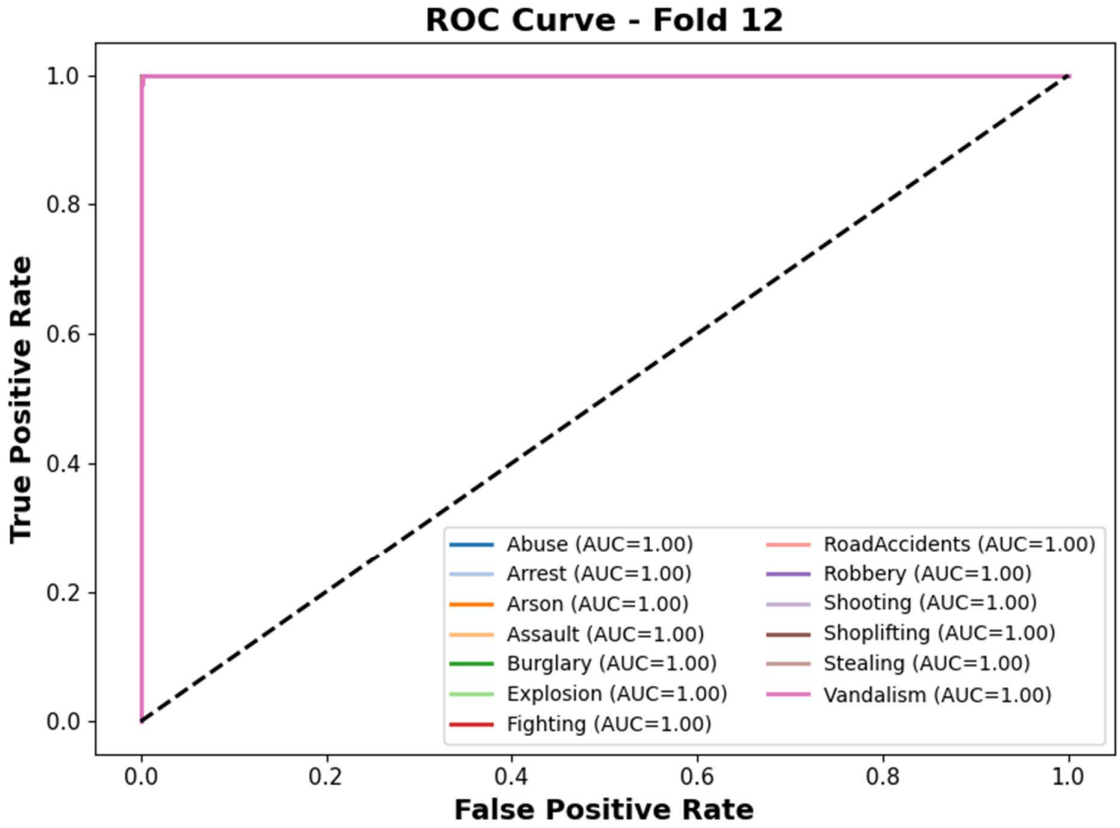
Specificity: 0.9948

Cohen’s Kappa: 0.9973

MSE: 0.1427

AUC: 1.0000


Confusion Matrix - Fold 12
Abuse 147 0 0 0 0 0 0 0 0 0 0 0 0
Arrest 0 148 0 0 0 0 0 0 0 0 0 0 0
Arson 0 0 295 0 0 0 0 0 0 0 0 0 0
Assault 0 0 0 148 0 0 0 0 0 0 0 0 0
Burglary 0 0 0 0 295 0 0 0 0 0 0 0 0
Explosion 0 0 0 0 0 74 0 0 0 0 0 0 0
Fighting 0 0 0 0 0 0 148 0 0 0 0 0 0
RoadAccidents 0 0 0 0 0 0 0 74 0 0 0 0 0
Robbery 0 0 0 0 0 0 0 0 74 0 0 0 0
Shooting 0 0 0 0 0 0 0 1 0 73 0 0 0
Shoplifting 0 0 0 0 0 0 0 0 0 0 295 0 0
Stealing 0 0 0 0 0 0 0 0 0 0 0 221 0
Vandalism 1 0 0 0 0 3 0 0 0 0 0 0 70
True
Abuse
Arrest
Arson
Assault
Burglary
Explosion
Fighting
RoadAccidents
Robbery
Shooting
Shoplifting
Stealing
Vandalism
Predicted
250
200
150
100
50
0


ROC Curve - Fold 12
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)

===== Fold 13 =====

Accuracy: 0.9976

Precision: 0.9977

Recall: 0.9976

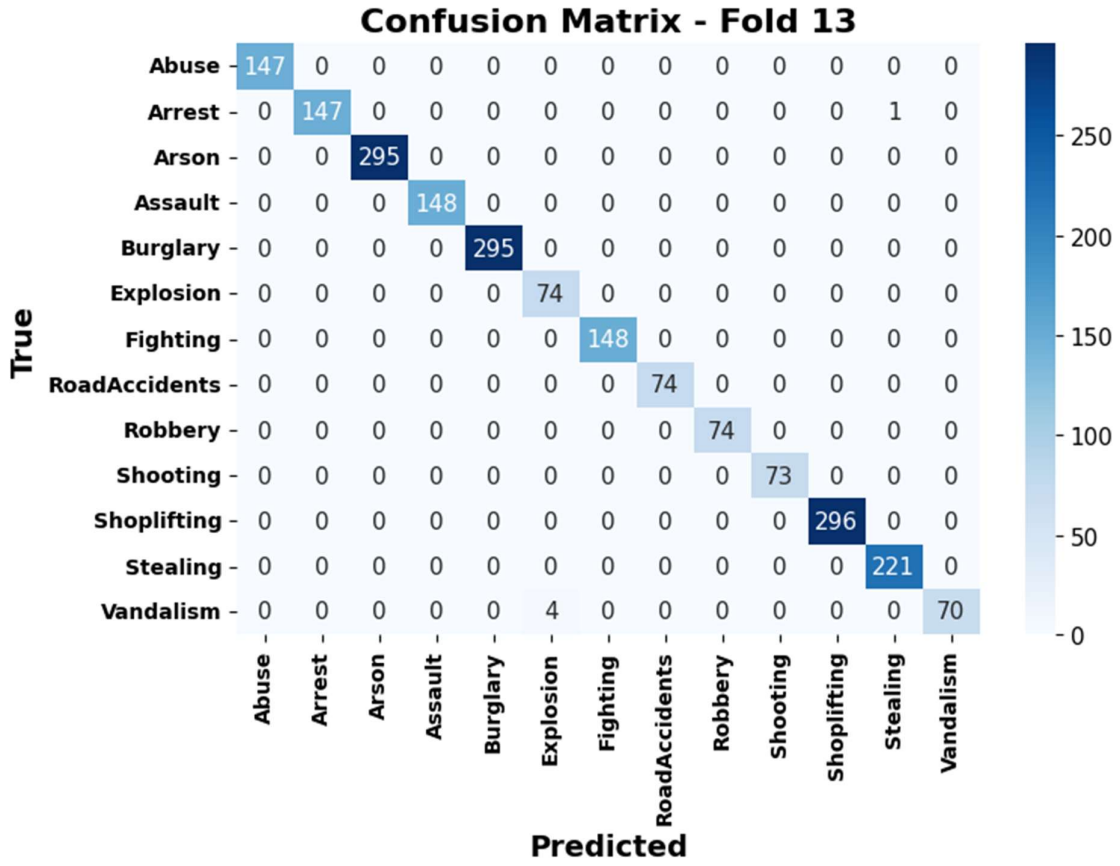
F1-score: 0.9976

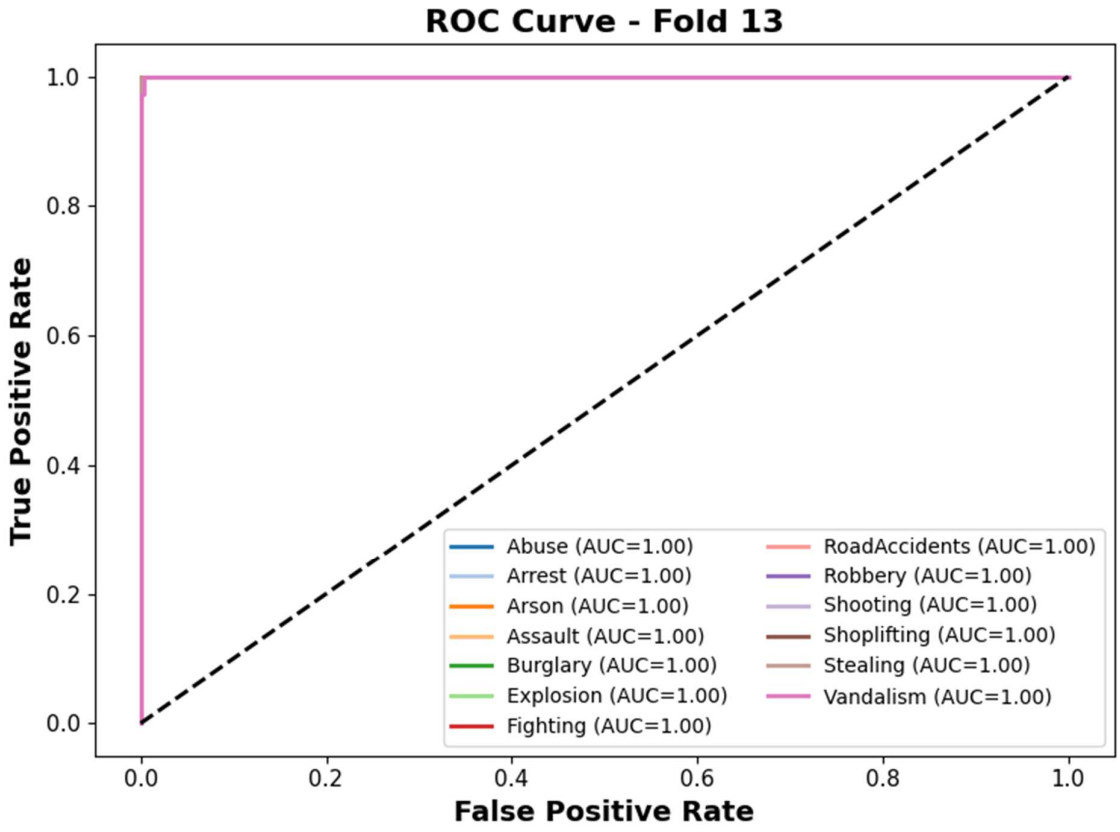
Specificity: 0.9953

Cohen’s Kappa: 0.9973

MSE: 0.1432

AUC: 1.0000




ROC Curve - Fold 13
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Abuse (AUC=1.00)
Arrest (AUC=1.00)
Arson (AUC=1.00)
Assault (AUC=1.00)
Burglary (AUC=1.00)
Explosion (AUC=1.00)
Fighting (AUC=1.00)
RoadAccidents (AUC=1.00)
Robbery (AUC=1.00)
Shooting (AUC=1.00)
Shoplifting (AUC=1.00)
Stealing (AUC=1.00)
Vandalism (AUC=1.00)