Website Classification

by Neurotic Networkers

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Problem Overview

A quick summary of the problem being addressed

Closed-World Multi-Class

(classification of monitored websites)

Open-World Binary

(classification between monitored and unmonitored websites)

Open-World Multi-Class

(classification of monitored websites and accounting for unmonitored websites)

02

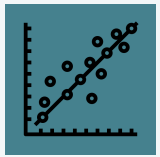
Model Introduction

Introduction to our choice of model

Empirical Results for Comparison: Closed-World Multi-Class

SVM

Model Accuracy: 35.95%

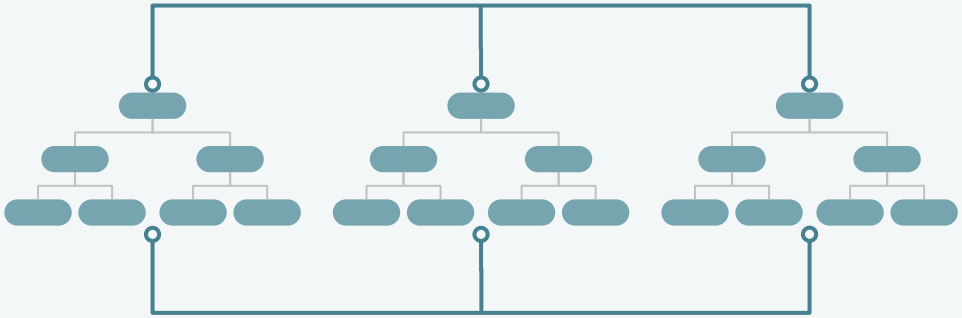


Linear Regression

Model Accuracy: 2.97%

Random Forest

- Suited to large datasets
- Able to handle complex, non-linear relationships
- Parallelization
- Able to classify monitored websites & identify unmonitored websites

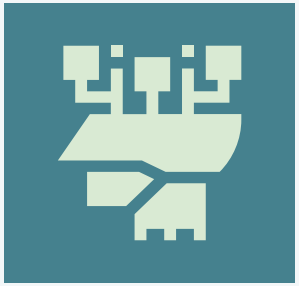


03

Model Development

Feature engineering and parameter selection

Experimental Situation



Processor Used: AMD Ryzen 9 5900HS, 3301 Mhz, 8 cores, 16 logical processors

Physical Memory: 16 GB

Sampling Method: Random (random state = 42)

Size of Data: 19,000 instances of monitored websites, 10,000 instances of unmonitored websites

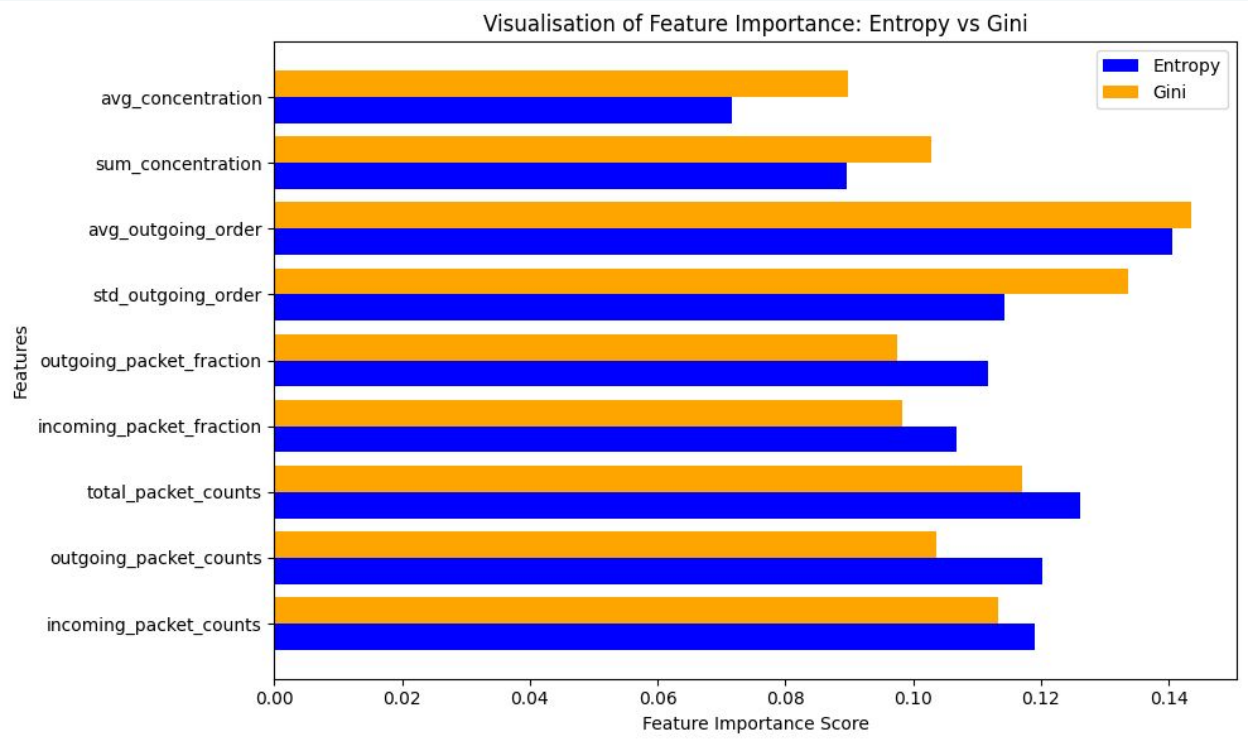
Tuning

Techniques Used:

Parameter Grid

Grid Search (Cross Validation)

Analyzed Feature Importance



Trial Feature Selection

Best features found:

Number of Incoming Packets

Total Number of Packets

Average of the Outgoing Packets Ordering List

Sum of All Items in Alternative Concentration Feature List

Accuracy went down by 3% and time only went down by 0.003 seconds (open-world multi-class), so reducing features is unnecessary

04

Experiment Results

Reporting results for each model

Closed-World Multi-Class

(classification of monitored websites)

Closed-World Multi-Class: RF Initial Metrics

Training

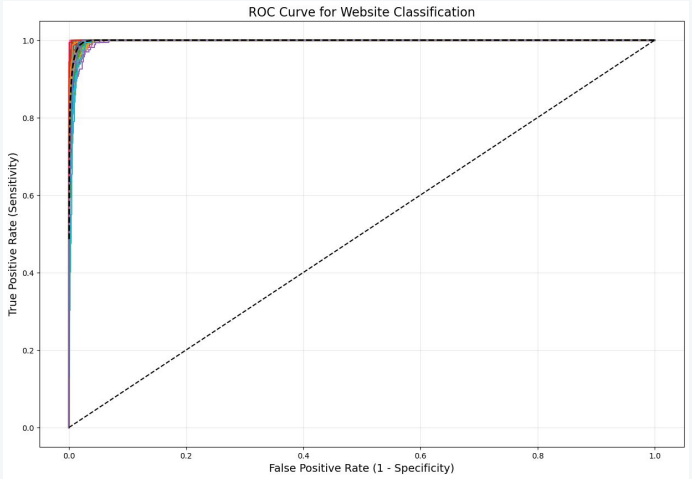
Memory used: 208.852 MB
Time taken to predict: 0.629 seconds
Model Accuracy: 83.7%

Metric	Precision	Recall	F1-Score
Accuracy			0.84
Macro Avg	0.85	0.84	0.84
Weighted Avg	0.85	0.84	0.84

Testing

Memory used: 209.195 MB
Time taken to predict: 0.143 seconds
Model Accuracy: 67.2%

Metric	Precision	Recall	F1-Score
Accuracy			0.67
Macro Avg	0.68	0.68	0.67
Weighted Avg	0.68	0.67	0.67



Closed-World Multi-Class: RF Final Metrics

Using best parameters found: {'bootstrap': True, 'criterion': 'entropy', 'max_depth': 20, 'min_samples_leaf': 5, 'min_samples_split': 10, 'n_estimators': 200}

Training

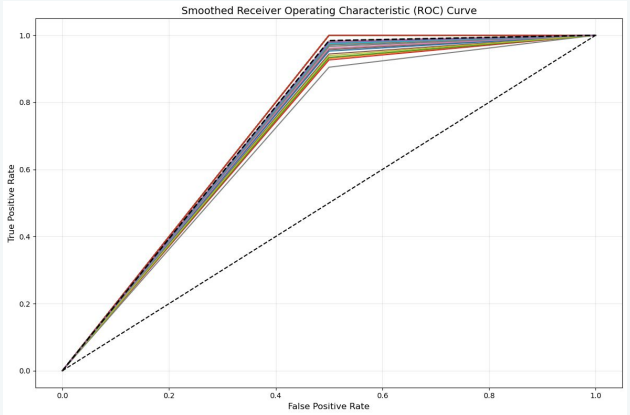
Memory used: 1034.355 MB
Time taken to predict: 1.181 seconds
Model Accuracy: 87.1%

Metric	Precision	Recall	F1-Score
Accuracy			0.87
Macro Avg	0.87	0.87	0.87
Weighted Avg	0.87	0.87	0.87

Testing

Memory used: 1034.434 MB
Time taken to predict: 0.269 seconds
Model Accuracy: 70.2%

Metric	Precision	Recall	F1-Score
Accuracy			0.70
Macro Avg	0.70	0.70	0.70
Weighted Avg	0.71	0.70	0.70



Open-World Binary

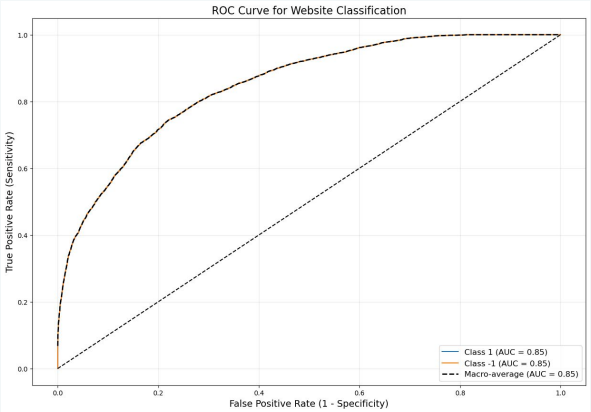
(classification between monitored and unmonitored websites)

Open-World Binary: RF Initial Metrics

Training

Memory used: 225.375 MB
Time taken to predict: 0.145 seconds
Model Accuracy: 77.3%

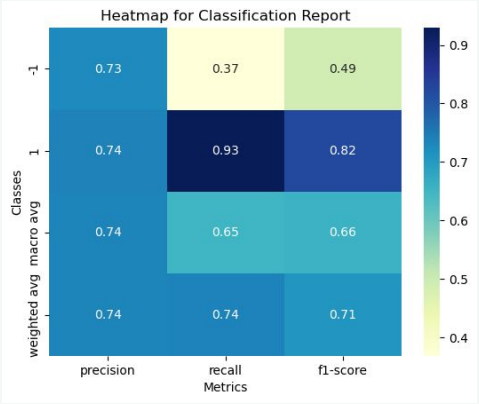
Metric	Precision	Recall	F1-Score
Accuracy			0.77
Macro Avg	0.79	0.69	0.71
Weighted Avg	0.78	0.77	0.75



Testing

Memory used: 225.383 MB
Time taken to predict: 0.043 seconds
Model Accuracy: 73.8%

Metric	Precision	Recall	F1-Score
Accuracy			0.74
Macro Avg	0.74	0.65	0.66
Weighted Avg	0.74	0.74	0.71



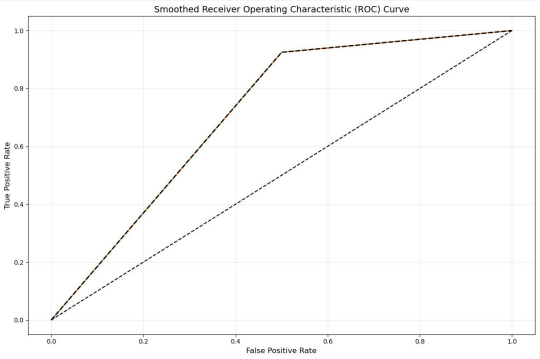
Open-World Binary: RF Final Metrics

Using best parameters found: {'bootstrap': True, 'criterion': 'gini', 'max_depth': 30, 'min_samples_leaf': 5, 'min_samples_split': 10, 'n_estimators': 200}

Training

Memory used: 288.023 MB
Time taken to predict: 0.638 seconds
Model Accuracy: 94.0%

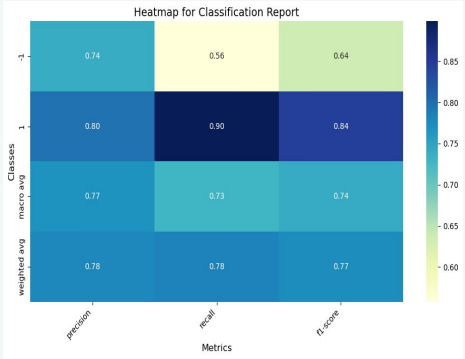
Metric	Precision	Recall	F1-Score
Accuracy			0.94
Macro Avg	0.95	0.92	0.93
Weighted Avg	0.94	0.94	0.94



Testing

Memory used: 288.188 MB
Time taken to predict: 0.183 seconds
Model Accuracy: 78.2%

Metric	Precision	Recall	F1-Score
Accuracy			0.78
Macro Avg	0.77	0.73	0.74
Weighted Avg	0.78	0.78	0.77



Open-World Multi-Class

(classification of monitored websites and accounting for unmonitored websites)

Open-World Multi-Class: RF Initial Metrics

Training

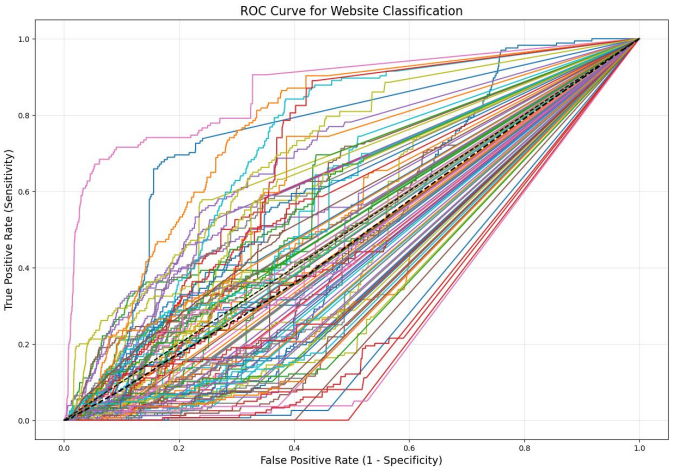
Memory used: 618.020 MB
Time taken to predict: 0.938 seconds
Model Accuracy: 70.3%

Metric	Precision	Recall	F1-Score
Accuracy			0.70
Macro Avg	0.88	0.57	0.66
Weighted Avg	0.78	0.70	0.68

Testing

Memory used: 618.043 MB
Time taken to predict: 0.245 seconds
Model Accuracy: 60.2%

Metric	Precision	Recall	F1-Score
Accuracy			0.60
Macro Avg	0.77	0.46	0.53
Weighted Avg	0.68	0.60	0.57



Open-World Multi-Class: RF Final Metrics

Using best parameters found: {'bootstrap': True, 'criterion': 'entropy', 'max_depth': 20, 'min_samples_leaf': 5, 'min_samples_split': 10, 'n_estimators': 200}

Training

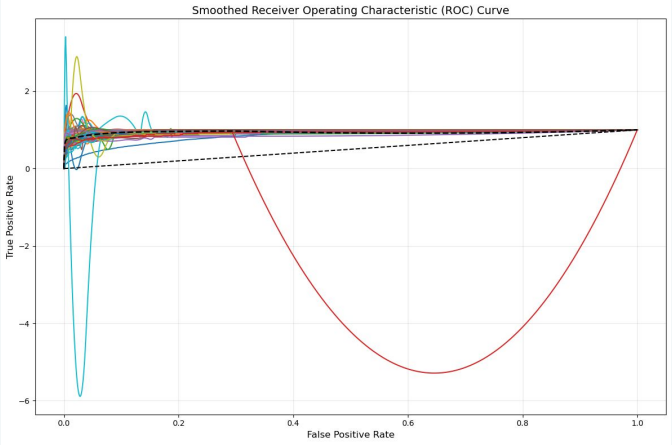
Memory used: 715.512 MB
Time taken to predict: 2.914 seconds
Model Accuracy: 82.9%

Metric	Precision	Recall	F1-Score
Accuracy			0.83
Macro Avg	0.93	0.76	0.82
Weighted Avg	0.86	0.83	0.82

Testing

Memory used: 717.316 MB
Time taken to predict: 0.818 seconds
Model Accuracy: 66.8%

Metric	Precision	Recall	F1-Score
Accuracy			0.67
Macro Avg	0.78	0.57	0.63
Weighted Avg	0.71	0.67	0.65



05

Discussion

Interpretations and learnings from this experiment

Final test accuracy		
Closed world multi-class	Open world binary	Open world multi-class
70.2%	78.2%	66.8%

Open world binary classification > Closed world multi-class > Open world multi-class

This ranking is logical as:

- Fewer classes makes decision boundary easier
- Open world multiclass adds further difficulty by requiring the model to recognize an additional class

The binary model also had a higher recall and precision than the other two models

- Multi-class models must distinguish among several classes, which can lead to more errors in both precision and recall.

Thanks!

The Neurotic Networkers

Project Github Link

Thanks!

Do you have any questions?

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