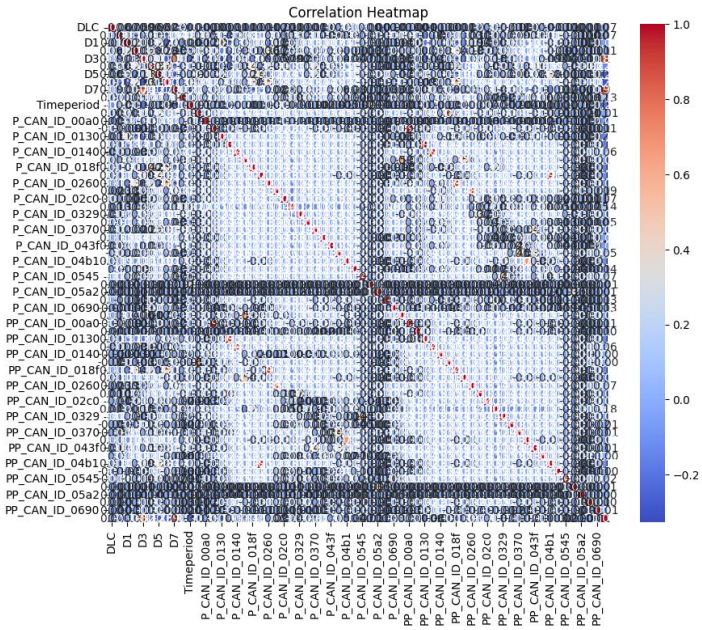
Question2.

The feature extraction process during data preprocessing is presented briefly, but some key details are missing. For example, how effective are the newly added features, such as "Time Interval" and "Chain of CAN IDs," in enhancing the accuracy of the model? Including a quantitative ablation study to demonstrate the impact of each feature on model performance would strengthen the paper. Additionally, specifying why these particular features were chosen over others would help in understanding their significance.

Answer:

We have computed the correlation of each feature in the Car Hacking 2018 dataset, specifically for each attack type. The correlation matrix reveals a strong relationship between the extracted features and the class label, highlighting their relevance in attack classification. Below, we provide the correlation values for each attack type, underscoring the significance of these features in our analysis.

RPM Attack:

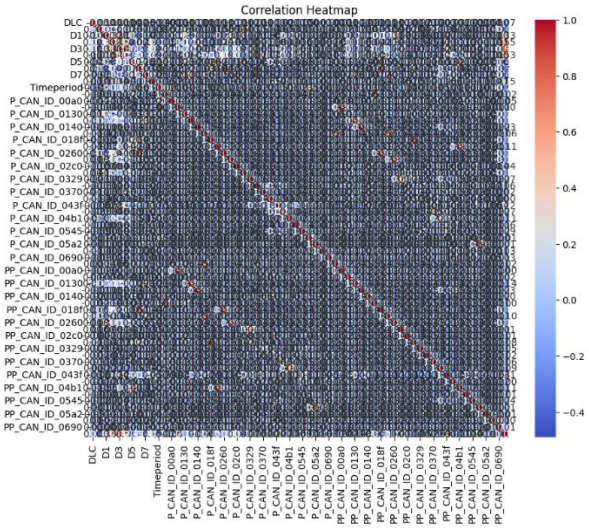


Features	***Correlation Value***
Class	1
D7	0.905454
D3	0.821226
PP_CAN_ID_0316	0.177125
P_CAN_ID_0316	0.138187
TimeInterval	0.130582
P_CAN_ID_02a0	0.091677
P_CAN_ID_02c0	0.074308
D0	0.070653

P_CAN_ID_0545	0.069476
DLC	0.066479
PP_CAN_ID_0260	0.065157
P_CAN_ID_0140	0.064043
PP_CAN_ID_0131	0.061057
P_CAN_ID_0440	0.054452
P_CAN_ID_0350	0.04739
P_CAN_ID_04f0	0.037217
P_CAN_ID_05f0	0.034511
P_CAN_ID_0690	0.031088
PP_CAN_ID_0545	0.023191
P_CAN_ID_05a2	0.012785
PP_CAN_ID_00a0	0.010951
P_CAN_ID_00a1	0.010458
D2	0.006706
PP_CAN_ID_05a0	0.005001
PP_CAN_ID_05a2	0.004473
PP_CAN_ID_00a1	0.004056
PP_CAN_ID_05f0	0.000553
PP_CAN_ID_0440	-0.00213
PP_CAN_ID_0153	-0.00274
PP_CAN_ID_04f0	-0.00355
PP_CAN_ID_0140	-0.00404
PP_CAN_ID_0350	-0.00623
PP_CAN_ID_0690	-0.00654
P_CAN_ID_05a0	-0.00949
PP_CAN_ID_043f	-0.01064
PP_CAN_ID_0370	-0.01119
P_CAN_ID_0002	-0.01162
PP_CAN_ID_02c0	-0.01738
P_CAN_ID_0329	-0.01863
PP_CAN_ID_0329	-0.02264
PP_CAN_ID_0002	-0.02282
P_CAN_ID_0430	-0.0334
D1	-0.03533
P_CAN_ID_0153	-0.04428
P_CAN_ID_0370	-0.0466
P_CAN_ID_00a0	-0.0501
P_CAN_ID_043f	-0.06549
PP_CAN_ID_02a0	-0.0714
PP_CAN_ID_01f1	-0.09305
PP_CAN_ID_0430	-0.09386
P_CAN_ID_0260	-0.09432
PP_CAN_ID_018f	-0.09925
PP_CAN_ID_04b1	-0.10753
P_CAN_ID_01f1	-0.10965

P_CAN_ID_04b1	-0.11495
D4	-0.12275
PP_CAN_ID_0130	-0.13857
P_CAN_ID_0131	-0.14956
P_CAN_ID_018f	-0.15676
P_CAN_ID_0130	-0.15924
Timeperiod	-0.21687
D5	-0.26455
D6	-0.30893

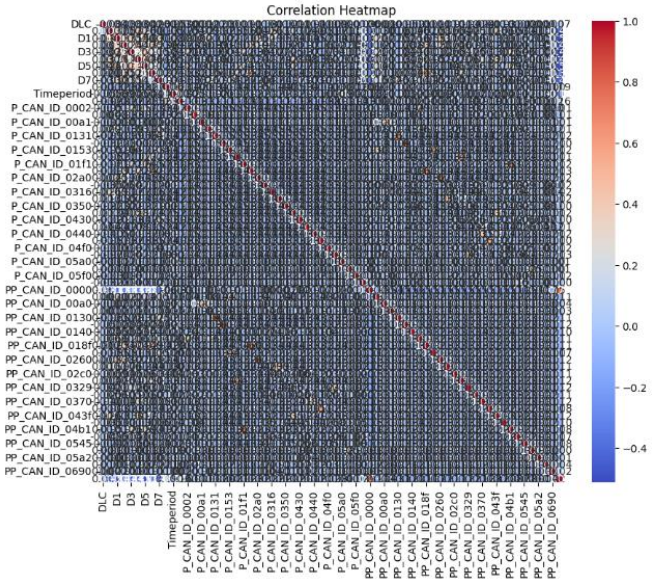
Gear Attack:



Features	Correlation Value
Class	1
D3	0.820598
D2	0.553703
D4	0.528321
D1	0.325892
PP_CAN_ID_043f	0.30933
P_CAN_ID_043f	0.219305
TimeInterval	0.151151
P_CAN_ID_0545	0.089008
DLC	0.07334
P_CAN_ID_0329	0.068972
P_CAN_ID_0440	0.06821
P_CAN_ID_04f0	0.058606
P_CAN_ID_0350	0.057367
P_CAN_ID_02c0	0.039513
PP_CAN_ID_0545	0.035049
P_CAN_ID_0140	0.030498
PP_CAN_ID_0131	0.029628

P_CAN_ID_0690	0.029015
P_CAN_ID_05f0	0.028476
P_CAN_ID_0370	0.02089
PP_CAN_ID_00a1	0.016224
PP_CAN_ID_0690	0.014116
PP_CAN_ID_02a0	0.011978
P_CAN_ID_05a2	0.011788
PP_CAN_ID_05a0	0.008019
PP_CAN_ID_0140	0.002592
P_CAN_ID_00a1	0.002001
PP_CAN_ID_05f0	0.000522
P_CAN_ID_0430	0.00034
PP_CAN_ID_00a0	-2.59E-16
PP_CAN_ID_0153	-0.00119
PP_CAN_ID_0440	-0.00211
P_CAN_ID_05a0	-0.005
PP_CAN_ID_04f0	-0.00531
PP_CAN_ID_05a2	-0.00707
PP_CAN_ID_02c0	-0.0077
P_CAN_ID_0002	-0.02056
PP_CAN_ID_0350	-0.02181
PP_CAN_ID_0002	-0.0224
PP_CAN_ID_0329	-0.047
P_CAN_ID_00a0	-0.05217
PP_CAN_ID_0370	-0.05724
P_CAN_ID_0153	-0.05903
PP_CAN_ID_0316	-0.0819
PP_CAN_ID_0430	-0.08667
PP_CAN_ID_01f1	-0.09639
PP_CAN_ID_04b1	-0.10628
P_CAN_ID_04b1	-0.10824
P_CAN_ID_01f1	-0.11458
PP_CAN_ID_0130	-0.13997
P_CAN_ID_0130	-0.14553
PP_CAN_ID_0260	-0.15012
P_CAN_ID_0131	-0.15086
P_CAN_ID_02a0	-0.15307
PP_CAN_ID_018f	-0.15366
P_CAN_ID_018f	-0.15384
P_CAN_ID_0316	-0.15396
P_CAN_ID_0260	-0.15505
Timeperiod	-0.25757
D6	-0.3107
D0	-0.40175
D7	-0.41458
D5	-0.49021

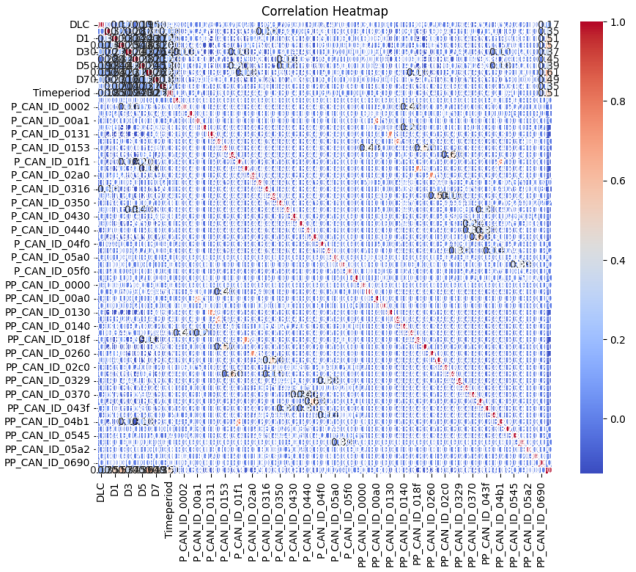
DoS Attack:



Features	Correlation Value
Class	1
PP_CAN_ID_0000	0.731852
TimeInterval	0.193054
P_CAN_ID_0000	0.161851
DLC	0.070172
P_CAN_ID_05a2	0.007072
P_CAN_ID_05a0	0.006398
PP_CAN_ID_05a0	-1.86E-18
P_CAN_ID_0140	-0.00098
P_CAN_ID_0690	-0.00231
P_CAN_ID_0350	-0.00345
P_CAN_ID_0430	-0.004
P_CAN_ID_04b1	-0.0043
P_CAN_ID_0130	-0.00734
P_CAN_ID_00a0	-0.00907
P_CAN_ID_00a1	-0.00999
P_CAN_ID_043f	-0.01125
PP_CAN_ID_05a2	-0.01225
P_CAN_ID_018f	-0.013
P_CAN_ID_0002	-0.01486
P_CAN_ID_0131	-0.01512
P_CAN_ID_01f1	-0.0164
PP_CAN_ID_0690	-0.01837

P_CAN_ID_0329	-0.01916
P_CAN_ID_0153	-0.02136
P_CAN_ID_0370	-0.02154
P_CAN_ID_02a0	-0.02306
P_CAN_ID_0440	-0.02322
P_CAN_ID_0316	-0.02351
P_CAN_ID_04f0	-0.0236
P_CAN_ID_02c0	-0.024
P_CAN_ID_05f0	-0.0245
PP_CAN_ID_00a1	-0.02603
P_CAN_ID_0545	-0.02697
P_CAN_ID_0260	-0.02831
PP_CAN_ID_00a0	-0.03718
PP_CAN_ID_05f0	-0.03905
PP_CAN_ID_04f0	-0.06766
PP_CAN_ID_01f1	-0.07452
PP_CAN_ID_0545	-0.07809
PP_CAN_ID_04b1	-0.08418
PP_CAN_ID_0430	-0.08477
PP_CAN_ID_0140	-0.10014
PP_CAN_ID_0440	-0.10428
PP_CAN_ID_018f	-0.10608
PP_CAN_ID_0350	-0.10821
PP_CAN_ID_02c0	-0.10828
PP_CAN_ID_0130	-0.11032
PP_CAN_ID_0002	-0.1118
PP_CAN_ID_02a0	-0.11259
PP_CAN_ID_0153	-0.11443
PP_CAN_ID_043f	-0.11534
PP_CAN_ID_0131	-0.11785
PP_CAN_ID_0316	-0.11999
PP_CAN_ID_0260	-0.12
PP_CAN_ID_0370	-0.1229
PP_CAN_ID_0329	-0.12462
Timeperiod	-0.16084
D6	-0.31068
D4	-0.40979
D2	-0.4159
D0	-0.41741
D7	-0.42765
D3	-0.44258
D1	-0.50246
D5	-0.51217

Fuzzy Attack:



Features	Correlation Value
Class	1
D6	0.61412
D2	0.56975
Timeperiod	0.513625
D1	0.505191
D7	0.489582
D4	0.454509
D5	0.386726
D3	0.371176
D0	0.353854
TimeInterval	0.35377
DLC	0.165742
P_CAN_ID_0545	0.024371
PP_CAN_ID_0690	0.012235
P_CAN_ID_05f0	0.008566
P_CAN_ID_05a2	0.007074
P_CAN_ID_0000	0.007072
PP_CAN_ID_0000	0.007071
PP_CAN_ID_0545	0.006909
P_CAN_ID_02c0	0.004769
P_CAN_ID_04f0	0.004744
P_CAN_ID_05a0	0.004473
PP_CAN_ID_04f0	0.003379
PP_CAN_ID_05a2	0.001544
PP_CAN_ID_00a0	0.001494
PP_CAN_ID_05a0	-2.31E-17
P_CAN_ID_0350	-0.00147

P_CAN_ID_0690	-0.00218
P_CAN_ID_0440	-0.00222
PP_CAN_ID_00a1	-0.00317
P_CAN_ID_00a1	-0.0038
PP_CAN_ID_05f0	-0.0038
PP_CAN_ID_0440	-0.00615
P_CAN_ID_0140	-0.00884
PP_CAN_ID_0131	-0.01853
PP_CAN_ID_02c0	-0.02257
P_CAN_ID_0430	-0.02417
PP_CAN_ID_0002	-0.02735
PP_CAN_ID_0140	-0.02888
P_CAN_ID_0002	-0.03057
PP_CAN_ID_0153	-0.03376
P_CAN_ID_00a0	-0.03837
PP_CAN_ID_043f	-0.04046
PP_CAN_ID_0350	-0.04203
P_CAN_ID_0153	-0.04804
P_CAN_ID_0329	-0.05737
PP_CAN_ID_0370	-0.06038
PP_CAN_ID_0329	-0.06186
PP_CAN_ID_0430	-0.06302
P_CAN_ID_04b1	-0.06792
P_CAN_ID_043f	-0.06836
P_CAN_ID_01f1	-0.07244
PP_CAN_ID_04b1	-0.07703
P_CAN_ID_0370	-0.08089
P_CAN_ID_0316	-0.08141
PP_CAN_ID_01f1	-0.08478
P_CAN_ID_018f	-0.08514
P_CAN_ID_02a0	-0.08537
PP_CAN_ID_02a0	-0.08922
PP_CAN_ID_0316	-0.09329
PP_CAN_ID_0130	-0.09506
P_CAN_ID_0260	-0.0959
P_CAN_ID_0130	-0.0985
PP_CAN_ID_0260	-0.10637
P_CAN_ID_0131	-0.10902
PP_CAN_ID_018f	-0.12141