**SUPERVISED LEARNING**

**Dataset Preparation:** This data was originally gathered at the TI in 1986-87 by

JP Siebert. It was partially financed by Barr and Stroud Ltd. The original purpose was to find a method of distinguishing 3D objects within a 2D image by application of an ensemble of shape feature extractors to the 2D silhouettes of the objects. Measures of shape features extracted from example silhouettes of objects to be discriminated were used to generate a classification rule tree by means of computer induction. This object recognition strategy was successfully used to discriminate between silhouettes of model cars, vans and buses viewed from constrained elevation but all angles of rotation. The rule tree classification performance compared favourably to MDC (Minimum Distance Classifier) and k-NN (k-Nearest Neighbour) statistical classifiers in terms of both error rate and computational efficiency. An investigation of these rule trees generated by example indicated that the tree structure was heavily influenced by the orientation of the objects, and grouped similar object views into single decisions. The features were extracted from the silhouettes by the HIPS (Hierarchical Image Processing System) extension BINATTS, which extracts a combination of scale independent features utilising both classical moments based measures such as scaled variance, skewness and kurtosis about the major/minor axes and heuristic measures such as hollows, circularity, rectangularity and compactness. Four "Corgie" model vehicles were used for the experiment: a double decker bus, Chevrolet van, Saab 9000 and an Opel Manta 400.

**Bayes.bayesNet:**

=== Classifier model (full training set) ===

Naive Bayes Classifier

Class

Attribute opel saab bus van

(0.25) (0.26) (0.26) (0.24)

=======================================================================

COMPACTNESS

mean 94.9974 97.2453 91.578 90.5056

std. dev. 8.1774 9.0909 8.6065 4.0111

weight sum 212 217 218 199

precision 1.0698 1.0698 1.0698 1.0698

CIRCULARITY

mean 46.5802 45.5346 45.0688 42.0704

std. dev. 7.2182 6.8034 5.0192 4.0728

weight sum 212 217 218 199

precision 1 1 1 1

DISTANCE-CIRCULARITY

mean 89.0743 88.6541 76.7197 73.3189

std. dev. 15.5555 17.026 12.0292 10.8137

weight sum 212 217 218 199

precision 1.1613 1.1613 1.1613 1.1613

RADIUS-RATIO

mean 180.2859 180.853 166.0278 147.0802

std. dev. 31.2924 30.7223 30.4572 29.8102

weight sum 212 217 218 199

precision 1.7218 1.7218 1.7218 1.7218

PR.AXIS-ASPECT-RATIO

mean 61.0721 61.2258 63.4264 61.2891

std. dev. 5.0572 4.3862 8.8268 11.4274

weight sum 212 217 218 199

precision 2.5278 2.5278 2.5278 2.5278

MAX.LENGTH-ASPECT-RATIO

mean 8.925 8.8903 7.1842 9.6412

std. dev. 2.0855 2.2589 4.8718 7.1185

weight sum 212 217 218 199

precision 2.65 2.65 2.65 2.65

SCATTER-RATIO

mean 182.1733 179.695 169.979 141.5383

std. dev. 32.7443 31.4383 33.2899 13.9536

weight sum 212 217 218 199

precision 1.1769 1.1769 1.1769 1.1769

ELONGATEDNESS

mean 37.9134 38.3681 40.2651 48.1289

std. dev. 7.8238 7.5772 6.6772 4.493

weight sum 212 217 218 199

precision 1.0294 1.0294 1.0294 1.0294

PR.AXIS-RECTANGULARITY

mean 21.5896 21.447 20.5734 18.5779

std. dev. 2.547 2.4473 2.7221 1.0286

weight sum 212 217 218 199

precision 1 1 1 1

MAX.LENGTH-RECTANGULARITY

mean 151.2772 148.6898 146.7876 145.2006

std. dev. 18.0956 16.0797 10.4646 11.0053

weight sum 212 217 218 199

precision 1.0769 1.0769 1.0769 1.0769

SCALED-VARIANCE-ALONG-MAJOR-AXIS

mean 198.5741 197.1011 192.9029 164.1234

std. dev. 28.6335 27.7863 33.8236 19.6532

weight sum 212 217 218 199

precision 1.4961 1.4961 1.4961 1.4961

SCALED-VARIANCE-ALONG-MINOR-AXIS

mean 508.4762 493.7891 448.8265 298.2018

std. dev. 172.0663 162.7785 192.7775 55.8744

weight sum 212 217 218 199

precision 1.9716 1.9716 1.9716 1.9716

SCALED-RADIUS-OF-GYRATION

mean 179.7782 179.3974 180.9989 157.2501

std. dev. 34.684 33.6916 31.1784 22.7642

weight sum 212 217 218 199

precision 1.1197 1.1197 1.1197 1.1197

SKEWNESS-ABOUT-MAJOR-AXIS

mean 70.2358 69.8065 77.055 72.8342

std. dev. 5.1799 5.3088 7.7345 8.8634

weight sum 212 217 218 199

precision 2 2 2 2

SKEWNESS-ABOUT-MINOR-AXIS

mean 6.6038 7.659 4.844 6.4171

std. dev. 5.181 5.8035 3.2131 4.6541

weight sum 212 217 218 199

precision 1 1 1 1

KURTOSIS-ABOUT-MINOR-AXIS

mean 15.0462 15.3419 10.3769 9.8791

std. dev. 10.0009 9.9013 6.8491 6.2513

weight sum 212 217 218 199

precision 1.025 1.025 1.025 1.025

KURTOSIS-ABOUT-MAJOR-AXIS

mean 189.4275 189.8729 187.8061 189.0348

std. dev. 5.4966 4.8815 7.1897 6.259

weight sum 212 217 218 199

precision 1.0345 1.0345 1.0345 1.0345

HOLLOWS-RATIO

mean 197.1132 198.0415 191.3257 196.1457

std. dev. 5.8323 6.5951 7.9001 7.3268

weight sum 212 217 218 199

precision 1 1 1 1

Time taken to build model: 0.03 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 379 44.7991 %

Incorrectly Classified Instances 467 55.2009 %

Kappa statistic 0.2697

Mean absolute error 0.2826

Root mean squared error 0.462

Relative absolute error 75.4027 %

Root relative squared error 106.7136 %

Total Number of Instances 846

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.415 0.172 0.447 0.415 0.430 0.249 0.702 0.449 opel

0.392 0.119 0.531 0.392 0.451 0.304 0.712 0.494 saab

0.147 0.027 0.653 0.147 0.240 0.224 0.843 0.609 bus

0.874 0.411 0.395 0.874 0.545 0.393 0.821 0.529 van

Weighted Avg. 0.448 0.177 0.510 0.448 0.413 0.291 0.769 0.521

=== Confusion Matrix ===

a b c d <-- classified as

88 60 0 64 | a = opel

62 85 3 67 | b = saab

43 8 32 135 | c = bus

4 7 14 174 | d = van

**Lazy.ibk:**

=== Classifier model (full training set) ===

IB1 instance-based classifier

using 1 nearest neighbour(s) for classification

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 591 69.8582 %

Incorrectly Classified Instances 255 30.1418 %

Kappa statistic 0.598

Mean absolute error 0.1519

Root mean squared error 0.3872

Relative absolute error 40.5184 %

Root relative squared error 89.4389 %

Total Number of Instances 846

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.481 0.148 0.520 0.481 0.500 0.342 0.666 0.396 opel

0.498 0.170 0.502 0.498 0.500 0.329 0.669 0.391 saab

0.931 0.037 0.898 0.931 0.914 0.884 0.952 0.871 bus

0.894 0.048 0.852 0.894 0.873 0.833 0.927 0.795 van

Weighted Avg. 0.699 0.101 0.691 0.699 0.694 0.594 0.802 0.611

=== Confusion Matrix ===

a b c d <-- classified as

102 94 6 10 | a = opel

85 108 11 13 | b = saab

4 3 203 8 | c = bus

5 10 6 178 | d = van

**Lazy.kstar:**

=== Classifier model (full training set) ===

KStar Beta Verion (0.1b).

Copyright (c) 1995-97 by Len Trigg (trigg@cs.waikato.ac.nz).

Java port to Weka by Abdelaziz Mahoui (am14@cs.waikato.ac.nz).

KStar options : -B 20 -M a

Time taken to build model: 0 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 604 71.3948 %

Incorrectly Classified Instances 242 28.6052 %

Kappa statistic 0.6186

Mean absolute error 0.1492

Root mean squared error 0.353

Relative absolute error 39.8121 %

Root relative squared error 81.5301 %

Total Number of Instances 846

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.429 0.151 0.487 0.429 0.456 0.290 0.788 0.463 opel

0.493 0.173 0.495 0.493 0.494 0.320 0.789 0.447 saab

0.991 0.016 0.956 0.991 0.973 0.964 0.999 0.998 bus

0.955 0.042 0.876 0.955 0.913 0.887 0.992 0.973 van

Weighted Avg. 0.714 0.096 0.701 0.714 0.707 0.612 0.891 0.717

=== Confusion Matrix ===

a b c d <-- classified as

91 104 5 12 | a = opel

92 107 5 13 | b = saab

0 0 216 2 | c = bus

4 5 0 190 | d = van

**Rules.part:**

=== Classifier model (full training set) ===

PART decision list

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ELONGATEDNESS <= 41 AND

MAX.LENGTH-ASPECT-RATIO <= 7 AND

COMPACTNESS > 95: bus (70.0/1.0)

ELONGATEDNESS <= 41 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

SCALED-VARIANCE-ALONG-MINOR-AXIS <= 721 AND

HOLLOWS-RATIO <= 195 AND

MAX.LENGTH-ASPECT-RATIO > 8 AND

KURTOSIS-ABOUT-MAJOR-AXIS > 185: opel (23.0)

ELONGATEDNESS <= 41 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

SCALED-VARIANCE-ALONG-MINOR-AXIS <= 721 AND

COMPACTNESS <= 109 AND

SKEWNESS-ABOUT-MAJOR-AXIS > 67 AND

COMPACTNESS > 106: saab (24.0/1.0)

ELONGATEDNESS <= 41 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

SCALED-VARIANCE-ALONG-MINOR-AXIS > 721: opel (23.0/1.0)

ELONGATEDNESS <= 41 AND

PR.AXIS-ASPECT-RATIO <= 68 AND

COMPACTNESS > 109: saab (16.0)

ELONGATEDNESS <= 41 AND

PR.AXIS-ASPECT-RATIO <= 68 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

PR.AXIS-ASPECT-RATIO <= 57 AND

HOLLOWS-RATIO > 197: opel (9.0)

ELONGATEDNESS <= 41 AND

PR.AXIS-ASPECT-RATIO <= 68 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

DISTANCE-CIRCULARITY > 103 AND

PR.AXIS-RECTANGULARITY <= 24 AND

ELONGATEDNESS > 30 AND

PR.AXIS-RECTANGULARITY > 22 AND

COMPACTNESS > 97 AND

PR.AXIS-RECTANGULARITY > 23: saab (18.0/3.0)

ELONGATEDNESS <= 41 AND

PR.AXIS-ASPECT-RATIO <= 68 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

SKEWNESS-ABOUT-MINOR-AXIS > 12 AND

KURTOSIS-ABOUT-MINOR-AXIS > 3 AND

KURTOSIS-ABOUT-MAJOR-AXIS <= 198: saab (16.0)

ELONGATEDNESS <= 41 AND

PR.AXIS-ASPECT-RATIO <= 68 AND

SKEWNESS-ABOUT-MINOR-AXIS > 10 AND

SKEWNESS-ABOUT-MAJOR-AXIS <= 69: opel (16.0/1.0)

ELONGATEDNESS <= 41 AND

MAX.LENGTH-ASPECT-RATIO > 7: opel (132.0/65.0)

MAX.LENGTH-ASPECT-RATIO > 8 AND

HOLLOWS-RATIO > 189 AND

SKEWNESS-ABOUT-MAJOR-AXIS > 63: van (107.0/2.0)

SCALED-VARIANCE-ALONG-MINOR-AXIS > 309 AND

DISTANCE-CIRCULARITY <= 76 AND

SKEWNESS-ABOUT-MINOR-AXIS <= 10 AND

SKEWNESS-ABOUT-MAJOR-AXIS > 64 AND

CIRCULARITY > 41: bus (107.0/1.0)

PR.AXIS-ASPECT-RATIO > 63 AND

ELONGATEDNESS <= 47 AND

MAX.LENGTH-ASPECT-RATIO <= 7 AND

KURTOSIS-ABOUT-MINOR-AXIS <= 23 AND

SCALED-RADIUS-OF-GYRATION <= 185: bus (35.0)

SCATTER-RATIO > 144 AND

PR.AXIS-ASPECT-RATIO <= 62 AND

MAX.LENGTH-ASPECT-RATIO <= 8 AND

PR.AXIS-ASPECT-RATIO <= 61: opel (60.0/29.0)

SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 173 AND

COMPACTNESS <= 82 AND

COMPACTNESS <= 81 AND

KURTOSIS-ABOUT-MINOR-AXIS > 4: opel (12.0)

SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 173 AND

COMPACTNESS > 82 AND

KURTOSIS-ABOUT-MINOR-AXIS <= 19 AND

SCATTER-RATIO <= 142 AND

PR.AXIS-RECTANGULARITY <= 17 AND

SKEWNESS-ABOUT-MINOR-AXIS <= 18: van (30.0/1.0)

SCALED-VARIANCE-ALONG-MAJOR-AXIS > 173 AND

PR.AXIS-ASPECT-RATIO <= 69 AND

COMPACTNESS > 91: saab (8.0/1.0)

SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 173 AND

MAX.LENGTH-RECTANGULARITY > 138 AND

PR.AXIS-RECTANGULARITY <= 18 AND

ELONGATEDNESS > 47: van (33.0)

PR.AXIS-ASPECT-RATIO > 65 AND

PR.AXIS-ASPECT-RATIO <= 70: van (4.0)

PR.AXIS-ASPECT-RATIO <= 68 AND

MAX.LENGTH-ASPECT-RATIO > 7 AND

KURTOSIS-ABOUT-MINOR-AXIS <= 17 AND

PR.AXIS-ASPECT-RATIO > 58: van (12.0)

ELONGATEDNESS > 46 AND

MAX.LENGTH-ASPECT-RATIO > 4 AND

SCALED-RADIUS-OF-GYRATION <= 124 AND

KURTOSIS-ABOUT-MINOR-AXIS <= 28 AND

MAX.LENGTH-RECTANGULARITY > 124: van (9.0)

PR.AXIS-ASPECT-RATIO <= 68 AND

MAX.LENGTH-ASPECT-RATIO <= 4: saab (7.0)

PR.AXIS-ASPECT-RATIO <= 68 AND

RADIUS-RATIO <= 120 AND

CIRCULARITY <= 38: saab (6.0/1.0)

PR.AXIS-ASPECT-RATIO <= 68 AND

RADIUS-RATIO > 120 AND

SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 163: opel (39.0/18.0)

ELONGATEDNESS > 48: van (5.0)

PR.AXIS-ASPECT-RATIO <= 68 AND

ELONGATEDNESS <= 44 AND

COMPACTNESS > 89 AND

PR.AXIS-RECTANGULARITY > 19: saab (4.0/1.0)

ELONGATEDNESS <= 44 AND

PR.AXIS-ASPECT-RATIO <= 68: opel (5.0)

SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 174: saab (12.0/3.0)

: bus (4.0)

Number of Rules : 29

Time taken to build model: 0.18 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 605 71.513 %

Incorrectly Classified Instances 241 28.487 %

Kappa statistic 0.62

Mean absolute error 0.1458

Root mean squared error 0.326

Relative absolute error 38.9075 %

Root relative squared error 75.3055 %

Total Number of Instances 846

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.443 0.136 0.522 0.443 0.480 0.326 0.773 0.498 opel

0.567 0.191 0.506 0.567 0.535 0.363 0.749 0.464 saab

0.950 0.016 0.954 0.950 0.952 0.935 0.964 0.913 bus

0.910 0.039 0.879 0.910 0.894 0.861 0.950 0.843 van

Weighted Avg. 0.715 0.096 0.713 0.715 0.713 0.618 0.857 0.677

=== Confusion Matrix ===

a b c d <-- classified as

94 106 3 9 | a = opel

74 123 7 13 | b = saab

2 6 207 3 | c = bus

10 8 0 181 | d = van

**Trees.j48:**

=== Classifier model (full training set) ===

J48 pruned tree

------------------

ELONGATEDNESS <= 41

| MAX.LENGTH-ASPECT-RATIO <= 7

| | COMPACTNESS <= 95

| | | PR.AXIS-ASPECT-RATIO <= 67

| | | | KURTOSIS-ABOUT-MAJOR-AXIS <= 196

| | | | | COMPACTNESS <= 89: opel (6.0/1.0)

| | | | | COMPACTNESS > 89

| | | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 72: saab (10.0)

| | | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 72: opel (2.0)

| | | | KURTOSIS-ABOUT-MAJOR-AXIS > 196: opel (3.0/1.0)

| | | PR.AXIS-ASPECT-RATIO > 67: bus (16.0)

| | COMPACTNESS > 95: bus (70.0/1.0)

| MAX.LENGTH-ASPECT-RATIO > 7

| | SCALED-VARIANCE-ALONG-MINOR-AXIS <= 721

| | | HOLLOWS-RATIO <= 195

| | | | MAX.LENGTH-ASPECT-RATIO <= 8

| | | | | ELONGATEDNESS <= 37: opel (2.0)

| | | | | ELONGATEDNESS > 37

| | | | | | DISTANCE-CIRCULARITY <= 82: opel (2.0)

| | | | | | DISTANCE-CIRCULARITY > 82: saab (6.0/1.0)

| | | | MAX.LENGTH-ASPECT-RATIO > 8

| | | | | KURTOSIS-ABOUT-MAJOR-AXIS <= 185

| | | | | | COMPACTNESS <= 102: opel (4.0)

| | | | | | COMPACTNESS > 102: saab (2.0)

| | | | | KURTOSIS-ABOUT-MAJOR-AXIS > 185: opel (23.0)

| | | HOLLOWS-RATIO > 195

| | | | COMPACTNESS <= 109

| | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 67

| | | | | | PR.AXIS-ASPECT-RATIO <= 58: opel (6.0)

| | | | | | PR.AXIS-ASPECT-RATIO > 58

| | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 61: saab (4.0)

| | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 61

| | | | | | | | HOLLOWS-RATIO <= 203

| | | | | | | | | DISTANCE-CIRCULARITY <= 78: saab (3.0)

| | | | | | | | | DISTANCE-CIRCULARITY > 78

| | | | | | | | | | KURTOSIS-ABOUT-MINOR-AXIS <= 16

| | | | | | | | | | | HOLLOWS-RATIO <= 198: opel (4.0)

| | | | | | | | | | | HOLLOWS-RATIO > 198

| | | | | | | | | | | | PR.AXIS-ASPECT-RATIO <= 59: opel (3.0)

| | | | | | | | | | | | PR.AXIS-ASPECT-RATIO > 59

| | | | | | | | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 66

| | | | | | | | | | | | | | HOLLOWS-RATIO <= 201

| | | | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO <= 9: saab (3.0)

| | | | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO > 9: opel (2.0)

| | | | | | | | | | | | | | HOLLOWS-RATIO > 201: opel (3.0)

| | | | | | | | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 66: saab (8.0/2.0)

| | | | | | | | | | KURTOSIS-ABOUT-MINOR-AXIS > 16: opel (12.0)

| | | | | | | | HOLLOWS-RATIO > 203

| | | | | | | | | PR.AXIS-ASPECT-RATIO <= 60: saab (8.0)

| | | | | | | | | PR.AXIS-ASPECT-RATIO > 60

| | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS <= 193: saab (5.0)

| | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS > 193

| | | | | | | | | | | PR.AXIS-ASPECT-RATIO <= 63

| | | | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS <= 196

| | | | | | | | | | | | | ELONGATEDNESS <= 33: opel (2.0)

| | | | | | | | | | | | | ELONGATEDNESS > 33: saab (4.0/1.0)

| | | | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS > 196: opel (11.0/1.0)

| | | | | | | | | | | PR.AXIS-ASPECT-RATIO > 63

| | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO <= 10: saab (4.0)

| | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO > 10: opel (3.0/1.0)

| | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 67

| | | | | | COMPACTNESS <= 106

| | | | | | | HOLLOWS-RATIO <= 198

| | | | | | | | PR.AXIS-RECTANGULARITY <= 24

| | | | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 72

| | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS <= 187

| | | | | | | | | | | DISTANCE-CIRCULARITY <= 98: opel (2.0)

| | | | | | | | | | | DISTANCE-CIRCULARITY > 98: saab (7.0)

| | | | | | | | | | KURTOSIS-ABOUT-MAJOR-AXIS > 187

| | | | | | | | | | | SCATTER-RATIO <= 204

| | | | | | | | | | | | HOLLOWS-RATIO <= 197

| | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO <= 9: saab (5.0)

| | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO > 9

| | | | | | | | | | | | | | CIRCULARITY <= 50: opel (4.0)

| | | | | | | | | | | | | | CIRCULARITY > 50: saab (2.0)

| | | | | | | | | | | | HOLLOWS-RATIO > 197

| | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO <= 8: opel (2.0)

| | | | | | | | | | | | | MAX.LENGTH-ASPECT-RATIO > 8

| | | | | | | | | | | | | | RADIUS-RATIO <= 193: saab (2.0)

| | | | | | | | | | | | | | RADIUS-RATIO > 193: opel (4.0)

| | | | | | | | | | | SCATTER-RATIO > 204: opel (9.0)

| | | | | | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 72: saab (12.0/1.0)

| | | | | | | | PR.AXIS-RECTANGULARITY > 24: opel (7.0)

| | | | | | | HOLLOWS-RATIO > 198

| | | | | | | | ELONGATEDNESS <= 34

| | | | | | | | | DISTANCE-CIRCULARITY <= 98: opel (3.0)

| | | | | | | | | DISTANCE-CIRCULARITY > 98

| | | | | | | | | | COMPACTNESS <= 101

| | | | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS <= 3: saab (3.0)

| | | | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS > 3: opel (4.0)

| | | | | | | | | | COMPACTNESS > 101: saab (15.0)

| | | | | | | | ELONGATEDNESS > 34: saab (7.0)

| | | | | | COMPACTNESS > 106: saab (24.0/1.0)

| | | | COMPACTNESS > 109: saab (16.0)

| | SCALED-VARIANCE-ALONG-MINOR-AXIS > 721: opel (23.0/1.0)

ELONGATEDNESS > 41

| MAX.LENGTH-ASPECT-RATIO <= 8

| | SCALED-VARIANCE-ALONG-MINOR-AXIS <= 305

| | | COMPACTNESS <= 82

| | | | PR.AXIS-RECTANGULARITY <= 18

| | | | | COMPACTNESS <= 81: opel (11.0)

| | | | | COMPACTNESS > 81: saab (5.0/1.0)

| | | | PR.AXIS-RECTANGULARITY > 18: saab (2.0)

| | | COMPACTNESS > 82

| | | | MAX.LENGTH-RECTANGULARITY <= 138

| | | | | PR.AXIS-RECTANGULARITY <= 17

| | | | | | SKEWNESS-ABOUT-MINOR-AXIS <= 18

| | | | | | | ELONGATEDNESS <= 58: van (30.0/3.0)

| | | | | | | ELONGATEDNESS > 58: saab (3.0)

| | | | | | SKEWNESS-ABOUT-MINOR-AXIS > 18: opel (3.0/1.0)

| | | | | PR.AXIS-RECTANGULARITY > 17

| | | | | | PR.AXIS-RECTANGULARITY <= 18

| | | | | | | MAX.LENGTH-RECTANGULARITY <= 128

| | | | | | | | HOLLOWS-RATIO <= 186: saab (6.0)

| | | | | | | | HOLLOWS-RATIO > 186

| | | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 164

| | | | | | | | | | MAX.LENGTH-RECTANGULARITY <= 124

| | | | | | | | | | | KURTOSIS-ABOUT-MINOR-AXIS <= 27: saab (2.0)

| | | | | | | | | | | KURTOSIS-ABOUT-MINOR-AXIS > 27: opel (3.0)

| | | | | | | | | | MAX.LENGTH-RECTANGULARITY > 124: opel (6.0)

| | | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS > 164: saab (2.0)

| | | | | | | MAX.LENGTH-RECTANGULARITY > 128

| | | | | | | | SCALED-RADIUS-OF-GYRATION <= 138: van (19.0/2.0)

| | | | | | | | SCALED-RADIUS-OF-GYRATION > 138

| | | | | | | | | PR.AXIS-ASPECT-RATIO <= 53: van (2.0)

| | | | | | | | | PR.AXIS-ASPECT-RATIO > 53

| | | | | | | | | | MAX.LENGTH-ASPECT-RATIO <= 5

| | | | | | | | | | | COMPACTNESS <= 84: opel (2.0)

| | | | | | | | | | | COMPACTNESS > 84: saab (4.0)

| | | | | | | | | | MAX.LENGTH-ASPECT-RATIO > 5

| | | | | | | | | | | DISTANCE-CIRCULARITY <= 66

| | | | | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS <= 4: opel (2.0)

| | | | | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS > 4: saab (2.0)

| | | | | | | | | | | DISTANCE-CIRCULARITY > 66: opel (5.0)

| | | | | | PR.AXIS-RECTANGULARITY > 18: saab (3.0)

| | | | MAX.LENGTH-RECTANGULARITY > 138

| | | | | ELONGATEDNESS <= 47

| | | | | | MAX.LENGTH-RECTANGULARITY <= 143: saab (3.0/1.0)

| | | | | | MAX.LENGTH-RECTANGULARITY > 143: van (4.0)

| | | | | ELONGATEDNESS > 47: van (39.0/1.0)

| | SCALED-VARIANCE-ALONG-MINOR-AXIS > 305

| | | DISTANCE-CIRCULARITY <= 76

| | | | SKEWNESS-ABOUT-MINOR-AXIS <= 10

| | | | | SKEWNESS-ABOUT-MAJOR-AXIS <= 64

| | | | | | CIRCULARITY <= 35: opel (2.0)

| | | | | | CIRCULARITY > 35: saab (2.0)

| | | | | SKEWNESS-ABOUT-MAJOR-AXIS > 64

| | | | | | SCATTER-RATIO <= 143

| | | | | | | DISTANCE-CIRCULARITY <= 70: bus (4.0)

| | | | | | | DISTANCE-CIRCULARITY > 70: van (2.0)

| | | | | | SCATTER-RATIO > 143

| | | | | | | CIRCULARITY <= 41

| | | | | | | | PR.AXIS-ASPECT-RATIO <= 62: saab (7.0)

| | | | | | | | PR.AXIS-ASPECT-RATIO > 62

| | | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 180: bus (19.0)

| | | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS > 180

| | | | | | | | | | DISTANCE-CIRCULARITY <= 74: saab (2.0)

| | | | | | | | | | DISTANCE-CIRCULARITY > 74: bus (2.0)

| | | | | | | CIRCULARITY > 41: bus (97.0)

| | | | SKEWNESS-ABOUT-MINOR-AXIS > 10

| | | | | PR.AXIS-ASPECT-RATIO <= 62

| | | | | | PR.AXIS-RECTANGULARITY <= 19

| | | | | | | ELONGATEDNESS <= 43: saab (2.0)

| | | | | | | ELONGATEDNESS > 43

| | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS <= 165: saab (2.0)

| | | | | | | | SCALED-VARIANCE-ALONG-MAJOR-AXIS > 165

| | | | | | | | | CIRCULARITY <= 42: opel (7.0)

| | | | | | | | | CIRCULARITY > 42

| | | | | | | | | | RADIUS-RATIO <= 151: saab (2.0)

| | | | | | | | | | RADIUS-RATIO > 151: opel (2.0)

| | | | | | PR.AXIS-RECTANGULARITY > 19: opel (2.0)

| | | | | PR.AXIS-ASPECT-RATIO > 62: bus (3.0)

| | | DISTANCE-CIRCULARITY > 76

| | | | PR.AXIS-ASPECT-RATIO <= 61

| | | | | PR.AXIS-RECTANGULARITY <= 19

| | | | | | SCALED-RADIUS-OF-GYRATION <= 132: saab (3.0)

| | | | | | SCALED-RADIUS-OF-GYRATION > 132

| | | | | | | MAX.LENGTH-RECTANGULARITY <= 145

| | | | | | | | HOLLOWS-RATIO <= 192

| | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS <= 8: saab (3.0)

| | | | | | | | | SKEWNESS-ABOUT-MINOR-AXIS > 8: opel (4.0)

| | | | | | | | HOLLOWS-RATIO > 192: opel (10.0)

| | | | | | | MAX.LENGTH-RECTANGULARITY > 145: saab (2.0)

| | | | | PR.AXIS-RECTANGULARITY > 19: saab (3.0/1.0)

| | | | PR.AXIS-ASPECT-RATIO > 61

| | | | | SKEWNESS-ABOUT-MINOR-AXIS <= 5

| | | | | | CIRCULARITY <= 38: opel (2.0)

| | | | | | CIRCULARITY > 38: van (3.0)

| | | | | SKEWNESS-ABOUT-MINOR-AXIS > 5: saab (3.0)

| MAX.LENGTH-ASPECT-RATIO > 8

| | HOLLOWS-RATIO <= 189: bus (5.0/1.0)

| | HOLLOWS-RATIO > 189

| | | SKEWNESS-ABOUT-MAJOR-AXIS <= 63: saab (4.0/1.0)

| | | SKEWNESS-ABOUT-MAJOR-AXIS > 63: van (107.0/2.0)

Number of Leaves : 98

Size of the tree : 195

Time taken to build model: 0.02 seconds

=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances 613 72.4586 %

Incorrectly Classified Instances 233 27.5414 %

Kappa statistic 0.6328

Mean absolute error 0.1415

Root mean squared error 0.3355

Relative absolute error 37.7493 %

Root relative squared error 77.4887 %

Total Number of Instances 846

=== Detailed Accuracy By Class ===

TP Rate FP Rate Precision Recall F-Measure MCC ROC Area PRC Area Class

0.613 0.166 0.553 0.613 0.582 0.433 0.784 0.544 opel

0.456 0.143 0.524 0.456 0.488 0.328 0.758 0.473 saab

0.950 0.019 0.945 0.950 0.947 0.929 0.977 0.945 bus

0.889 0.040 0.872 0.889 0.881 0.843 0.932 0.793 van

Weighted Avg. 0.725 0.093 0.722 0.725 0.722 0.631 0.862 0.687

=== Confusion Matrix ===

a b c d <-- classified as

130 74 2 6 | a = opel

96 99 6 16 | b = saab

3 4 207 4 | c = bus

6 12 4 177 | d = va

Now considering these five classifier’s performance, there are True positive (TP) value and False positive (FP) for each of the classifier. Plotting these values of TP and FP in the ROC graph:

**Analysis:** Now (0.448, 0.177) which is for Naive Bayes Classifier is closer to the best point(0,1). The rest of four classifier belong to the worst triangle. Naive Bayes Classifier is adjacent to the best point. So, Naive Bayes Classifier is the best and suitable classifier for this dataset.