

Predicting Bean Type Based on Metamorphic Measurements

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Utilizing a dataset from Seed Size and Shape Analysis of Registered Common Bean (*Phaseolus vulgaris* L.) Cultivars in Turkey Using Digital Photography
from the Journal of Agricultural Science

Intro and Objective

- Objective: Test various predictive analytics algorithms for multiclass classification to sort beans based on their morphometric measurements
- Dataset
 - 3000 observations
 - 500 observations per class
 - 6 classes
 - No additional assumptions
- Measures
 - Accuracy
 - Weight differential between predictions and actual values
 - Cost differential between predictions and actual values

Intro and Objective

- Dependent Variable Classes:

ClassID <dbl>	Class <chr>	dollars_per_lb <dbl>	grams_per_seed <dbl>	approx_lbs_per_seed <dbl>	approx_dollars_per_seed <dbl>	approx_dollars_per_gram <dbl>
1	BOMBAY	5.56	1.92	0.0042	0.0234	0.0123
2	CALI	6.02	0.61	0.0013	0.0078	0.0133
3	DERMASON	1.98	0.28	0.0006	0.0012	0.0044
4	HOROZ	2.43	0.52	0.0011	0.0027	0.0054
5	SEKER	2.72	0.49	0.0011	0.0030	0.0060
6	SIRA	5.40	0.38	0.0008	0.0043	0.0119

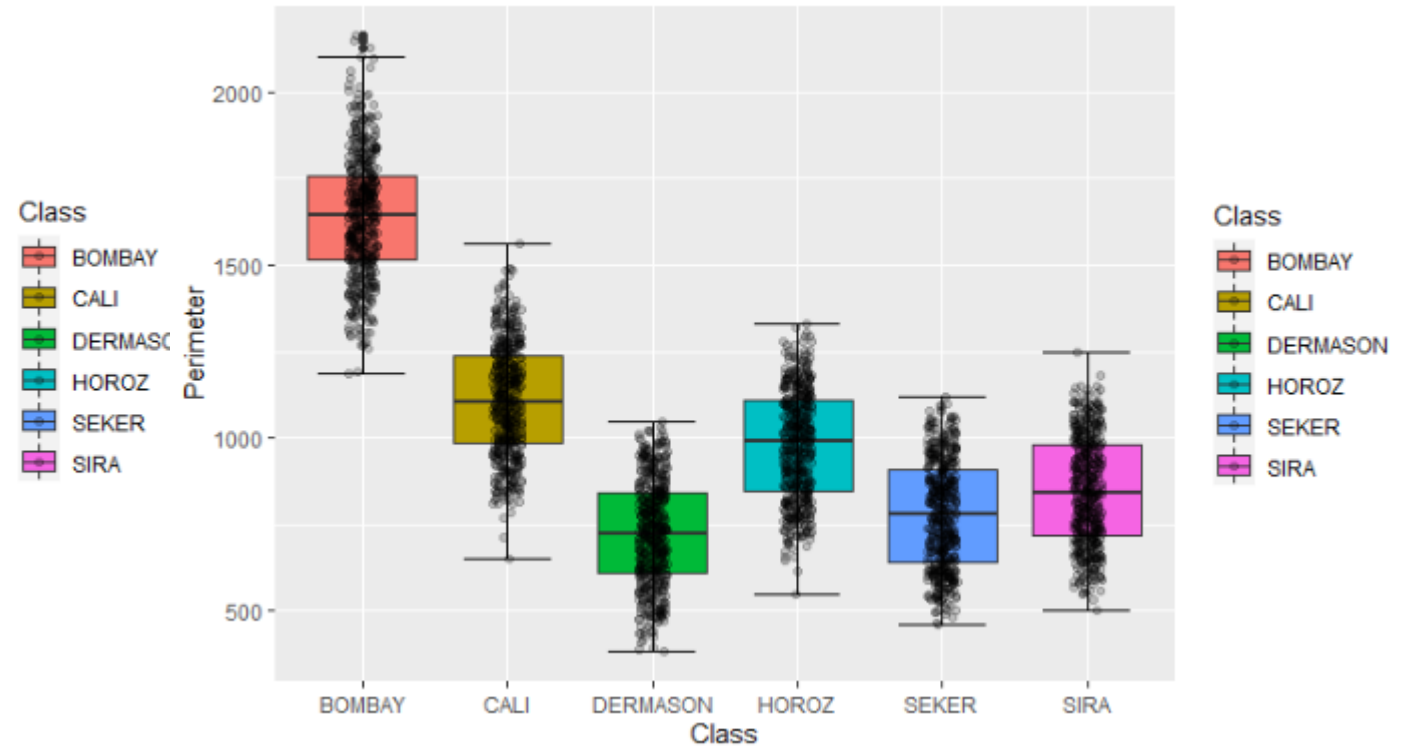
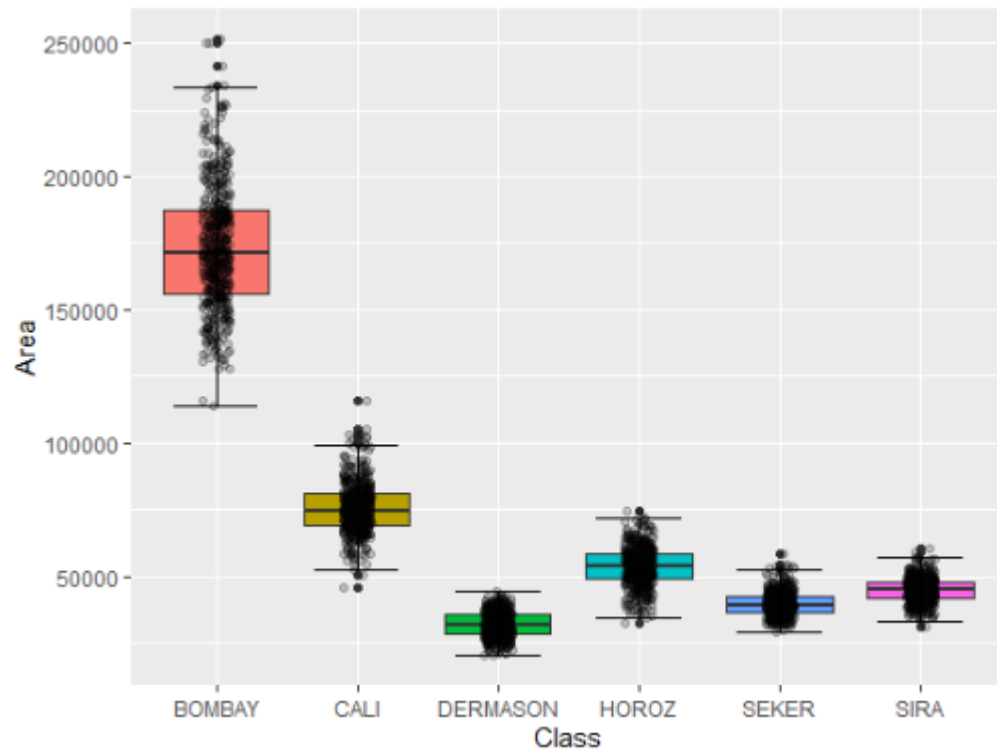
- Independent Variables:

ID <dbl>	name <chr>	description <chr>
1	Area	The area of a bean zone and the number of pixels within its boundaries.
2	Perimeter	Bean circumference is defined as the length of its border.
3	MajorAxisLength	The distance between the ends of the longest line that can be drawn from a bean.
4	MinorAxisLength	The longest line that can be drawn from the bean while standing perpendicular to the main axis.
5	Eccentricity	Eccentricity of the ellipse having the same moments as the region.
6	ConvexArea	Number of pixels in the smallest convex polygon that can contain the area of a bean seed.
7	Extent	The ratio of the pixels in the bounding box to the bean area.

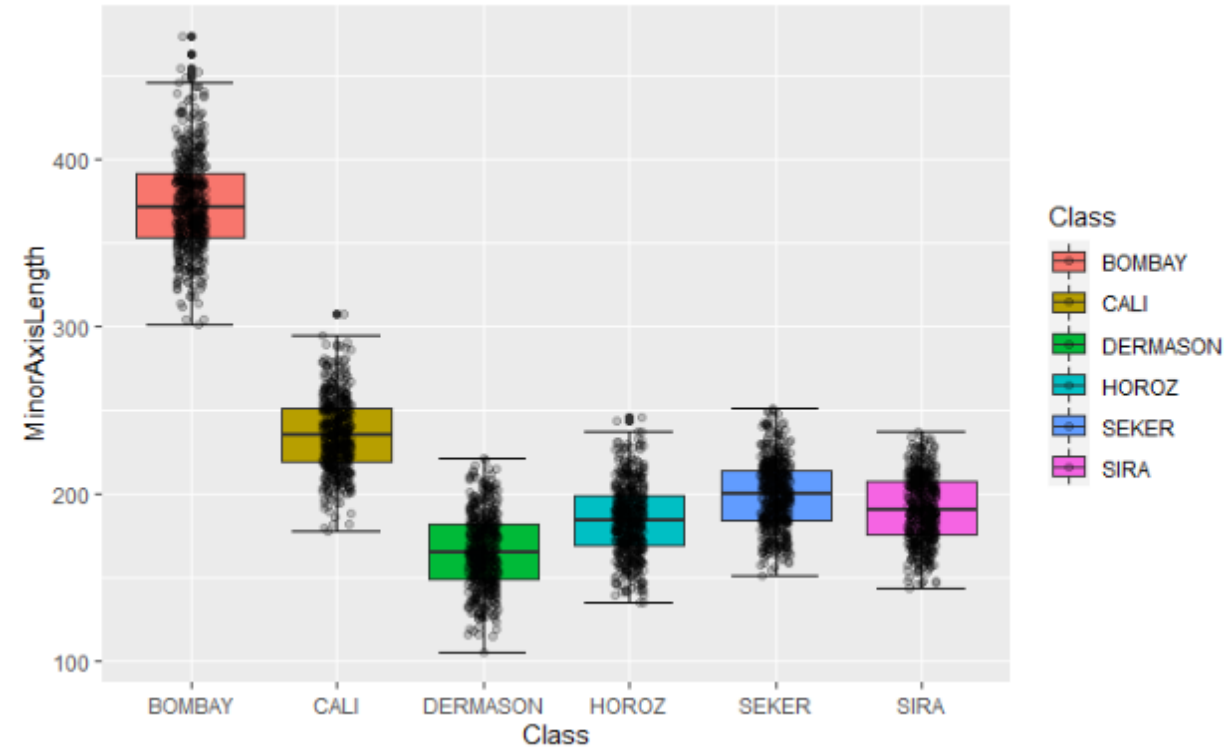
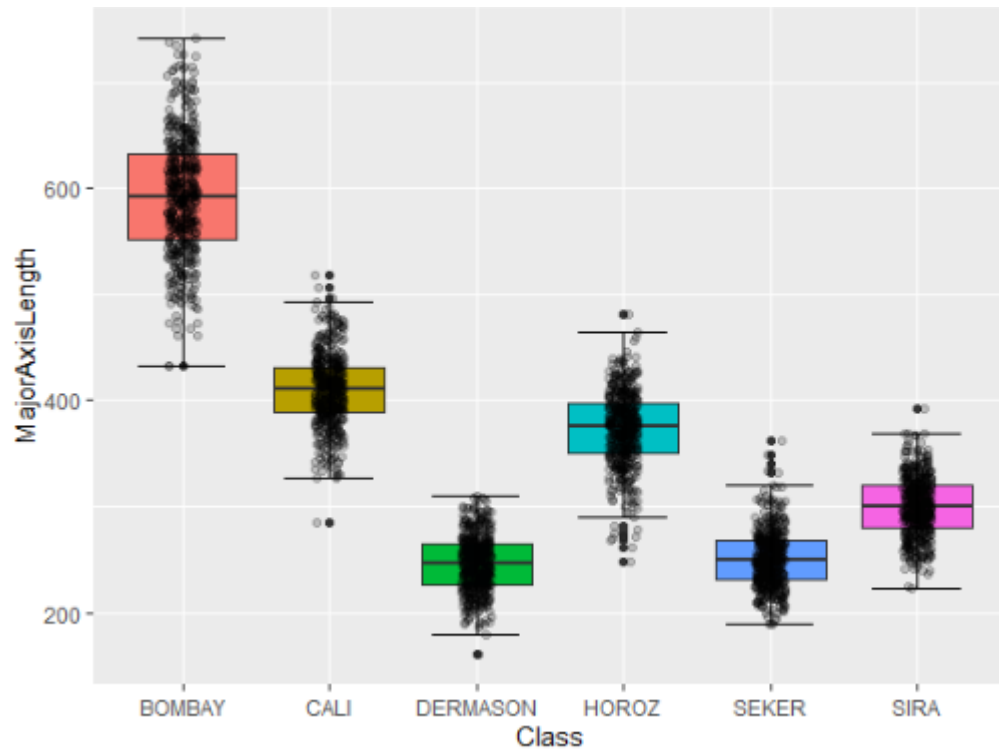
Methods

- Validation Technique
 - Leave One Out Cross-Validation
 - 80/20 data split with 80% of the data being used for training and validation while the last 20 is used to test the final model(s) and obtain a final accuracy rate
- Normalization/Standardization Technique
 - Z-Score
- Feature Selection Method
 - Best Subset Selection with residual sum of squares and then adjusted R^2 as the criteria for feature selection
- Statistical Models
 - Multinomial Logistic Regression
 - Linear Discriminant Analysis
 - K-Nearest Neighbors Classifier
 - Quadratic Discriminant Analysis
 - Naïve Bayes

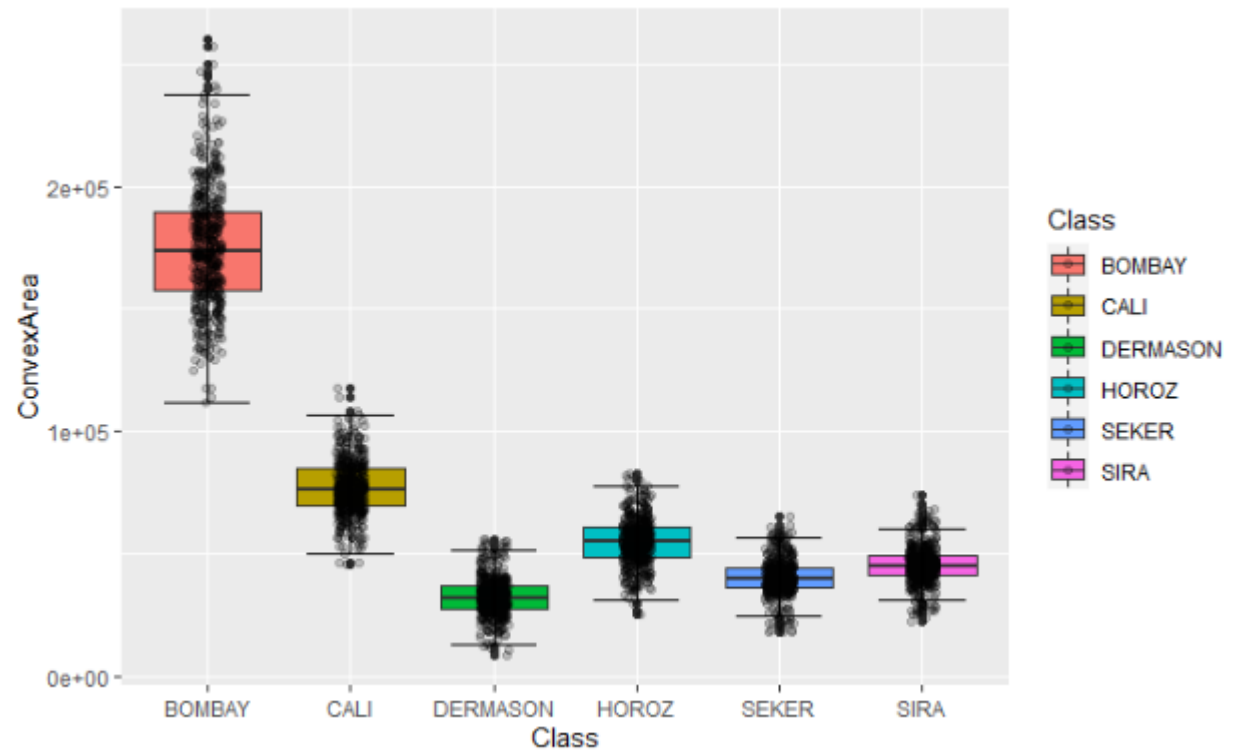
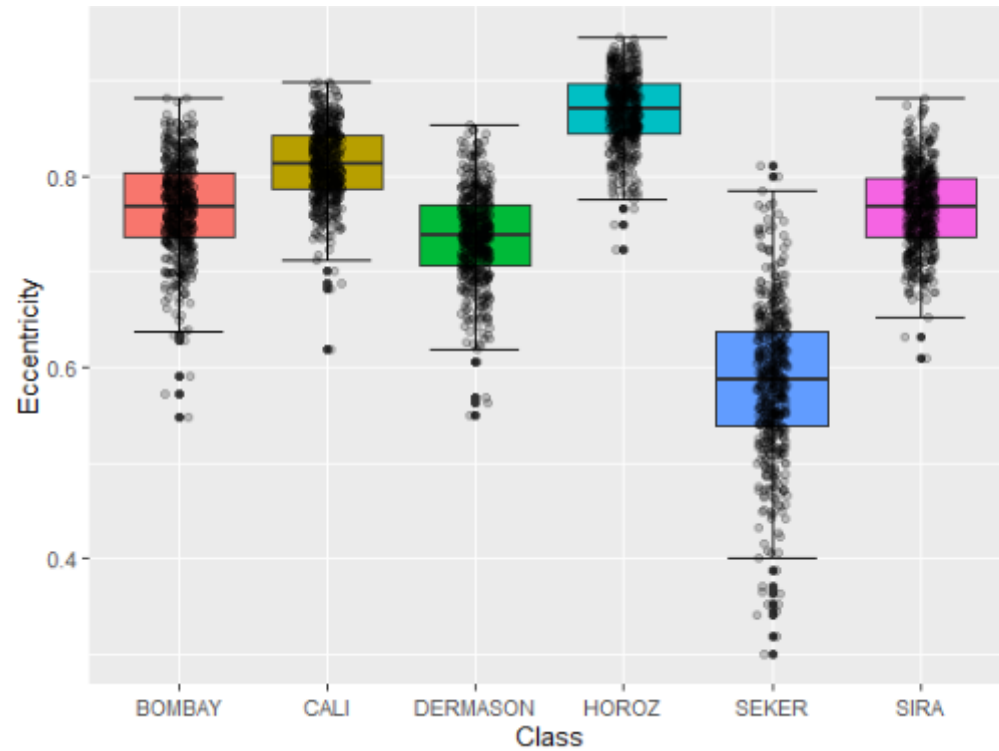
Exploratory Analysis



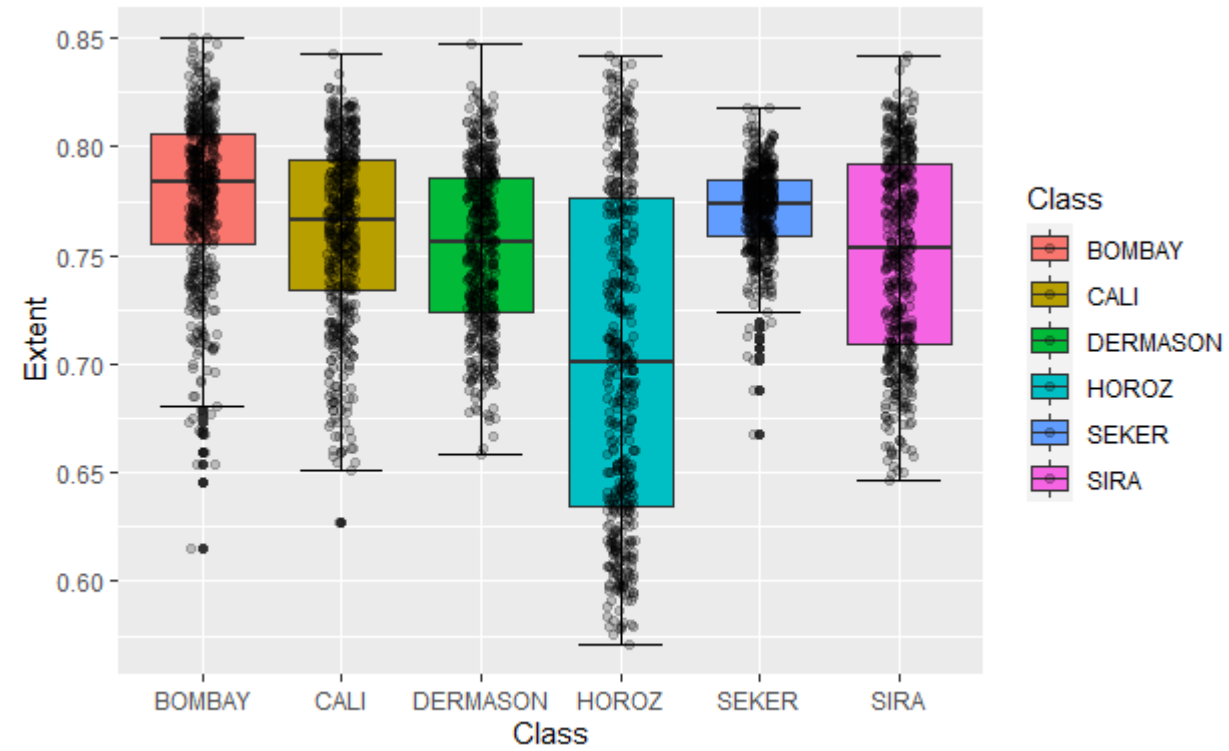
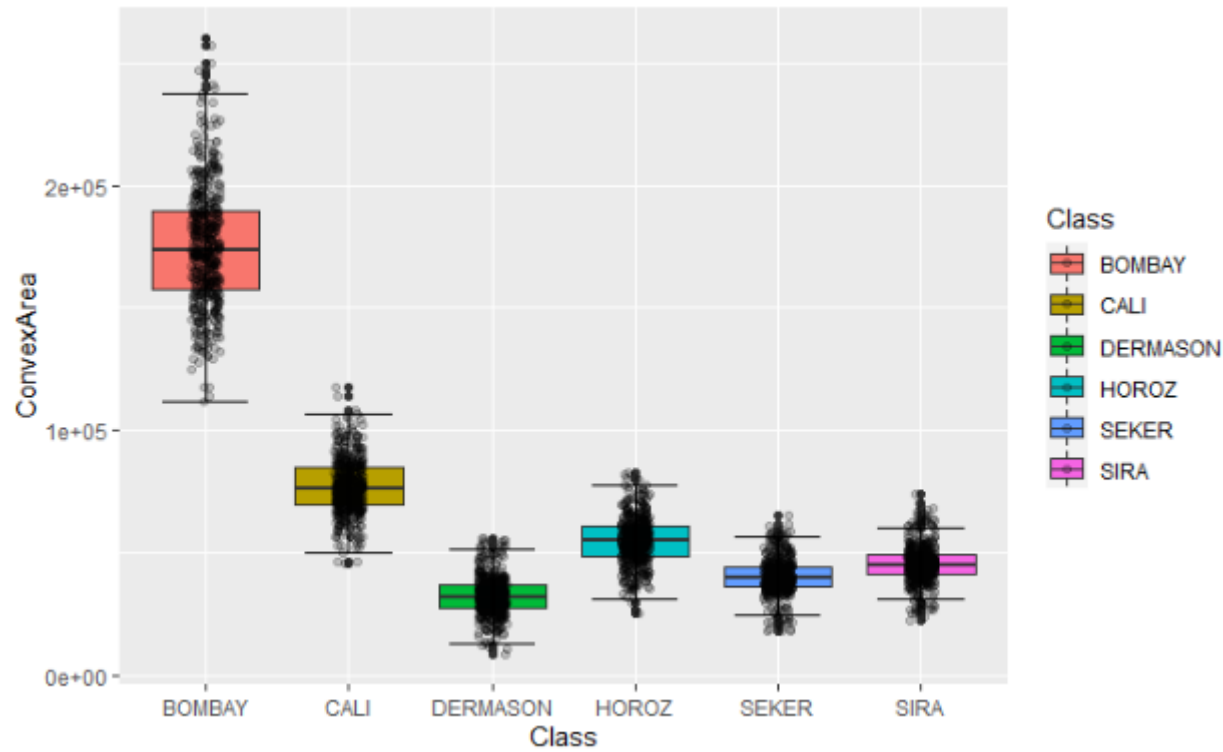
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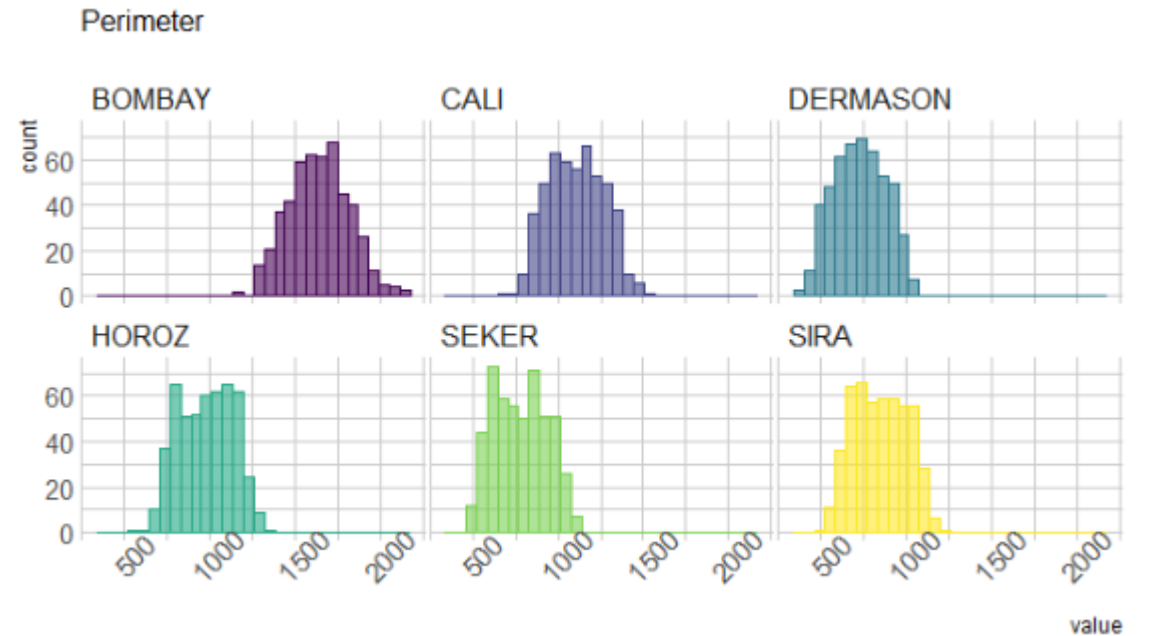
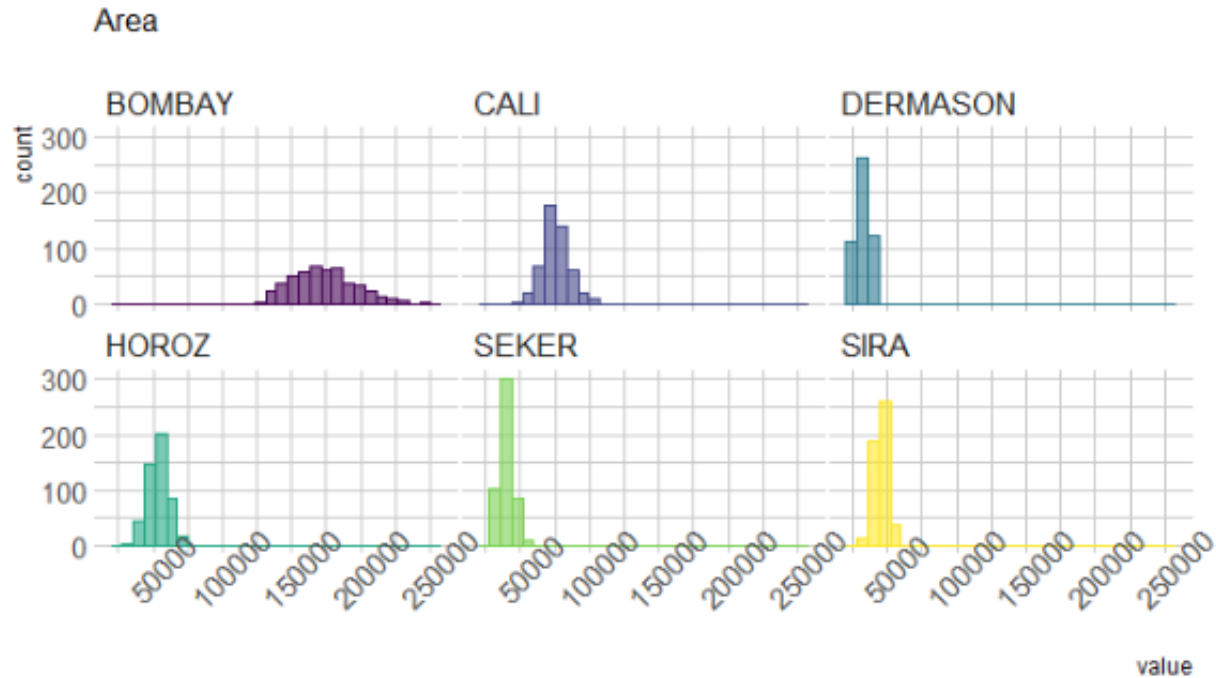
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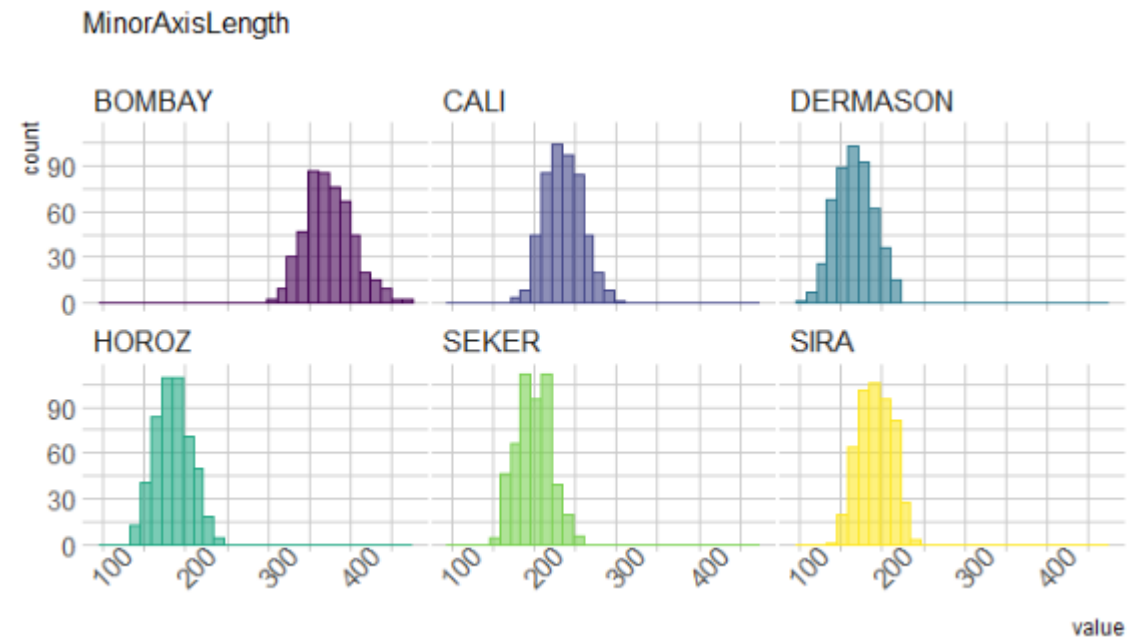
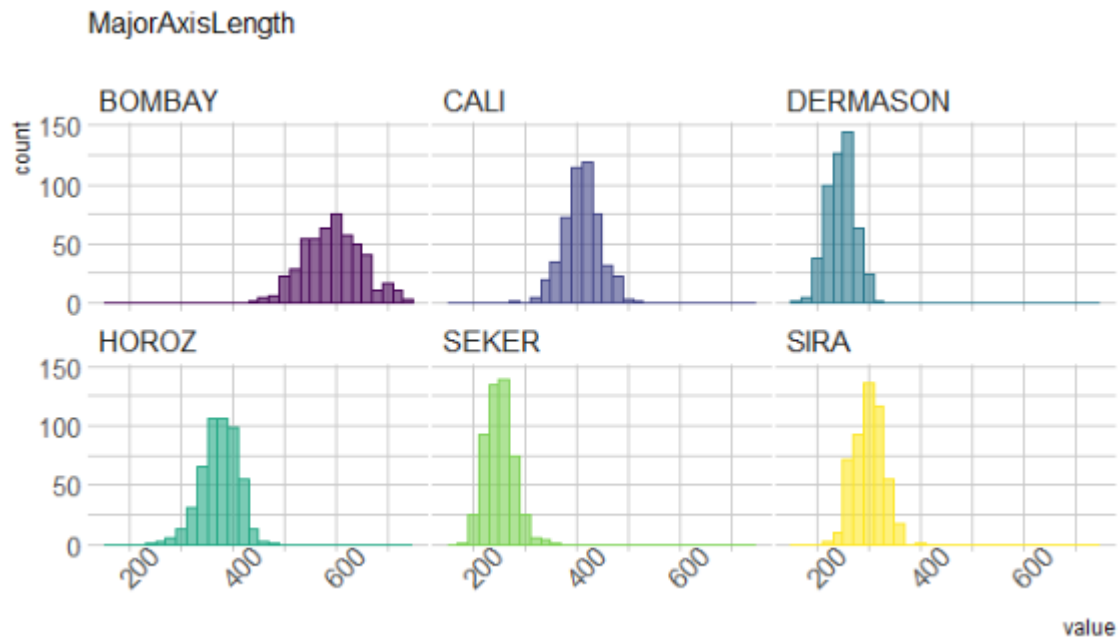
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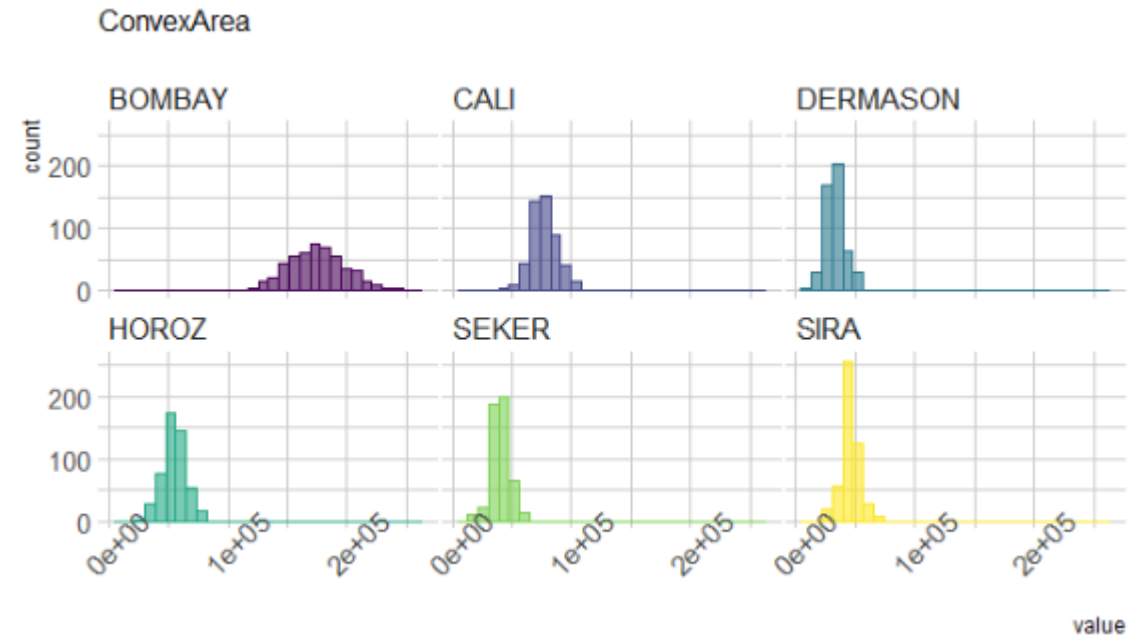
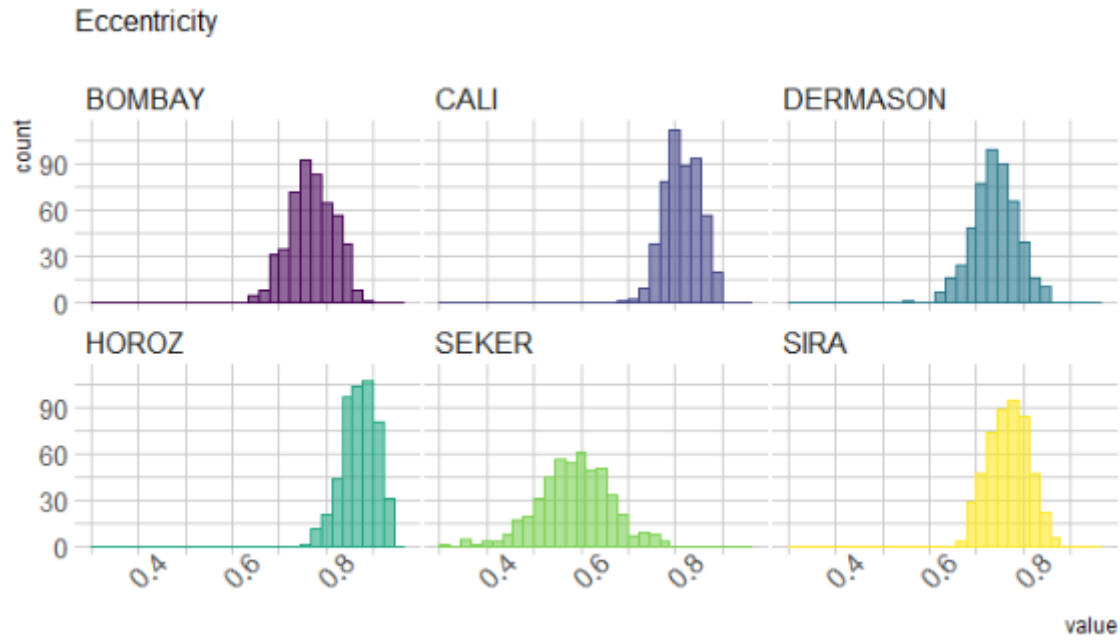
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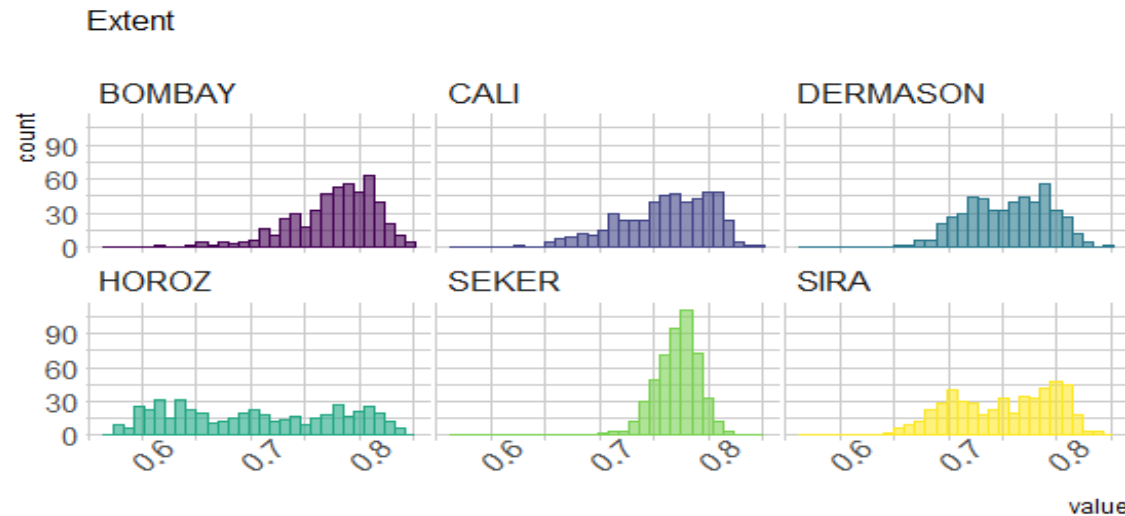
Exploratory Analysis



Exploratory Analysis



Exploratory Analysis



Class <chr>	Freq <int>
BOMBAY	500
CALI	500
DERMASON	500
HOROZ	500
SEKER	500
SIRA	500

- Results:
 - Most of the data is normally distributed with the least normally distributed variable being Extent
 - The dataset has many outliers as revealed by the boxplots. These will be removed in order to optimize the predictive models.

Exploratory Analysis

- Results After Outlier Removal
 - Dataset was reduced from 3000 observations to 2731

Class <chr>	Freq <int>
BOMBAY	460
CALI	468
DERMASON	470
HOROZ	474
SEKER	422
SIRA	437

Results Analysis

- Leave-One-Out Cross Validation Results and chosen models:

	ModelID	Model_Name	Accuracy	Weight_Differential	Cost_Differential
1	1	Multinomial Logistic Regression	0.9849	0.15	0.0393
2	2	Linear Discriminant Analysis	0.978	6.95	0.0275
3	3	K-Nearest Neighbors	0.9876	5.01	0.012
4	4	Quadratic Discriminant Analysis	0.9679	1.05	0.0951
5	5	Naive Bayes Analysis	0.9611	1	0.0383

- 2 models were chosen as they were both optimal but based on different criteria

Results Analysis

- Test dataset results:

	ModelID	Model_Name	Accuracy	Weight_Differential	Cost_Differential
1	1	Multinomial Logistic Regression	0.9835	0.22	0.0055
2	2	K-Nearest Neighbors	0.9817	1.21	0.0232

- The results on the test dataset indicated strong results on all three measures and by both models.

Conclusions

- Multinomial Logistic Regression and K-Nearest Neighbors were the most accurate when making predictions on bean types based on the morphometric measurement features
 - Both had accuracy rates of over 98% on the validation and test datasets
 - Both also had the lowest weight differential and cost differential respectively compared to the other models when tested on the validation dataset

References

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