45. **Planetary Classification Using Machine Learning Techniques**

**Abstract:** This research investigates the use of various machine learning models—Quadratic Discriminant Analysis (QDA) and Naive Bayes classifiers—to classify planets based on their solar radiation, atmospheric composition, and other planetary characteristics. The study aims to evaluate the effectiveness of these models in accurately predicting planetary classification and identify decision boundaries for optimal model selection.

**Introduction:** Planetary classification is a challenging task due to the variety of planetary environments and their unique characteristics. In this study, we explore the application of machine learning techniques to classify planets based on several factors, including solar radiation, atmospheric composition, and other relevant metrics. Our goal is to determine which classification method provides the best performance in terms of accuracy and interpretability.

**Methodology:** We use a dataset consisting of multiple planetary attributes, including solar radiation, atmospheric composition, and other characteristics. The dataset includes 200 observations across various planets, including names such as Bloopa, Chucklestar, Giggletron, and others. The data is processed using two machine learning models:

1. **Quadratic Discriminant Analysis (QDA):** A probabilistic classification model that assumes different covariance matrices for each class. QDA is particularly useful when the decision boundary between classes is non-linear.
2. **Naive Bayes Classifier:** A simple probabilistic classifier based on Bayes’ theorem with strong independence assumptions between features.

**Results:**

1. **Confusion Matrix Analysis:** The confusion matrix reveals the performance of the models in classifying different planets. Each matrix indicates the number of correctly and incorrectly classified instances for each planetary class. The matrices show a mix of high and low prediction accuracy across different classes, highlighting the challenges in classifying planets with overlapping features.
2. **Quadratic Discriminant Analysis Decision Boundaries:** The decision boundaries for the QDA model (Figure 2) show complex, non-linear contours indicating the regions in which each planet is classified. The model accounts for variations in both solar radiation and atmospheric composition to delineate boundaries between different planets.
3. **Naive Bayes Decision Boundaries:** The Naive Bayes classifier's decision boundaries (Figure 3) demonstrate smoother transitions between different planetary classes. Unlike QDA, which allows for complex and non-linear boundaries, the Naive Bayes model assumes independence between features, leading to more straightforward decision regions.

**Discussion:** The analysis suggests that while QDA can capture complex, non-linear relationships between planetary features, it may overfit in cases where the classes overlap significantly, as indicated by the confusion matrix. The Naive Bayes classifier, with its simpler decision boundaries, provides a more generalized approach but might lack precision in highly variable environments.

**Conclusion:** Both QDA and Naive Bayes classifiers offer unique advantages for planetary classification. QDA's flexibility in modeling complex boundaries makes it suitable for datasets with non-linear separations, whereas Naive Bayes is more appropriate for cases with simpler, independent feature relationships. Future work could explore combining these models or applying other machine learning techniques, such as neural networks or support vector machines, to enhance classification accuracy.