Naive Bayes Classification Report

Group_3

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Introduction to the Topic

Naïve Bayes Classifier is one of the most simple and effective classification algorithms which assumes that features for the description of observation are conditionally independent, given the class label. It can also be viewed as a simple and probabilistic model used for classification tasks that are based on Bayes' theorem which make assumptions of independence between attributes or variables used to describe data point. The Naïve part of the classifier was derived from assumption that the presence or absent of one feature does not affect the presence or absent of another feature. The setback with this classifier arises when there is violation of its assumption of independent features.

Naïve Bayes classifier to calculate conditional probability of a class © for a given set of features (N) can be expressed mathematically thus: .

If; P(C|N) = probability of class C given the features N,

P(N|C) = Probability of observing N given the class C

P© =P(C) = Probability of class C before any additional information is considered

P(X) = probability of observing features N. (Evidence)

Then: $P(C|N) = \frac{P©P(N|C)}{P(N)}$

In the other hand, Decision Tree Classifier is a Tree-like model which splits data based on features. They are very useful in classification and regression problems.

Random Forest classifier is an ensembled Decision Trees. They are more accurate in classification and achieve this by constructing numerous decision trees during the training process and ultimately predicting the class that appears most frequently across these individual trees. The main disadvantage is overfitting and less interpretable.

Data Loading and Preprocessing:

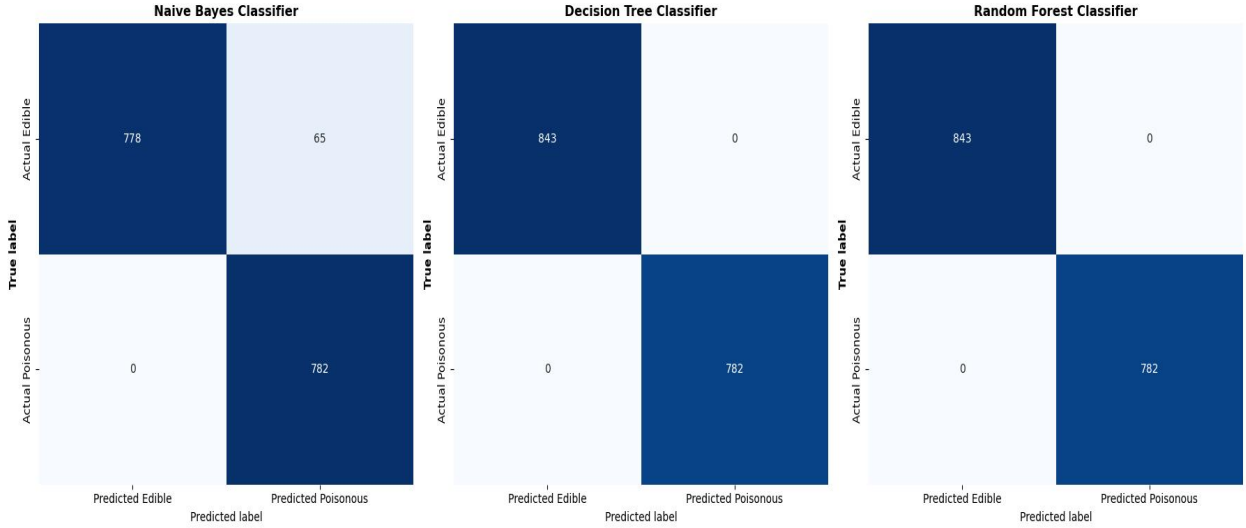
The data for the exercise is from: https://archive.ics.uci.edu/ml/datasets/Mushroom

The aim is to process the data and subsequently evaluate model on a dataset, specifically the "Agaricus-Lepiota.data" mushroom dataset. The objective is to classify mushrooms as edible or poisonous using classifiers: Naive Bayes, Decision Tree/Random Forest and compare their precisions.

The mushroom dataset loaded into pandas Dataframe was without column header which was processed to include descriptive column names from an accompanying 'agaricus-lepiota.names' file. Also, attribute names were also extracted from the .names file. For better readability and analysis, these attributes including the target variables (class: Edible or poisonous) were assigned to the Dataframe.

Lastly, OneHotEncoder was employed to creates a new binary variable for each level of the categorical variable. Mushroom data then is split into training and testing sets.

Data Analysis and visualization



Comparing and Contrasting Results:

The accuracy of Naïve Bayes' Classifier on the dataset is 96% and has some misclassifications thus: 65 false positives and zero false negatives. The custom threshold (normally 0.5) was reduced to 0.4 to ensure that no potentially poisonous mushrooms are misclassified as edible, the model was retrained. Though, False positive increased from 65 to 68 and accuracy reduced to 95.8%, it was pertinent to err on the side of caution. The Decision Tree and Random Forest Classifiers achieved 100% accuracy on the dataset with no misclassification error.

Correlation matrix was checked to figure out the reason Naïve Baye's classifier could not achieve 100% accuracy. This can only be possible when there are no violations of its assumption of independent features. The Correlation matrix showed that there are instances of this violation which can be attributed to the classifier performing at 96% accuracy. Few of correlation table as shown below.

Pairs of features with high correlation:

```
stalk-color-below-ring_c    ring-number_n                1.000000
odor_m                      stalk-color-below-ring_c     1.000000
                            ring-number_n                1.000000
                            ring-type_n                  1.000000
stalk-color-above-ring_y    veil-color_y                 1.000000
stalk-color-above-ring_o    stalk-color-below-ring_o     1.000000
```

In conclusion, while each model has its strengths and limitations, the choice of classifier in such applications must be guided not only by accuracy metrics but also by the understanding of underlying data characteristics and model assumptions. The ability of the Decision Tree and Random Forest models to perfectly classify the mushrooms, along with their robustness to feature inter dependencies, positions them as more suitable for this particular dataset. Nonetheless, the Naive Bayes classifier, with its threshold adjustment, remains a viable option, especially in scenarios where simplicity and speed are priorities.

References:

Machine Learning with Python Cookbook, 2nd Edition (oreilly.com) Chp 18