Mushroom Classification

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Mushroom Data

- Mushrooms (5935 observations) are categorized as Edible (3767 observations) or Poisonous (2168 observations). [1]
- Covariate data is composed of 22 categorical factors (e.g. CapColor, VeilColor, CapShape,...etc) of a Mushroom.
  - e.g. CapColor is either brown, gray, red,... etc
- Objective: Accurately classify a mushroom with as few and as unambiguous categorical factors as possible.

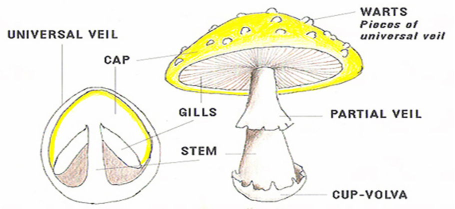
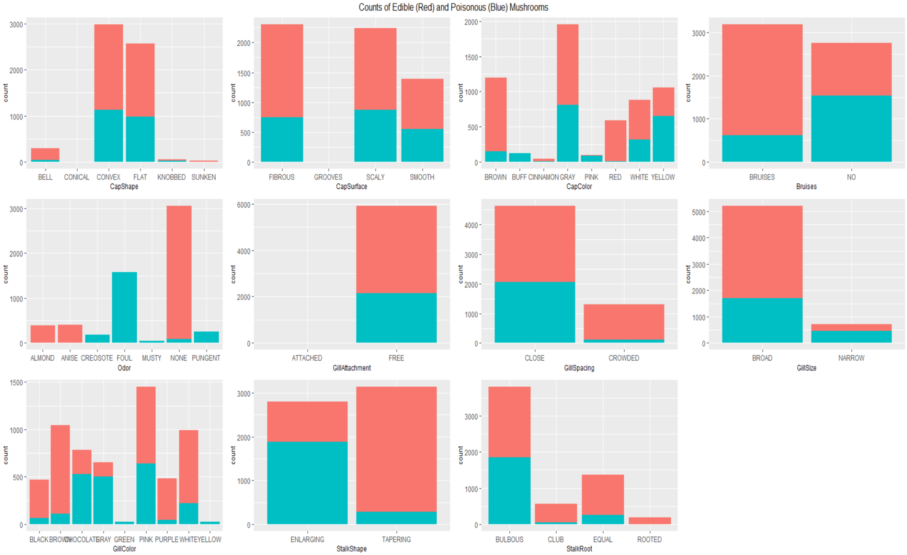
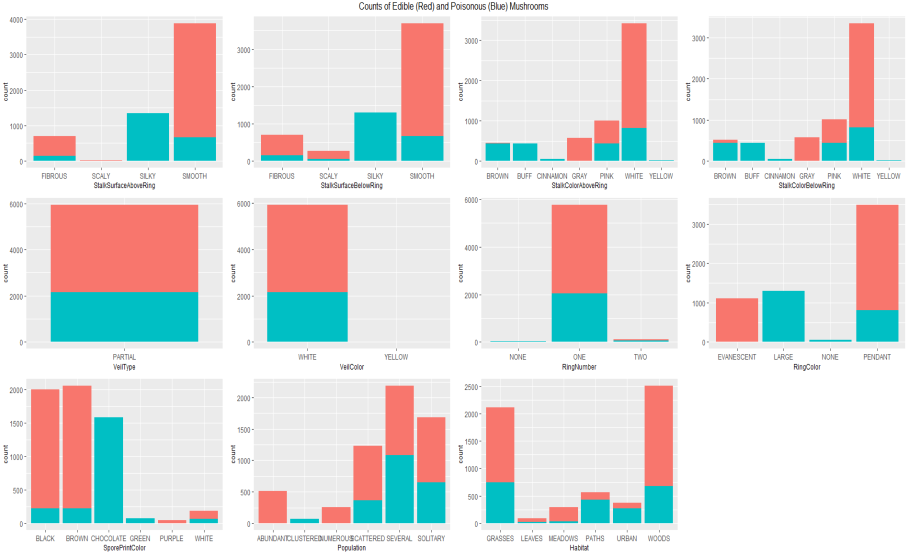


image from https://anandakalyani.org/blog/2015/12/07/discovering-mushrooms-at-master-unit/

Stacked Bar Graph of Mushroom Data

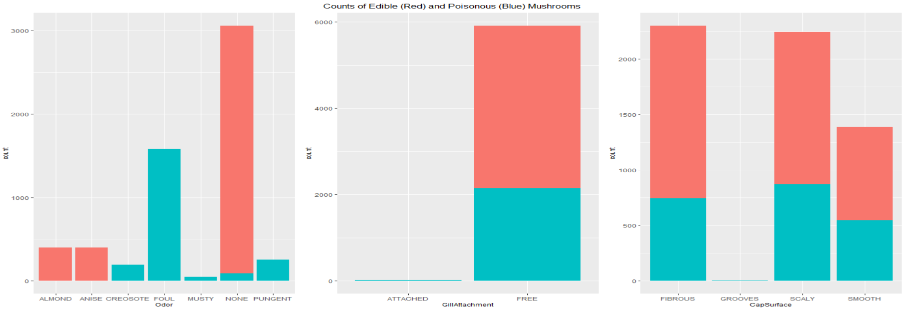

Counts of Edible (Red) and Poisonous (Blue) Mushrooms

Stacked Bar Graph of Mushroom Data



Stacked Bar Graph of Mushroom Data

- Some covariates (i.e GillAttachment) have no meaningful contribution
- Some covariates have good separation (i.e. Odor)
- Most covariates are mixed.



Classification and Variable Reduction Methods

- Using the full set of covariates results in an average ARI of 1 for all classification methods listed below (fifteen different 50:50 train/test set).
- Association rules and stacked bar graphs will be used to choose a subset of covariates for classification. Average ARI will be used for comparisons.
- 2 Classification methods will be optimized on the chosen subset of covariates
  - Random Forests
  - Neural Networks

Classification and Variable Reduction Methods: Association Rules

- Association rules are statements wherein a set of non-empty covariates (A) is "associated" to a different non-empty set of Covariates (B).
- Certain measures have been used to characterize whether a rule is meaningful or interesting (lift, support, confidence, etc).
- Support: $s(A \Rightarrow B) = P(A, B)$
- Confidence: $c(A \Rightarrow B) = \frac{P(A,B)}{P(A)}$
- Lift: $L(A \Rightarrow B) = \frac{P(A,B)}{P(A)P(B)}$

Classification and Variable Reduction Methods: Random Forest

- Uses M classification trees to make a prediction based on the given predictor variables
- At each split, a random subset of the predictor variables are considered for the next split. Size of the subset can be controlled.
- M classification trees are produced via a re-sampling method of the training set.
- $\hat{f}$ Indicates the prediction. The predictions are hardened for classifications.

$$\hat{f}_{\text{forest}}(x) = \frac{1}{M} \sum_{m=1}^{M} \hat{f}^{m}(x)$$

Classification and Variable Reduction Methods: Neural Network

- Composed of a hidden layer, input covariates and an output
- An activation function that controls the activation in the hidden layer

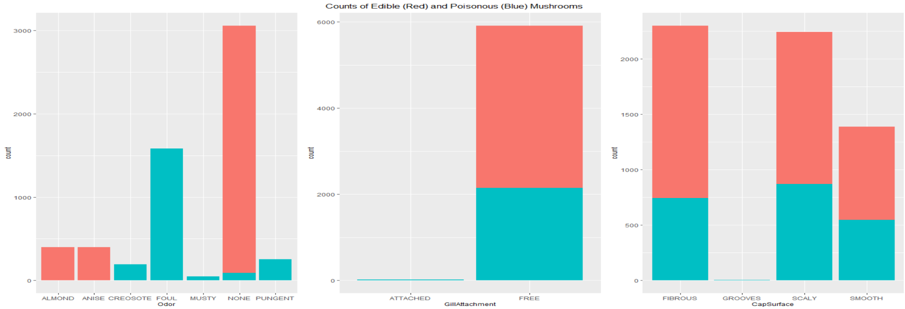
$$\sigma(v) = \frac{1}{1 - e^{-v}}$$

- An output function that transforms the neural network output to something more usable

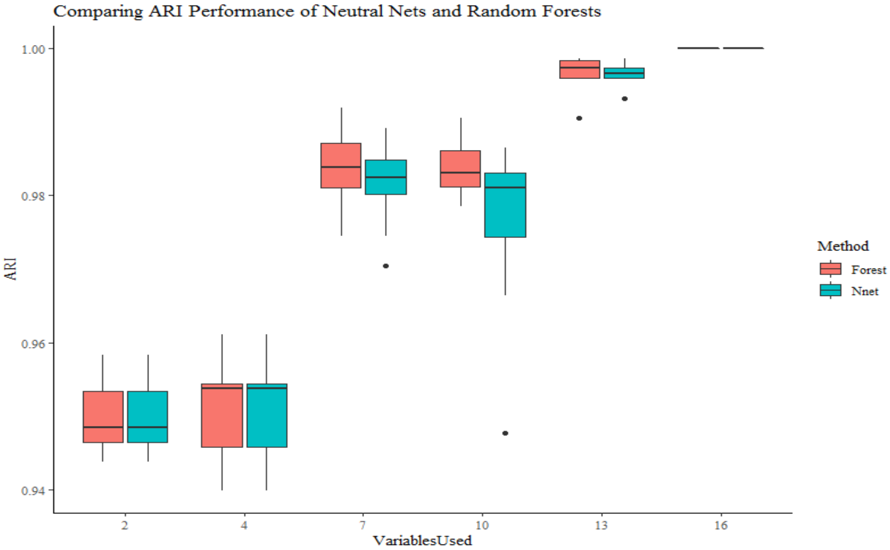
$$g_k(T) = \frac{E^{T_k}}{\sum_{h=1}^{K} e^{T_k}}$$

Variable Reduction

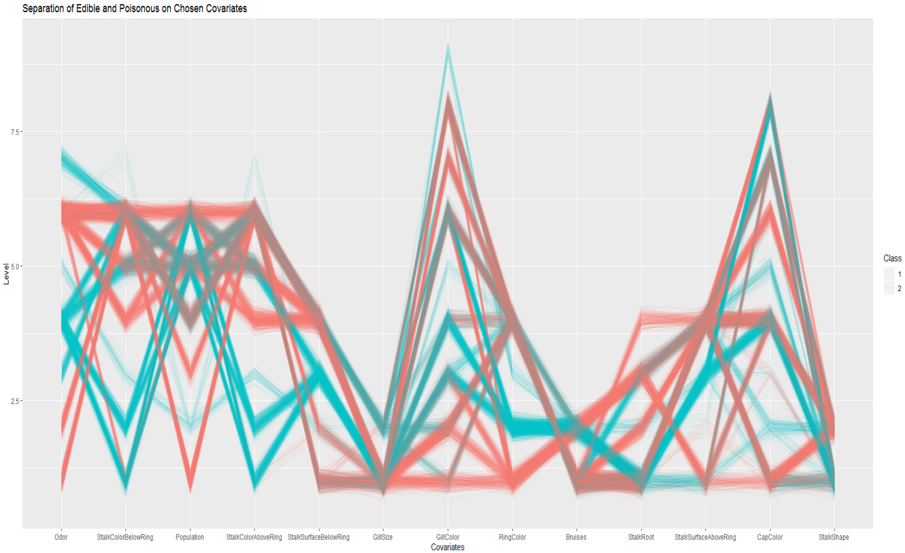
- The covariates used in the final model are based off of the associated rules with the highest standardized lift and on stacked bar graphs like the bottom left one
- ARI's were calculated (on unoptimized methods) as covariates were added to the model



Variable Reduction



Variable Reduction



Classification

- 13 Variables will be used - We will see if parameter optimization can increase the ARI to 1.
- Parameters were optimized for Random Forests and Neural Network
- Random Forest: $\text{mTry} = 5, \text{nTree} = 300 \Rightarrow \text{ARI} = 0.9979$
- Neural Net: $\text{size} = 2, \text{maxit} = 100, \text{decay} = 06 \Rightarrow \text{ARI} = 0.9972$

Conclusion

- Depending on how high of an ARI desired, we can choose between 2 and 16 variables to get from near perfect classification to perfect classification.
- It is possible to classify whether a mushroom is poisonous or edible based on less than the 22 covariates.
- There might be an issue with over fitting the data.

References

[1] Dheeru Dua and Casey Graff. Uci machine learning repository, Access 2019.

[2] McNicholas. Mcmaster stats 780 data science lecture notes, 2019.