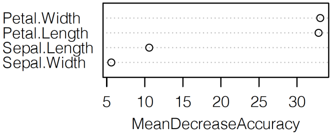
Introduction to Machine Learning

Random Forests: Feature Importance



Learning goals

- Understand that the goal of defining variable importance is to enhance interpretability of the random forest
- Know definition of variable importance based on improvement in split criterion
- Know definition of variable importance based on permutations of OOB observations

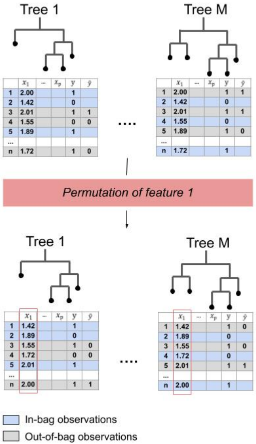
VARIABLE IMPORTANCE

- Single trees are highly interpretable
- Random forests as ensembles of trees lose this feature
- Contributions of the different features to the model are difficult to evaluate
- Way out: variable importance measures
- Basic idea: by how much would the performance of the random forest decrease if a specific feature were removed or rendered useless?

VARIABLE IMPORTANCE / 2

Measure based on improvement in split criterion

for features x_j, $j = 1$ to p **do**
    for tree base learners $\hat{b}^{[m]}$, $m = 1$ to M **do**
        Find all nodes $\mathcal{N}$ in $\hat{b}^{[m]}$ that use x_j.
        Compute improvement in splitting criterion achieved by them.
        Add up these improvements.
    end for
    Add up improvements over all trees to get feature importance of x_j.
end for



Measure based on permutations of OOB obs.

Estimate OOB error $\widehat{\text{err}}_{\text{OOB}}$.
for features x_j, $j = 1$ to p **do**
  Perform permutation ψ_j on x_j to distort feature-target relation for x_j.
  for distorted observations $(\mathbf{x}^{(i)}_{\psi_j}, y^{(i)})$, $i = 1$ to n **do**
    Compute OOB prediction $\hat{y}^{(i)}_{\text{OOB},\psi_j}$.
    Compute corresponding loss $L(y^{(i)}, \hat{y}^{(i)}_{\text{OOB},\psi_j})$.
  end for
  Estimate importance of j-th variable

$$\widehat{\text{VI}}_j = \widehat{\text{err}}_{\text{OOB},\psi_j} - \widehat{\text{err}}_{\text{OOB}} = \frac{1}{n}\sum_{i=1}^{n} L(y^{(i)}, \hat{y}^{(i)}_{\text{OOB},\psi_j}) - \widehat{\text{err}}_{\text{OOB}}.$$

end for

VARIABLE IMPORTANCE / 4

- Measure based on improvement in split criterion: MeanDecreaseGini (average total decrease in node impurities, measured by the Gini index)
- Measure based on permutations of OOB observations: MeanDecreaseAccuracy (average decrease in accuracy for predictions of OOB observations after permuting the *j*-th feature)