Lecture 8: Out-of-Bag (OOB) Error

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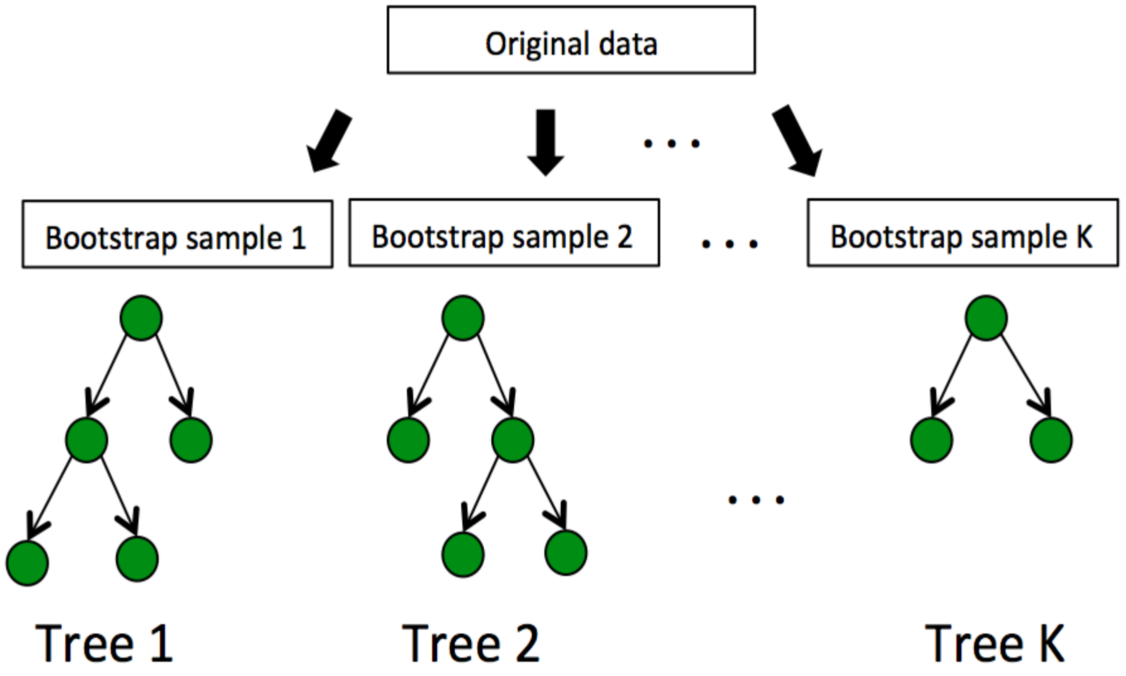
The Out-of-Bag (OOB) error

- The out-of-bag (OOB) error in a random forest model provides a computationally convenient approach to evaluate the model without using a testing dataset, neither a cross-validation procedure



The idea behind the OOB error

- The probability of a data point from the training data is missing from a bootstrapped dataset is

$$\left(1 - \frac{1}{N}\right)^N.$$

- When N is sufficiently large, we can have

$$lim_{N \to \infty} \left(1 - \frac{1}{N}\right)^N = e^{-1} \approx 0.37.$$

- Therefore, roughly 37% of the data points from S are not contained in any bootstrapped dataset B_i.
- And thus, not used for training tree i. These excluded data points are referred as the out-of-bag samples for the bootstrapped dataset B_i and tree i.

Further develop the line of argument

- As there are 37% of probability that a data point is not used for training a tree, we can infer that, a data point is not used for training about 37% of the trees.
- Therefore, for each data point, in theory, there are 37% of trees trained without this data point. These trees can be used to predict on this data point, which can be considered as testing an unseen data.
- The out-of-bag error estimation can then be calculated by aggregating the out-of-bag testing error of all the data points.
- The out-of-bag error can be calculated after random forests are built, and are significantly less computationally than cross-validation.

A Simple Example

- Suppose that we have a training dataset of 5 instances (IDs as 1,2,3,4,5).

Bootstrap	Tree
1,1,4,4,5	1
2,3,3,4,4	2
1,2,2,5,5	3

Table 5.3: The out-of-bag (OOB) errors

Tree	Training data	1 (C1)	2 (C2)	3 (C2)	4 (C1)	5 (C2)
1	1,1,4,4,5		C1	C2		
2	2,3,3,4,4	C1				C2
3	1,2,2,5,5			C2	C1	

- We can see that, as the data instance (ID = 1) is not used in training Tree 2, we can use Tree 2 to predict on this data instance, and we see that it correctly predicts the class as C1.
- Similarly, Tree 1 is used to predict on data instance (ID=2), and the prediction is wrong. Finally, we can see that the overall out-of-bag (OOB) error is 1/6.

R lab

- Download the markdown code from course website
- Conduct the experiments
- Interpret the results
- Repeat the analysis on other datasets