HAL
open science

Cost-complexity pruning of random forests

B Ravi Kiran, Jean Serra

To cite this version:

B Ravi Kiran, Jean Serra. Cost-complexity pruning of random forests. ISMM 2017, May 2017, Fontainebleu, France. 10.1007/978-3-319-57240-6_18 . hal-02568714

HAL Id: hal-02568714

https://hal.science/hal-02568714v1

Submitted on 10 May 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

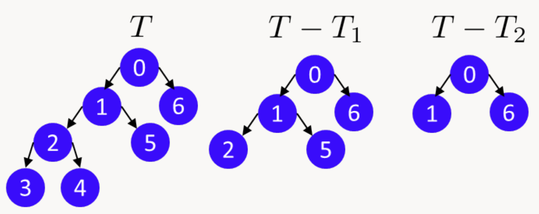
Cost-complexity pruning of random forests

ISMM 2017, 13th International Symposium on Mathematical Morphology, Fontainebleau, France, May 15 - 17, 2017

Why perform pruning ?

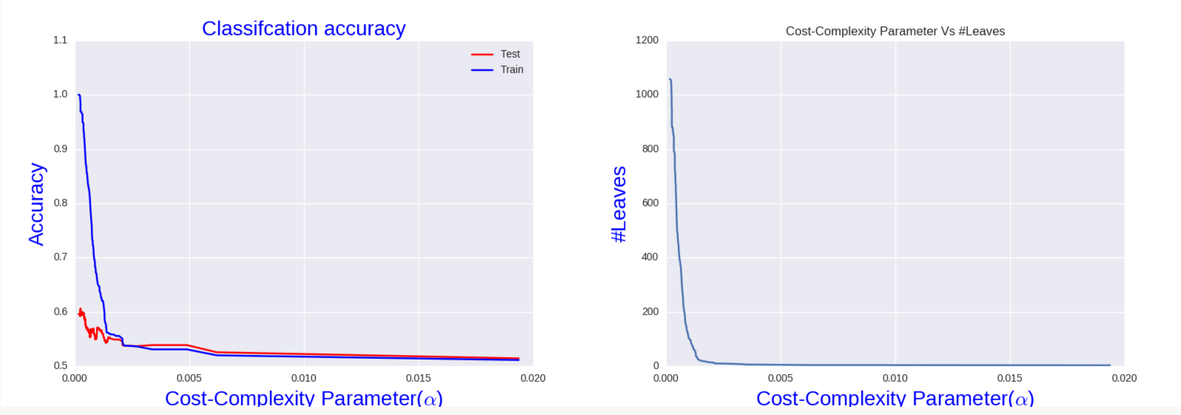
- Out-of-bag samples are un-used samples from the Bootstrap Aggregation procedure in random forests.
- We study the effect of using the out-of-bag samples to improve the generalization error first of the decision trees, and second the random forest by post-pruning.

Decision Tree Pruning

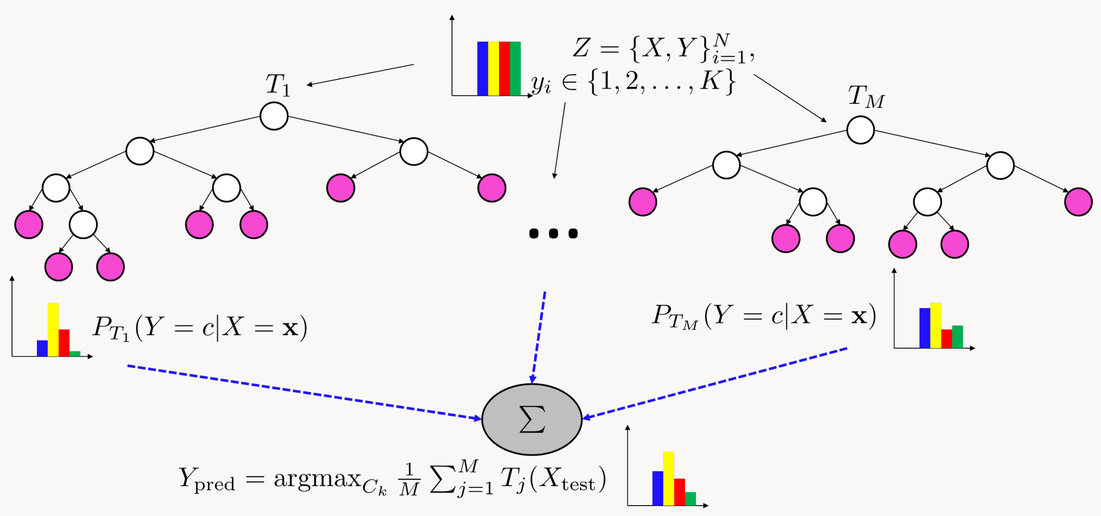


$\text{Leaves}(T) = \{3, 4, 5, 6\}$
Internal nodes $= \{1, 2\}$
Sequence of subtrees : $T \supseteq T - T_2 \supseteq T - T_1$
Cost complexity values : $g(t) = 0, \alpha_2, \alpha_1$
Final set of trees and parameters : $\mathcal{T}, \mathcal{A}$

- Cost-Complexity function : $g(t) = \frac{R(t) - R(T_t)}{|\text{Leaves}(T_t)| - 1}$
- $R(T) = \sum_{t \in \text{Leaves}(T)} r(t) \cdot p(t) = \sum_{t \in \text{Leaves}(T)} R(t)$
- $R(T)$ is the training error, Leaves(T) is #leaves of tree T
- $r(t) = 1 - \max_k p(C_k)$ is the misclassification rate and $p(t) = n_t / N$ is the number of samples in node n_t to total training samples N.



Random Forests



Decision tree ensembles : Random Forests (RF), Extremely Randomize Trees (ET), Bagged trees (BT)
Randomization Methods : Boostrap Aggregation, Random Feature selection, Random Threshold section

Out-Of-Bag Cost Complexity Pruning

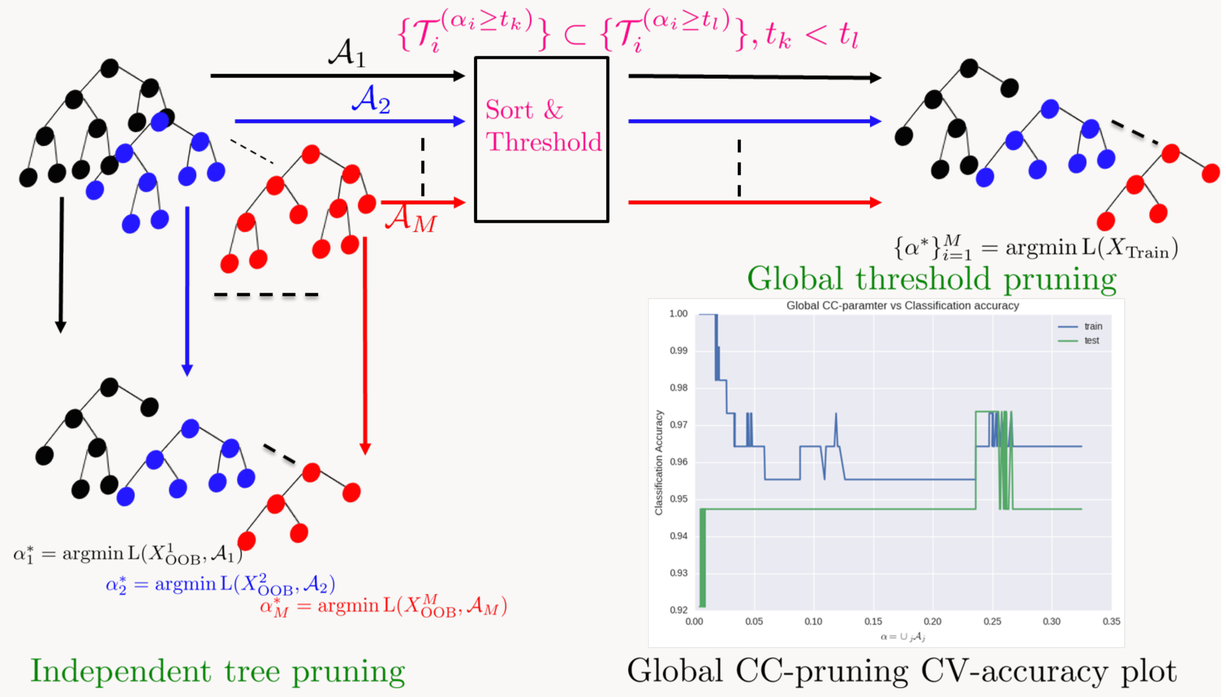
Independent tree pruning :

$$\mathcal{T}_j^* = \text{argmin}_{\alpha \in \mathcal{A}_j} \mathbb{E}\left[\| Y_{\text{OOB}} - \mathcal{T}_j^{(\alpha)}(X_{\text{OOB}}^j) \|^2 \right]$$

Global threshold pruning :

$$\{\mathcal{T}_j^*\}_{j=1}^M = \text{argmin}_{\alpha \in \cup_j \mathcal{A}_j} \mathbb{E}\left[\| Y_{\text{train}} - \frac{1}{M} \sum_{j=1}^M \mathcal{T}_j^{(\alpha)}(X_{\text{OOB}}^j) \|^2 \right]$$

Overview of method



Global CC-pruning CV-accuracy plot

Results and Analysis

Plots of $\mathcal{A}_j \forall j$ for RFs, ETs, BTs :

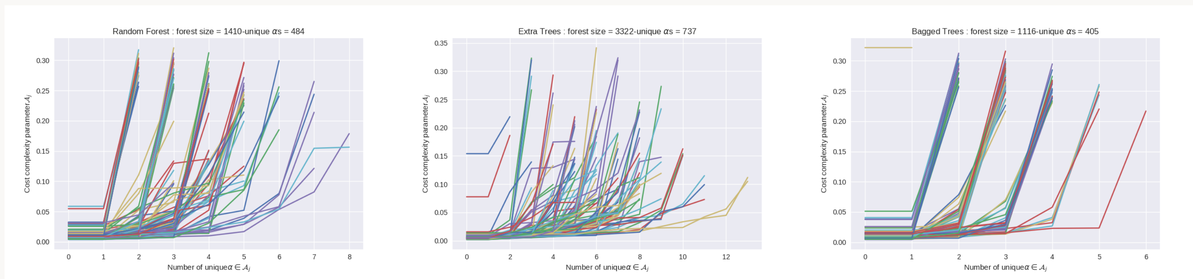
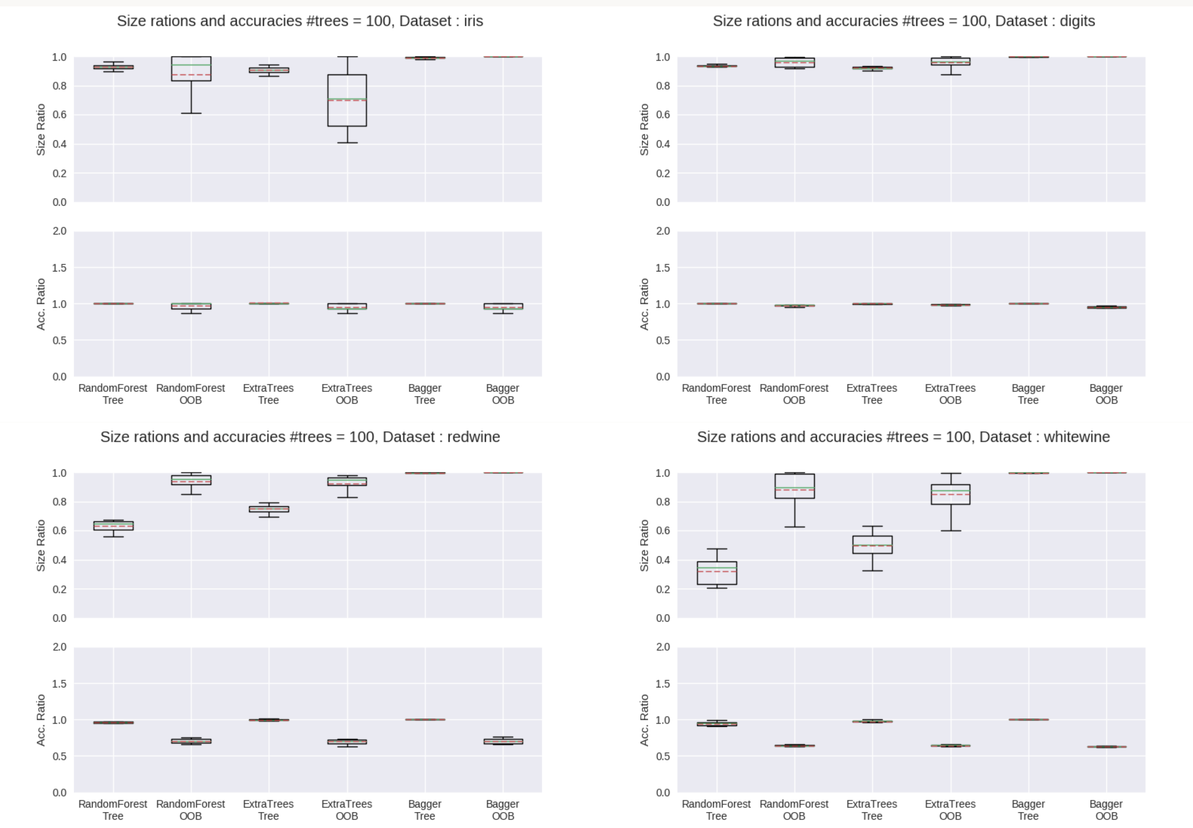


Figure: RFs and ETs provide a larger subset of CC-parameter values $\mathcal{A}_j$ and thus subtrees $\mathcal{T}_j$ for the cross-validation step.

Performance on datasets from UCI repository :



- Reduction in forest size for marginal loss in classification accuracy.
- Out-of-Bag samples provide cross-validation mechanism to prune forests.

Future work

- Understand non-monotonicity (spikes) of random forest training error.
- Does post-pruning preserve consistency of forests ?
- How to define a global cost-complexity parameter for random forests ?

B Ravi Kiran*, Jean Serra+
beedotkiran@gmail.com, https://beedotkiran.github.io/forest.html
Université Lille 3, CRIStAL, Université*, Ecole des Mines de Paris, CMM +