Class -22
Boosting algorithms (AdaBoost, GBM, XGBoost)

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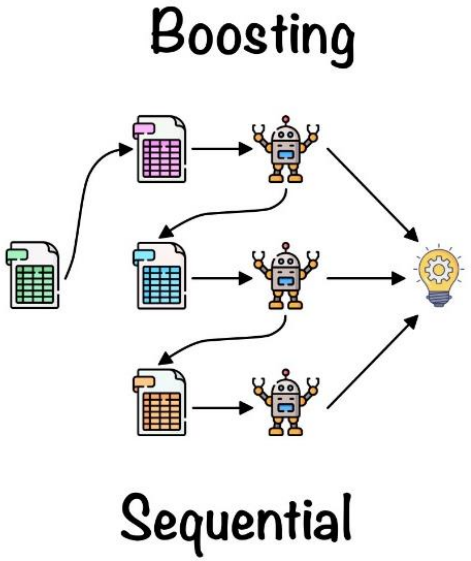
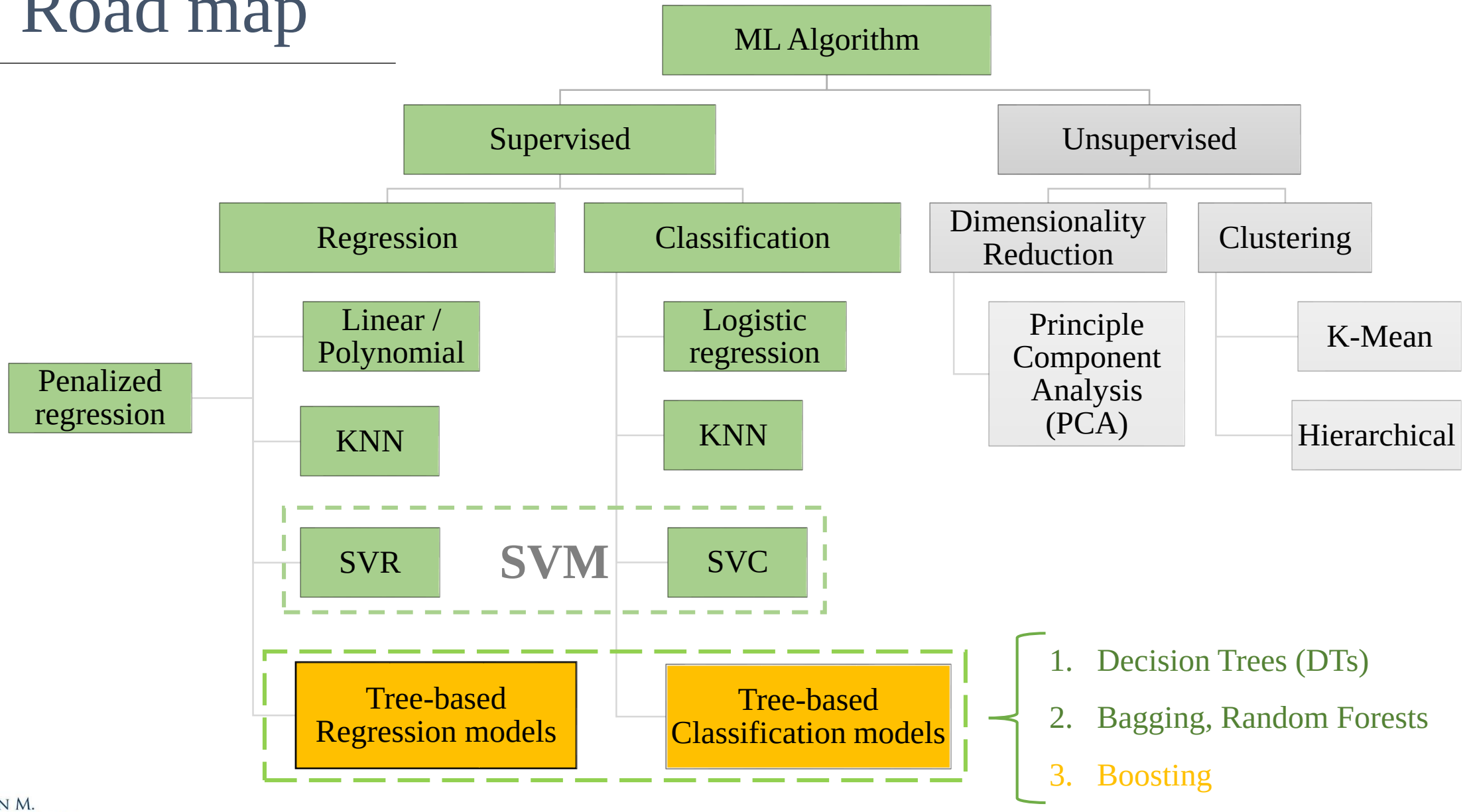


Road map


ML Algorithm
Supervised
Unsupervised
Regression
Classification
Dimensionality Reduction
Clustering
Linear / Polynomial
Logistic regression
Principle Component Analysis (PCA)
K-Mean
Penalized regression
KNN
KNN
Hierarchical
SVR
SVM
SVC
Tree-based Regression models
Tree-based Classification models
1. Decision Trees (DTs)
2. Bagging, Random Forests
3. Boosting

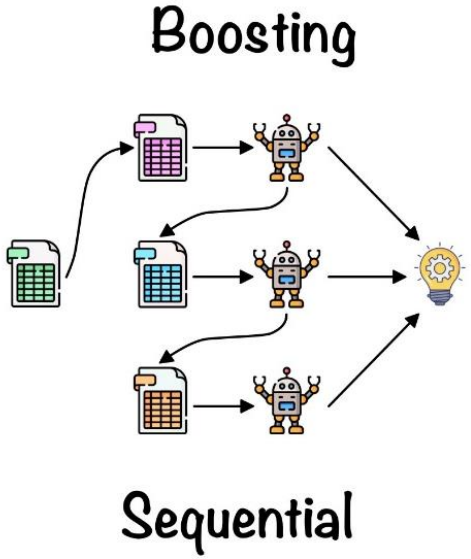
Topics

Part I

1. Bagging vs Boosting
2. AdaBoost
3. Gradient Boosting Machine (GBM)
4. XGBoost

Part II

Pros and Cons

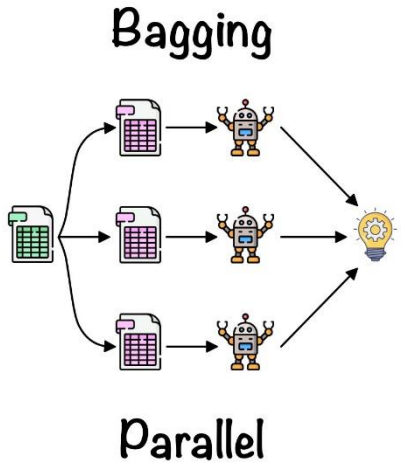


Part I

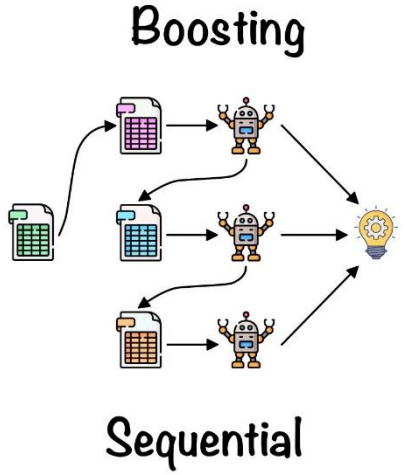
1. Bagging vs Boosting
2. AdaBoost
3. Gradient Boosting Machine (GBM)
4. XGBoost

Bagging vs Boosting

- Bagging consists of creating many "copies" of the training data (each copy is slightly different from another) and then apply the weak learner to each copy to obtain multiple weak models and then combine them.
- In bagging, the bootstrapped trees are independent from each other.



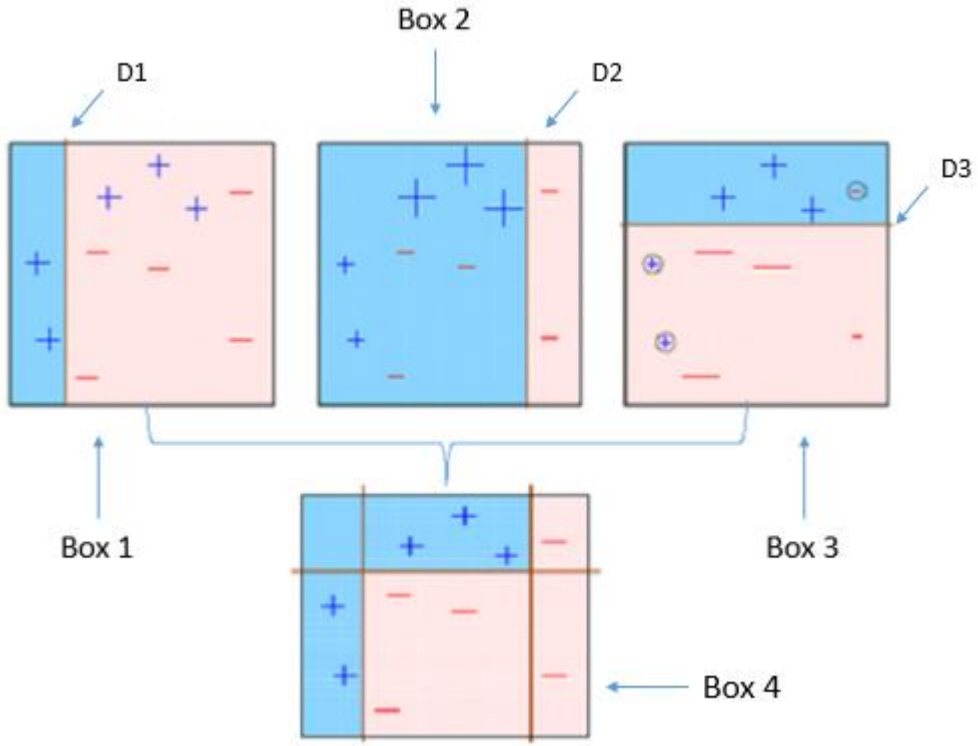
- Boosting consists of using the "original" training data and iteratively creating multiple models by using a weak learner. Each new model would be different from the previous ones in the sense that the weak learner, by building each new model tries to "fix" the errors which previous models make.
- In boosting, each tree is grown using information from previous tree.



AdaBoost (Adaptive Boosting)

- Forest of weak learners (trees with only 1 feature; stumps).
- Each tree (stump) depends on the previous tree's errors rather than being independent.

1) Starting with usual splitting criteria!
2) Each tree (stump) gets different weight based on its prediction accuracy.
3) Each observation gets a weight inversely related to its predicted outcome. (ex, misclassified ones get more weight).
4) Aggregation is done based on each weak learner's weight.

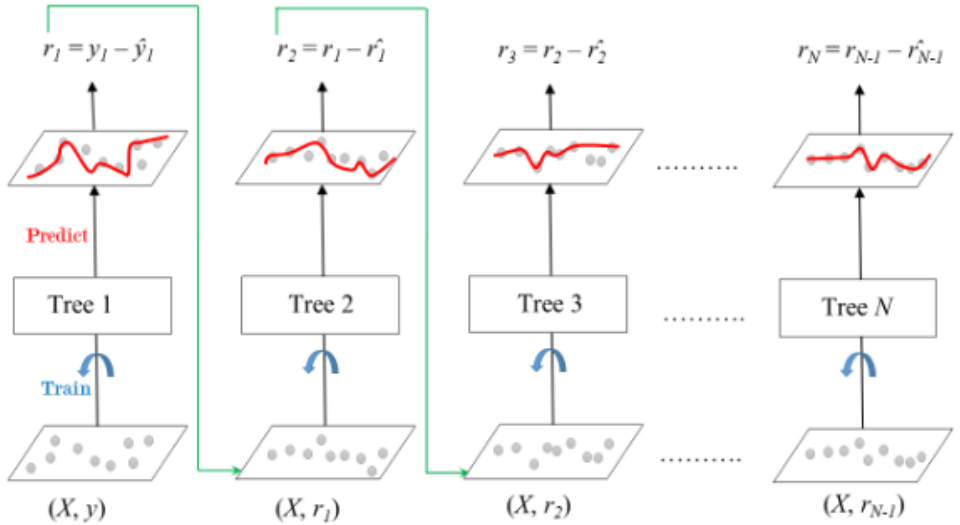


Source: Towards data science

Gradient Boosting Machine (GBM)

- In gradient boosting, each weak learner corrects its predecessor's error.
- Unlike AdaBoost, the weights of the training instances are not tweaked, instead, each predictor is trained using the residual errors of predecessor as labels.
- Unlike AdaBoost, each tree can be larger than a stump. However, the trees are still small. By fitting a small tree to the residuals, the GBM slowly improve $\hat{f}$ in areas where it does not perform well.

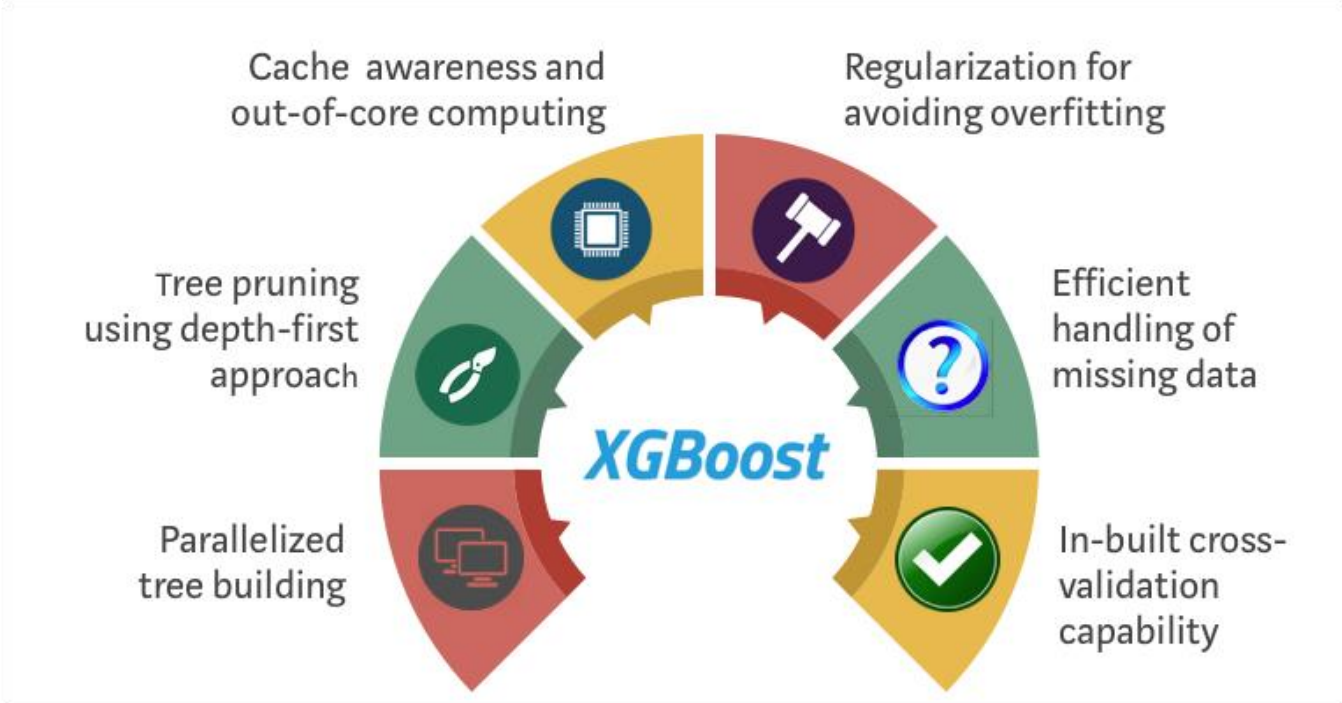
Source: Geeksforgeeks



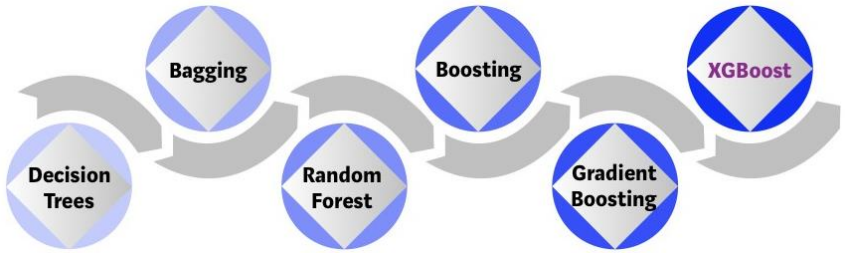
- Learning rate shrinks the contribution of each tree. There is a trade-off between learning rate and number of trees. Learning rate slows down the process even further, allowing for more and different shaped trees to attack the residuals.
- Aggregation is done by adding the first tree predictions and a scaled (shrunk) version of the following trees.

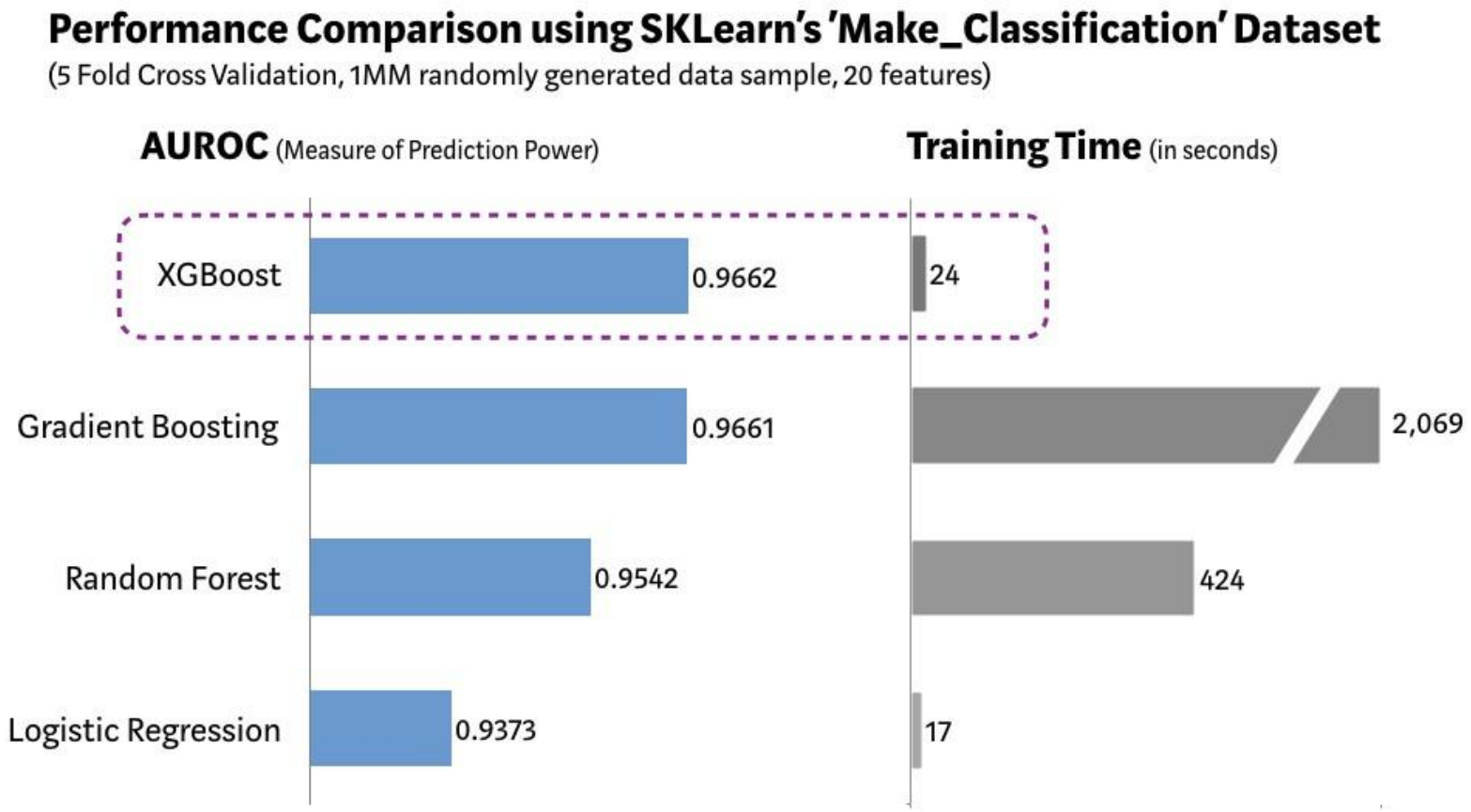
Extreme Gradient Boosting (XGBoost)

- XGBoost is a refined and customized version of a gradient boosting decision tree system, created with performance and speed in mind.
- Extreme refers to the fact that the algorithms and methods have been customized to push the limit of what is possible for gradient boosting algorithms.



Put it all together!



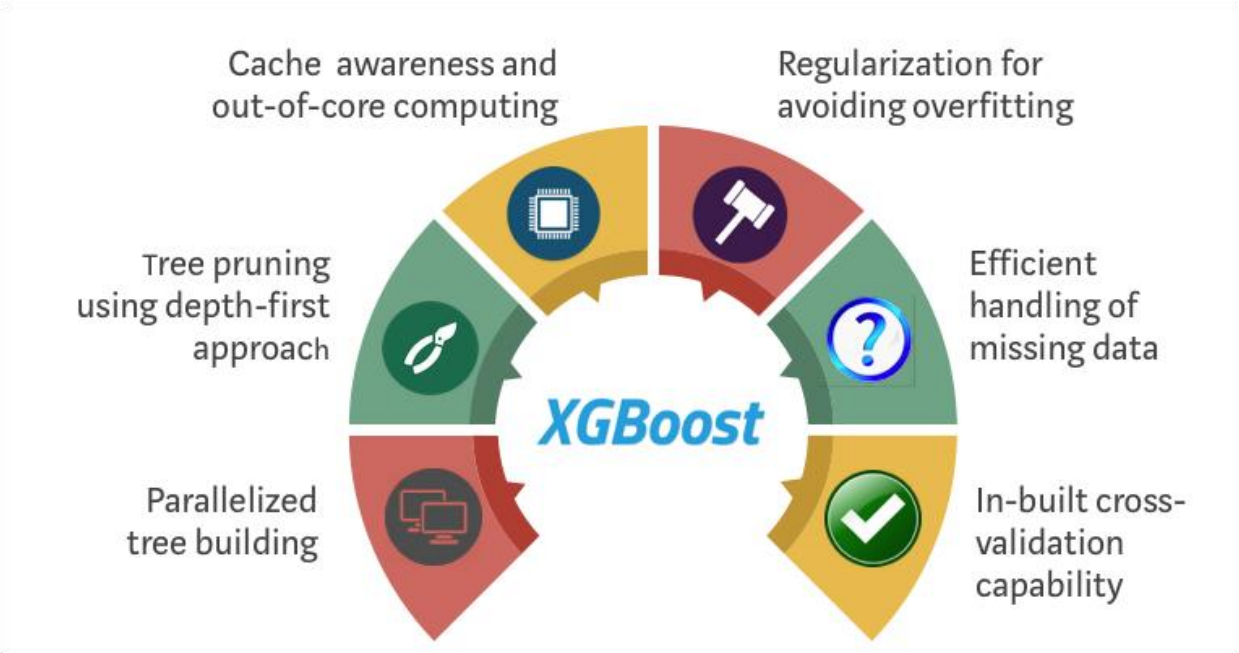


Part II

Pros and Cons

XGBoost's Pros and Cons

Pros:



Cons:

- XGBoost is more difficult to understand, visualize and to tune compared to AdaBoost and random forests. There is a multitude of hyperparameters that can be tuned to increase performance.

Students' questions

1. I'm still a little unclear on what exactly boosting is and how it differs from bagging.
2. Is boosting just a decision tree thing? Or can the same technique be applied to other models?
3. Why would you use something other than XGboost?
4. What is the "additive" model utilized by Gradient Boosting?