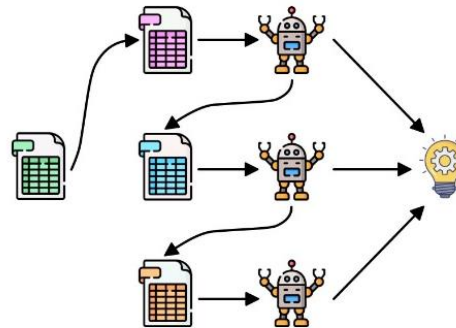# Module 10- Part II
Boosting Models
AdaBoost, GBM, XGBoost

Prof. Pedram Jahangiry
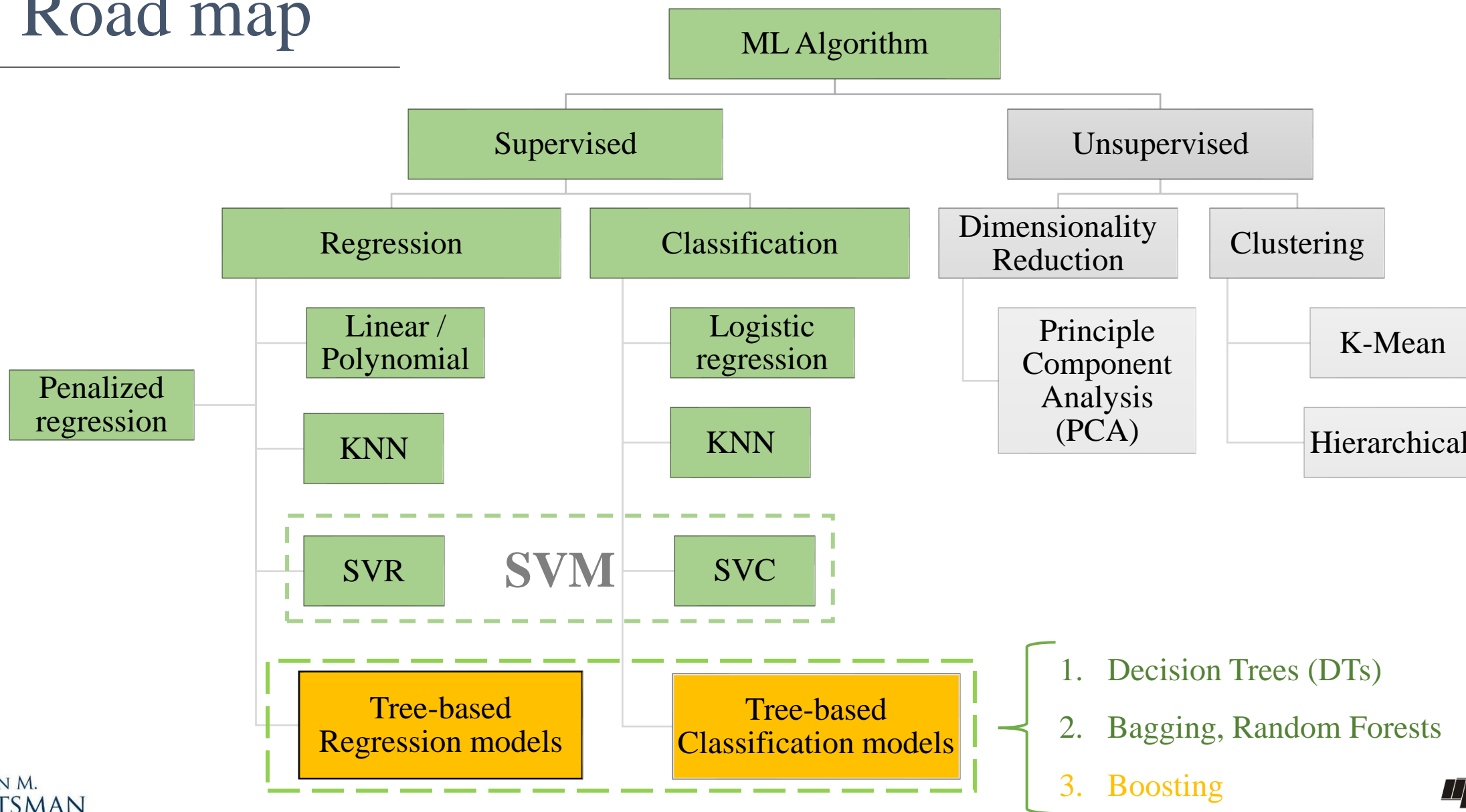
Boosting

Sequential

Class Modules

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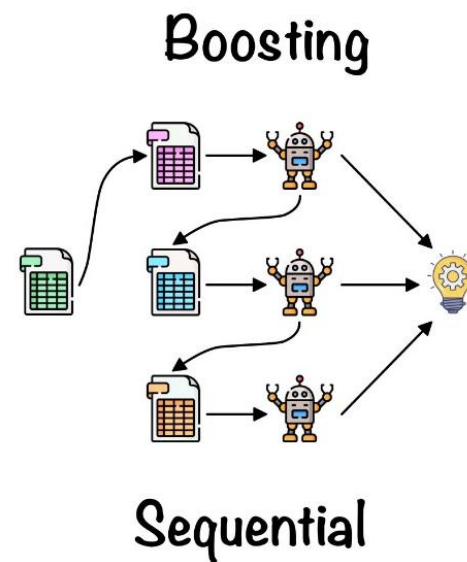JON M. HUNTSMAN SCHOOL OF BUSINESS
UtahStateUniversity

Pedram Jahangiry
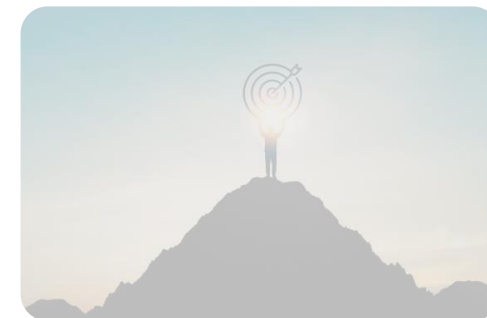
Road map

Topics

Part I

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

Part II

Pros and Cons

Boosting

Sequential
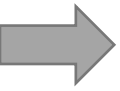
Part I

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.
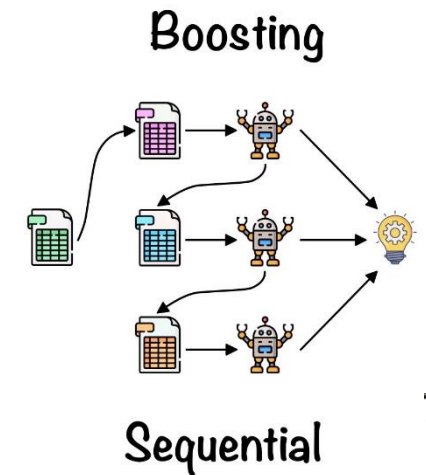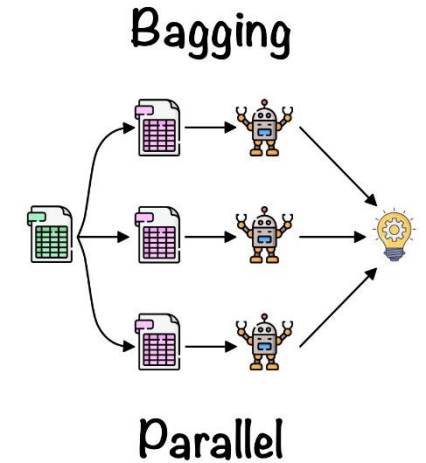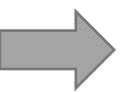
AdaBoost (Adaptive Boosting)

- 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.
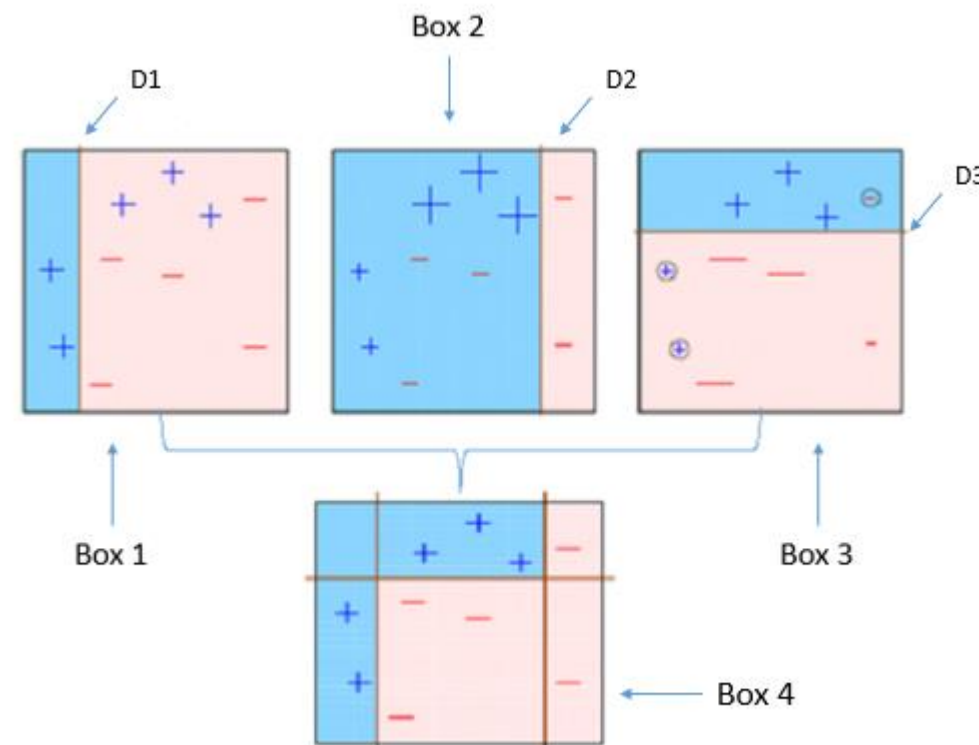
Source: Towards data science

AdaBoost

Key features:

- Adaptive: Updates the weights of misclassified instances at each step.

- Tends to be sensitive to noise and outliers.

- Can be used with various base classifiers, but most commonly used with decision stumps.

- AdaBoost is old: AdaBoost is a popular boosting technique introduced by Yoav Freund and Robert Schapire in 1996.

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.

- 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.
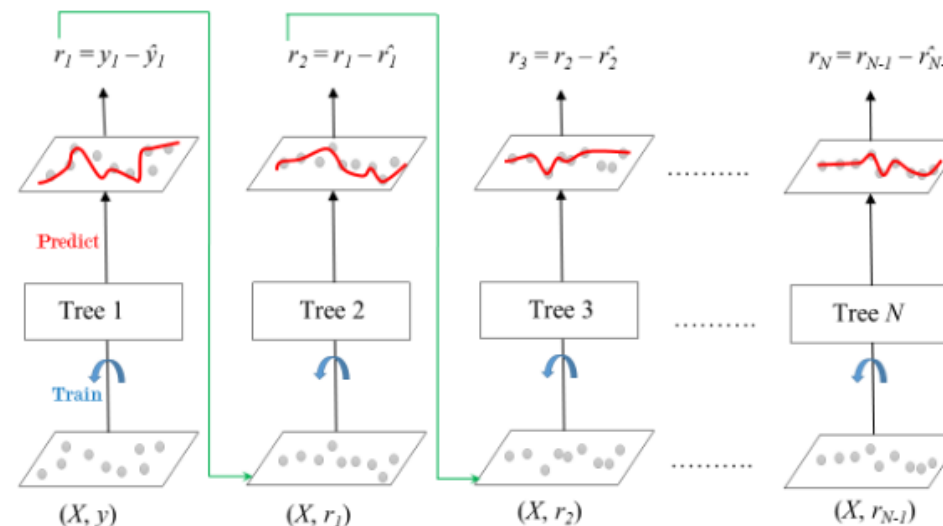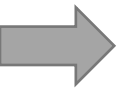
Extreme Gradient Boosting (XGBoost)

- 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.
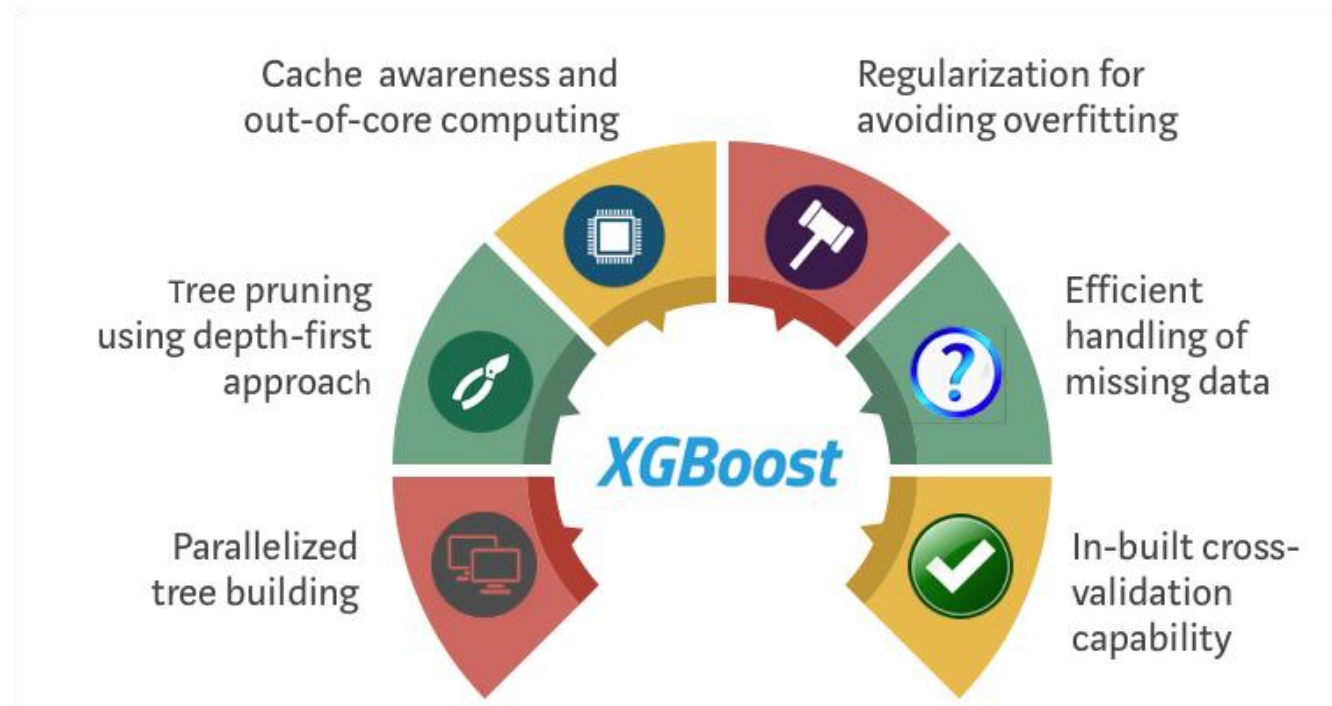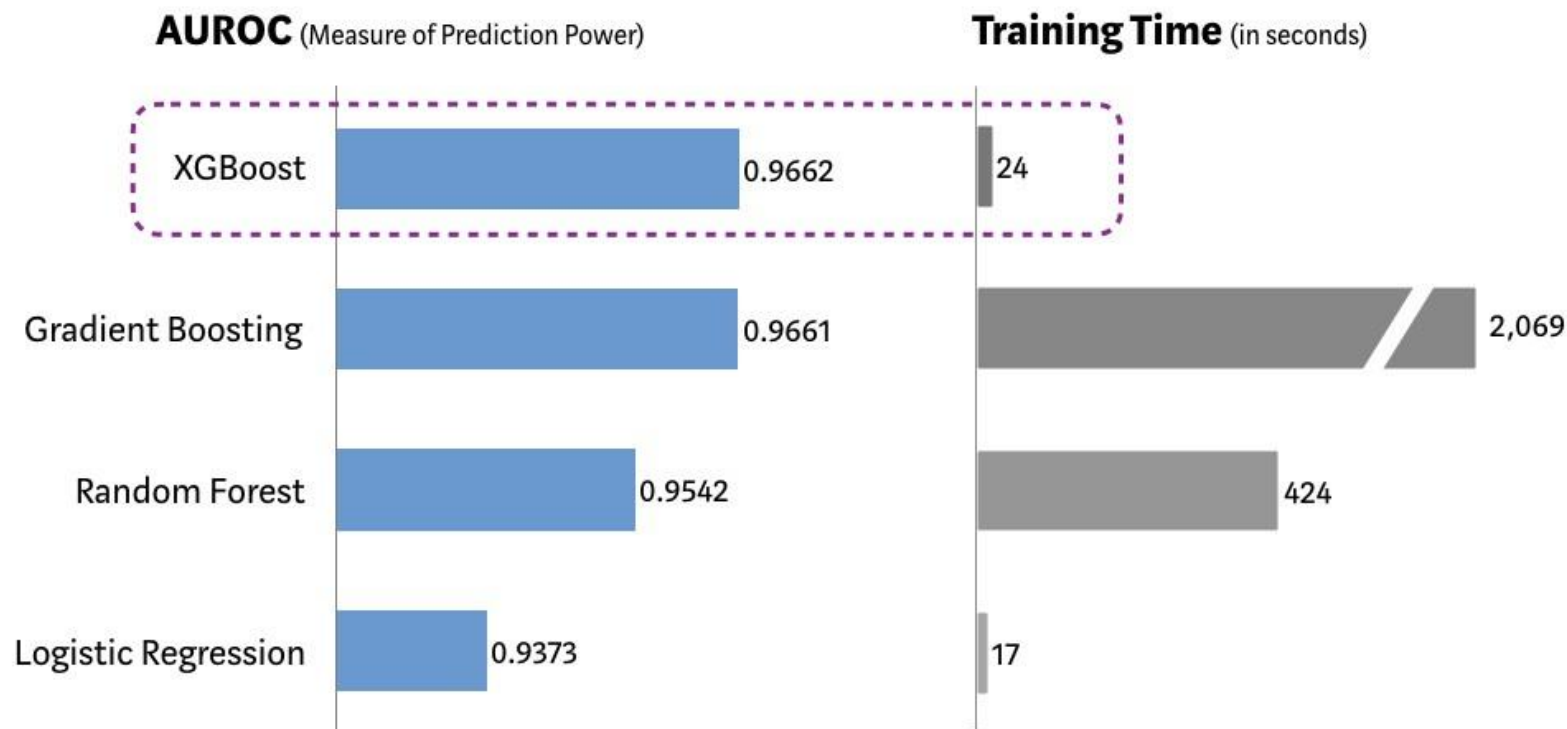
Put it all together!
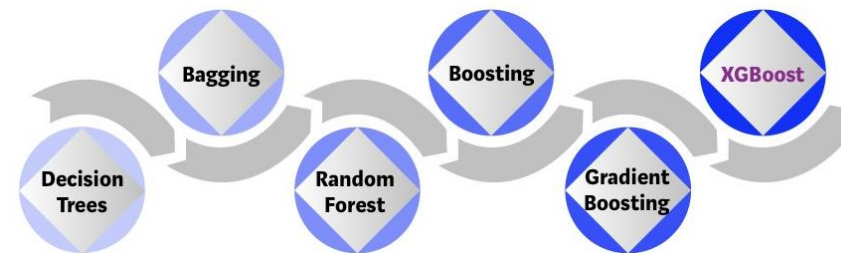
Performance Comparison using SKLearn's 'Make_Classification' Dataset
(5 Fold Cross Validation, 1MM randomly generated data sample, 20 features)

AUROC (Measure of Prediction Power)   **Training Time** (in seconds)

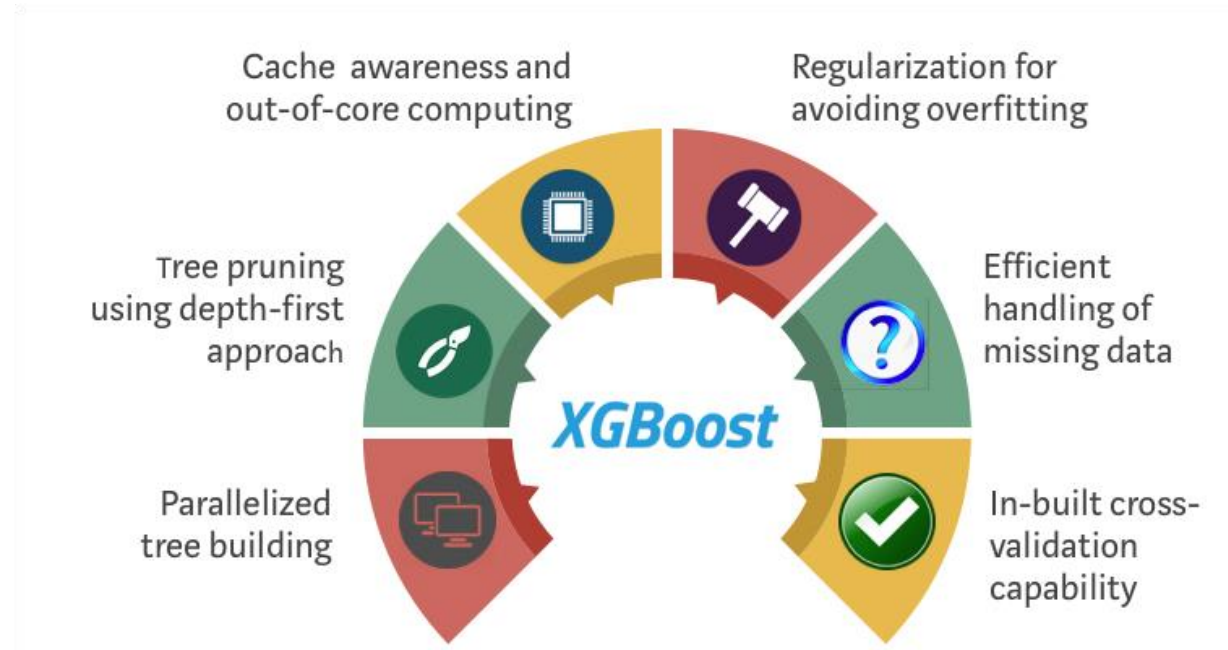| Model	AUROC	Training Time
XGBoost	0.9662	24
Gradient Boosting	0.9661	2,069
Random Forest	0.9542	424
Logistic Regression	0.9373	17

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.

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