Machine Learning Workshop Part II

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WiSER (Women in Science, Engineering & Research)

AltaML

Who Am I?

- Machine Learning Engineer, AltaML, 2020-Now
- PhD, Computing Science, UofA

My Support Team:

- Navneeth: Lead Machine Learning developer AltaML, 2020-Now
- Graham: Lead Machine Learning developer AltaML, 2020-Now
- Mark: Vice President, People

ML Workshop Outline

Part I

- General Concepts of Machine Learning
- ML standard process Steps from data preparation to evaluation
- Hands-On

13 May 2021

6 May 2021

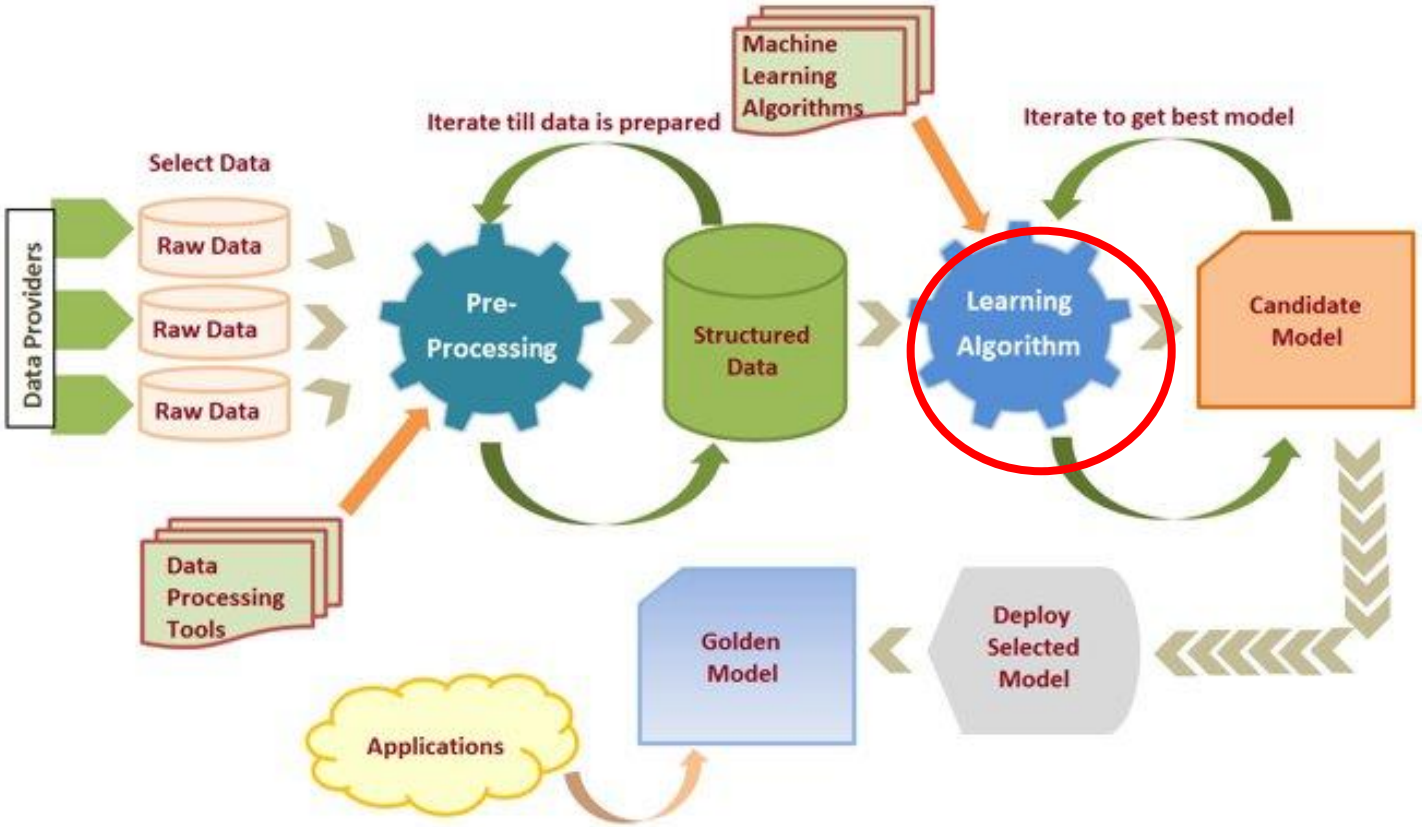
Part II

- Machine Learning Algorithms
- Hands-On

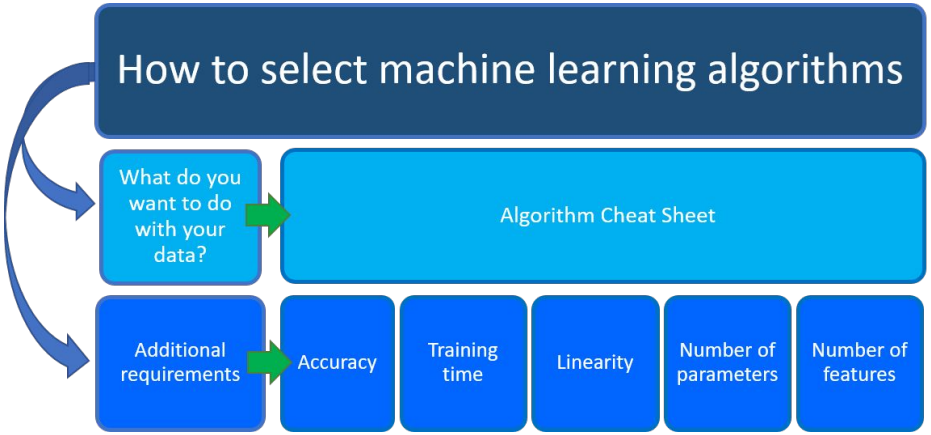
Part II Agenda

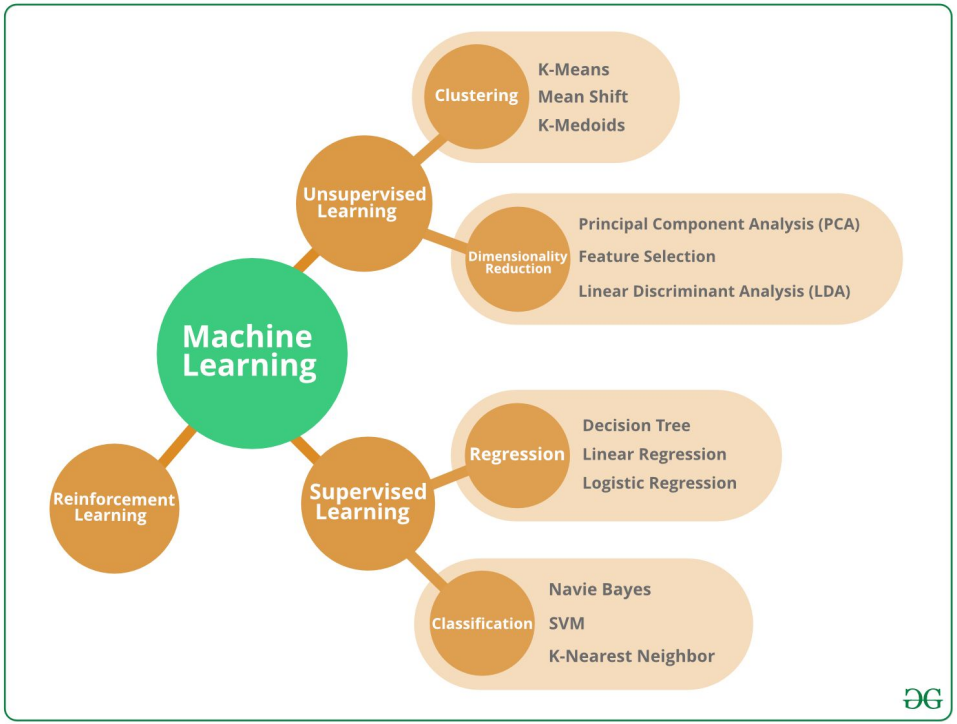
- **WiSER Introduction (3-5 min)**
- **General Introduction of the team and the AltaML company (3-5 min)**
- **Machine Learning Theoretical Concepts (1h 15min)**
  - Machine Learning General Frameworks
  - Machine Learning Algorithms (Supervised, Unsupervised)
  - Machine Learning Performance Analysis
- **Break (5min)**
- **Hands-On (20-25 min)**
- **Q&A (5 min)**
- **WiSER Closing (2-3 min)**

Machine Learning (ML) WorkFlow



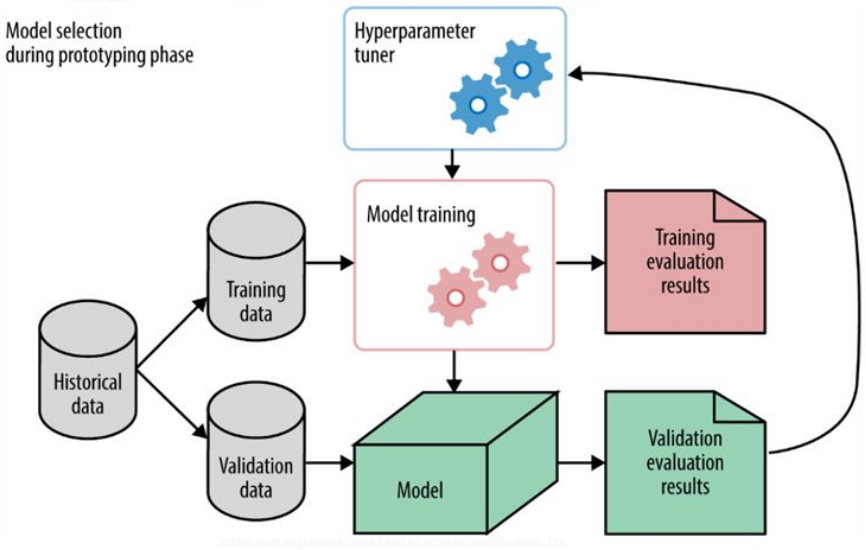
ML Algorithms





Ml Algorithm hyperparameter Tuning

- Most algorithms have parameters that guide how the algorithms work which have to be tuned to specific problems/data
- Typically a grid search is performed where different sets of parameters are tried
- Model with a given set of parameters is trained and evaluated, using training set
- The set with highest score is selected
- There are also more complex search approaches used But you have to be careful when you selecting hyperparameters to make sure model still works well on unseen data



ML Algorithm Performance Analysis

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Underfitting

Overfitting

Your model is underfitting the training data when the model performs poorly on the training data. model unable to capture the underlying pattern of the data.

Reasons:

- Not enough data
- Simple model (Ex: data is nonlinear but our model is linear)

Your model is overfitting your training data when you see that the model performs well on the training data but does not perform well on the evaluation data. The model captures the noise along with the underlying pattern in data.

Reasons:

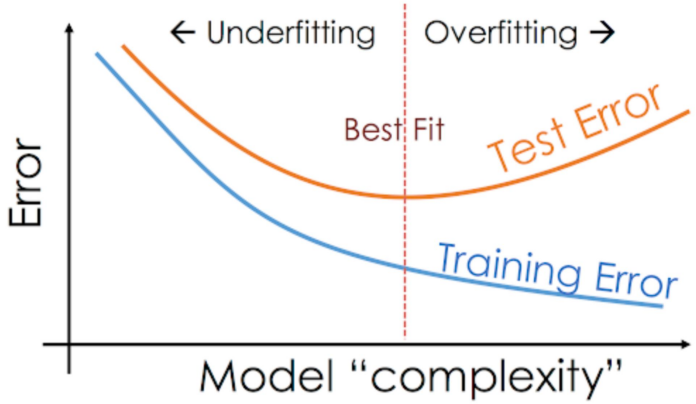
- Too Complex model
- Noisy data
- Not enough data

ML Algorithm Performance Analysis

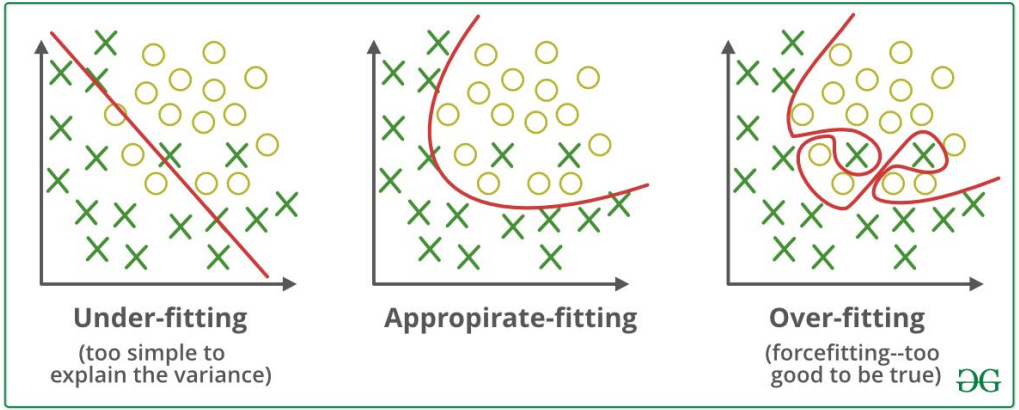
AltaML

Underfitting

Overfitting



Bias-Variance Tradeoff

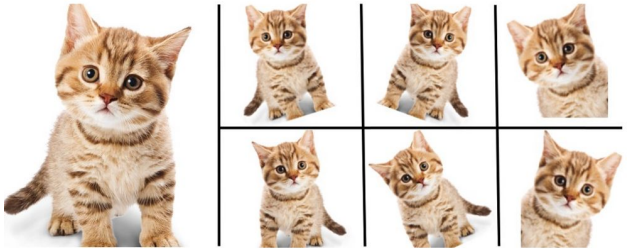


ML Algorithm Performance Analysis

AltaML

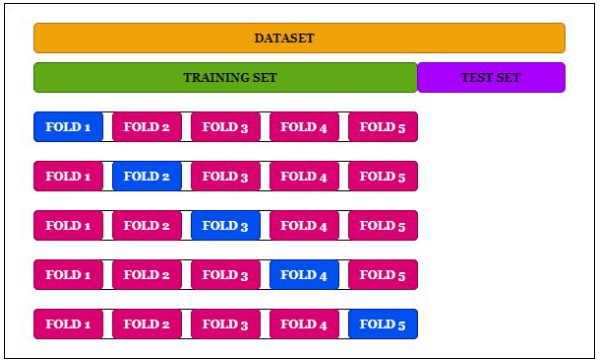
Techniques aim at building generalized models

- Sampling techniques - increase the number of training samples
- Cross Validation - Split training dataset and use splits to choose best parameters for a model
- Model Complexity (model type, model hyperparameters numbers,..)
- Regularization - Allow for error on training data



Enlarge your Dataset

$$\text{Cost} = \underbrace{\sum_{i=0}^{N}(y_i - \sum_{j=0}^{M} x_{ij}W_j)^2}_{\text{Loss function}} + \underbrace{\lambda \sum_{j=0}^{M} W_j^2}_{\text{Regularization Term}}$$



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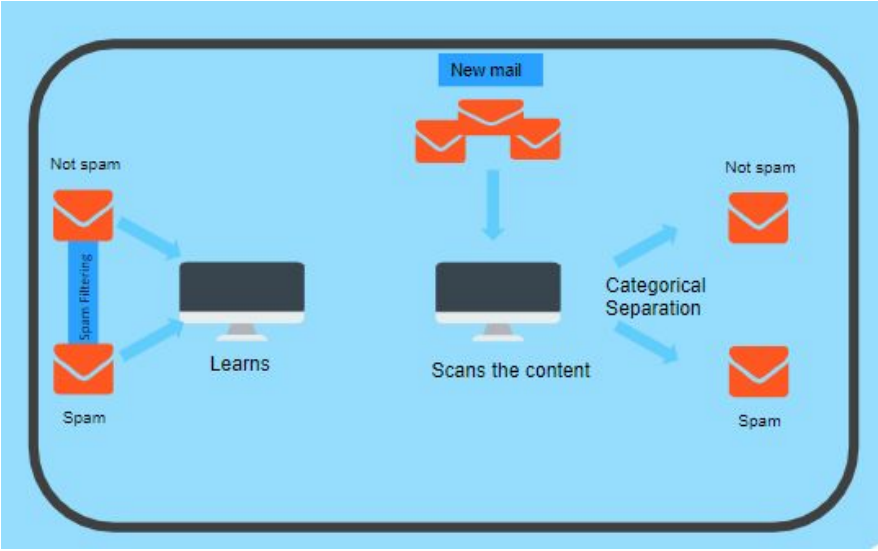
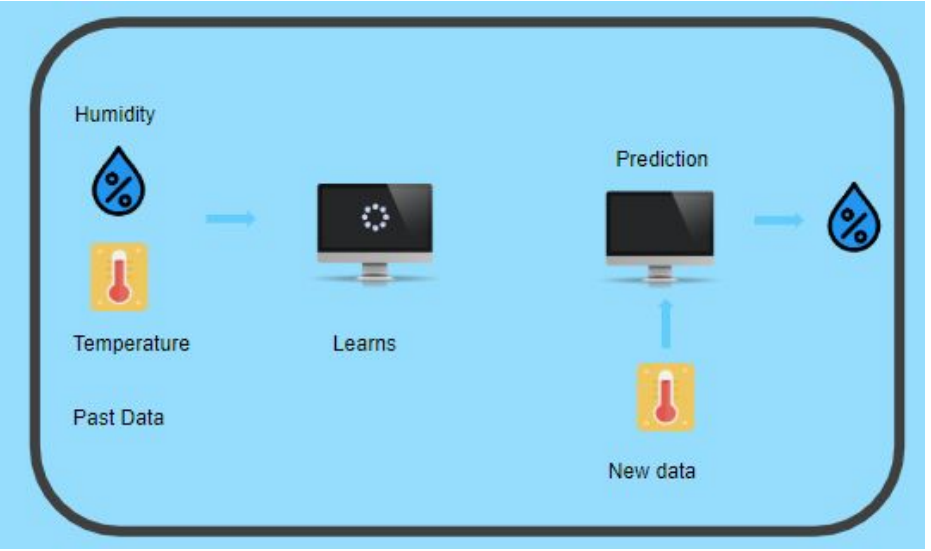
Supervised ML Algorithms

Classification vs Regression

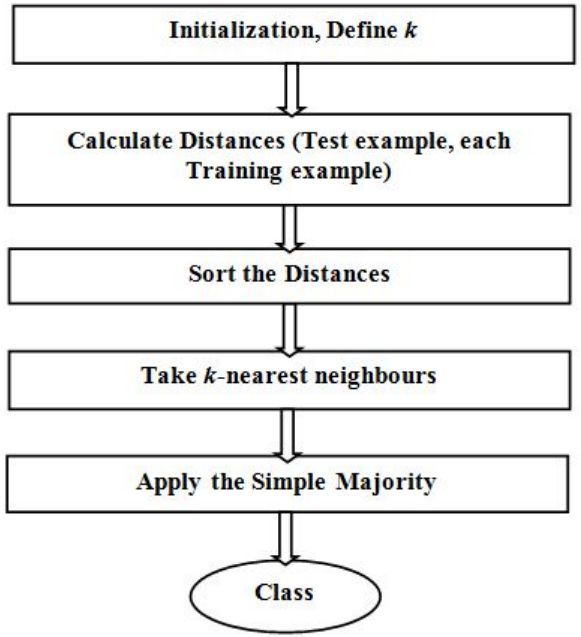
Classification and Regression come under the same umbrella of Supervised Machine Learning and share the common concept of using past data to make predictions, or take decisions, that's where their similarity ends.

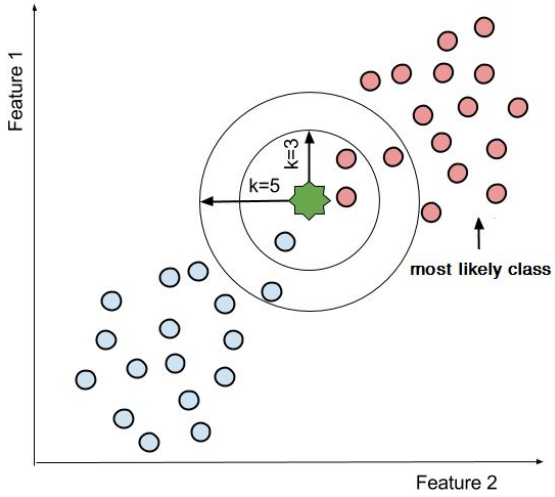




K Nearest Neighbors

The k-nearest neighbors (KNN) algorithm is a simple, easy-to-implement supervised machine learning algorithm that can be used to solve both classification and regression problems. It's a Lazy and non parametric learning algorithms.





Distance functions

Euclidean $\sqrt{\sum_{i=1}^{k}(x_i - y_i)^2}$

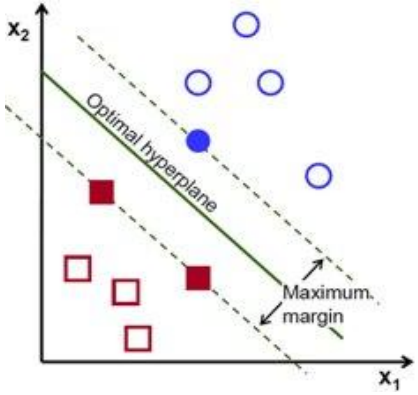
Manhattan $\sum_{i=1}^{k}|x_i - y_i|$

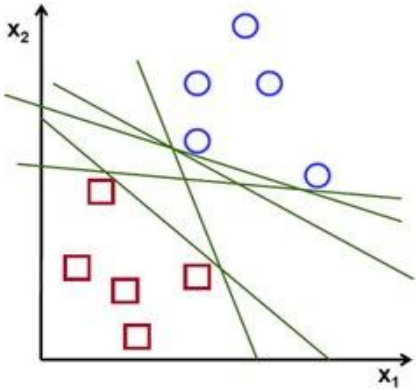
Minkowski $\left(\sum_{i=1}^{k}(|x_i - y_i|)^q\right)^{1/q}$

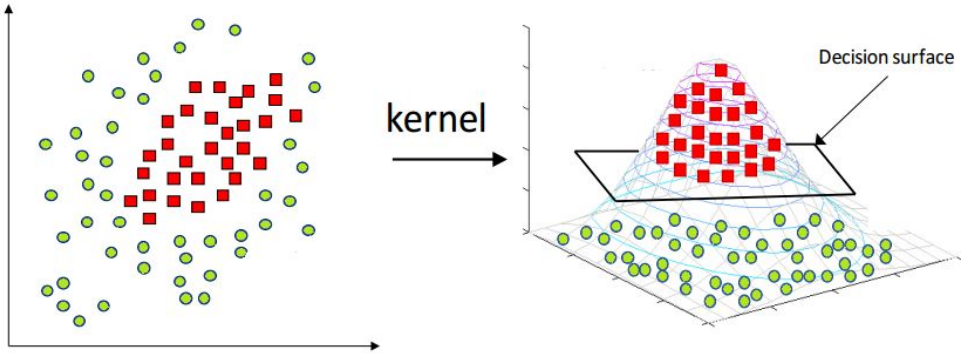
Computationally expensive (Time, memory)

SVM

- A Support Vector Machine (SVM) is a supervised machine learning algorithm that can be employed for both classification and regression purposes.
- SVMs are based on the idea of finding a hyperplane that best divides a dataset into two classes, as shown in the image below
- But what happens when there is no clear hyperplane? it's necessary to move away from a 2d view of the data to a 3d view.







SVM

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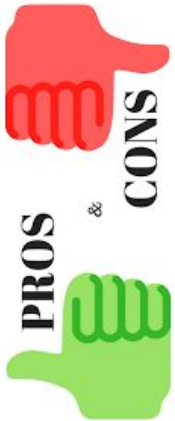
Pros:

1. It is really effective in the higher dimension.
2. Effective when the number of features are more than training examples.
3. Best algorithm when classes are separable
4. The hyperplane is affected by only the support vectors thus outliers have less impact.
5. SVM is suited for extreme case binary classification.

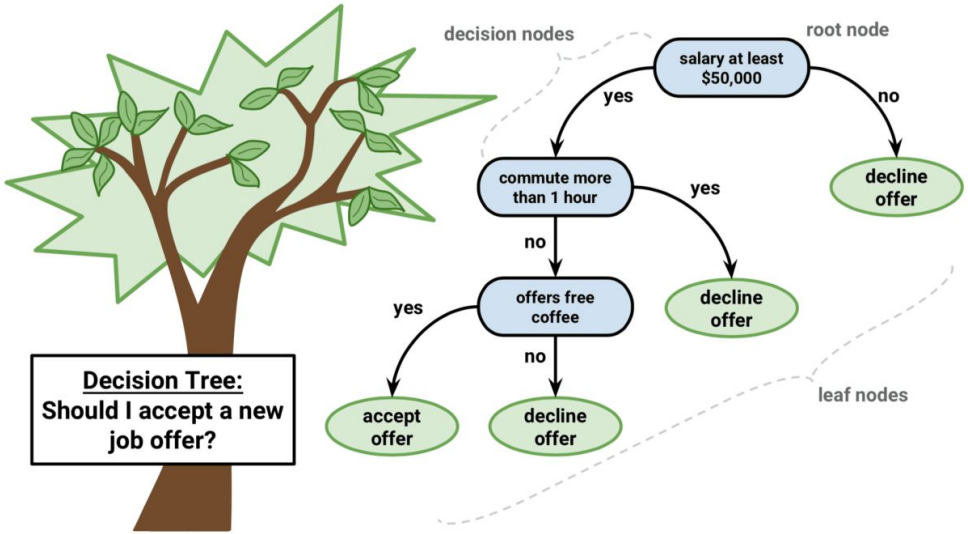


cons:

1. For larger dataset, it requires a large amount of time to process.
2. Does not perform well in case of overlapped classes.
3. Selecting, appropriately hyperparameters of the SVM that will allow for sufficient generalization performance.
4. Selecting the appropriate kernel function can be tricky.

Decision Tree

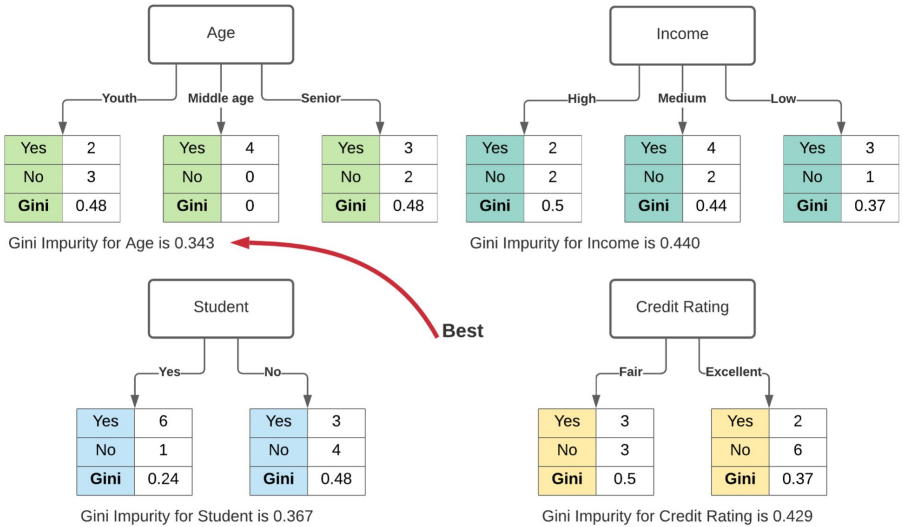
- Decision Tree solves the problem of machine learning by transforming the data into a tree representation.
- A decision tree algorithm can be used to solve both regression and classification problems
- A decision tree is a flowchart-like structure in which:
  - each internal node represents a test on a feature (e.g. whether a coin flip comes up heads or tails)
  - each leaf node represents a class label (decision taken after computing all features)
  - branches represent conjunctions of features that lead to those class labels.



Decision Tree

AltaML

Gini Impurity: What's the probability we classify the datapoint incorrectly



$$Gini = 1 - \sum_{i=1}^{C} (p_i)^2$$

$$= 1 - \sum_{t=0}^{t=1} P_t^2$$

Out of 14 instances ,
yes=9,no=5
1 - (9/14)^2- (5/14)^2

1-0.413-0.127= 0.46
Gini = 0.46

Pros:

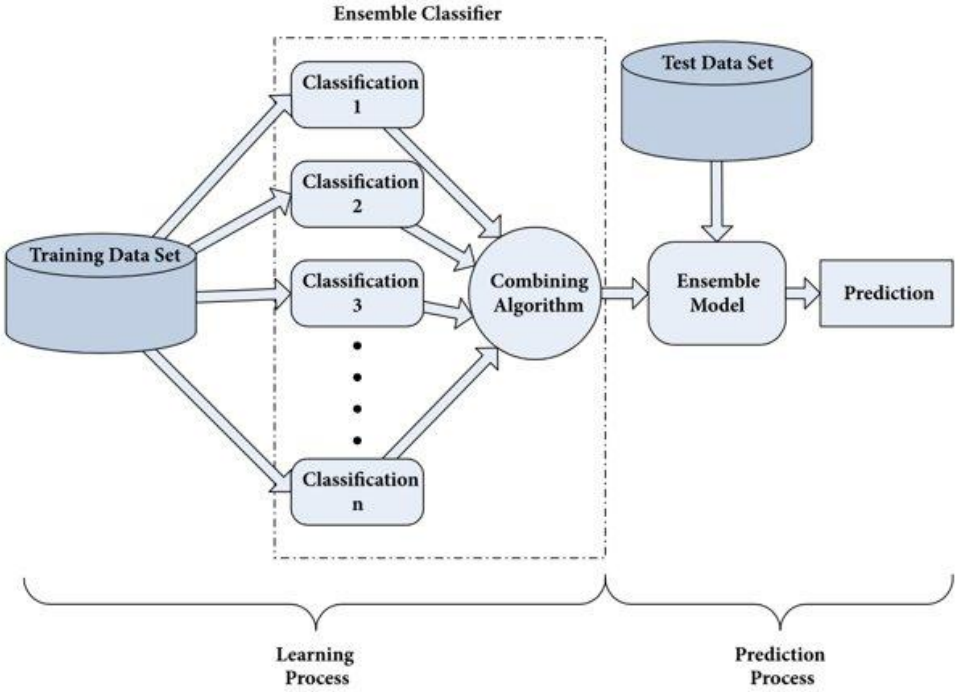
- Easy to understand and interpret
- Low effort for data preprocessing (normalization, missing values,..)

Cons:

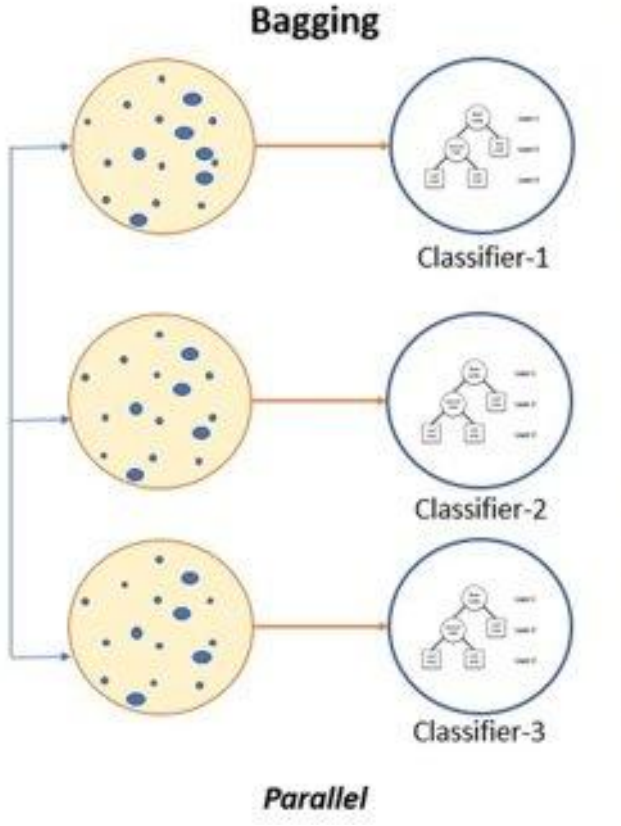
- Computationally expensive (time)
- Performance
- Easy to overfit

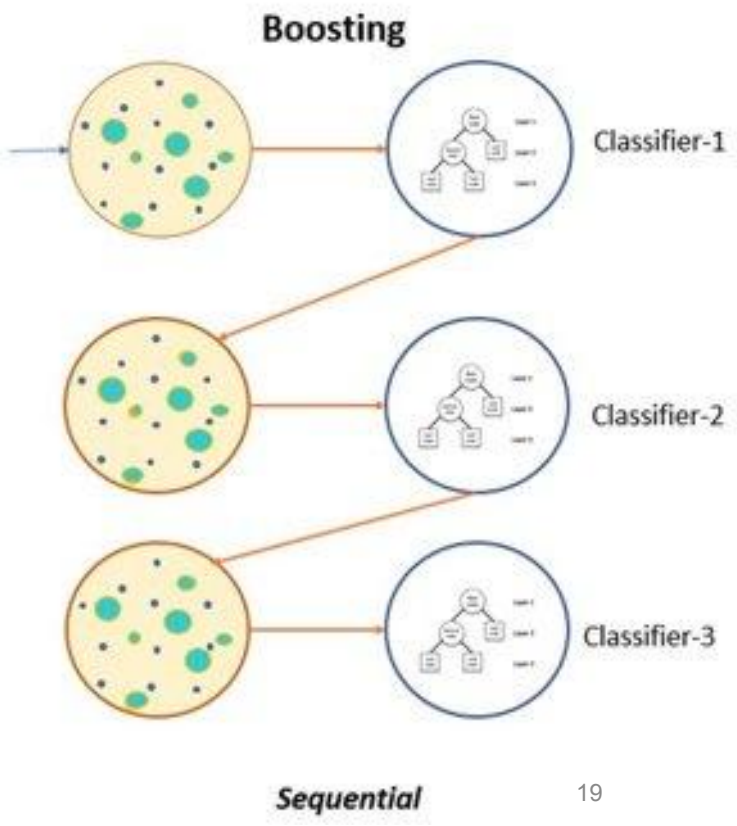
Ensemble Learning Algorithms

- Ensemble learning is a machine learning paradigm where multiple models (often called “weak learners”) are trained to solve the same problem and combined to get better results.
- The main hypothesis is that when weak models are correctly combined, we can obtain more accurate and/or robust models.

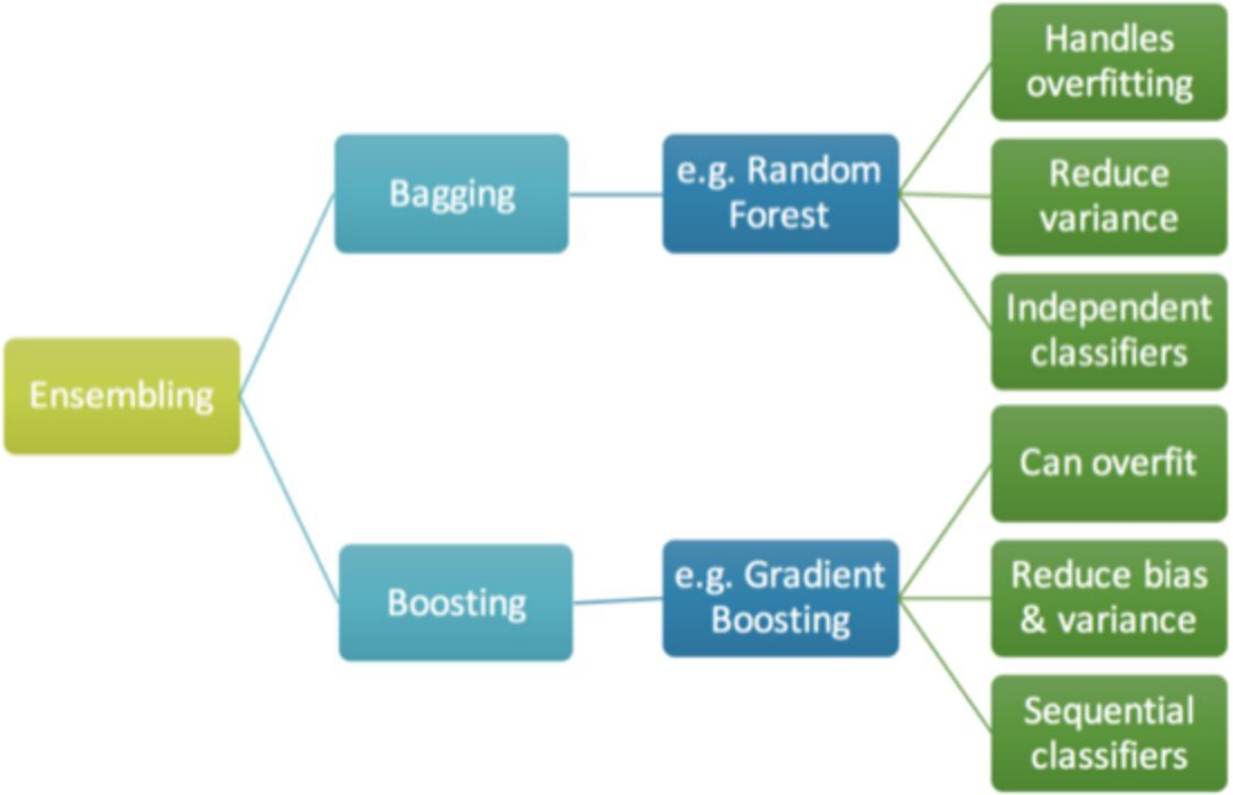


Ensemble Learning Algorithms



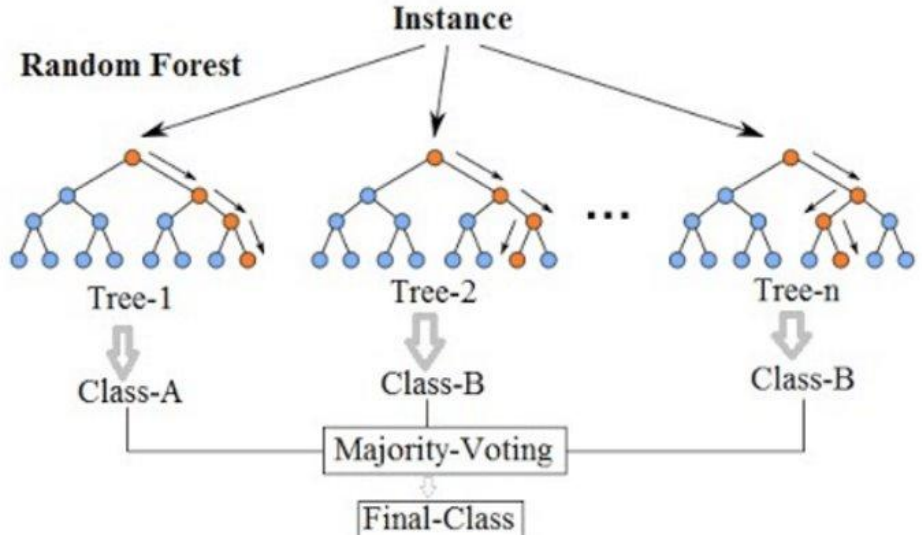


Ensemble Learning Algorithms



Random Forest

- Random Forest is an ensemble learning method that operates by constructing multiple decision trees.
- The final decision is made based on the majority of the trees and is chosen by the random forest.
  - Step 1 – First, start with the selection of random samples from a given dataset.
  - Step 2 – Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree.
  - Step 3 – In this step, voting will be performed for every predicted result.
  - Step 4 – At last, select the most voted prediction result as the final prediction result.



Random Forest

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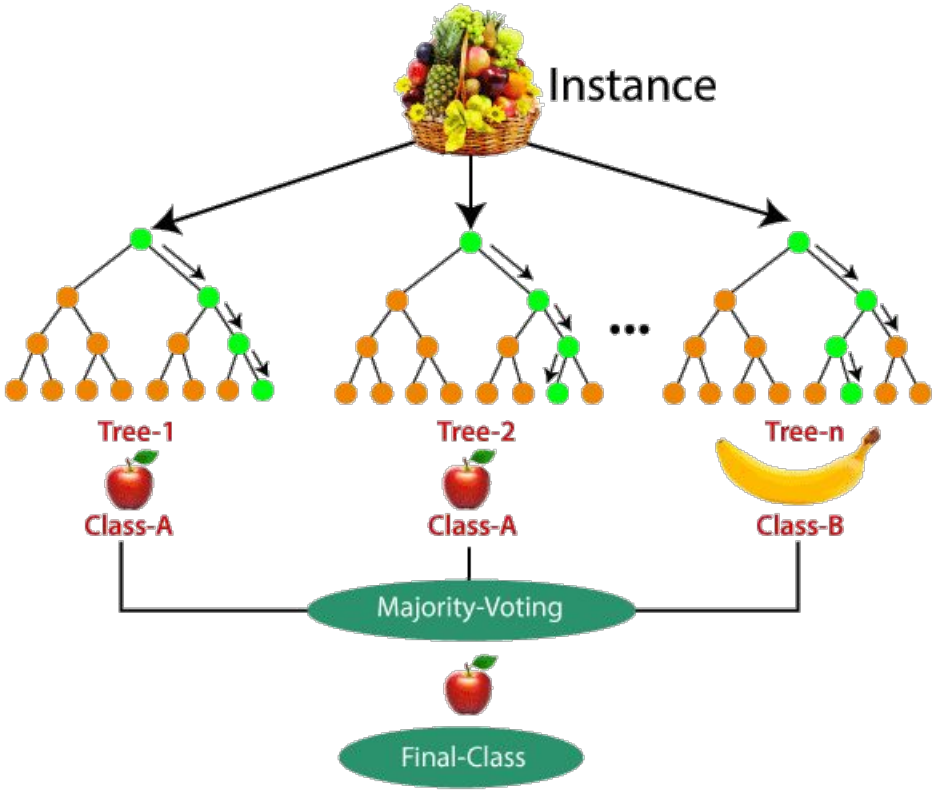
Pros:

- Robust to outliers.
- Works well with non-linear data.
- Lower risk of overfitting.
- Runs efficiently on a large dataset.
- Better accuracy than other classification algorithms.

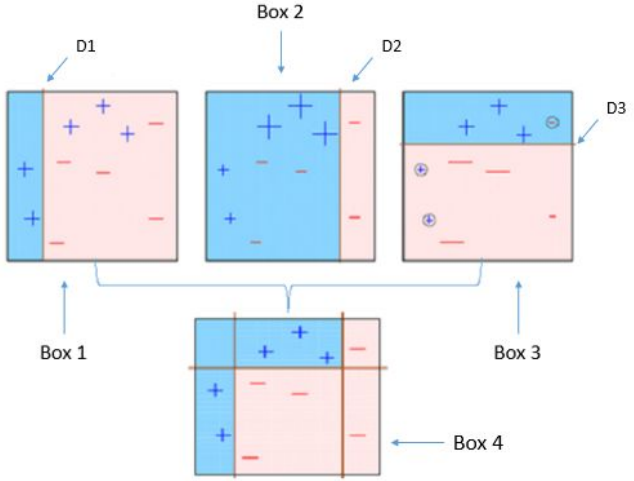
Cons:

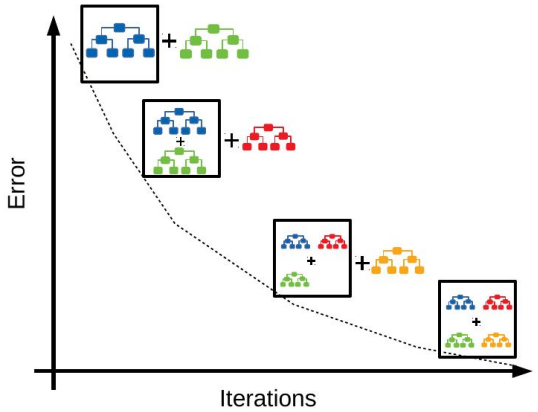
- Not descriptive
- Slow → big number of tree
- Not suitable for linear methods with a lot of sparse features



XGBOOST

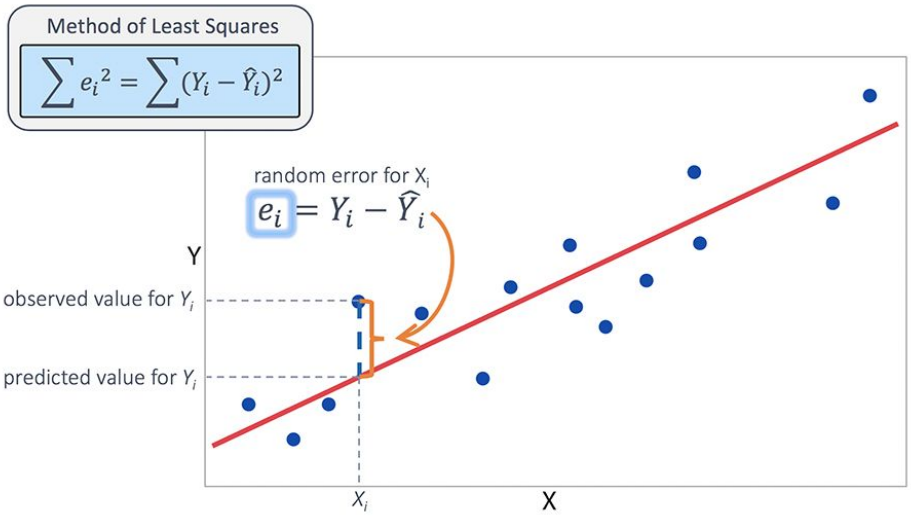
- XGBoost is a decision-tree-based ensemble Machine Learning algorithm that uses a gradient boosting framework. In prediction problems involving unstructured data (images, text, etc.) artificial neural networks tend to outperform all other algorithms or frameworks.
  - Box 1: The first classifier creates a vertical line (split) at D1.
  - Box 2: The next classifier says don't worry I will correct your mistakes. Therefore, it gives more weight to the three + misclassified points (see bigger size of +) and creates a vertical line at D2.
  - Box 3: The next classifier continues to bestow support.
  - Box 4: It is a weighted combination of the weak classifiers. As you can see, it does good job at classifying all the points correctly.
- Should we use it?
  - Pros: High Performance,
  - Cons: Sensitive to outliers, hard to scale up.

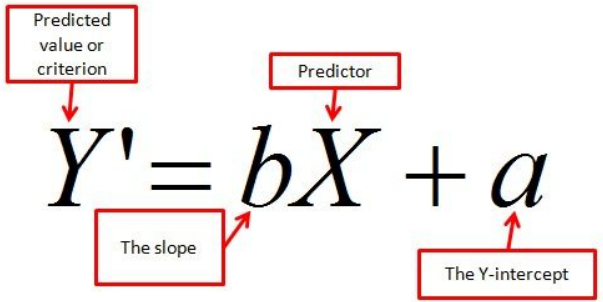




Regression

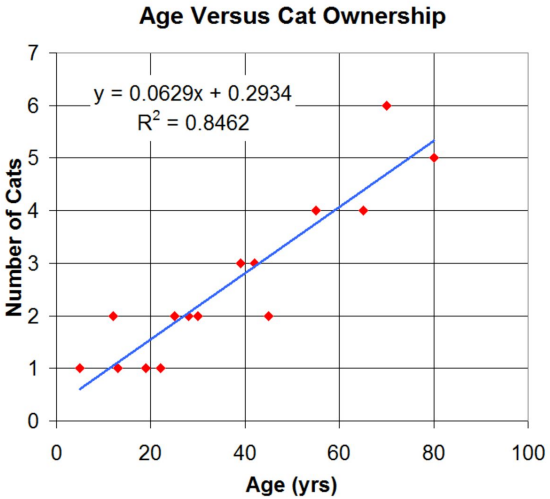
- ML can also be used to predict continuous target variables
- All three classifiers that we have learnt so far can be modified to do that But there are different algorithms just used for this task
- Target variable is continuous so there is no confusion matrix nor predicted probabilities
- Predict the value of a dependent variable based on the value of at least one independent variable





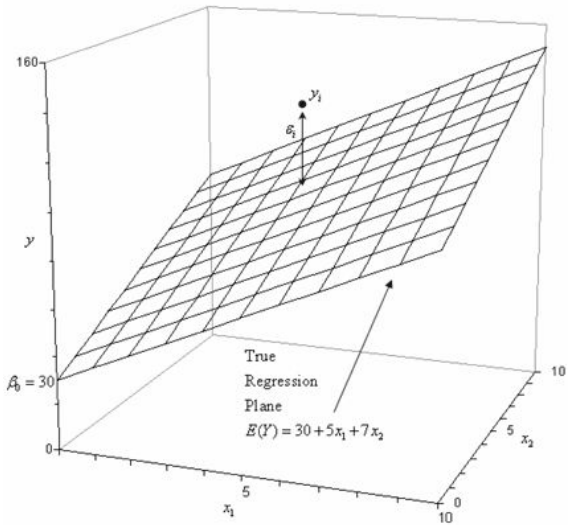
Linear vs Nonlinear Regression vs Multi Regression

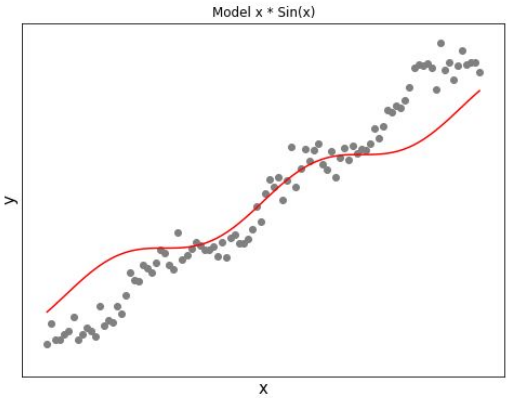
AltaML



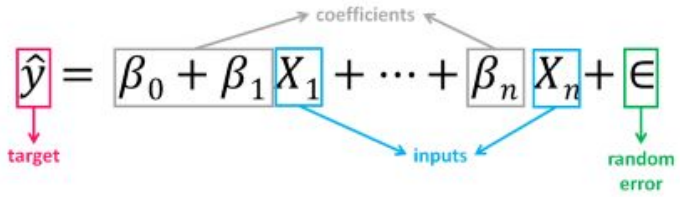
linear

Multi Regression



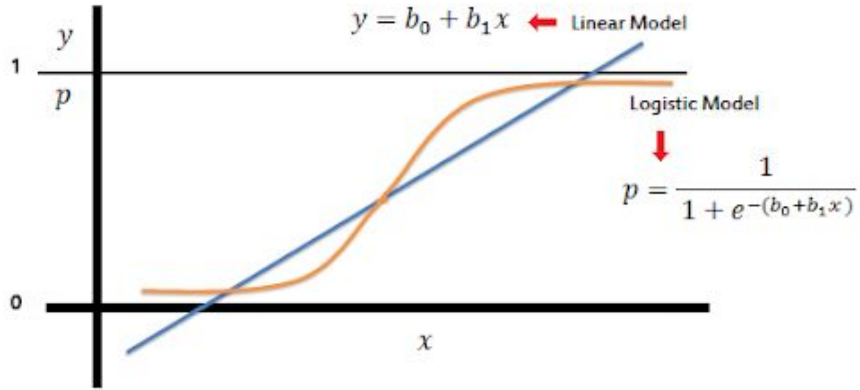


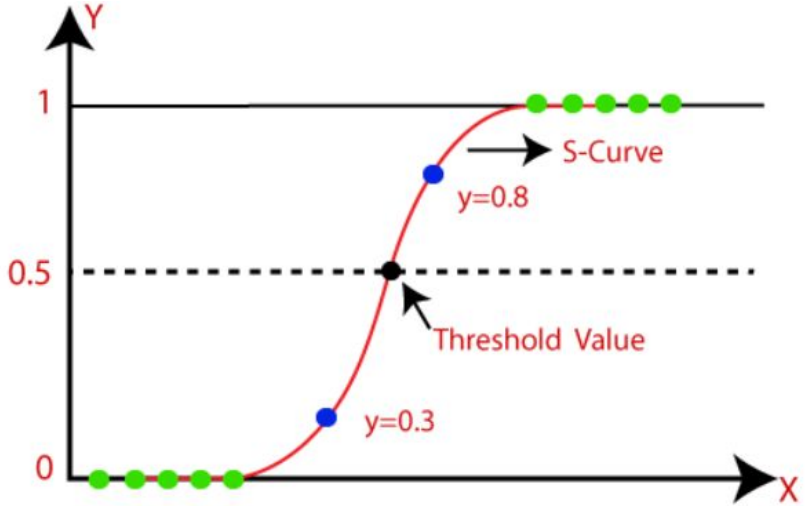
nonlinear



Logistic Regression

- The other type of regression analysis is logistic regression.
- Logistic regression is essentially used to calculate (or predict) the probability of a binary (yes/no) event occurring.

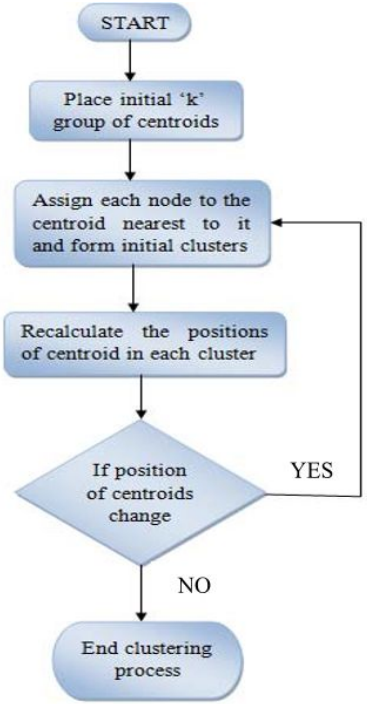


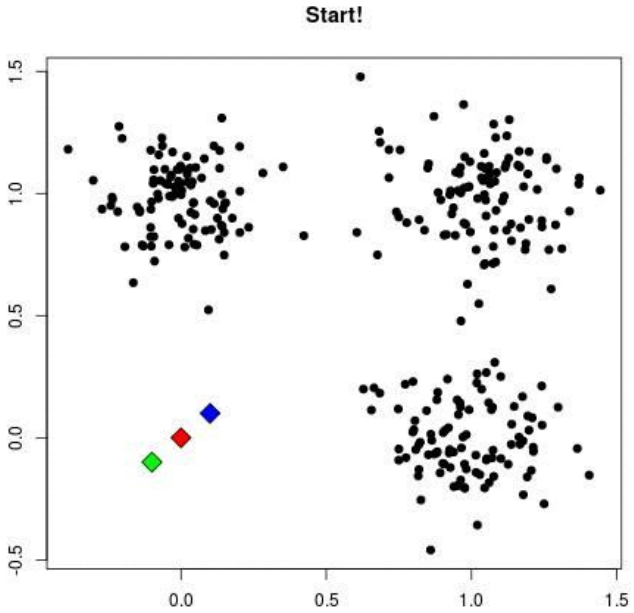


Unsupervised ML Algorithms

K Means

K Means algorithm is an iterative algorithm that tries to partition the dataset into K pre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to only one group.





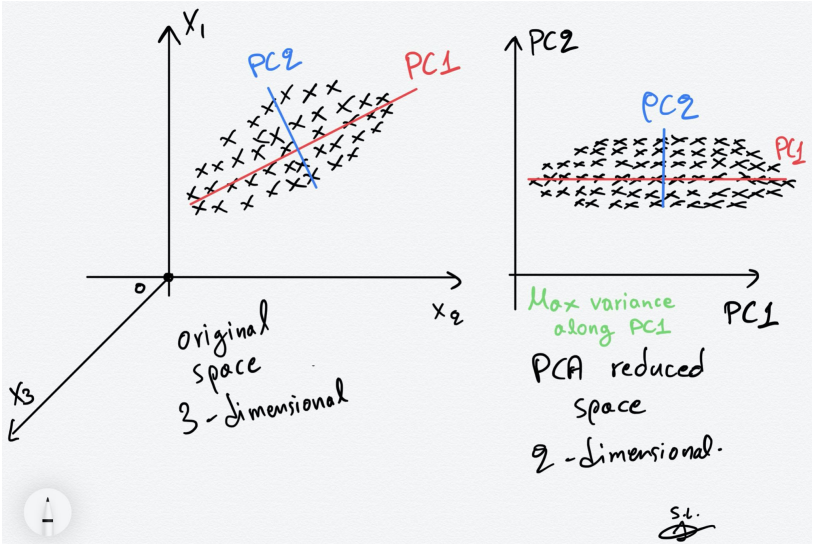
Pros:
Low complexity

Cons:

- **Necessity of specifying k**
- **Sensitive to noise and outliers**
- **Sensitive to initial centroids assignments**

Principal Component Analysis

- Although big data analytics is used in bettering many aspects of human life, it comes with its own problems. One of them is 'Curse of dimensionality'.
- Principal Component Analysis (PCA) is one of the most popular linear dimension reduction.
- it finds best linear combinations of the original variables so that the variance or spread along the new variable is maximum



Algorithm:

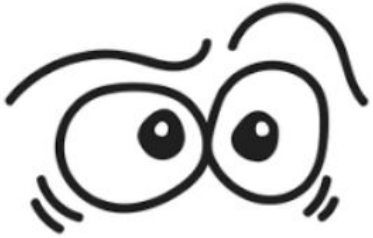
Step 1: Get the data from $m \times n$ matrix A

Step 2: Calculate the covariance matrix

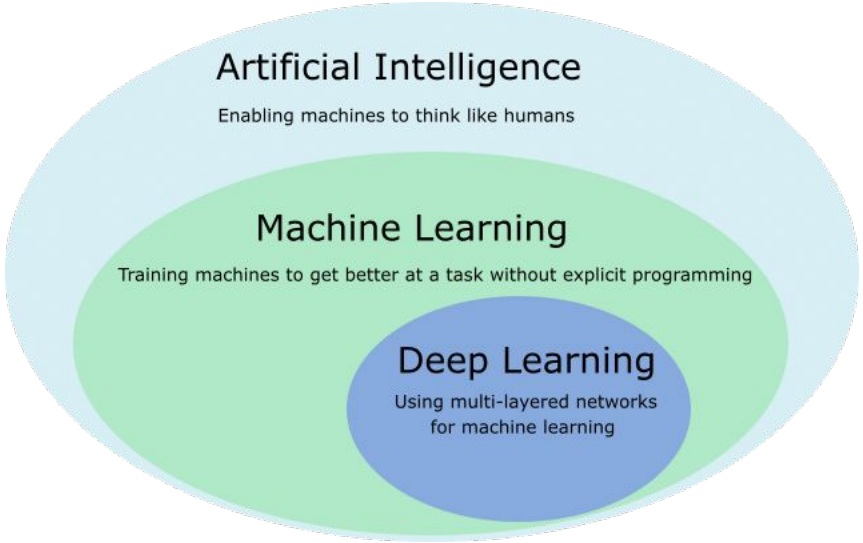
Step 3: Calculate the eigenvectors and eigenvalues of the covariance matrix

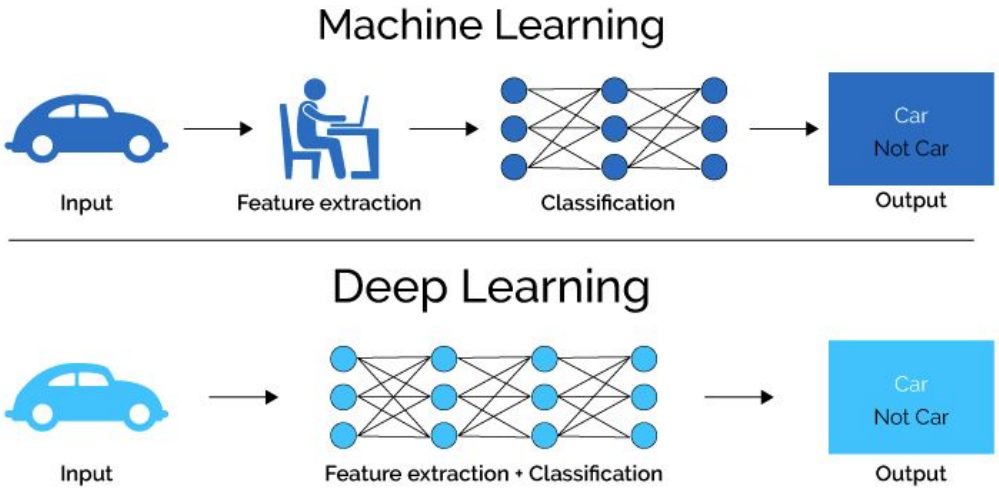
Step 4: Choosing principal components and forming a feature vector

Step 5: Deriving the new data set and forming the clusters



Deep Learning





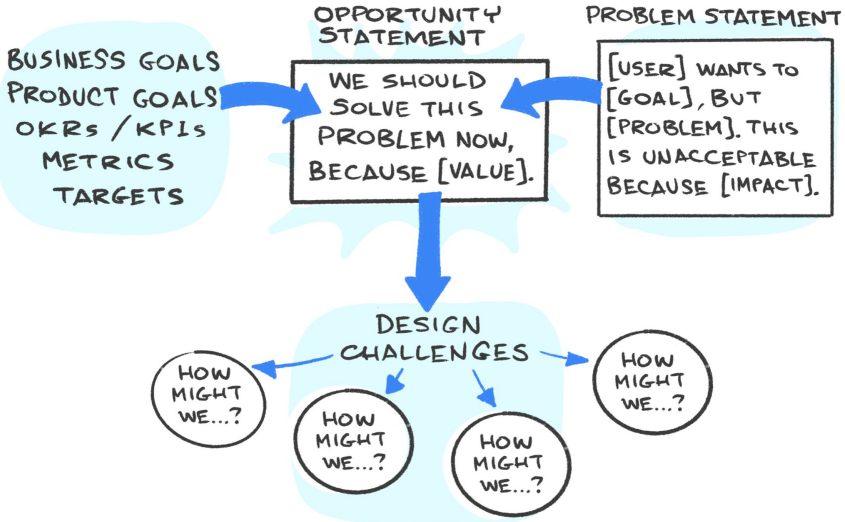
DL or ML?

Future Workshops...

AltaML

MACHINE LEARNING VS DEEP LEARNING

	MACHINE LEARNING	DEEP LEARNING
Approach	Requires structure data	Does not require structure data
Human Intervention	Requires human intervention for mistakes	Does not require human intervention for mistakes
Hardware	Can function on CPU	Requires GPU / significant computing power
Time	Takes seconds to hours	Takes weeks
Uses	Forecasting, predicting and other simple applications	More complex applications like autonomous vehicles



AltaML

hands-on
TRAINING

Q&A

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THANK YOU