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Artificial Learning Models

Lecture 4 : K-Nearest Neighbors

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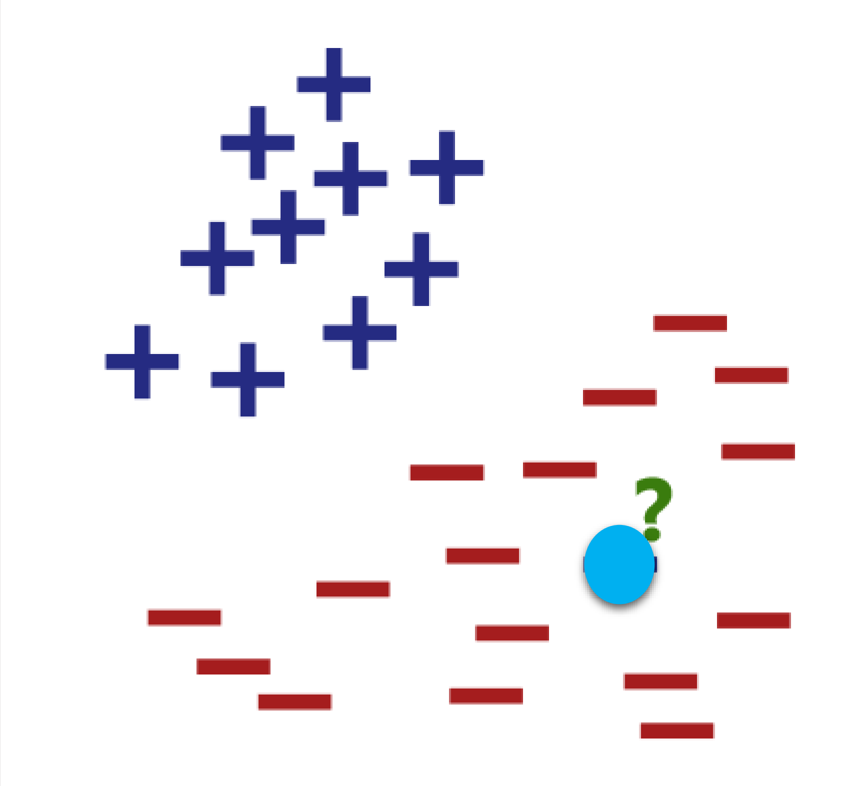
2023

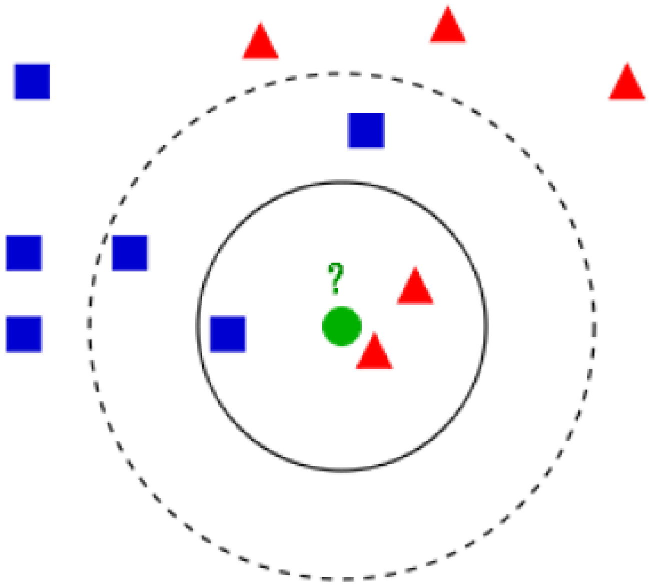
Introduction

- Consider 2 classes
  - Positive vs negative
  - The blue new point
- What is the classe of the blue point ?
- voting system or a popularity contest



K-Nearest Neighbor (KNN)

- Supervised machine learning algorithm
  - Used for classification
  - But it can also be used for regression
  - Very simple but effective
- Used to classify new data points based on “distance” to known data
  - Need a distance measure
- Find the K nearest neighbors, based on the distance metric
  - Let them all vote on the classification



K-Nearest Neighbors (KNN)
How does it work ?

- **In training phase** :
  - We define number of neighbors (k) and distance metric to be used.
  - There is no training
  - KNN model stores the training data with it’s labels/categories.

- **In Prediction (or test) phase** : If we provide a query point to the model :
  - It will find the distance of all the training data points with the query point,
  - Sort the distances in ascending order.
  - Then choose k number of nearest neighbor.
  - Whichever group will have more data points out of k neighbors, query point will be assigned to that group.

K-Nearest Neighbor (KNN)
Distance

- In D-dimensional space,
  - Minkowski distance

$$d_{minkowski} = \left(\sum_{i=1}^{n} |x_i - y_i|^p\right)^{1/p}$$

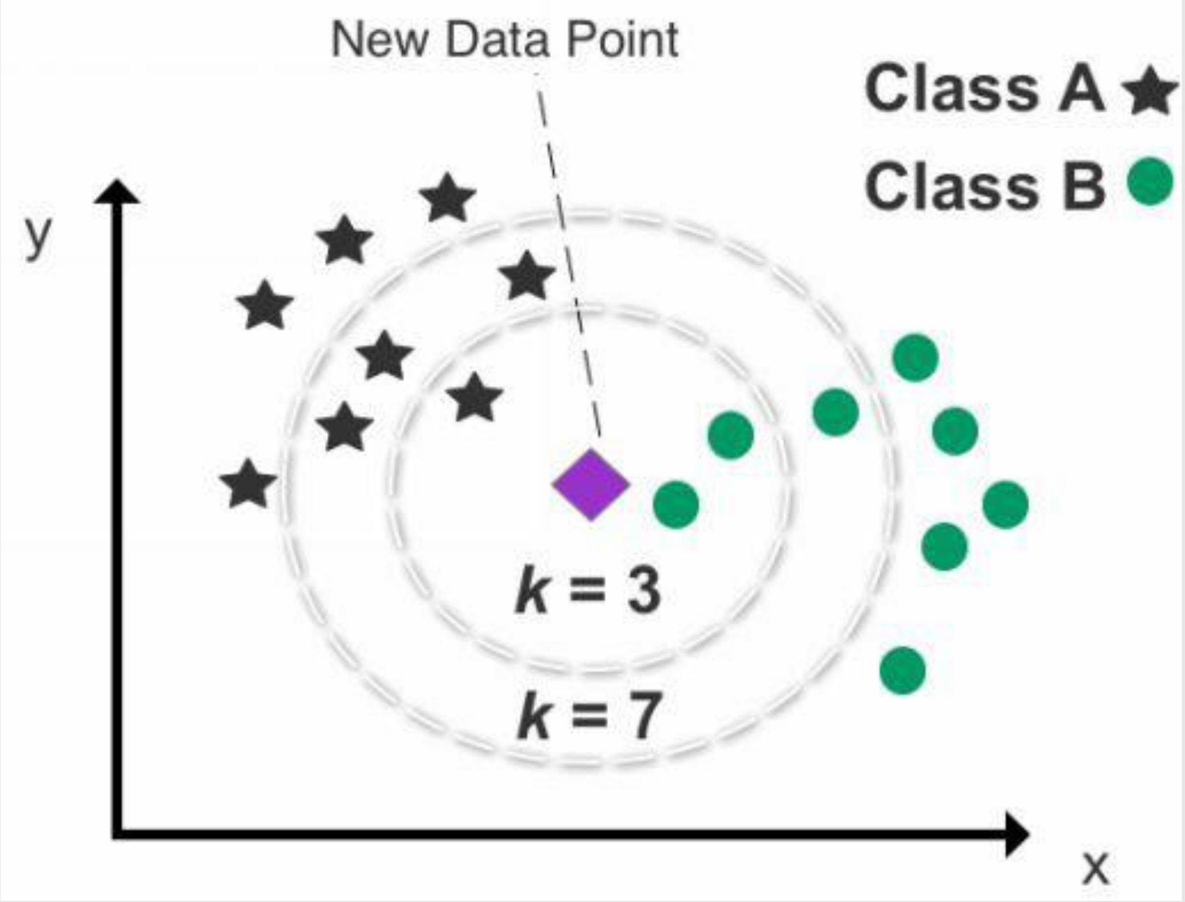
  - the Euclidean distance

$$d_{euclidean} = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

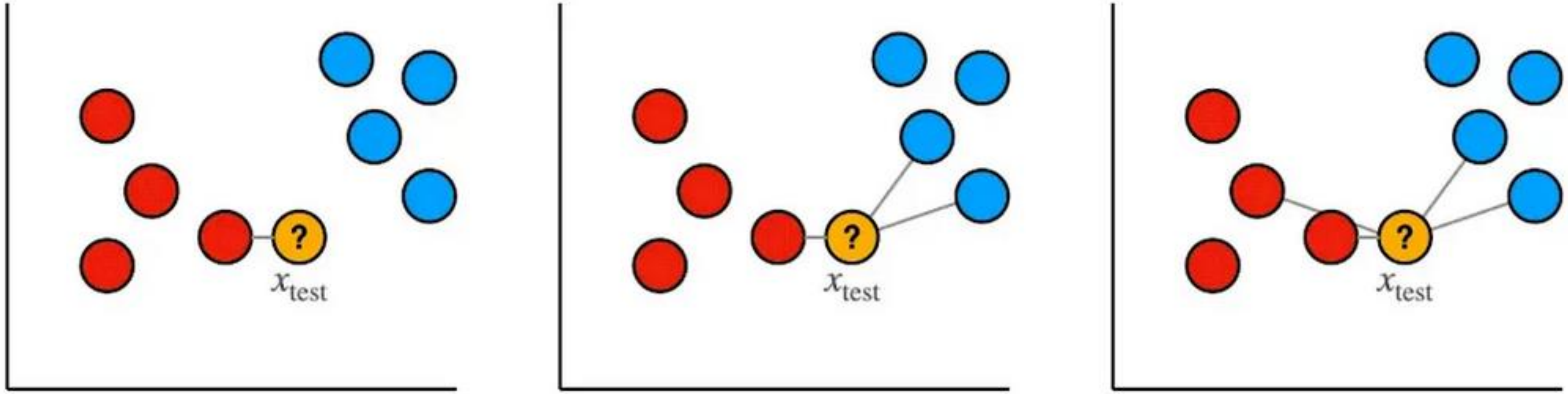
  - Manhattan distance

$$d_{manhattan} = \sum_{i=1}^{n} |x_i - y_i|$$

K-Nearest Neighbor (KNN)
Impact of K



K-Nearest Neighbor (KNN)
Impact of K



$k = 1$

Nearest point is red, so x_{test} classified as red

$k = 3$

Nearest points are {red, blue, blue} so x_{test} classified as blue

$k = 4$

Nearest points are {red, red, blue, blue} so classification of x_{test} is not properly defined

K-Nearest Neighbor (KNN)
How to choose K ?

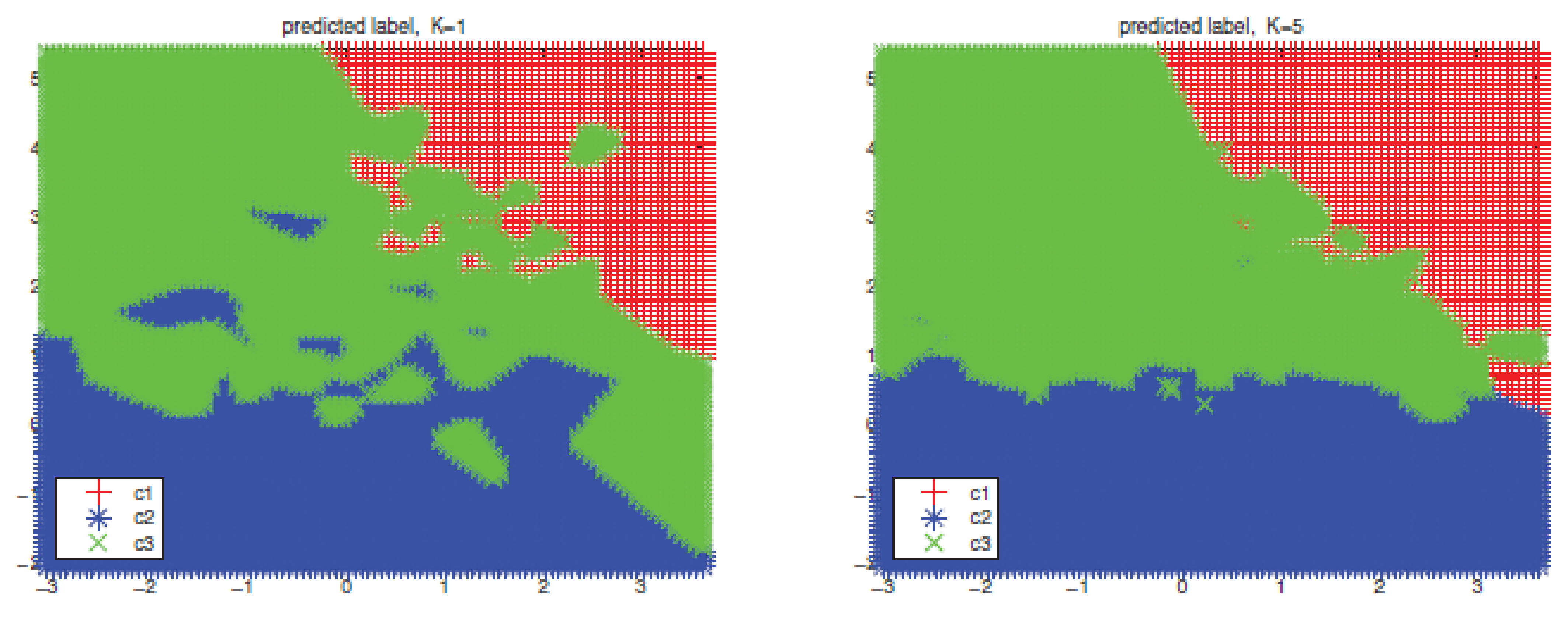
- choose odd value of k to avoid ties in classification.
- Approach :
  - Create different KNN model for k = 1, k = 3,…., k = 21…
  - Train these different KNN model on training data.
  - Run trained model on test data.
  - Find accuracy score.
  - Select one with high accuracy.

K-Nearest Neighbor (KNN)

value of K vs overfitting and underfitting ?

- Small K value (like 1 or 3):
  - ☺ Capture fine details in the data
  - ☹ May also be sensitive to noise and outliers.
- Large value of K :
  - ☺ Provides more generalized predictions
  - ☺ Reduces the risk of overfitting
  - ☹ Could underfit if taken to an extreme.
- If the data is densely packed,
  - a smaller ‘k’ might suffice
- sparse datasets
  - might benefit from a larger ‘k’

K-Nearest Neighbor (KNN) Decision boundary



K-Nearest Neighbor (KNN)

Variants : Weighted KNN

- Instandard KNN
  - Each of the K neighbors contributes equally to the final decision (vote)
  - Distance to the query point change ➔ it is unfair to give them the same importance

⬇

Weighted KNN

  - neighbors are assigned weights based on their distance to the query point.
  - closer neighbors are given more influence in determining the output than those further away.

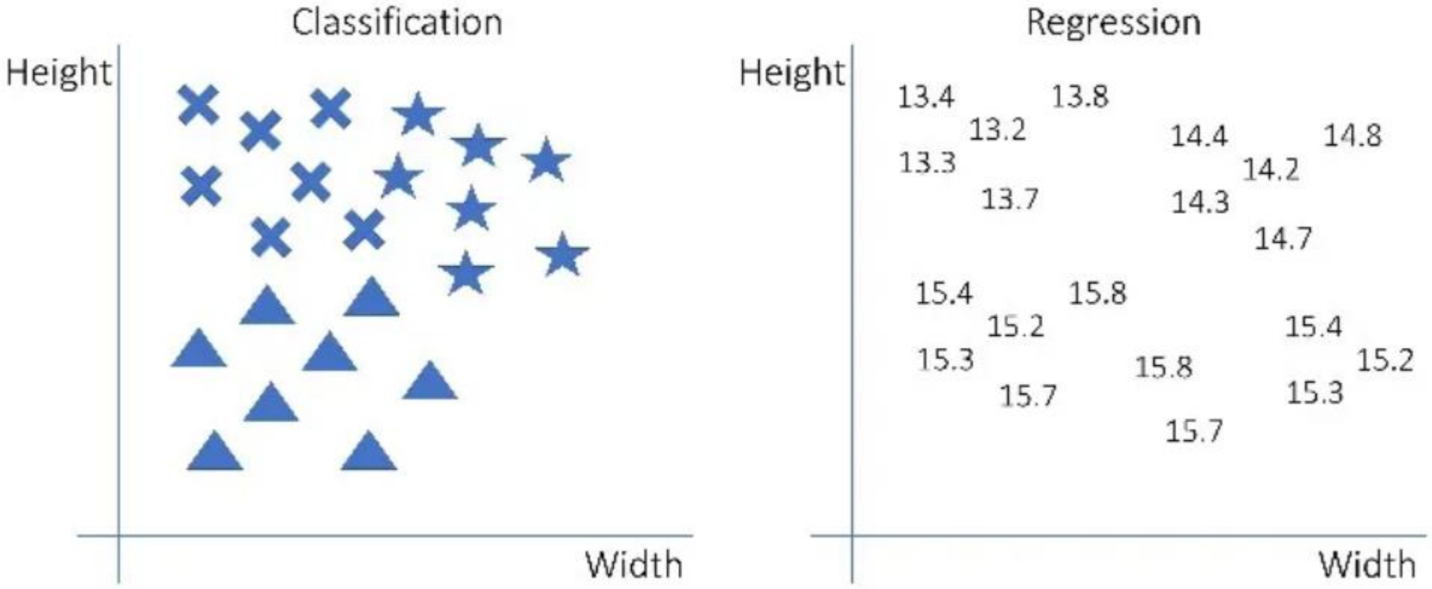
K-Nearest Neighbor (KNN) Applications

- Prediction
- Imputing missing data
  - If you have a small amount of data, predict the missing values using k-nearest neighbors (KNN)

K-Nearest Neighbor (KNN)
KNN for regression

- For classification problems,
  - the algorithm assigns a class label based on a majority vote

- For regression problems,
  - Continuous values are applied
  - The average is used to identify the k nearest neighbors.



K-Nearest Neighbor (KNN)

Advantages and disadvanges

- Advantages:
  - ☺ Simple
  - ☺ Training process is very fast
  - ☺ Easy implementation

- Disadvantages:
  - ☹ Huge memory consumption (because it needs to store all the data).
  - ☹Time complexity at testing
  - ☹Does not work well with large datasets
  - ☹Does not work well with high dimensionality
  - ☹Sensitive to noisy data