Data Mining
Classification: Alternative Techniques

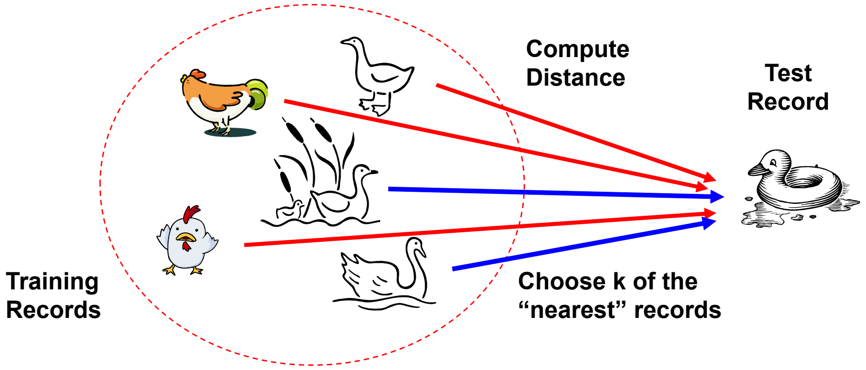
Lecture Notes for Chapter 4

Instance-Based Learning

Introduction to Data Mining , 2nd Edition
by
Tan, Steinbach, Karpatne, Kumar

Nearest Neighbor Classifiers

- Basic idea:
  - If it walks like a duck, quacks like a duck, then it's probably a duck



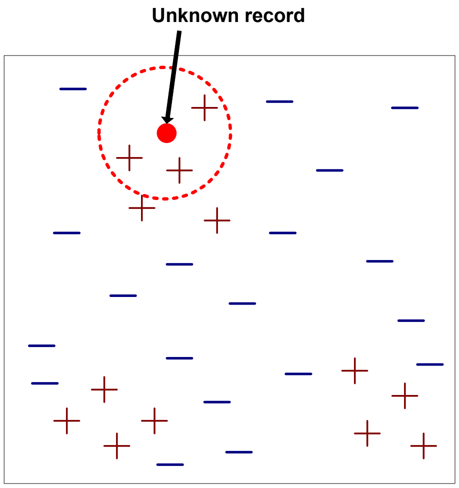
Compute Distance

Test Record

Training Records

Choose k of the "nearest" records

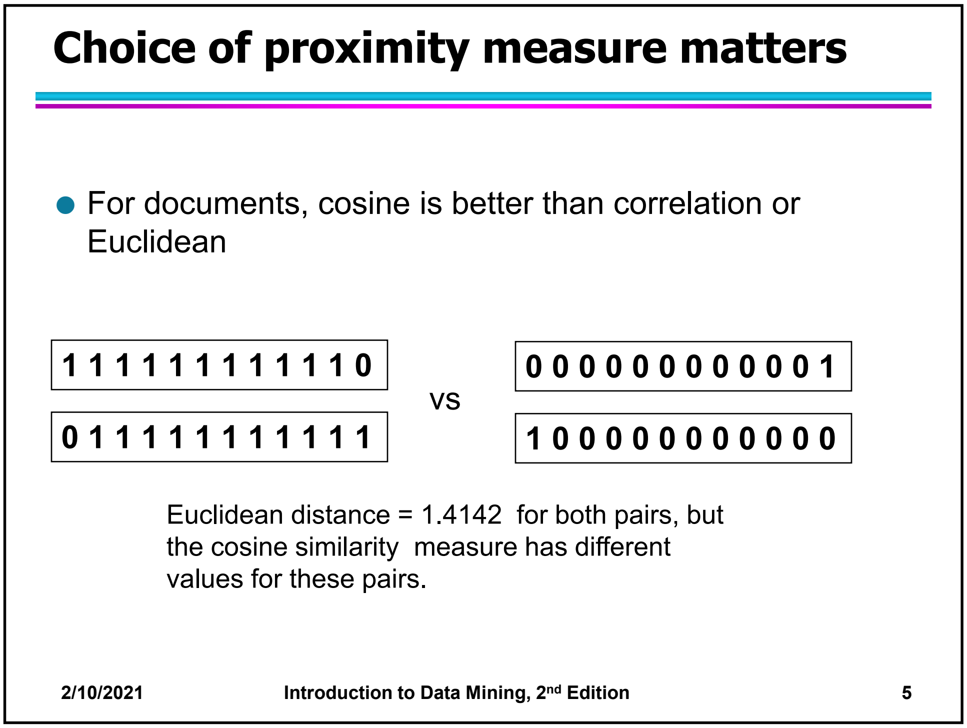
Nearest-Neighbor Classifiers



- Requires the following:
  - A set of labeled records
  - Proximity metric to compute distance/similarity between a pair of records
    - e.g., Euclidean distance
  - The value of *k*, the number of nearest neighbors to retrieve
  - A method for using class labels of K nearest neighbors to determine the class label of unknown record (e.g., by taking majority vote)

How to Determine the class label of a Test Sample?

- Take the majority vote of class labels among the k-nearest neighbors
- Weight the vote according to distance
  - weight factor, $w = 1/d^2$



Choice of proximity measure matters

- For documents, cosine is better than correlation or Euclidean

1 1 1 1 1 1 1 1 1 1 1 0

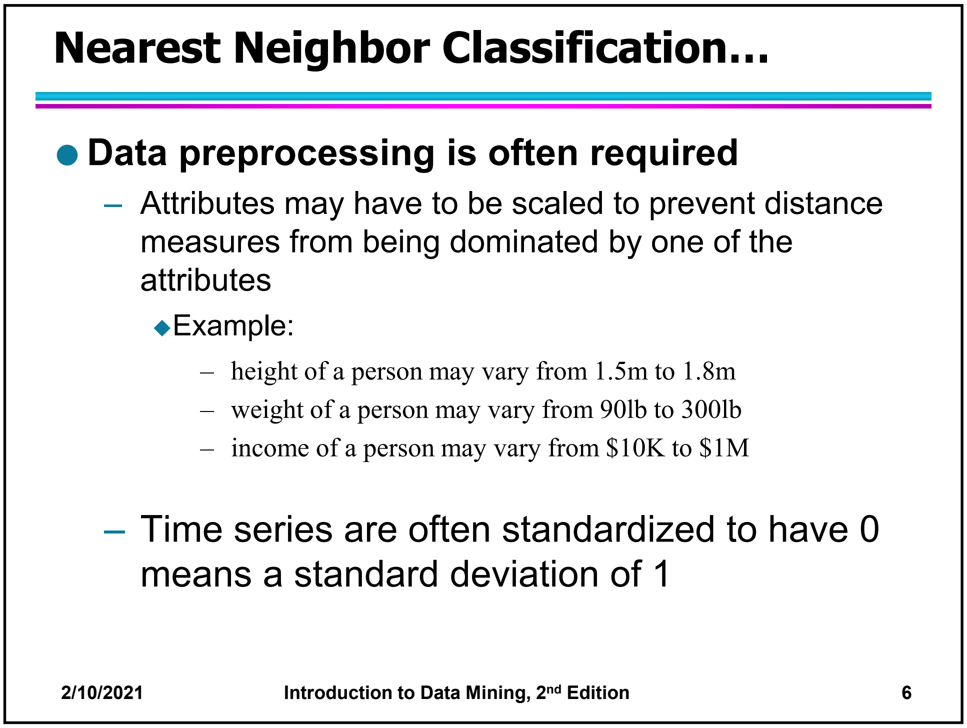
0 1 1 1 1 1 1 1 1 1 1 1

vs

0 0 0 0 0 0 0 0 0 0 0 1

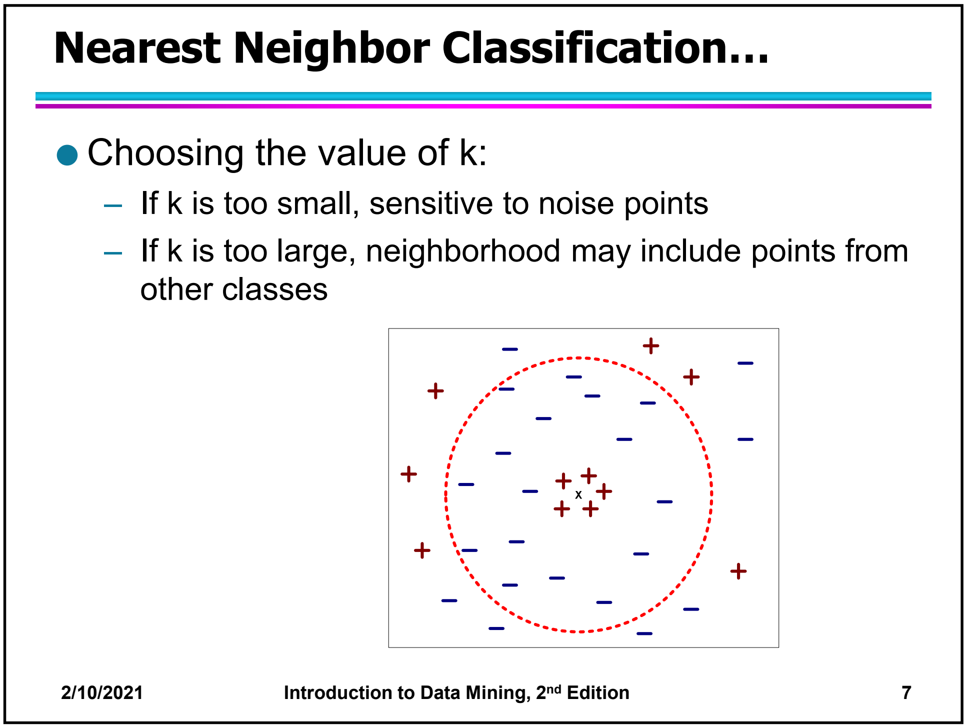
1 0 0 0 0 0 0 0 0 0 0 0

Euclidean distance = 1.4142 for both pairs, but the cosine similarity measure has different values for these pairs.



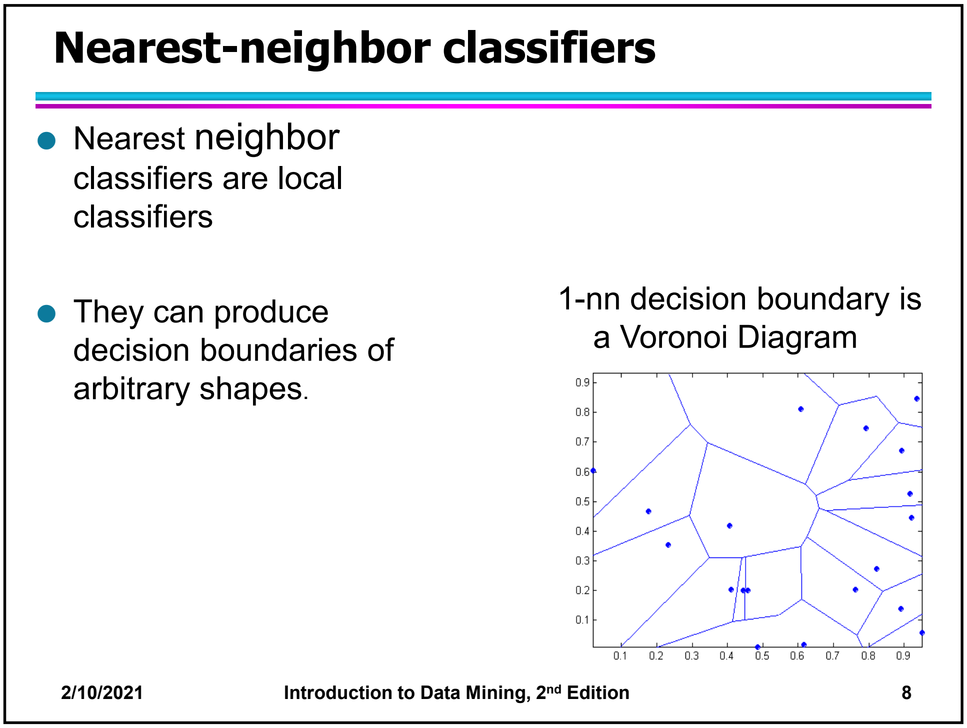
Nearest Neighbor Classification…

- **Data preprocessing is often required**
  - Attributes may have to be scaled to prevent distance measures from being dominated by one of the attributes
    - Example:
      - height of a person may vary from 1.5m to 1.8m
      - weight of a person may vary from 90lb to 300lb
      - income of a person may vary from $10K to $1M
  - Time series are often standardized to have 0 means a standard deviation of 1



Nearest Neighbor Classification…

- Choosing the value of k:
  - If k is too small, sensitive to noise points
  - If k is too large, neighborhood may include points from other classes



Nearest-neighbor classifiers

- Nearest neighbor classifiers are local classifiers

- They can produce decision boundaries of arbitrary shapes.

1-nn decision boundary is a Voronoi Diagram

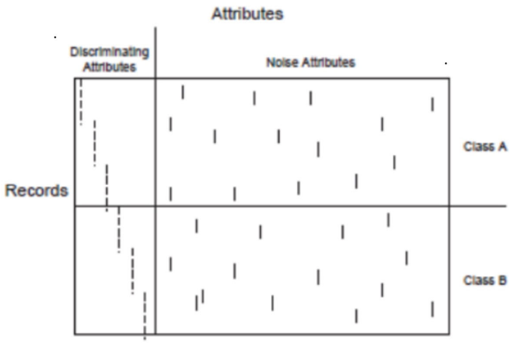
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

Nearest Neighbor Classification…

- **How to handle missing values in training and test sets?**
  - Proximity computations normally require the presence of all attributes
  - Some approaches use the subset of attributes present in two instances
    - This may not produce good results since it effectively uses different proximity measures for each pair of instances
    - Thus, proximities are not comparable

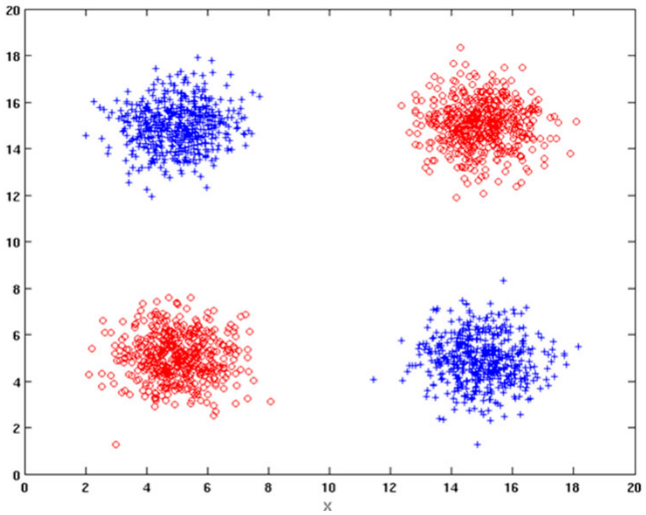
K-NN Classificiers…
Handling Irrelevant and Redundant Attributes

- Irrelevant attributes add noise to the proximity measure
- Redundant attributes bias the proximity measure towards certain attributes

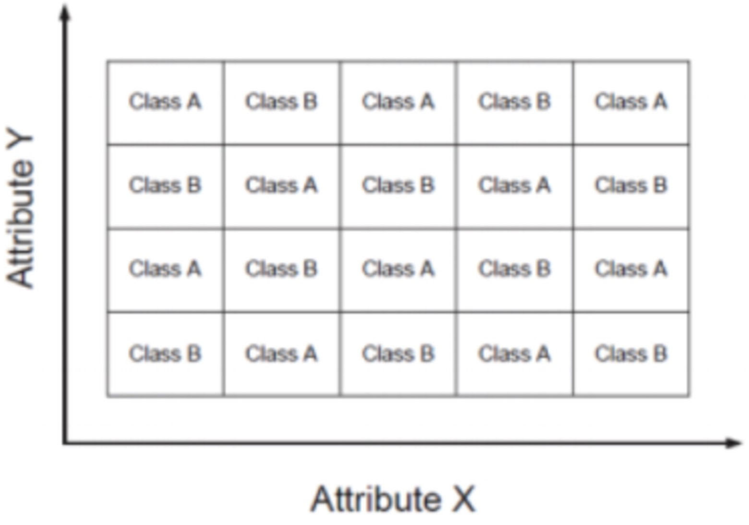


(a) Synthetic data set 1.

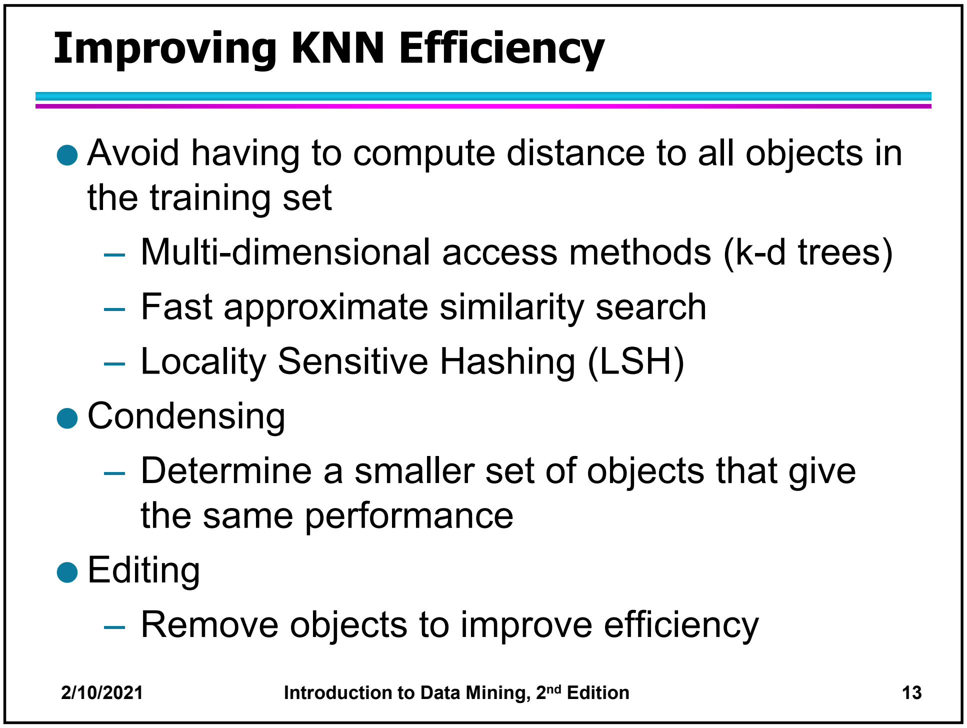
K-NN Classifiers: Handling attributes that are interacting



Handling attributes that are interacting



Class A	Class B	Class A	Class B	Class A
Class B	Class A	Class B	Class A	Class B
Class A	Class B	Class A	Class B	Class A
Class B	Class A	Class B	Class A	Class B



Improving KNN Efficiency

- Avoid having to compute distance to all objects in the training set
  - Multi-dimensional access methods (k-d trees)
  - Fast approximate similarity search
  - Locality Sensitive Hashing (LSH)
- Condensing
  - Determine a smaller set of objects that give the same performance
- Editing
  - Remove objects to improve efficiency