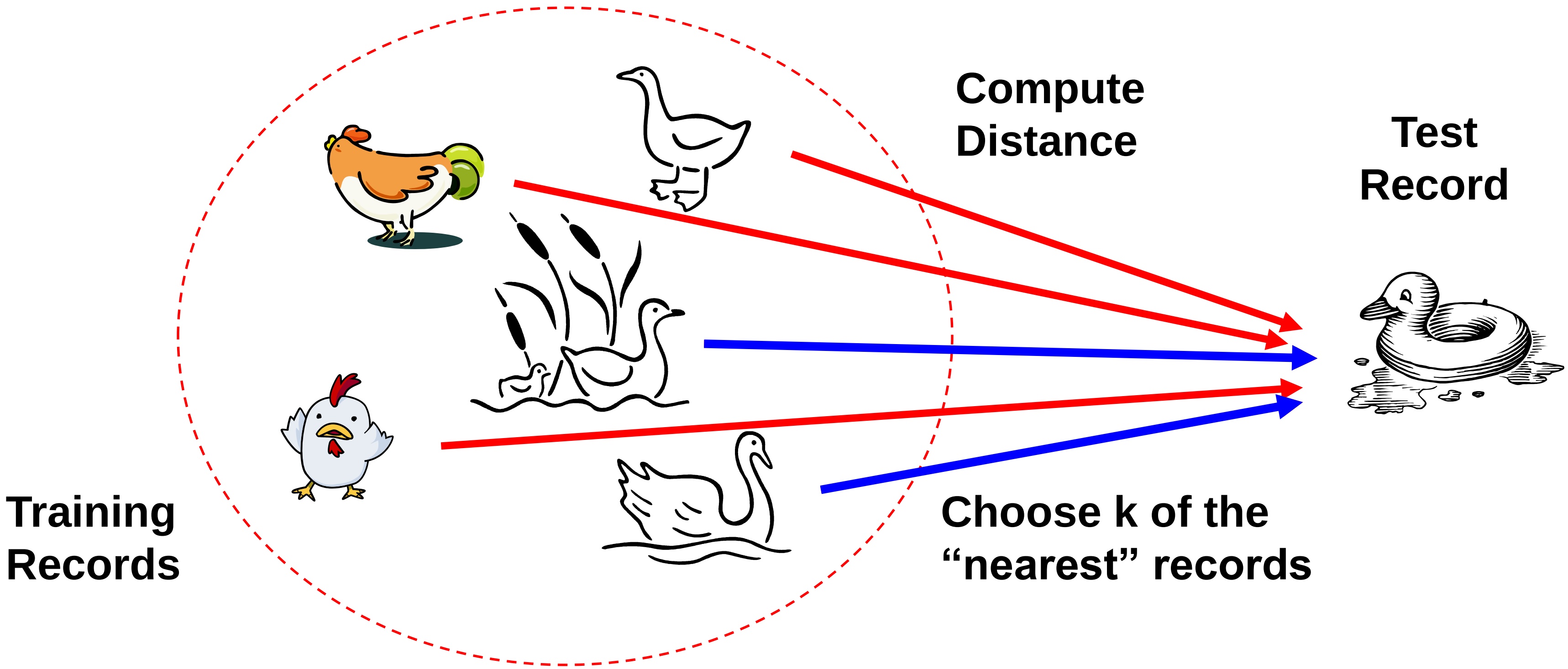
Data Mining

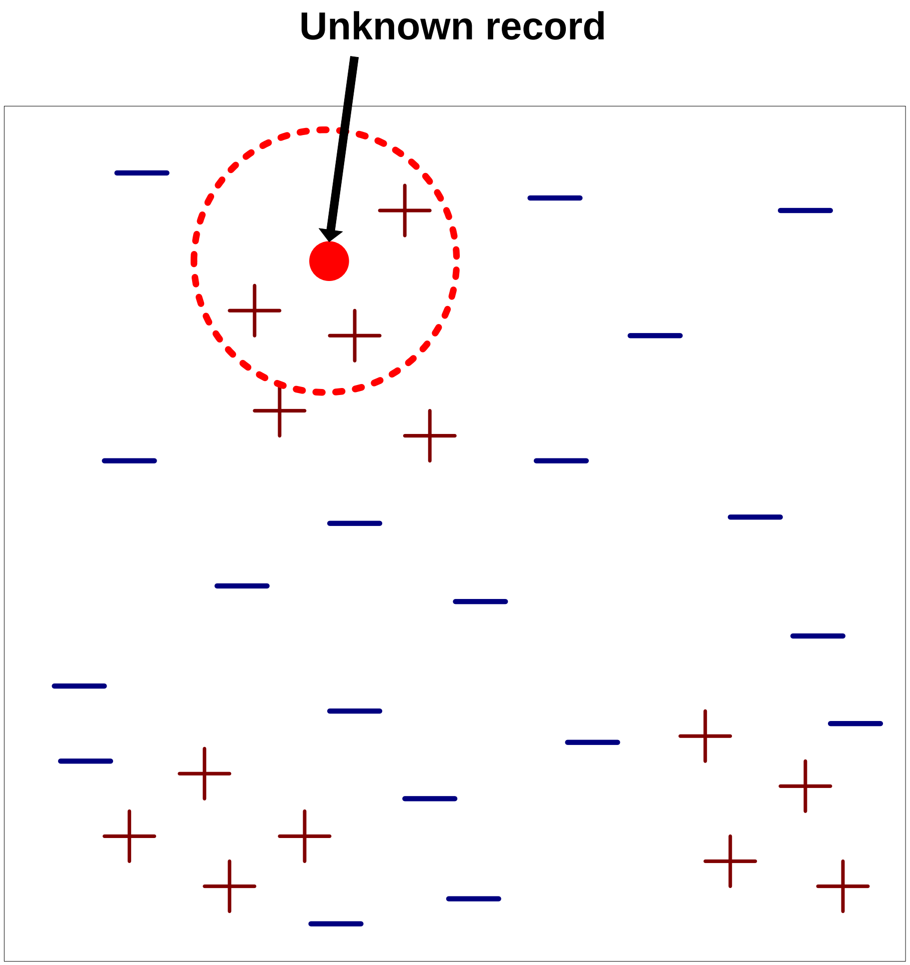
Instance-Based Learning

Nearest Neighbor Classifiers

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



Nearest-Neighbor Classifiers



- Requires three things
  - The set of labeled records
  - Distance metric to compute distance between records
  - The value of *k*, the number of nearest neighbors to retrieve
- To classify an unknown record:
  - Compute distance to other training records
  - Identify *k* nearest neighbors
  - Use class labels of nearest neighbors to determine the class label of unknown record (e.g., by taking majority vote)

Nearest Neighbor Classification

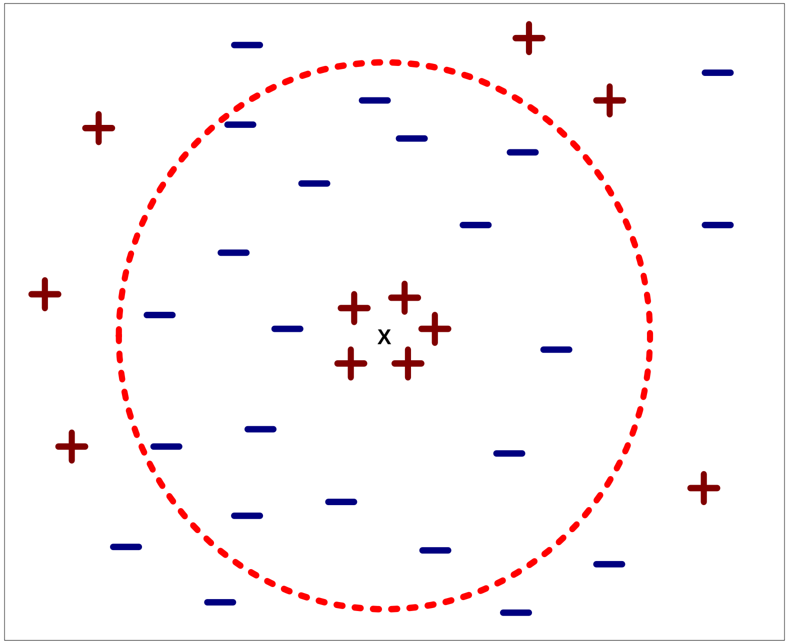
- Compute proximity between two points:
  - Example: Euclidean distance

$$d(\boldsymbol{x}, \boldsymbol{y}) = \sqrt{\sum_i (\boldsymbol{x_i} - \boldsymbol{y_i})^2}$$

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

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 Classification…

- **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

Nearest Neighbor Classification…

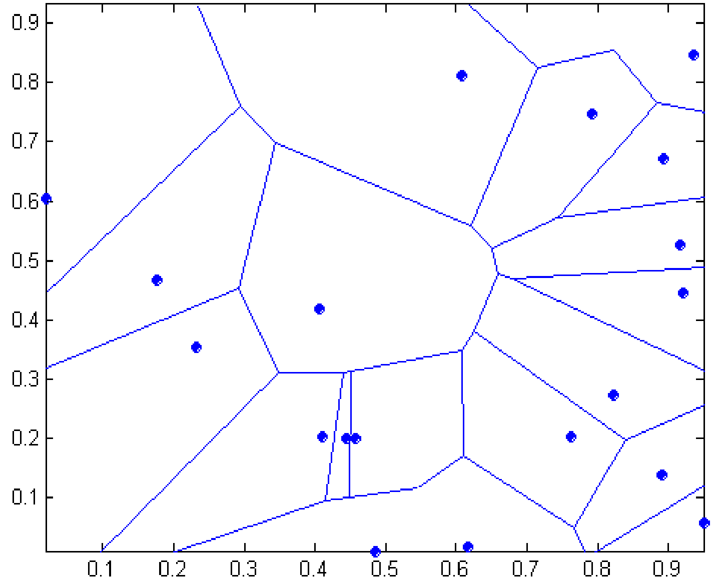
- **Data preprocessing is often required**
  - Attributes may have to be scaled to prevent distance measures from being dominated by one of the attributes
    - Example:
      - height of a person may vary from 1.5m to 1.8m
      - weight of a person may vary from 90lb to 300lb
      - income of a person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

Nearest-neighbor classifiers

- Nearest neighbor classifiers are local classifiers

- They can produce decision boundaries of arbitrary shapes.

1-nn decision boundary is a Voronoi Diagram



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

Nearest Neighbor Classification…

- **Handling irrelevant and redundant attributes**
  - Irrelevant attributes add noise to the proximity measure
  - Redundant attributes bias the proximity measure towards certain attributes
  - Can use variable selection or dimensionality reduction to address irrelevant and redundant attributes

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