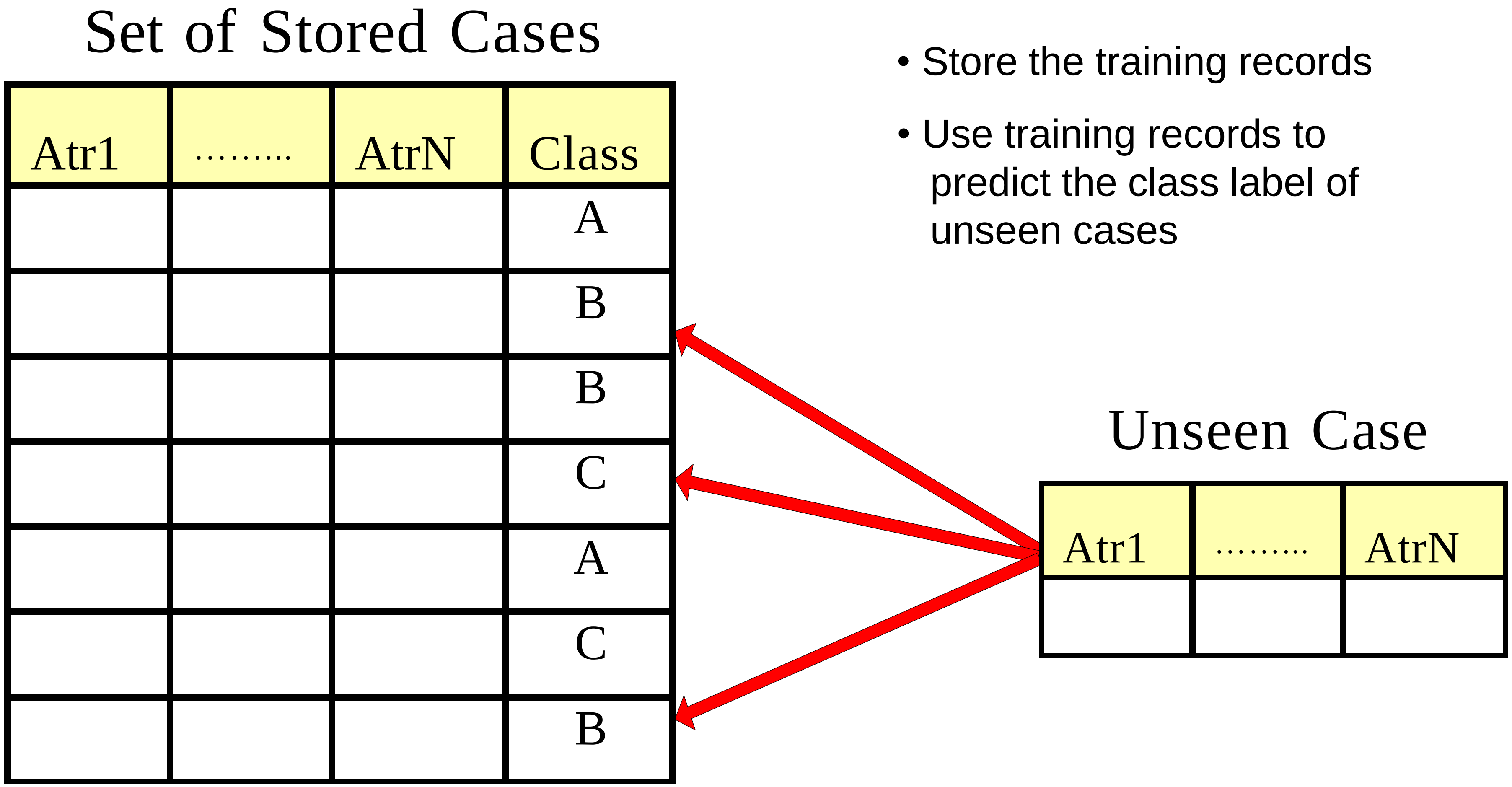
Nearest-Neighbor Classifier

Instance-Based Classifiers

- Store the training records
- Use training records to predict the class label of unseen cases



Set of Stored Cases

Atr1	………	AtrN	Class
			A
			B
			B
			C
			A
			C
			B

Unseen Case

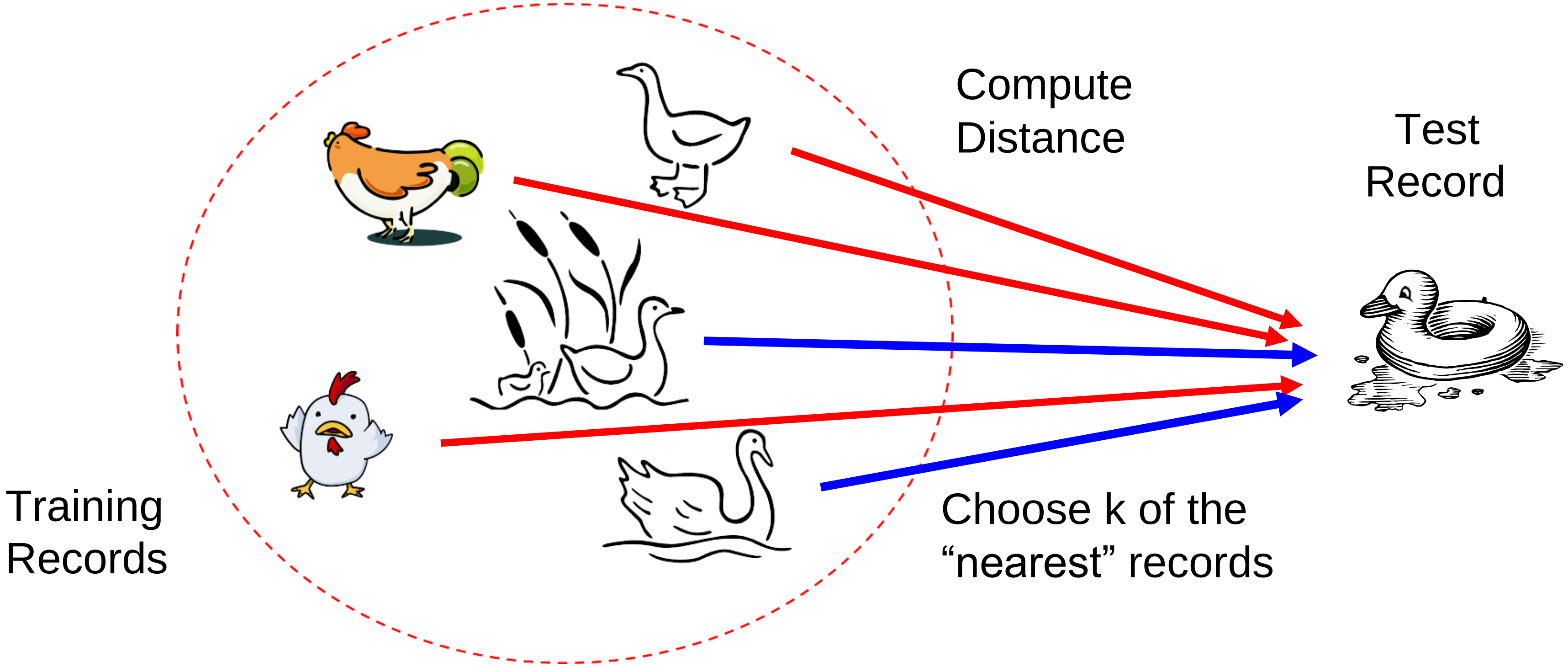
Atr1	………	AtrN

Instance Based Classifiers

- Examples:
  - Rote-learner
    - Memorizes entire training data and performs classification only if attributes of record match one of the training examples exactly
  - Nearest neighbor
    - Uses k “closest” points (nearest neighbors) for performing classification

Nearest Neighbor Classifiers

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



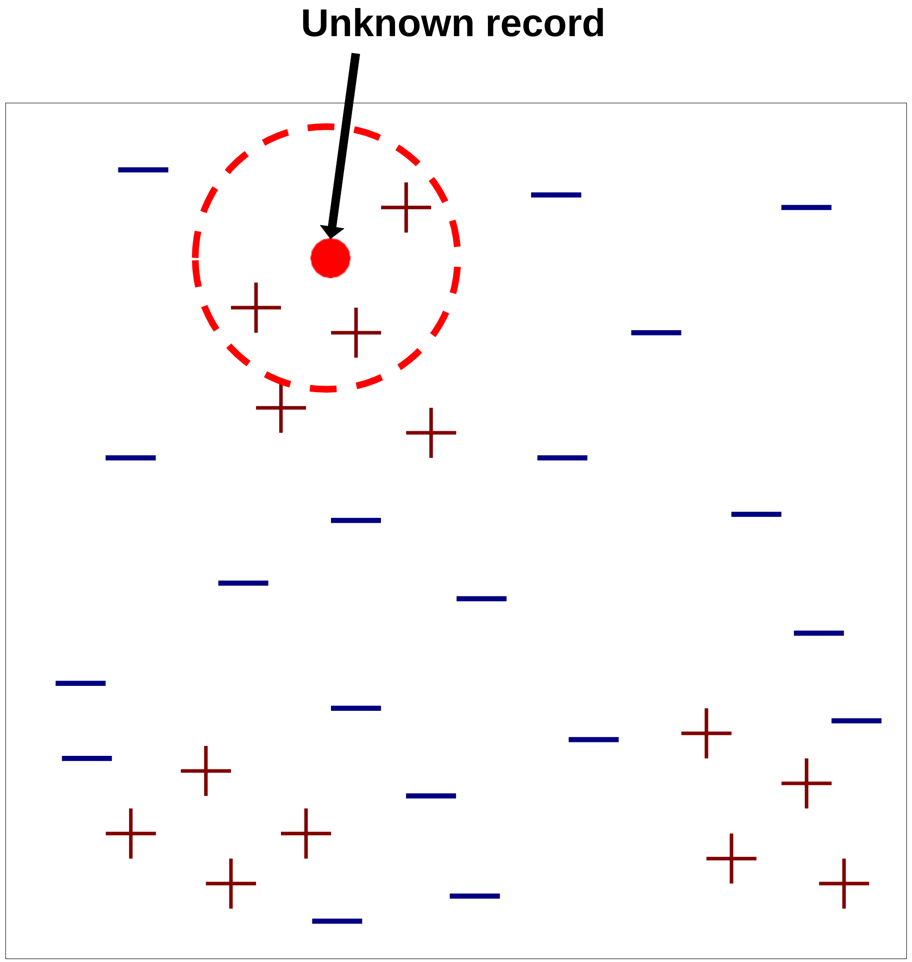
Compute Distance

Test Record

Training Records

Choose k of the "nearest" records

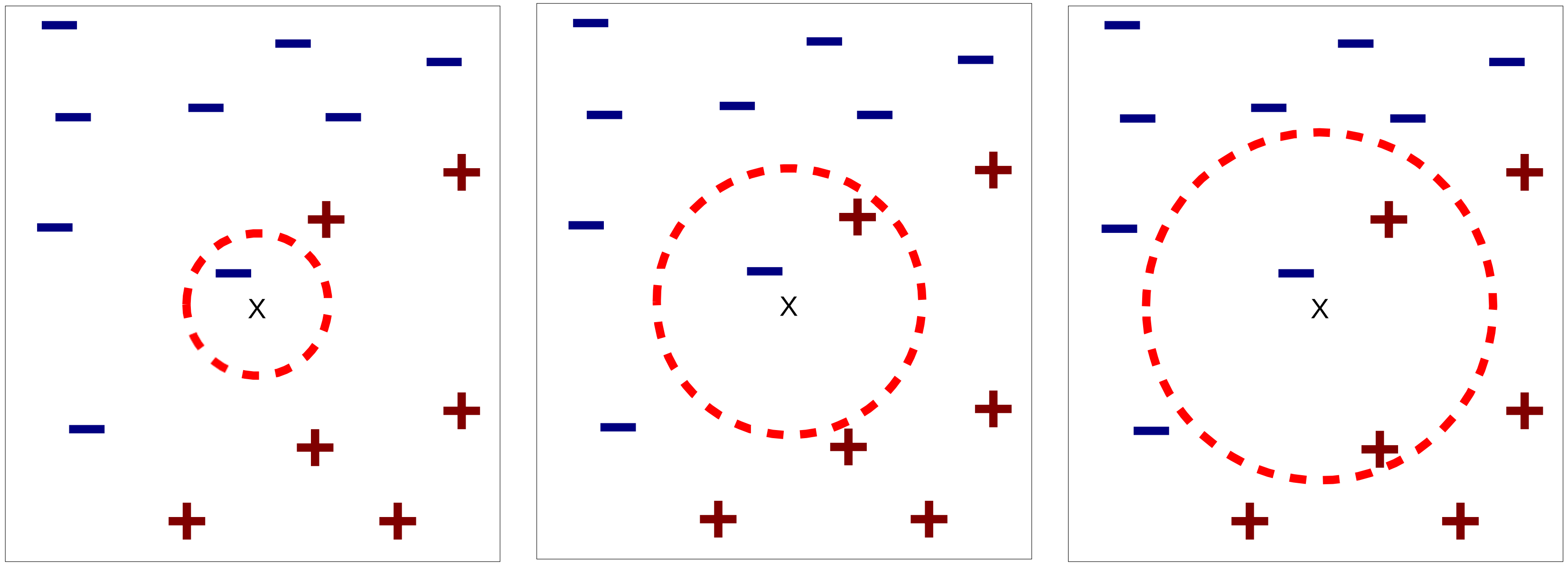
Nearest-Neighbor Classifiers



- Requires three things
  - The set of stored 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)

Definition of Nearest Neighbor

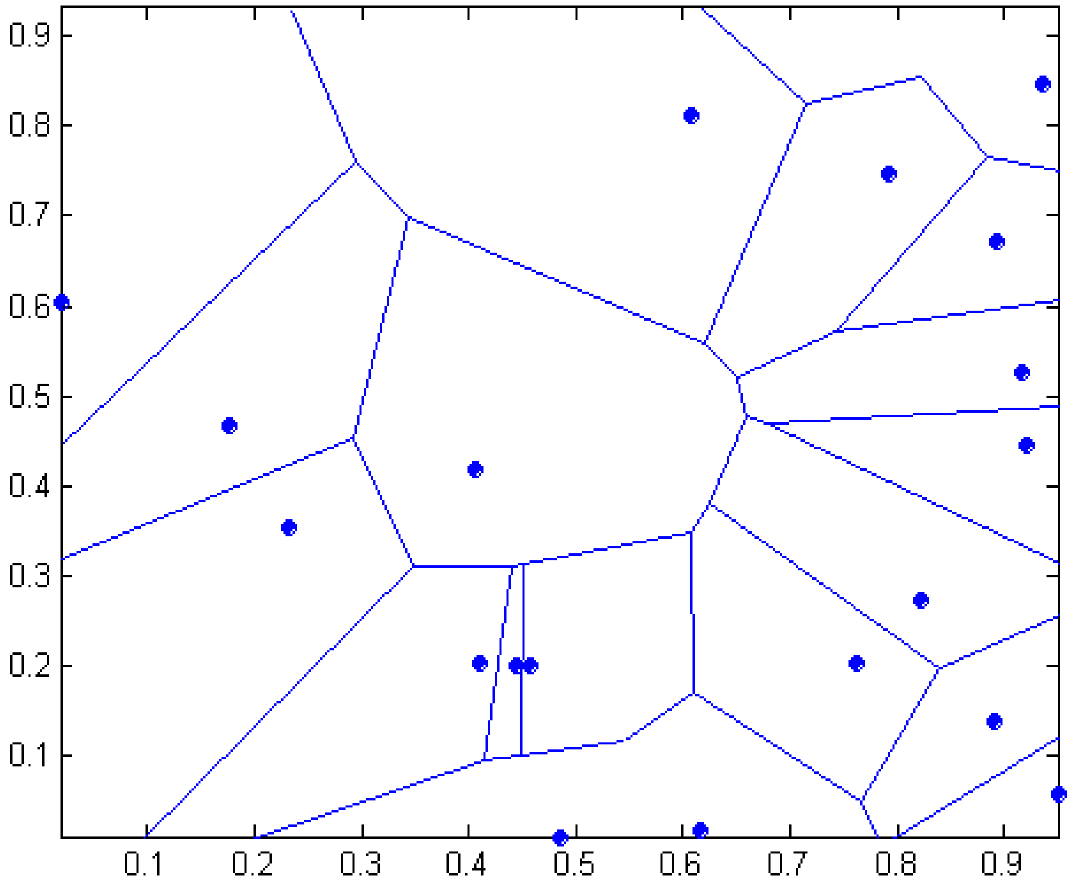


(a) 1-nearest neighbor (b) 2-nearest neighbor (c) 3-nearest neighbor

K-nearest neighbors of a record x are data points that have the k smallest distance to x

1 nearest-neighbor

Voronoi Diagram



Nearest Neighbor Classification

- Compute distance between two points:
  - Euclidean distance

$$d(p,q)=\sqrt{\sum_i (p_i - q_i)^2}$$

  - Manhatten distance

$$d(p,q) = \sum_i |p_i - q_i|$$

  - q norm distance

$$d(p,q) = \left(\sum_i |p_i - q_i|^q\right)^{1/q}$$

- Determine the class from nearest neighbor list
  - take the majority vote of class labels among the k-nearest neighbors

$$y' = \underset{v}{\operatorname{argmax}} \sum_{(\boldsymbol{x}_i, y_i) \in D_z} I(v = y_i)$$

where D_z is the set of k closest training examples to z.

  - Weigh the vote according to distance

$$y' = \underset{v}{\operatorname{argmax}} \sum_{(\boldsymbol{x}_i, y_i) \in D_z} w_i \times I(v = y_i)$$

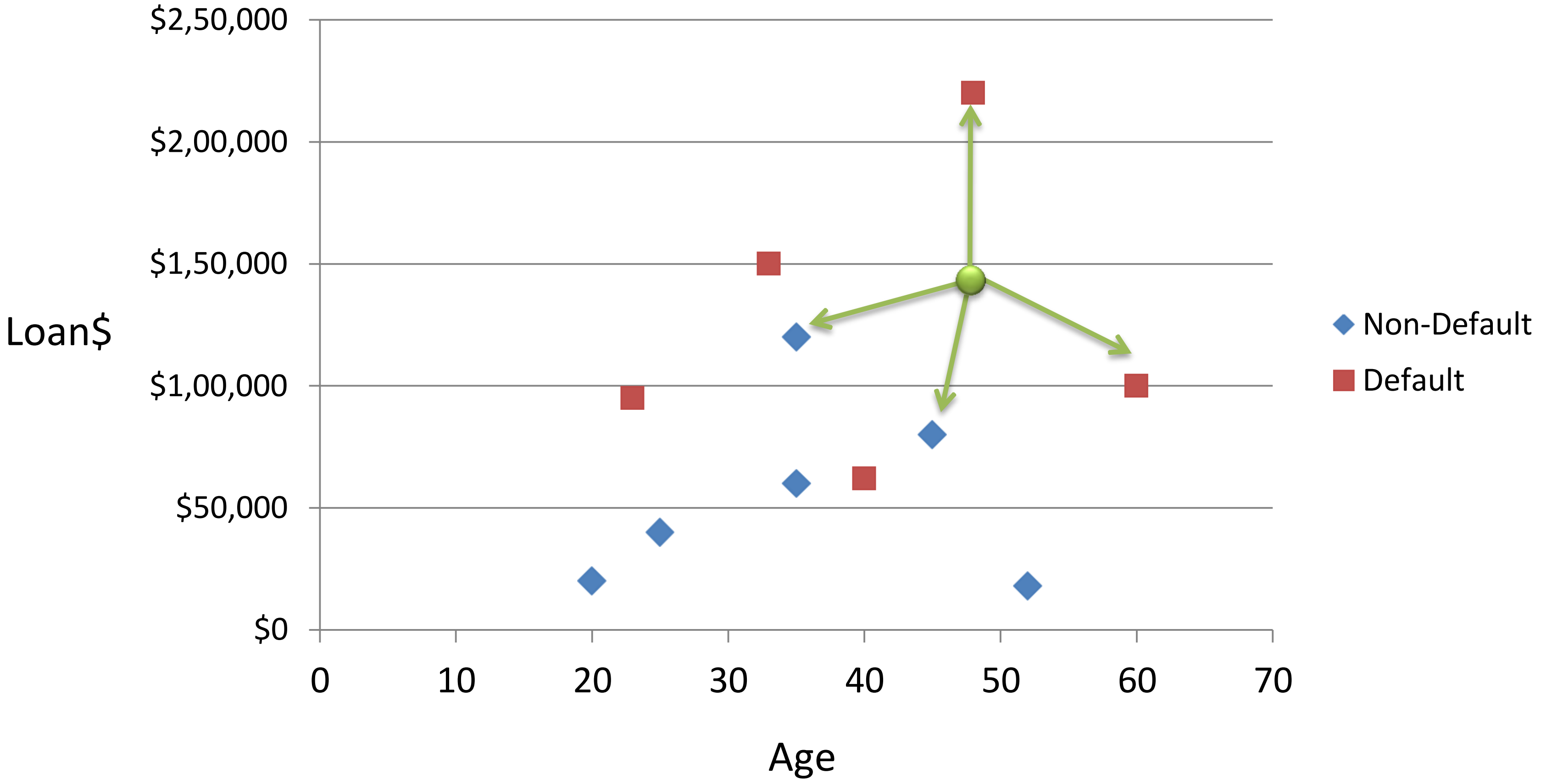
    - weight factor, $w = 1/d^2$

The KNN classification algorithm

Let k be the number of nearest neighbors and D be the set of training examples.

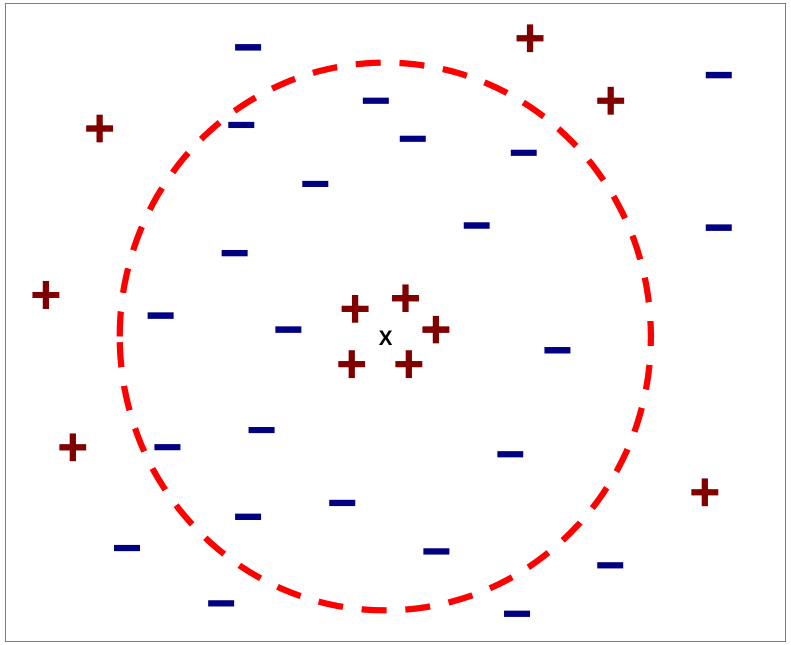
```
1. for each test example z = (x',y') do
2.     Compute d(x',x), the distance between z and every example, (x,y) ∈ D
3.     Select $D_z \subseteq D$, the set of k closest training examples to z.
4.     $y' = \underset{v}{\operatorname{argmax}} \sum_{(\boldsymbol{x}_i, y_i) \in D_z} I(v = y_i)$
5. end for
```

KNN Classification



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…

- Scaling issues
  - 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 60 KG to 100KG
    - income of a person may vary from Rs10K to Rs 2 Lakh

Nearest Neighbor Classification…

- Problem with Euclidean measure:
  - High dimensional data
    - curse of dimensionality: all vectors are almost equidistant to the query vector
  - Can produce undesirable results

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

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

d = 1.4142

vs

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

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

d = 1.4142

◆ Solution: Normalize the vectors to unit length

Nearest neighbor Classification…

- k-NN classifiers are lazy learners
  - It does not build models explicitly
  - Unlike eager learners such as decision tree induction and rule-based systems
  - Classifying unknown records are relatively expensive

Thank You