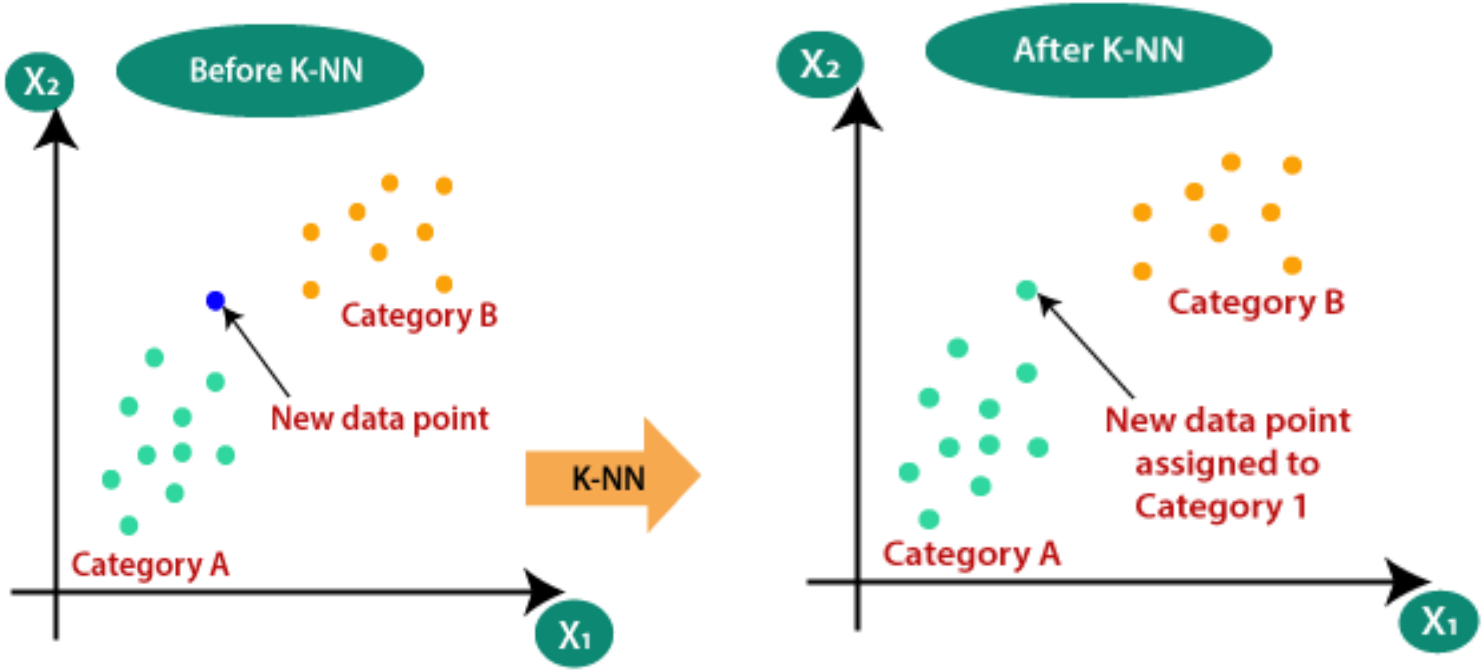
Machine Learning

K- Nearest Neighbour (K-NN) Algorithm

What is K-NN

An Example

Working Principle



Different Steps In KNN

Step-1: Select the number K of the neighbors

Step-2: Calculate the Euclidean distance of **K number of neighbors**

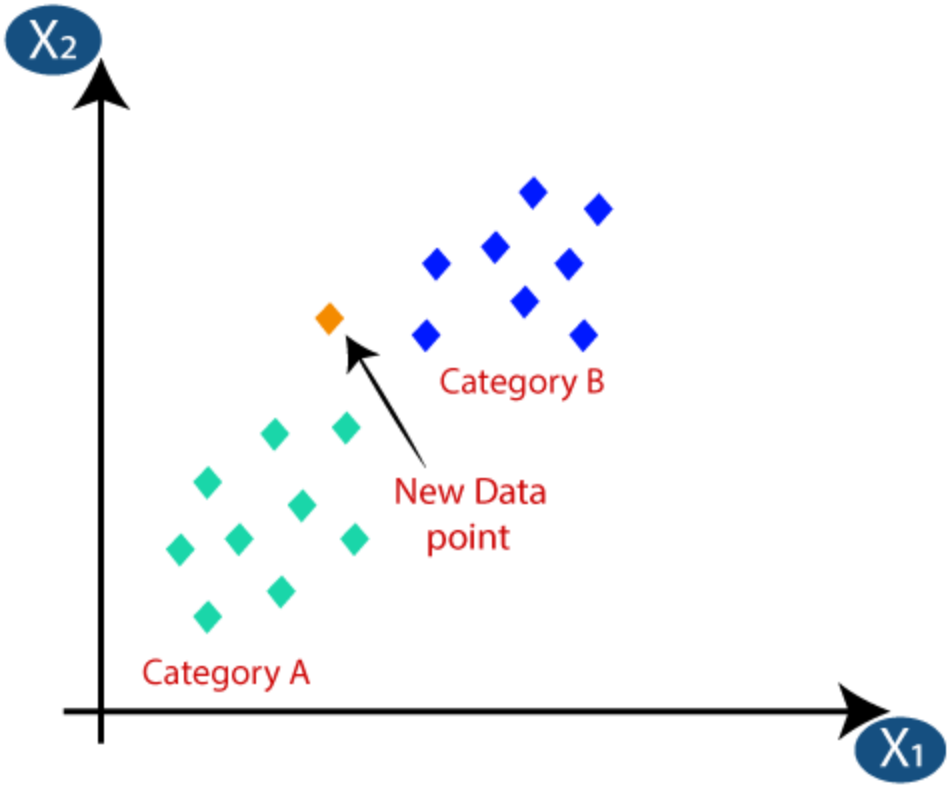
Step-3: Take the K nearest neighbors as per the calculated Euclidean distance.

Step-4: Among these k neighbors, count the number of the data points in each category.

Step-5: Assign the new data points to that category for which the number of the neighbor is maximum.

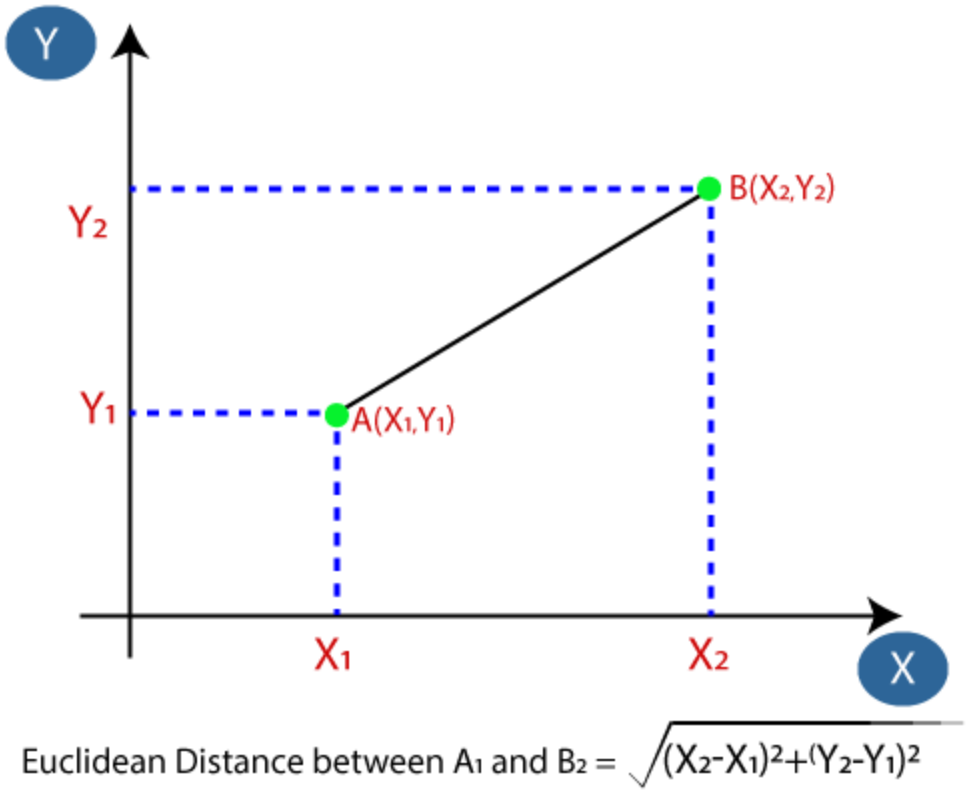
Step-6: Our model is ready.

Illustration

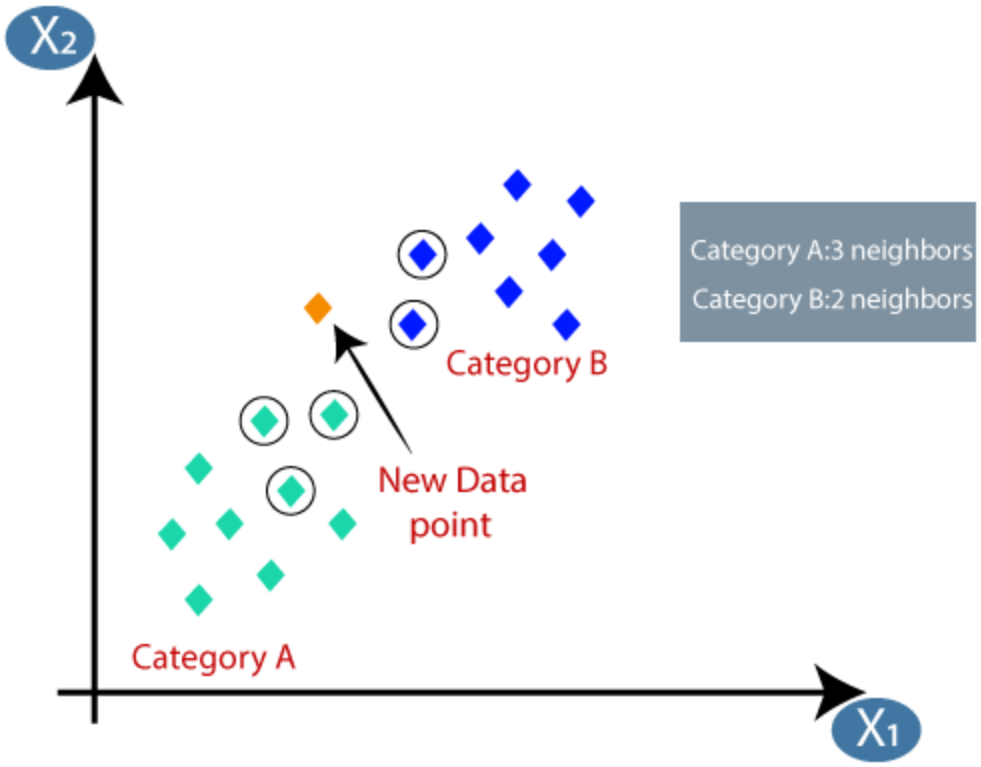


Firstly, we will choose the number of neighbors, so we will choose the k=5.

- Next, we will calculate the **Euclidean distance** between the data points. The Euclidean distance is the distance between two points, which we have already studied in geometry. It can be calculated as:



By calculating the Euclidean distance we got the nearest neighbors, as three nearest neighbors in category A and two nearest neighbors in category B. Consider the below image:



As we can see the 3 nearest neighbors are from category A, hence this new data point must belong to category A.

KNN Algorithm

- K-Nearest Neighbour is one of the simplest Machine Learning algorithms based on Supervised Learning technique.
- K-NN algorithm assumes the similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.
- This means when new data appears then it can be easily classified into a well suite category by using K- NN algorithm.
- K-NN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems.
- K-NN is a **non-parametric algorithm**, *which means it does not make any assumption on underlying data.*
- It is also called a **lazy learner algorithm** because it does not learn from the training set immediately instead it stores the dataset and at the time of classification, it performs an action on the dataset.

Applications of KNN

Banking System

KNN can be used in banking system to predict weather an individual is fit for loan approval? Does that individual have the characteristics similar to the defaulters one?

Calculating Credit Ratings

KNN algorithms can be used to find an individual's credit rating by comparing with the persons having similar traits.

Politics

With the help of KNN algorithms, we can classify a potential voter into various classes like "Will Vote", "Will not Vote", "Will Vote to Party 'Congress', "Will Vote to Party 'BJP'.

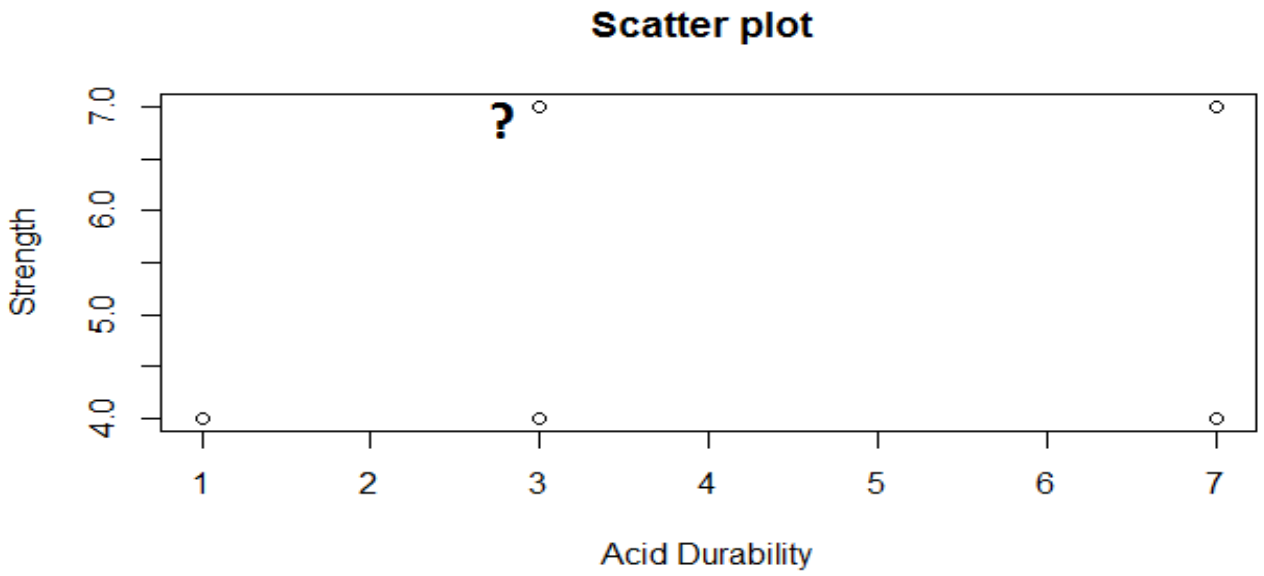
Other areas in which KNN algorithm can be used are Speech Recognition, Handwriting Detection, Image Recognition and Video Recognition.

Consider to classify special paper tissue is of good or bad quality

Points	X1 (Acid Durability)	X2(strength)	Y=Classification
P1	7	7	BAD
P2	7	4	BAD
P3	3	4	GOOD
P4	1	4	GOOD

Example

Points	X1(Acid Durability)	X2(Strength)	Y(Classification)
P1	7	7	BAD
P2	7	4	BAD
P3	3	4	GOOD
P4	1	4	GOOD
P5	3	7	?



Procedure

- **Step:1**- Determine K= Number of Neighbours
- Let us select K=3
- **Step:2-** Calculate the distance between the query-instance and all the training Samples
- **Step:3-** Sort the distance and determine nearest neighbors based on the K-th Minimum distance
- **Step:4-** Gather the category of classes
- **Step:5-** Use simple majority of classes category as the classified value of query instance

Euclidean Distance From Each Point

KNN				
Euclidean Distance of P5(3,7) from	P1	P2	P3	P4
	(7,7)	(7,4)	(3,4)	(1,4)
	Sqrt((7-3) ^{2} + (7-7)^2) = $\sqrt{16}$ = 4	Sqrt((7-3) ^{2} + (4-7)^2) = $\sqrt{25}$ = 5	Sqrt((3-3) ^{2} + (4-7)^2) = $\sqrt{9}$ = 3	Sqrt((1-3) ^{2} + (4-7)^2) = $\sqrt{13}$ = 3.60

3 Nearest NeighBour

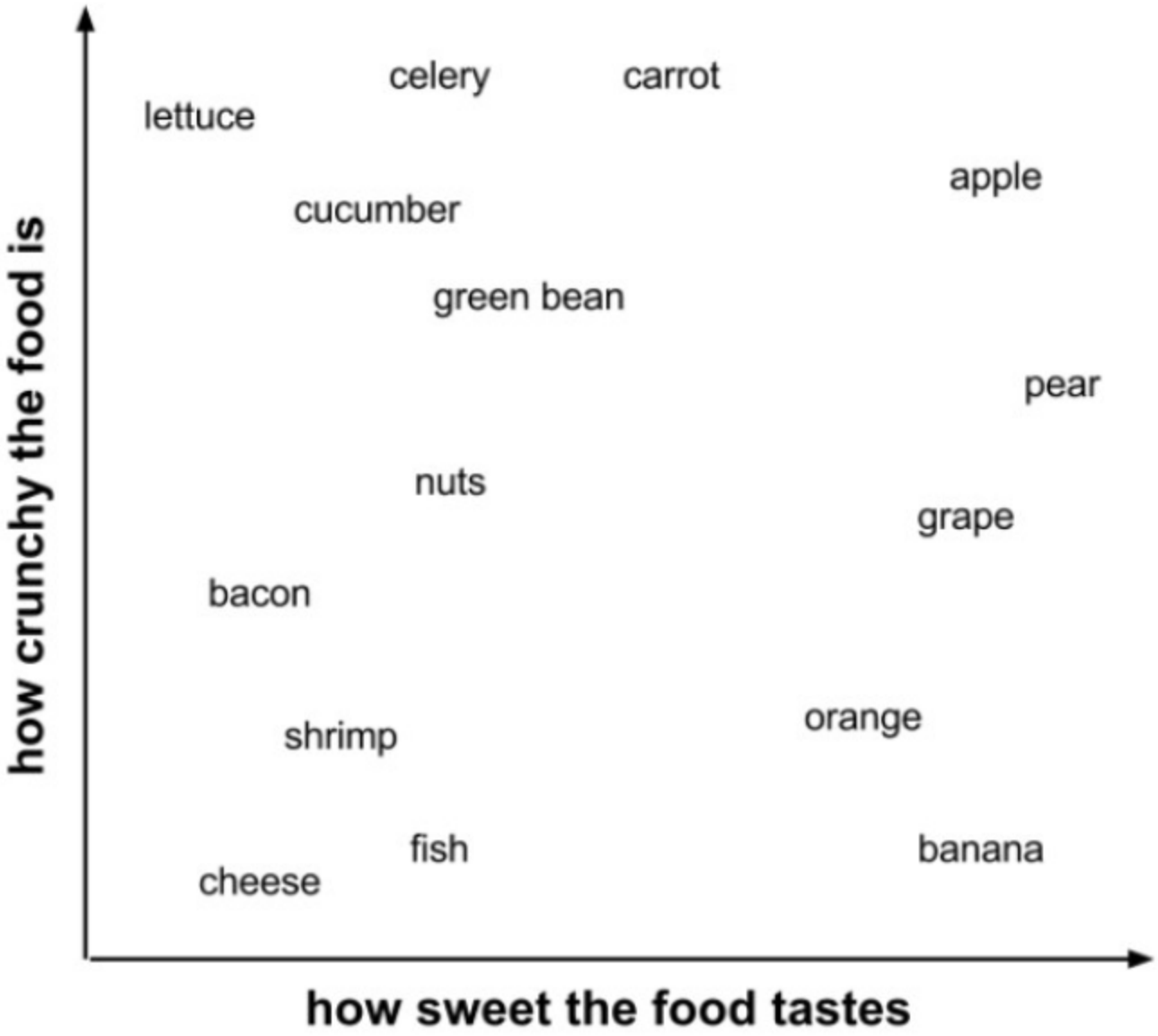
Euclidean Distance of P5(3,7) from	P1	P2	P3	P4
	(7,7)	(7,4)	(3,4)	(1,4)
	Sqrt((7-3) ^{2} + (7-7)^2) = $\sqrt{16}$ = 4	Sqrt((7-3) ^{2} + (4-7)^2) = $\sqrt{25}$ = 5	Sqrt((3-3) ^{2} + (4-7)^2) = $\sqrt{9}$ = 3	Sqrt((1-3) ^{2} + (4-7)^2) = $\sqrt{13}$ = 3.60
Class	BAD	BAD	GOOD	GOOD

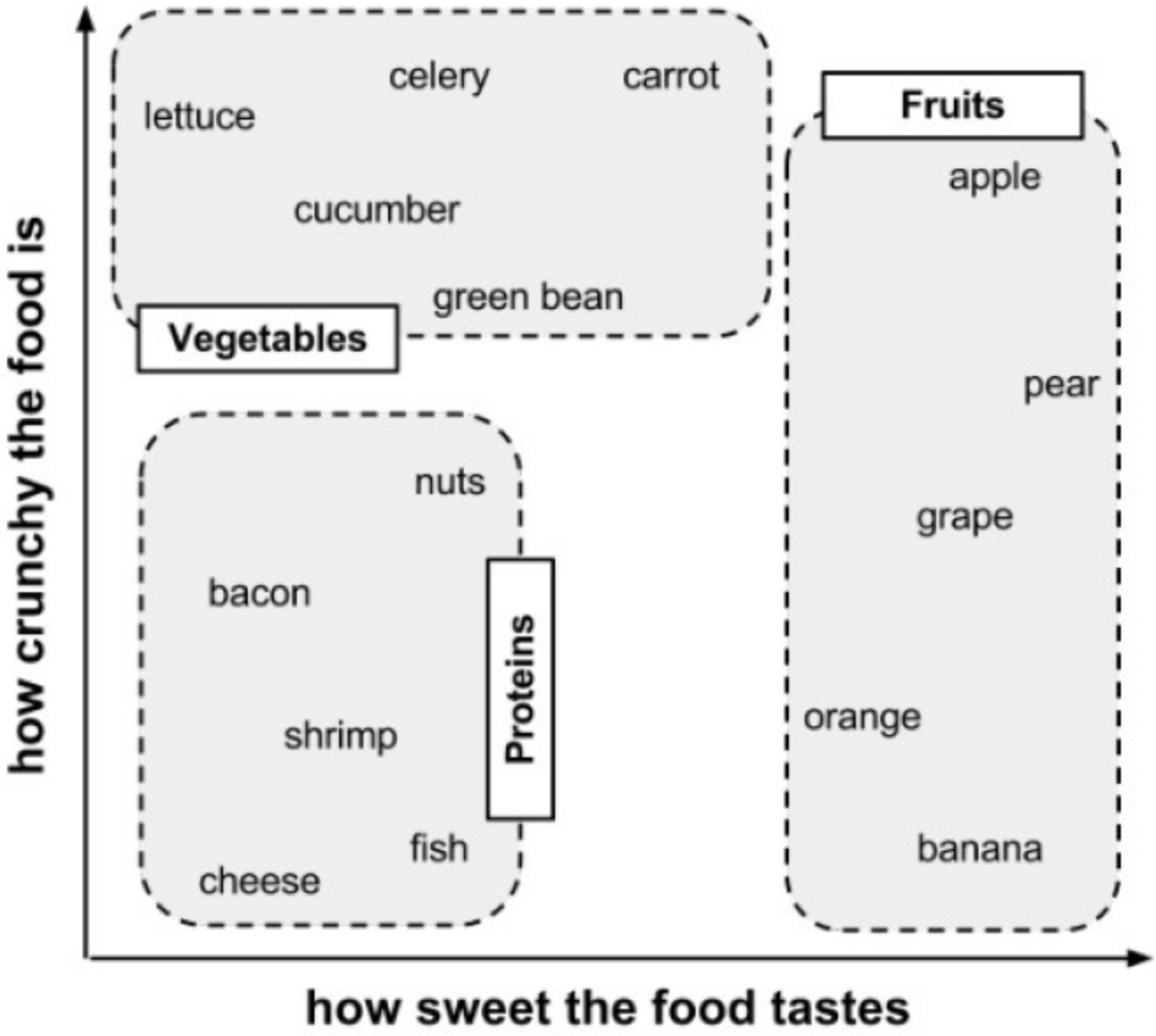
Example

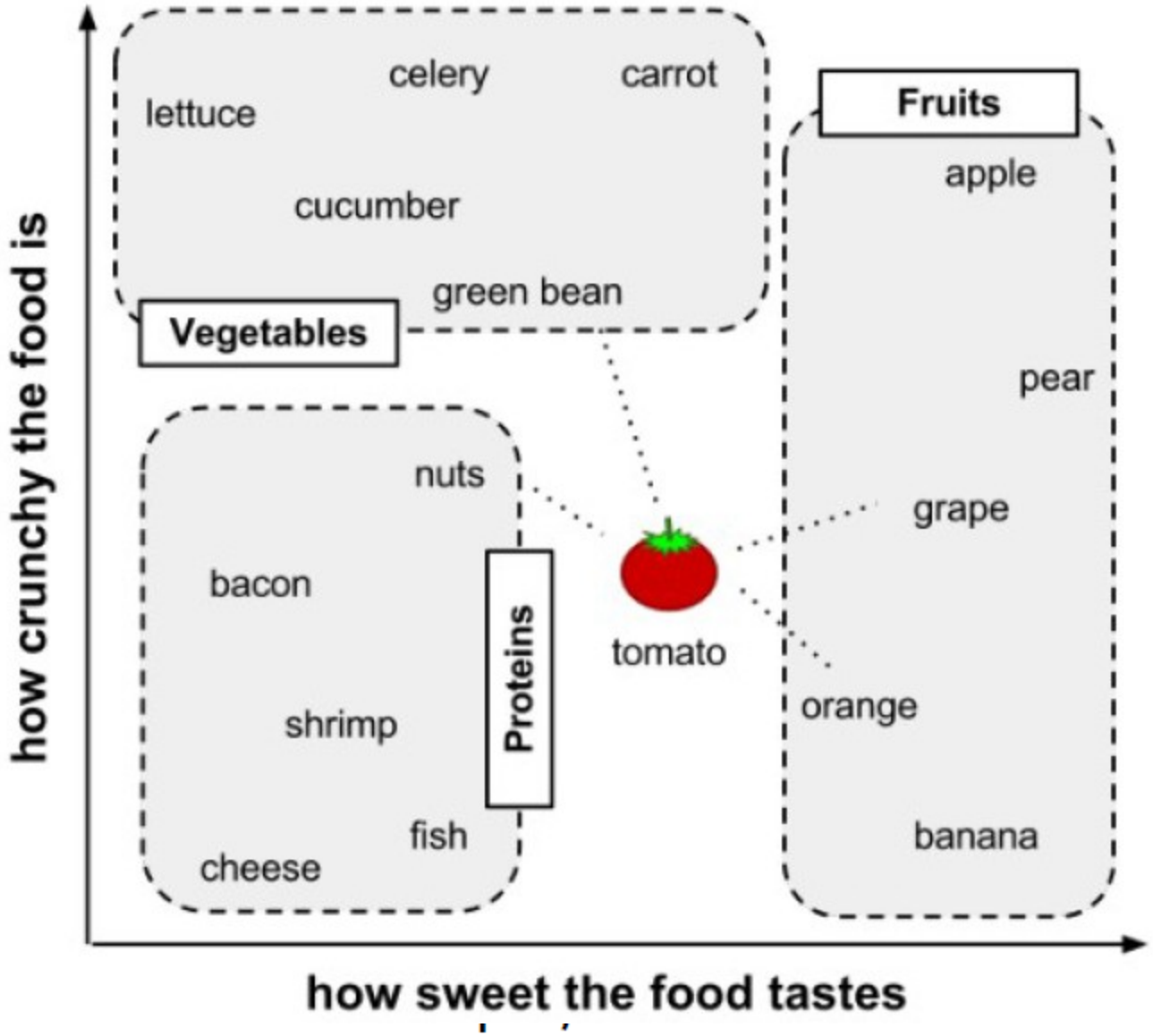
Points	X1(Durability)	X2(Strength)	Y(Classification)
P1	7	7	BAD
P2	7	4	BAD
P3	3	4	GOOD
P4	1	4	GOOD
P5	3	7	GOOD

Example: 2

ingredient	sweetness	crunchiness	food type
apple	10	9	fruit
bacon	1	4	protein
banana	10	1	fruit
carrot	7	10	vegetable
celery	3	10	vegetable
cheese	1	1	protein


celery
carrot
lettuce
apple
cucumber
green bean
pear
nuts
grape
bacon
orange
shrimp
fish
banana
cheese
how crunchy the food is
how sweet the food tastes

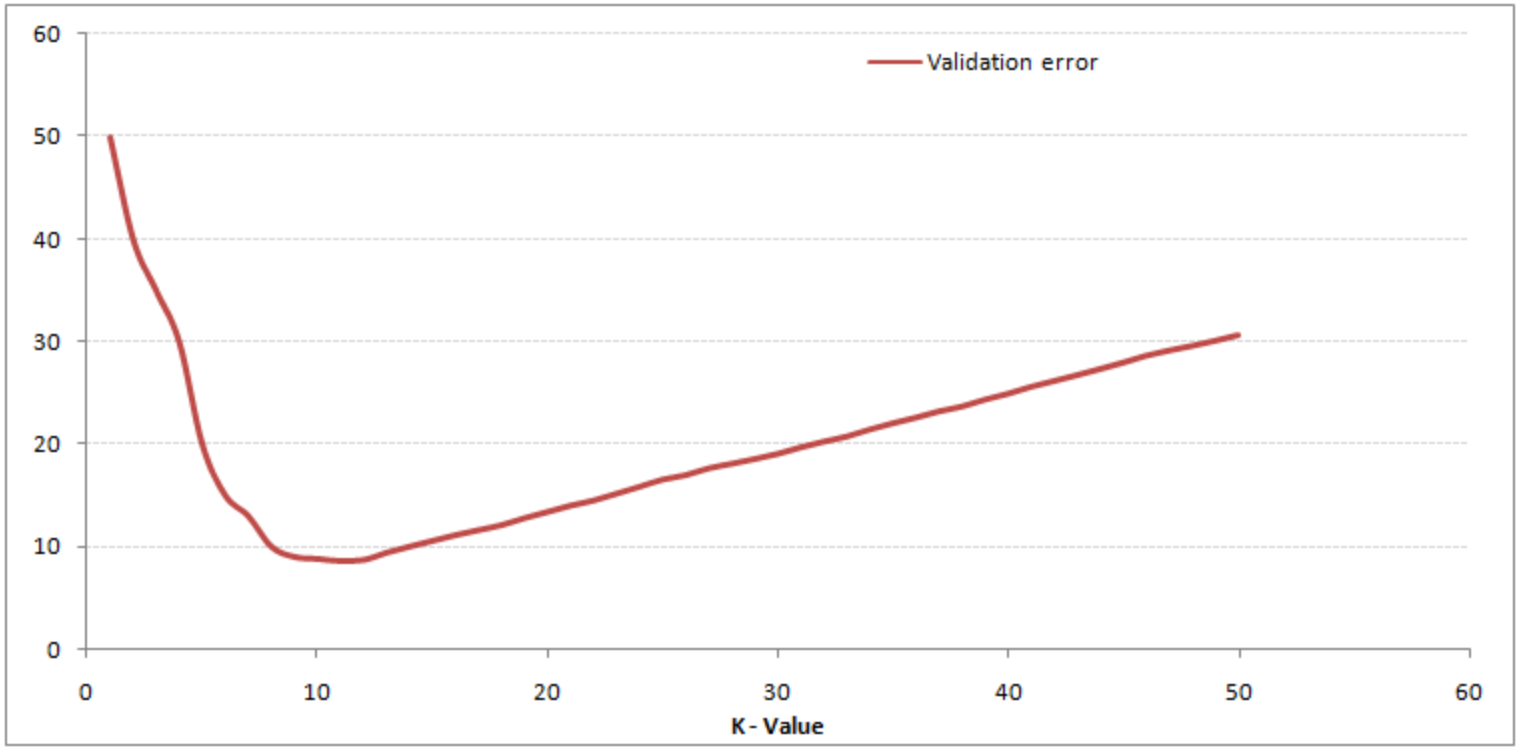

how crunchy the food is
how sweet the food tastes
celery
carrot
lettuce
cucumber
green bean
Vegetables
Fruits
apple
pear
grape
orange
banana
nuts
bacon
shrimp
fish
cheese
Proteins



tomato (sweetness = 6, crunchiness = 4)

Calculation

ingredient	sweetness	crunchiness	food type	distance to the tomato
grape	8	5	fruit	*sqrt((6 - 8)^2 + (4 - 5)^2) = 2.2*
green bean	3	7	vegetable	*sqrt((6 - 3)^2 + (4 - 7)^2) = 4.2*
nuts	3	6	protein	*sqrt((6 - 3)^2 + (4 - 6)^2) = 3.6*
orange	7	3	fruit	*sqrt((6 - 7)^2 + (4 - 3)^2) = 1.4*


Validation error
60
50
40
30
20
10
0
0
10
20
30
40
50
60
K - Value

Distance functions

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

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

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

Hamming Distance

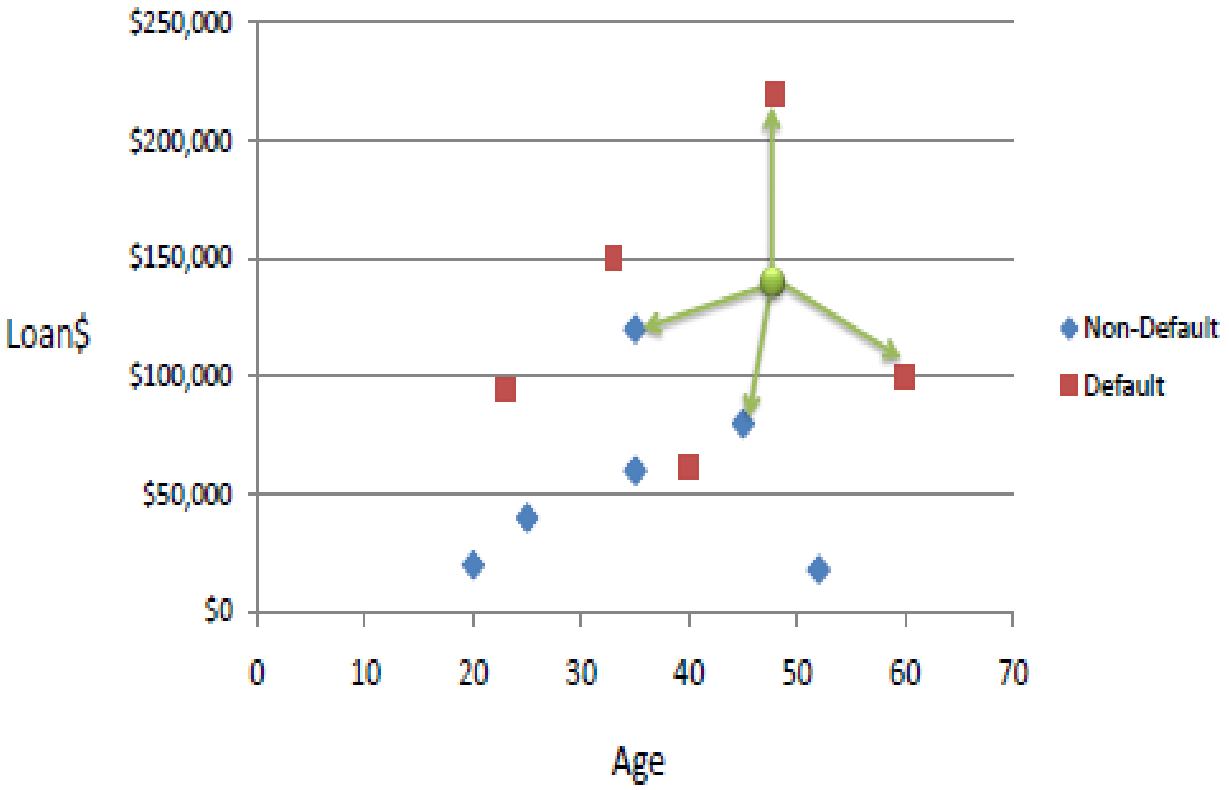
$$D_H = \sum_{i=1}^{k} |x_i - y_i|$$

$$x = y \Rightarrow D = 0$$

$$x \neq y \Rightarrow D = 1$$

X	Y	Distance
Male	Male	0
Male	Female	1

Consider the following data concerning credit default. Age and Loan are two numerical variables (predictors) and Default is the target.



We can now use the training set to classify an unknown case (Age=48 and Loan=$142,000) using Euclidean distance. If K=1 then the nearest neighbor is the last case in the training set with Default=Y.

Age	Loan	Default	Distance	
25	$40,000	N	102000	
35	$60,000	N	82000	
45	$80,000	N	62000	
20	$20,000	N	122000	
35	$120,000	N	22000	2
52	$18,000	N	124000	
23	$95,000	Y	47000	
40	$62,000	Y	80000	
60	$100,000	Y	42000	3
48	$220,000	Y	78000	
33	$150,000	Y	8000	1
48	**$142,000**	**?**		

Euclidean Distance

$$D = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$$

With K=3, there are two Default=Y and one Default=N out of three closest neighbors. The prediction for the unknown case is again Default=Y.

Standardized Distance

One major drawback in calculating distance measures directly from the training set is in the case where variables have different measurement scales or there is a mixture of numerical and categorical variables.

Age	Loan	Default	Distance
0.125	0.11	N	0.7652
0.375	0.21	N	0.5200
0.625	0.31	N	0.3160
0	0.01	N	0.9245
0.375	0.50	N	0.3428
0.8	0.00	N	0.6220
0.075	0.38	Y	0.6669
0.5	0.22	Y	0.4437
1	0.41	Y	0.3650
0.7	1.00	Y	0.3861
0.325	0.65	Y	0.3771
0.7	**0.61**	**?**	

Standardized Variable

$$X_s = \frac{X - Min}{Max - Min}$$

Using the standardized distance on the same training set, the unknown case returned a different neighbor which is not a good sign of robustness.

How to select the value of K in the K-NN Algorithm?

- There is no particular way to determine the best value for "K", so we need to try some values to find the best out of them. The most preferred value for K is 5.
- A very low value for K such as K=1 or K=2, can be noisy and lead to the effects of outliers in the model.
- Large values for K are good, but it may find some difficulties.

Advantages of KNN Algorithm:

- It is simple to implement.
- It is robust to the noisy training data
- It can be more effective if the training data is large.

Disadvantages of KNN Algorithm:

- Always needs to determine the value of K which may be complex some time.
- The computation cost is high because of calculating the distance between the data points for all the training samples.