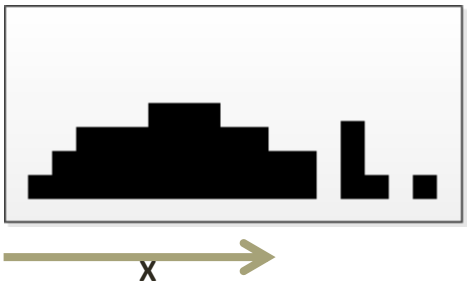
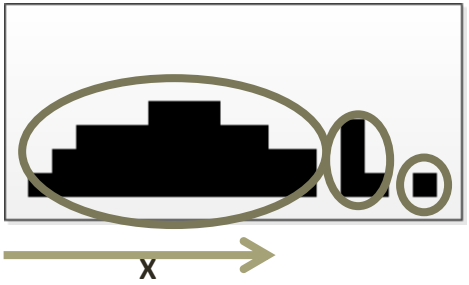
Dimensions in Clustering

Clustering: Dimensions (1)



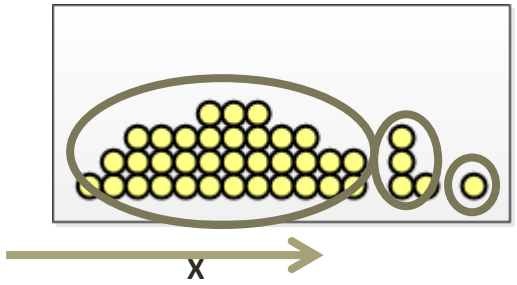
Where are the three clusters?

Clustering: Dimensions (2)



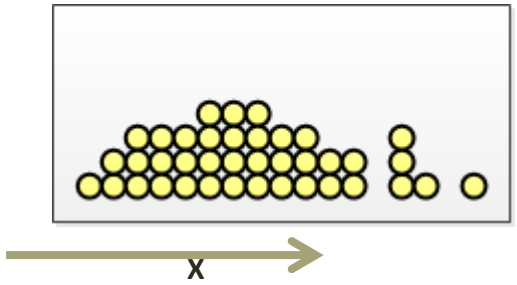
Simple assignment based on a 1D distribution

Clustering: Dimensions (3)



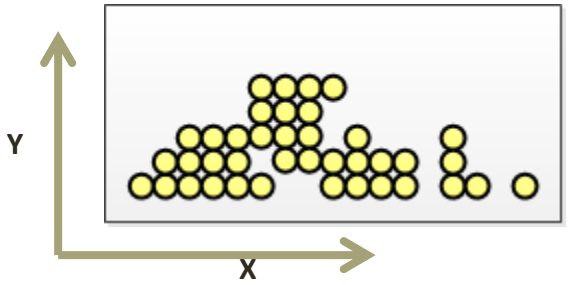
Simple assignment based on a 1D distribution

Clustering: Dimensions (4)



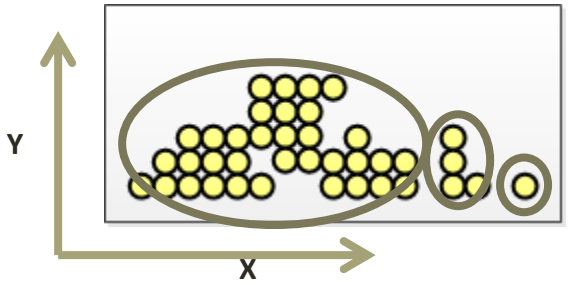
What if this was not a 1D distribution?

Clustering: Dimensions (5)



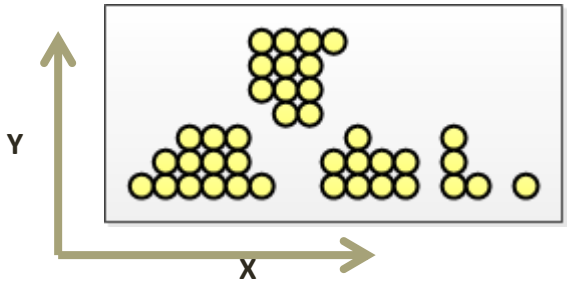
The distribution is in 2D. Some points differ in the 2nd D

Clustering: Dimensions (6)



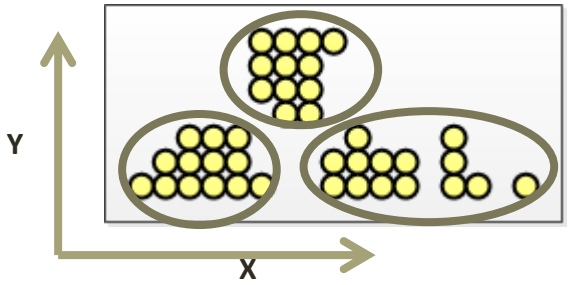
If the difference is minor, we still get the same clusters

Clustering: Dimensions (7)



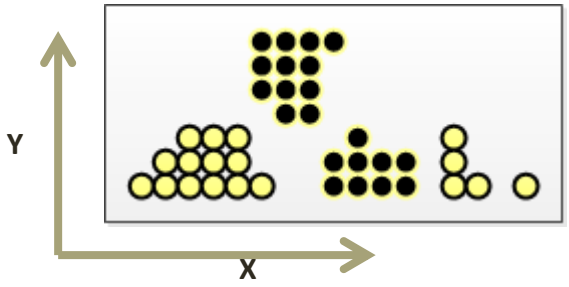
The difference could be significant

Clustering: Dimensions (8)



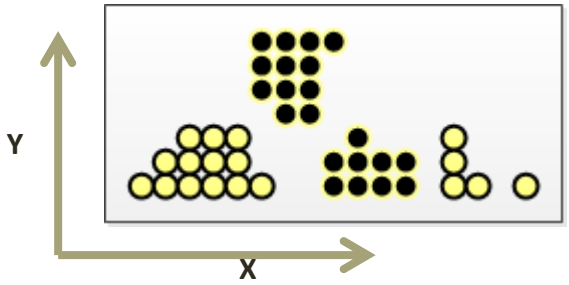
A big difference in the 2nd D can lead to different clusters

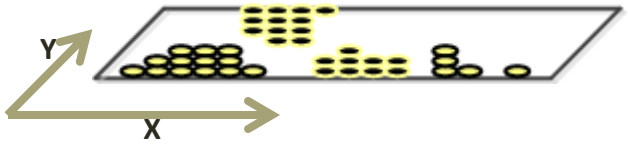
Clustering: Dimensions (9)



We can introduce another D by color coding. This is a Boolean Dimension

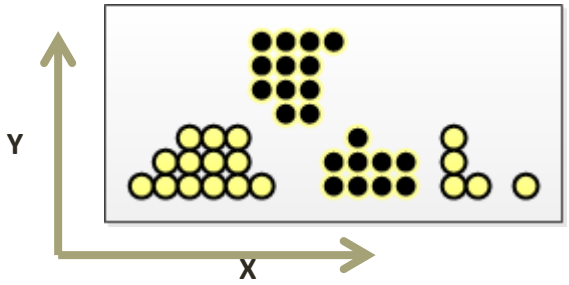
Clustering: Dimensions (10)

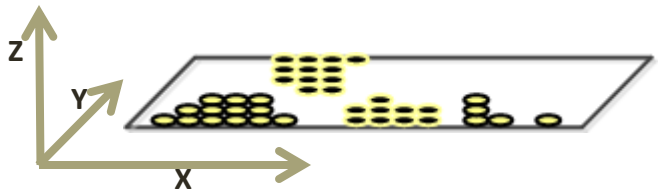




Create a 3rd Dimansion

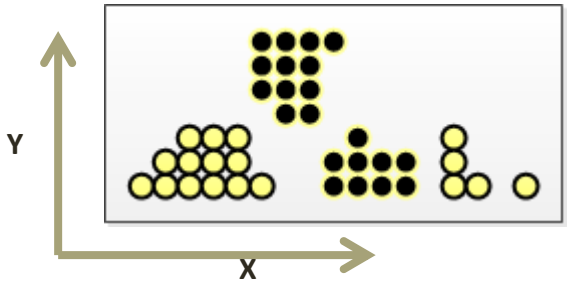
Clustering: Dimensions (11)

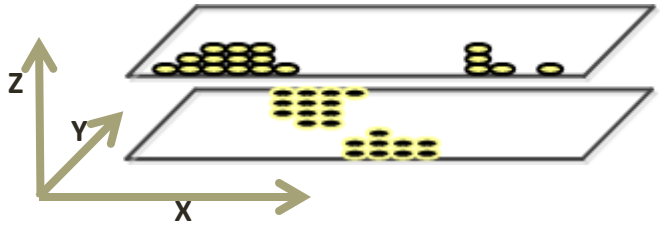




Create a 3rd Dimansion

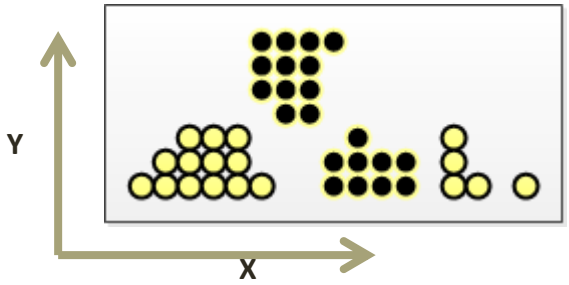
Clustering: Dimensions (12)

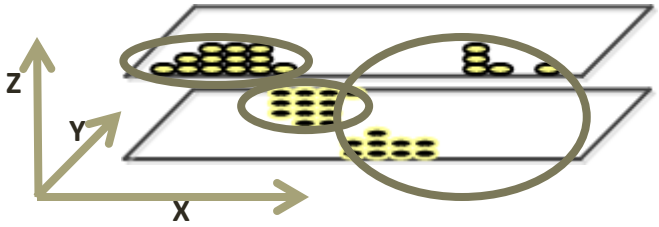


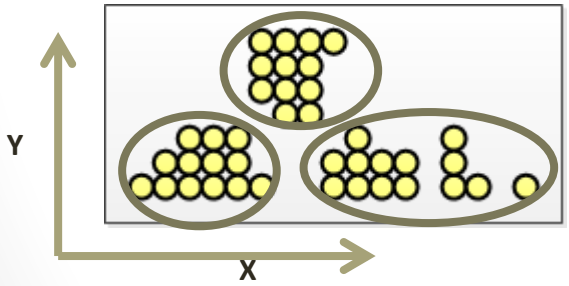


Where are the 3 clusters now?

Clustering: Dimensions (13)

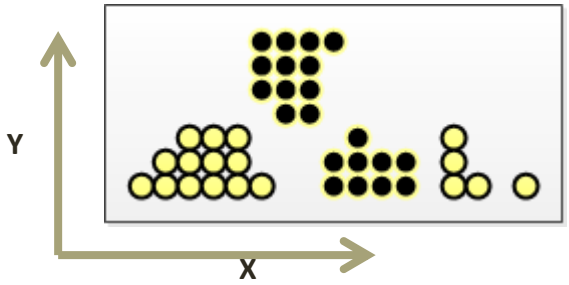


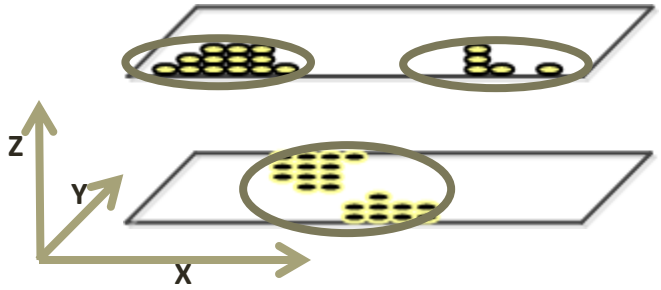


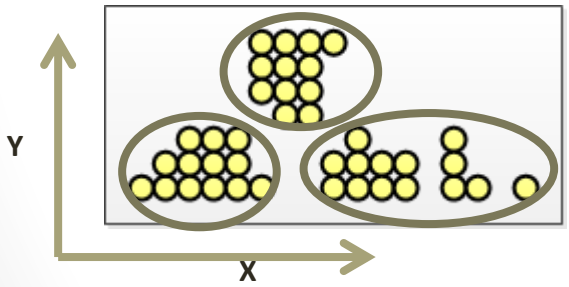


If the 3rd is small, then the clustering is the same as in 2D

Clustering: Dimensions (14)



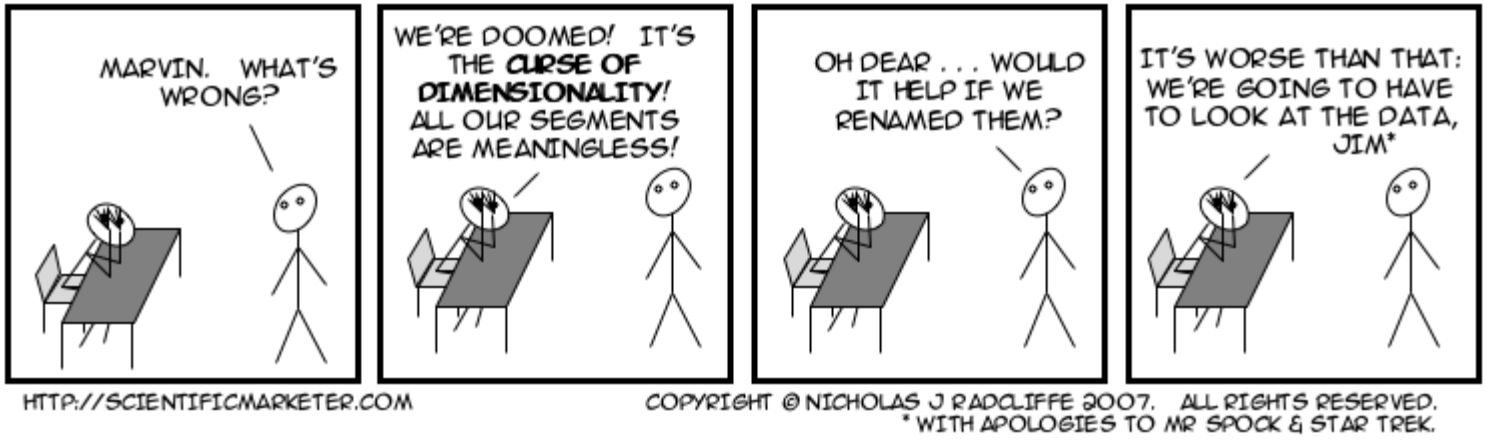




If the 3rd is big, then the clustering differs from 2D

Dimensions in Clustering

Break

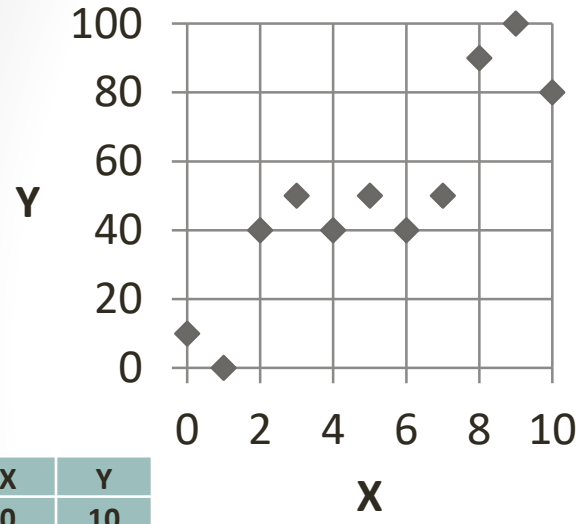

MARVIN. WHAT'S WRONG?
WE'RE DOOMED! IT'S THE CURSE OF DIMENSIONALITY! ALL OUR SEGMENTS ARE MEANINGLESS!
OH DEAR . . . WOULD IT HELP IF WE RENAMED THEM?
IT'S WORSE THAN THAT: WE'RE GOING TO HAVE TO LOOK AT THE DATA, JIM*
HTTP://SCIENTIFICMARKETER.COM
COPYRIGHT © NICHOLAS J RADCLIFFE 2007. ALL RIGHTS RESERVED.
* WITH APOLOGIES TO MR SPOCK & STAR TREK.

Normalization in Clustering

Normalization of a linear relationship (1)

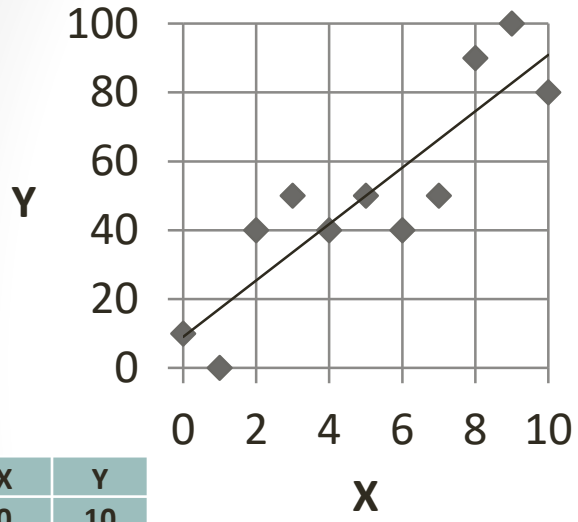
X	Y
0	10
1	0
2	40
3	50
4	40
5	50
6	40
7	50
8	90
9	100
10	80

Normalization of a linear relationship (2)



X	Y
0	10
1	0
2	40
3	50
4	40
5	50
6	40
7	50
8	90
9	100
10	80

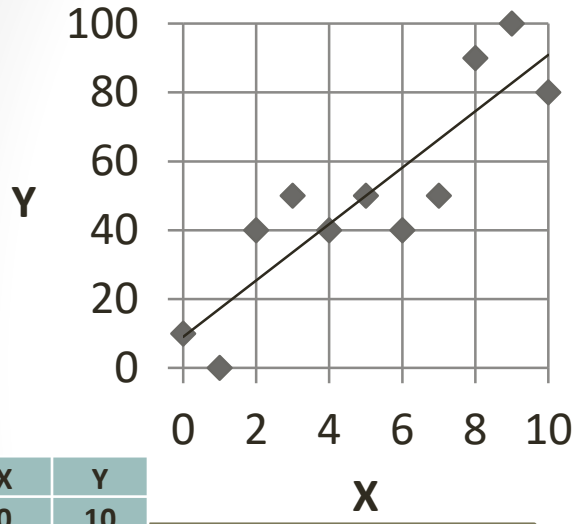
Normalization of a linear relationship (3)



X	Y
0	10
1	0
2	40
3	50
4	40
5	50
6	40
7	50
8	90
9	100
10	80

$Y = 10 + 8*X$

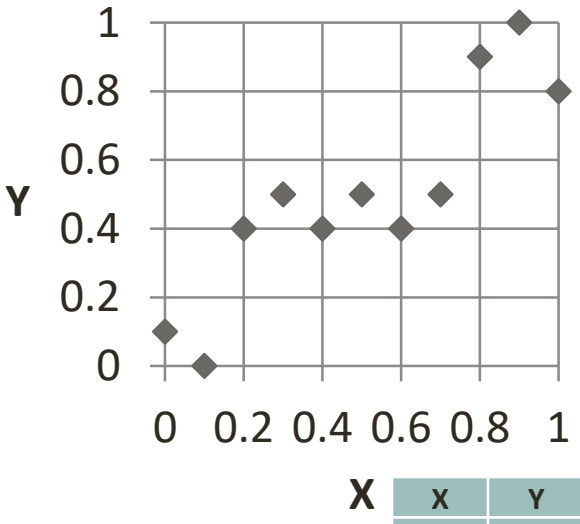
Normalization of a linear relationship (4)



X	Y
0	10
1	0
2	40
3	50
4	40
5	50
6	40
7	50
8	90
9	100
10	80

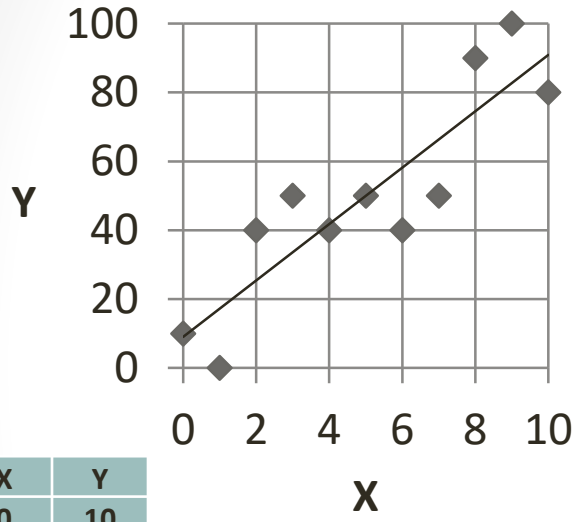
$Y = 10 + 8*X$

Normalize



X	Y
0	0.1
0.1	0
0.2	0.4
0.3	0.5
0.4	0.4
0.5	0.5
0.6	0.4
0.7	0.5
0.8	0.9
0.9	1
1	0.8

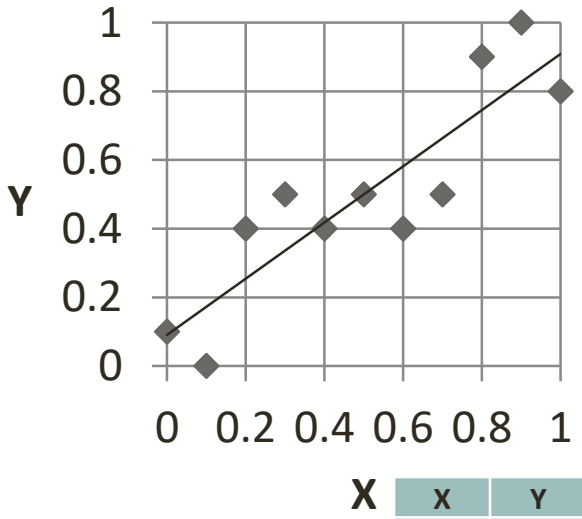
Normalization of a linear relationship (5)



X	Y
0	10
1	0
2	40
3	50
4	40
5	50
6	40
7	50
8	90
9	100
10	80

Y = 10 + 8*X

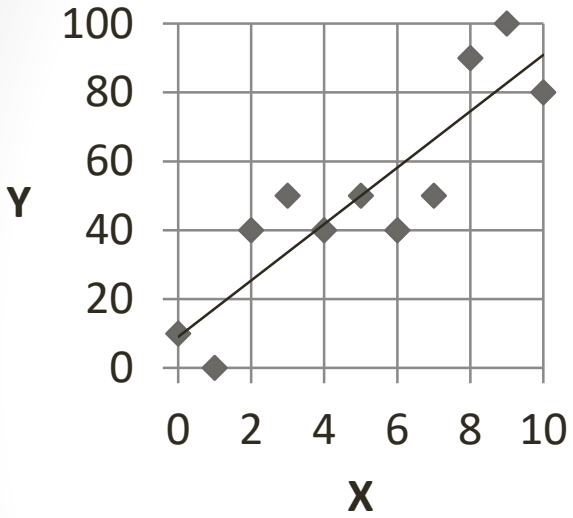
Normalize



Y = 0.1 + 0.8*X

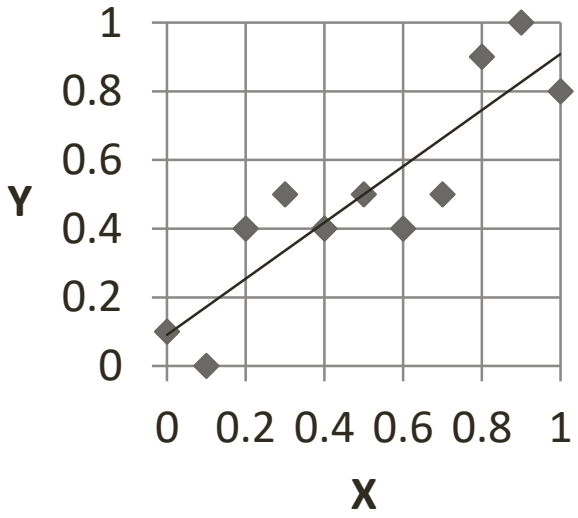
X	Y
0	0.1
0.1	0
0.2	0.4
0.3	0.5
0.4	0.4
0.5	0.5
0.6	0.4
0.7	0.5
0.8	0.9
0.9	1
1	0.8

Normalization of a linear relationship (6)



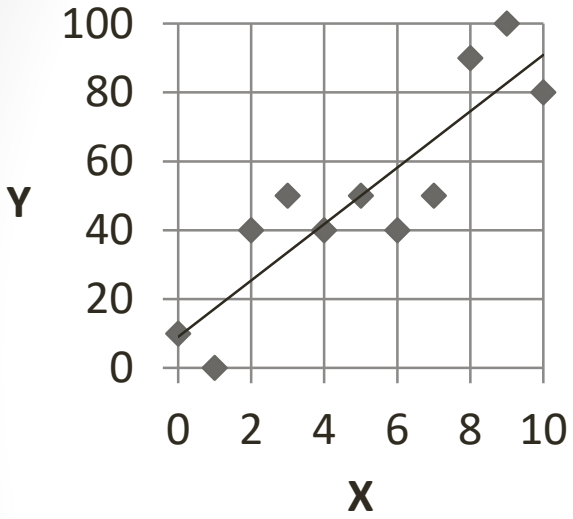
Y = 10 + 8*X

Normalize



Y = 0.1 + 0.8*X

Normalization of a linear relationship (7)



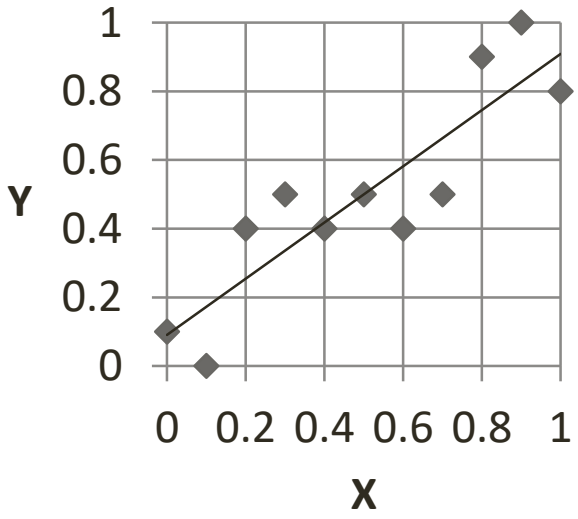
Y = 10 + 8*X

Normalize

Normalize Input
X = 2 -> X' = 0.2

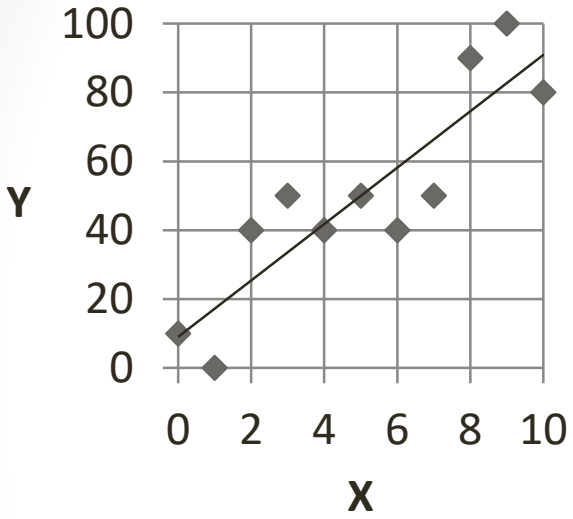
Predict Output
X' = 0.2 -> Y'= 0.26

Denormalize Output
Y'= 0.26 -> Y = 26



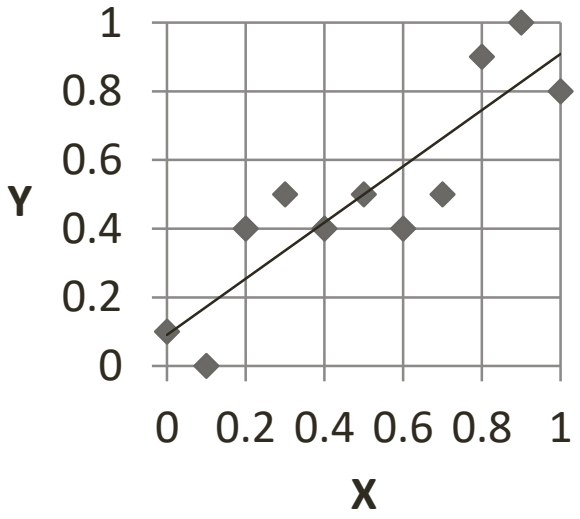
Y = 0.1 + 0.8*X

Normalization of a linear relationship (8)



Y = 10 + 8*X

Normalize



Y = 0.1 + 0.8*X

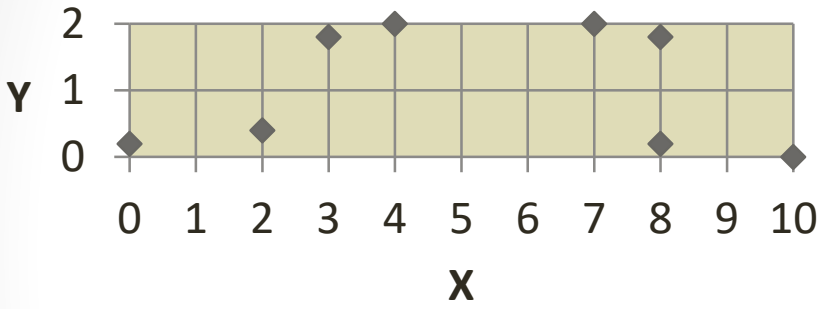
Normalize Input
X = 2 -> X' = 0.2

Predict Output
X' = 0.2 -> Y'= 0.26

Denormalize Output
Y'= 0.26 -> Y = 26

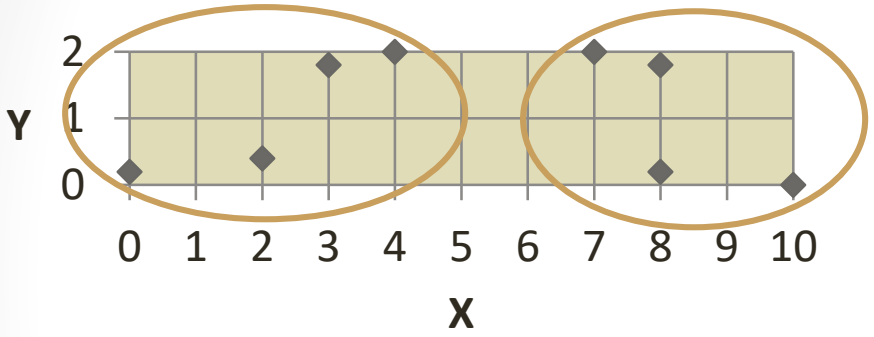
Prediction in Original Space:
X = 2 -> Y = 26

Normalization of a non-linear relationship (1)



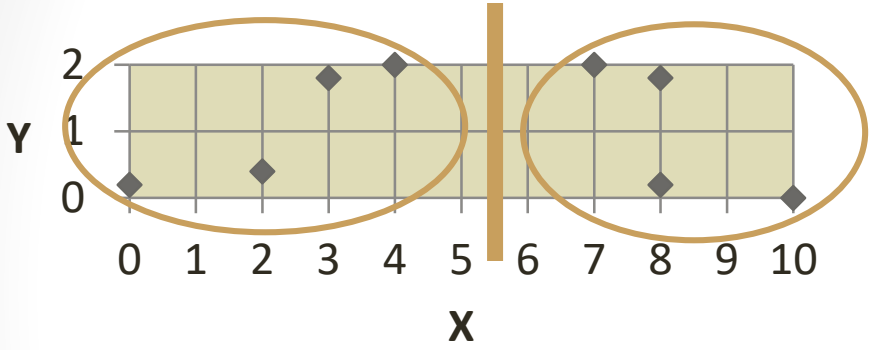
Original data in 2D:
Find 2 clusters

Normalization of a non-linear relationship (2)



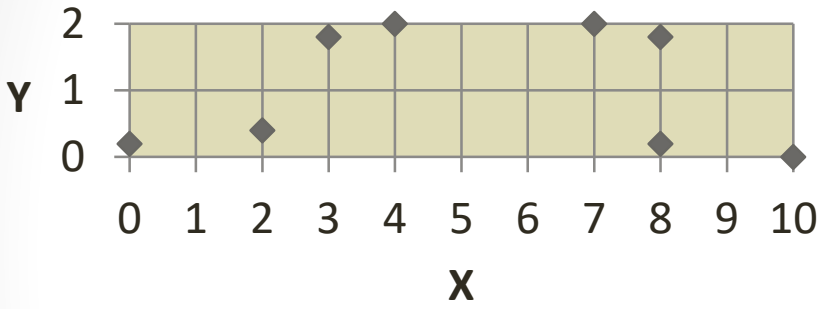
Found 2 Clusters

Normalization of a non-linear relationship (3)



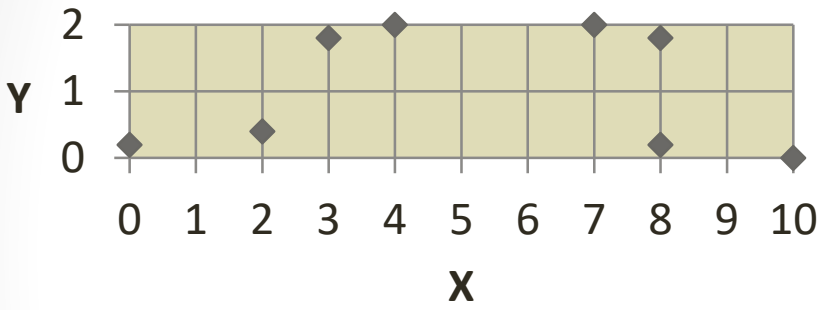
Clusters segment the image

Normalization of a non-linear relationship (4)

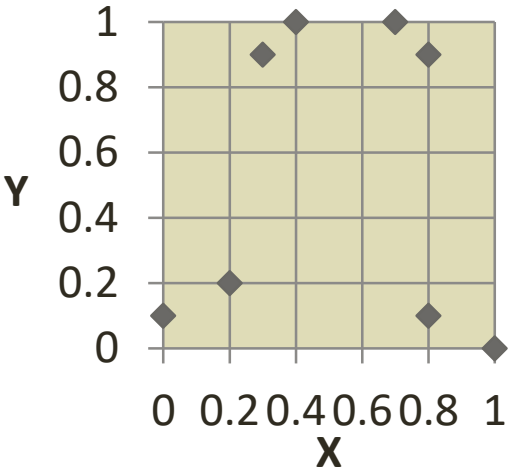


Non-normalized 2D data

Normalization of a non-linear relationship (5)



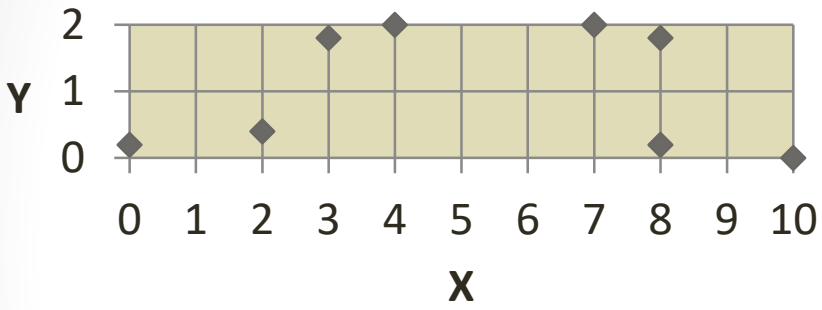
Normalize



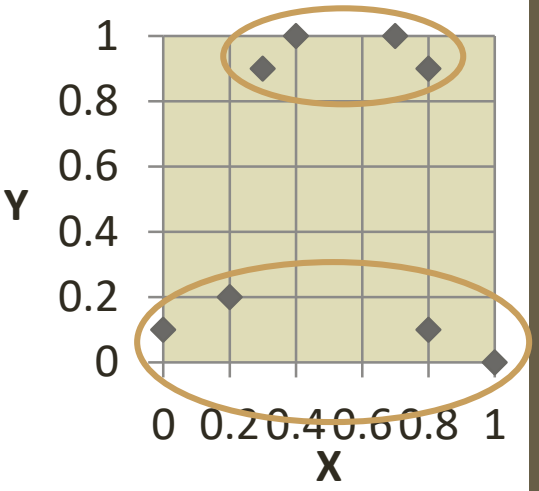
Non-normalized 2D data

Normalize the data:
Search for 2 Clusters

Normalization of a non-linear relationship (6)



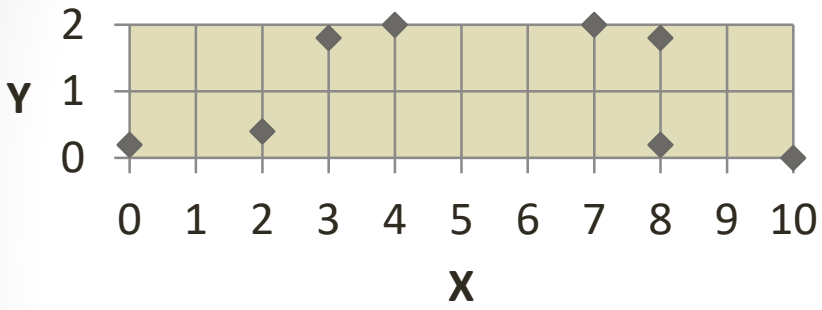
Normalize



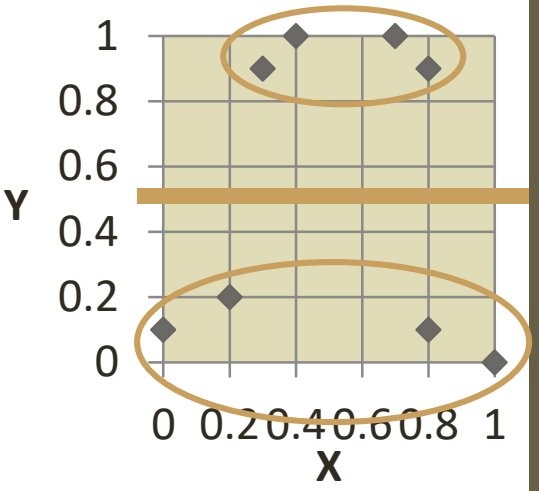
Non-normalized 2D data

Found 2 Clusters in the normalized data

Normalization of a non-linear relationship (6)



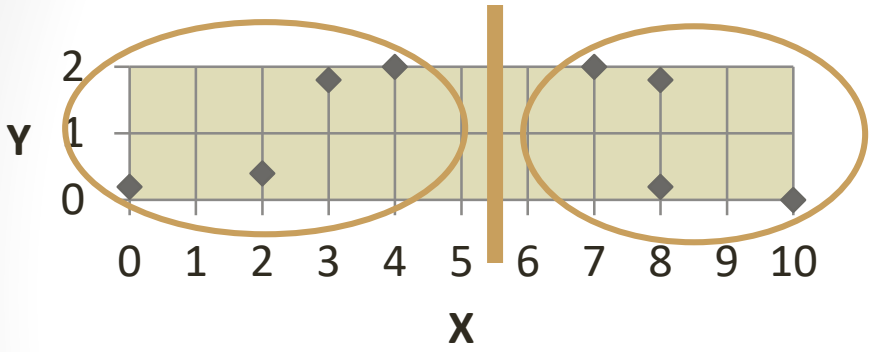
Normalize



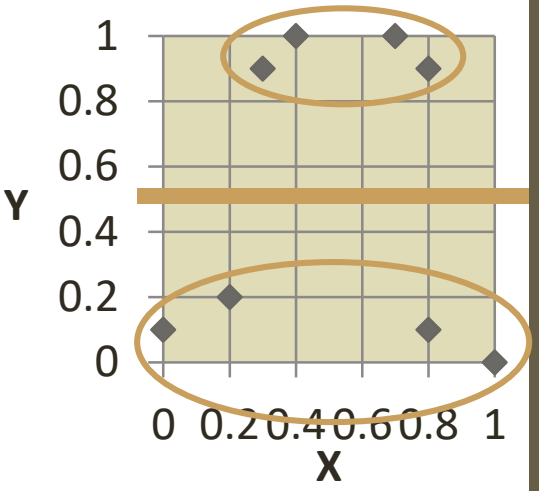
Non-normalized 2D data

Clusters Segment the Image

Normalization of a non-linear relationship (7)



Normalize



Clustering before normalization

Clustering after normalization

Normalization of Linear and Non-Linear Outcomes

- Non-linear (Normalization can change outcome):
  - K-Means
  - Neural Net

- Linear (Normalization should not change outcome):
  - Logistic Regression
  - Linear Regression
  - Mixture of Gaussians

- https://en.wikipedia.org/wiki/Linearity
- https://en.wikipedia.org/wiki/Linear_function

Normalization in Clustering

In-Class Exercise

Normalization in K-Means

- Download L07-2-KMeansNorm_Incomplete.py from Canvas and load into Spyder.
- Run the script: Some results will be wrong
- Add code to normalize each input dimension
- Add code to de-normalize the output
- Specifically, replace all lines that say: "**Replace this line with code**".
- Run the script: Results should be correct

In-Class Exercise

1. L07-2-KMeansNorm_Incomplete.py
   a. Get mean and standard deviation of point dimensions. Use the np.mean and np.std functions
   b. Z-Normalize points and centroid guesses based on distribution of points
   c. Let the KMeans function determine the labels and the centroids in normalized space
   d. De-normalize the centroids
   e. Return the labels and the de-normalized centroids
2. Answer the following questions
   a) What is the single most obvious difference between the distributions of the first and second dimensions?
   b) Does separation of clusters in Test 1 occur along the x, y, or both dimensions? Why?
   c) Does separation of clusters in Test 2 occur along the x, y, or both dimensions? Why?
   d) Does separation of clusters in Test 3 occur along the x, y, or both dimensions? Why?
   e) Does separation of clusters in Test 4 occur along the x, y, or both dimensions? Why?
3. Why is normalization important in K-means clustering?
4. How do you encode categorical data in a K-means clustering?
5. Why is clustering un-supervised learning as opposed to supervised learning?