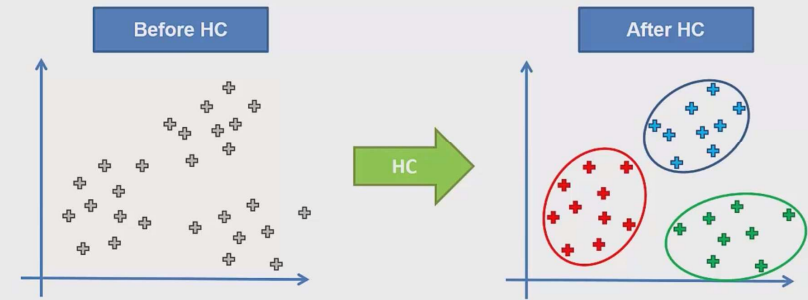


Hierarchical Clustering

Machine Learning
Dr. Adnan Abid

What HC does for you



Same as K-Means but different process

NOTE:
Agglomerative
&
Divisive

Agglomerative HC

STEP 1: Make each data point a single-point cluster → That forms N clusters



STEP 2: Take the two closest data points and make them one cluster → That forms $N-1$ clusters



STEP 3: Take the two closest clusters and make them one cluster → That forms $N-2$ clusters

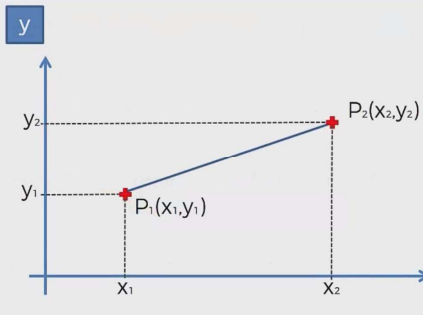


STEP 4: Repeat STEP 3 until there is only one cluster



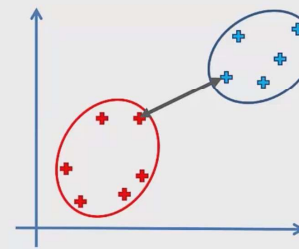
FIN

Euclidean Distance



$$\text{Euclidean Distance between } P_1 \text{ and } P_2 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

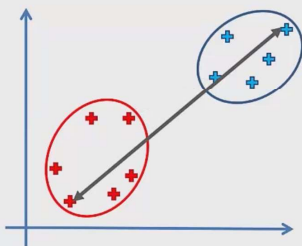
Distance Between Clusters



Distance Between Two Clusters:

- Option 1: Closest Points

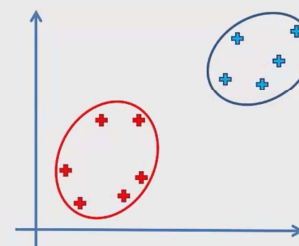
Distance Between Clusters



Distance Between Two Clusters:

- Option 1: Closest Points
- Option 2: Furthest Points

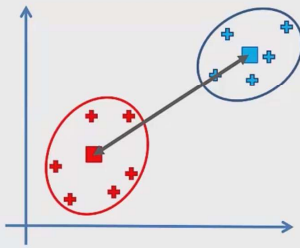
Distance Between Clusters



Distance Between Two Clusters:

- Option 1: Closest Points
- Option 2: Furthest Points
- Option 3: Average Distance

Distance Between Clusters

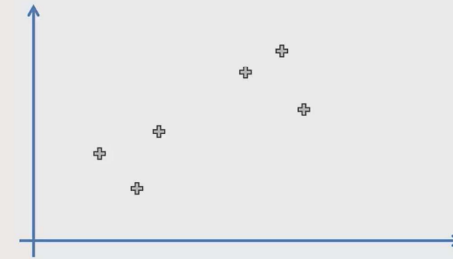


Distance Between Two Clusters:

- Option 1: Closest Points
- Option 2: Furthest Points
- Option 3: Average Distance
- Option 4: Distance Between Centroids

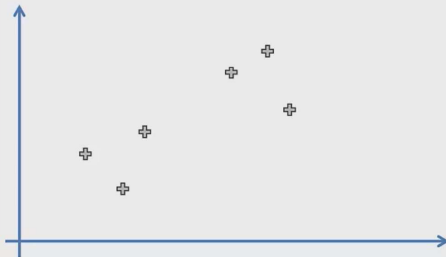
Agglomerative HC

Consider the following dataset of $N = 6$ data points



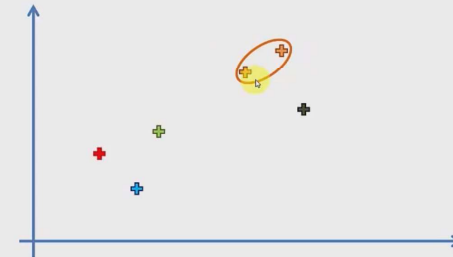
Agglomerative HC

STEP 1: Make each data point a single-point cluster → That forms 6 clusters



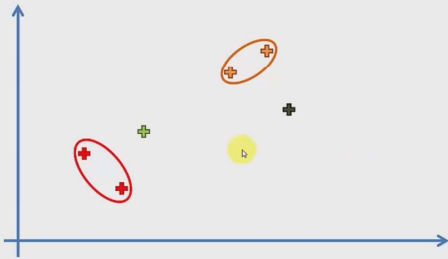
Agglomerative HC

STEP 2: Take the two closest data points and make them one cluster → That forms 5 clusters



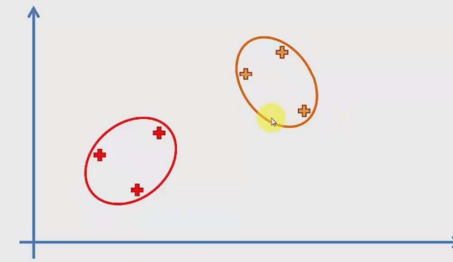
Agglomerative HC

STEP 3: Take the two closest clusters and make them one cluster
 → That forms 4 clusters



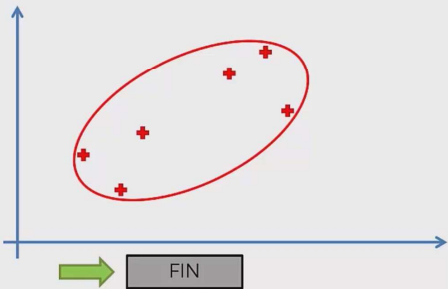
Agglomerative HC

STEP 4: Repeat STEP 3 until there is only one cluster



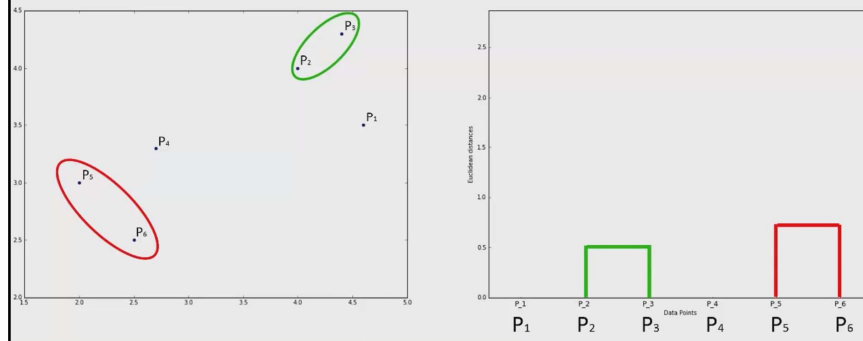
Agglomerative HC

STEP 4: Repeat STEP 3 until there is only one cluster

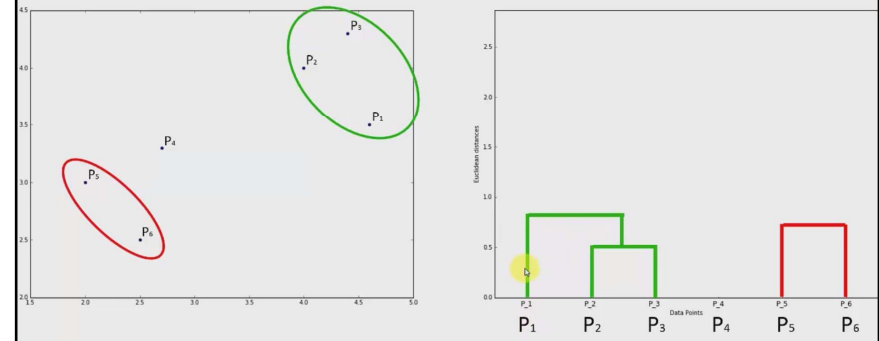


**HC Intuition:
How Do Dendograms Work?**

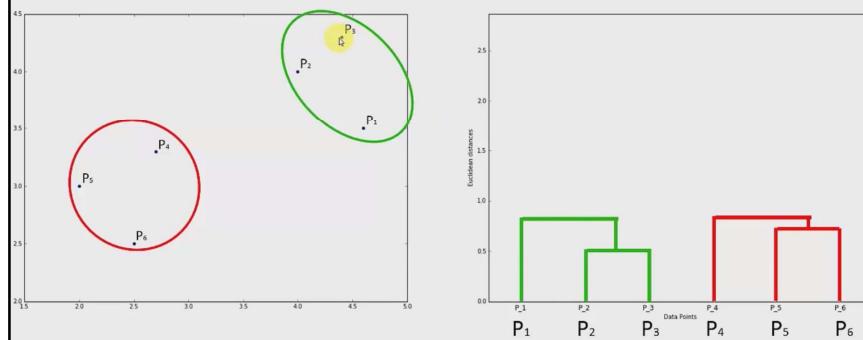
How Do Dendograms Work?



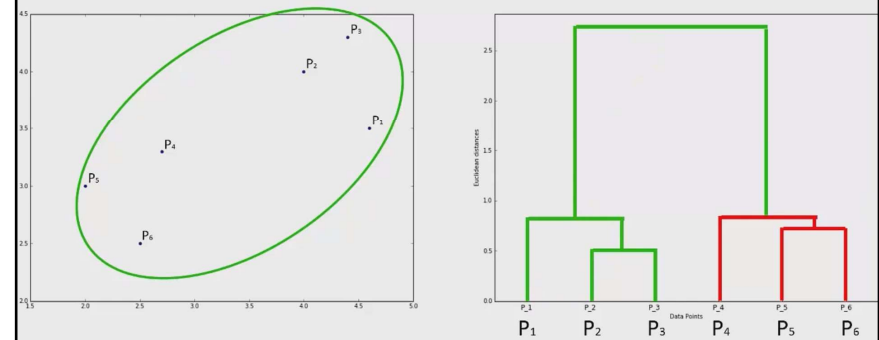
How Do Dendograms Work?



How Do Dendograms Work?

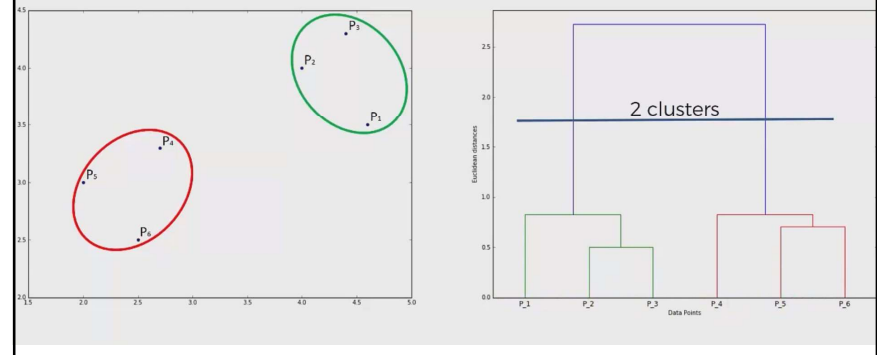


How Do Dendograms Work?

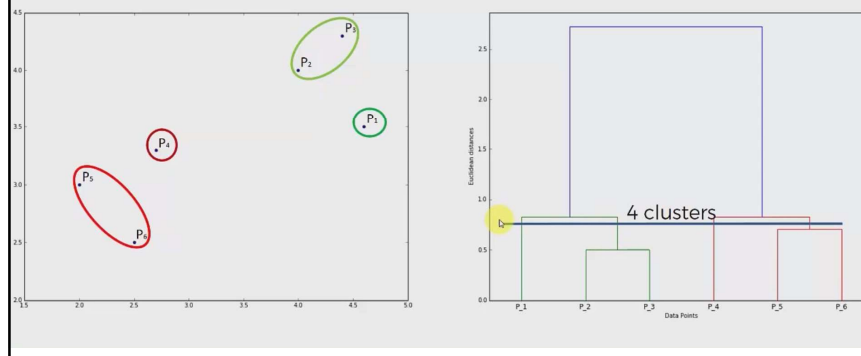


HC Intuition: Using Dendrograms

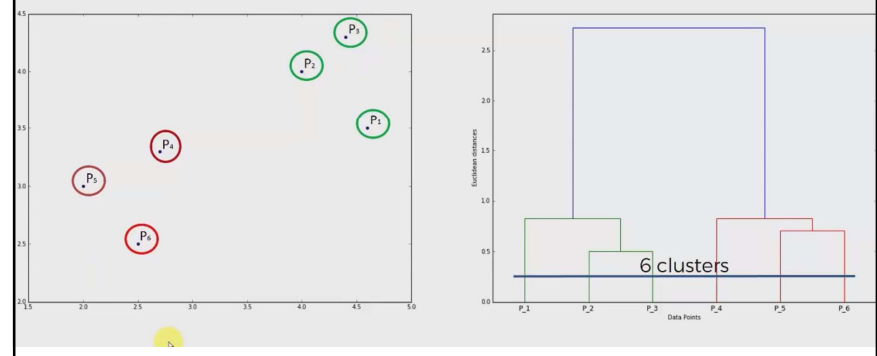
Dendrograms - Two Clusters



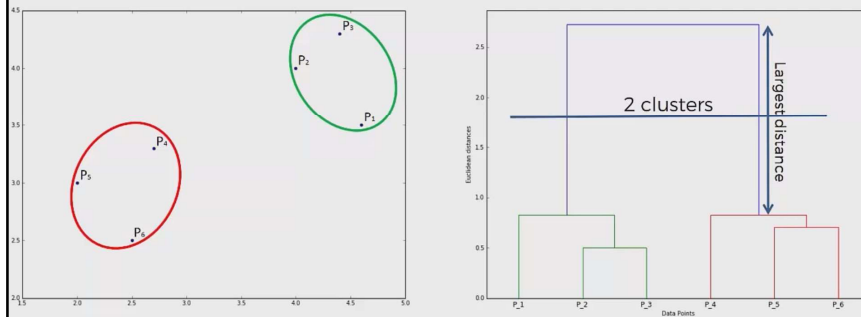
Dendrograms - Four Clusters



Dendrograms - Six Clusters

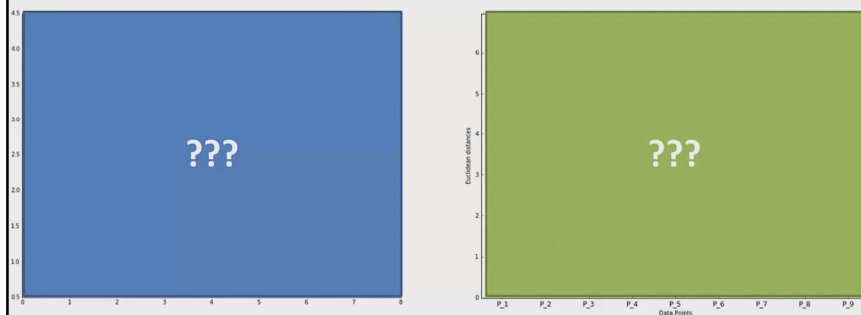


Dendrograms - Optimal # of Clusters

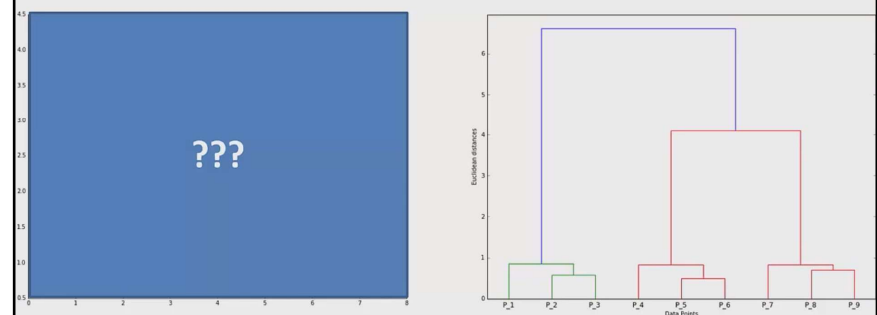


Knowledge Test

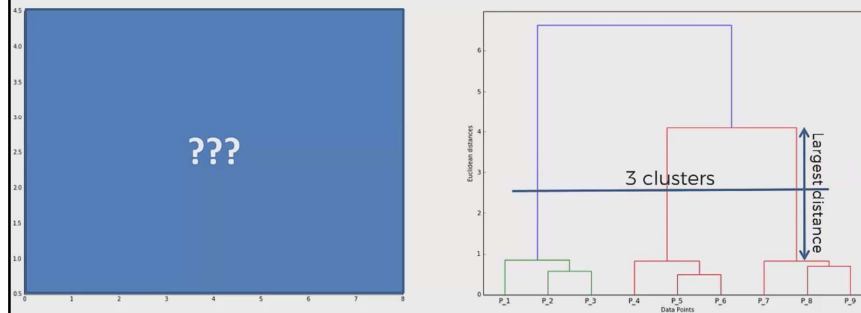
Dendrograms - Knowledge Test



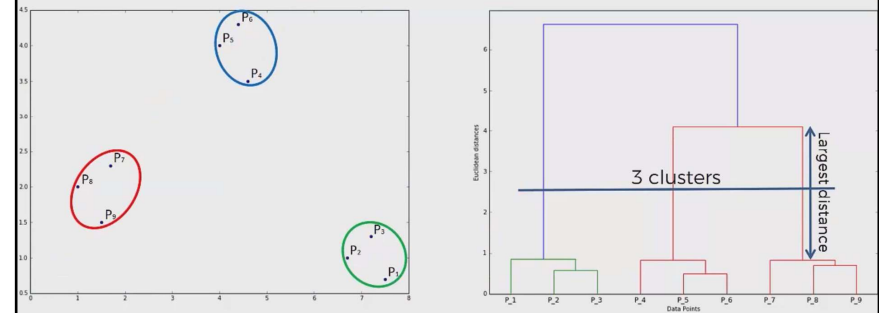
Dendrograms - Knowledge Test



Dendrograms – Knowledge Test



Dendrograms – Knowledge Test



Agglomerative Hierarchical Clustering Solved Example

- Consider the following set of 6 one dimensional data points:
- 18, 22, 25, 42, 27, 43
- Apply the **agglomerative hierarchical clustering** algorithm to build the hierarchical clustering **dendrogram**.
- Merge the clusters using **Min distance** and update the proximity matrix accordingly.
- Clearly show the **proximity matrix** corresponding to each iteration of the algorithm.

Agglomerative Hierarchical Clustering Solved Example

- Step – 1

	18	22	25	27	42	43
18	0	4	7	9	24	25
22	4	0	3	5	20	21
25	7	3	0	2	17	18
27	9	5	2	0	15	16
42	24	20	17	15	0	1
43	25	21	18	16	1	0

Agglomerative Hierarchical Clustering Solved Example

- Step – 1

	18	22	25	27	42	43
18	0	4	7	9	24	25
22	4	0	3	5	20	21
25	7	3	0	2	17	18
27	9	5	2	0	15	16
42	24	20	17	15	0	1
43	25	21	18	16	1	0

(42, 43)

Agglomerative Hierarchical Clustering Solved Example

- Step – 2

	18	22	25	27	42, 43
18	0	4	7	9	24
22	4	0	3	5	20
25	7	3	0	2	17
27	9	5	2	0	15
42, 43	24	20	17	15	0

- Step – 2

	18	22	25	27	42, 43
18	0	4	7	9	24
22	4	0	3	5	20
25	7	3	0	2	17
27	9	5	2	0	15
42, 43	24	20	17	15	0

(42, 43), (25, 27)

- Step – 3

	18	22	25, 27	42, 43
18	0	4	7	24
22	4	0	3	20
25, 27	7	3	0	15
42, 43	24	20	15	0

- Step – 3

	18	22	25, 27	42, 43
18	0	4	7	24
22	4	0	3	20
25, 27	7	3	0	15
42, 43	24	20	15	0

(42, 43), ((25, 27), 22)

- Step – 4

	18	22, 25, 27	42, 43
18	0	4	24
22, 25, 27	4	0	15
42, 43	24	15	0

- Step – 4

	18	22, 25, 27	42, 43
18	0	4	24
22, 25, 27	4	0	15
42, 43	24	15	0

(42, 43), (((25, 27), 22), 18)

- Step – 5

	18, 22, 25, 27	42, 43
18, 22, 25, 27	0	15
42, 43	15	0

- Step – 6

	18, 22, 25, 27, 42, 43
18, 22, 25, 27, 42, 43	0

- Step – 5

	18, 22, 25, 27	42, 43
18, 22, 25, 27	0	15
42, 43	15	0

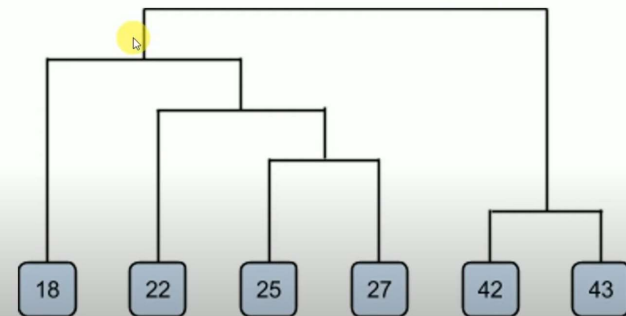
$((42, 43), ((25, 27), 22), 18)$

- Step – 6

	18, 22, 25, 27, 42, 43
18, 22, 25, 27, 42, 43	0

- Dendrogram

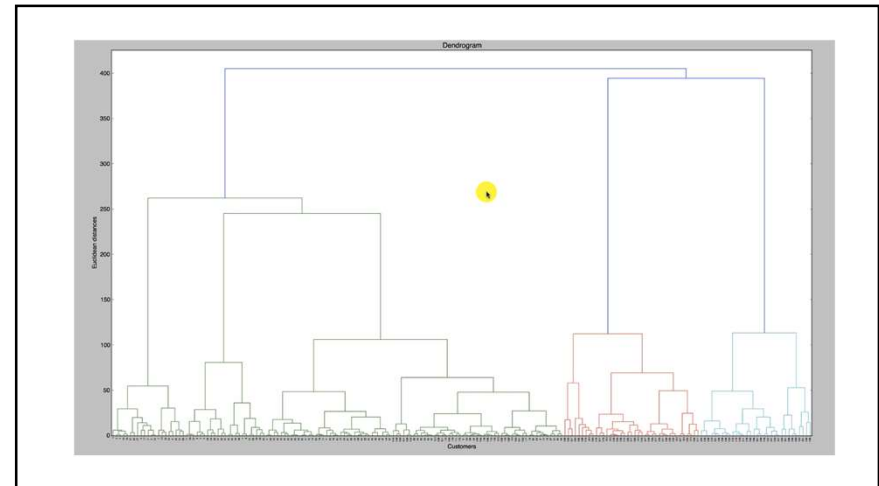
$((42, 43), ((25, 27), 22), 18)$



```

1# Hierarchical Clustering
2
3##reset -f
4
5# Importing the libraries
6import numpy as np
7import matplotlib.pyplot as plt
8import pandas as pd
9
10# Importing the mall dataset with pandas
11dataset = pd.read_csv('mall.csv')
12X = dataset.iloc[:, [3, 4]].values
13
14# Using the dendrogram to find the optimal number of clusters
15import scipy.cluster.hierarchy as sch
16dendrogram = sch.dendrogram(sch.linkage(X, method = 'ward'))
17plt.title('Dendrogram')
18plt.xlabel('Customers')
19plt.ylabel('Euclidean distances')
20plt.show()

```



```

5# Importing the libraries
6import numpy as np
7import matplotlib.pyplot as plt
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17plt.title('Dendrogram')
18plt.xlabel('Customers')
19plt.ylabel('Euclidean distances')
20plt.show()
21
22# Fitting hierarchical clustering to the mall dataset
23from sklearn.cluster import AgglomerativeClustering
24hc = AgglomerativeClustering(n_clusters = 5, affinity = 'euclidean', linkage = 'ward')
25y_hc = hc.fit_predict(X)

```