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## Agglomerative Clustering

Point	$w$	$y$
P1	0.40	0.53
P2	0.22	0.38
P3	0.35	0.32
P4	0.26	0.19
P5	0.08	0.41
P6	0.45	0.30

①	1	2	3	4	5	6
1	0					
2	0.234307	0				
3	0.21587	0.14317	0			
4	0.367696	0.194165	0.158114	0		
5	0.34176	0.143178	0.284605	0.284253	0	
6	0.235372	0.243516	0.010198	0.217545	0.386005	0

→ Applying distance formulae

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

$$\textcircled{1} P(2,1) \Rightarrow \{(0.22, 0.38), (0.40, 0.53)\}$$

$$\Rightarrow \sqrt{(0.40 - 0.22)^2 + (0.53 - 0.38)^2} \Rightarrow 0.234307$$

$$\textcircled{2} P(3,1) \Rightarrow \{(0.35, 0.32), (0.40, 0.53)\}$$

$$\Rightarrow \sqrt{(0.40 - 0.35)^2 + (0.53 - 0.32)^2} \Rightarrow 0.21587$$

$$\textcircled{3} P(3,2) \Rightarrow \{(0.35, 0.32), (0.22, 0.38)\}$$

$$\Rightarrow \sqrt{(0.22 - 0.35)^2 + (0.38 - 0.32)^2} \Rightarrow 0.143178$$



$$\begin{array}{l} \textcircled{4} \quad P(4,1) \Rightarrow \{(0.26, 0.49), (0.40, 0.53)\} \\ \textcircled{5} \quad P(4,2) \Rightarrow \{(0.26, 0.19), (0.22, 0.38)\} \\ \textcircled{6} \quad P(4,3) \Rightarrow \{(0.26, 0.19), (0.26, 0.32)\} \end{array}$$

$$\begin{array}{l} \textcircled{7} \quad P(5,1) \Rightarrow \{(0.08, 0.41), (0.40, 0.53)\} \\ \textcircled{8} \quad P(5,2) \Rightarrow \{(0.08, 0.41), (0.22, 0.38)\} \\ \textcircled{9} \quad P(5,3) \Rightarrow \{(0.08, 0.41), (0.38, 0.32)\} \\ \textcircled{10} \quad P(5,4) \Rightarrow \{(0.08, 0.41), (0.26, 0.19)\} \end{array}$$

$$\begin{array}{l} \textcircled{11} \quad P(6,1) \Rightarrow \{(0.48, 0.30), (0.40, 0.53)\} \\ \textcircled{12} \quad P(6,2) \Rightarrow \{(0.48, 0.30), (0.22, 0.38)\} \\ \textcircled{13} \quad P(6,3) \Rightarrow \{(0.48, 0.30), (0.38, 0.32)\} \\ \textcircled{14} \quad P(6,4) \Rightarrow \{(0.48, 0.30), (0.26, 0.19)\} \\ \textcircled{15} \quad P(6,5) \Rightarrow \{(0.48, 0.38), (0.08, 0.41)\} \end{array}$$

	1	2	$\{3, 6\}$	4	5
1	0				
2	0.23436	0			
$\{3, 6\}$	0.215870	0.143178	0		
4	0.367690	0.194165	0.158114	0	
5	0.34176	0.143178	0.284605	0.284253	0

$\Rightarrow \text{Dist } \{(3, 6), 1\} \Rightarrow \min \{(3, 1)\} \Rightarrow \{(0.38, 0.32), (0.40, 0.53)\}$

$$\Rightarrow \sqrt{(0.40 - 0.38)^2 + (0.53 - 0.32)^2} \Rightarrow 0.215870$$

$$\Rightarrow \min \{(6, 1)\} \Rightarrow \{(0.48, 0.30), (0.26, 0.19)\}$$

$$\Rightarrow \sqrt{(0.40 - 0.48)^2 + (0.53 - 0.30)^2} = 0.19$$

$$\cancel{\Rightarrow} P(3,1) \Rightarrow 0.215870$$

$$\Rightarrow 0.23532$$



$$\begin{aligned} \text{Dist} \{ (3,6), 1 \} &\rightarrow \min \{ 3, 1 \} \rightarrow \{ (0.35, 0.32), (0.40, 0.53) \} \\ &\rightarrow \sqrt{(0.22 - 0.35)^2 + (0.38 - 0.32)^2} = 0.143178 \\ &\rightarrow \min \{ 6, 2 \} \rightarrow \{ (0.45, 0.30), (0.22, 0.28) \} \\ &\rightarrow \sqrt{(0.22 - 0.45)^2 + (0.38 - 0.30)^2} = 0.2435159 \\ \hookrightarrow P(3,2) &\rightarrow 0.143178 \end{aligned}$$

(3)	1	$\{2, 5\}$	$\{3, 6\}$	4
1	0			
$\{2, 5\}$	$0.234307$	0		
$\{3, 6\}$	$0.21587$	$0.143178$	0	
4	$0.397696$	$0.1991765$	$0.158114$	0

$$\begin{aligned} \rightarrow \text{Dist} \{ (2,5), 1 \} &\rightarrow \min \{ 2, 1 \} \rightarrow \{ (0.22, 0.38), (0.40, 0.53) \} \\ &\rightarrow 0.234307 \\ &\rightarrow \min \{ 5, 1 \} \rightarrow \{ (0.08, 0.41), (0.40, 0.53) \} \\ &\rightarrow 0.341760 \\ \hookrightarrow P(2,1) &\rightarrow 0.234307 \end{aligned}$$

$$\begin{aligned} \rightarrow \text{Dist} \{ (3,6), 1 \} &\rightarrow \min \{ 3, 1 \} \rightarrow \{ (0.35, 0.32), (0.40, 0.53) \} \\ &\rightarrow 0.215870 \\ &\rightarrow \min \{ 6, 1 \} \rightarrow \{ (0.45, 0.30), (0.40, 0.53) \} \\ &\rightarrow 0.235372 \\ \hookrightarrow P(3,1) &\rightarrow 0.215870 \end{aligned}$$

$$\begin{aligned} \rightarrow \text{Dist} \{ \{3,6\}, \{2,5\} \} &\rightarrow \min \{ 3, 2 \} \rightarrow 0.143178 \\ &\rightarrow \min \{ 3, 5 \} \rightarrow 0.28460 \\ &\rightarrow \min \{ 6, 2 \} \rightarrow 0.2435159 \\ &\rightarrow \min \{ 6, 5 \} \rightarrow 0.386005 \\ \hookrightarrow P(3,2) &\rightarrow 0.143178 \end{aligned}$$



1: Complete

④	1	$\{2, 3, 5, 6\}$	4
	1	0	
	$\begin{bmatrix} 2, 3 \\ 5, 6 \end{bmatrix}$	$0.21587$	0
	4	$0.36767$	$0.158114$

$$\Rightarrow \text{Dist } \{2, 3, 5, 6\}, 1 \} \Rightarrow \text{miu}(2, 1) \Rightarrow 0.23537$$

$$\rightsquigarrow \text{miu}(3, 1) \Rightarrow 0.21587$$

$$\Rightarrow \text{miu}(5, 1) \Rightarrow 0.3417$$

$$\Rightarrow \text{miu}(6, 1) \Rightarrow 0.23537$$

$$\rightsquigarrow P(3, 1) = 0.21587$$

$$\Rightarrow \text{Dist } \{4, \{2, 3, 5, 6\}\} \Rightarrow \text{miu}(4, 2) \Rightarrow 0.194165$$

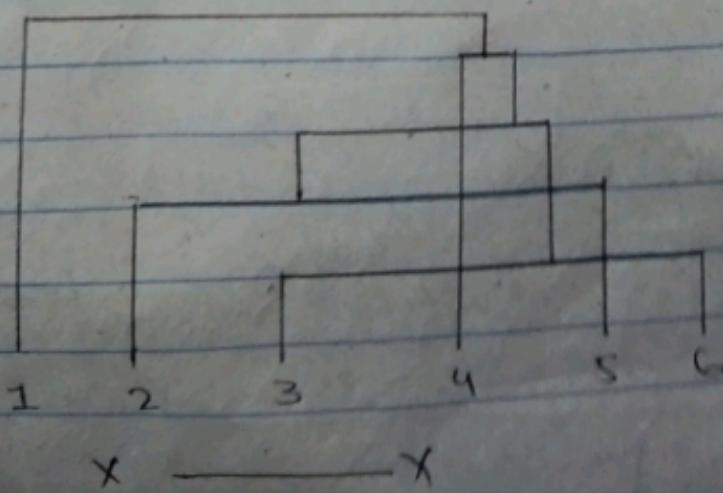
$$\rightsquigarrow \text{miu}(4, 3) \Rightarrow 0.158114$$

$$\Rightarrow \text{miu}(4, 5) \Rightarrow 0.284253$$

$$\Rightarrow \text{miu}(4, 6) \Rightarrow 0.219844$$

$$\rightsquigarrow P(4, 3) \Rightarrow 0.158114$$

⑤	1	0 1	$\{2, 3, 4, 5, 6\}$
	$\{2, 3, 4, 5, 6\}$		0

Dendrogram

(2)

## 1: Complete linkage

(1)	1	2	3	4	5	6
1	0					
2	0.234307	0				
3	0.21587	0.14319	0			
4	0.367696	0.194165	0.158114	0		
5	0.34176	0.143178	0.284605	0.284253	0	
6	0.235372	0.2435	0.10198	0.219545	0.386005	0

→ Merge 3 & 6

(2)	1	2	{3,6}	4	5
1	0				
2	0.234307	0			
3	0.21587	0.235372	0.243519	0	
4	0.367696	0.194165	0.158114	0	
5	0.34176	0.143178	0.284605	0.284253	0

$$\Rightarrow \text{Dist}\{(3,6), 1\} \Rightarrow \max\{(3,1) \Rightarrow 0.215870\}$$

$$\checkmark \max(6,1) \Rightarrow 0.235372$$

$$\checkmark P(6,1) \Rightarrow 0.235372$$

$$\Rightarrow \text{Dist}\{(3,6), 2\} \Rightarrow \max(3,2) \Rightarrow 0.143178$$

$$\checkmark \max(6,2) = 0.2435159$$

$$\checkmark P(6,2) \Rightarrow 0.2435159$$



⑤	1	$\{2,5\}$	$\{3,6\}$	4
1	0			
$\{2,5\}$	0.341760	0		
$\{3,6\}$	0.235372	0.386005	0	
4	0.341760	0.284253	0.219544	0

1	$\{2,5\}$	0
$\{2,5\}$	0.341760	
$\{3,6\}$	0.235372	0.386005

Dist  $\{2,5\}$

Dist  $\{3,6\}$

Dist  $\{3\}$

$$\Rightarrow \text{Dist } \{2,5\}, 1 \} \rightarrow \max(2,1) = 0.234307$$

$\swarrow \max(5,1) = 0.341760$

~~$\Rightarrow P(5,1) = 0.341760$~~

$$\Rightarrow \text{Dist } \{3,6\}, 1 \} \rightarrow \max(3,1) = 0.215870$$

$\swarrow \max(6,1) = 0.235372$

$$\Rightarrow \text{Dist } \{3,6\}, \{2,5\} \} \rightarrow \max(3,2) = 0.143178$$

$\max(3,5) = 0.28460$

$\max(6,2) = 0.2435159$

$\max(6,5) = 0.386005$

$$\Rightarrow \text{Dist } \{4, \{2,5\}\} \rightarrow \max(4,2) = 0.194165$$

$\swarrow \max(4,5) = 0.284253$

$$\Rightarrow \text{Dist } \{4, \{3,6\}\} \rightarrow \max(4,3) = 0.158114$$

$\swarrow \max(4,6) = 0.219544$

⑤

→ Merge 4 &  $\{3,6\}$

1 →



Shot on Y11  
Vivo AI camera

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	1	{2,5}	{3,4,6}
1	0		
{2,5}	0.39126	0	
{3,4,6}	0.235372	0.386005	0

$$\text{Dist } \{(2,5), 1\} \rightarrow \max(2,1) \rightarrow 0.235372$$

$$\leftarrow \max(5,1) \rightarrow 0.39126$$

$$\text{Dist } \{(3,4,6), 1\} \rightarrow \max(3,1) \rightarrow 0.21537$$

$$\leftarrow \max(4,1) \rightarrow 0.284253$$

$$\max(6,1) \rightarrow 0.235372$$

$$\text{Dist } \{(3,4,6), (2,5)\} \rightarrow \max(3,2) \rightarrow 0.19317$$

$$\max(3,5) \rightarrow$$

$$\max(4,2) \rightarrow 0.194166$$

$$\max(4,5) \rightarrow 0.284253$$

$$\max(6,2) \rightarrow 0.235372$$

$$\leftarrow \max(6,5) \rightarrow 0.386005$$

→ Merge (2,5) & 1

⑤	{1,2,5}	{3,4,6}
	0	
{1,2,5}	0.386005	0

$$\Rightarrow \text{Dist } \{(3,4,6), (1,2,5)\} \rightarrow \max(3,1) \rightarrow 0.21537$$

$$(4,5) \rightarrow 0.284253$$

$$(3,2) \rightarrow 0.19317$$

$$(6,1) \rightarrow 0.235372$$

$$(3,5) \rightarrow 0.284253$$

$$(4,1) \rightarrow 0.386005$$

$$(4,2) \rightarrow 0.19317$$

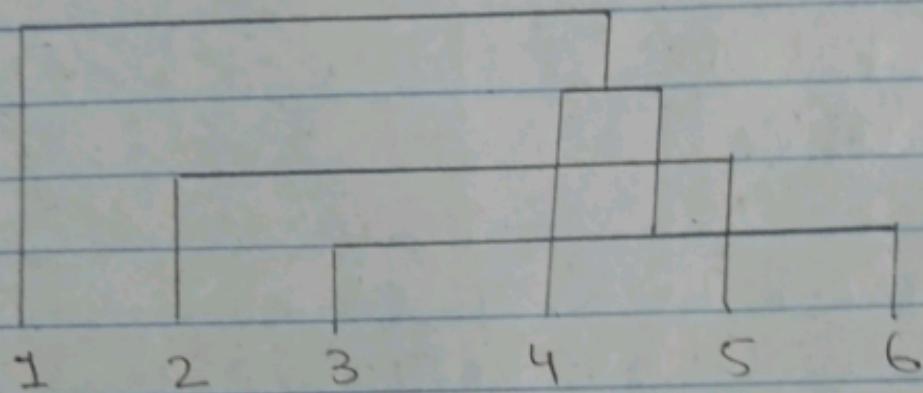


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Vivo AI camera 6005

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## Dendrogramme



X — X

## 2: Group linkage Average

Just as above.

↪ Merge 3 & 6

②      1      2      {3,6}      4      5

1      0

2      0.234307      0

{3,6}      0.225621      0.1933      0

4      some      some      0.188829      0

5      some      some      0.335305      some      0

$$\Rightarrow \text{Dist } \{3,6\}, 1 \rightarrow D(3,1) + D(6,1) \Rightarrow 0.21587 + 0.2353$$

2+1                          2

$\swarrow \rightarrow 0.225621$

$$\Rightarrow \text{Dist } \{3,6\}, 2 \rightarrow D(3,2) + D(6,2) \Rightarrow 0.14317 + 0.2435$$

2+1                          2

$\swarrow \rightarrow 0.193343$

$$\Rightarrow \text{Dist } \{4, \{3,6\}\} \rightarrow D(4,3) + D(4,6) \Rightarrow 0.158114 + 0.21954$$

2                                  2

$\swarrow \rightarrow 0.188829$

$$\Rightarrow \text{Dist } \{5, \{3,6\}\} \rightarrow D(5,3) + D(5,6) \Rightarrow 0.284605 + 0.28$$

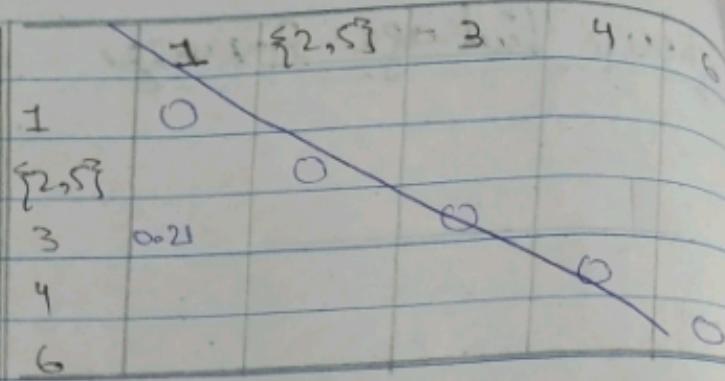
2                                  2

$\swarrow \rightarrow 0.335305$

↪ Merge 2 & 5



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	1	$\{2, 5\}$	$\{3, 6\}$	4
1	0			
$\{2, 5\}$		0		
3	0.21			
4			0	
6				0

$$\Rightarrow \text{Dist} \{2, 5\}, 1 \rightarrow D(2, 1) + D(5, 1) \rightarrow \\ \xleftarrow[2]{} 0.2880335$$

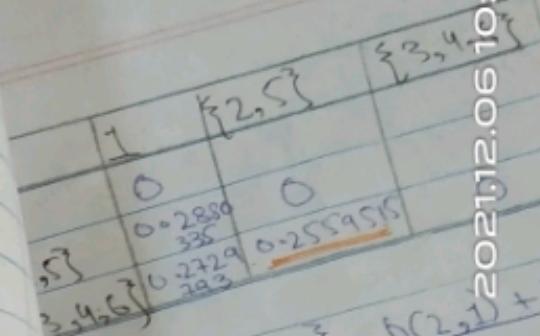
$$\Rightarrow \text{Dist} \{3, 6\}, 1 \rightarrow D(3, 1) + D(6, 1) \rightarrow \\ \xleftarrow[2]{} 0.25621$$

$$\Rightarrow \text{Dist} \{3, 6\}, \{2, 5\} \rightarrow D(3, 2) + D(3, 5) + D(6, 2) \rightarrow \\ \xleftarrow[4]{} 0.26432275$$

$$\Rightarrow \text{Dist} \{4, \{2, 5\}\} \rightarrow D(4, 2) + D(4, 5) \rightarrow \\ \xleftarrow[2]{} 0.2392$$

$$\Rightarrow \text{Dist} \{4, \{3, 6\}\} \rightarrow D(4, 3) + D(4, 6) \rightarrow \\ \xleftarrow[2]{} 0.18882$$

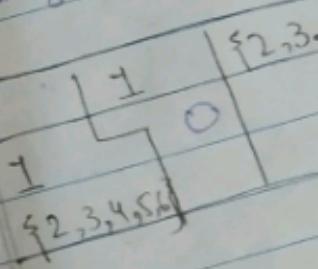
$\hookrightarrow$  Merge 4 &  $\{3, 6\}$



$$\text{Dist} \{2, 5\}, 1 \rightarrow D(2, 1) + D(5, 1) \rightarrow \\ \text{Dist} \{3, 4, 6\}, 1 \rightarrow D(3, 1) + D(4, 1) + D(6, 1) \rightarrow 0.2229$$

$$\text{Dist} \{3, 4, 6\}, \{2, 5\} \rightarrow D(3, 2) + D(3, 5) + D(4, 2) + D(4, 5) + D(6, 2) + D(6, 5) \rightarrow 0.2559515$$

Merge (2, 5) &



	1	$\{2, 5\}$	$\{3, 4, 6\}$	
1	0			
$\{2, 5\}$	0.2880 335	0		
$\{3, 4, 6\}$	0.2729 793	0.2559515	0	

$$\text{Dist}[\{2, 5\}, 1] \rightarrow D(2, 1) + D(5, 1) \Rightarrow 0.2880335$$

$$\text{Dist}[\{3, 4, 6\}, 1] \rightarrow D(3, 1) + D(4, 1) + D(6, 1)$$

$$\Rightarrow 0.272979$$

$$\text{Dist}[\{3, 4, 6\}, \{2, 5\}] \rightarrow D(3, 2) + D(3, 5) + D(4, 2) + D(4, 5) + D(6, 2) + D(6, 5)$$

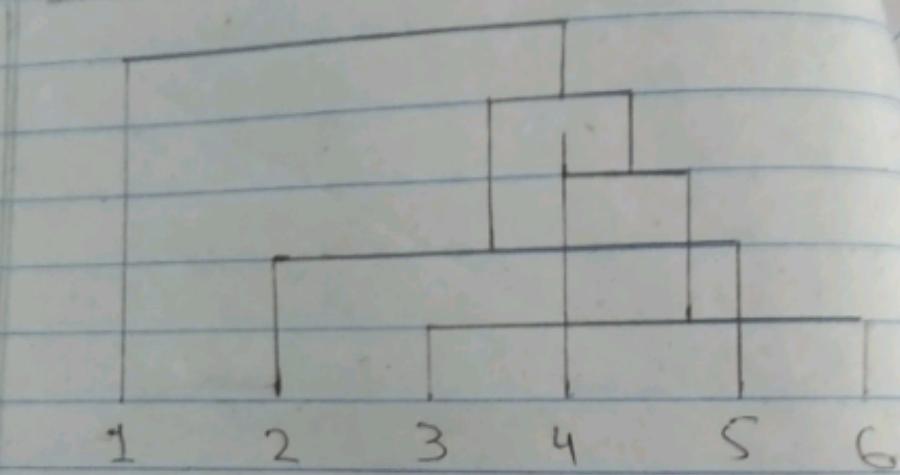
$$\Rightarrow 0.2559515$$

Merge  $(2, 5)$  &  $(3, 4, 6)$

	1	$\{2, 3, 4, 5, 6\}$	
1	0		
$\{2, 3, 4, 5, 6\}$		0	



Dendrogram



x ————— x

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## K-Means Algorithm

Indians	1	2	3	4	5	6
X	1	1	2	3	3	3
Y	1.5	4.5	1.5	3.5	2.5	6.5

initial pick Indians 1 & 3 as initial centroids

Indians	dist with c1	dist with c2
1	1.66	3.16
2	1.66	3.16
3	2.24	1.66
4	2.24	1.66
5	6.02	5.31
6	6.02	5.31

And now we have 4 clusters

#2 (1, 4.5)

$$c_1(1, 1.5) \rightarrow \sqrt{(1-1)^2 + (4.5-1.5)^2} \approx 3.66$$

$$c_2(2, 1.5) \rightarrow \sqrt{(2-1)^2 + (1.5-1.5)^2} \approx 1.41$$

#4 (2, 3.5)

$$c_1(1, 1.5) \rightarrow \sqrt{(2-1)^2 + (3.5-1.5)^2} \approx 2.24$$

$$c_2(2, 1.5) \rightarrow \sqrt{(2-2)^2 + (3.5-1.5)^2} \approx 2.00$$

#5 (3, 2.5)

$$c_1(1, 1.5) \rightarrow \sqrt{(3-1)^2 + (2.5-1.5)^2} \approx 2.24$$

$$c_2(2, 1.5) \rightarrow \sqrt{(3-2)^2 + (2.5-1.5)^2} \approx 1.41$$

