Morphological Solution

Question 1

→ I am considering structure element ones (15,15)

→ Save the image into a variable 'img'

→ do the erosion on image 'img' with structure element.

→ Now the string attached to the centes square will be disappeared, withe 'bwlabel' function and label disconnected components

→ imclear matlab function, clear the components at the boundary, ~~save~~ substract this image(y) from the above image img i.e

Y_img = will give the expected output.

Problem 1 Medium Level Image Processing

The morphological solution to keep all 16 rounded thick sticks on the border

Problem 2 : Seeded region growing

3	2	2	1	1	1	1	1
6	5	2	2	1	1	1	1
7	7	7	7	7	1	1	1
7	7	6	7	6	7	1	1
8	7	7	8	6	7	1	1
8	8	7	3	2	1	1	1
8	8	8	4	2	1	2	1
8	8	8	5	1	1	1	1

Seeded region 1

sum= 6+7+7+7+7+7+6+8+7+7+8+8+7+8+8+8+8+8+8 = 140
Total numbers = 19
Mean = 140/19=7.368421053

Seeded region 2
Sum = 1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1+2+1+1+1+2+1+2+1+1+1+1+1 = 31
Total elements = 28
Mean = 31/28 = 1.107142857

The value ‘7’ 4 row 4 column is not shared. (blue colored)
It is closer to the mean value 7.3, so it will be merged with seeded region 1.

brown colored line would be boundary line between 2 regions.

3	2	2	1	1	1	1	1
6	5	2	2	1	1	1	1
7	7	7	7	7	1	1	1
7	7	6	7	6	7	1	1
8	7	7	8	6	7	1	1
8	8	7	3	2	1	1	1
8	8	8	4	2	1	2	1
8	8	8	5	1	1	1	1

2.2 even regions selections are interchanged as mentioned in the question, i think there would not be a difference. The segmentation results would be same as this one.

Watershed segmentation

In the first image, these are the minimas because they are surrounded by larger values.

8	8	7	8	9	9	9	9
8	8	3	3	9	9	4	9
8	8	9	9	9	9	9	9
8	7	6	8	9	9	9	9
7	6	6	7	7	9	1	1
7	2	2	7	6	5	1	1
7	6	6	7	11	12	5	5
7	7	6	7	11	11	7	5

8	8	7	8	9	9	9	9
8	8	3	3	9	9	4	9
8	8	9	9	9	9	9	9
8	7	6	8	9	9	9	9
7	6	6	7	7	9	1	1
7	2	2	7	6	5	1	1
7	6	6	7	11	12	5	5
7	7	6	7	11	11	7	5

8	8	7	8	9	9	9	9
8	8	3	3	9	9	4	9
8	8	9	9	9	9	9	9
8	7	6	8	9	9	9	9
7	6	6	7	7	9	1	1
7	2	2	7	6	5	1	1
7	6	6	7	11	12	5	5
7	7	6	7	11	11	7	5

Final Result

8	8	7	8	9	9	9	9
8	8	3	3	9	9	4	9
8	8	9	9	9	9	9	9
8	7	6	8	9	9	9	9
7	6	6	7	7	9	1	1
7	2	2	7	6	5	1	1
7	6	6	7	11	12	5	5
7	7	6	7	11	11	7	5

K-means Algorithm

{(0,0), (0,1), (6,7), (5,5), (4,5), (1,2)}

Points {(4,5)} {(0,1)}

	$(4,5)_{C1}$	$(0,1)_{C2}$	
(0,0)	6.40	1 ✓	C2
(0,1)	5.65	0 ✓	C2
(6,7)	2.82 ✓	8.48	C1
(5,5)	1 ✓	6.40	C1
(4,5)	0 ✓	5.65	C1
(1,2)	4.24	1.41 ✓	C2

C1	C2
(6,7)	(0,0)
(5,5)	(0,1)
(4,5)	(1,2)

↓

$$\text{Centers} = \left(\frac{6+5+4}{3}, \frac{7+5+5}{3}\right) \left(\frac{0+0+1}{3}, \frac{0+1+2}{3}\right)$$

$$= \left(\frac{15}{3}, \frac{17}{3}\right) \left(\frac{1}{3}, 1\right)$$

$$= \left(5, \frac{17}{3}\right) \left(\frac{1}{3}, 1\right)$$

	$(5, 17/3)_{C1}$	$(1/3, 1)_{C2}$	
(0,0)	7.5	1.04 ✓	C2
(0,1)	6.8	0.3 ✓	C2
(6,7)	1.72 ✓	8.27	C1
(5,5)	0.6 ✓	6.17	C1
(4,5)	1.16 ✓	5.45	C1
(1,2)	5.38	1.22 ✓	C2

C1	C2
(6,7)	(0,0)
(5,5)	(0,1)
(4,5)	(1,2)

$$\text{center}_2 = \left(\frac{6+5+4}{3}, \frac{7+5+5}{3}\right)\left(\frac{0+0+1}{3}, \frac{0+1+2}{3}\right)$$

$$\left(\frac{15}{3}, 17/3\right)\left(1/3, 1\right)$$

$$(5, 17/3)\,(1/3, 1)$$

Previous center and above center are same,

the centroid of cluster 1 and cluster 2 are $(5, 17/3)\,(1/3, 1)$

cluster 1	cluster 2
(6,7)	(0,0)
(5,5)	(0,1)
(4,5)	(1,2)

Hierarchical clustering algorithm

$\{P_1(0,0)\ P_2(0,1)\ P_3(6,7)\ P_4(5,5)\ P_5(4,5)\ P_6(1,2)\}$

	P_1	P_2	P_3	P_4	P_5	P_6
P_1	0	(1)	9.21	7.07	8.06	2.23
P_2		0	8.48	6.40	5.65	1.414
P_3			0	2.23	2.82	7.07
P_4				0	1	5
P_5					0	4.24
P_6						0

	P_1, P_2	P_3	P_4	P_5	P_6
P_1, P_2	0	8.48	~~7.07~~ 6.4	5.65	1.414
P_3		0	2.23	2.82	7.07
P_4			0	(1)	5
P_5			●	0	4.24
P_6				●	0

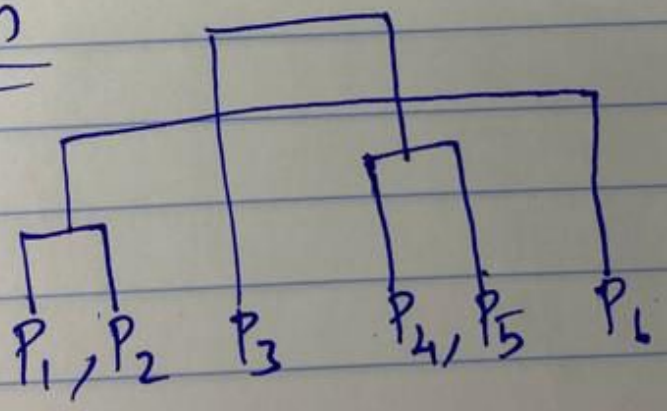
	P_1, P_2	P_3	P_4, P_5	P_6
P_1, P_2	0	8.48	5.65	(1.414)
P_3		0	2.23	7.07
P_4, P_5			0	4.24
P_6				0

	P_1, P_2, P_6	P_3	$P_4 P_5$
P_1, P_2, P_6	0	7.07	4.25
P_3		0	2.23
P_4, P_5			0

cluster 1 $= \{P_1, P_2, P_6\}$

cluster 2 $= \{P_3, P_4, P_5\}$

dendrogram



Problem 3.3 - Perceptron algorithm
(0,0) (0,1) (6,7) (5,5) (4,5) (1,2)

W1 = (1,1,2)

X1 = (0,0,1) X4=(6,7,1)
X2 = (0,1,1) X5=(5,5,1)
X3 = (1,2,1) X6=(4,5,1)

Expected X1,x2,x3 >0 x4,x5,x6<0

W1x1 = (1,1,2) (0,0,1)' = 2 >0 no change w2=w1
W2x2 = (1,1,2) (0,1,1)' = 3 >0 no change w3=w2
W3x3 = (1,1,2) (1,2,1)' = 5 >0 no change w4=w3

W4x4 = (1,1,2) (6,7,1) = 15 >0 w5 = w(4) - x(4) = (1,1,2) - (6,7,1) = (-5,-6,1)
W5x5 = (-5,-6,1) (5,5,1) ' = -54 <0 no change w6=w5
W6x6 = (-5,-6,1) (4,5,1) ' = -49 <0 no change w7=w6

W7x1 = (-5,-6,1) (0,0,1)' = 1 >0 no change w8=w7
W8x2 = (-5,-6,1) (0,1,1)' = -5 <0 w9=w8+x2 = (-5,-6,1)+(0,1,1)=(-5,-5,2)
W9x3 = (-5,-5,2) (1,2,1)' = -13 <0 w10=w9+x3 = (-5,-5,2)+(1,2,1)=(-4,-3,3)

W10x4 = (-4,-3,3) (6,7,1) = -44 <0 no change w11=w12
W11x5 = (-4,-3,3) (5,5,1) ' = -34 <0 no change w12=w11
W12x6 = (-4,-3,3) (4,5,1) ' = -18 <0 no change w13=w7

W13x1 = (-4,-3,3) (0,0,1)' = 3 >0 no change w14=w13
W14x2 = (-4,-3,3) (0,1,1)' = 0 =0 w15 = w14+x2 = (-4,-3,3)+(0,1,1) = (-4,-2,4)
W15x3 = (-4,-2,4) (1,2,1)' = -4 <0 w16=w15+x3 = (-4,-2,4)+(1,2,1)=(-3,0,5)

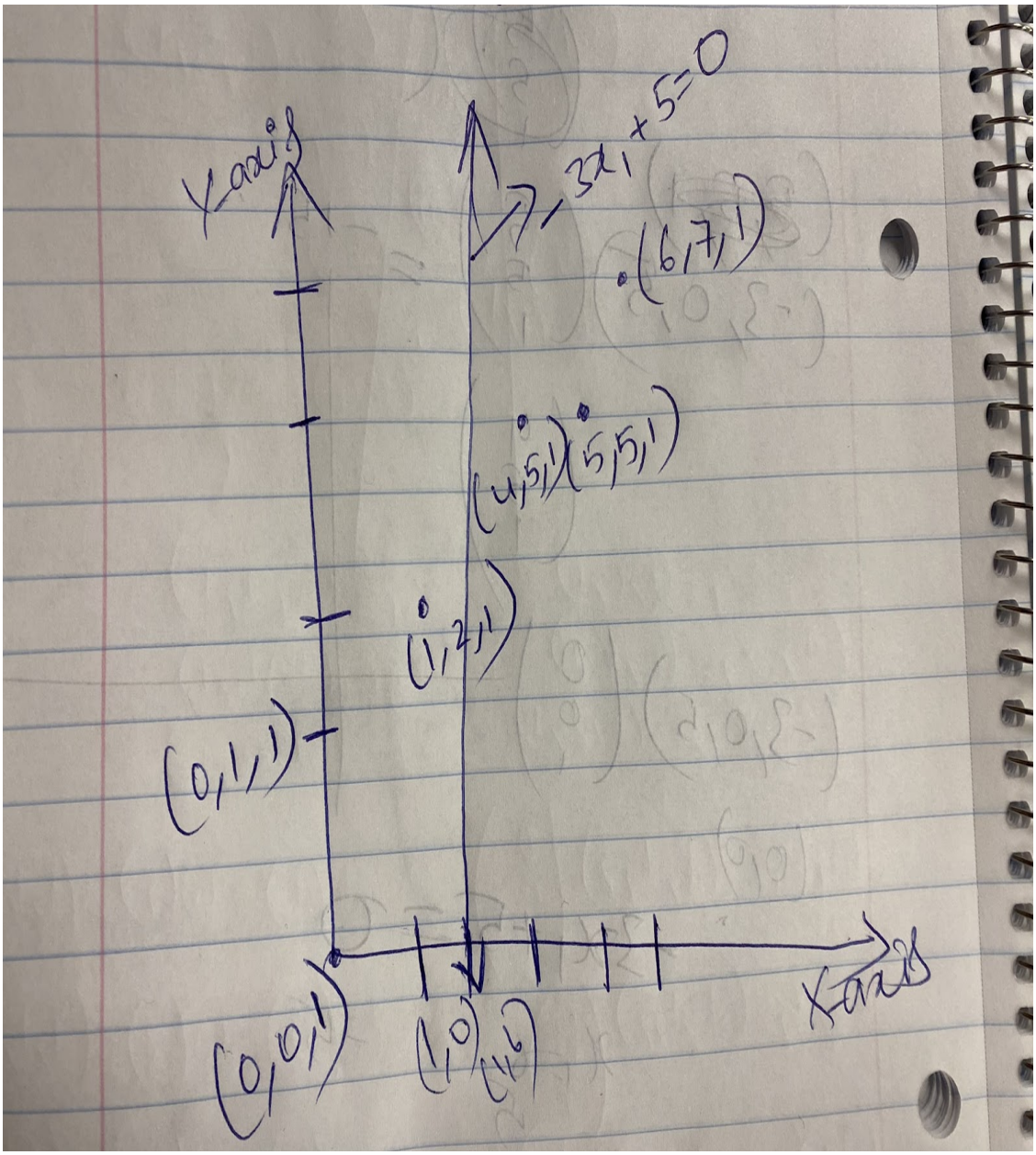
W16x4 = (-3,0,5) (6,7,1) = -13 <0 no change w17=w16
W17x5 = (-3,0,5) (5,5,1) ' = -10 <0 no change w18=w17
W18x6 = (-3,0,5) (4,5,1) ' = -7 <0 no change w19=w18

W13x1 = (-3,0,5) (0,0,1)' = 5 >0 no change w20=w19
W14x2 = (-3,0,5) (0,1,1)' = 5 >0 no change w21 = w20
W15x3 = (-3,0,5) (1,2,1)' = 2 >0 no change w22=w21

The final weight is (-3,0,5)

The equation of line is -3x1+5=0

Plot all your original data and sketch the found decision boundary on a graph.



Decide which class an unknown pattern (2, 2) belongs to and explain how you made the decision.

-3x1+5=0
-3(2)+5 = -6+5 = -1

Which is less than 0, so (2,2) lies right side of the line

3.4

minimal distance classification

{(0,0), (0,1) (6,7), (5,5), (4,5), (1,2)}

A(0,0) B(0,1) C(1,2) — cluster 1

D(4,5) E(5,5) F(6,7) — cluster 2

mean of cluster 1 $M_1 = \frac{0+0+1}{3} \quad \frac{0+1+2}{3} = \left(\frac{1}{3}, \frac{3}{3}\right)$

$= (0.3, 1)$

mean of cluster 2 $M_2 = \frac{4+5+6}{3} \quad \frac{5+5+7}{3} = (5, 5.6)$

$= (5, 5.6)$

$M_1 * M_1^T = (0.3, 1)\begin{pmatrix} 0.3 \\ 1 \end{pmatrix} = 1.09$

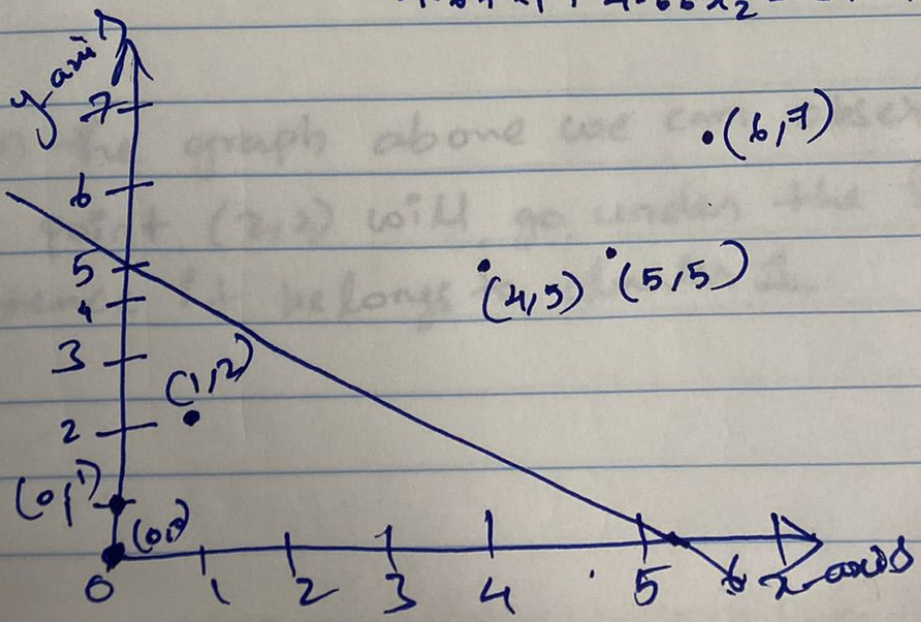
$D_1(x) = 0.3x_1 + x_2 - 0.55$

$M_2 * M_2^T = \begin{pmatrix} 5 \\ 5.6 \end{pmatrix}(5, 5.6) = 56.36$

$D_2(x) = 5x_1 + 5.66x_2 - 28.51$

$D_{12} = d_1(x) - d_2(x) = -4.67x_1 - 4.66x_2 + 27.9$

$= 4.67x_1 + 4.66x_2 - 27.9 = 0$



from the graph above we can observe that the point (2,2) will go under the line, hence it belongs to cluster 1

Question 3.5

Input values (points)

$\{(0,0)\ (0,1)\ (6,7)\ (5,5)\ (4,5)\ (1,2)\}$

$x_1\ 2\ 3\ 4\ 5\ 6$

$x \rightarrow [0, 0, 6, 5, 4, 1]$

$y \rightarrow [0, 1, 7, 5, 5, 2]$

variance $= [2.6, 3.3]$

find co-variance matrix

$x_1 - M = \begin{bmatrix} -2.6 \\ -3.3 \end{bmatrix}$

$x_2 - M = [-2.6, 2.3]$

⋮

final co-variance matrix would be

$$= \begin{bmatrix} 5.89 & 5.7 \\ 5.9 & 6.2 \end{bmatrix}$$

eigen values = of vector $1 = [-1.02, 1]$

$= [0.97, 1]$

transformation matrix = ~~[illegible]~~

$$TM = \begin{bmatrix} 0.97 & -1.03 \\ 1 & 1 \end{bmatrix}$$

transformed values = M^T (variance)

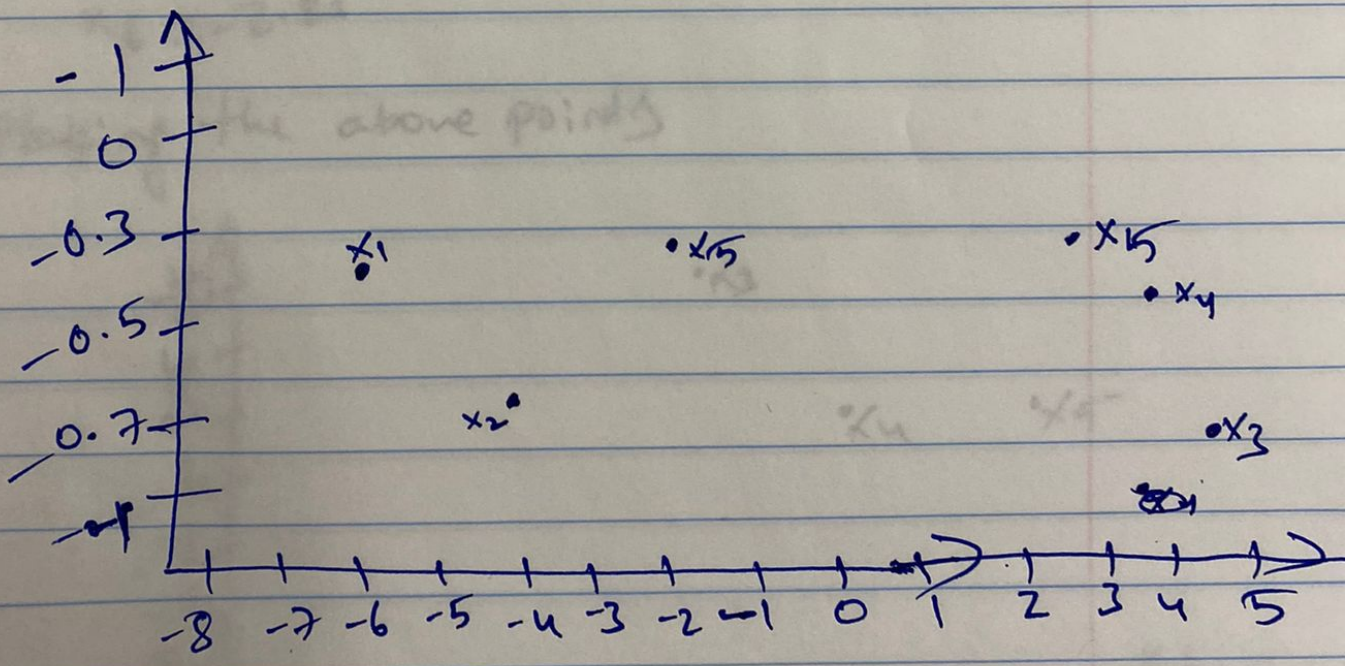
$$x_1 = \begin{pmatrix} 0.97 & 1 \\ -1.03 & 1 \end{pmatrix} \begin{pmatrix} -2.6 \\ -3.3 \end{pmatrix} = \begin{pmatrix} -5.8 \\ -0.6 \end{pmatrix}$$

$$x_2 = \begin{pmatrix} -4.8 \\ 0.4 \end{pmatrix} \quad x_3 = \begin{pmatrix} 7.0 \\ 0.2 \end{pmatrix}$$

$$x_4 = \begin{pmatrix} 4.0 \\ -0.8 \end{pmatrix} \quad x_5 = \begin{pmatrix} 3.1 \\ 0.3 \end{pmatrix} \quad x_6 = \begin{pmatrix} -2.8 \\ 0.3 \end{pmatrix}$$

the variance of above calculated points is

(23.174, 0.274)



~~calculating the variance of~~ th Principal component with new transformation matrix

$$U = \begin{bmatrix} 0.97 \\ 1 \end{bmatrix}$$

$$X_1 = \begin{bmatrix} 0.97 & 1 \end{bmatrix} \begin{bmatrix} -2.6 \\ -3.3 \end{bmatrix} = -5.09$$

$X_2 = -4.76$

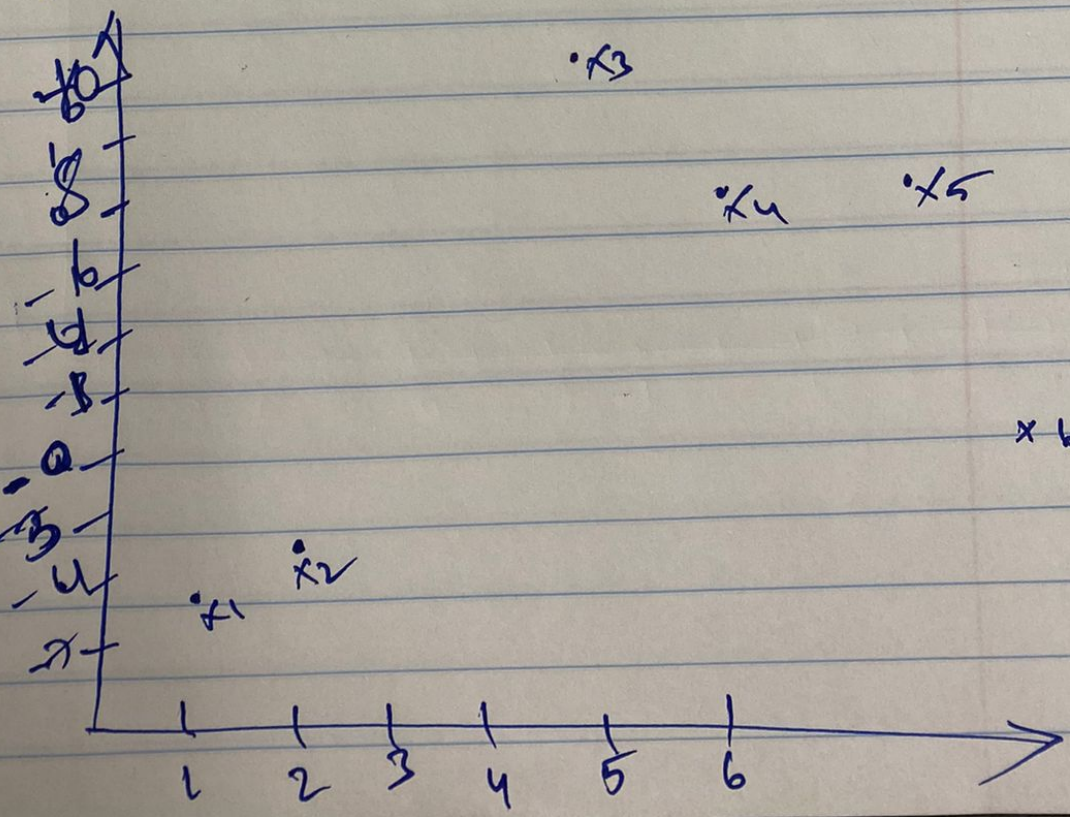
$X_3 = 7$

$X_4 = 4$

$X_5 = 3.1$

$X_6 = -2.8\bar{3}$

Plotting the above points



the variance of the above points = 23.2

This describes the dataset calculated by two principal components.

→ The second variance reduce the dimensionality gives less dataset information