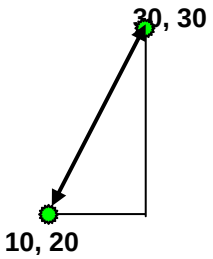
Unsupervised Classification

Unsupervised classification is a process of predicting "land cover" by

1) Assigning pixels that have similar spectral response patterns to spectral classes.
2) Deciding what cover type each spectral class represents
3) Aggregating spectral classes into cover classes.

Spectral distance is often used to determine what pixels are similar. For example for a pixel a with band 1 DN of 10, band2 DN of 20, the spectral distance to pixel b with spectral values of 30,30 is:

$$\text{SQRT}[\ (\text{band1a} - \text{band1b})^2 + (\text{band2a} - \text{band2b})^2\ ] =$$
$$\text{SQRT}[\ (10 - 30)^2 + (20 - 30)^2\ ]$$



Spectral distance can be computed in N-dimensions. For a 5-band image, the spectral distance between pixel a and pixel b would be:

$$\text{SQRT}[\ (65 - 75)^2 + (40 - 50)^2 + (50 - 55)^2 + (120 - 140)^2 + (60 - 65)^2]$$

Pixel A	Pixel B
65	75
40	50
50	55
120	140
60	65

Here is a simple example. Imagine that you want to map water versus land with a 2-band image. We will apply the Iterative Self-Organizing Data or ISODATA algorithm with these user-defined parameters: 4 classes, 30 iterations, min_class_size = 2, convergence threshold = 95 percent

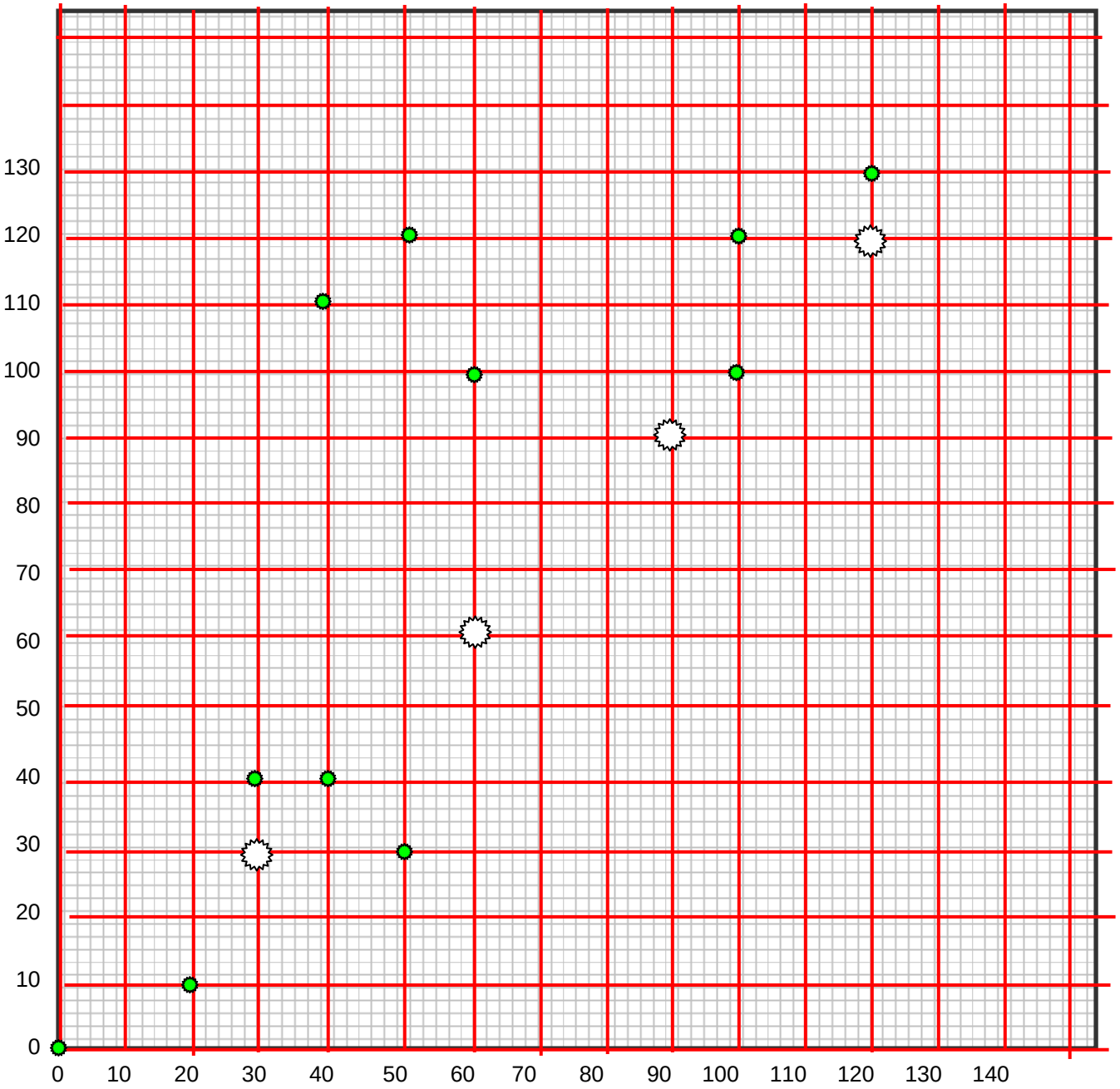
0 0	100 100	110 100	120 110	40 110	30 120
50 30	110 150	100 110	100 120	50 120	50 130
30 40	40 60	120 130	120 120	60 100	60 110
40 40	50 50	20 10	120 120	110 100	120 110

The first step in clustering is to determine spectral class statistics such as means. Since images typically have thousands of pixels, a sample of image pixels can be used to estimate spectral class statistics and speed up this process.

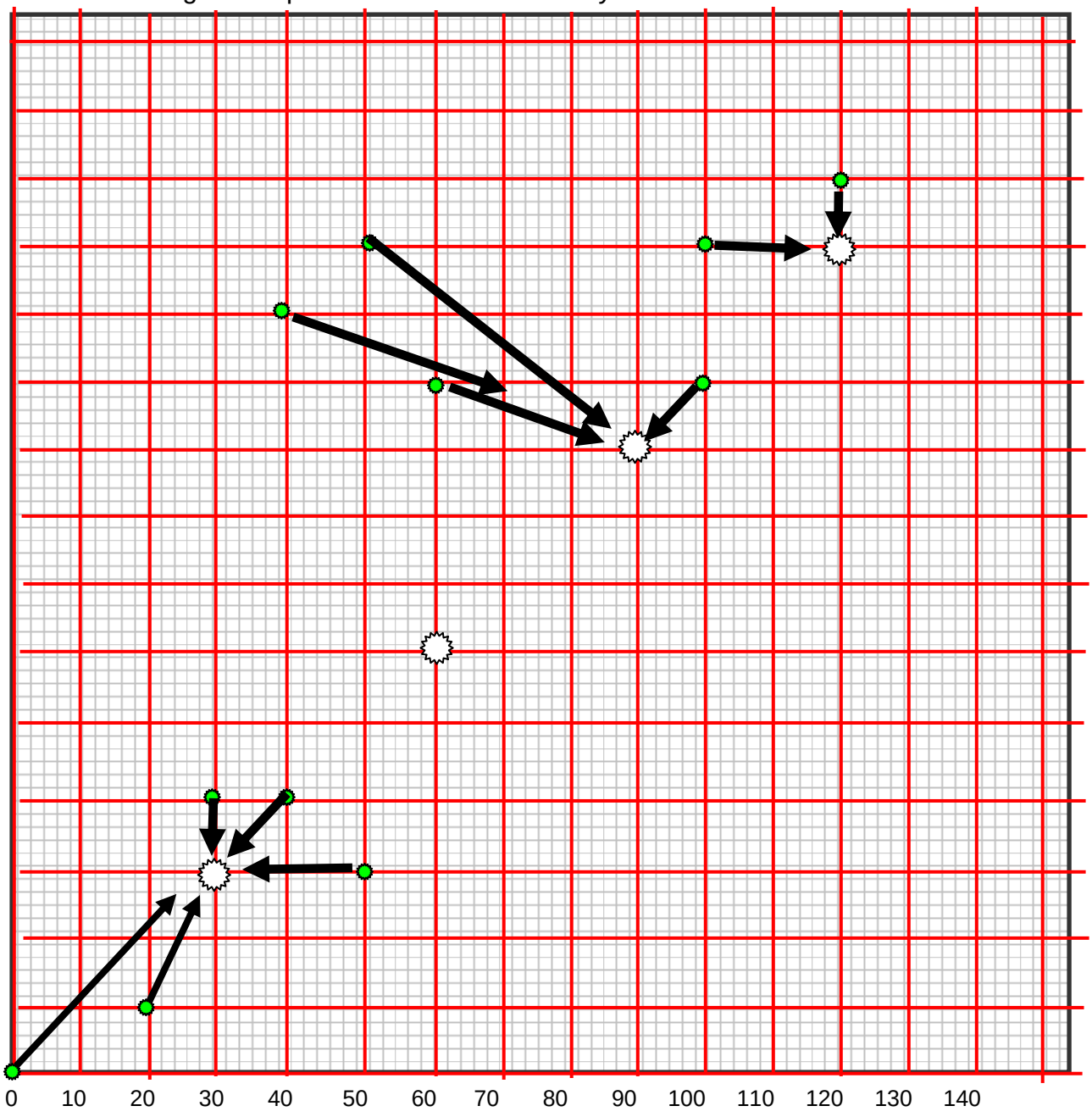
sample_interval or skip factor= 2

0 0	100 100	110 100	120 110	40 110	30 120
50 30	110 150	100 120	100 120	50 120	50 130
30 40	40 60	120 130	120 120	60 100	60 110
40 40	50 50	20 10	120 120	100 100	120 110

Start with 4 means at arbitrary intervals. The range of pixel values is 0 to 120. 120/4 classes = 30, so the starting means are class 1 (30,30), class 2 (60,60) class 3 (90,90), class 4(120,120).


130
120
110
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140

Iteration#1. Assign each pixel to it's closest arbitrary class mean.



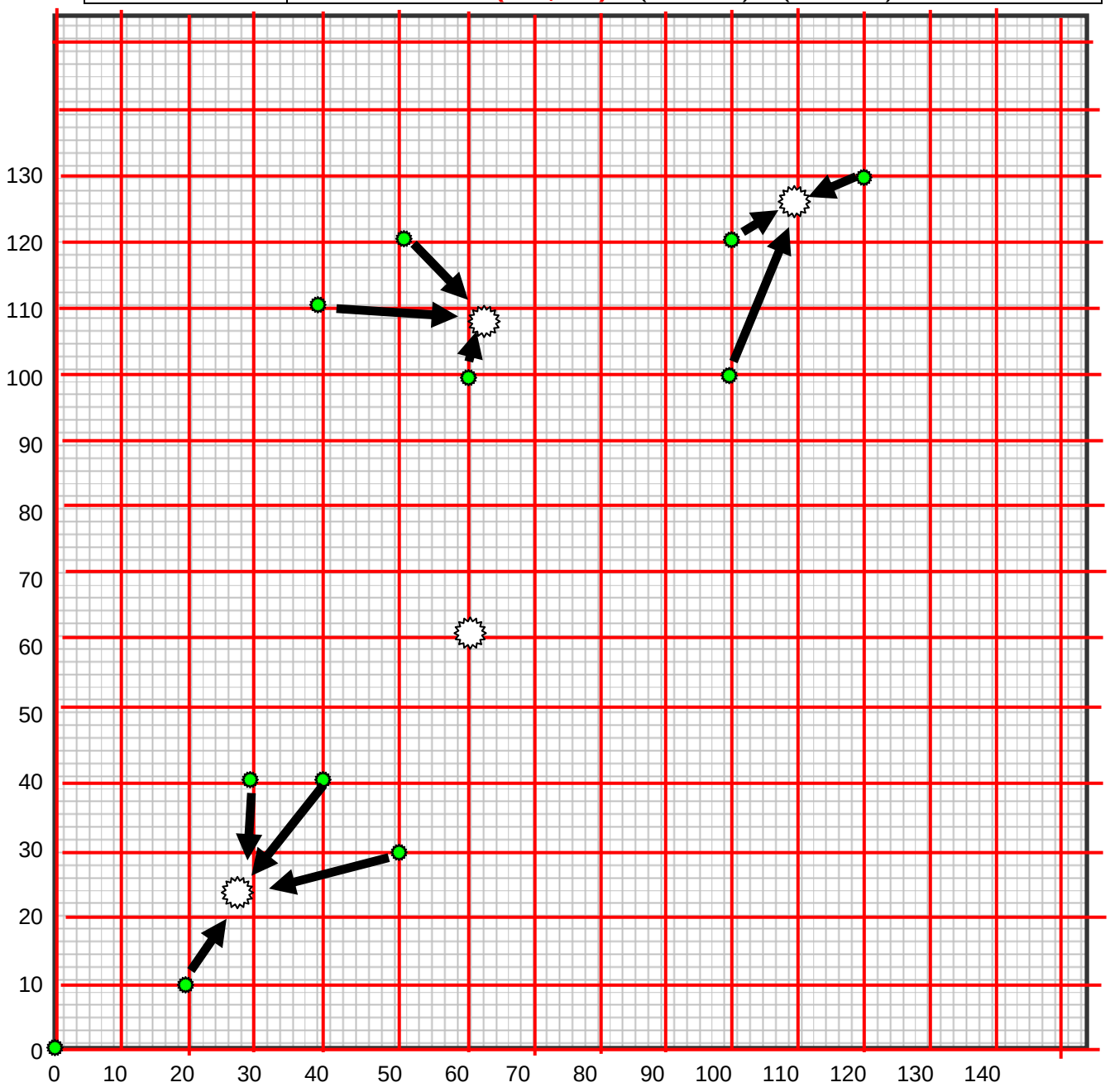
Class	Members
1	(0,0) (20,10) (30,40) (40,40) (50,30)
2	none
3	(40,110) (50,120) (60,100) (100,100)
4	(100,120) (120,130)

And compute the new class means…

Class	Band1 Mean	Band2 Mean
1	28	24
2	60	60
3	62.5	107.5
4	110	125

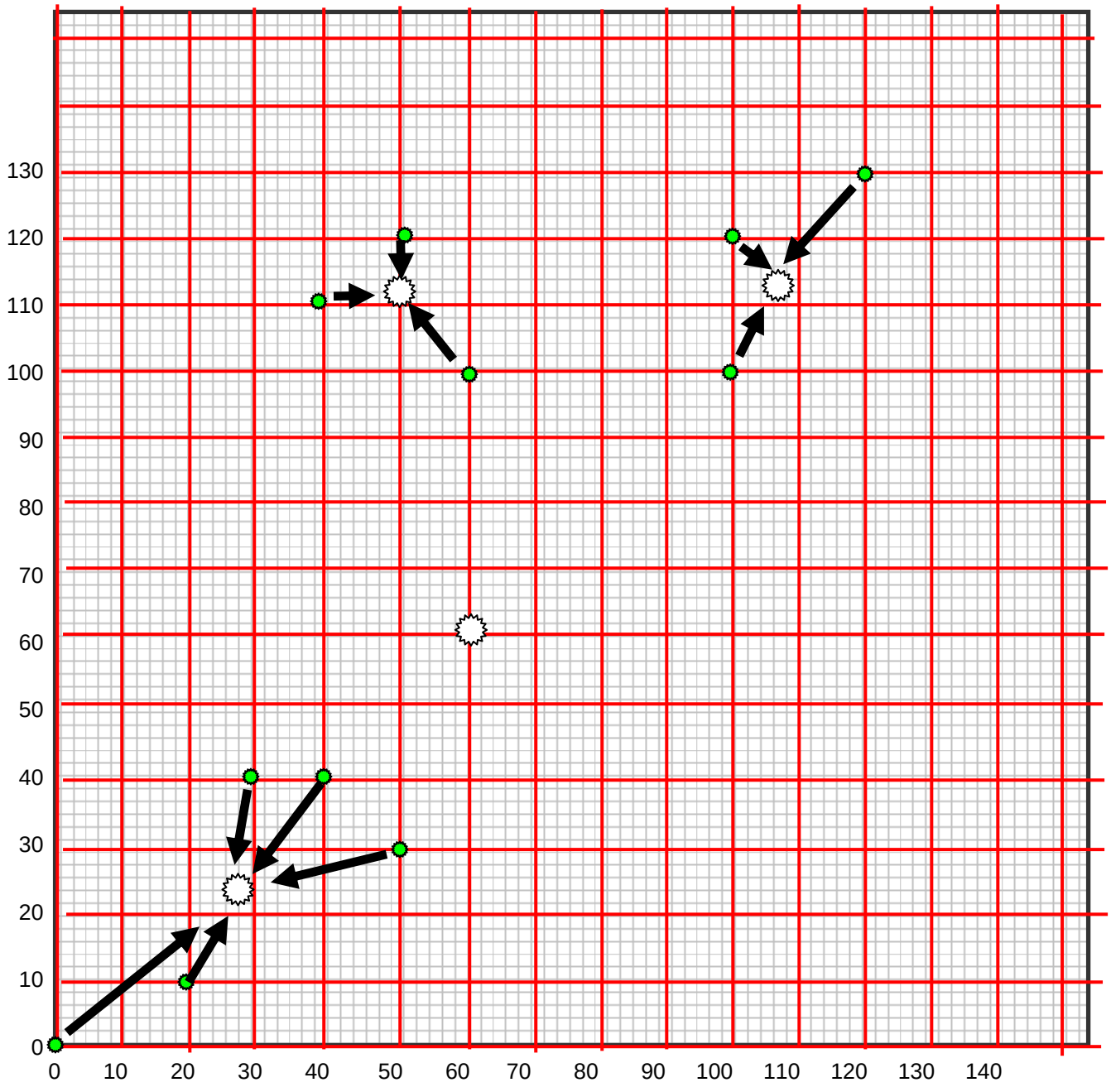
Next iteration…Assign the closest members.

Class	Members
1	(0,0) (20,10) (30,40) (40,40) (50,30)
2	none
3	(40,110) (50,120) (60,100)
4	**(100,100)** (100,120) (120,130)



3	50	110
4	106.67	113.33

Next iteration, assign members…



No members changed….so stop the ISODATA clustering.

Class	X-mean	Y-mean
1	28	24
2	60	60
3	50	110
4	106.67	113.33

The next step is to some rule to predict the spectral class of every pixel in the image. In this example, use the spectral distance rule to classify the original image:

Original Two-band Image

0	100	110	120	40	30
0	100	100	110	110	120
50	110	100	100	50	50
30	150	120	120	120	130
30	40	120	120	60	60
40	60	130	120	100	110
40	50	20	120	100	120
40	50	10	120	100	110

Classified Raster

1	4	4	4	3	3
1	4	4	4	3	3
1	2	4	4	3	3
1	2	1	4	4	3

Grouping Spectral Classes

You have the following spectral classes:

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Band1	65	75	65	60	55	60
Band 2	40	45	40	30	40	45
Band 3	30	35	40	35	35	30
Band 4	120	130	120	130	120	110
Band 5	80	90	80	90	70	60

Which spectral classes are similar to each other? One way to answer this question is to develop a map of spectral similarity called a dendrogram…

Step 1) Compute a matrix of spectral distances.

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Class 1	-	18.7	**10.0***	18.7	15.0	23.5
Class 2		-	16.6	21.2	30.4	39.4
Class 3			-	18.7	15.0	25.5
Class 4				-	25.0	39.4
Class 5					-	16.6
Class 6						-

Step 2) Group the most similar spectral classes and recomputed matrix:

	Class 1&3	Class 2	Class 4	Class 5	Class 6
Band1	65	75	60	55	60
Band 2	40	45	30	40	45
Band 3	35	35	35	35	30
Band 4	120	130	130	120	110
Band 5	80	90	90	70	60

	Class 1&3	Class 2	Class 4	Class 5	Class 6
Class 1&3	-	18.0	18.0	**14.1***	24.0
Class 2		-	21.2	30.4	39.4
Class 4			-	25.0	39.4
Class 5				-	16.6
Class 6					-

Step 3) Group the most similar spectral classes and recomputed matrix:

	Class 1&3&5	Class 2	Class 4	Class 6
Band1	61.67	75	60	60
Band 2	40	45	30	45
Band 3	35	35	35	30
Band 4	120	130	130	110
Band 5	76.67	90	90	60

	Class 1&3&5	Class 2	Class 4	Class 6
Class 1&3&5	-	21.9	**19.5***	20.75
Class 2		-	21.2	39.4
Class 4			-	39.4
Class 6				-

Step 4) Group the most similar spectral classes and recomputed matrix:

	Class 1&3&5&4	Class 2	Class 6
Band1	61.25	75	60
Band 2	37.5	45	45
Band 3	35.0	35	30
Band 4	122.5	130	110
Band 5	80.0	90	60

	Class 1&3&5 &4	Class 2	Class 6
Class 1&3&5 &4	-	**20.0***	25.3
Class 2		-	39.4
Class 6			-

Step 5) Group the most similar spectral classes and recomputed matrix:

	Class 1&3&5&4 & 2	Class 6
Band1	61.25	60
Band 2	37.5	45
Band 3	35.0	30
Band 4	122.5	110
Band 5	80.0	60

	Class 1&3&5 &4 &2	Class 6
Class 1&3&5 &4&2	-	27.5

Final step, draw a map of spectral similarities.