1. Exercises.

1.1 Watersheds

a. Define geodetic distance. Determine the geodetic distance between pixels (2,5) , and (4,7) in the set defined by the 9's in the given data. Use 8-connectivity.
.b. Identify the minimums in the given data.
c. Briefly describe the method for obtaining catchment basins.
d. Determine the catchment basins for the given data.

0	0	7	8	9	9	9	9
0	1	7	7	9	9	9	9
0	0	9	9	9	9	9	9
1	0	5	8	9	9	9	9
1	0	0	1	0	9	1	1
0	0	0	0	3	5	1	1
0	1	0	0	11	12	5	5
0	0	0	1	11	11	4	5

Image Data

the origin is in the lower left corner

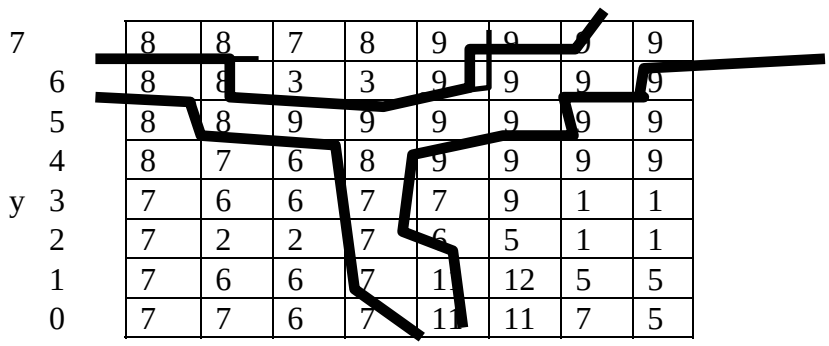
1.2

1.3 Watersheds

Determine the catchment basins for the given data.
explain your calculations.

y								
	7	8	8	7	8	9	9	9	9
	6	8	8	3	3	9	9	9	9
	5	8	8	9	9	9	9	9	9
	4	8	7	6	8	9	9	9	9
	3	7	6	6	7	7	9	1	1
	2	7	2	2	7	6	5	1	1
	1	7	6	6	7	11	12	5	5
	0	7	7	6	7	11	11	7	5
		0	1	2	3	4	5	6	7
			x						

Solution



1.4 Exercise

y								
7	8	8	7	8	9	9	9	9
6	8	8	3	3	9	9	9	9
5	8	8	9	9	9	9	9	9
4	8	7	6	8	9	9	9	9
3	7	6	6	7	7	9	1	1
2	7	2	2	7	6	5	1	1
1	7	6	6	7	11	12	5	5
0	7	7	6	7	11	11	7	5
	0	1	2	3	4	5	6	7
		x						

a.
Identify the minimums in the given data.

Solution

y								
7	8	8	7	8	9	9	9	9
6	8	8	3	3	9	9	9	9
5	8	8	9	9	9	9	9	9
4	8	7	6	8	9	9	9	9
3	7	6	6	7	7	9	1	1
2	7	2	2	7	6	5	1	1
1	7	6	6	7	11	12	5	5
0	7	7	6	7	11	11	7	5
	0	1	2	3	4	5	6	7
		x						

b.
Describe the method for obtaining catchment basins. Describe how boundaries between basins are handled.

Solution

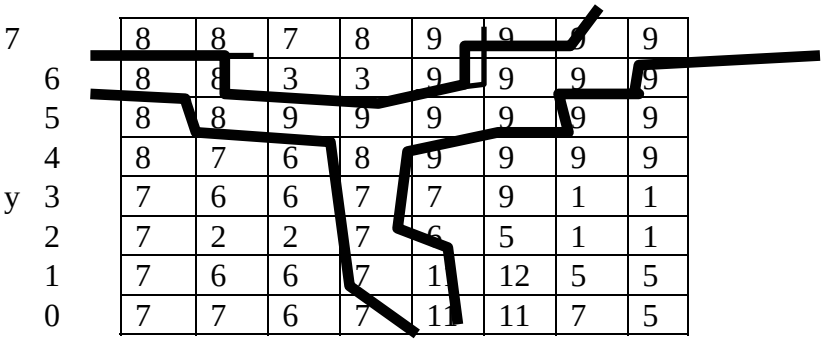
Suppose flooding has progressed to level h. Then every catchment basin whose minimum is $\leq h$ has a unique label. For the next level, one then needs to compute geodesic influence zones of the labeled regions within the T_{h+1} set of pixels. Consider pixels at gray-level h+1. Call this set W.. These are the pixels that must be included in the geodesic influence zones of the already labeled regions.

Step 1. Consider all pixels p in W where p has a neighbor in D a component of S_h. These pixels are of geodesic distance one from a component of S_h. If p has two neighbors in different components say D_1 and D_2 of S_h, then p is not a candidate for inclusion in the geodesic influence zone of any D component of S_h. Otherwise, place p in the geodesic

influence zone of D where D is in the neighborhood of p. . Call this new component of D as D'.
Step 2. We now iterate the process using D' instead of D.
Step 3. Continue until no more points at gray-level h+1 can be added to the existing catchment basins.
Step 4. Label the minimums at gray-level h+1.
Step 5. Increase h by one and repeat the entire process.

A boundary point between basin is a point to be considered to be added to a catchment basin in the flooding step where there are two different basins of distance one from the point. Use a 4-neighbor or 8-neighbor definition for distance if you want a 4-connected or 8-connected boundary

c.
determine the catchment basins for the given data.
explain your calculations.
Solution



y								
7	8	8	7	8	9	9	9	9
6	8	8	3	3	9	9	9	9
5	8	8	9	9	9	9	9	9
4	8	7	6	8	9	9	9	9
3	7	6	6	7	7	9	1	1
2	7	2	2	7	6	5	1	1
1	7	6	6	7	11	12	5	5
0	7	7	6	7	11	11	7	5

d.
For the watershed method, the data are assumed to be of a certain type. Explain this type.
Solution
The data are assumed to be elevation data in integer format.

e.
If the data are of light refectance, what must one do to get the data into the correct form for a watershed algorithm?
Solution
One must compute the magnitude of the gradient image, scale to positive integer values.

1.5 Exercise

a. identify the minimums in the given data.

b. Describe the method for obtaining catchment basins. Describe how boundaries between basins are handled.

c. determine the catchment basins for the given data.

explain your calculations.

y								
	7	8	8	7	9	9	9	8	7
	6	8	8	7	8	9	9	8	7
	5	8	8	7	9	9	9	7	7
	4	8	7	6	8	9	7	6	6
	3	7	6	6	7	9	7	1	1
	2	7	2	2	7	9	5	1	1
	1	7	6	6	7	11	12	5	5
	0	7	7	6	7	11	11	7	5
		0	1	2	3	4	5	6	7
			x						

Solution

a boundary point between basin is a point to be considered to be added to a catchment basin in the flooding step where there are two different basins of distance one from the point. Use a 4-neighbor or 8-neighbor definition for distance if you want a 4-connected or 8-connected boundary

y								
	7	8	8	7	9	9	9	8	7
	6	8	8	7	8	9	9	8	7
	5	8	8	7	9	9	9	7	7
	4	8	7	6	8	9	7	6	6
	3	7	6	6	7	9	7	1	1
	2	7	2	2	7	9	5	1	1
	1	7	6	6	7	11	12	5	5
	0	7	7	6	7	11	11	7	5
		0	1	2	3	4	5	6	7
			x						

1.6 Exercise

Watershed segmentation

a. Identify the minimums in the given data. Explain why they are a minimum.

b. How many catchment basins, regions, will result from the watershed algorithm applied to the following data?

d. If one of the minimums was removed, how many catchment basins, regions, would result from the watershed algorithm?

y								
7	8	8	7	9	9	9	8	7
6	8	8	7	8	9	9	8	7
5	8	8	7	9	9	9	7	7
4	8	7	6	8	9	7	6	6
3	7	6	6	7	9	7	1	1
2	7	2	2	7	9	5	1	1
1	7	6	6	7	11	12	5	5
0	7	7	6	7	11	11	7	5
	0	1	2	3	4	5	6	7
		x						

Solution

a boundary point between basin is a point to be considered to be added to a catchment basin in the flooding step where there are two different basins of distance one from the point. Use a 4-neighbor or 8-neighbor definition for distance if you want a 4-connected or 8-connected boundary

y								
7	8	8	7	9	9	9	8	7
6	8	8	7	8	9	9	8	7
5	8	8	7	9	9	9	7	7
4	8	7	6	8	9	7	6	6
3	7	6	6	7	9	7	1	1
2	7	2	2	7	9	5	1	1
1	7	6	6	7	11	12	5	5
0	7	7	6	7	11	11	7	5
	0	1	2	3	4	5	6	7
		x						

A minimum is defined as a region of constant gray-levels, say k, such that one in constructing a path to a lower gray-level must first increase in gray level above k before the gray-levels may decrease. We also allow the condition for the minimum to touch directly the boundary of the image.

There are two minimums and there would be two catchment basins formed from the image data.

If one of the minimums was removed, entirely, so that there is only one minimum, then the entire image would form one catchment basin. There would only be one region on the segmented image.

1.7 Exercise.

Watersheds

a.

For the watershed method, the data are assumed to be of a certain type. Explain this type.

b.

If the data are of light intensities, what must one do to get the data into the correct form for a watershed algorithm?

c.

The supplied data are intensity information. Convert it to the required form of data for the watershed algorithm to give a reasonable segmentation.

d.

Describe the method for obtaining catchment basins. Describe how boundaries between basins are handled.

e.

Determine the catchment basins for the data produced in part c. Give the minimums. Explain your calculations.

y								
7	8	8	8	9	2	2	2	2
6	8	8	8	8	2	2	2	2
5	8	8	7	9	2	2	2	2
4	8	7	8	8	2	2	2	2
3	7	8	6	7	2	2	1	1
2	7	8	8	7	2	2	1	1
1	7	8	8	7	2	2	2	2
0	7	7	7	7	2	2	2	2
	0	1	2	3	4	5	6	7
		x						

Solution

a. The data are assumed to be elevation data in integer format.

b. One must compute the magnitude of the gradient image, scale to positive integer values.

c. calculation using abs(g(x+1,y)-g(x,y)). This is a poor edge detector and only suffices to demonstrate the method.

y									
	7	0	0	1	7	0	0	0	0
	6	0	0	0	6	0	0	0	0
	5	0	1	2	7	0	0	0	0
	4	1	1	0	6	0	0	0	0
	3	1	2	1	5	0	1	0	0
	2	1	0	1	5	0	1	0	0
	1	1	0	1	5	0	0	0	0
	0	0	0	0	5	0	0	0	0
		0	1	2	3	4	5	6	7
			x						

e.
minimums are enclosed in dark lines.
Final watershed in dashed lines.