Instituto Superior de Agronomia
Geographic Information Systems 2013–2014
Third test, May 21, 2014
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One possible solution

1. Consider the following digital elevation model (DEM) data set with a 10m resolution and the derived slope raster data set.

DEM (resolution=10m)

15	11	8	8	9	13	18	21	23	24
19	15	11	9	10	13	17	21	22	24
21	19	15	12	10	12	16	20	21	23
23	21	19	16	13	13	14	18	20	22
25	23	21	19	17	14	15	16	18	20
27	25	23	21	20	17	15	16	17	19
28	27	25	23	22	20	18	16	17	18
30	29	27	25	24	23	21	19	17	17
32	31	29	28	27	25	24	22	19	18
34	33	31	30	29	28	27	24	23	20

Slope (rounded to 2 decimals)

	0.51	0.43	0.21	0.17	0.36	0.41	0.26	0.17	
	0.42	0.48	0.38	0.16	0.25	0.38	0.3	0.2	
	0.32	0.39	0.43	0.32	0.15	0.25	0.29	0.25	
	0.28	0.3	0.34	0.36	0.22	0.11	0.19	0.23	
	0.27	0.28	0.27	0.32	0.32	0.16	0.08	0.16	
	0.25	0.28	0.25	0.27	0.34	0.31	0.16	0.06	
	0.25	0.28	0.27	0.28	0.31	0.34	0.31	0.15	
	0.25	0.27	0.26	0.28	0.3	0.33	0.36	0.31	

(a) Write an expression using arithmetical and logical operations to reclassify the DEM raster data set according to the following table:

current value	new value
elevation less than 21m	0
elevation equal to 21 m	1
elevation higher than 21m and less than 25.5m	2
elevation equal or higher than 25.5m	3

One solution:

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0 * (DEM < 21) +
1 * (DEM = 21) +
2 * (DEM > 21 AND DEM < 25.5) +
3 * (DEM >= 25.5)
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(b) Estimate the flow direction at the gray pixel;

One solution: The flow direction is given by the vector $(-S_x, -S_y)$ where S_x is the estimate of the slope along the x direction and S_y is the estimate of the slope along the y direction. The usual estimates of S_x and S_y are:

$$S_x = \frac{(21-13)+2\times(20-12)+(18-13)}{8\times10} = 0.3625$$

$$S_y = \frac{(13-13)+2\times(17-14)+(21-18)}{8\times10} = 0.1125$$

Therefore, the estimated flow direction is given by the vector $(-0.3625, -0.1125)$ that points towards the third quadrant (since both coordinates are negative).

(c) Estimate the aspect of the surface at that pixel (if you haven't answered the previous question, consider that the estimates of the slope along the X direction and the y direction are, respectively, $S_x = 0.35$ and $S_y = 0.1$);

One solution: The aspect is the flow direction given by its azimuth (from North, clockwise). Since the flow direction points towards the 3rd quadrant, then the azimuth has to be between 180º and 270 º. More precisely it is $\arctan(S_x/S_y) + 180^o = \arctan(0.3625/0.1125) + 180^o = 72.758^o + 180^o = 252.758^o$. Its direction is W.

(d) Apply a uniform moving window with the following kernel

$$\begin{bmatrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{bmatrix}$$

to the DEM at the location in gray. In general, what is the effect of applying a uniform moving window to a raster data set?

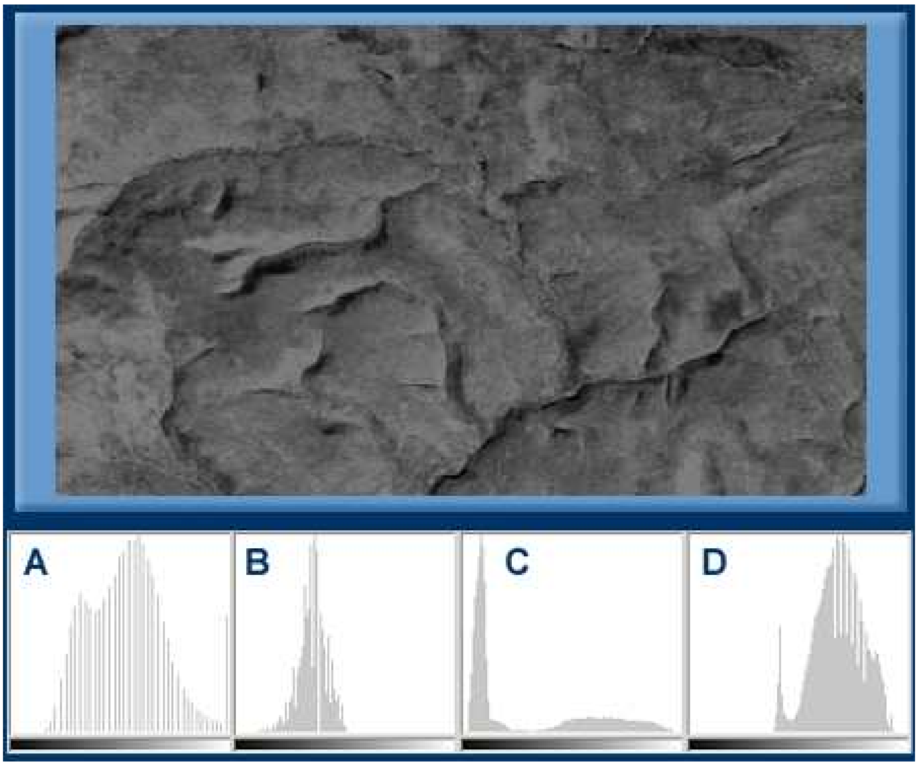
One solution: The result of the application of the moving window to the pixel in gray returns

$$\frac{1}{9} \times 13 + \frac{1}{9} \times 17 + \frac{1}{9} \times 21 + \frac{1}{9} \times 12 + \frac{1}{9} \times 16 + \frac{1}{9} \times 20 + \frac{1}{9} \times 13 + \frac{1}{9} \times 14 + \frac{1}{9} \times 18 = 16.$$

Since the windows is uniform (i.e. all the weights of the kernel are equal) and the weights are $\frac{1}{9}$ for a kernel with 9 cells, then this is just the average of the window values. In general, the application of a moving window like this one is going to *smooth* the input image.

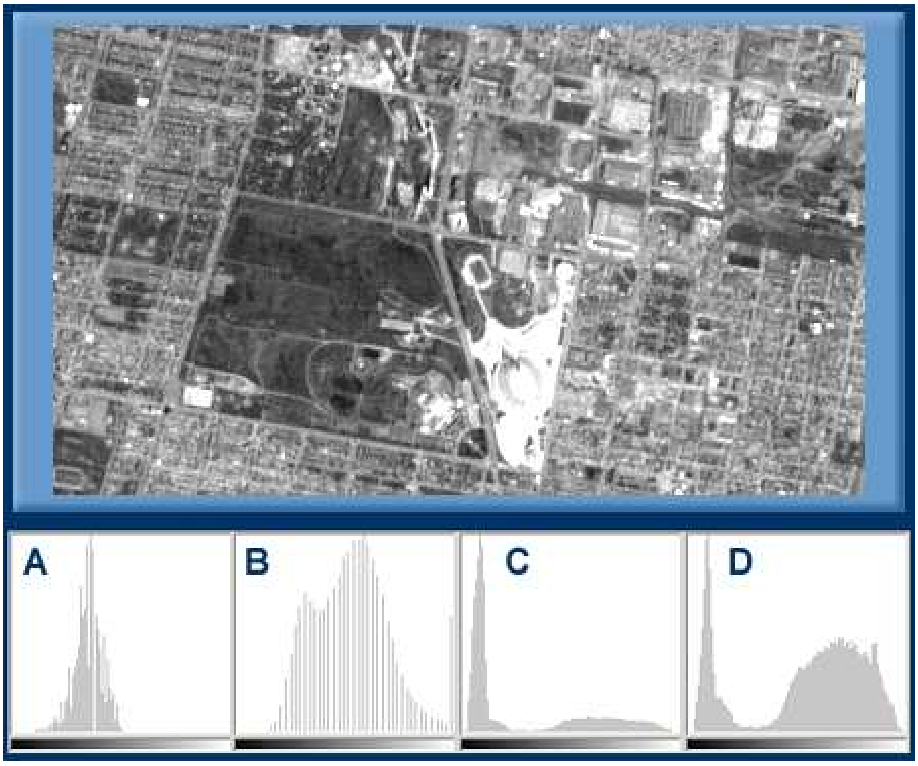
2. Consider the following raster data sets. Indicate the correct histogram for each one and explain your choice. Note that the x axis of the histogram indicates *increasing* cell values (from left to right) and the y axis indicates frequencies (number of pixels) .

(a) Raster 1:



One solution: The answer is B, since it is a a mostly dark gray image, with low contrast. A would correspond to an raster with the whole range of digital numbers, for 0 to the maximum, with a saturation for bright pixels (see following problem). C corresponds to an image with mostly very dark pixels (very low digital numbers) and some bright pixels, up to to the maximum digital number. D would correspond to a bright image.

(b) Raster 2:



One solution: The answer is B since it is the histogram of a raster with the whole range of digital numbers, for 0 to the maximum, with a saturation for bright pixels. A is the histogram of the previous problem. C corresponds to an image with mostly very dark pixels (very low digital numbers) and some bright pixels, up to to the maximum digital number. D would correspond to an image with approximately 1/4 of very dark pixels, and 3/4 of bright and very bright pixels, with a gap in between.

(c) Which one of the above images is likely to benefit from a linear contrast enhancement? (if you have answered to the previous questions, use your answers explain your choice; otherwise explain how a linear contrast enhancement would modify the intensity of the images, and choose the image that would benefit the most from that technique by inspecting visualy each of them).

One solution: The image that would benefit the most from linear enhancement would be the image from problem (a). If we call z_{min} the value associated to the left tail of the histogram, and z_{max} the value associated to the right tail of the histogram, the contrast of the image could be enhanced by given the lowest intensity to z_{min} and the maximum intensity to z_{max}. Applying the same procedure to the image of problem (b), would not change significantly the intensity of its pixels (and therefore its contrast).

3. Whenever a GPS receiver is turned on, a synchronization process starts. The user must wait until the synchronization process is over before gathering data. Explain why prior synchronization is necessary to obtain accurate positional data.

   One solution: On GPS satellites, timing is almost perfect since satellites use precise atomic clocks. Atomic clocks are too expensive to be used by GPS receivers. Therefore, GPS receivers do a fourth measurement (in addition to the three measurements that would be sufficient to determine the position if the clocks were perfectly synchronized) to determine a correction factor that can be applied to its own (imprecise) timing measurements. This is called the “the synchronization process”.