Grey Level Co-occurrence Matrices

National Oceanography Centre

Rationale:

This tool creates Grey-Level Co-occurrence Matrices (GLCM) grids for an input grid, such as a backscatter mosaic. Matrices include: Contrast, Dissimilarity, Homogeneity, Energy, Entropy, Angular Second Momentum (ASM), Standard Deviation, and Mean. Options include pixel box size, sampling distance, grey levels and pixel pair angle. These equate to different types of texture measurements of the input imagery. They are sometimes referred to as second-order derivatives.

Usage:

This tool requires six user inputs:

- An input image. This image will be converted into an 8 bit grey-scale image for processing. This bathymetry file must be in a meter projection such as UTM or Mercator and not geographic coordinates.
- Eight GLCMs are available for calculation, the pull-down menu lists all of them.
- Sampling Box is the size of the area in pixels over which the texture is measured. Default size is 5 pixels square. A larger box will result in lower resolution detection.
- Sampling distance is the pixel to pixel distance measuring the image's calculation of texture. Default size is 1 pixel. A larger value may result in smoother changes in texture.
- Number of grey-levels is set as 8 as default. It reduces the number of texture levels. Greater values will slow the calculation process and may be limited by the available memory of the processor
- The pixel pair angle can be altered by the user to any direction. It is the direction that comparison and calculations are made for the texture mapping equations.

The output raster filename is automatically generated from the input filename plus the GLCM type and its 4 parameters. This can be edited by the user

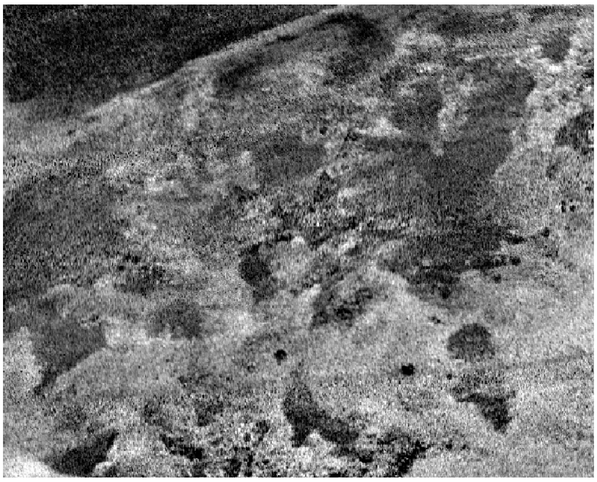
The equations and some descriptors for the GLCMs are:

$Contrast = \sum_i \sum_j (i-j)^2 * P(i,j)$	Contrast, also known as inertia, is a measure that describes the degree to which the intensity of different pixels in an image varies. If contrast is high, it means that there is a lot of variation in pixel intensity.
$Dissimilarity = \sum_i \sum_j \lvert i-j \rvert * P(i,j)$	Measures the average difference in intensity between neighbouring pixels. High dissimilarity values indicate greater heterogeneity in texture.
$Homogeneity = \sum_i \sum_j \frac{P(i,j)}{1+(i-j)^2}$	Homogeneity is a measure that reflects the degree to which the matrix elements are close to the diagonal of the GLCM matrix. The homogeneity value will be high if the matrix elements that have high values are located near the diagonal.

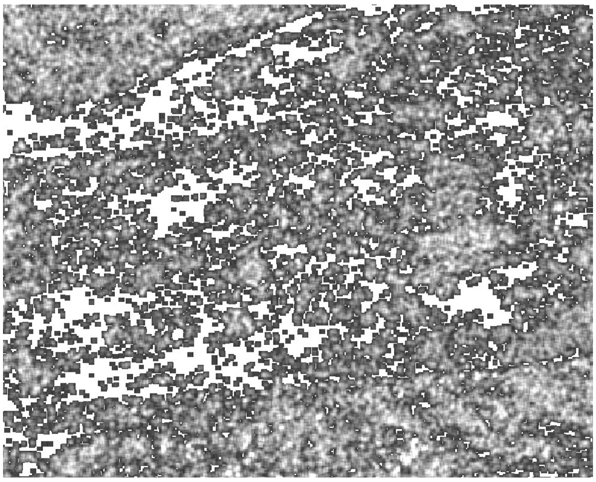
$$Energy = \sqrt{\sum_i \sum_j P(i,j)^2}$$	The energy value will be high if the elements in the image tend to have the same or uniform values.
$$Entropy = -\sum_i \sum_j P(i,j) * \log(P(i,j))$$	Entropy is a measure of the complexity of the texture or information contained in an image. Higher entropy values indicate higher texture or information complexity.
$$Correlation = \frac{\sum_i \sum_j [ij * P(i,j)] - \mu_x * \mu_y}{\sigma_x * \sigma_y}$$ $Similar\ to\ Standard\ Deviation\ and\ Variance$	Correlation is a measure that describes the extent of the relationship between two pixels. A high correlation indicates a strong dependency between two pixels.
$$Angular\ Second\ Momentun = \sum_i \sum_j P(i,j)^2$$	ASM is very similar to energy value output, where values will be high if the elements in the image tend to have the same or uniform values.
$$Mean = \sum_i \sum_j P(i,j)$$	Mean measures the frequency of the combination with neighbouring pixel values.

Example:

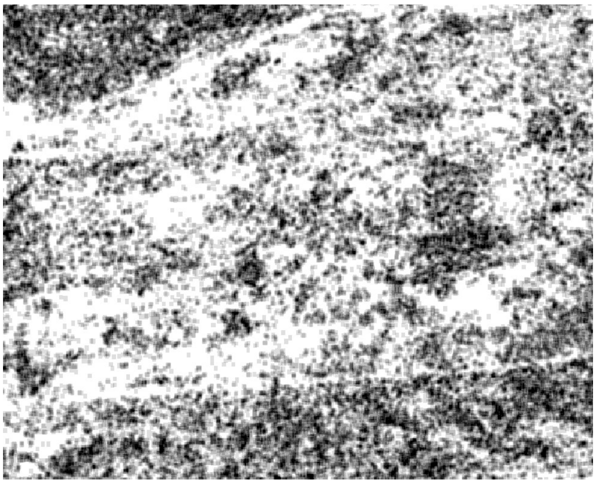
Multibeam backscatter



Contrast – 5x5 box 1 pixel sampling



Homogeneity – 5x5 box 1 pixel sampling



Entropy – 5x5 box 1 pixel sampling