“what is or is not a cow is for the public to decide.”

-L. Wittgenstein

-Image Classification-

Gray Level Co-Occurrence Matrix (GLCM)

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What is it?

- A co-occurrence matrix, also referred to as a co-occurrence distribution, is defined over an image to be the distribution of co-occurring values at a given offset

Or

Represents the distance and angular spatial relationship over an image sub-region of specific size.

What are Co-occurring Values?

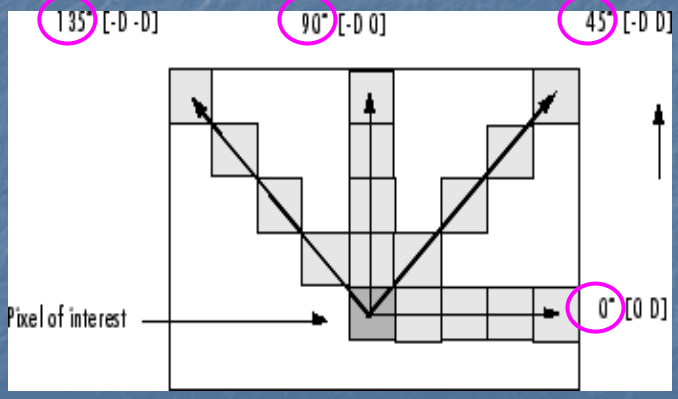
- The GLCM is created from a gray-scale image.
- The GLCM is calculates how often a pixel with gray-level (grayscale intensity or Tone) value *i* occurs either horizontally, vertically, or diagonally to adjacent pixels with the value *j* .

GLCM directions of Analysis

- 1. Horizontal (0^0)
- 2. Vertical (90^0)
- 3. Diagonal:
  - a.) Bottom left to top right (-45^0)
  - b.) Top left to bottom right (-135^0)

- Denoted P_0, P_{45}, P_{90}, & P_{135} Respectively.
- Ex. $P_0(i, j)$

Example of directional Analysis P_0, P_{45}, P_{90}, & P_{135}



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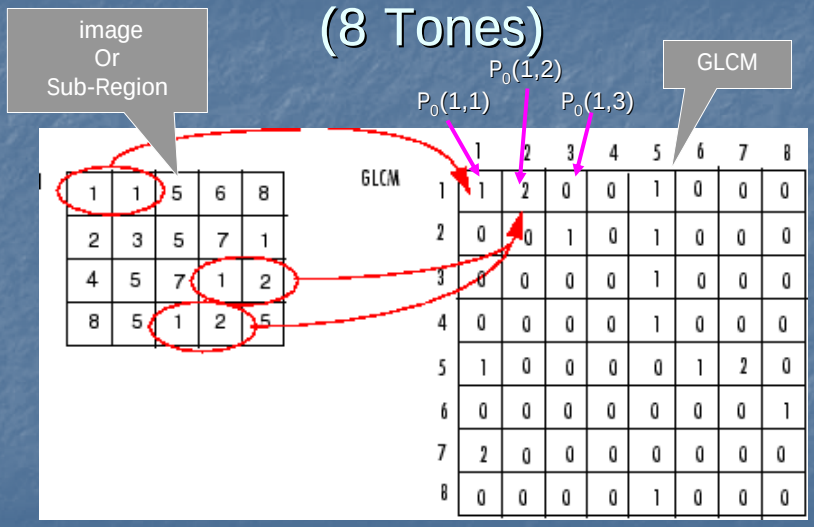
- Where *i* & *j* are the gray level values (tone) in the image.
- This is based in the resolution of the image (i.e. does the image have 8 gray tones or 256?)

Example Image (8 Tones)



After you create the GLCMs, you can derive several statistics from them using the different formulas.

These statistics provide information about the texture of an image.

Property	Description	Formula
'Contrast'	Returns a measure of the intensity contrast between a pixel and its neighbor over the whole image. Range = [0 (size(GLCM,1)-1)^2] Contrast is 0 for a constant image.	$\sum_{i,j} \lvert i-j \rvert^2 p(i,j)$
'Correlation'	Returns a measure of how correlated a pixel is to its neighbor over the whole image. Range = [-1 1] Correlation is 1 or -1 for a perfectly positively or negatively correlated image. Correlation is NaN for a constant image.	$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j}$
'Energy'	Returns the sum of squared elements in the GLCM. Range = [0 1] Energy is 1 for a constant image.	$\sum_{i,j} p(i,j)^2$
'Homogeneity'	Returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. Range = [0 1] Homogeneity is 1 for a diagonal GLCM.	$\sum_{i,j} \frac{p(i,j)}{1+\lvert i-j \rvert}$

Example

- The textures below were run using a 7x7 window.
- All used the invariant direction, which is an average of all four spatial arrangements.
- Pixel offset is 1 in all cases.

Original Image

GLCM Contrast

Original Image

GLCM Homogeneity

Sources:

- http://www.mathworks.com/access/helpdesk/help/toolbox/images/index.html?/access/helpdesk/help/toolbox/images/graycomatrix.html&http://www.google.com/search?hl=en&client=firefox-a&rls=org.mozilla:en-US:official&hs=Os5&sa=X&oi=spell&resnum=0&ct=result&cd=1&q=grayscale+cooccurrence+matrix+example&spell=1
- http://www.fp.ucalgary.ca/mhallbey/tutorial.htm
- http://www.fp.ucalgary.ca/mhallbey/examples.htm
- Our Book