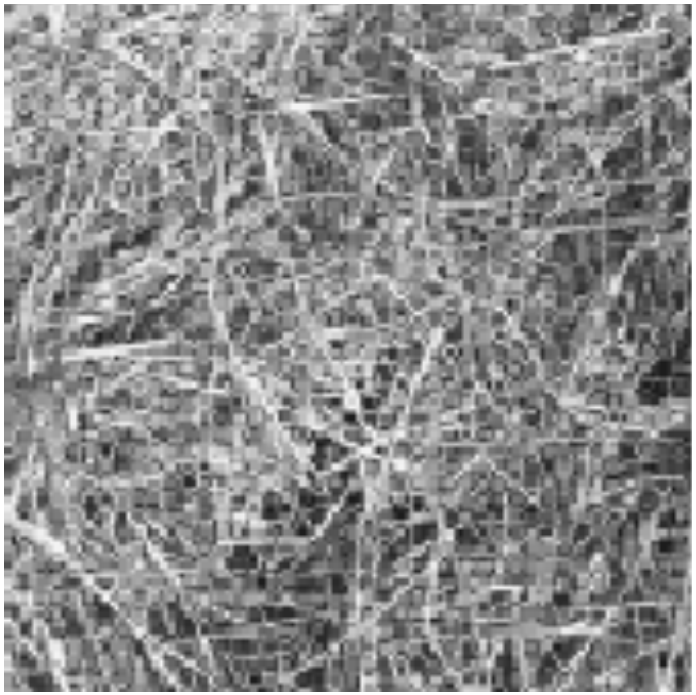
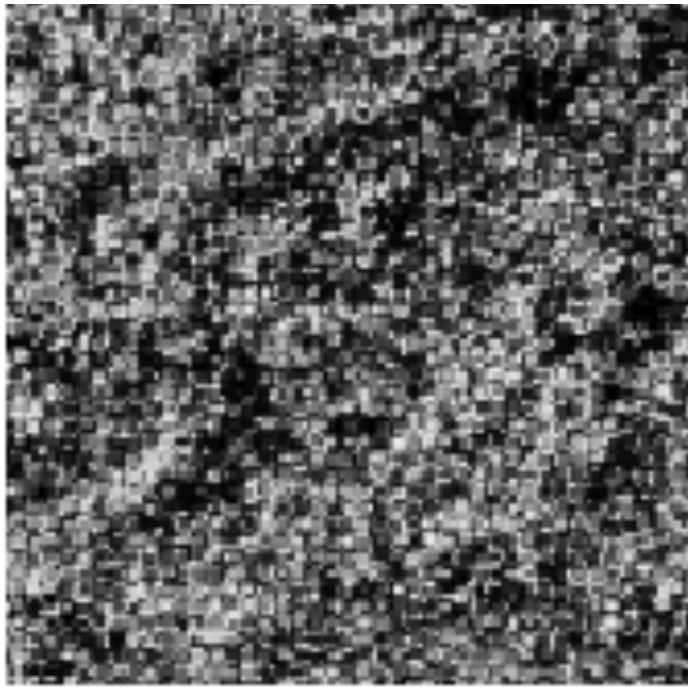
Natural Textures



grass



leaves

What/where are the textures?
How to describe the textures?

Some Simple Statistical Texture Measures

1. Edge Density and Direction

- Use an edge detector as the first step in texture analysis.
- The number of edge pixels in a fixed-size region tells us how busy that region is.
- The directions of the edges also help characterize the texture

Two Edge-based Texture Measures

1. edgeness per unit area

$$F_{edgeness} = |\{ p \mid gradient\_magnitude(p) \geq threshold \}| / N$$

where N is the size of the unit area

2. edge magnitude and direction histograms

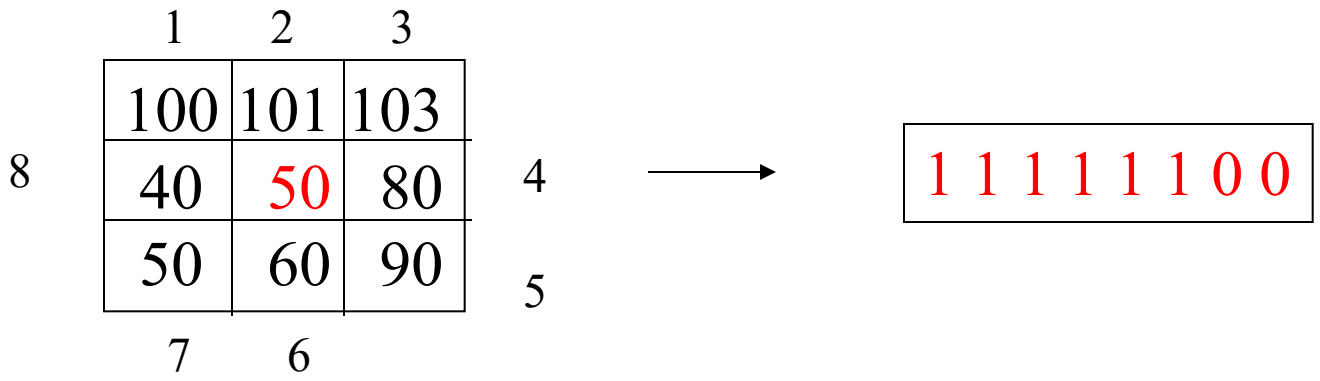
$$F_{magdir} = (H_{magnitude}, H_{direction})$$

where these are the normalized histograms of gradient magnitudes and gradient directions, respectively.

Local Binary **Pattern** Measure

- For each pixel p, create an 8-bit number $b_1\ b_2\ b_3\ b_4\ b_5\ b_6\ b_7\ b_8$, where $b_i = 0$ if neighbor i has value less than or equal to p's value and 1 otherwise.

- Represent the texture in the image (or a region) by the histogram of these numbers.



Local Binary Pattern (LBP)

$$LBP_{p,r}(N_c) = \sum_{p=0}^{P-1} g\left(N_p - N_c\right)2^p$$

N_c: center pixel
N_p: neighbor pixel
r: radius (for 3x3 cell, it is 1).

binary threshold function $g(x)$ is,

$$g(x) = \begin{cases} 0, & x < 0 \\ 1, & x \geq 0 \end{cases}$$

Co-occurrence Matrix Features

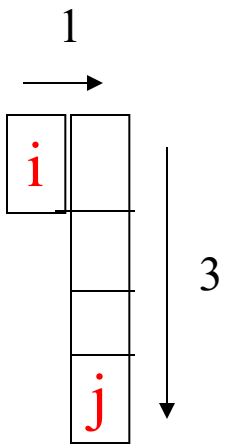
A co-occurrence matrix is a 2D array C in which

- Both the rows and columns represent a set of possible image values.
- $C_d(i,j)$ indicates how many times value i co-occurs with value j in a particular spatial relationship d.
- The spatial relationship is specified by a vector d = (dr,dc).

Co-occurrence Example

1	1	0	0
1	1	0	0
0	0	2	2
0	0	2	2
0	0	2	2
0	0	2	2

gray-tone image



d = (3,1)

	0	1	2
0	1	0	3
1	2	0	2
2	0	0	1

C_d

co-occurrence matrix

From C_d we can compute N_d, the normalized co-occurrence matrix, where each value is divided by the sum of all the values.

But how do you choose d?

- This is actually a critical question with **all** the statistical texture methods.
- Are the "texels" tiny, medium, large, all three …?
- Not really a solved problem.