



Texture in Medical Images

Dr. Debdoott Sheet

Assistant Professor

Department of Electrical Engineering
Indian Institute of Technology Kharagpur

www.facweb.iitkgp.ernet.in/~debdoot/



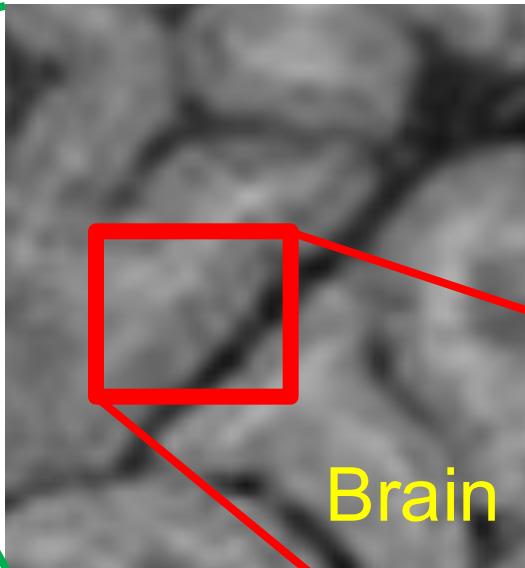
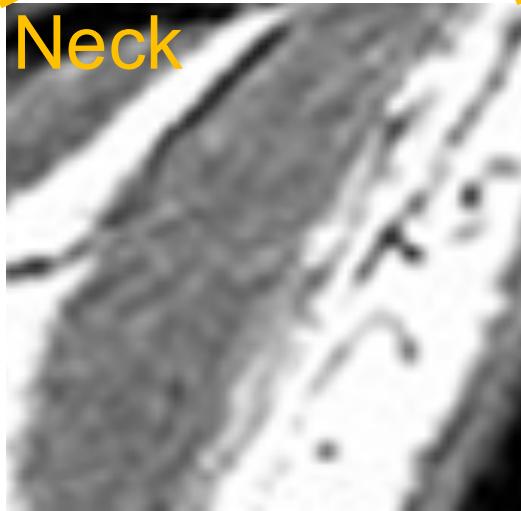
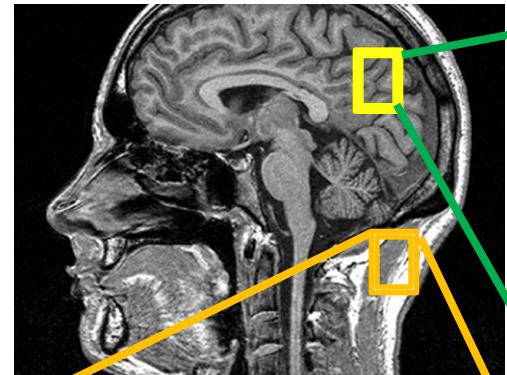


Contents

- Introductory concepts
- Texture characterization – statistical vs. structural
- Co-occurrence matrices
- Orientation histograms
- Local binary patterns (LBP)
- Texture from Fourier features
- Wavelets



Introductory Concepts



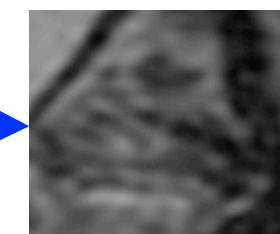
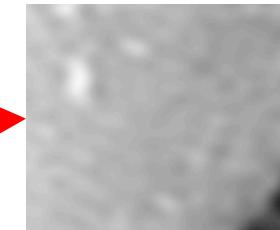
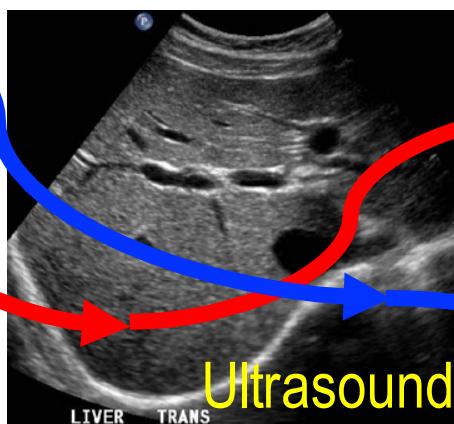
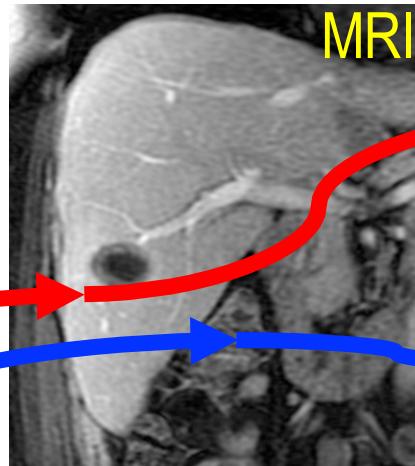
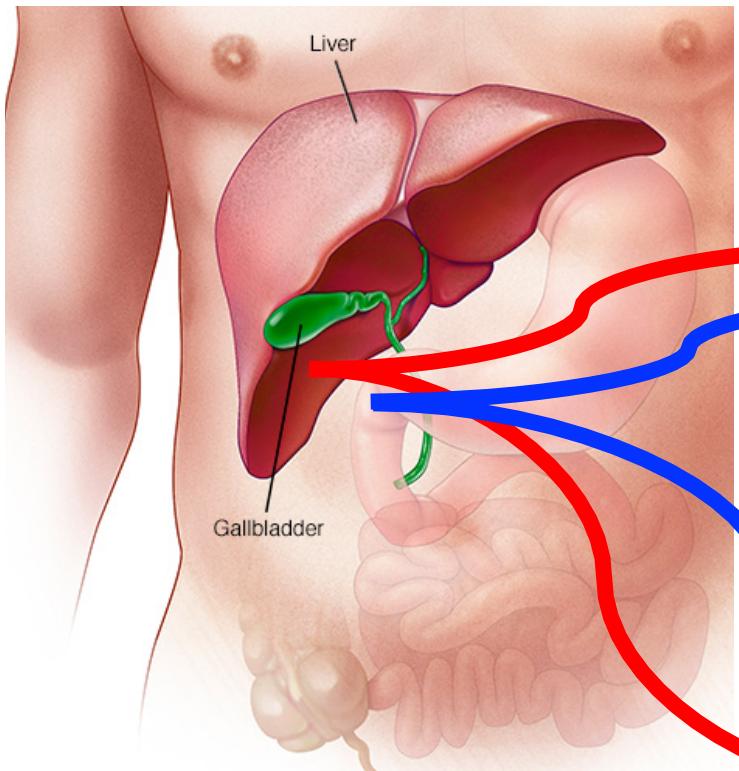
Noise
Uncertainty in image sensing by the instrument



Texture
Local variation in intensity due to tissue heterogeneity



Structural vs. Statistical Textures



Liver
parenchyma

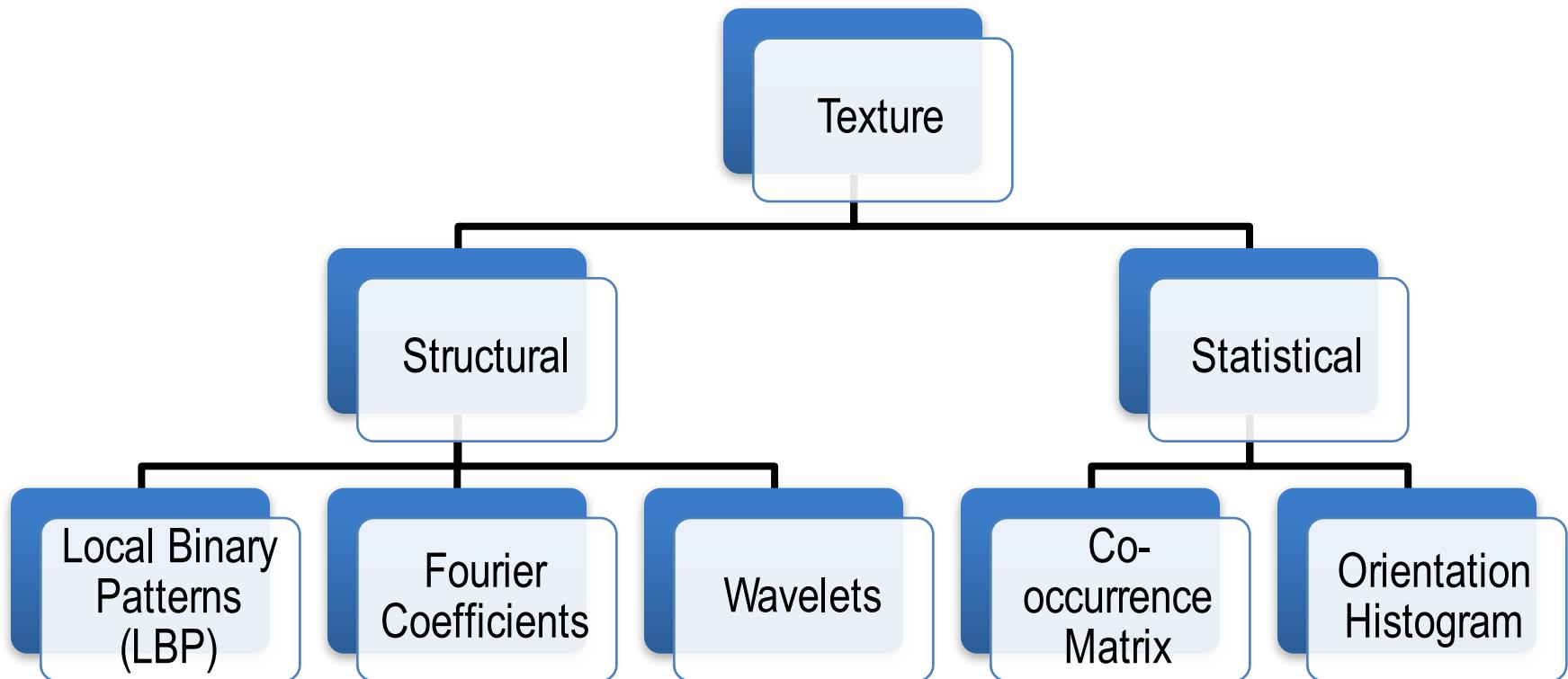
External
tissue

Liver
parenchyma

External
tissue



Family of Texture Metrics



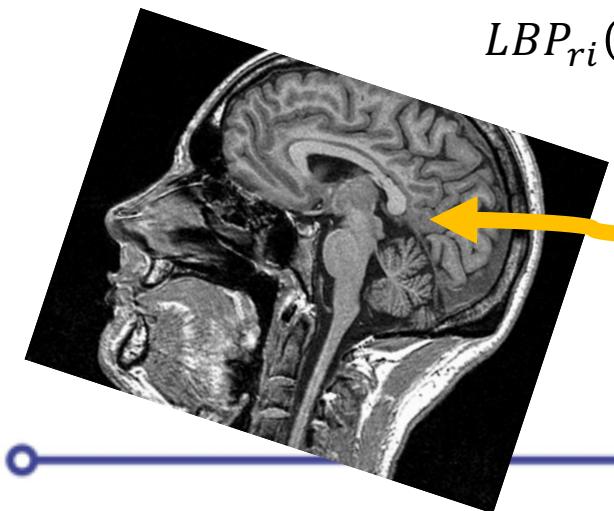
Local Binary Patterns



$$b_k = \begin{cases} 1 & \text{if } g_k \geq g(\mathbf{x}) \\ 0 & \text{otherwise} \end{cases}$$

$$LBP_{ri}(\mathbf{x}) = \min\{P_j\}$$

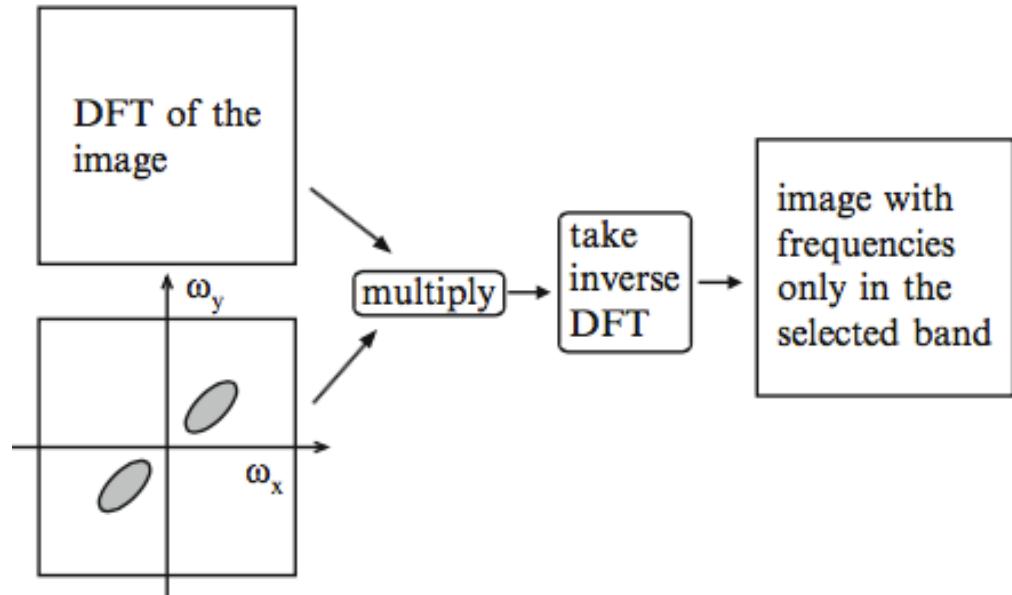
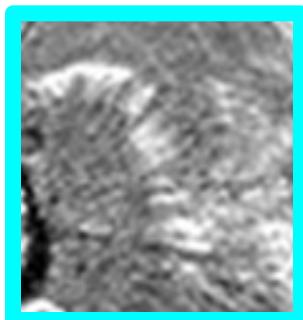
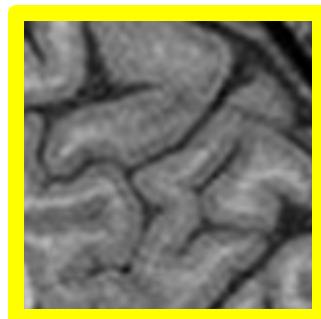
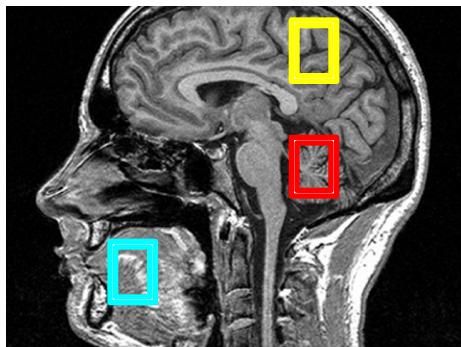
6	10	12
7	7	9
10	16	19



1	1	1	1	1	1	1	0	$P_0=254$
1	1	1	1	1	1	0	1	$P_1=253$
1	1	1	1	1	0	1	1	$P_2=251$
1	1	1	1	0	1	1	1	$P_3=247$
1	1	1	0	1	1	1	1	$P_4=239$
1	1	0	1	1	1	1	1	$P_5=223$
1	0	1	1	1	1	1	1	$P_6=191$
0	1	1	1	1	1	1	1	$P_7=127$



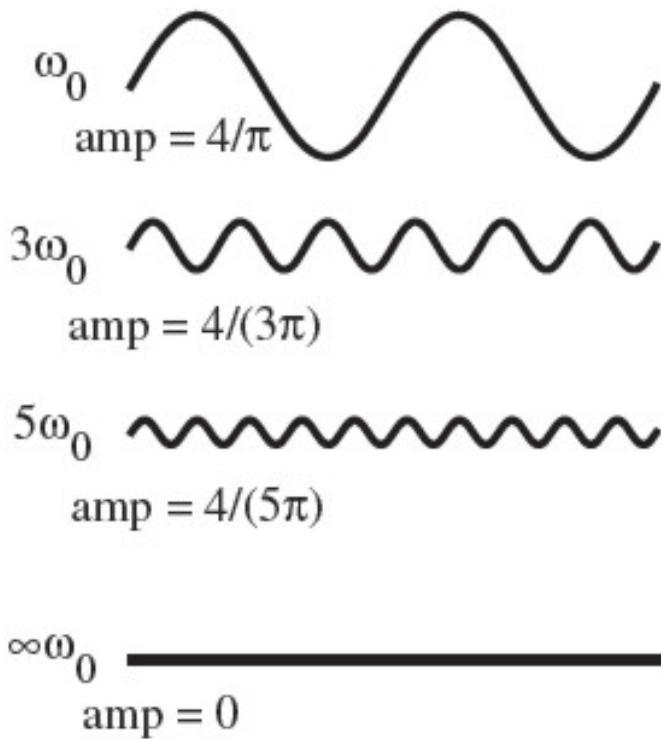
Texture from Fourier Features



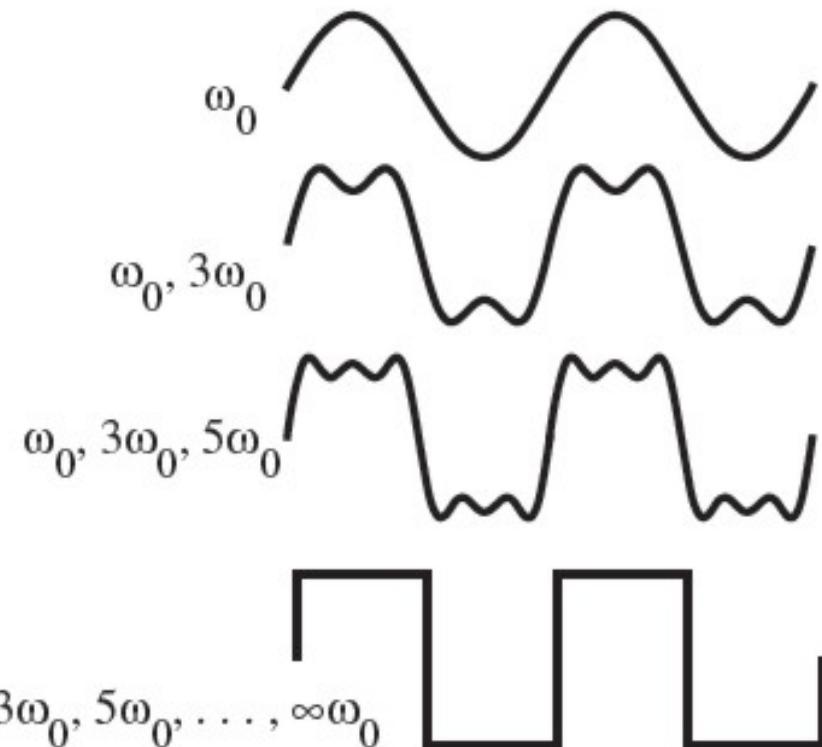


Wavelet Texture Descriptors

individual harmonics



combined harmonics





Laws Masks

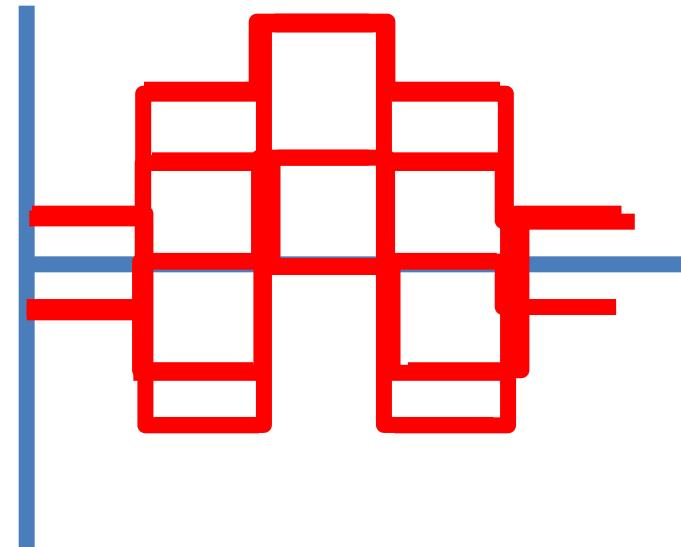
Level: $L_5 = [1, 4, 6, 4, 1]$

Edge: $E_5 = [-1, -2, 0, 2, 1]$

Spot: $S_5 = [-1, 0, 2, 0, -1]$

Wave: $W_5 = [-1, 2, 0, -2, 1]$

Ripple: $R_5 = [1, -4, 6, -4, 1]$



$$L_5^T \times S_5 = \begin{bmatrix} -1 & 0 & 2 & 0 & -1 \\ -4 & 0 & 8 & 0 & -4 \\ -6 & 0 & 12 & 0 & -6 \\ -4 & 0 & 8 & 0 & -4 \\ -1 & 0 & 2 & 0 & -1 \end{bmatrix}$$

$$E_5^T \times S_5 = \begin{bmatrix} 1 & 0 & -2 & 0 & 1 \\ 2 & 0 & -4 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 \\ -2 & 0 & 4 & 0 & -2 \\ -1 & 0 & 2 & 0 & -1 \end{bmatrix}$$



Gabor Wavelets

$$G(x, y) = \frac{1}{2\pi\sigma\beta} e^{-\pi\left(\frac{(x-x_0)^2}{\sigma^2} + \frac{(y-y_0)^2}{\beta^2}\right)} e^{i(\xi_0 x + \nu_0 y)}$$

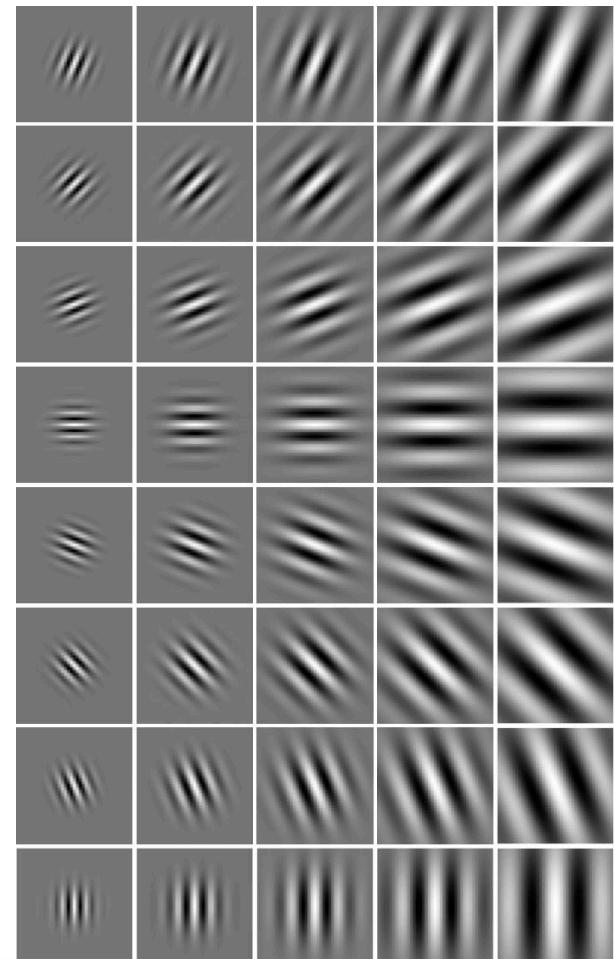
Gaussian

Sinusoidal

(x_0, y_0) = centroid of receptive field

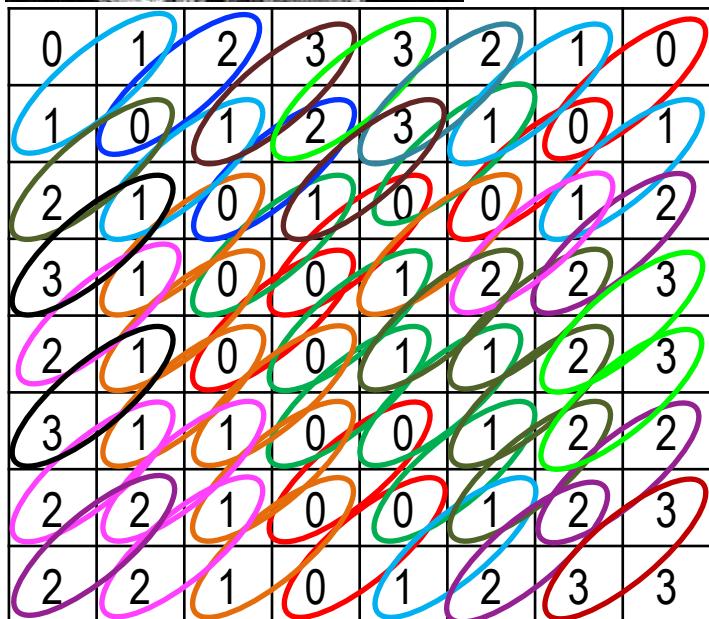
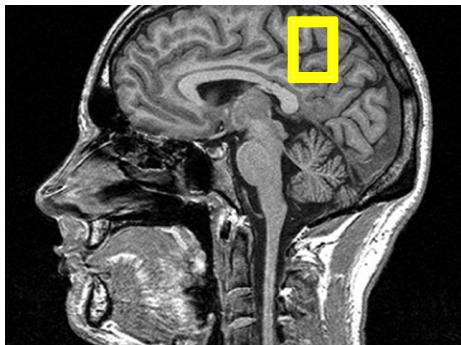
(ξ_0, ν_0) = spatial frequency

(σ, β) = std. dev. of elliptical Gaussian





Co-occurrence Matrices



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

Operator: NE 1px

	0	1	2	3
0	6/49	6/49	2/49	0
1	1/7	5/49	4/49	2/49
2	1/49	5/49	4/49	3/49
3	0	2/49	1/49	1/49

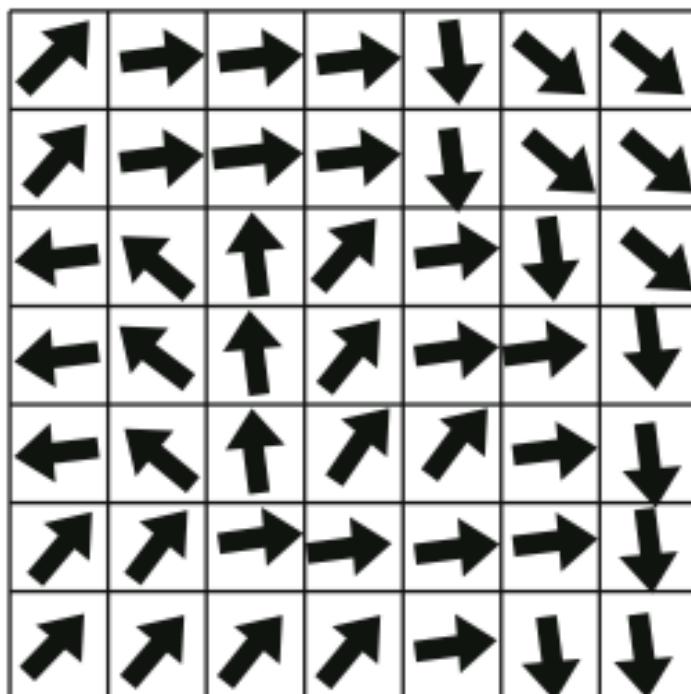
Probability

$$Energy = \sum_{a,b} P_{\varphi,d}^2(a, b)$$

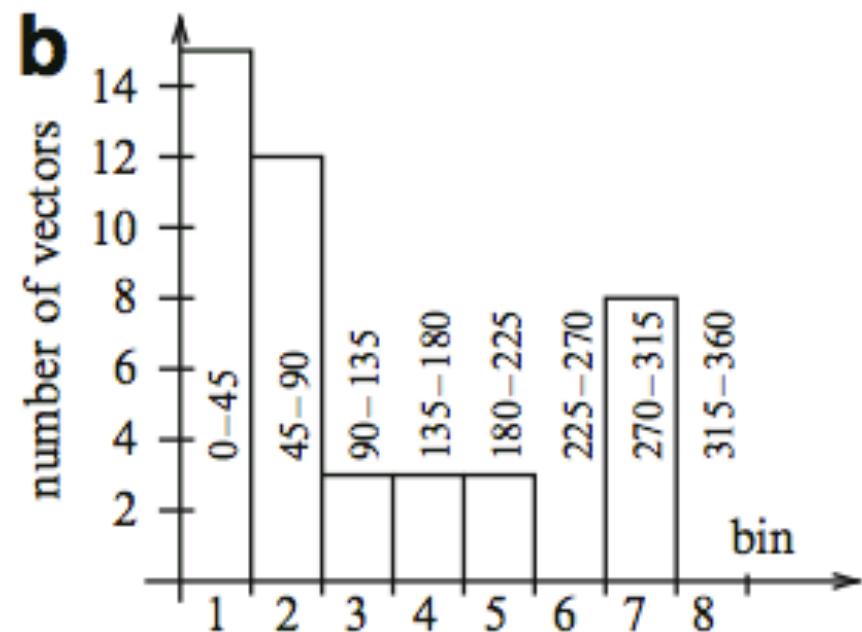
$$Entropy = \sum_{a,b} P_{\varphi,d}(a, b) \log(P_{\varphi,d}(a, b))$$

$$Contrast = \sum_{a,b} |a - b|^\kappa P_{\varphi,d}^\lambda(a, b)$$

Orientation Histogram

a

Local orientation in an image

b

Histogram of orientation



Take home message

- M. Petrou, "Texture in Biomedical Images", *Biomedical Image Processing*, [Ed. T. M. Deserno], pp. 157-176, 2011, Springer-Verlag.
- M. Petrou and P. G. Sevilla, *Image Processing Dealing with Texture*, John Wiley and Sons, Ltd. 2006.