Feature Extraction for Visual Computing

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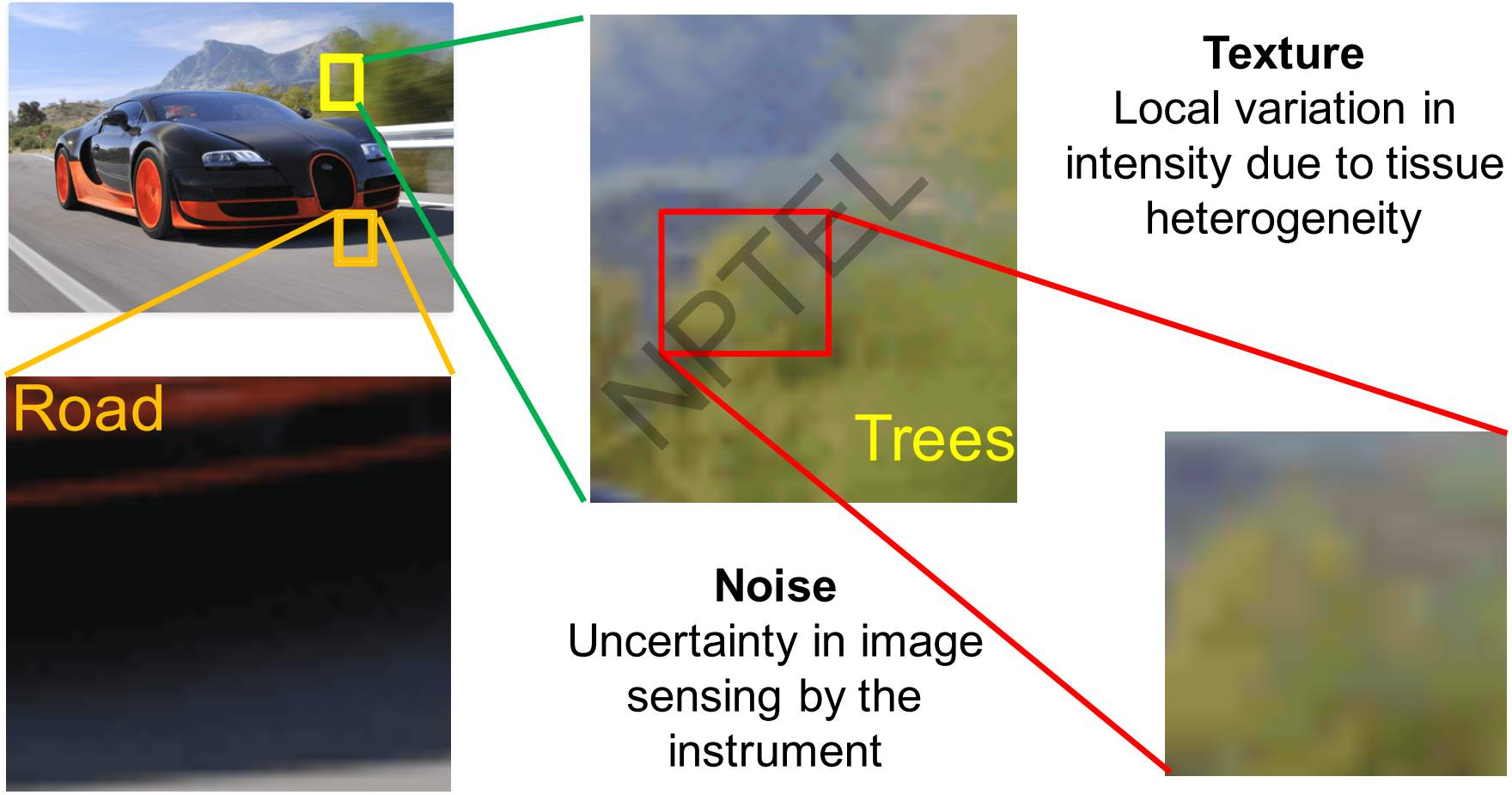
Introductory Concepts



Texture
Local variation in intensity due to tissue heterogeneity

Noise
Uncertainty in image sensing by the instrument

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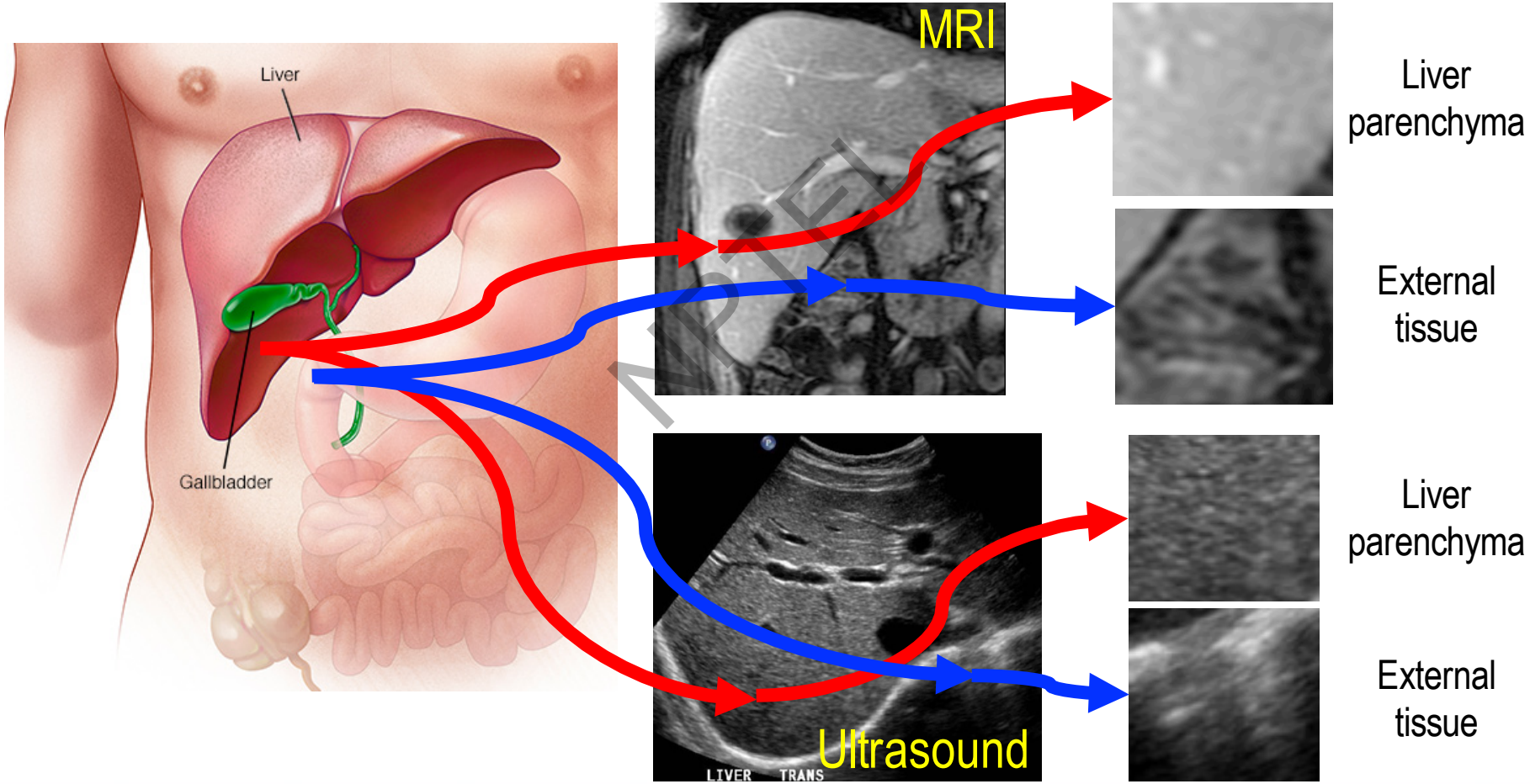
Structural vs. Statistical Textures



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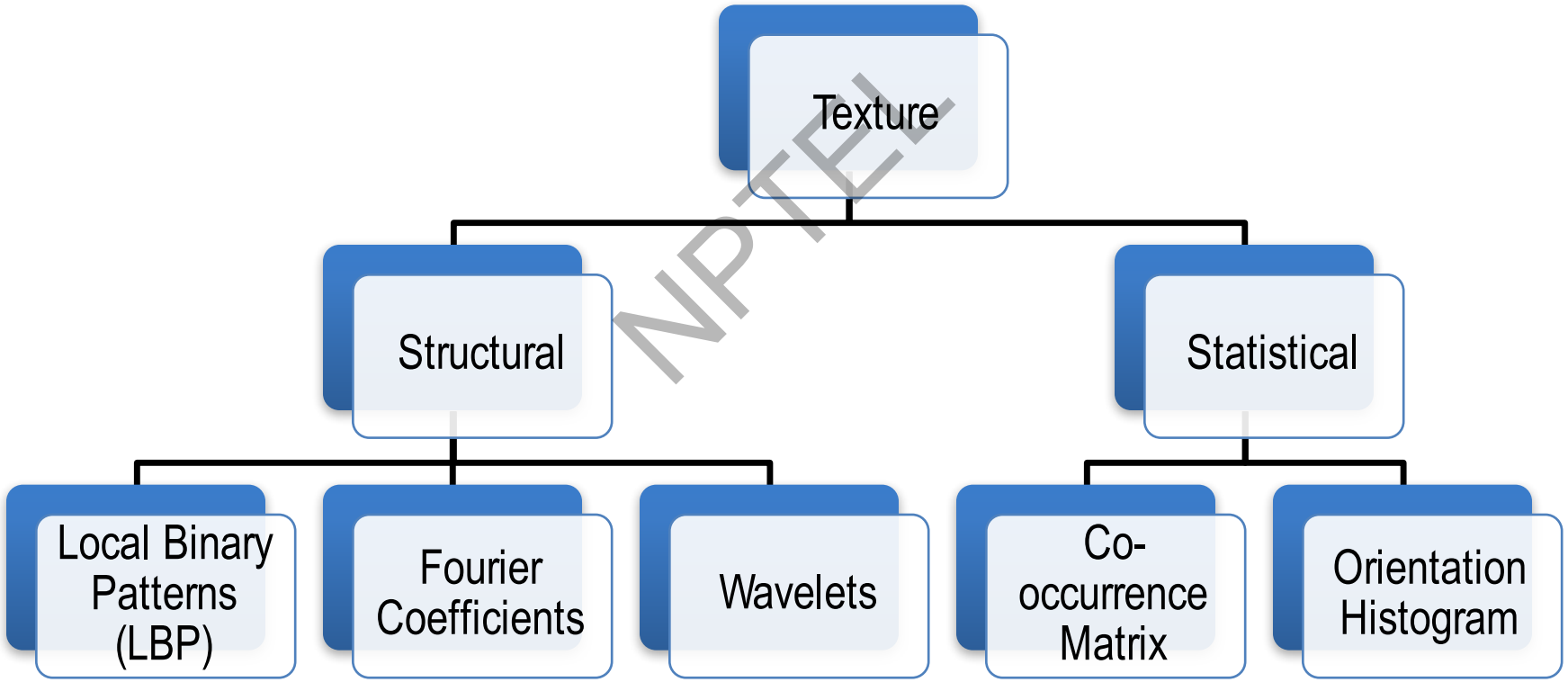
Family of Texture Metrics



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Local Binary Patterns

10	12	9
6	7	19
7	10	16

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

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

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

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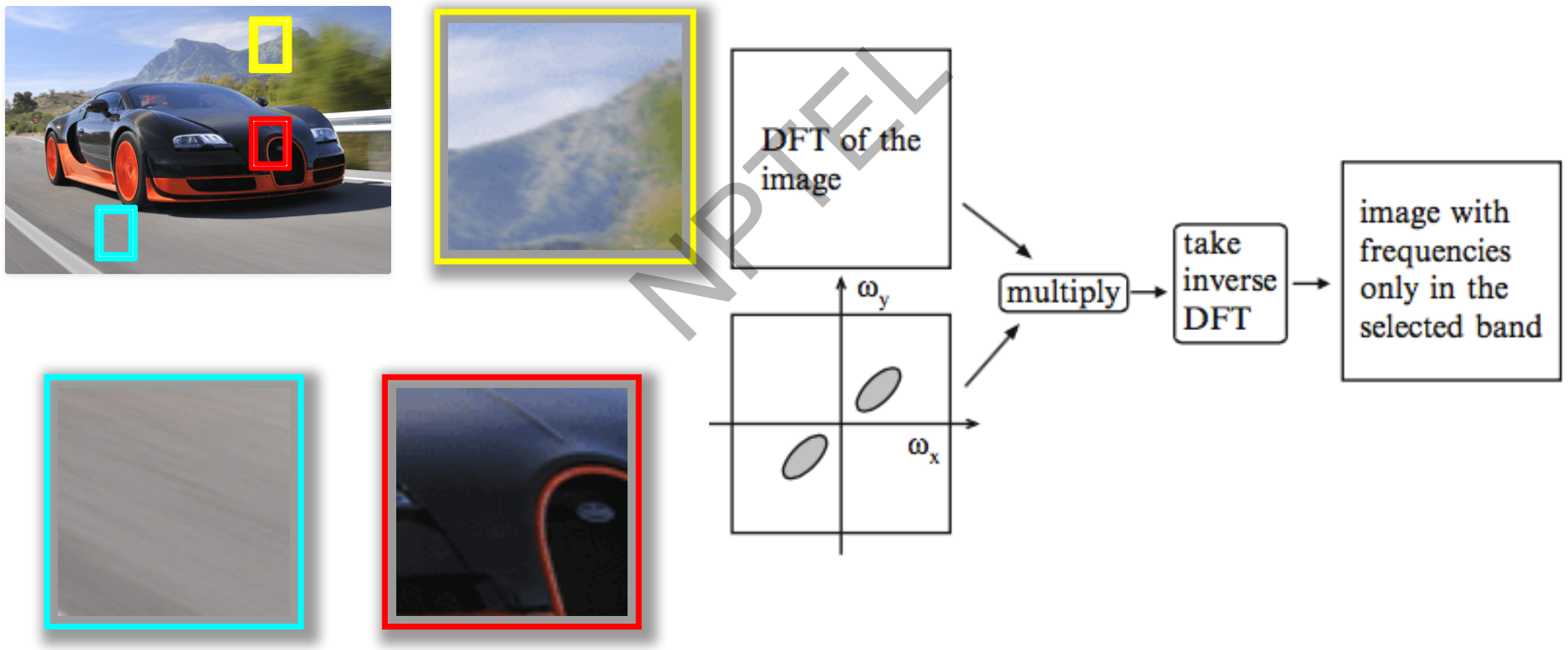
Texture from Fourier Features



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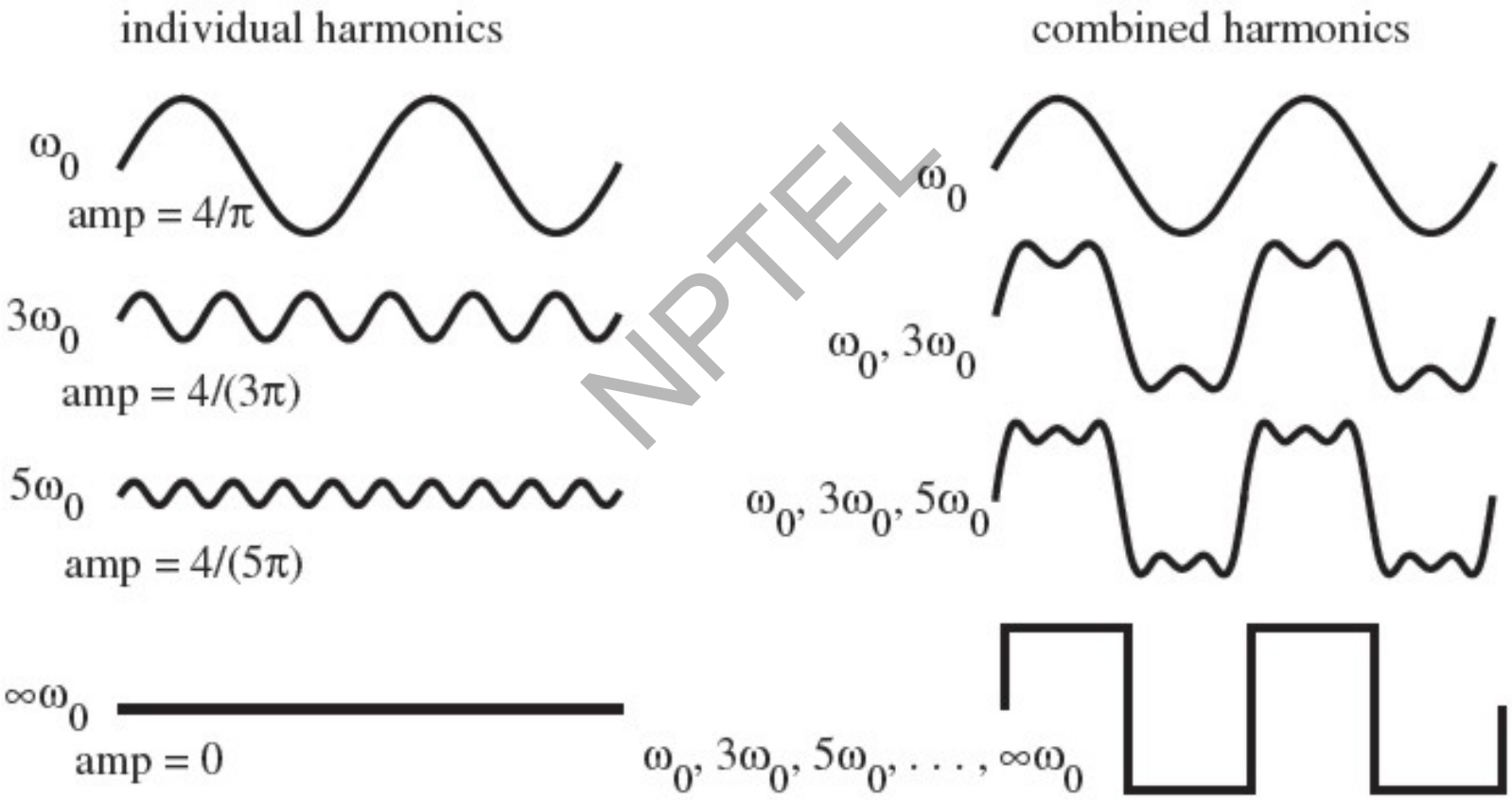
Wavelet Texture Descriptors



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Laws Masks

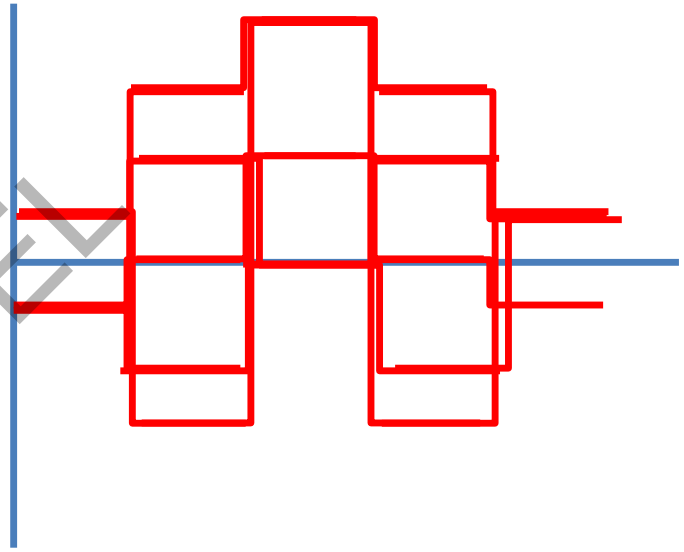
$Level$: $L_5 = [1, 4, 6, 4, 1]$

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

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

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

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



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

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

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

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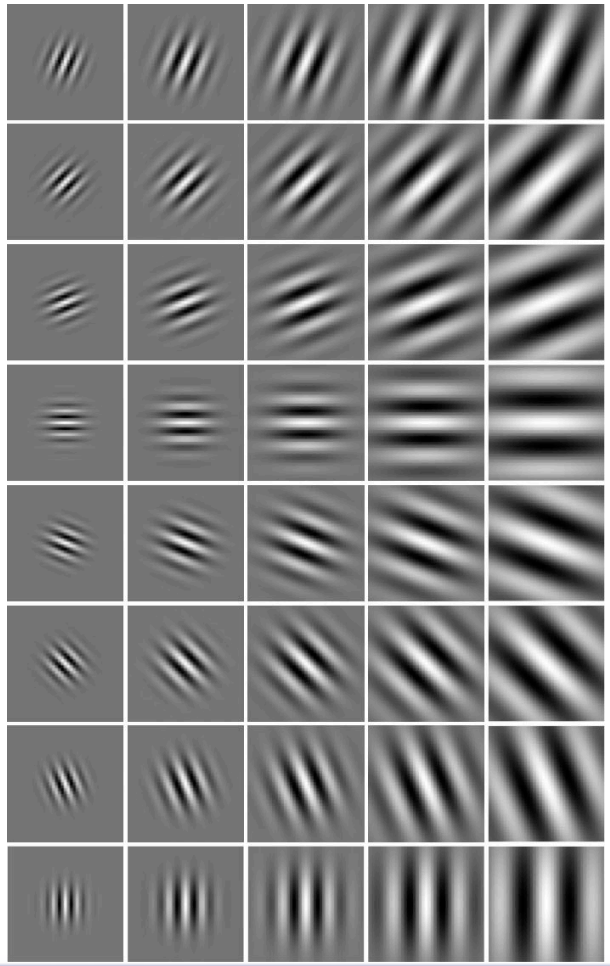
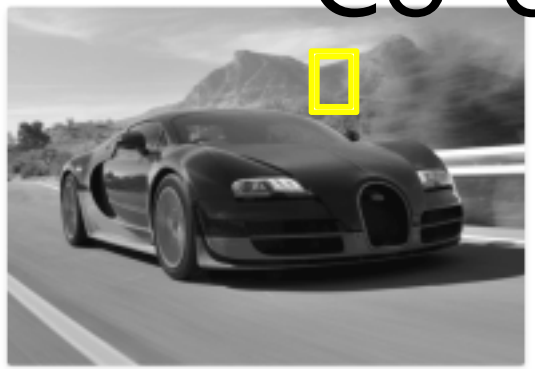


(x_0, y_0) = centroid of receptive field

(ξ_0, ν_0) = spatial frequency

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

Co-occurrence Matrices



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

	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

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

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

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

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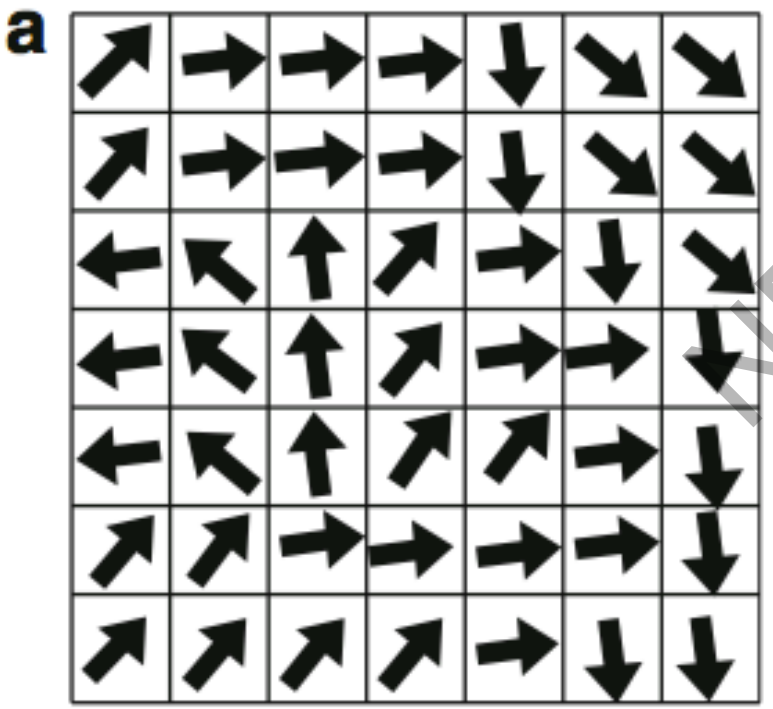
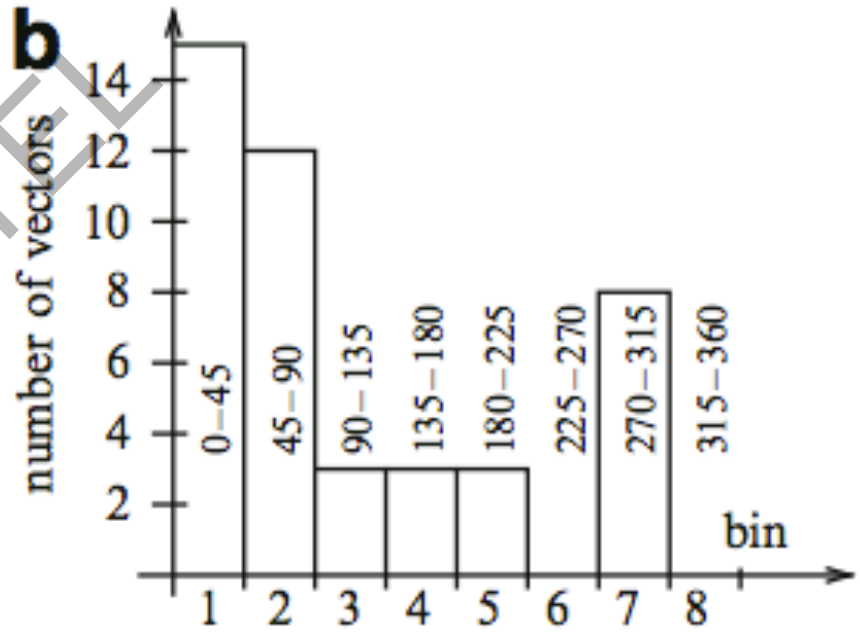
Orientation Histogram



Local orientation in an image



Histogram of orientation

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Take home message

- M. Petrou and P. G. Sevilla, *Image Processing Dealing with Texture*, John Wiley and Sons, Ltd. 2006.

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