

Research Article

Sparse Approximation of Images Inspired from the Functional Architecture of the Primary Visual Areas

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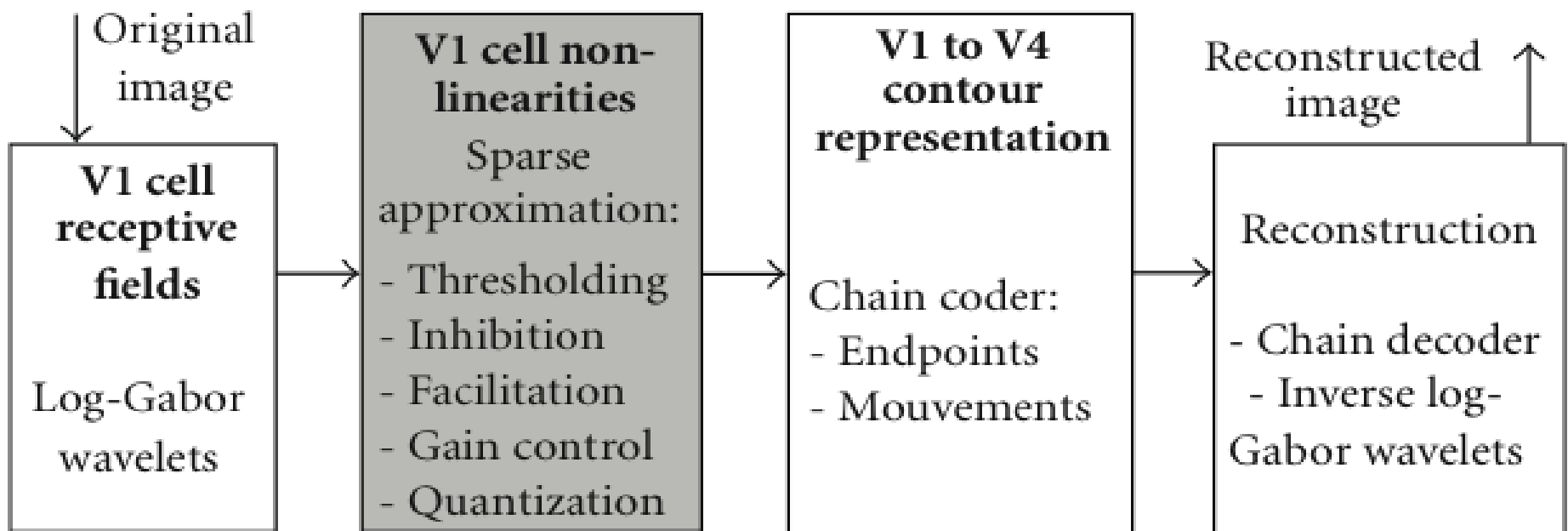
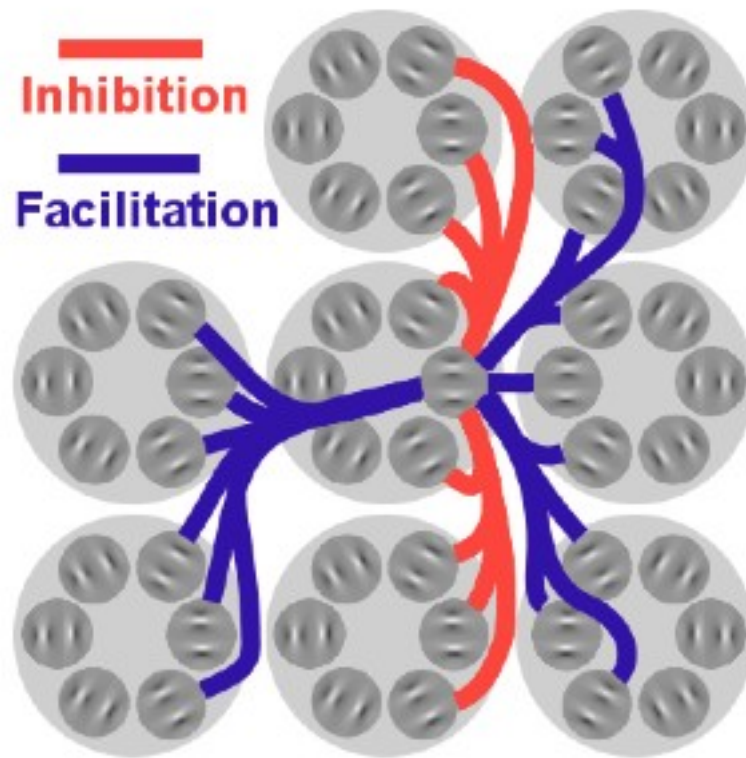
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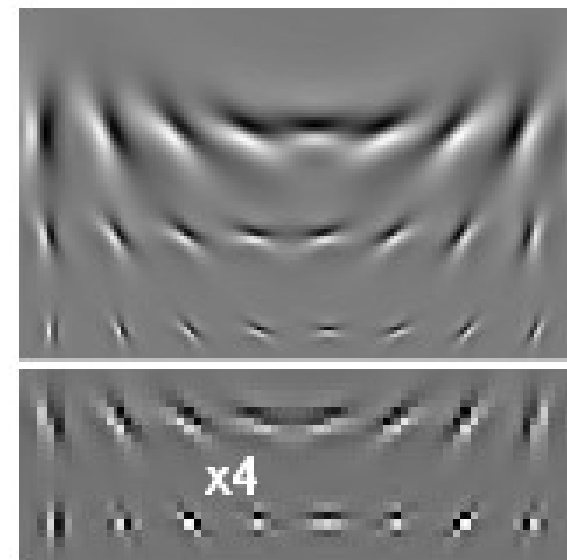
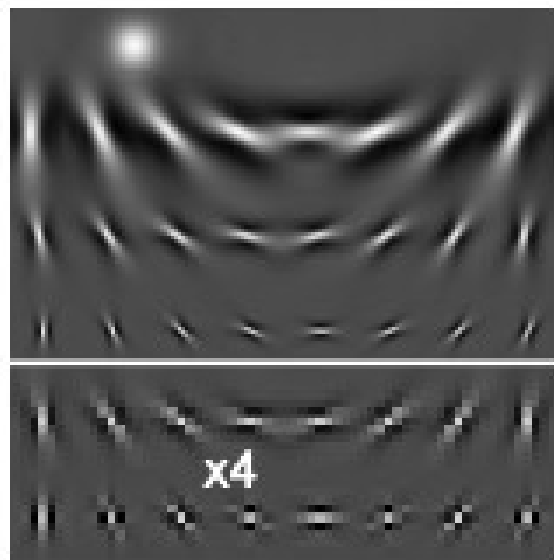
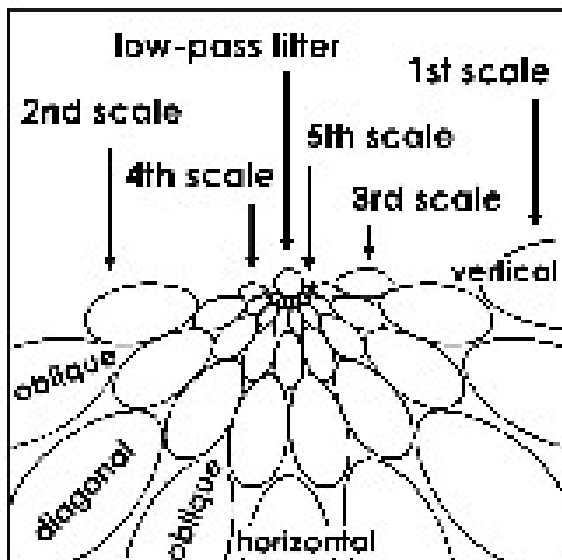
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Several drawbacks of critically sampled wavelets can be solved by overcomplete multiresolution transforms and sparse approximation algorithms. Facing the difficulty to optimize such nonorthogonal and nonlinear transforms, we implement a sparse approximation scheme inspired from the functional architecture of the primary visual cortex. The scheme models simple and complex cell receptive fields through log-Gabor wavelets. The model also incorporates inhibition and facilitation interactions between neighboring cells. Functionally these interactions allow to extract edges and ridges, providing an edge-based approximation of the visual information. The edge coefficients are shown sufficient for closely reconstructing the images, while contour representations by means of chains of edges reduce the information redundancy for approaching image compression. Additionally, the ability to segregate the edges from the noise is employed for image restoration.

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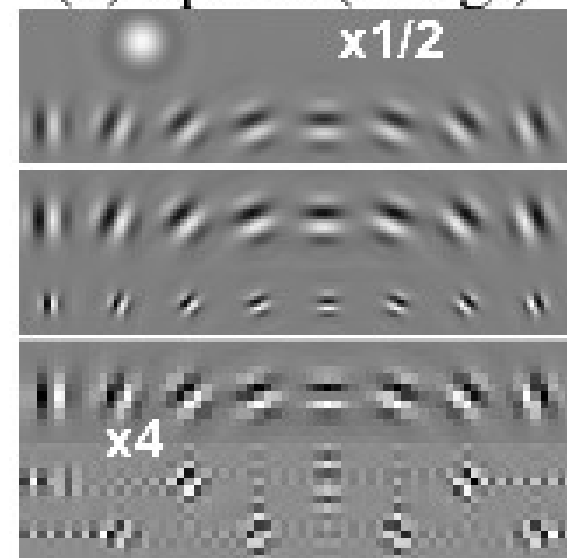
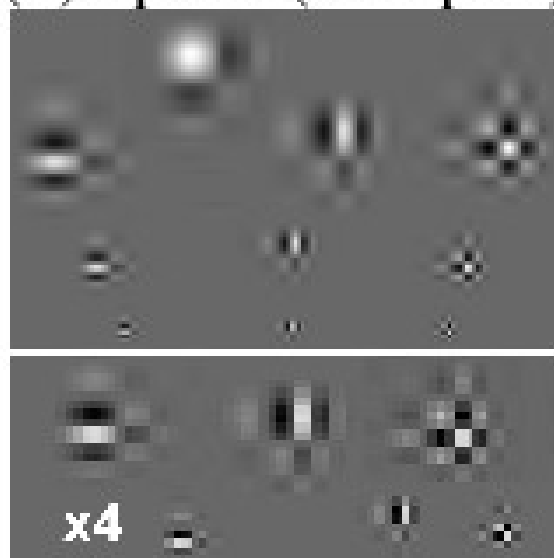
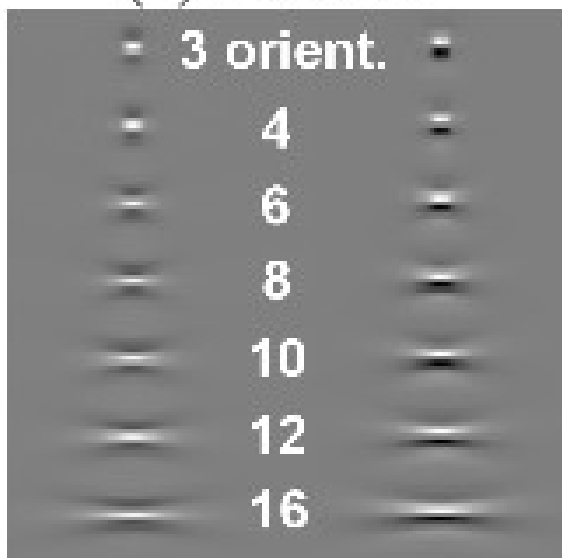




(a) Fourier

(b) space (real part)

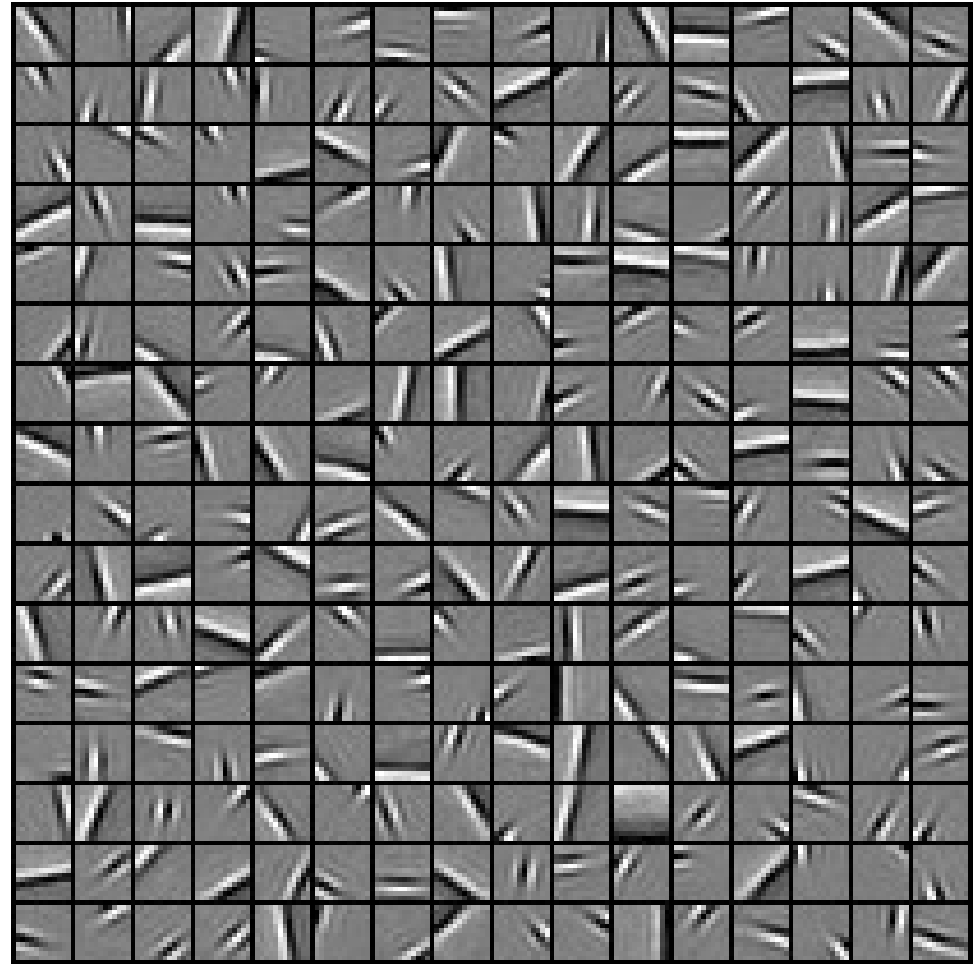
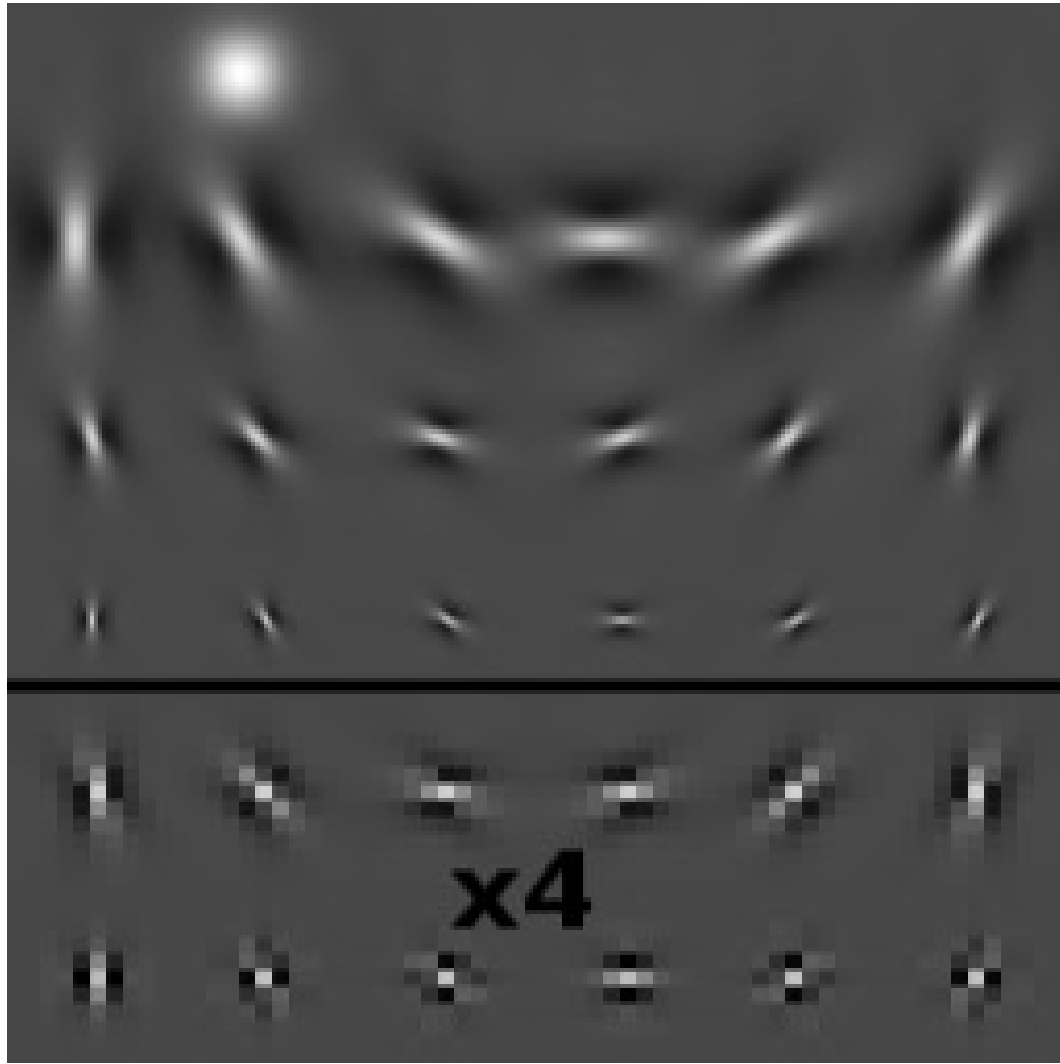
(c) space (imag.)



(d) log-Gabor

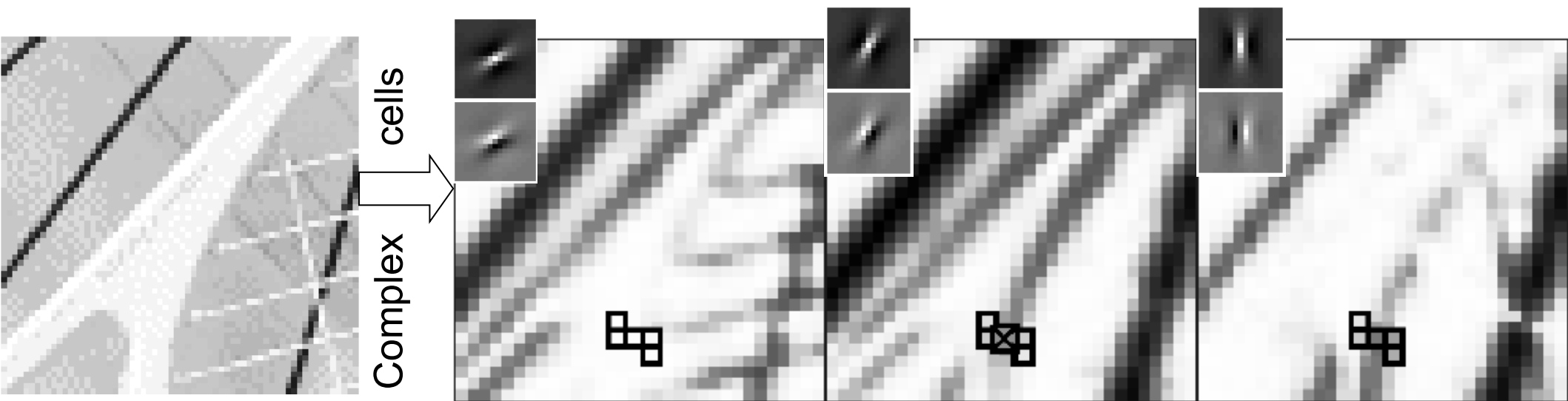
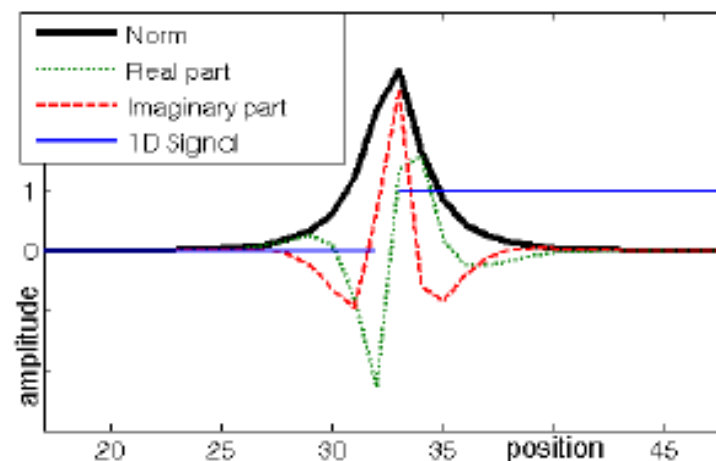
(e) 'Db4' wavelets

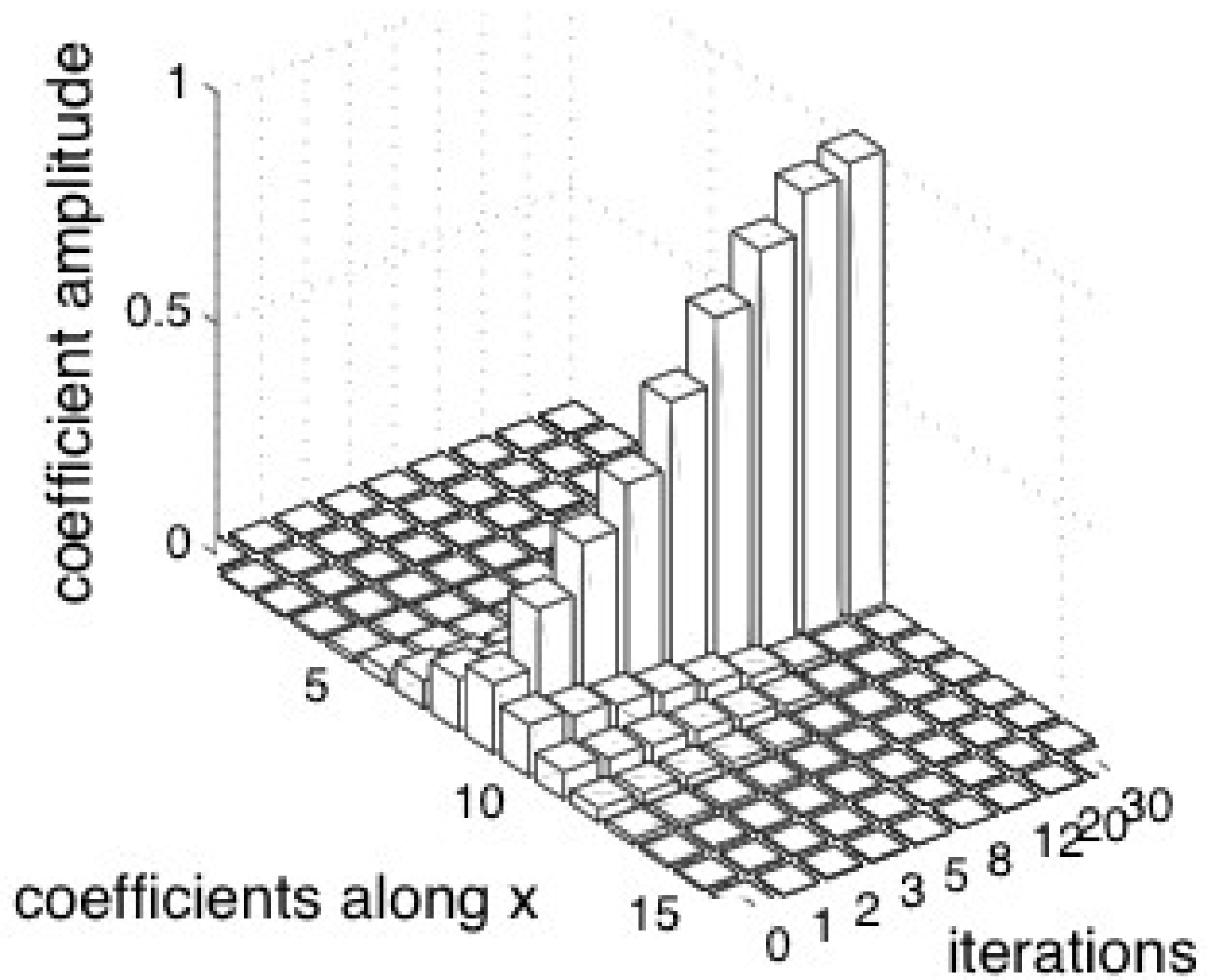
(f) Steerable pyramid



Complex cells as the energy of simple cells in quadrature of phase.

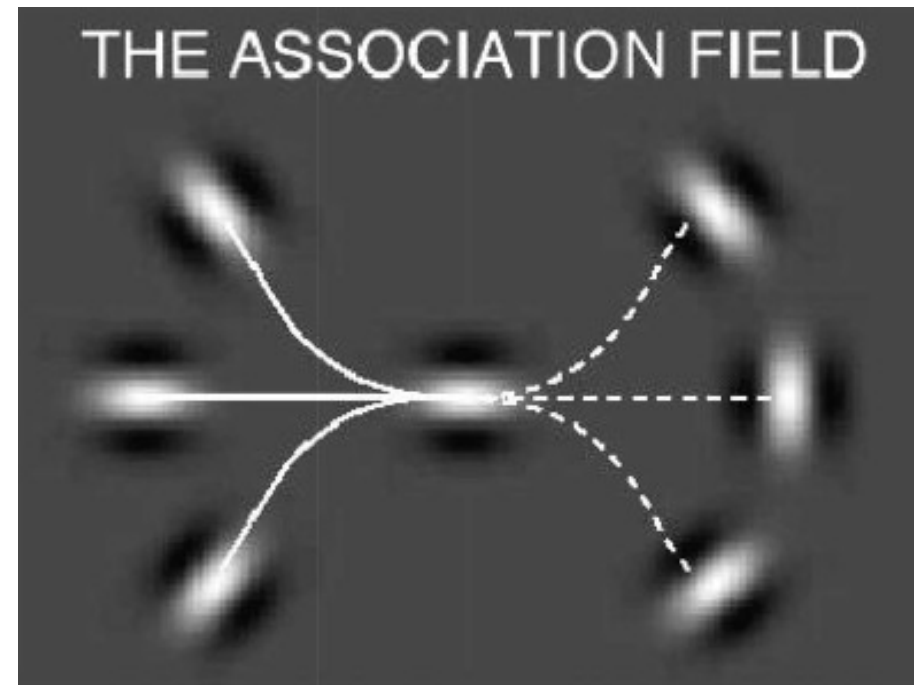
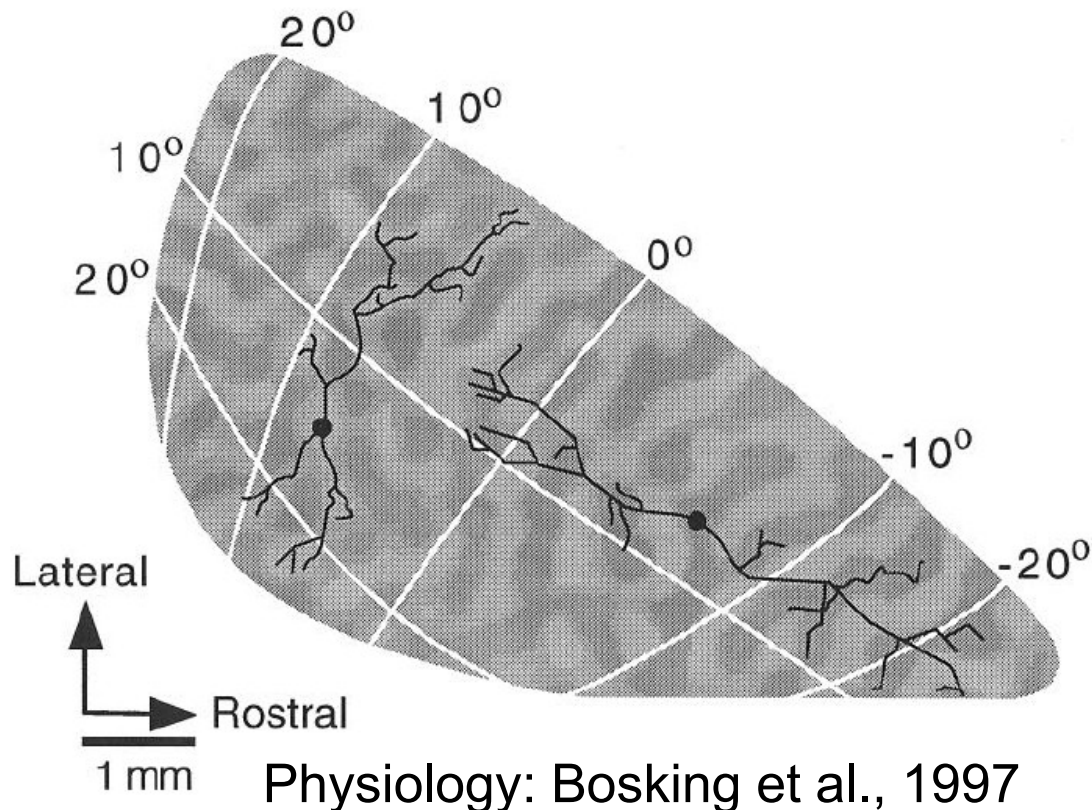
-> Monomodal response.



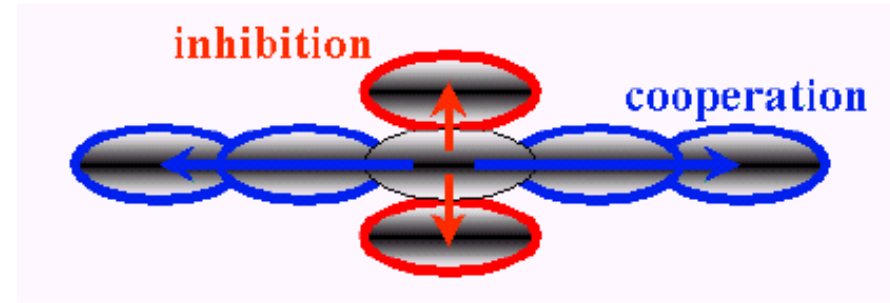


Facilitation between V1 neurons

Facilitation: close, co-aligned and co-circular stimuli are facilitated. Facilitation phenomenon is observed congruently in psychophysics, Gestalt psychology, and physiology.

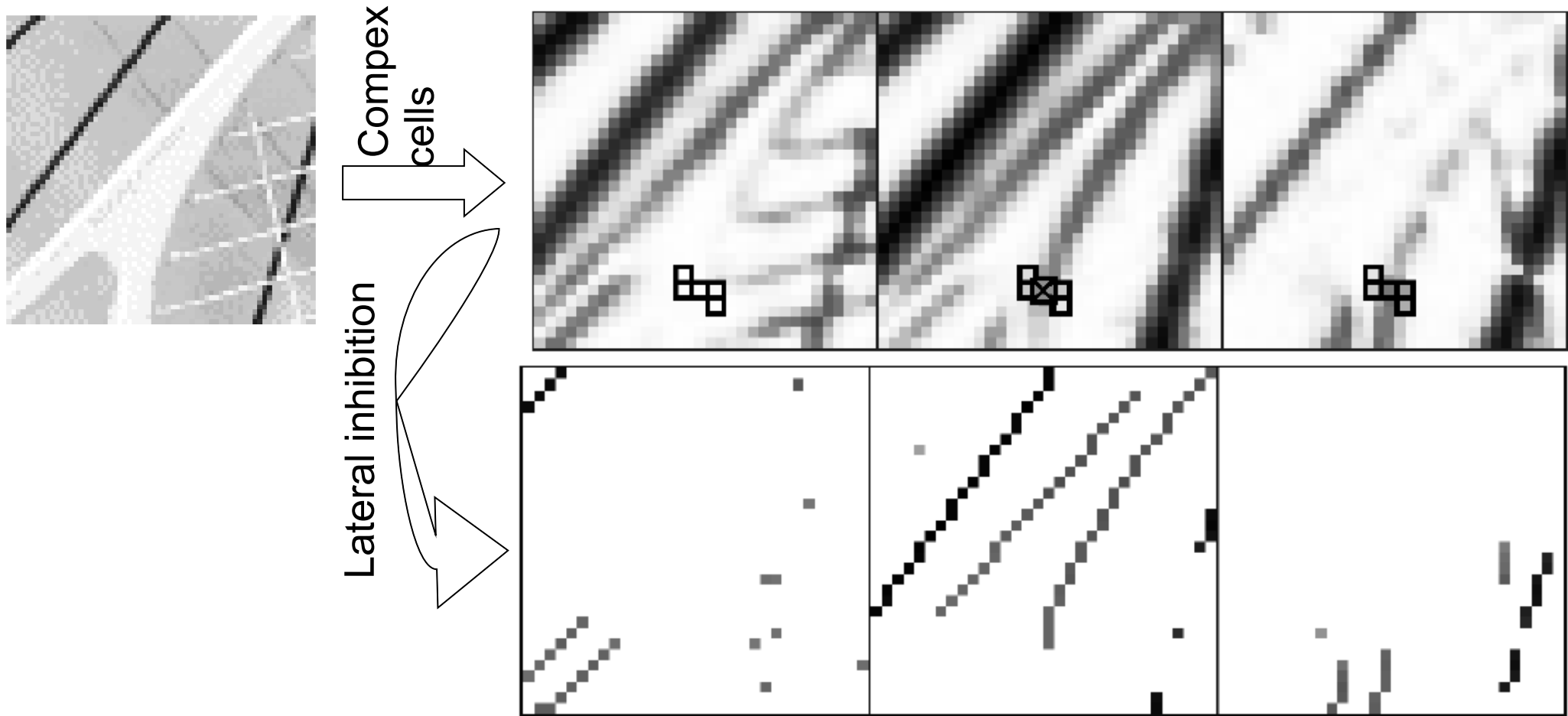


Non-classical receptive fields on complex cells



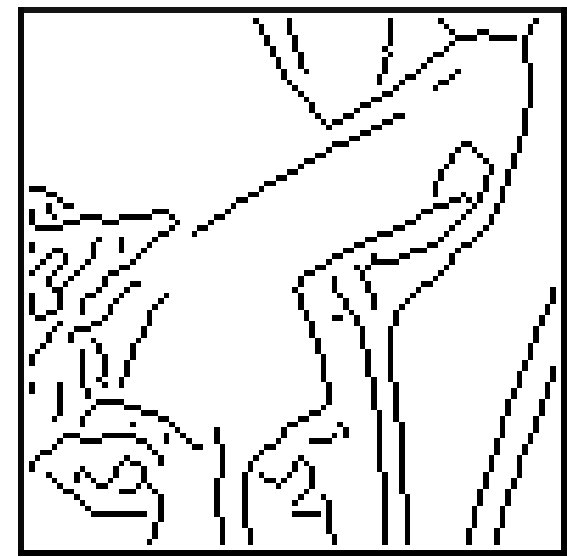
inhibition: Edge localization by non-maxima suppression.

facilitation: Facilitate closed coaligned coefficients

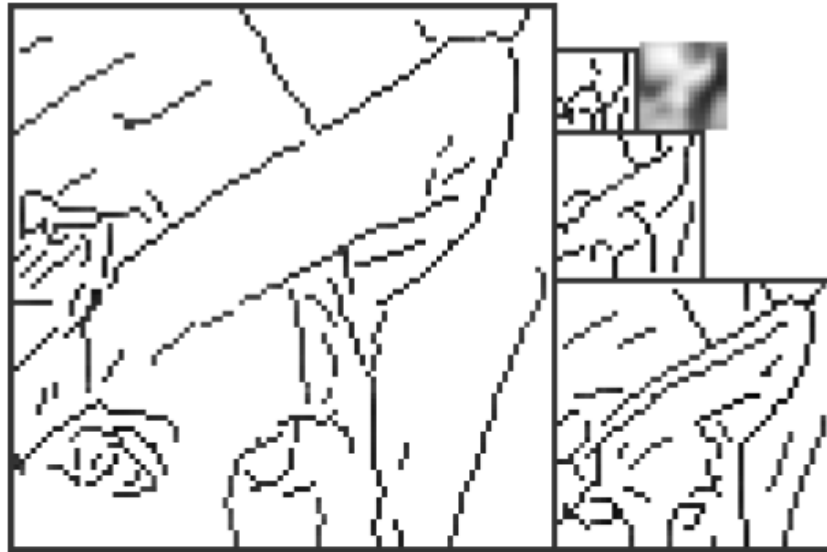




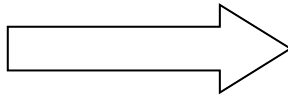
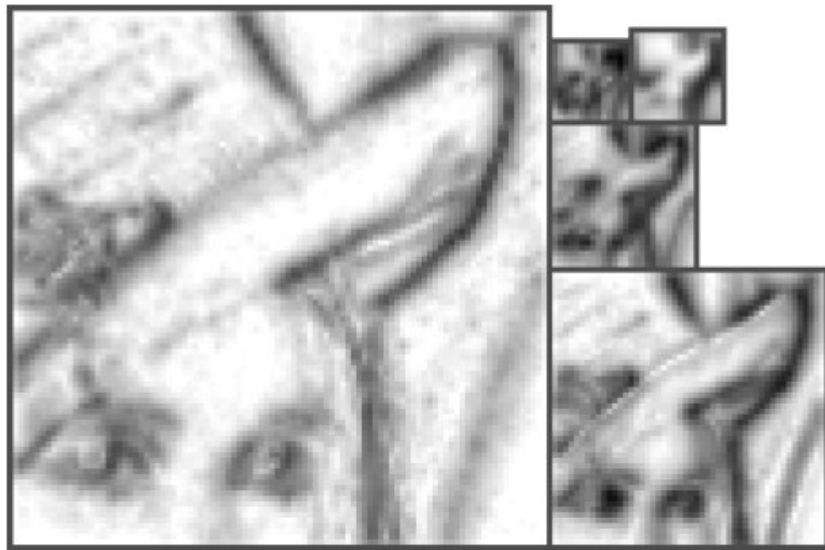
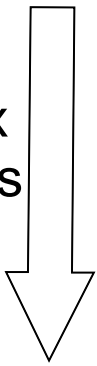
Edge extraction using complex cells model: example



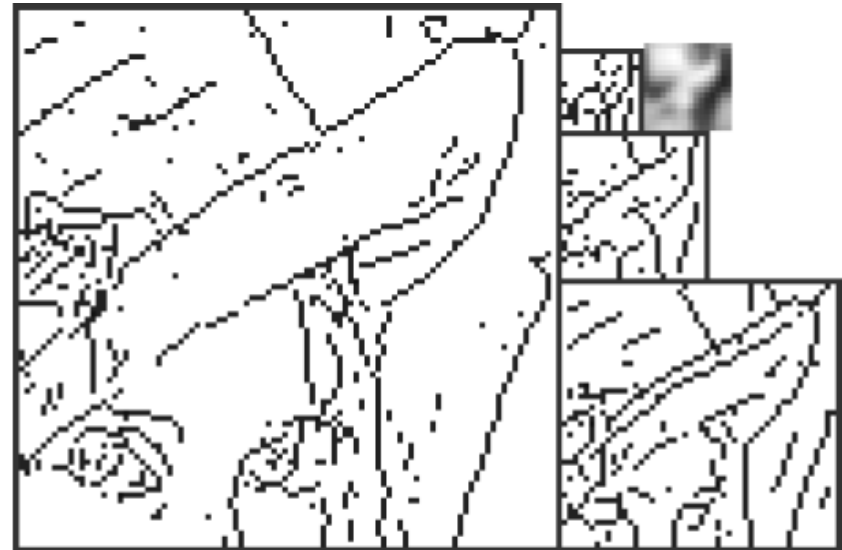
Comparison with Canny method



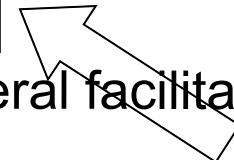
Complex cells



Lateral inhibition



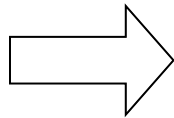
Lateral facilitation



Multiscale edge extraction



Multiscale edges

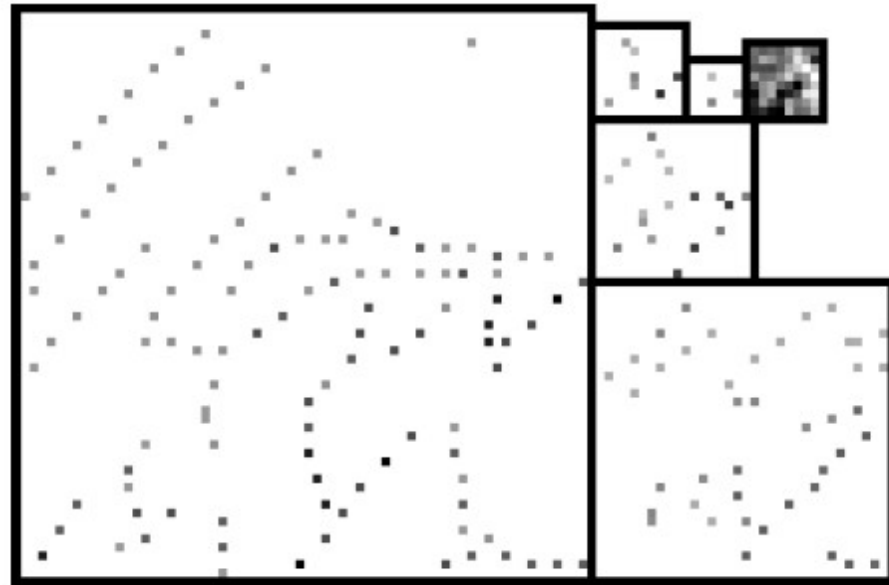


Comparison with Canny method

Comparative compression at 0.93 bpp



(a) original



Sparse representation: active cells in gray



(c) JPEG



(d) JPEG-2000



reconstruction

Noise robustness: Denoising



(a) Lena



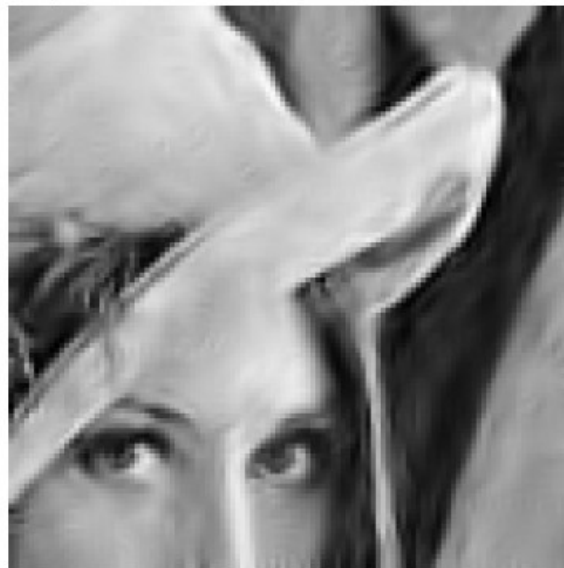
(b) Noisy version



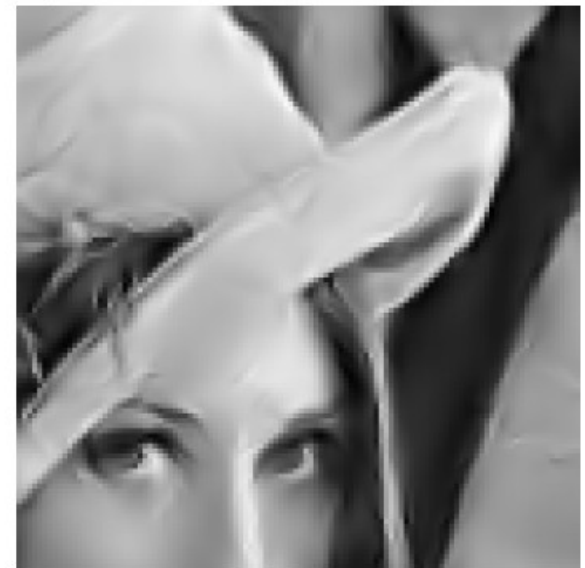
(c) orthogonal wavelets



(d) undecimated wavelets



(e) GSM model



(f) model