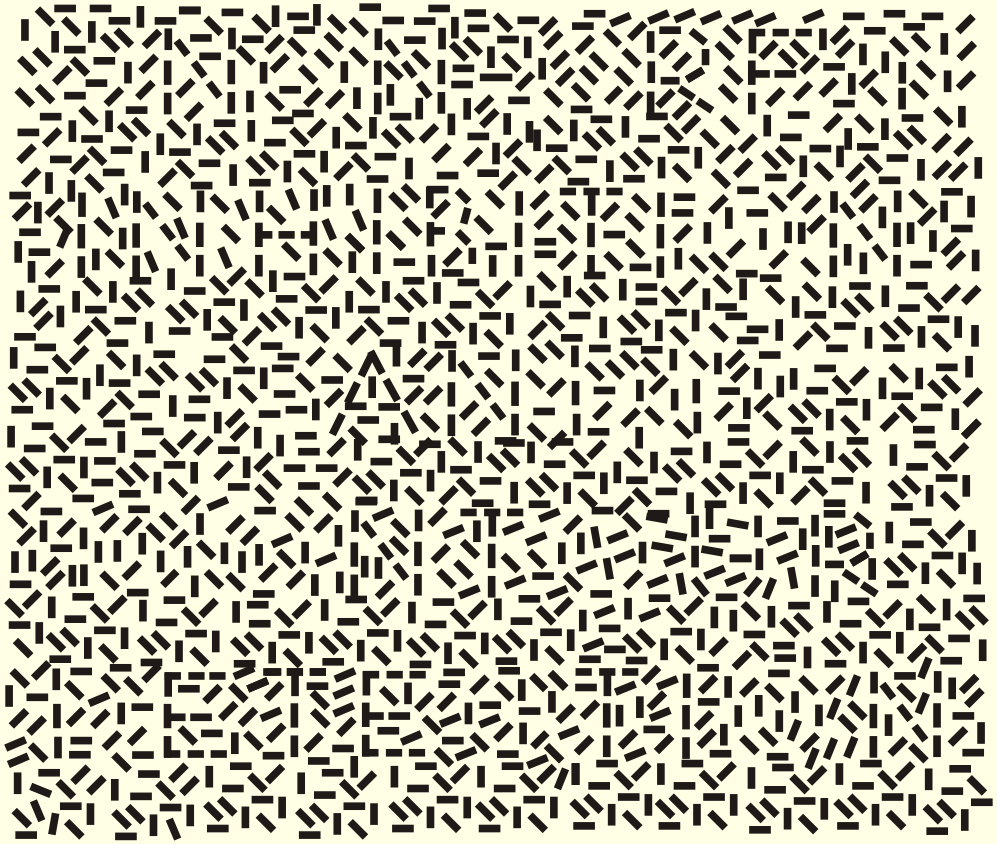
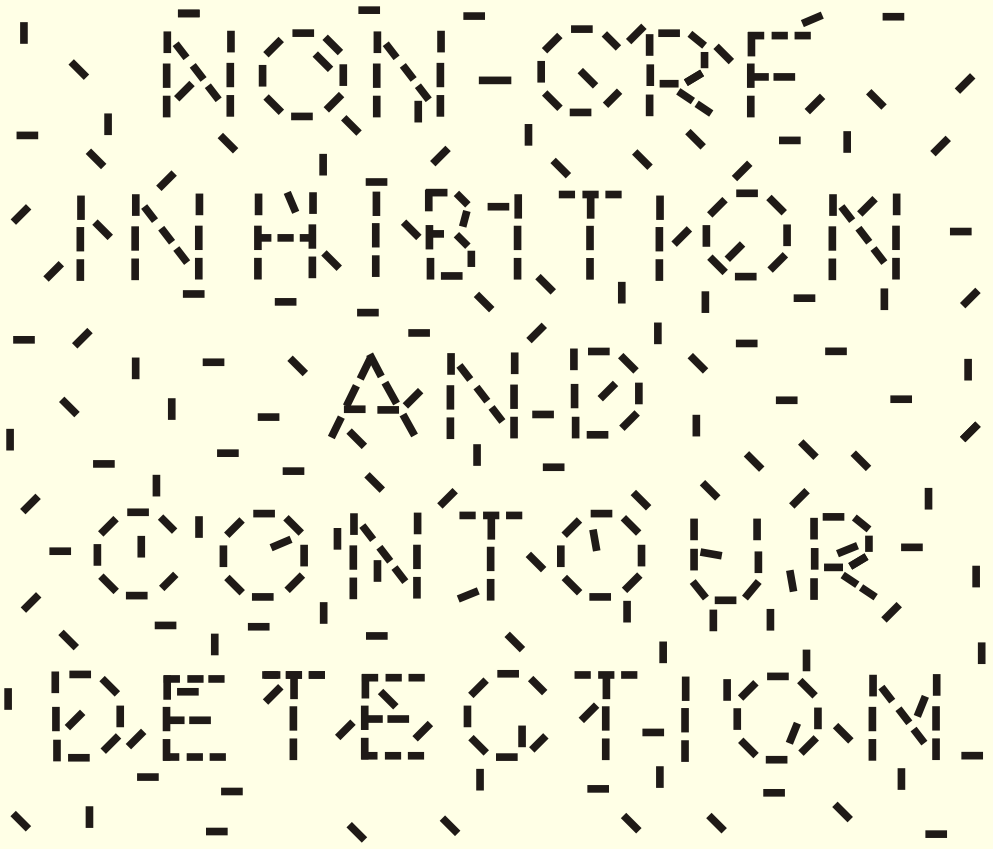
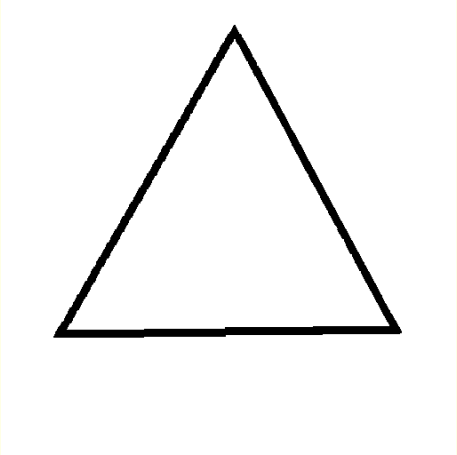
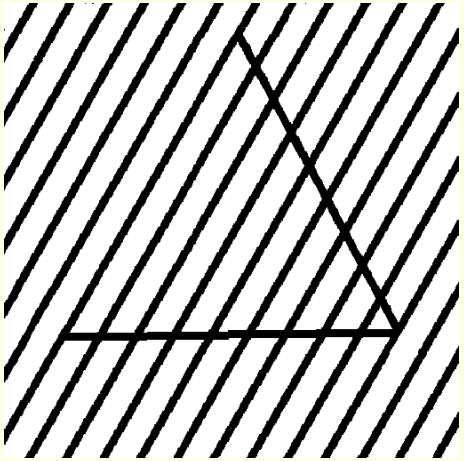



NON-GRF
INHIBITION
AND
CONTOUR
DETECTION

NON-CRF INHIBITION AND CONTOUR DETECTION

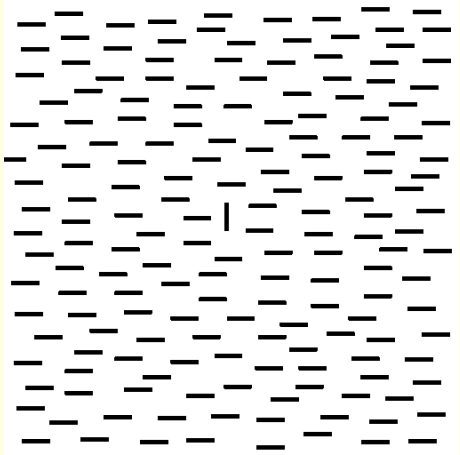
Visual perception

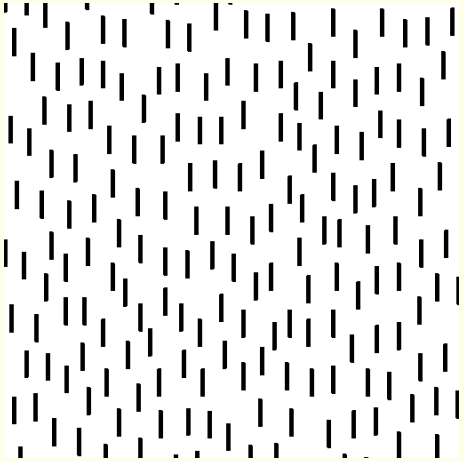




Galli and Zama (1931)

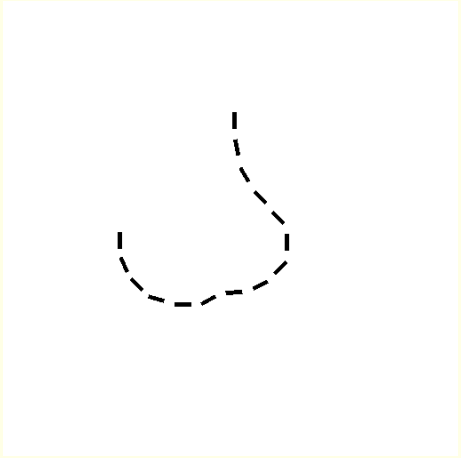
Visual perception

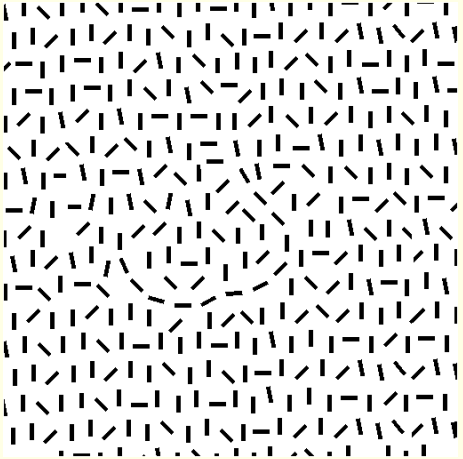




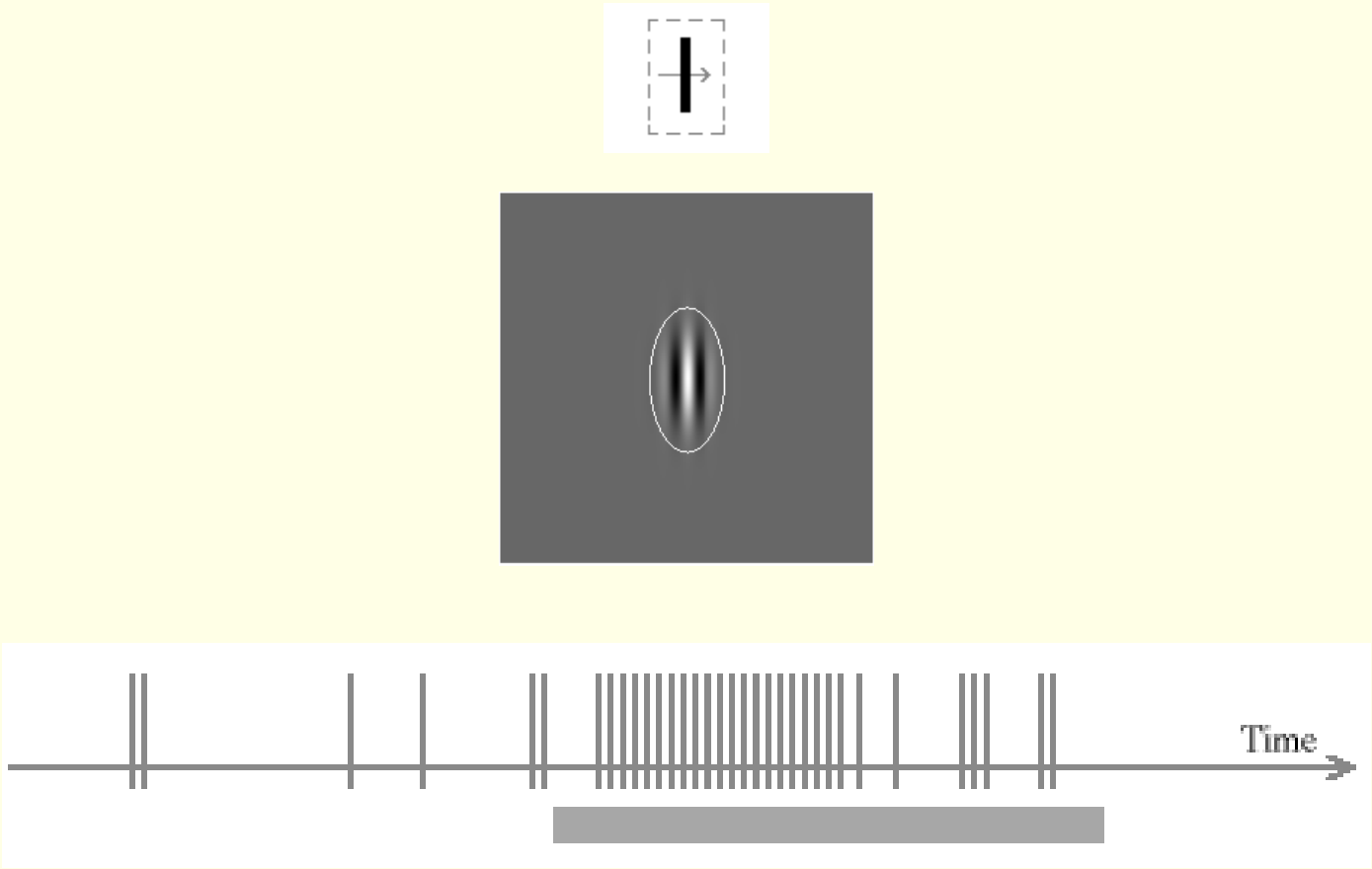
Orientation-contrast pop-out

Visual perception

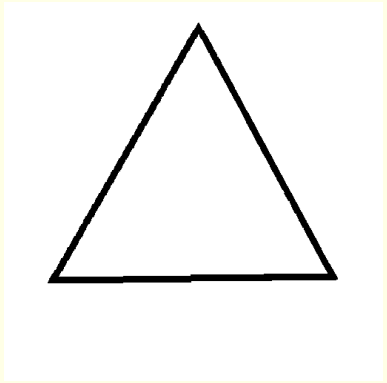


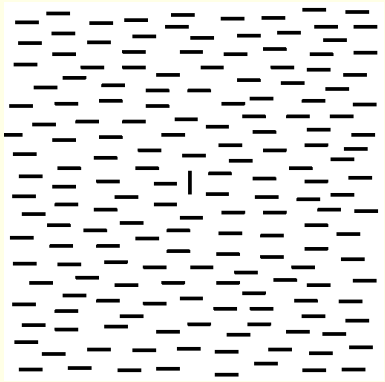


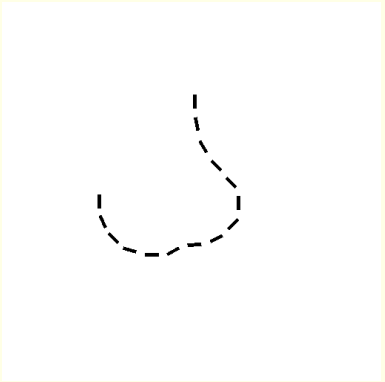
Neurophysiology

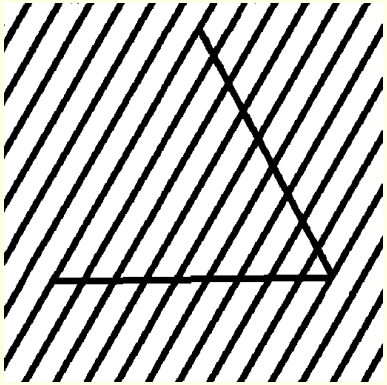


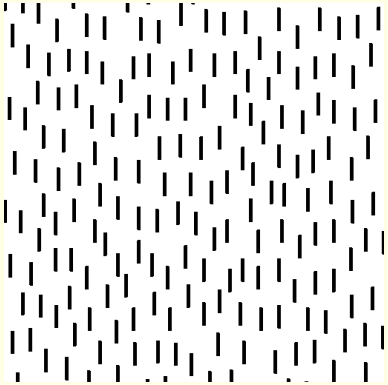
The (classical) receptive field of an orientation selective neuron (Hubel and Wiesel, 1962)

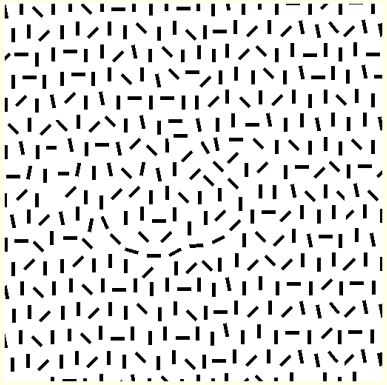




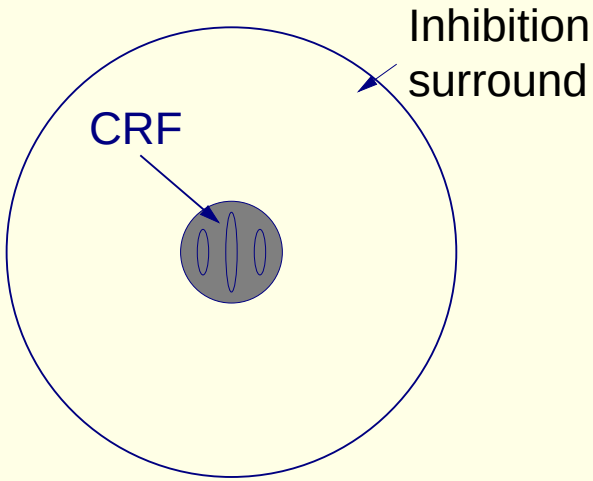




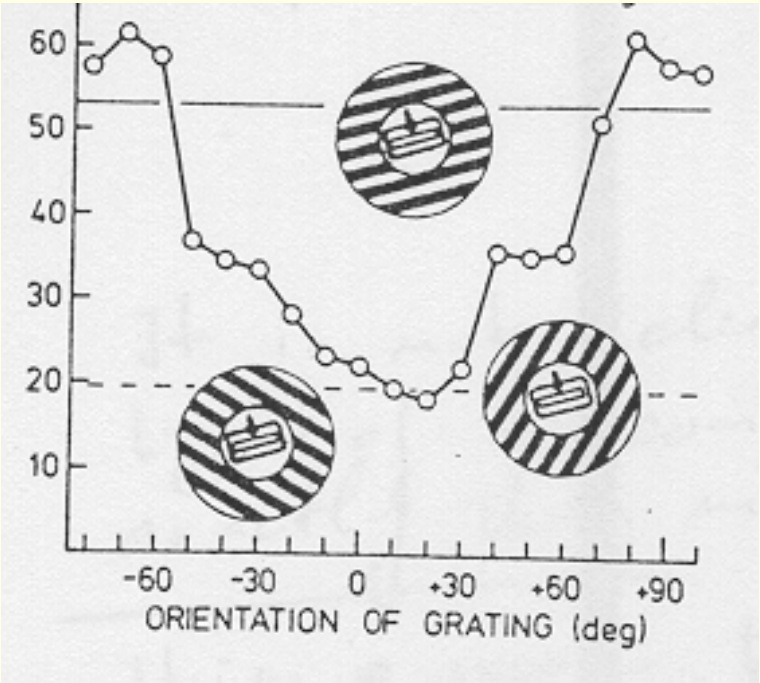




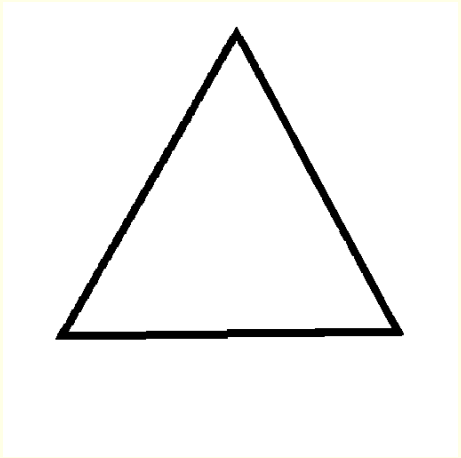
Neurophysiology

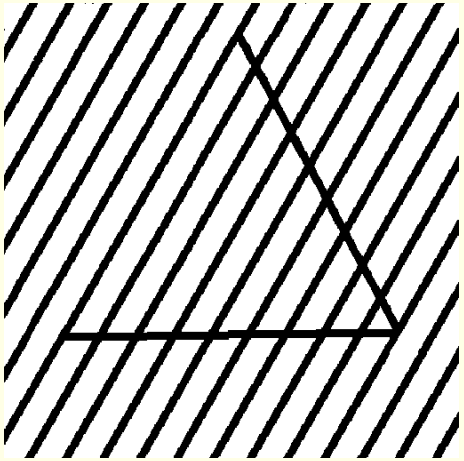


Neurophysiology

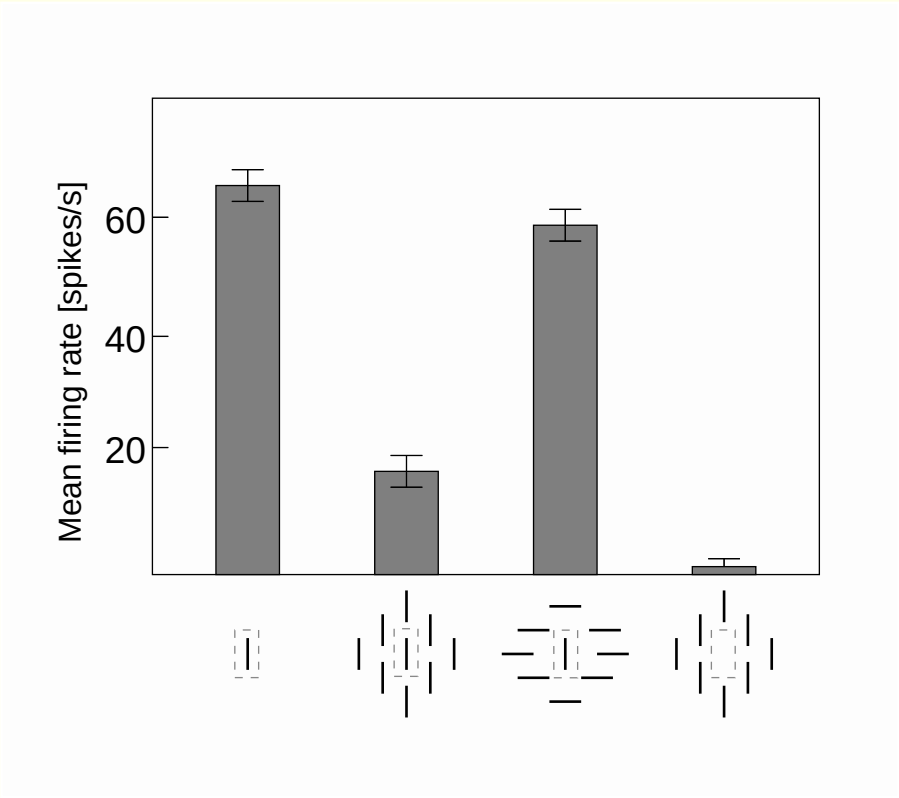


Blakemore and Tobin (1972)

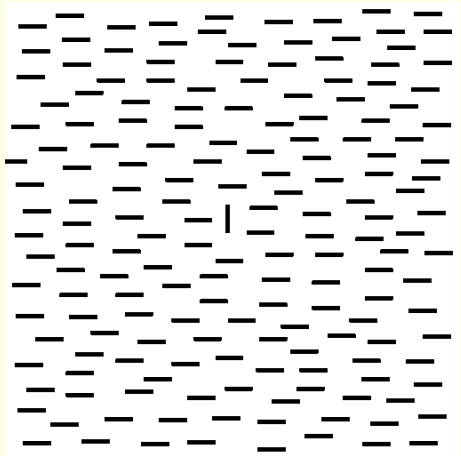


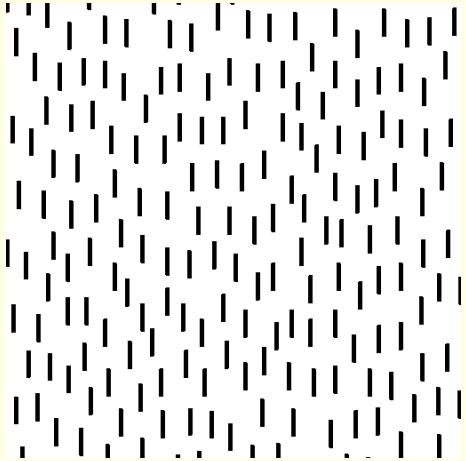


Neurophysiology



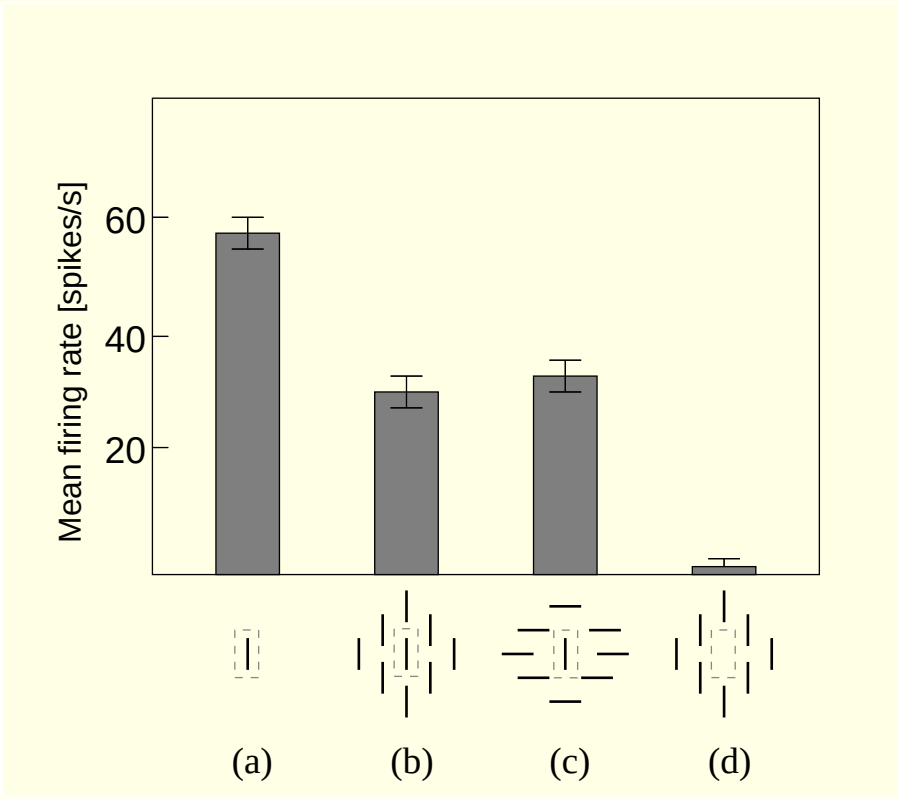
Orientation-contrast cell (Nothdurft et. al, 1999).



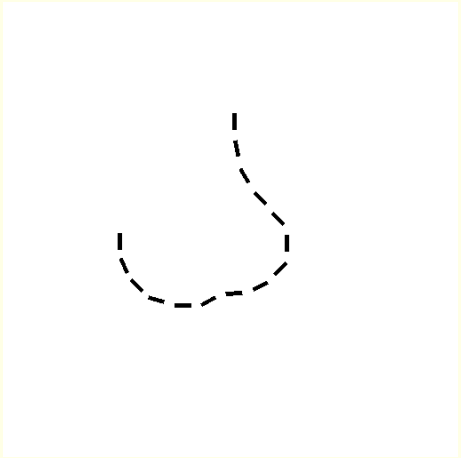


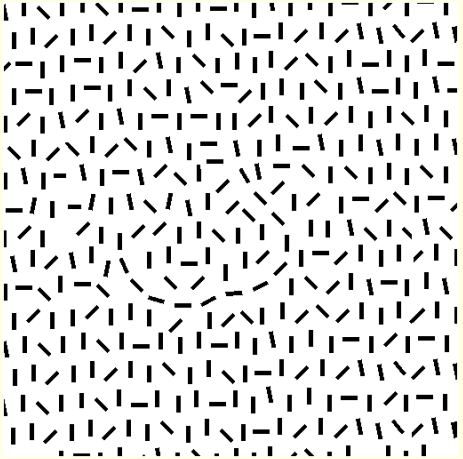
Orientation-contrast pop-out

Neurophysiology



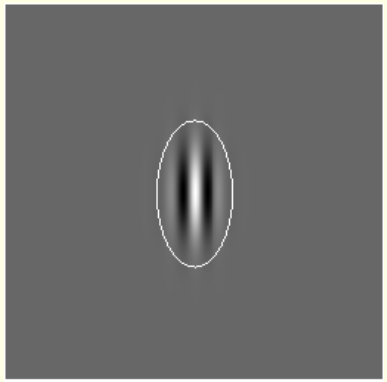
General suppression cell (Nothdurft et. al, 1999).





Computational model

Gabor filter



$$g_{\lambda,\sigma,\theta,\varphi}(x,y) = e^{-\frac{\tilde{x}^2+\gamma^2\tilde{y}^2}{2\sigma^2}} \cos(2\pi\frac{\tilde{x}}{\lambda}+\varphi) \tag{1}$$

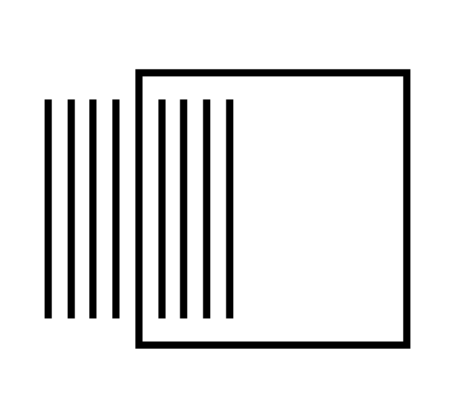
$$r_{\lambda,\sigma,\theta,\varphi}(x,y) = (f * g_{\lambda,\sigma,\theta,\varphi})(x,y) \tag{2}$$

Gabor energy filter

Gabor energy:

$$E_{\lambda,\sigma,\theta}(x,y) = \sqrt{r^2_{\lambda,\sigma,\theta,0}(x,y) + r^2_{\lambda,\sigma,\theta,-\frac{\pi}{2}}(x,y)} \tag{3}$$

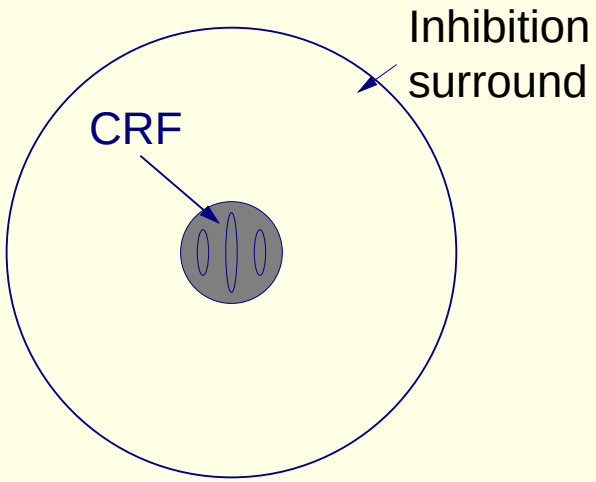
$$\widehat{E}_{\lambda,\sigma}(x,y) = \max\{E_{\lambda,\sigma,\theta_i}(x,y) \mid i = 0,1,\ldots,N_\theta - 1\} \tag{4}$$



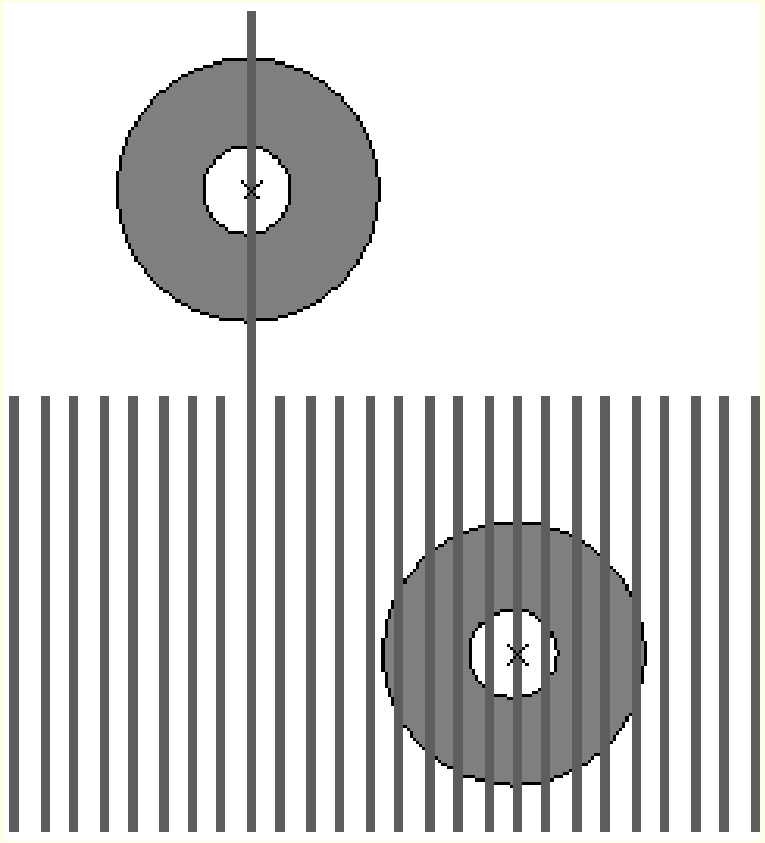
0°

90°

max

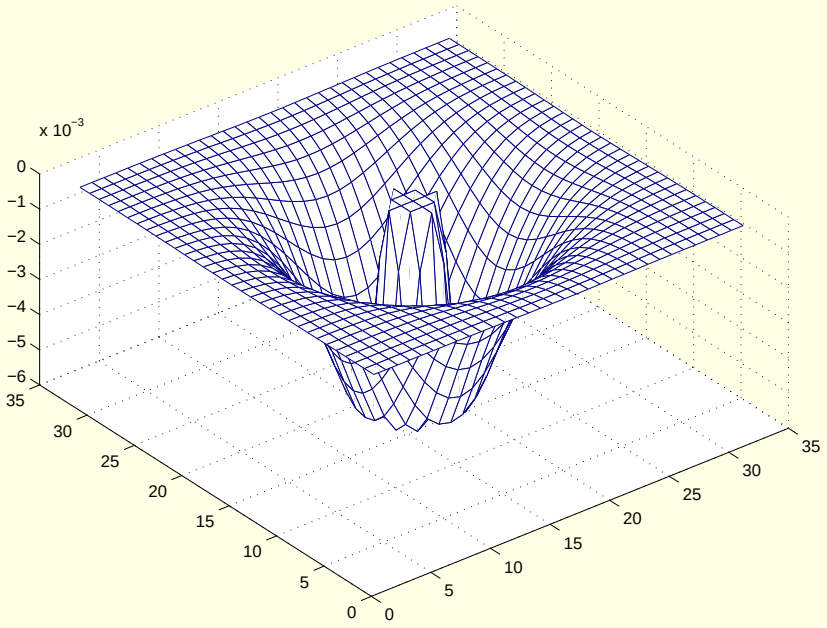

Inhibition
surround
CRF

Non-CRF inhibition



Different contributions of the surround.

Weighting function



Weighting function which models the contribution of surround inhibition.

Weighting function

$$w_\sigma(x,y) = \frac{1}{|| H(\, DoG_\sigma \,) ||_1} \, H(\, DoG_\sigma(x,y) \,)$$

$$DoG_\sigma(x,y) = \frac{1}{2\pi(4\sigma)^2} \, e^{-\frac{x^2+y^2}{2\,(4\sigma)^2}} - \frac{1}{2\pi\sigma^2} \, e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{5}$$

$$H(z) = \begin{cases} 0 & z < 0 \\ z & z \geq 0. \end{cases}$$

Anisotropic inhibition

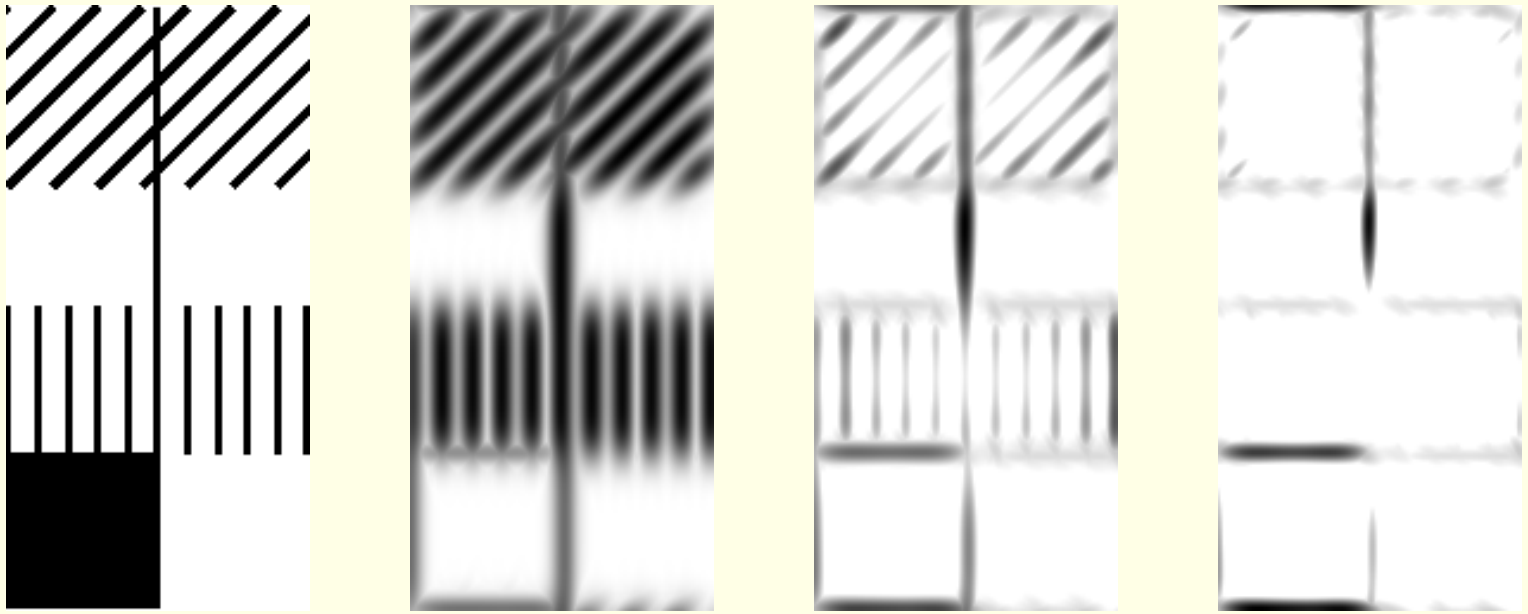
Inhibition term:

$$t^A_{\lambda,\sigma,\theta}(x,y) = (E_{\lambda,\sigma,\theta} * w_\sigma)(x,y) \tag{6}$$

Contour operator:

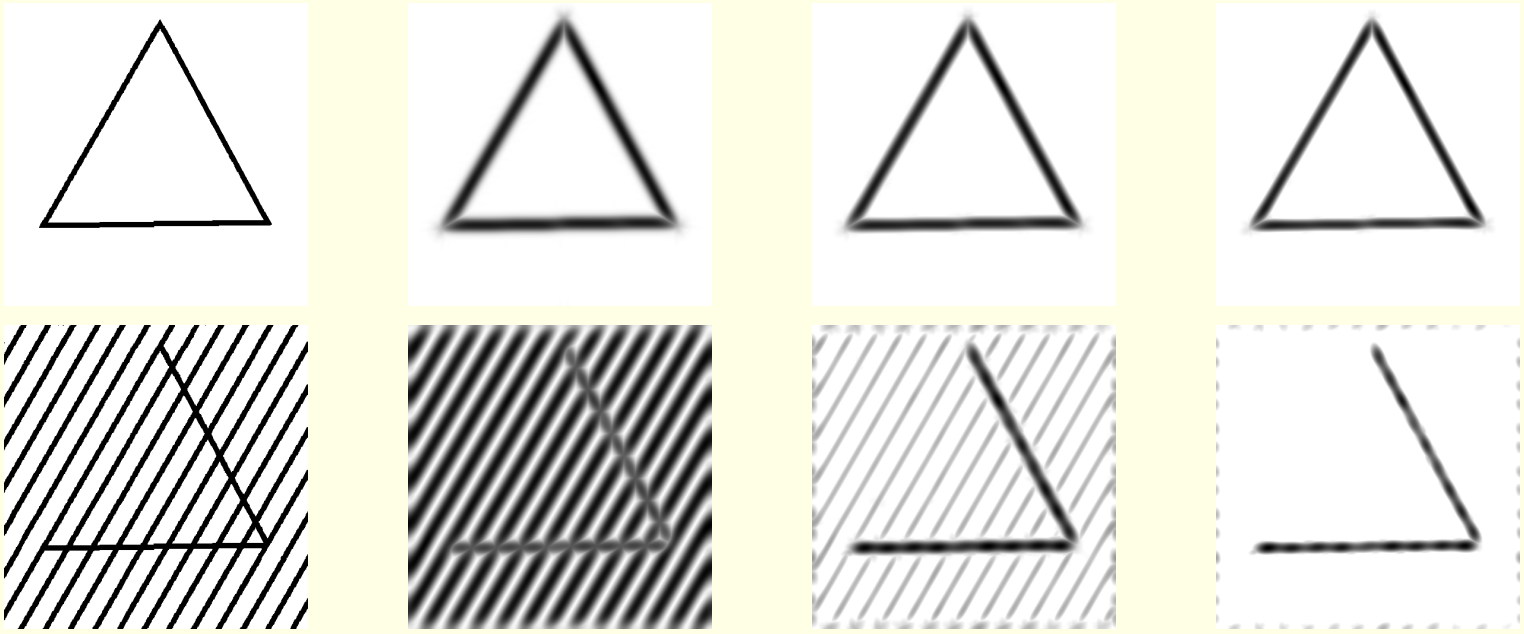
$$\tilde{b}^A_{\lambda,\sigma,\theta}(x,y) = H(E_{\lambda,\sigma,\theta}(x,y) - \alpha t^A_{\lambda,\sigma,\theta}(x,y)) \tag{7}$$

Anisotropic inhibition



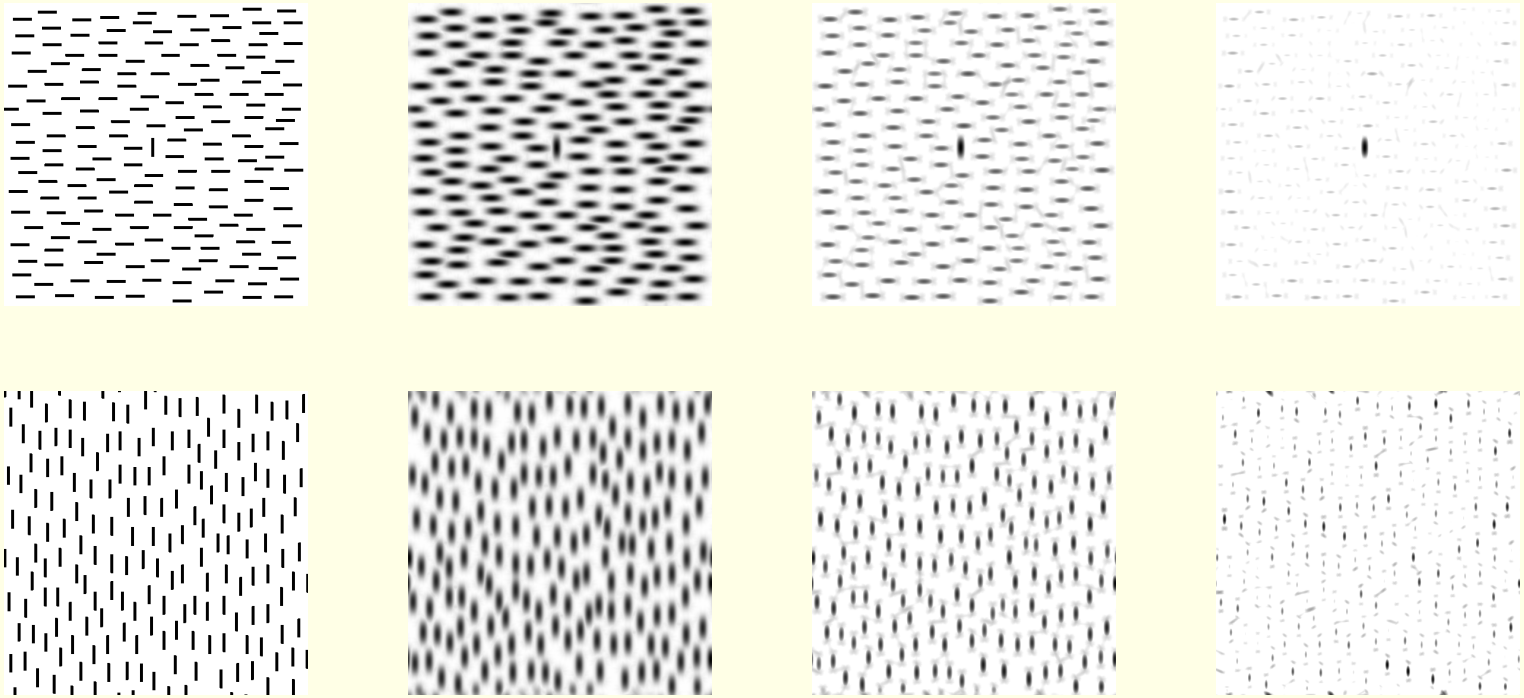
(a) Input image. (b) Gabor energy. (c) Moderate inhibition. (d) Strong inhibition.

Anisotropic inhibition



(a) Input image. (b) Gabor energy. (c) Moderate inhibition. (d) Strong inhibition.

Anisotropic inhibition



(a) Input image. (b) Gabor energy. (c) Moderate inhibition. (d) Strong inhibition.

Isotropic inhibition

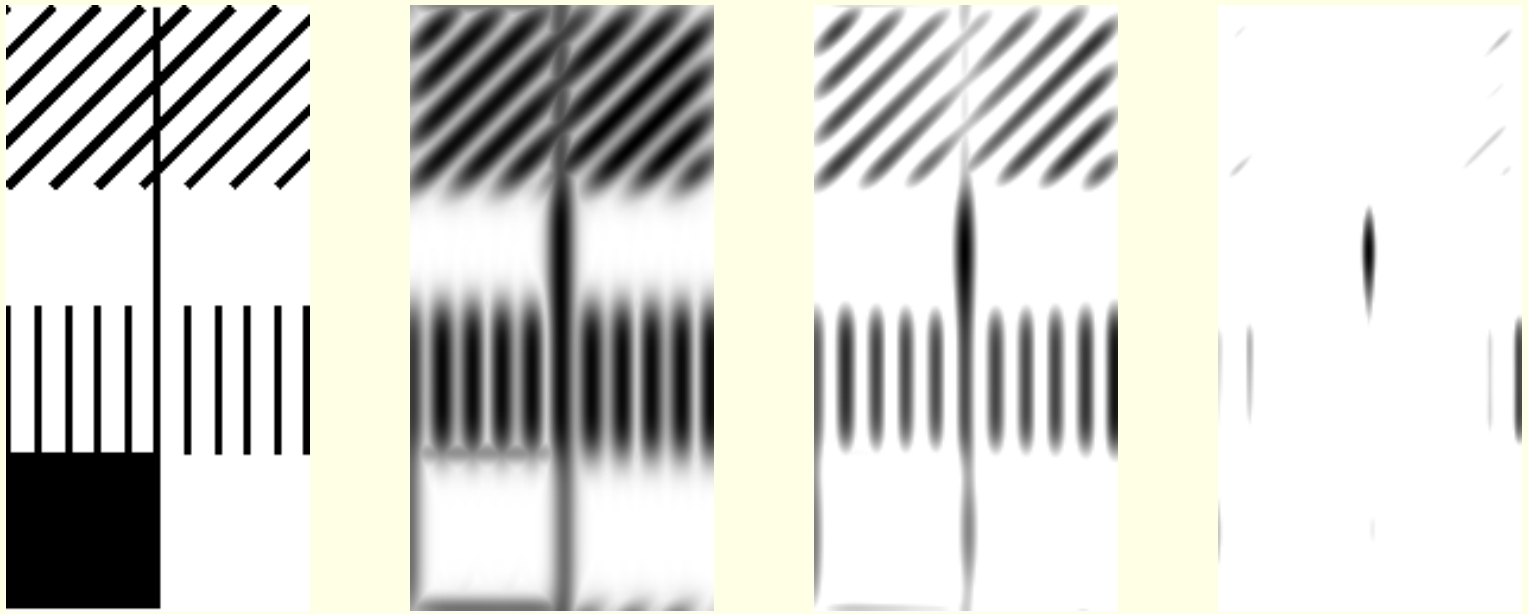
Inhibition term:

$$t^I_{\lambda,\sigma}(x,y) = (\widehat{E}_{\lambda,\sigma} * w_\sigma)(x,y) \tag{8}$$

Contour operator:

$$b^I_{\lambda,\sigma,\theta}(x,y) = H(E_{\lambda,\sigma,\theta}(x,y) - \alpha t^I_{\lambda,\sigma}(x,y)) \tag{9}$$

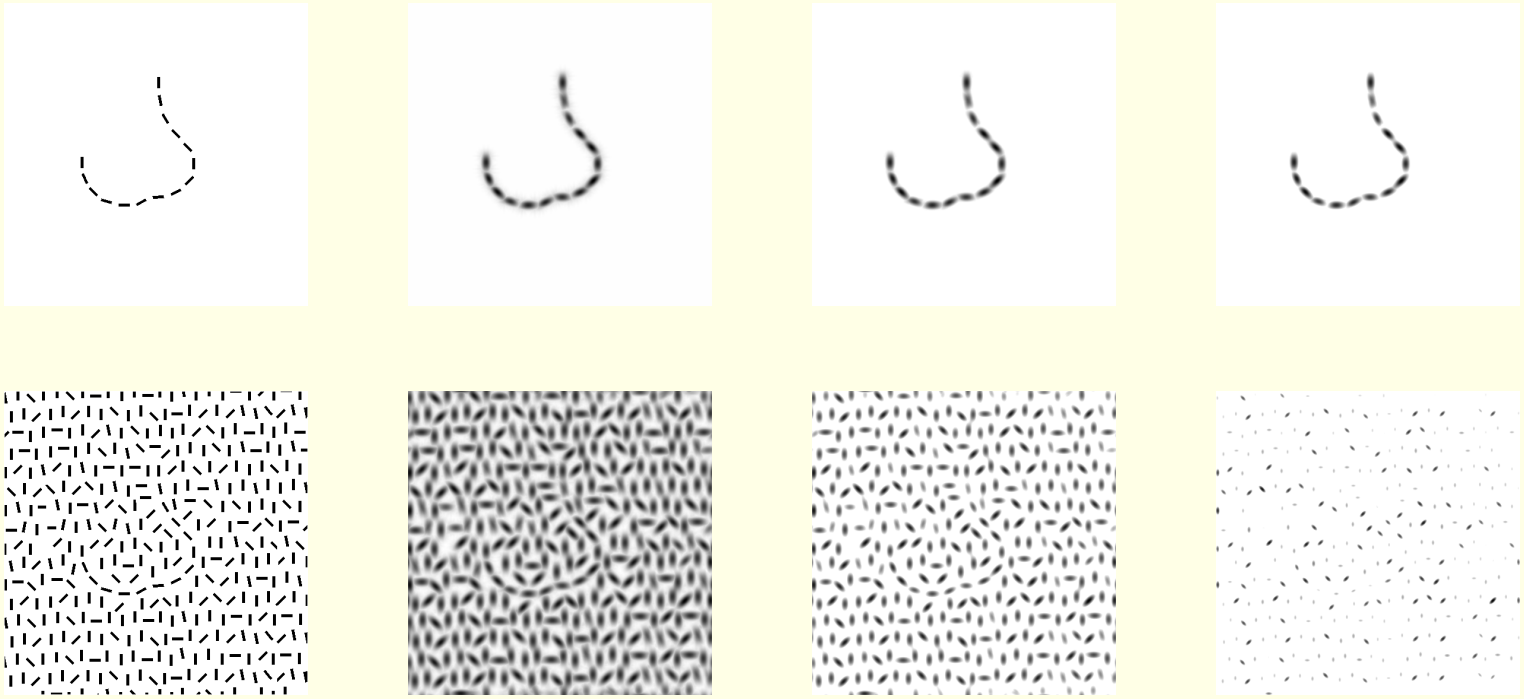
Isotropic inhibition



(a) (b) (c) (d)

(a) Input image. (b) Gabor energy. (c) Moderate inhibition. (d) Strong inhibition.

Isotropic inhibition



(a) (b) (c) (d)

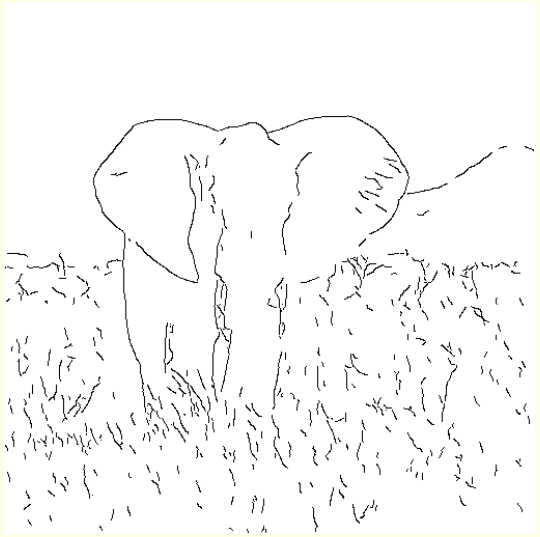
(a) Input image. (b) Gabor energy. (c) Moderate inhibition. (d) Strong inhibition.

Computer vision application

Binary contour maps

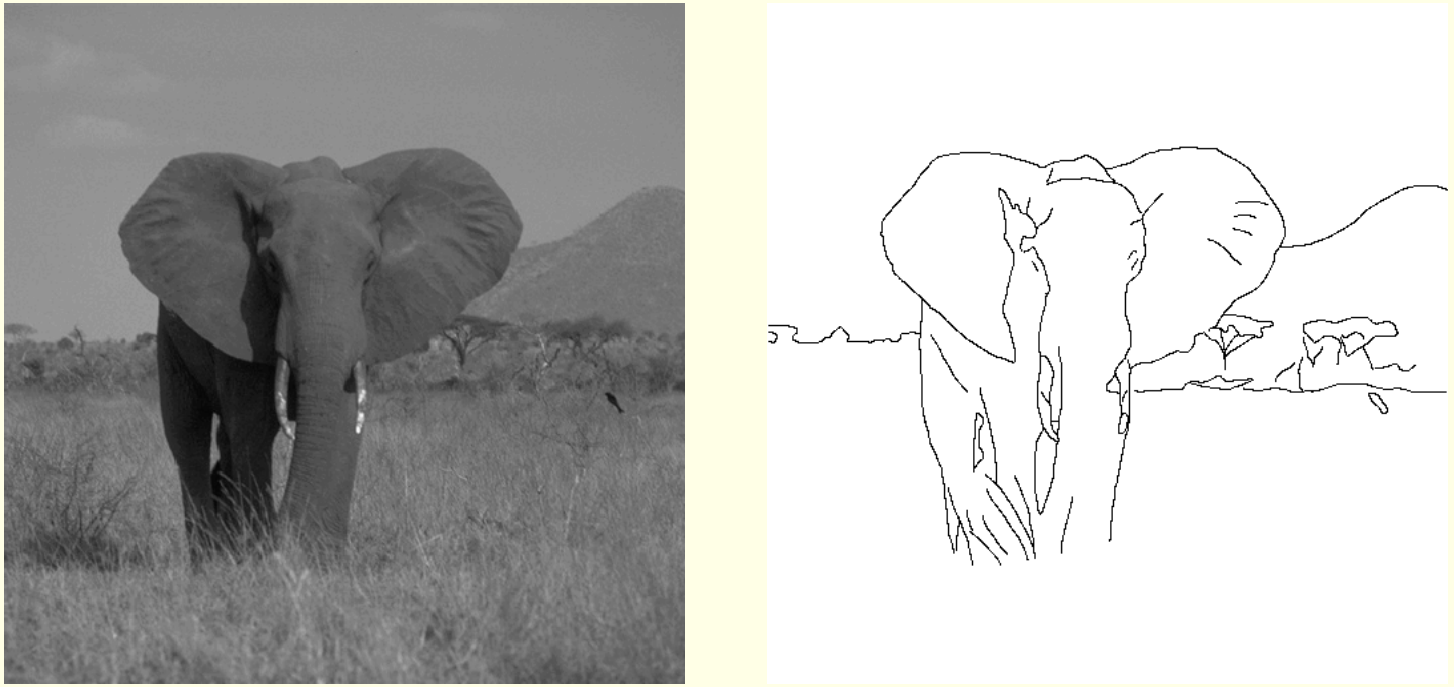
(a) Input image

(b) Operator response



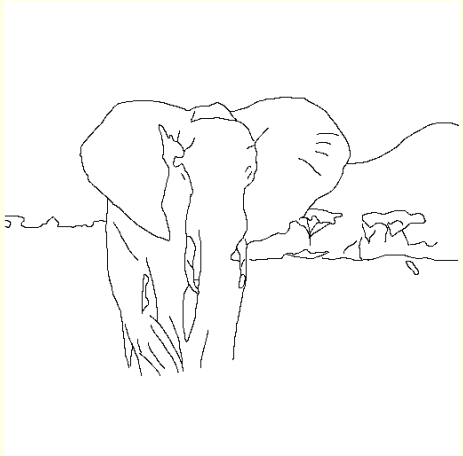
(c) Binary contour map

Ground truth

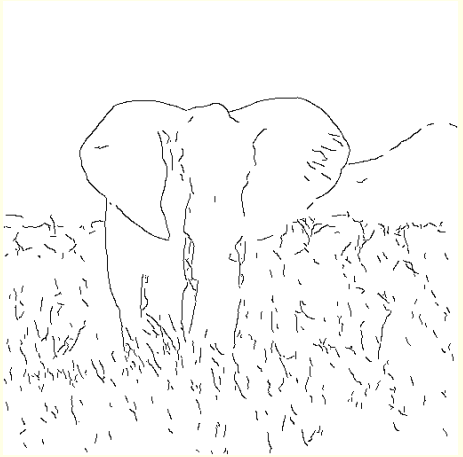


Input image and its associated ground truth contours.

Performance measure



(a) Ground truth contours.

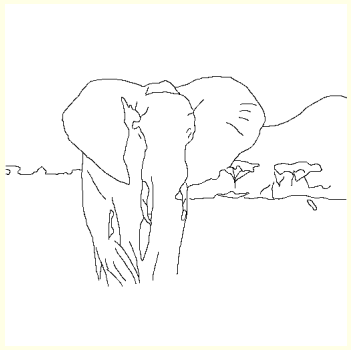
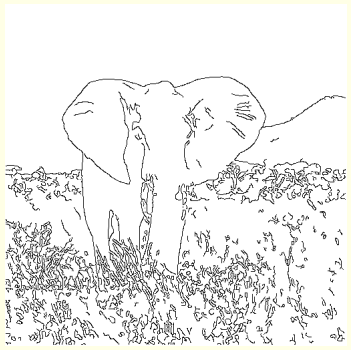
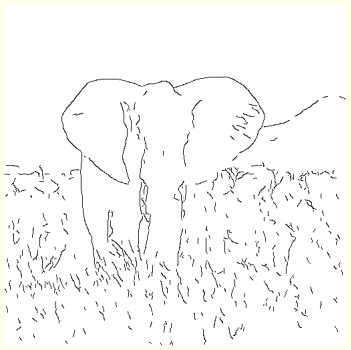
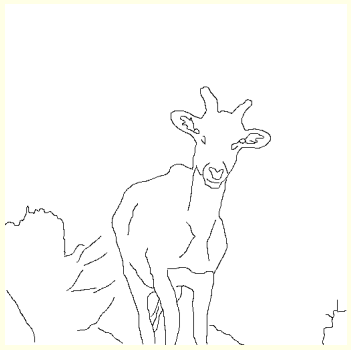


(b) Operator-detected contours.

Correctly detected contour pixels: E
False positives (spurious contours): E_{FP}
False negatives (missed ground truth contours): E_{FN}

$$P = \frac{\mathrm{card}(E)}{\mathrm{card}(E) + \mathrm{card}(E_{\mathsf{FP}}) + \mathrm{card}(E_{\mathsf{FN}})} \tag{10}$$

Comparison

Original image	Ground truth edge map	Best Canny edge map	Best non-CRF inhibition map
			
Elephant 2		$P = 0.23$, $\sigma = 1.8$, $p = 10\%$,	$P = 0.42$, $\sigma = 2.0$, $\alpha = 1.0$, $p = 10\%$,
			
Goat 3		$P = 0.14$, $\sigma = 2.4$, $p = 10\%$,	$P = 0.34$, $\sigma = 2.0$, $\alpha = 1.0$, $p = 10\%$,

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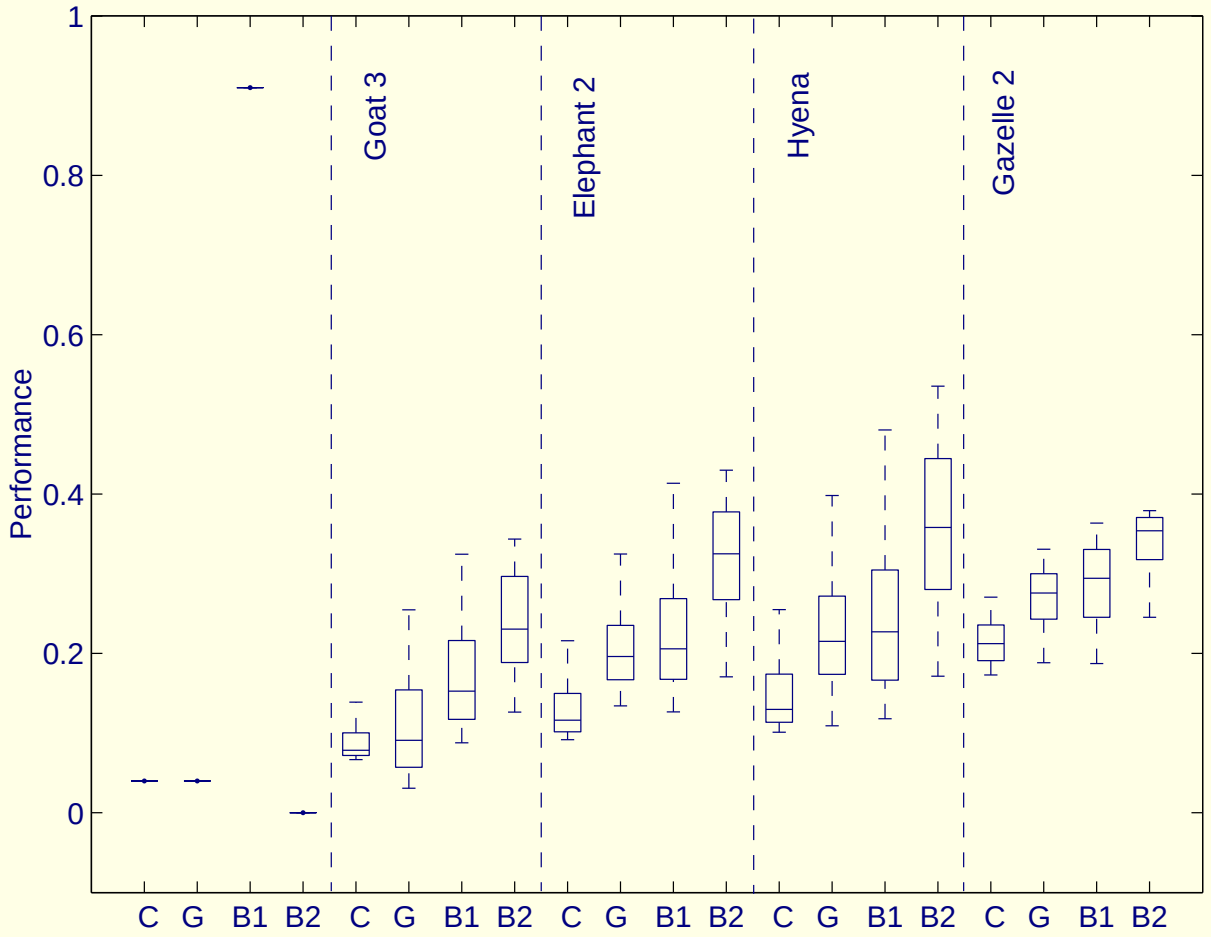
Comparison



Box-and-whisker plots of the performance of Canny edge detector (C), Gabor energy operator (G), anisotropic (B1) and isotropic (B2) non-CRF inhibition operator.

Camouflage

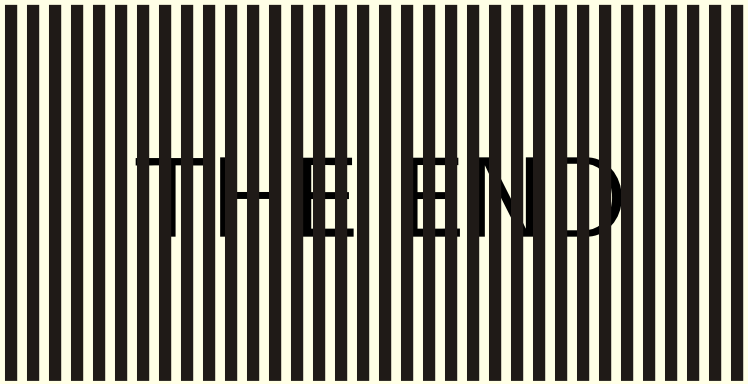
Camouflage

Camouflage

Camouflage

Camouflage


Couleur - Noir
Farbe - Schwarz
Size - One Size
Taille - Taille Unique
Größe - Eine Für Alle


THE END

THE END

PS: operator available at:

`www.cs.rug.nl/~ imaging`