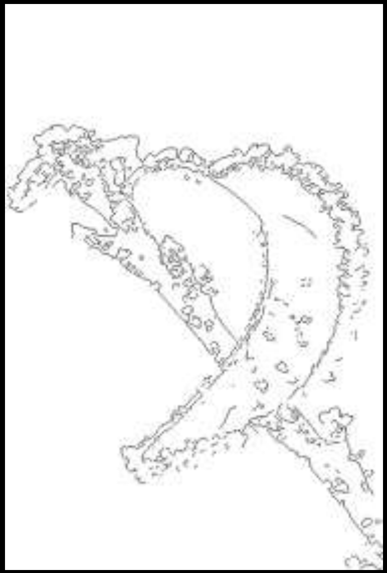
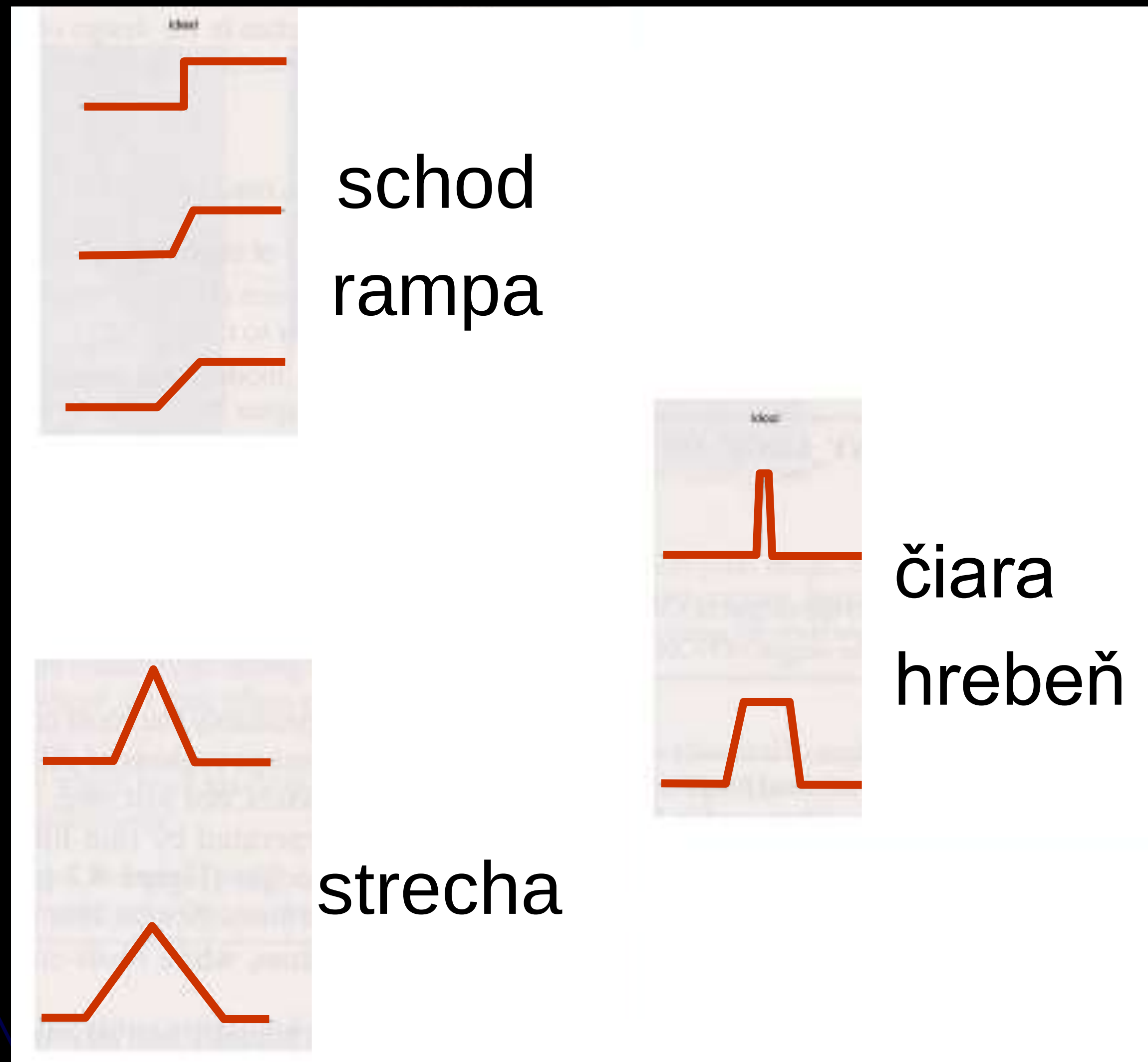
Hľadanie hrán

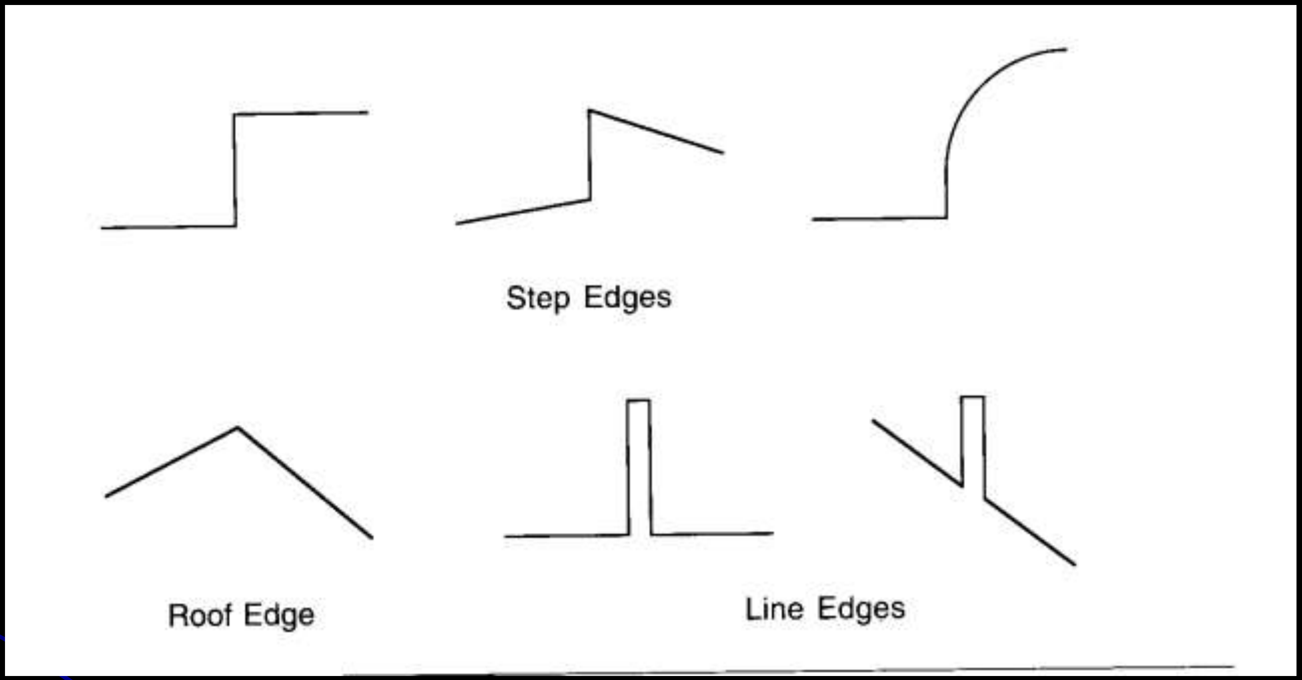


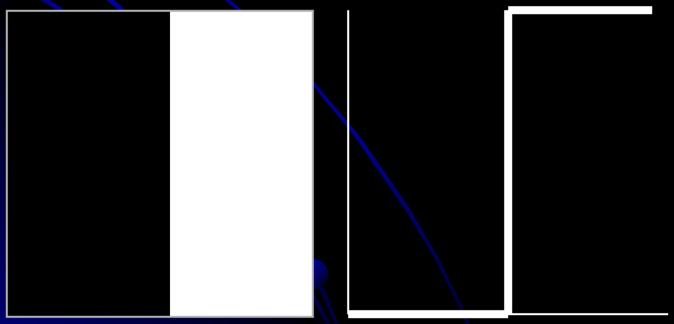
Typy hrán

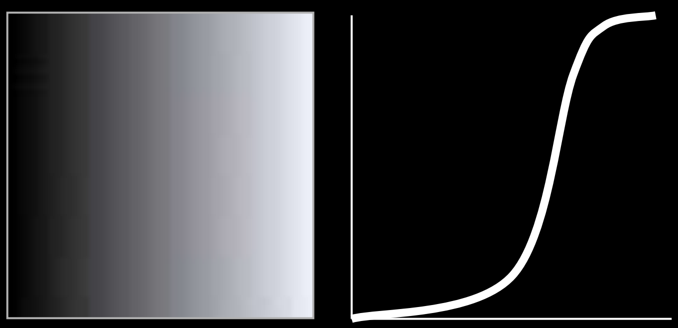
skutočné hrany - šum



Typy hrán







Hľadanie hrán

skúmame body v okolí (pomocou **derivácie**)

Ak sa intenzity príliš nelíšia - pravdepodobne tam nie je hrana

Ak sa líšia - bod môže patriť hrane

Metódy hľadania hrán

- konvolučné masky
- diskrétna aproximácia diferenciálnych operátorov (miera zmeny intenzity)
- Informácia o:
  - existencia ✓
  - orientácia ?

Diferencovanie 2D

$$\frac{\partial f(x,y)}{\partial x} \approx \frac{f(x_{n+1},y_m) - f(x_n,y_m)}{\Delta x}$$

$$\frac{\partial f(x,y)}{\partial y} \approx \frac{f(x_n,y_{m+1}) - f(x_n,y_m)}{\partial y}$$

$$\begin{bmatrix} 1 & -1 \end{bmatrix} \qquad \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$$\frac{\partial I(x,y)}{\partial x} = \frac{I(x+1,y) - I(x-1,y)}{2}$$

$$\frac{\partial I(x,y)}{\partial y} = \frac{I(x,y+1) - I(x,y-1)}{2}$$

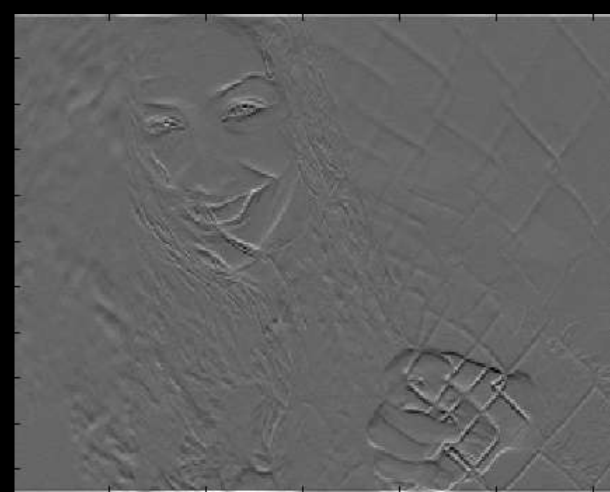
$$\frac{\partial I}{\partial x} = I * \begin{bmatrix} 1 & 0 & -1 \end{bmatrix}$$

$$\frac{\partial I}{\partial y} = I * \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

Diferencovanie

I

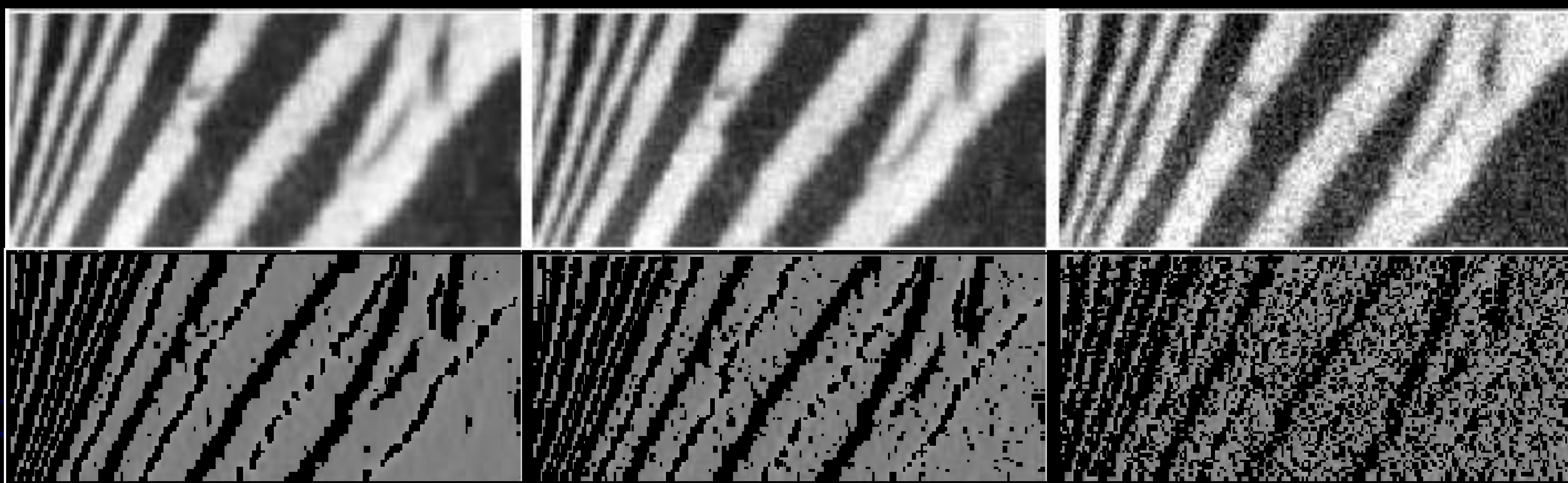
$$I_x = I * \begin{bmatrix} 1 & -1 \end{bmatrix}$$



$$I_y = I * \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

Ktorý obrázok je I_x?

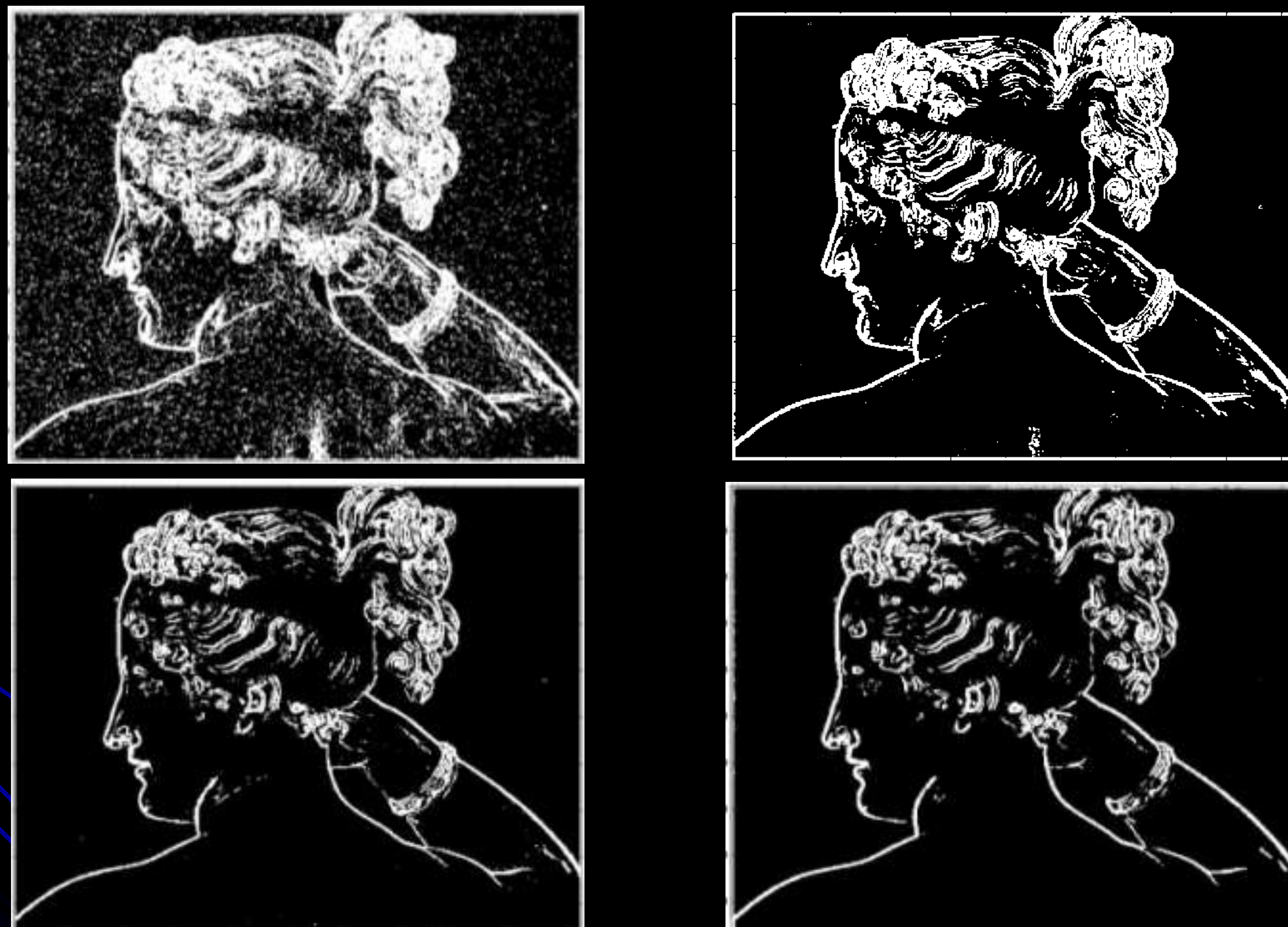
Diferencovanie a šum



Vyhladenie

prah 20

prah 50

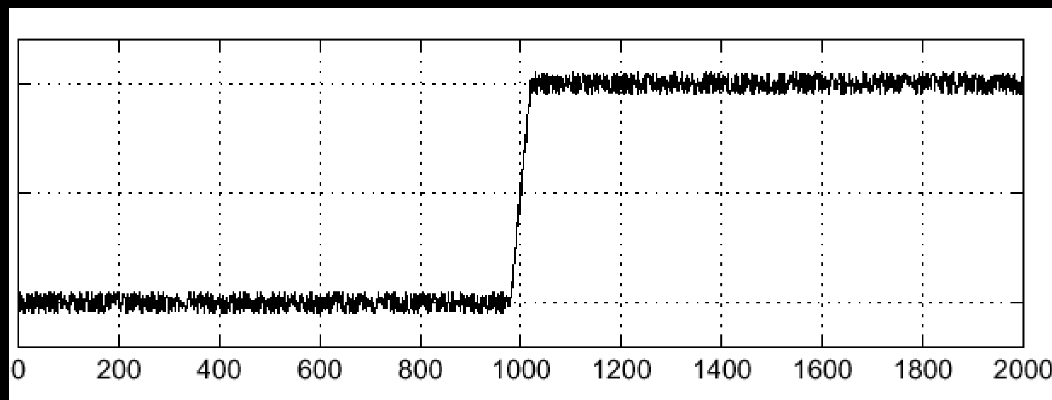


originál

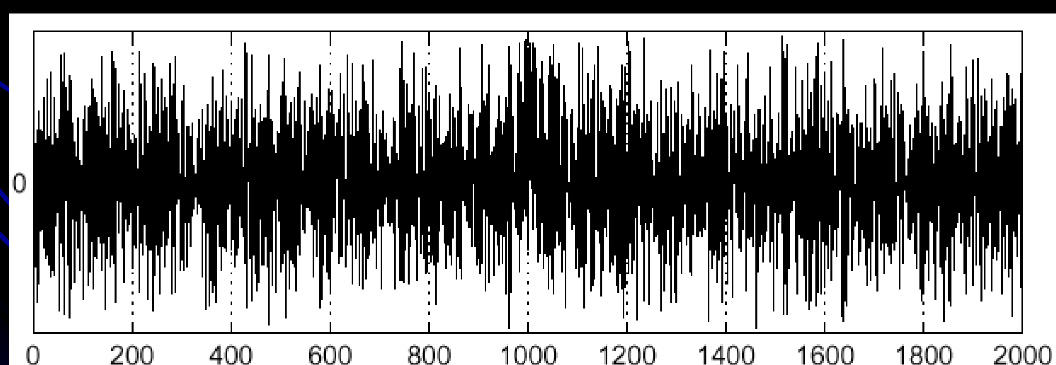
Gaussovské vyhladenie

Následky šumu

$f(x)$

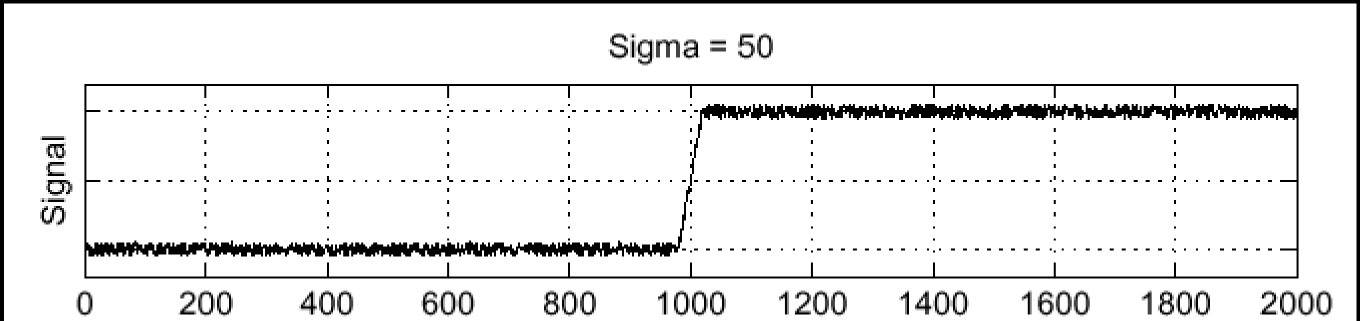


$\frac{d}{dx}f(x)$



Vyhladenie

f



h

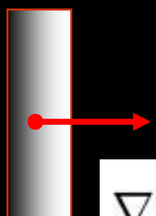
$h \star f$

$\frac{\partial}{\partial x}(h \star f)$

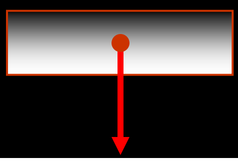
Gradient

Gradient: $\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$

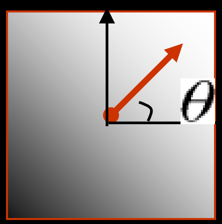
Smer – najväčšia zmena intenzity



$\nabla f = \left[\frac{\partial f}{\partial x}, 0\right]$



$\nabla f = \left[0, \frac{\partial f}{\partial y}\right]$



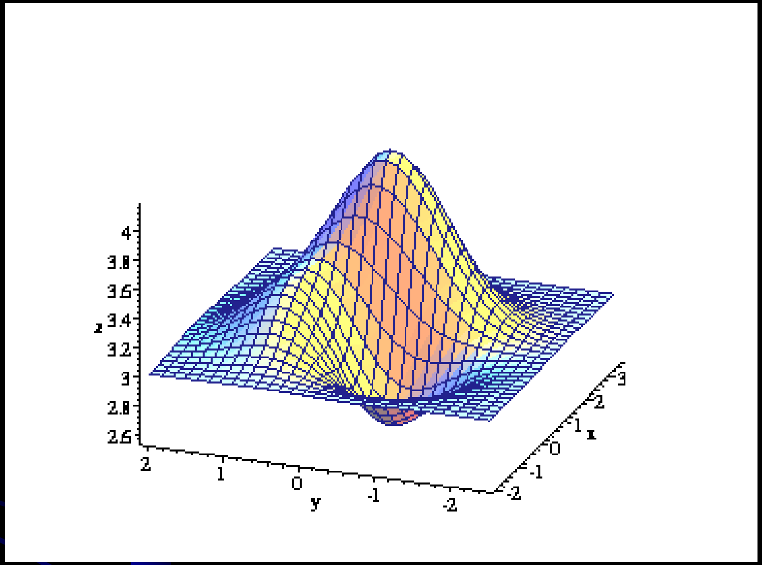
$\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$

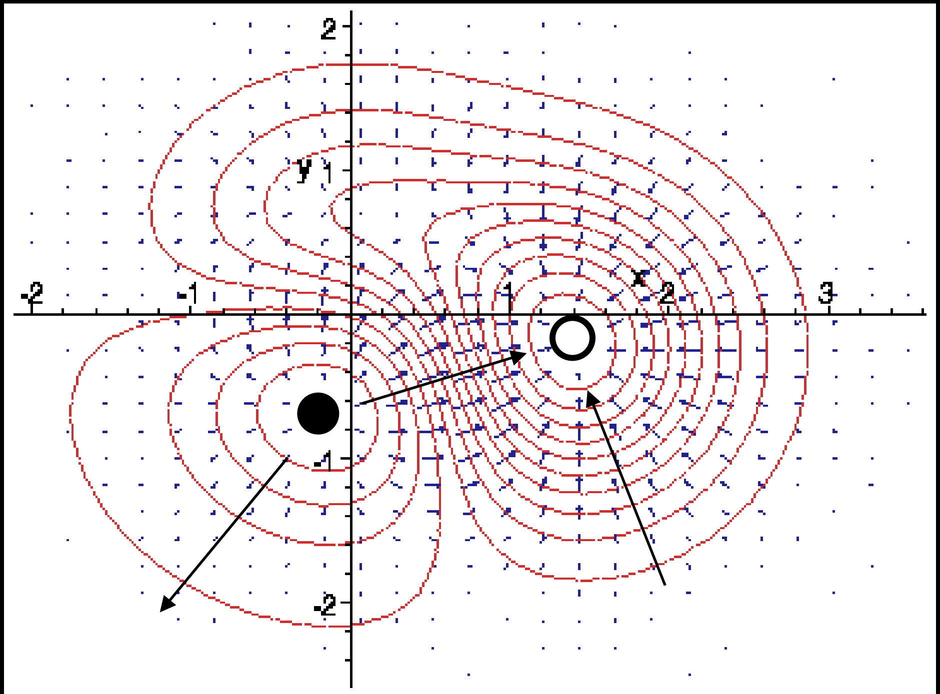
Smer gradientu: $\theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$

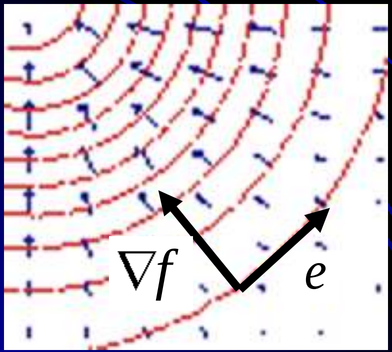
Veľkosť gradientu: $\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$

$$\|\nabla f\| \approx |G_x| + |G_y|$$

Gradient / hrany







Sila (dôležitosť) hrany = veľkosť gradientu
Smer hrany = smer gradientu – 90

Gradient

Roberts

-1	0
0	1

0	-1
1	0

Najjednoduchšie masky

- Len body hrán
- Nie orientácia
- Vhodné pre binárne obrazy
- Nevýhody:
  - Veľká citlivosť na šum
  - Nepresná lokalizácia
  - Málo bodov na aproximáciu gradientu

Sobel

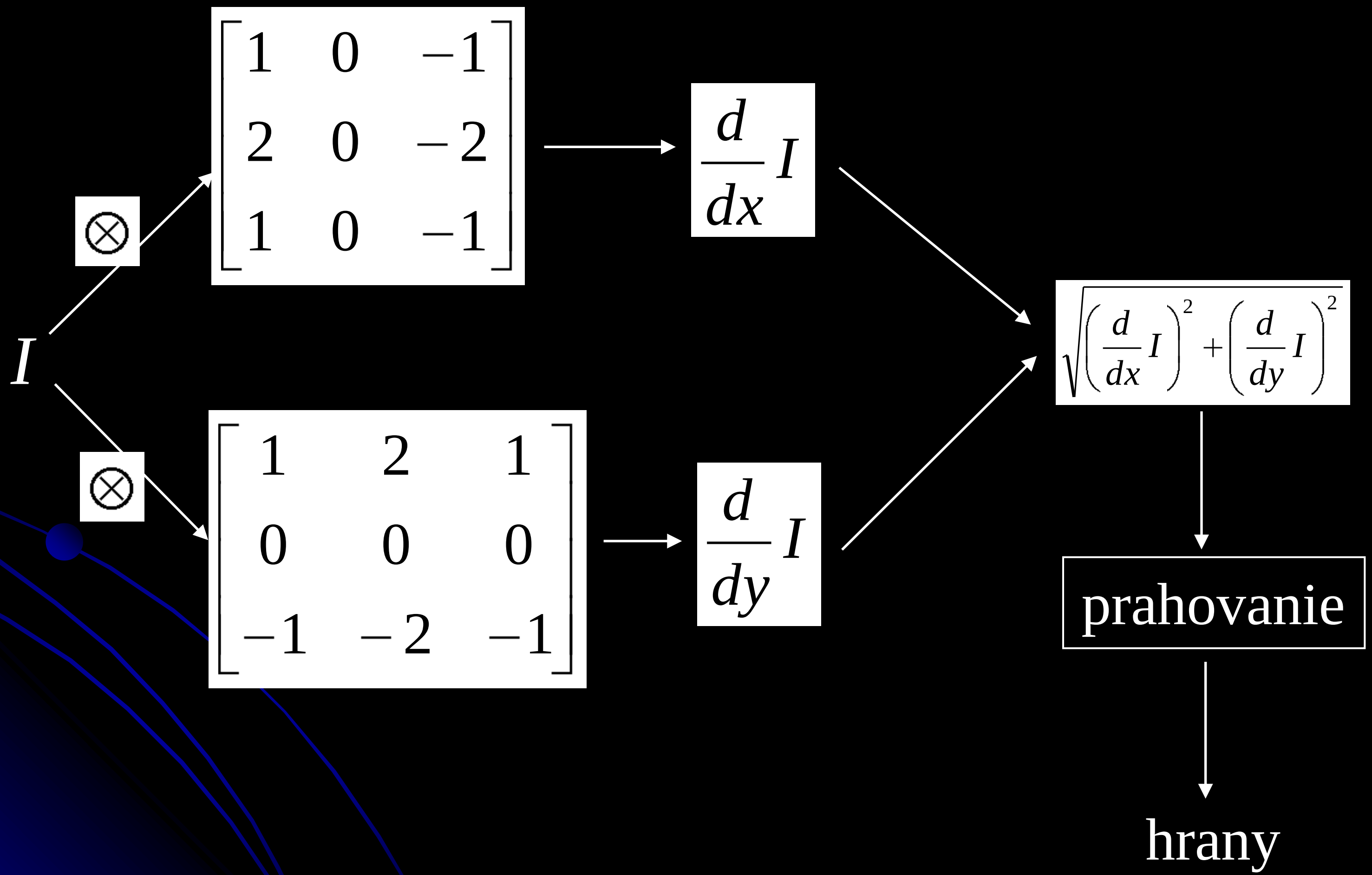
Hľadá horizontálne a vertikálne hrany

Konvolučné masky:

$$y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

$$x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Sobel



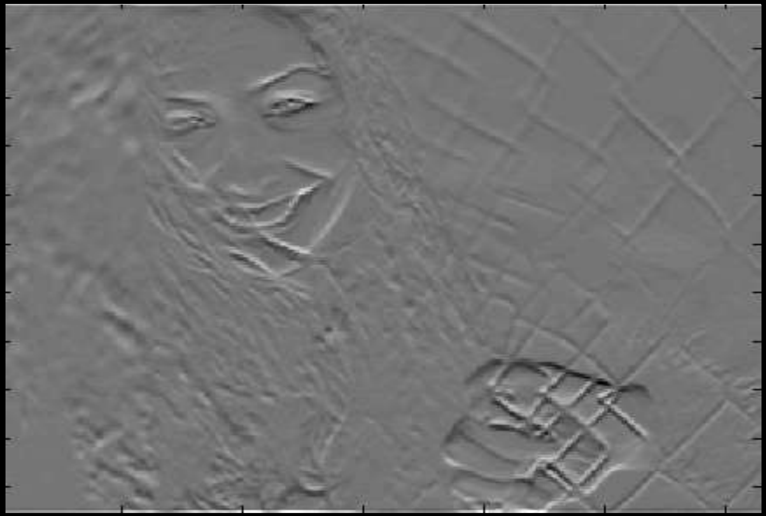
I
$\otimes$
$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$
$\frac{d}{dx} I$
$\otimes$
$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$
$\frac{d}{dy} I$
$\sqrt{\left(\frac{d}{dx} I\right)^2 + \left(\frac{d}{dy} I\right)^2}$
prahovanie
hrany

Sobel

$\frac{d}{dx} I$

I

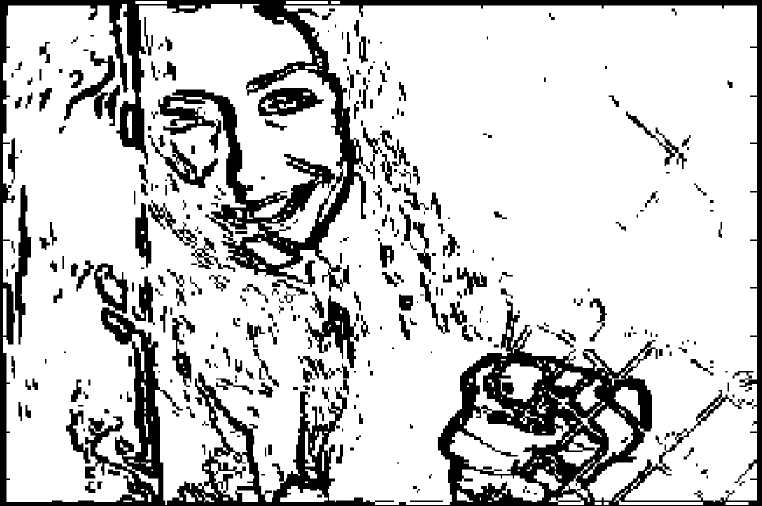
$\frac{d}{dy} I$



Sobel

$$E = \sqrt{\left(\frac{d}{dx}I\right)^2 + \left(\frac{d}{dy}I\right)^2}$$

I



$E \geq Threshold = 100$

Prewitt

Podobne ako Sobel

Masky:

$$y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

$$x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

Prewitt

$$\frac{d}{dx} I$$

$$I$$

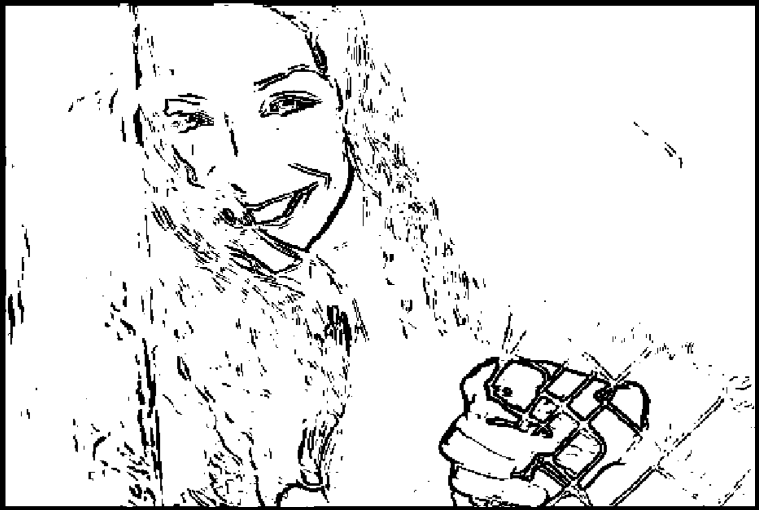
$$\frac{d}{dy} I$$

Prewitt

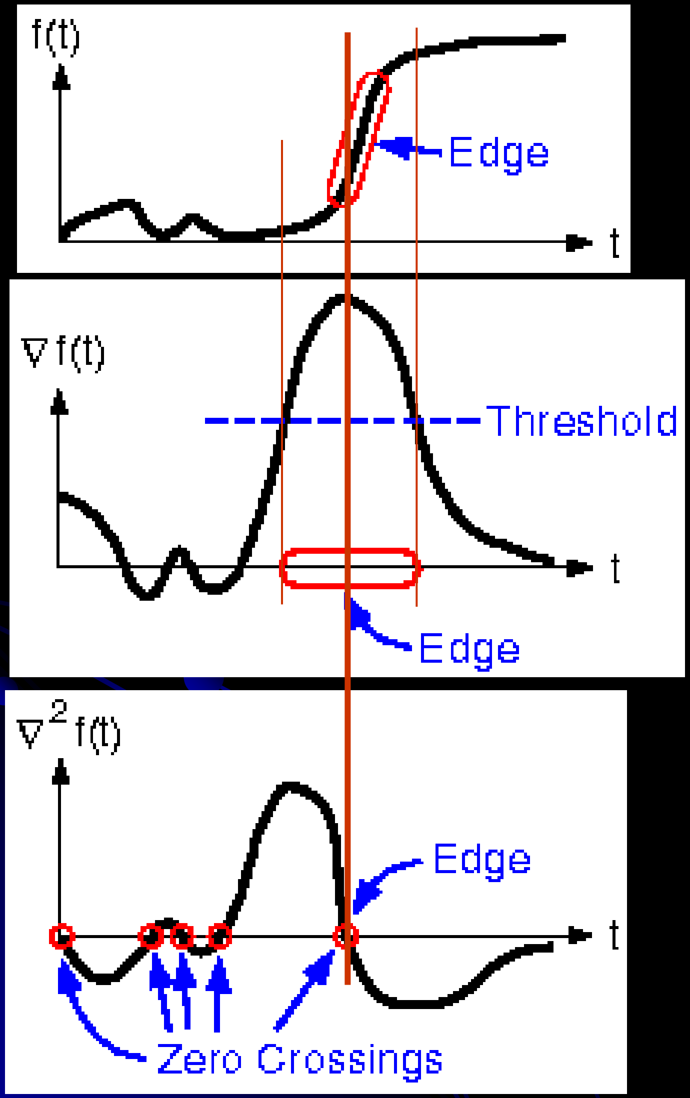
$$E = \sqrt{\left(\frac{d}{dx} I\right)^2 + \left(\frac{d}{dy} I\right)^2}$$

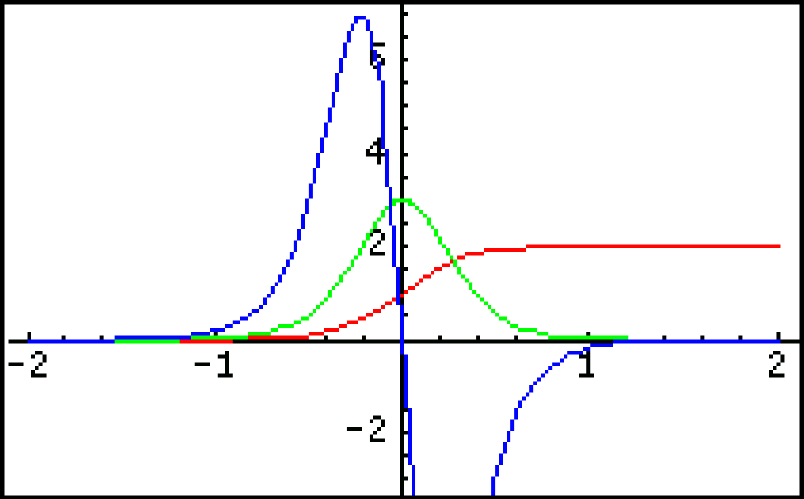
I

$E \geq 100$



Druhá derivácia





Laplacián

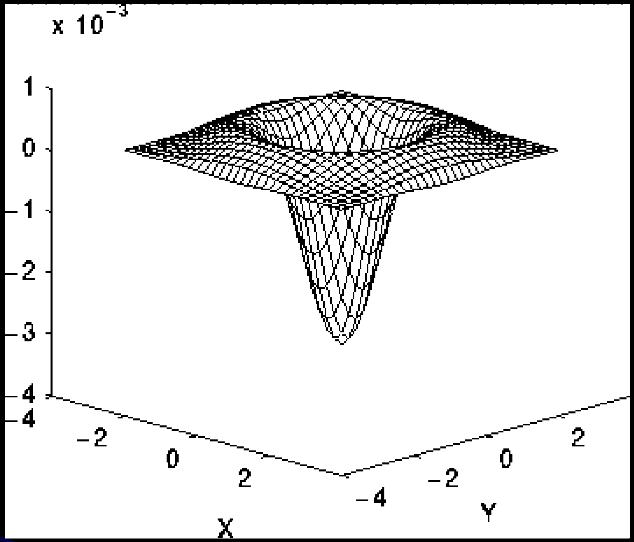
$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

$$\frac{\partial^2 f}{\partial x^2} = f(i, j+1) - 2f(i, j) + f(i, j-1)$$

$$\frac{\partial^2 f}{\partial y^2} = f(i+1, j) - 2f(i, j) + f(i-1, j)$$

Konvolúcia [1, -2, 1]

Laplacián



0	1	0
1	-4	1
0	1	0

1	1	1
1	-8	1
1	1	1

Nevýhody:

- Veľmi citlivý na šum
- Produkuje dvojité hrany
- Neurčuje smer hrany

Laplacián

3×3 5×5 7×7

Laplacián Gaussiánu

Marr – Hildreth operátor, LoG operátor

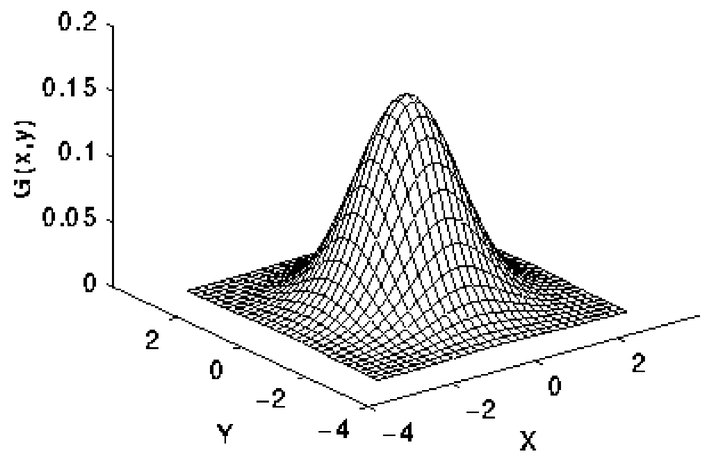
Vyhladenie pomocou 2D Gaussiánu

$$S = G_\sigma \otimes I$$

Následná aplikácia Laplaciánu

$$G_\sigma = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

$$\nabla^2 S = \frac{\partial^2}{\partial x^2} S + \frac{\partial^2}{\partial y^2} S$$

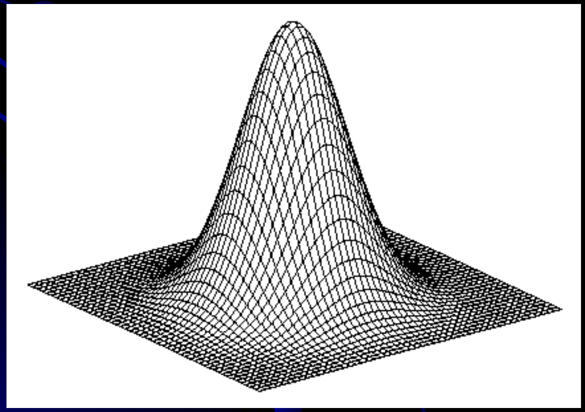


Laplacián Gaussiánu

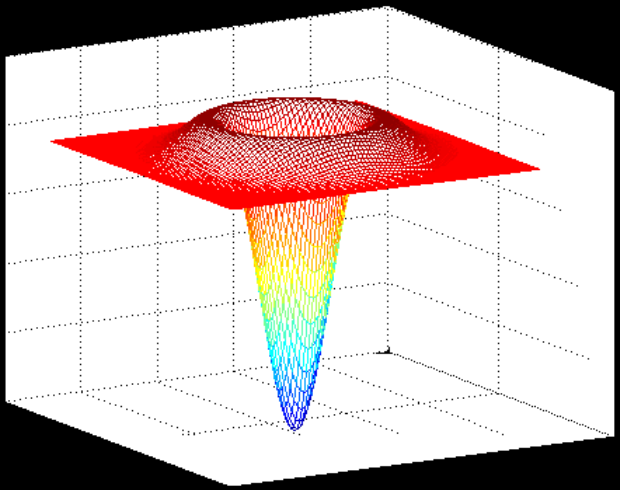
$$E = (I * G) * L = I * (G * L)$$

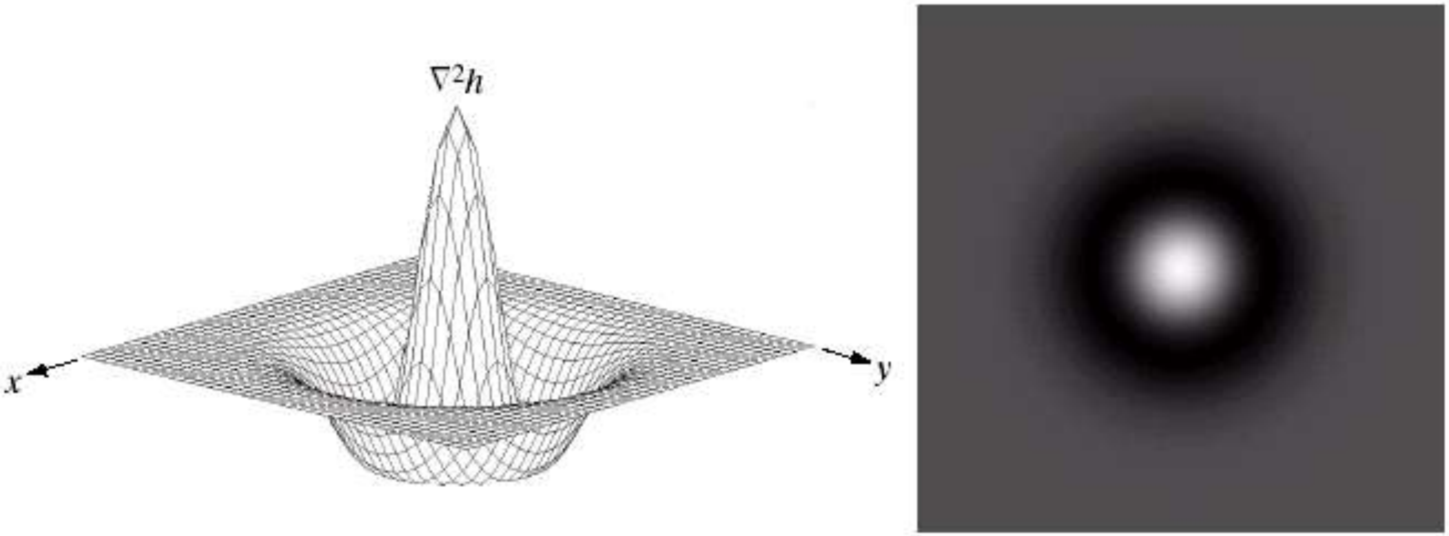
$$\nabla^2 S = \nabla^2 (G_\sigma * I) = \nabla^2 G_\sigma * I$$

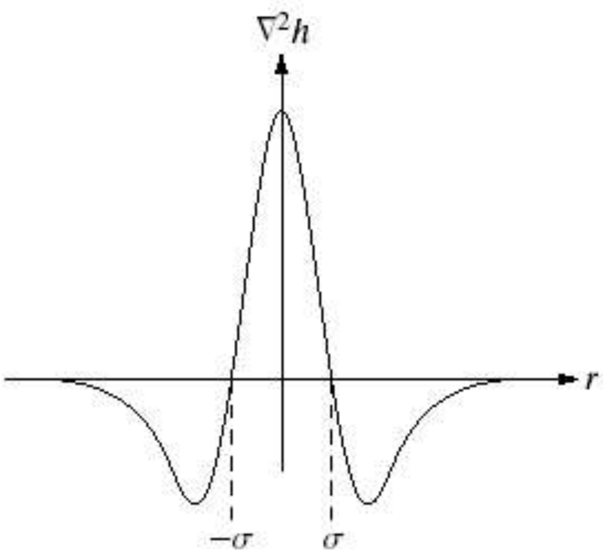
Gaussian



Laplacian of Gaussian







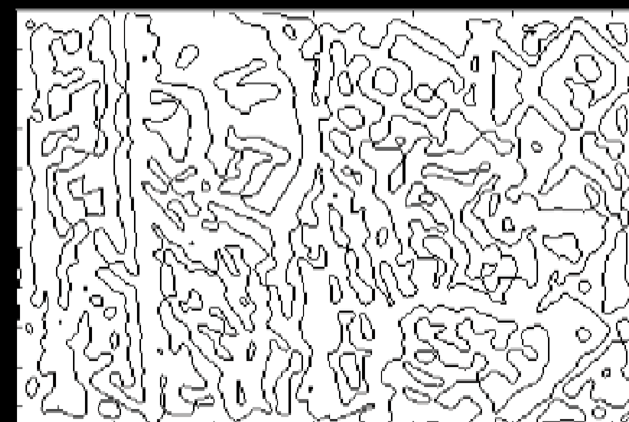
0	0	−1	0	0
0	−1	−2	−1	0
−1	−2	16	−2	−1
0	−1	−2	−1	0
0	0	−1	0	0

a b
c d

FIGURE 10.14 Laplacian of a Gaussian (LoG). (a) 3-D plot. (b) Image (black is negative, gray is the zero plane, and white is positive). (c) Cross section showing zero crossings. (d) 5 × 5 mask approximation to the shape of (a).

$\sigma = 1$

$\sigma = 3$



$\sigma = 6$

Canny

1. Good detection – maximalizovať signal-to-noise pomer
2. Good localization – detekovaný bod hrany by mal byť čo najbližšie ku stredu skutočnej hrany
3. Only one response to a single edge

JOHN CANNY: A Computational Approach to Edge Detection
IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. PAMI-8, NO. 6, NOVEMBER 1986

Canny

1) Vyhladenie Gaussiánom

2) Gradientný operátor

Veľkosť gradientu

Smer gradientu

3) Výber maxím v danom smere

4) Prahovanie dvoma prahmi

Original

Canny

Canny

Vyhladenie Gaussiánom $S = G_\sigma * I$

$$G_\sigma = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Gradientný operátor (Sobel)

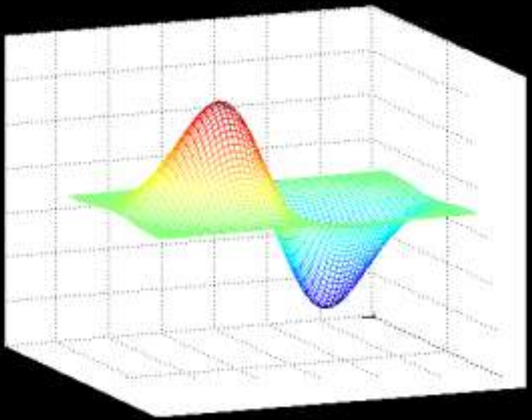
$$\nabla S = \begin{bmatrix} \frac{\partial}{\partial x} S & \frac{\partial}{\partial y} S \end{bmatrix}^T = \begin{bmatrix} S_x & S_y \end{bmatrix}^T$$

Veľkosť gradientu $|\nabla S| = \sqrt{S_x^2 + S_y^2}$

Smer gradientu $\theta = \tan^{-1} \frac{S_y}{S_x}$

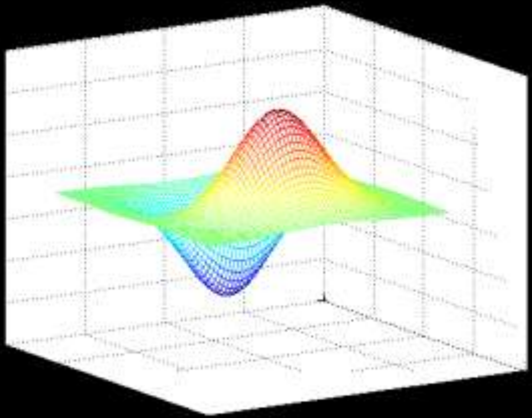
Canny

$$\nabla S = \nabla \left(G_\sigma * I \right) = \nabla G_\sigma * I$$

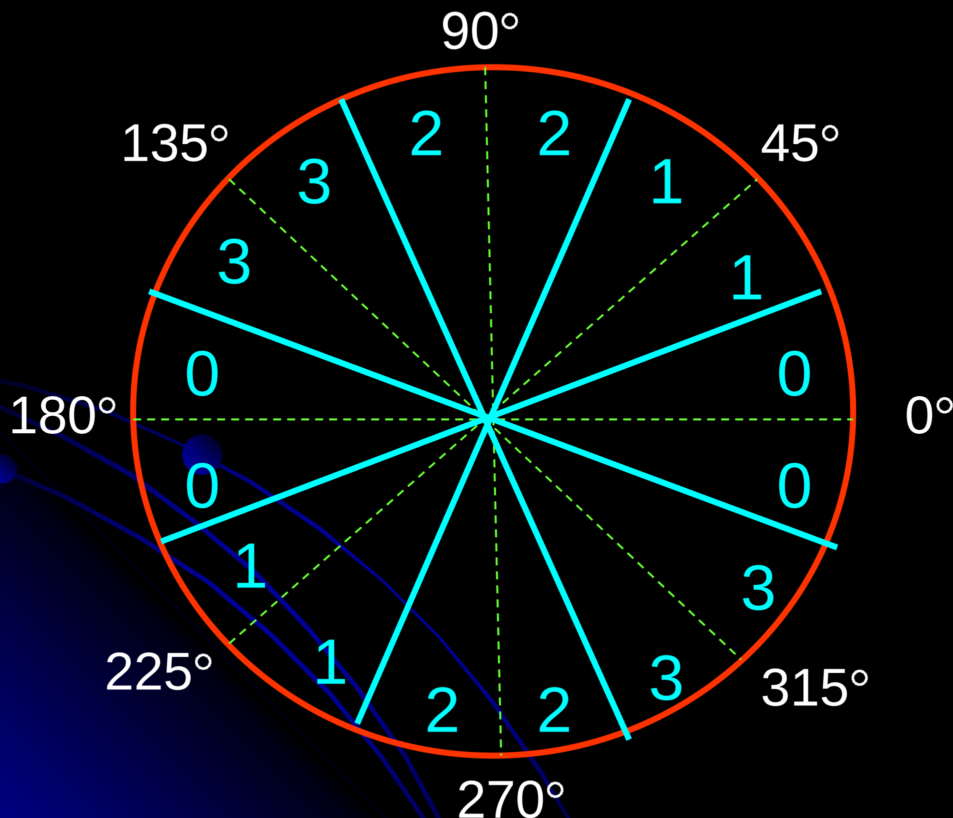


$$\nabla G_\sigma = \left[\frac{\partial G_\sigma}{\partial x} \quad \frac{\partial G_\sigma}{\partial y} \right]^T$$

$$\nabla S = \left[\frac{\partial G_\sigma}{\partial x} * I \quad \frac{\partial G_\sigma}{\partial y} * I \right]^T$$



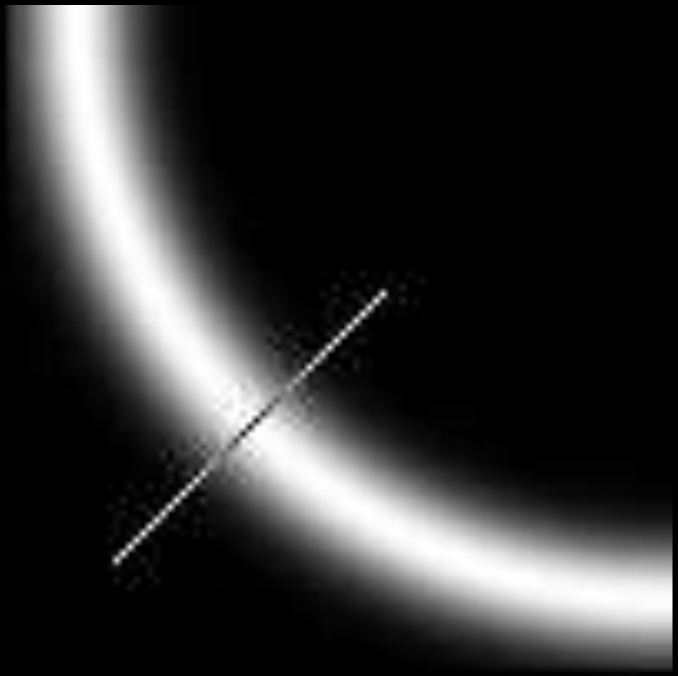
Canny

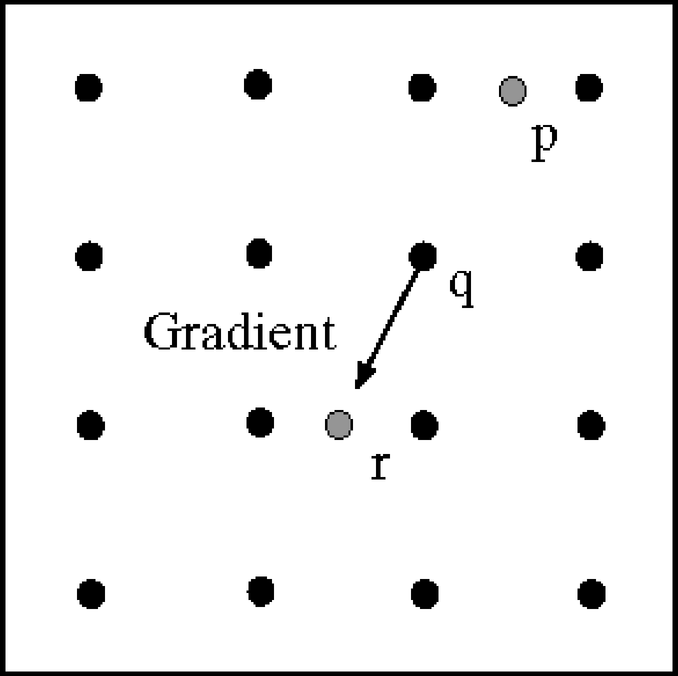


$M = |\nabla S|$

Θ

Non-maximum suppression

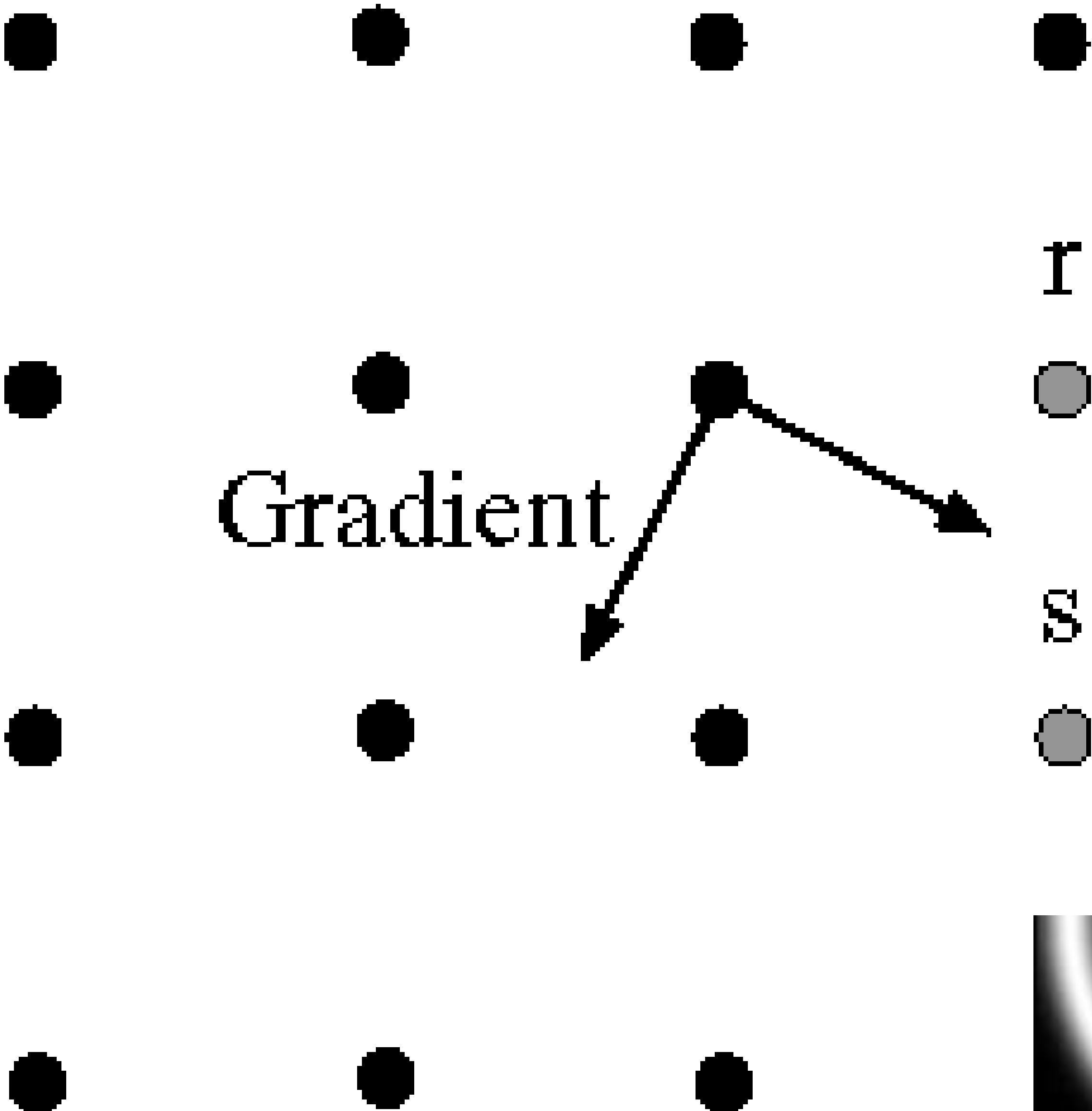




Check if pixel is local maximum along gradient direction

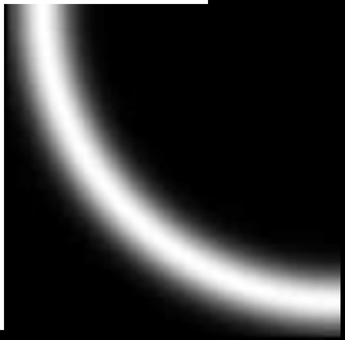
requires checking interpolated pixels p and r

Predicting the next edge point

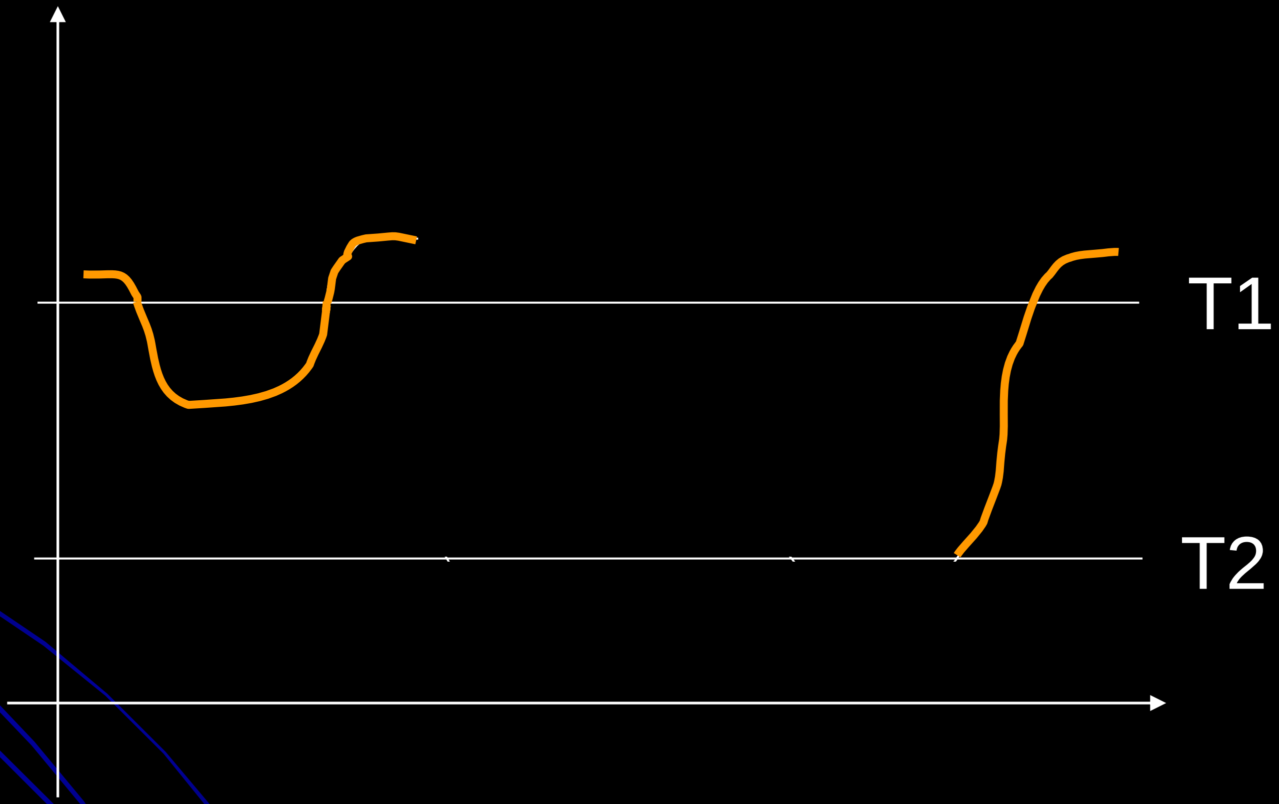


Assume the marked point is an edge point. Then we construct the tangent to the edge curve (which is normal to the gradient at that point) and use this to predict the next points (here either r or s).

(Forsyth & Ponce)

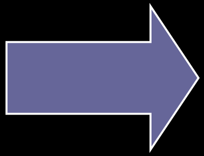


Canny



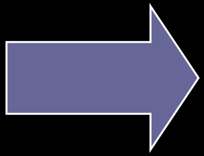
Canny príklady

Gauss 5x5, T1=255, T2=1



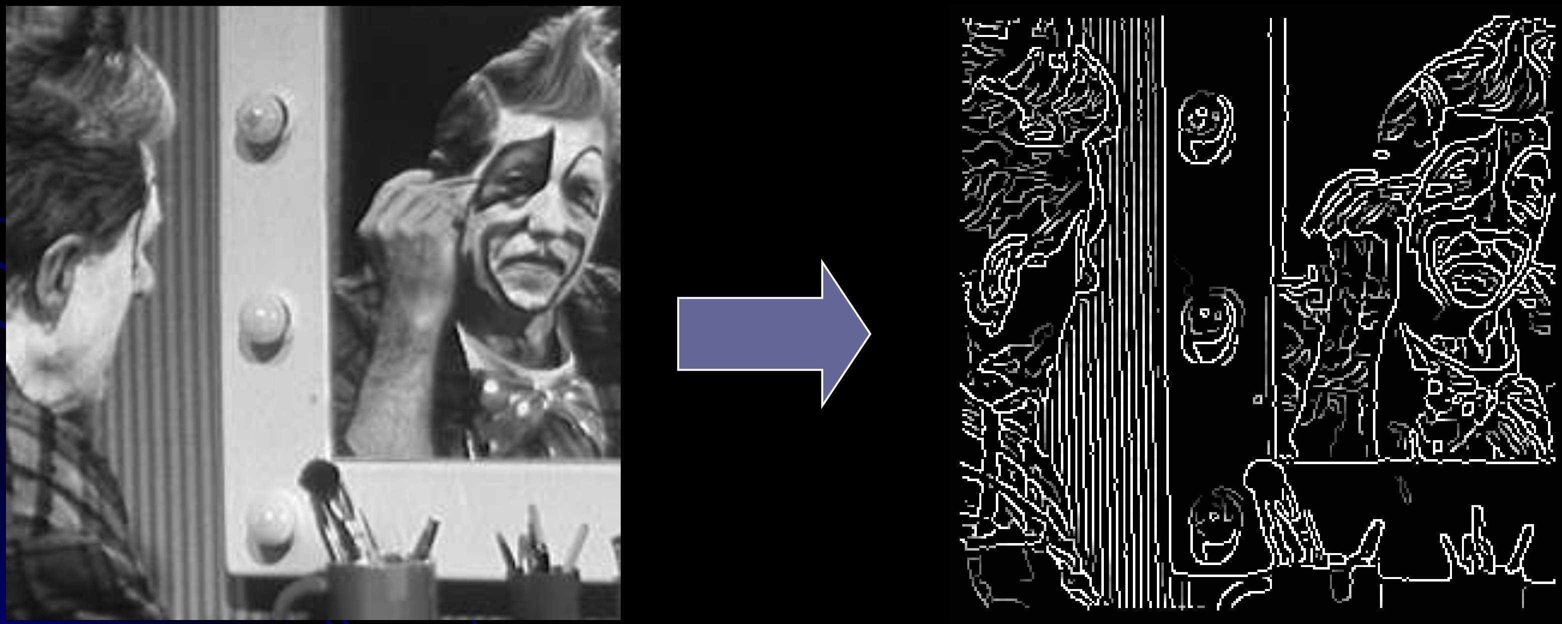
Canny príklady

Gauss 5x5, T1=255, T2=220



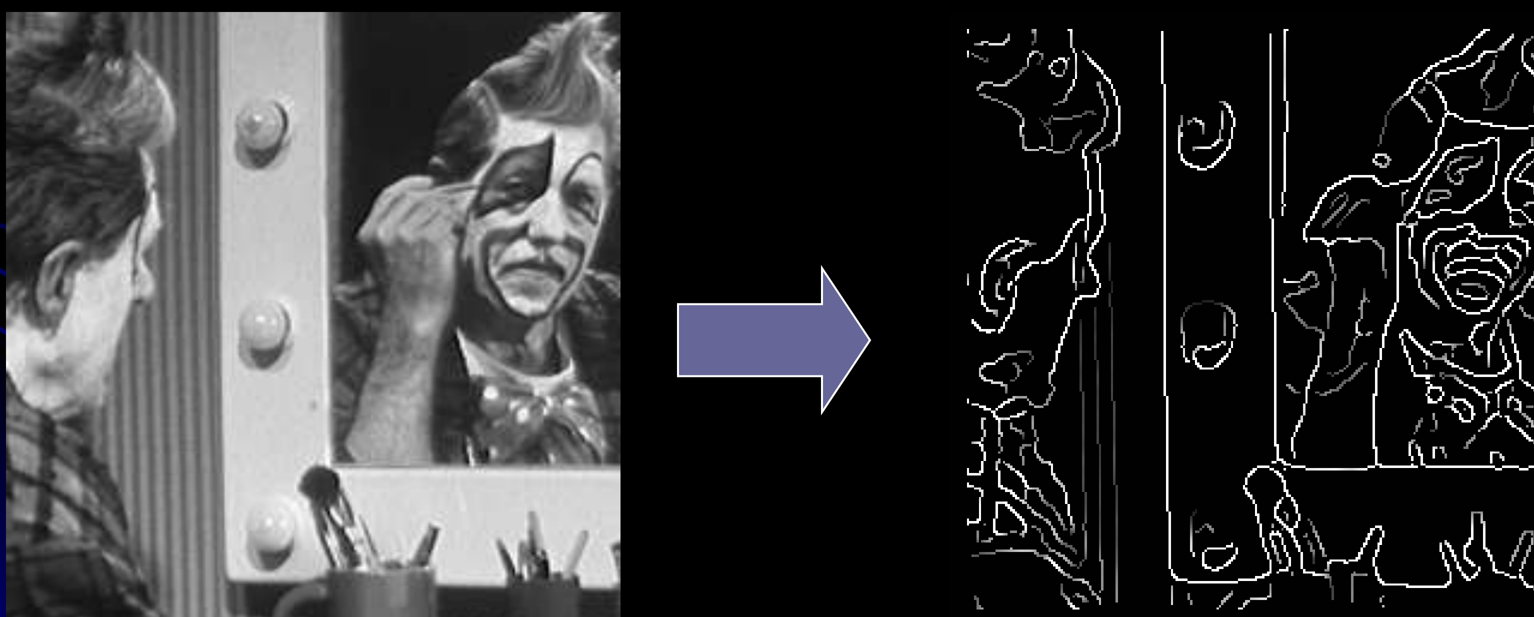
Canny príklady

Gauss 5x5, T1=128, T2=1



Canny príklady

Gauss 9x9, T1=128, T2=1



Kirsch - kompas operátor

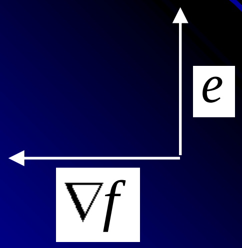
Rotujúca maska

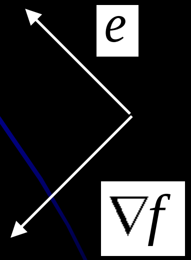
Smery: 0 , 45 , 90 , 135 , ...

Sila hrany – maximum cez jednotlivé masky

Smer hrany – maska dávajúca maximum

$$\begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix} \quad \begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix} \quad \begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \quad \begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \quad \ldots$$





Robinson

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & 1 \\ -1 & -1 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & -1 \\ 1 & -1 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & -1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & 1 \end{bmatrix}$$

Gradient direction	Robinson	Kirsch	Prewitt	Sobel
East H_1	$\begin{bmatrix} 1 & 1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & -1 \end{bmatrix}$	$\begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$
Northeast H_2	$\begin{bmatrix} 1 & -1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{bmatrix}$	$\begin{bmatrix} 0 & -1 & -1 \\ 1 & 0 & -1 \\ 1 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{bmatrix}$
North H_3	$\begin{bmatrix} -1 & -1 & -1 \\ 1 & -2 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix}$	$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$
Northwest H_4	$\begin{bmatrix} -1 & -1 & 1 \\ -1 & -2 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix}$	$\begin{bmatrix} -1 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$
West H_5	$\begin{bmatrix} -1 & 1 & 1 \\ -1 & -2 & 1 \\ -1 & 1 & 1 \end{bmatrix}$	$\begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix}$	$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$
Southwest H_6	$\begin{bmatrix} 1 & 1 & 1 \\ -1 & -2 & 1 \\ -1 & -1 & 1 \end{bmatrix}$	$\begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 1 \\ -1 & 0 & 1 \\ -1 & -1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$
South H_7	$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & 1 \\ -1 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$
Southeast H_8	$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & -1 \\ 1 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -1 \end{bmatrix}$	$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix}$

Farebné obrazy

Previesť na šedotónový a použiť niektorý z predchádzajúcich metód

Problém ak je hrana medzi dvomi farbami s rovnakým jasom

Vo farebnom obraze vieme určiť 90% hrán z šedotónového obrazu

Zvyšných 10% hrán z farebného obrazu

Farebné obrazy

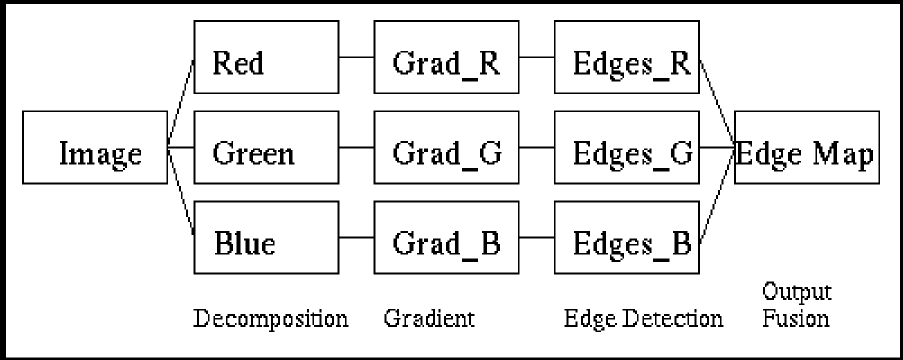
Sekvenčný prístup:

Jednotlivé kanály samostatne

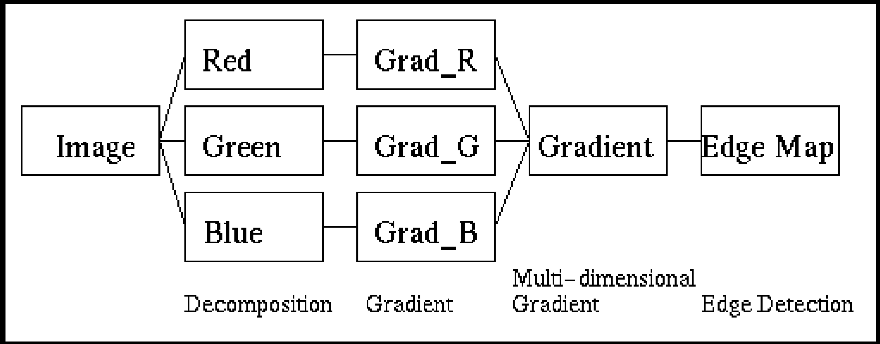
$$G(x,y) = \sqrt{G_{red}^2 + G_{green}^2 + G_{blue}^2}$$

Metódy

- output fusion methods



- multi-dimensional gradient methods



- vector methods

Vektorový prístup

$u = (R'_x, G'_x, B'_x)$
$v = (R'_y, G'_y, B'_y)$

$$u = \frac{\partial R}{\partial x} r + \frac{\partial G}{\partial x} g + \frac{\partial R}{\partial x} b$$
$$v = \frac{\partial R}{\partial y} r + \frac{\partial G}{\partial y} g + \frac{\partial R}{\partial y} b$$

$$g_{xx} = u \cdot u = u^T u = \left|\frac{\partial R}{\partial x}\right|^2 + \left|\frac{\partial G}{\partial x}\right|^2 + \left|\frac{\partial B}{\partial x}\right|^2$$
$$g_{yy} = v \cdot v = v^T v = \left|\frac{\partial R}{\partial y}\right|^2 + \left|\frac{\partial G}{\partial y}\right|^2 + \left|\frac{\partial B}{\partial y}\right|^2$$
$$g_{xy} = u \cdot v = u^T v = \frac{\partial R}{\partial x}\frac{\partial R}{\partial y} + \frac{\partial G}{\partial x}\frac{\partial G}{\partial y} + \frac{\partial B}{\partial x}\frac{\partial B}{\partial y}$$

smer $$\theta = \frac{1}{2}\tan^{-1}\left[\frac{2 g_{xy}}{(g_{xx} - g_{yy})}\right]$$

veľkosť $$F(\theta) = \sqrt{\frac{1}{2}\left[(g_{xx} + g_{yy}) - (g_{xx} - g_{yy})\cos(2\theta) + 2 g_{xy}\sin(2\theta)\right]}$$

Vector order statistics

- Používa sa R-ordering
- Okno **W** veľkosti **n** pixelov

- ***Vector range (VR) edge detector*** – najjednoduchší

  $$VR=D(\mathbf{x}^{(n)}, \mathbf{x}^{(1)})$$

  $\mathbf{x}^{(1)}$ – median , $\mathbf{x}^{(n)}$ - outlier

  citlivý na šum
- ***Vector dispersion edge detectors*** **(VDED)**

$$VDED = \left\| \sum_{i=1}^{n} \alpha_i \mathbf{X}^{(i)} \right\|$$

a_i váhy

VR špeciálny prípad VDED kde $a_{(1)}=-1$ a $a_{(n)}=1$, $a_{(i)}=0$ $i=2,...n-1$

Fig. 4. Test image 'Lena'

Fig. 5. Test image 'Lena' distorted with the Gaussian and impulsive noises

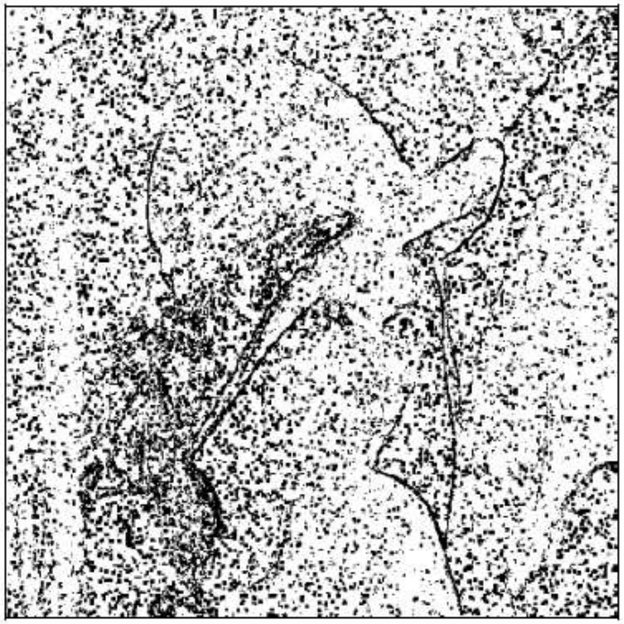


Fig. 6. VR detector: edges of the noised image 'Lena'

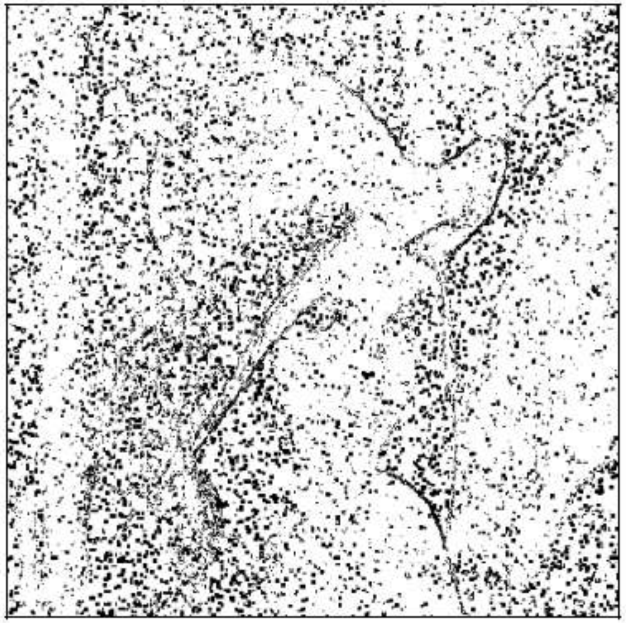


Fig. 7. VDED detector: edges of the noised image 'Lena'

Minimum vector range

Uvažujeme k rozdielov – odstránime citlivosť na šum (impulsive, exponential noise)

$$MVR = \min_{j} \left\{ \left\| \mathbf{X}^{(n-j+1)} - \mathbf{X}^{(1)} \right\| \right\},$$
$$j = 1, 2, \ldots, k, \; k < n$$

Minimum vector dispersion – odstráni citlivosť aj na Gaussov šum

$$MVD = \min_{j} \left\{ \left\| \mathbf{X}^{(n-j+1)} - \sum_{i=1}^{l} \frac{\mathbf{X}^{(i)}}{l} \right\| \right\},$$
$$j = 1, 2, \ldots, k, \; k, l < n$$

Používa α-trimmed mean

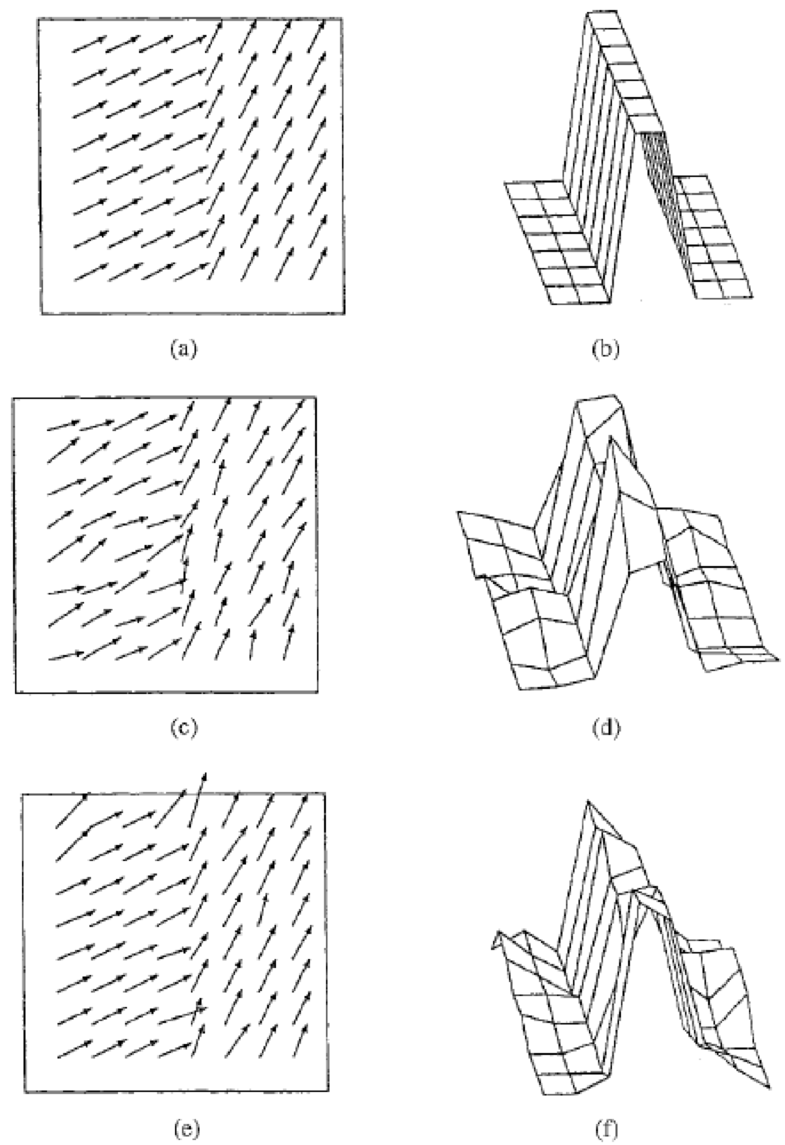


Fig. 4. Response of MVD to noise contaminated edge. (a) Initial edge, (b) Response of MVD to (a), (c) edge (a) corrupted with gaussian noise, (d) response of MVD to (c), (e) edge (a) corrupted with double-exponential noise, (f) response of MVD to (e).

Nearest neighbour vector range

$$\mathrm{NNVR} = D\left[x^{(n)}, \sum_{i=1}^{n} w_i x^{(i)} \right]$$

$w_i \geq 0$

$$\sum_{i=1}^{n} w_i = 1$$

$$w_i = \frac{d^{(n)} - d^{(i)}}{n \cdot d^{(n)} - \sum_{j=1}^{n} d^{(j)}}$$

$$d_i = \sum_{j=1}^{n} D(x_i, x_j), \quad i = 1, 2, \ldots, n$$

Nemôže byť použité na homogénne oblasti

- Kombináciou MVD a NNVR

$$\mathrm{NNMVD} = \min_j \left\{ D\left[x^{(n-j+1)} - \sum_{i=1}^{n} w_i x^{(i)} \right] \right\}$$

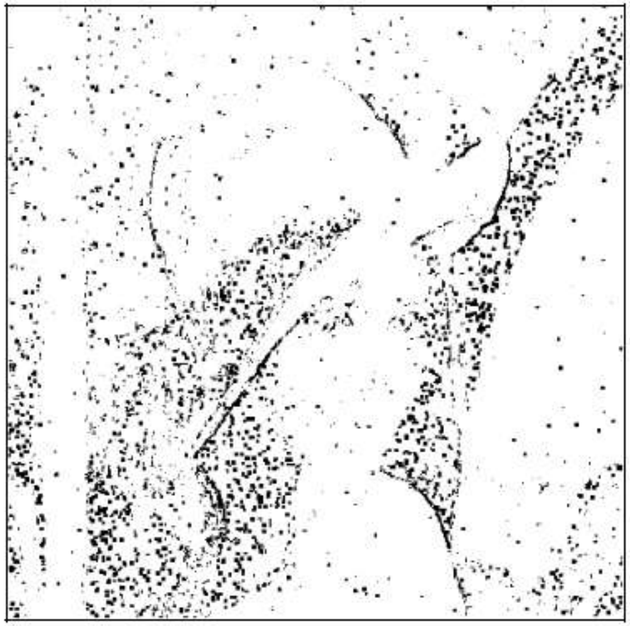


Fig. 8. NNVR detector: edges of the noised image 'Lena'

Fig. 9. MVD detector: edges of the noised image 'Lena'

Fig. 10. NNMVD detector: edges of the noised image 'Lena'

Difference vector operators

Každý pixel reprezentovaný ako vektor v RGB

Vypočítame gradient v 4 smeroch

$$|\nabla f|_{0^\circ} = \|\boldsymbol{Y}_{0^\circ} - \boldsymbol{X}_{0^\circ}\|$$

$$|\nabla f|_{90^\circ} = \|\boldsymbol{Y}_{90^\circ} - \boldsymbol{X}_{90^\circ}\|$$

$$|\nabla f|_{45^\circ} = \|\boldsymbol{Y}_{45^\circ} - \boldsymbol{X}_{45^\circ}\|$$

$$|\nabla f|_{135^\circ} = \|\boldsymbol{Y}_{135^\circ} - \boldsymbol{X}_{135^\circ}\|$$

$$DV = \max\left(|\nabla f|_{0^\circ}, |\nabla f|_{45^\circ}, |\nabla f|_{90^\circ}, |\nabla f|_{135^\circ}\right)$$

Fig. 11. DV detector: edges of the noised image 'Lena'

X, Y sú 3D vektorové konvolučné masky

Základná maska pre okno 3x3

v(x,y) – pixel, ***v***(x_0,y_0) - stredný pixel

$$X_{0^\circ} = v(x_{-1}, y_0), \qquad Y_{0^\circ} = v(x_1, y_0)$$

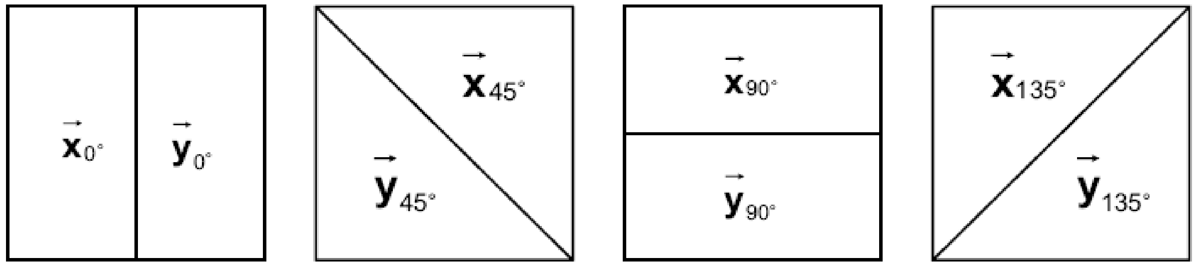
$$X_{45^\circ} = v(x_{-1}, y_1), \qquad Y_{45^\circ} = v(x_1, y_{-1})$$

$$X_{90^\circ} = v(x_0, y_1), \qquad Y_{90^\circ} = v(x_0, y_{-1})$$

$$X_{135^\circ} = v(x_1, y_1), \qquad Y_{135^\circ} = v(x_{-1}, y_{-1})$$

Pred detekciou môžeme obraz filtrovať – treba použiť väčšiu masku

Ak okno **W** je veľkosti **n** x **n** (n=2k+1) vytvoríme sub-okno veľkosti $N = (n^2-1)/2$



Configuration of sub-windows for VD filters

$$X_d = f\left(v_{d,1}^{sub_1}, v_{d,2}^{sub_1}, \ldots, v_{d,N}^{sub_1}\right)$$

$$Y_d = f\left(v_{d,1}^{sub_2}, v_{d,2}^{sub_2}, \ldots, v_{d,N}^{sub_2}\right)$$

where: $d = 0°, 45°, 90°, 135°.$

Podľa typu šumu môžeme použiť rôzne filtre

Vector median filter

$$f_{VM}(v_1, v_2, \ldots, v_N) = v^{(1)}$$

Efektívny pri redukovaní impulsného šumu

Vector mean filter

$$f_{\overline{VM}}(v_1, v_2, \ldots, v_N) = \frac{1}{N}\sum_{i=1}^{N} v_i$$

Efektívny pri redukovaní Gaussovho šumu

Kombináciou predchádzajúcich

α-trimmed mean filter

$$f_{\alpha-\mathrm{trim}}(v_1, v_{2,\dots,}v_N) = \frac{1}{N(1-2\alpha)} \sum_{i=1}^{N(1-2\alpha)} v^{(i)}$$

where: α is within [0, 0,5) interval.

Adaptive nearest neighbour filter

$$f_{\mathrm{adap}}(v_1, v_{2,\dots,}v_N) = \sum_{i=1}^{N} w_i v_i$$

Fig. 12. DV_mean detector: edges of the noised image 'Lena'

Fig. 13. DV_α-trim detector: edges of the noised image 'Lena'

Fig. 14. DV_adapt detector: edges of the noised image 'Lena'

Difference vector iba v 2 smeroch

horizontalne a vertikálne

$$DV\_hv = \max\left(\left|\nabla f\right|_{0^\circ}, \left|\nabla f\right|_{90^\circ}\right)$$

- Ľudský vizuálny systém je viac citlivý na horizontálne a vertikálne hrany
- časovo menej náročný
- horizontálne a vertikálne rozdiely vo vektoroch prispievajú k detekcii diagonálnych hrán – detekované hrany sú tenšie

Fig. 16. DV_hv$_{mean}$ detector: edges of the noised image 'Lena'

Fig. 15. DV_hv detector: edges of the noised image 'Lena'

Fig. 17. DV_hv$_{\alpha\text{-trim}}$ detector: edges of the noised image 'Lena'

Fig. 18. DV_hv$_{adapt}$ detector: edges of the noised image 'Lena'

Detekcia hrán pomocou zgrupovania

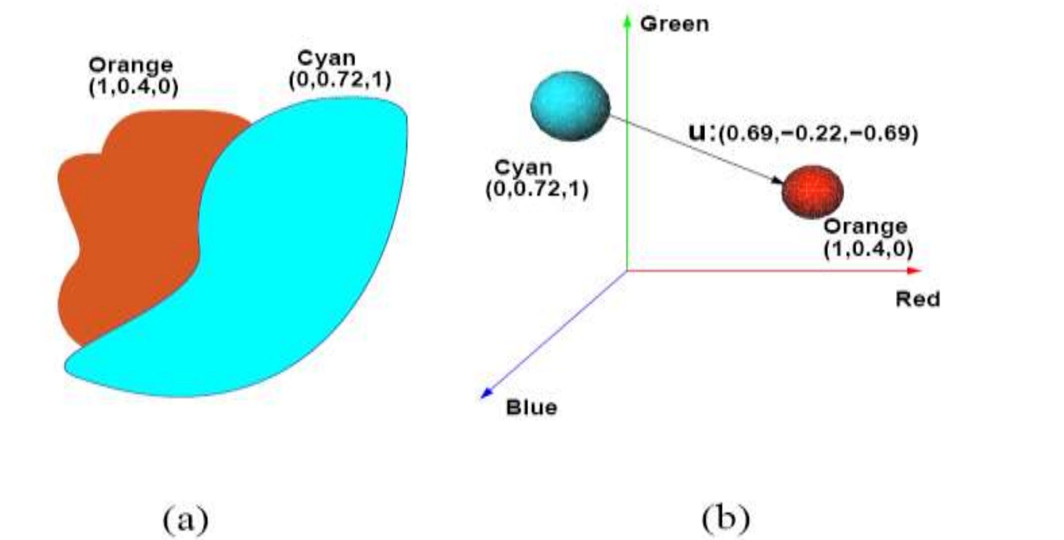
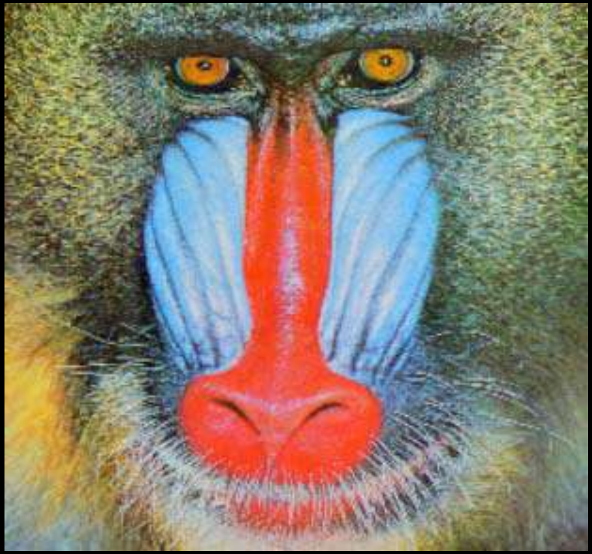
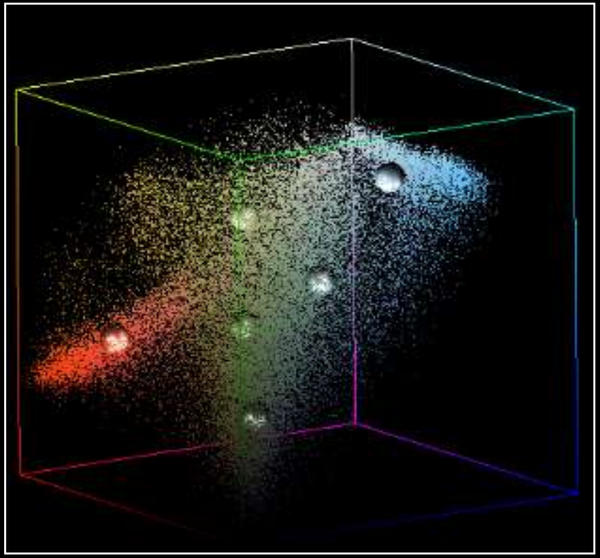


Figure 1: (a) edge between two color regions (b) u - the best linear combination.





Sobel edge detection on gray
Mandrill image

edge detected using proposed
method resulted clusters

Color Edge Detection Based on Morphology

bc, de – hrany

f(x) – originálna funkcia

Erodovaný - aghijf

Dilatovany - akmnof

Výsledný f (x) - agpqmdef

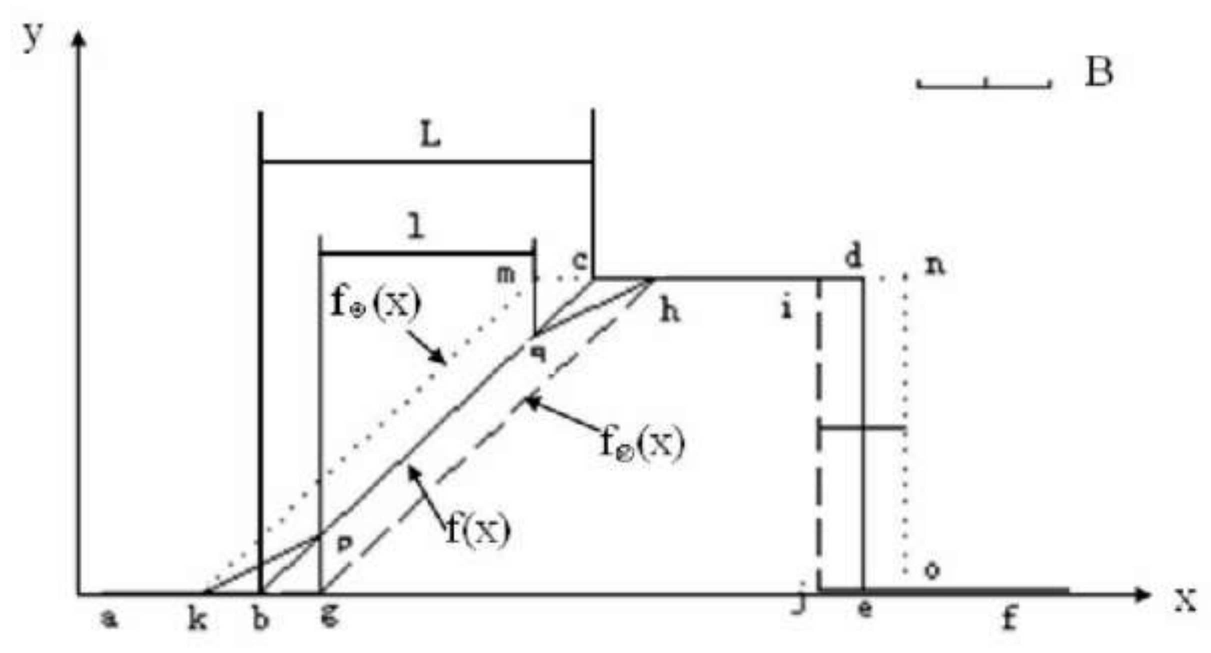


Figure 1. The sketch map of the new algorithm

$$f'(x) = \begin{cases} f_{\oplus}(x) & if\ f(x) \geq (f_{\oplus}(x) + f_{\otimes}(x))/2 \\ f_{\otimes}(x) & if\ f(x) < (f_{\oplus}(x) + f_{\otimes}(x))/2 \end{cases}$$

Color Edge Detection Based on Morphology

1. Erózia a dilatácia každého pixla na každom farebnom kanále
2. Vypočítaj f (x) 2 krát
3. Vypočítaj gradient farebného obrazu
4. Detekcia hrán
5. Odstránenie šumových hranových bodov (izolovaný bod)

Jin Zou; Hongsong Li; Bin Liu; Renfei Zhang : Color Edge Detection Based on Morphology ,2006. ICCE '06. First International Conference on Communications and Electronics, 2006 , Page(s): 291 - 293

Color Edge Detection Based on Morphology

Figure2. The origin color image

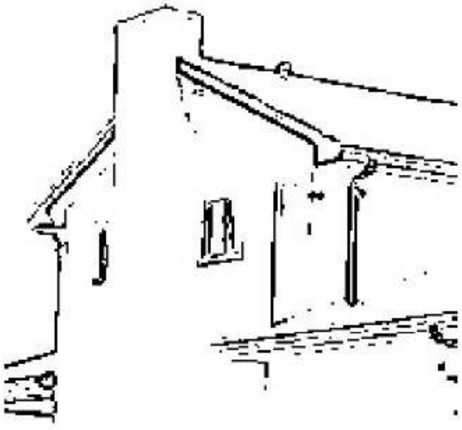


Figure 3. The edge image with Sobel operator

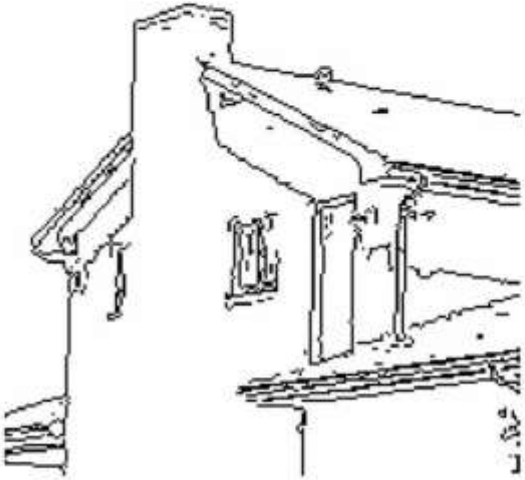


Figure 4. The edge image with morphology preprocess