



flusser@utia.cas.cz

Prof. Ing. Jan Flusser, DrSc.

Digitální zpracování obrazu

Lecture 1

Image enhancement

- **Změny kontrastu a jasu**
- **Potlačení šumu**
- **Detekce a zvýraznění hran**

Detekce a zvýraznění hran

- **Jednoduché metody zaostření obrazu**
- **Detekce hran**

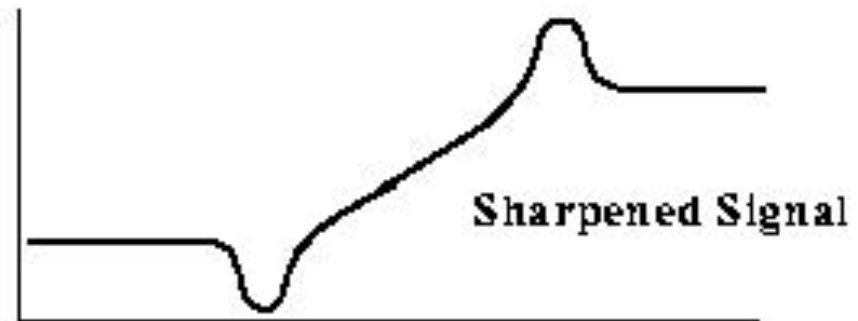
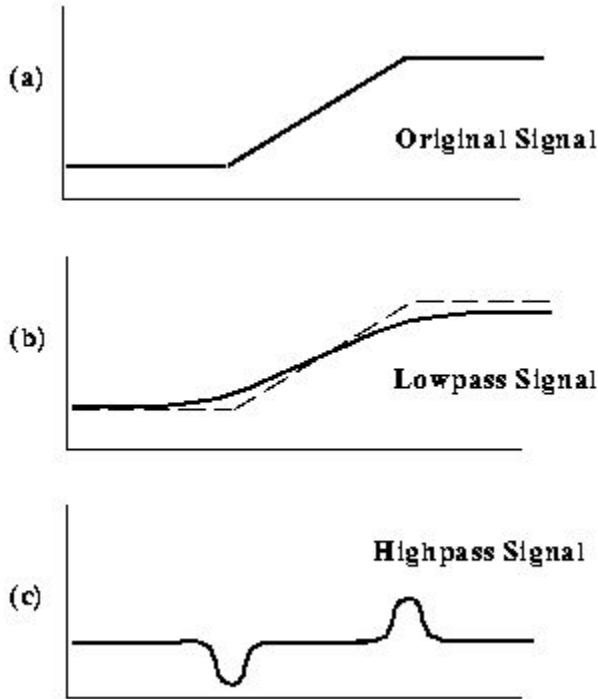
Jednoduché metody zaostření obrazu

- **Unsharp masking (neostré maskování)**
- **Odečtení Laplace: $f - \Delta f$**

Unsharp masking

$$g(x, y) = f(x, y) - f_{smooth}(x, y)$$

$$f_{sharp}(x, y) = f(x, y) + k * g(x, y)$$



Jednoduché metody zaostření obrazu

- Unsharp masking (neostré maskování)



Neostré maskování - Laplace

$$\mathbf{A} = \begin{array}{ccc|ccc} \mathbf{0} & \mathbf{1} & \mathbf{0} & & & \\ \mathbf{1/5} & & & \mathbf{1} & \mathbf{1} & \mathbf{1} \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & & & \end{array} \quad - \left(\frac{\partial}{\partial x^2} + \frac{\partial}{\partial y^2} \right)$$

$$\mathbf{B} = \begin{array}{ccc|ccc} \mathbf{0} & \mathbf{0} & \mathbf{0} & & & \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & & & \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & & & \end{array} \quad \begin{array}{ccc|ccc} & & & \mathbf{0} & \mathbf{-1} & \mathbf{0} \\ \mathbf{B-A} = & \mathbf{1/5} & \mathbf{-1} & \mathbf{4} & & \mathbf{-1} \\ & & & \mathbf{0} & \mathbf{-1} & \mathbf{0} \end{array}$$

Neostré maskování



ori
g

Zaostření obrazu - Laplace

Zaostření obrazu - Laplace

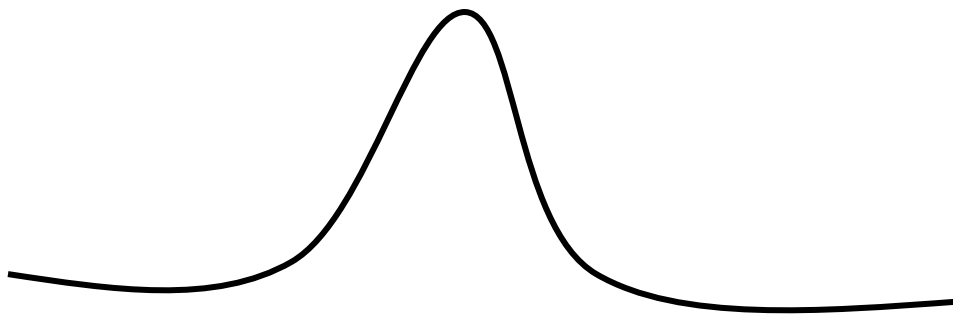
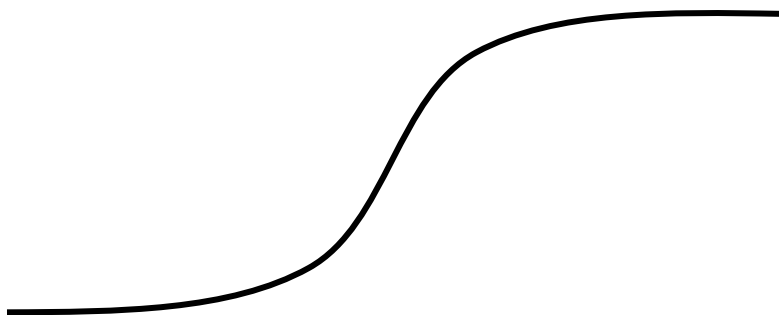
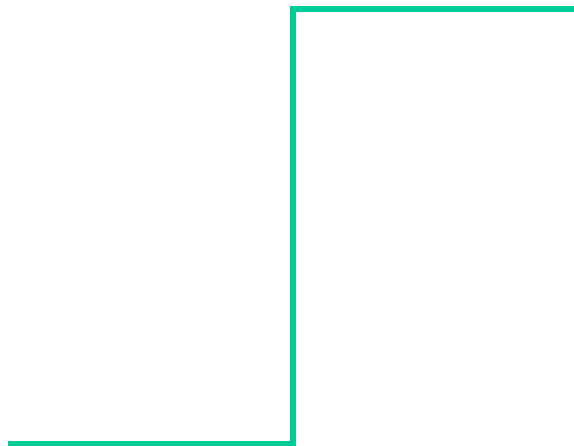


ori
g

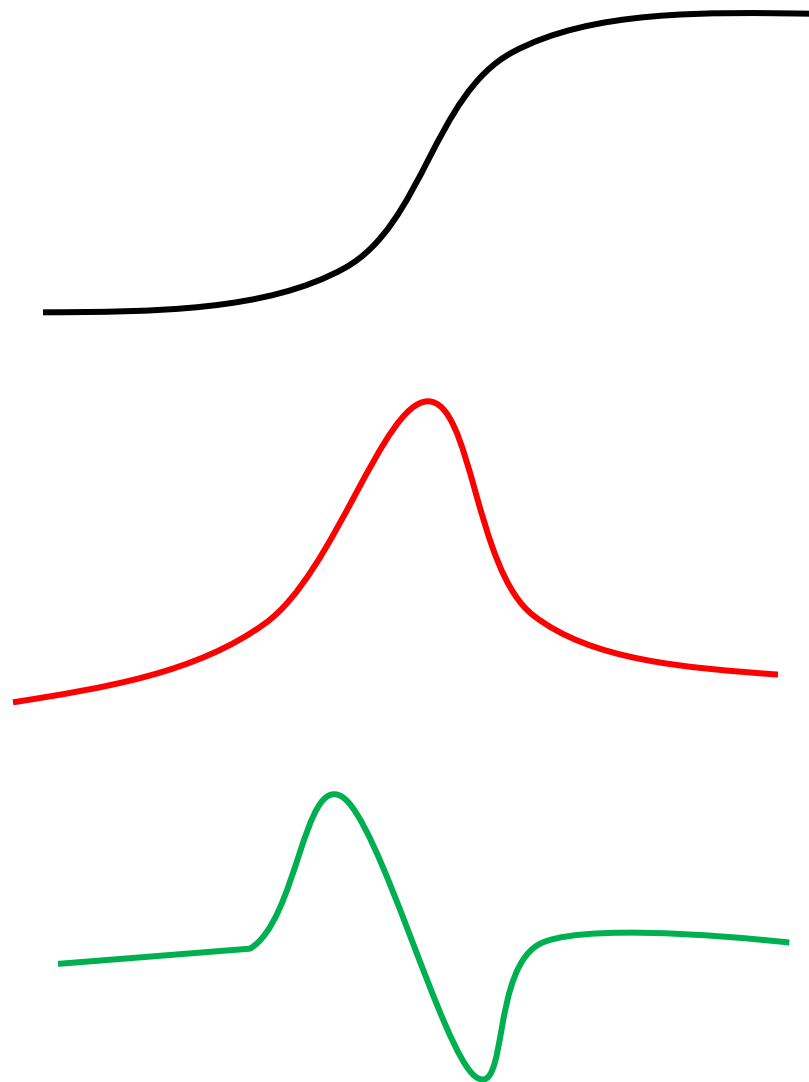
Přehnané zaostření obrazu - Laplace



Detekce hran



Detekce hran



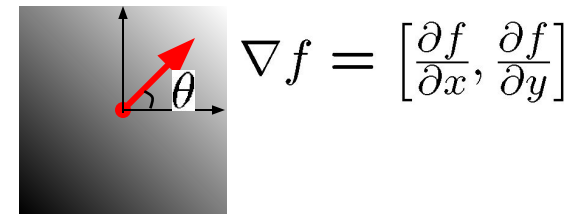
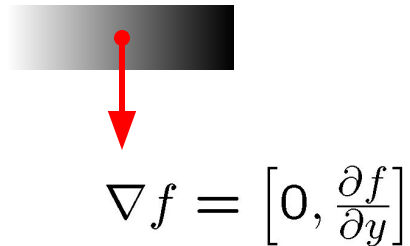
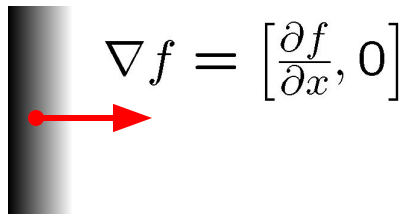
Detekce hran

- **Detektory založené na 1. derivaci obrazu**
- **Detektory založené na 2. derivaci obrazu**
- **Detektory které nepracují s derivacemi**
- **Detekce hran ve Fourierově oblasti**

Gradient obrázku

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

Gradient ukazuje ve směru nejrychlejší změny intenzity

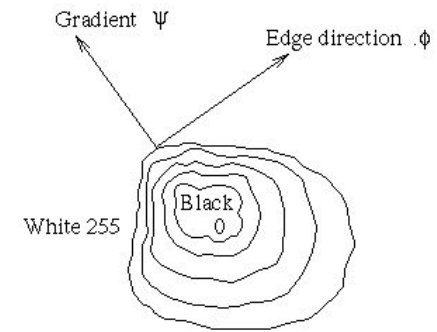


Směr gradientu je dán

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

Síla hrany je dána velikostí gradientu

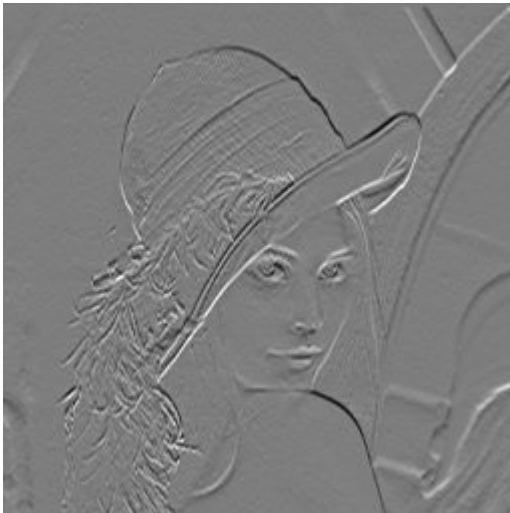
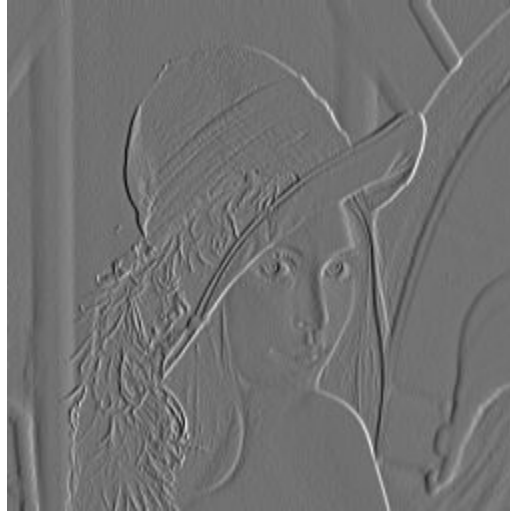
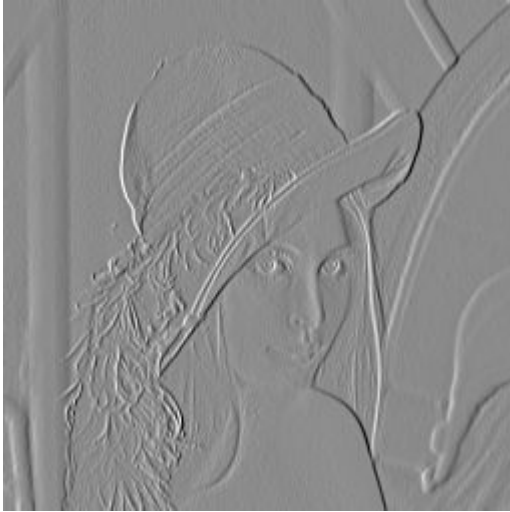
$$\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x} \right)^2 + \left(\frac{\partial f}{\partial y} \right)^2}$$



Jednoduché detektory založené na 1. derivaci

- **Roberts**
- **Sobel**
- **Prewitt**
- **Kirsch**

Robert S





Prewit

t

1 1 1

0 0 0

-1 -1 -1

vyhlazení

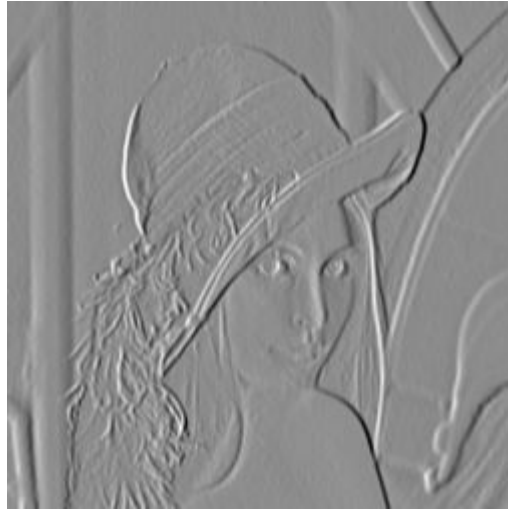
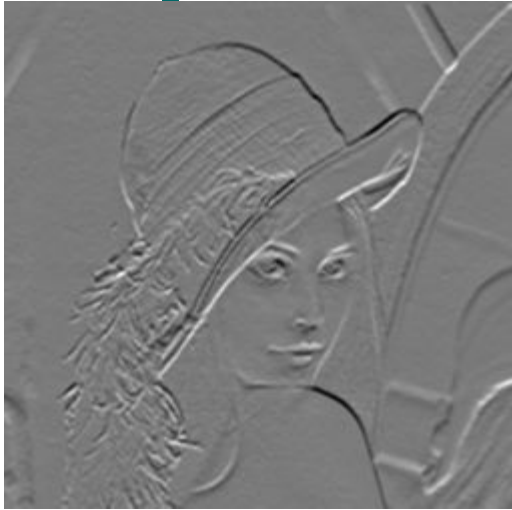
1 -1 0 1

1 * -1 0 1 = -1 0

1

1 -1 0 1

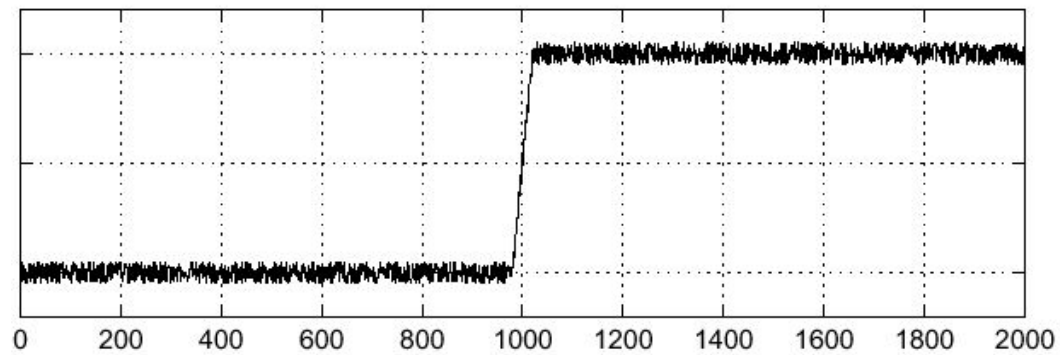
Sobel



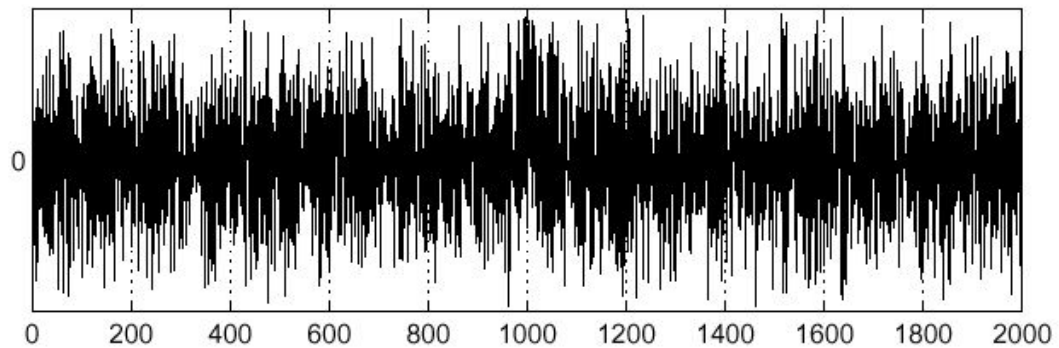
1 2 1
0 0 0
-1 -2 -1



$f(x)$

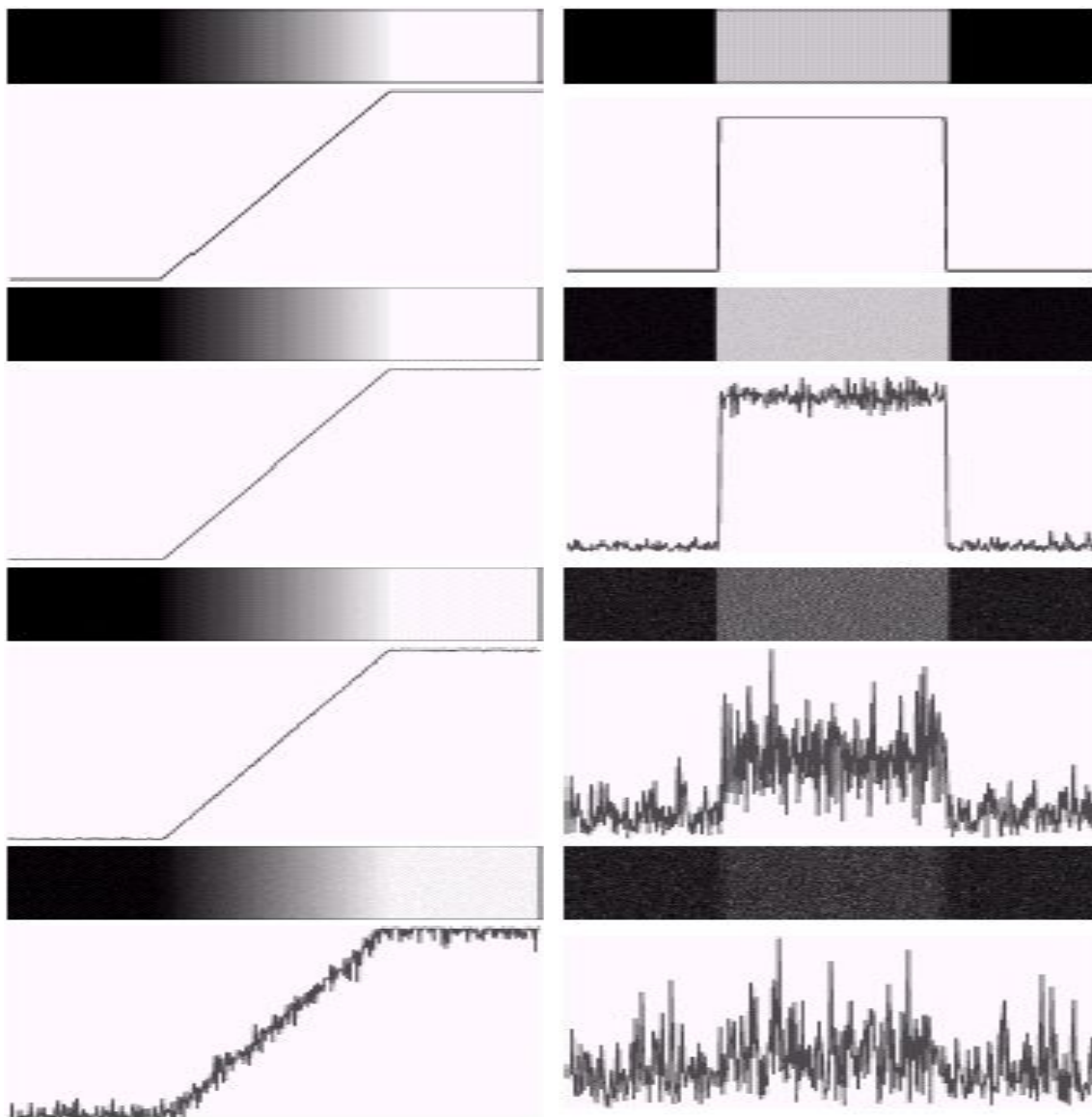


$\frac{d}{dx}f(x)$

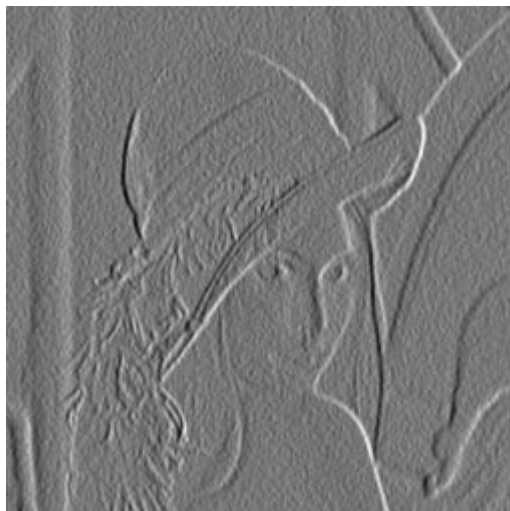
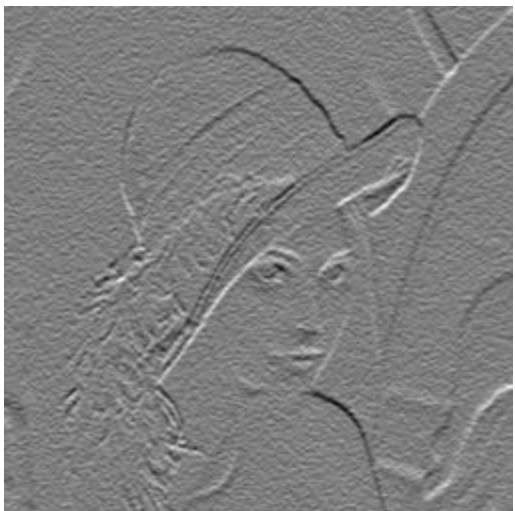
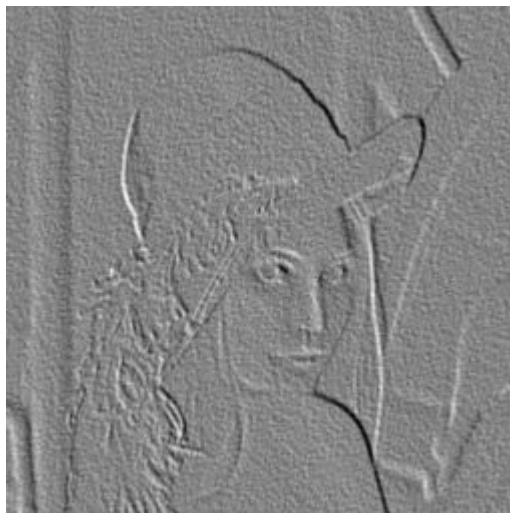


Kde je hrana?

Hrany a šum

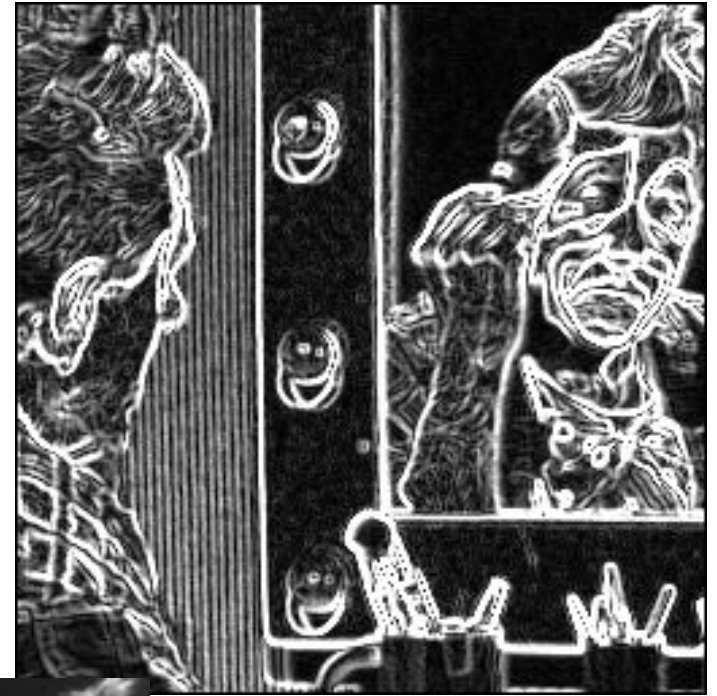


Sobel na obrázku se šumem





- Roberts



- Sobel



Canny

- vymyšleno pro skokové hrany
 - jedna hrana jedna odezva
 - přesná lokalizace hran

Postup:

1. obraz se vyhladí gausem $f * G$
2. spočítají se derivace $(f * G)'$ - Sobel
3. hledání maxim
maximum = kandidát na hranu
4. Prahování – prahy $T1$, $T2$
 - $>T2$ = hrana
 - $<T2 \ \& \ >T1$ = hrana, jen soused hrany

Canny

- málo, dobře, jednou
- vyhlazení
- první derivace
- detekce hřbetů
- non-maximal suppression





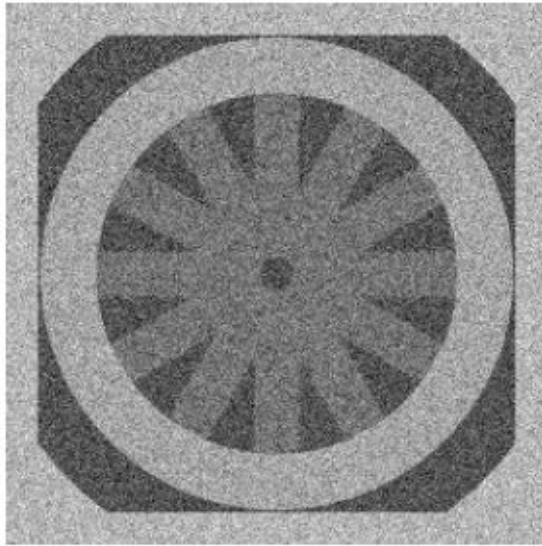
Canny

y

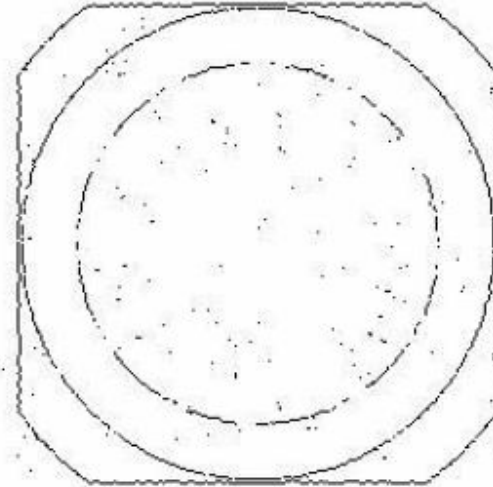


Porovnání

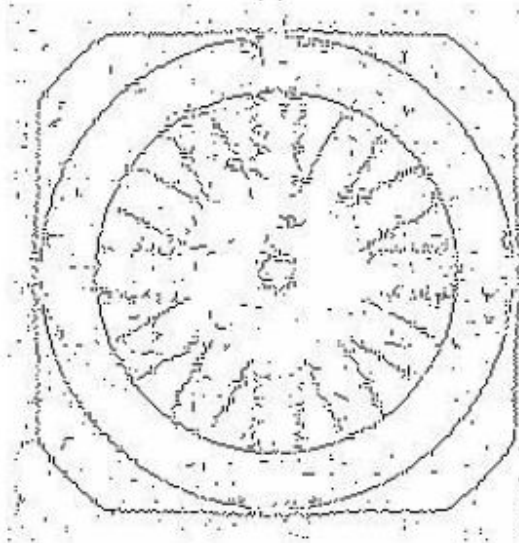
obr a šum



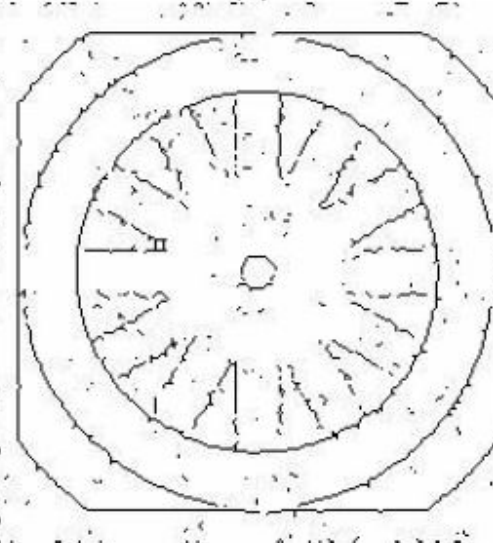
Sobel



Canny

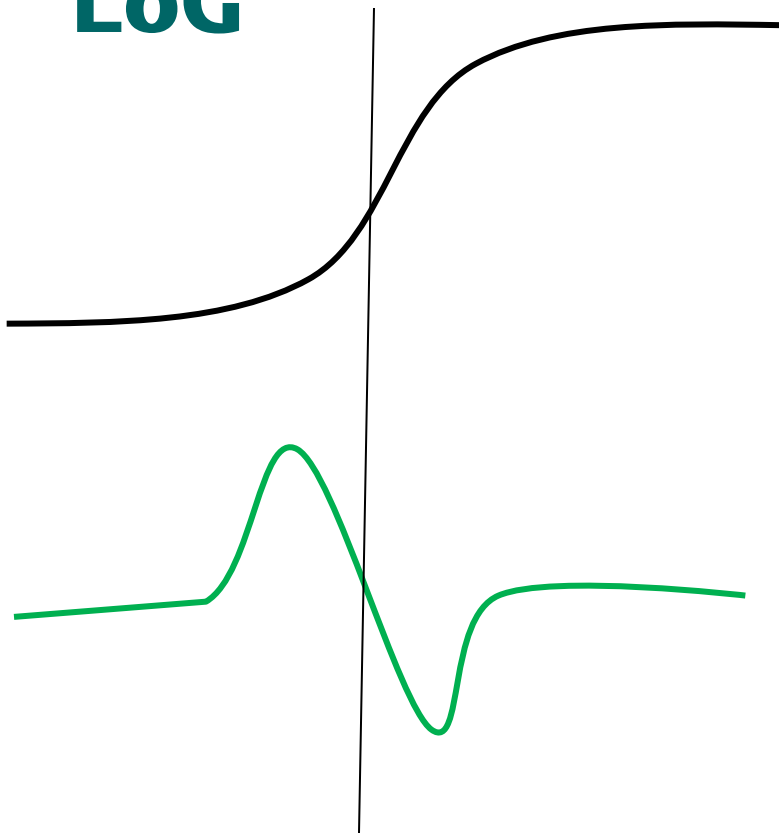


wavelety

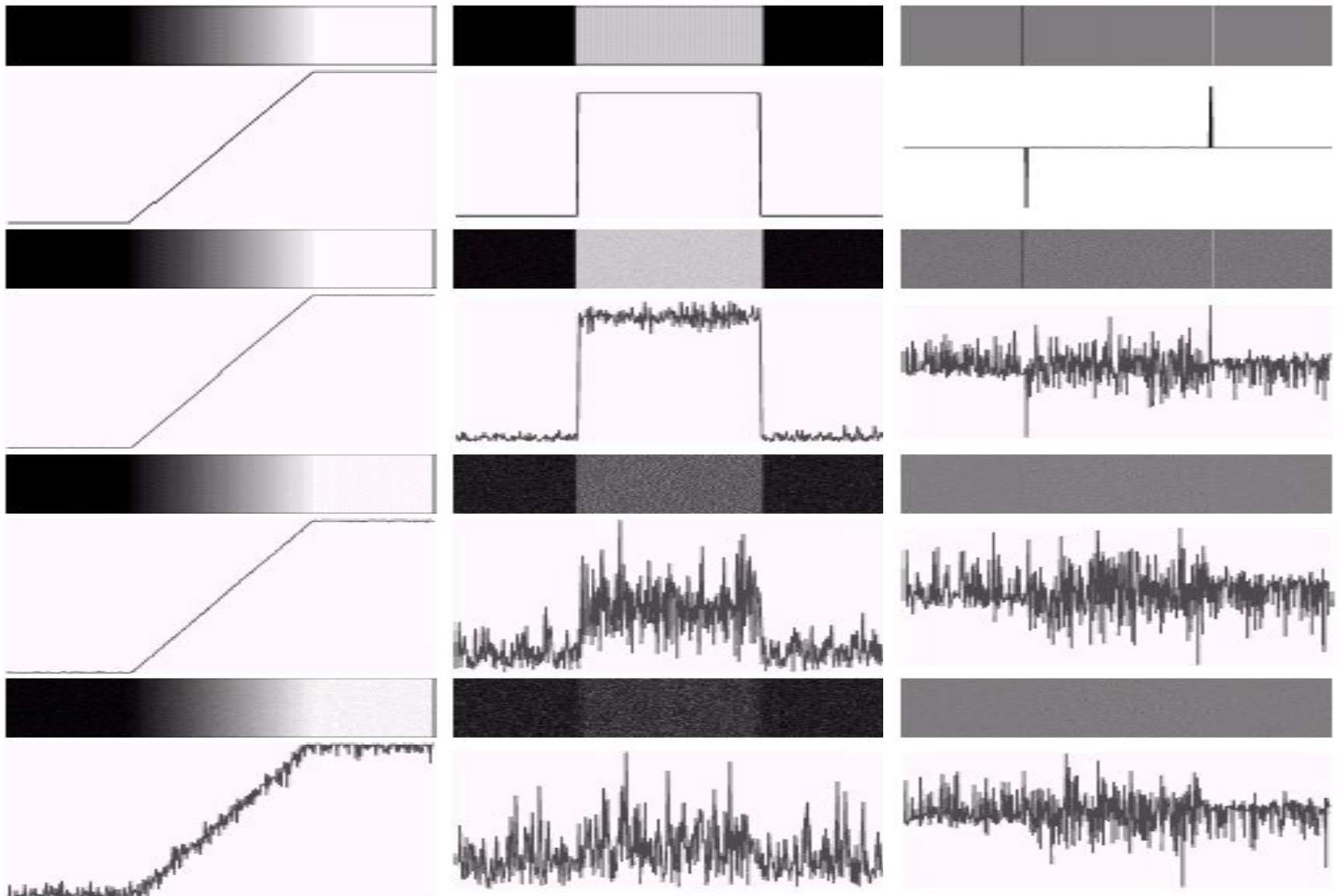


Detektory založené na 2. derivaci

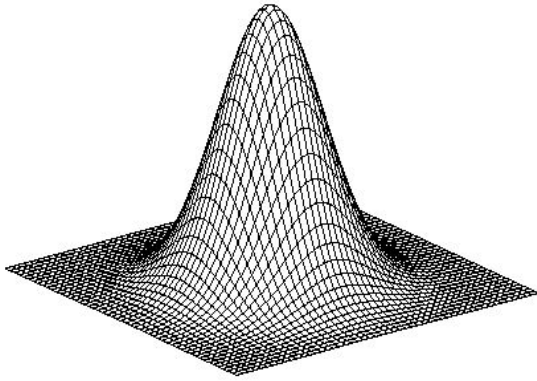
**D. Marr, E. Hildreth (1980) --
LoG**



Hrany a šum

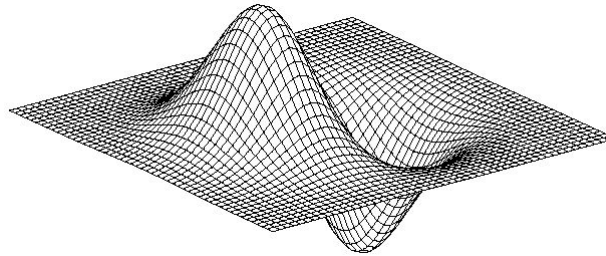


Laplacian of Gaussian



Gaussian

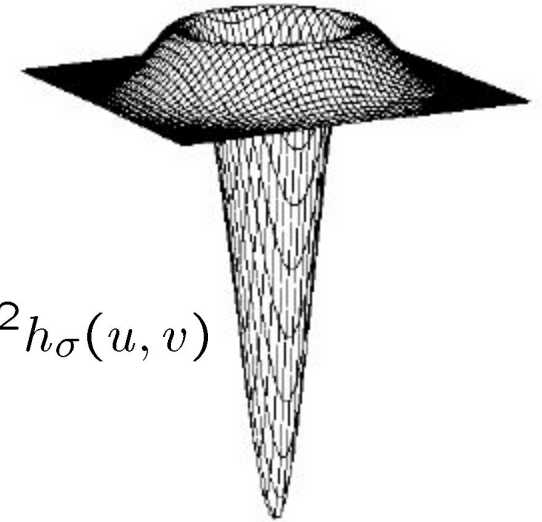
$$h_{\sigma}(u, v) = \frac{1}{2\pi\sigma^2} e^{-\frac{u^2+v^2}{2\sigma^2}}$$



derivative of Gaussian

$$\frac{\partial}{\partial x} h_{\sigma}(u, v)$$

Laplacian of Gaussian



$$\nabla^2 h_{\sigma}(u, v)$$

- ∇^2 is the **Laplacian** operator:

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

Detektory založené na 2. derivaci

**D. Marr, E. Hildreth (1980) --
LoG**



sigma = 0.5
1.5

1

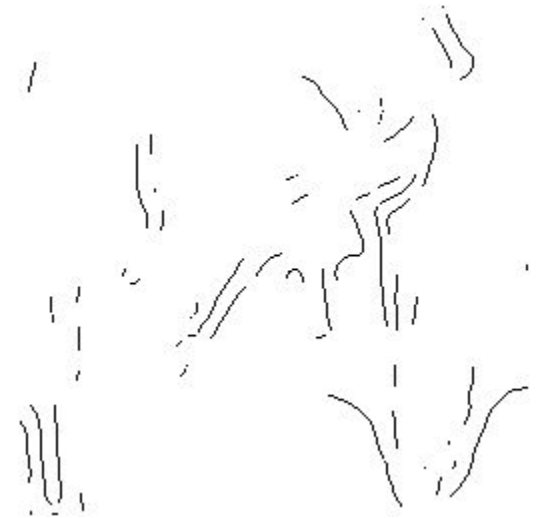
Zero crossing množiny ΔG^*f



sigma = 2



3



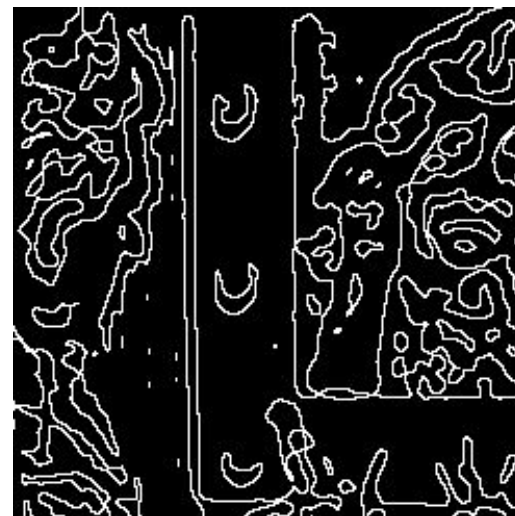
4

Porovnání Canny a Marr

originál

Canny

Marr



Whitening

original image



“whitened” image



**Díky, pro dnešek
končíme s detektory hran**

!

Nějaké otázky ?