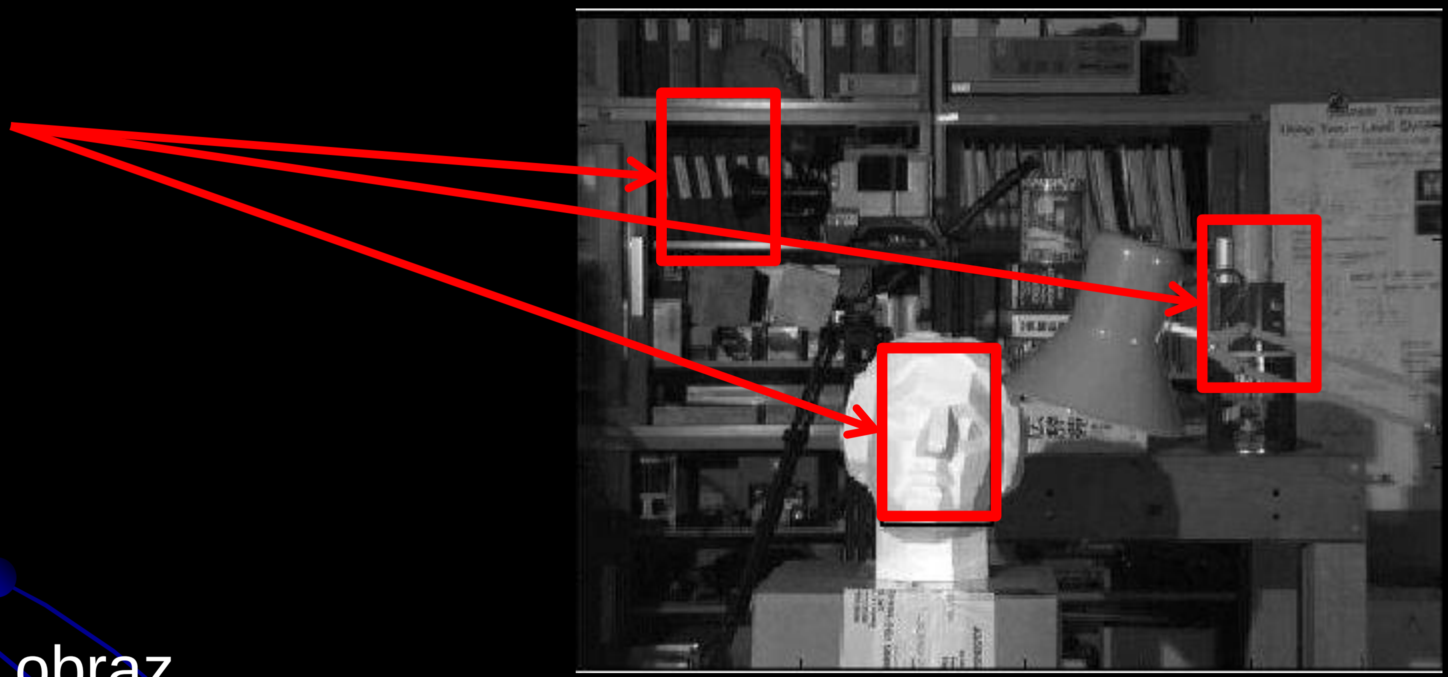
Hľadanie objektov

Prikladanie šablón



M x N obraz

P x Q šablóna

O(MNPQ)

Ak nepoznáme škálu šablóny, ešte horšie

Nájdi  v obraze

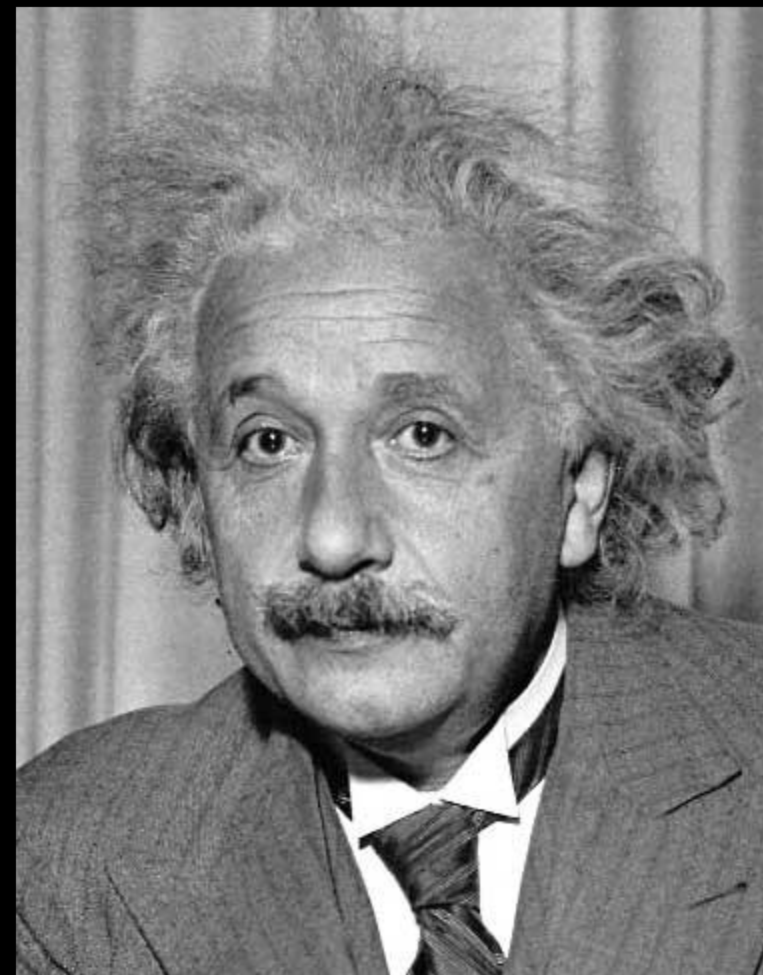
Ktorú mieru podobnosti použiť?

Korelácia

Korelácia s nulovým priemerom

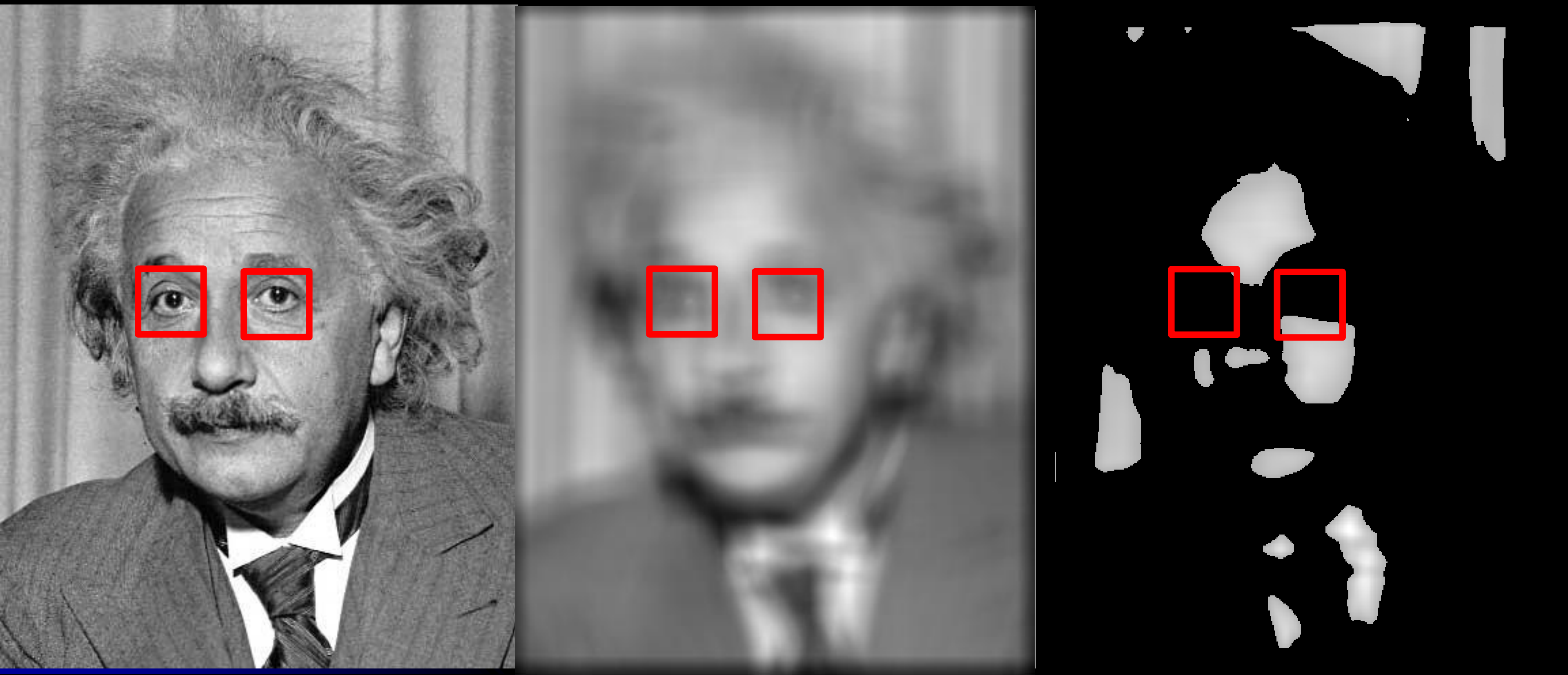
Suma štvorcov vzdialeností

Normalizovaná korelácia



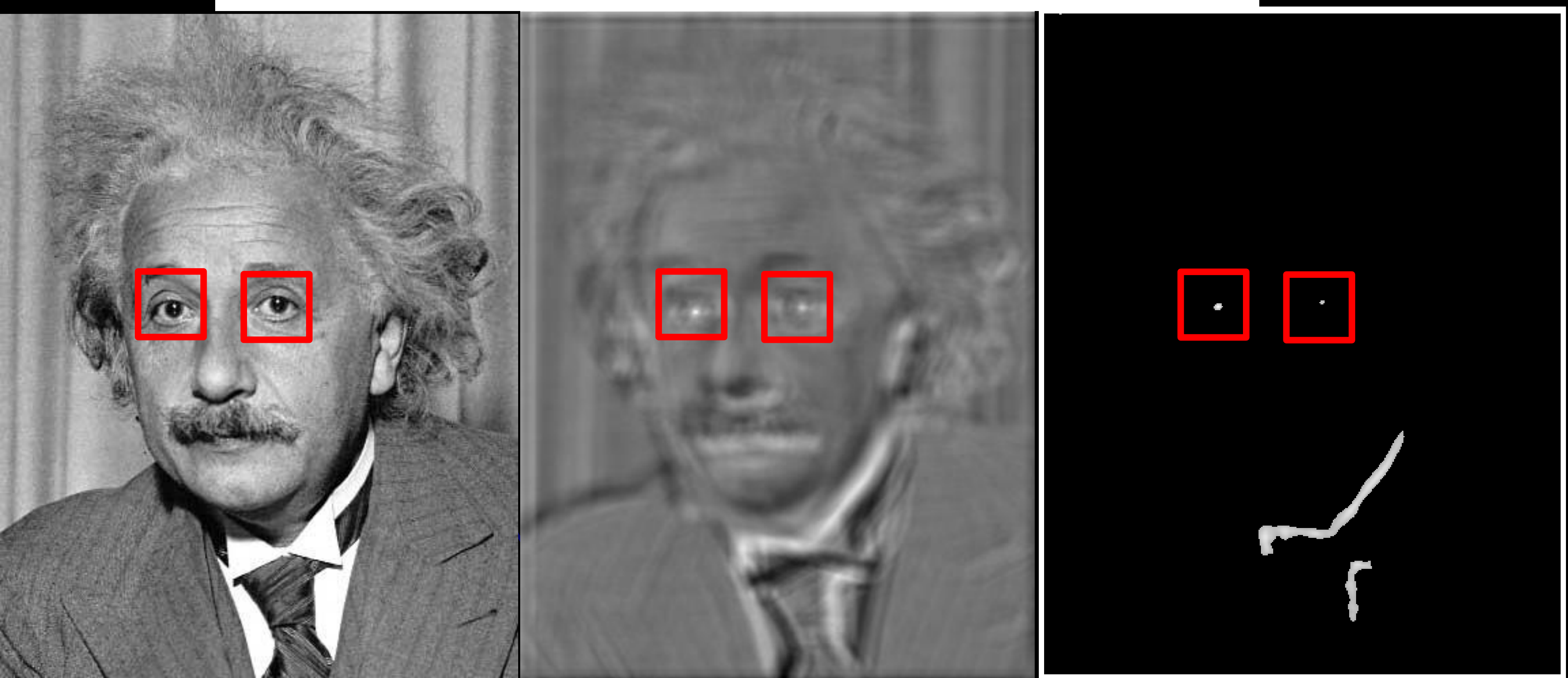
Korelácia

$$h[m,n] = \sum_{k,l} g[k,l]\ f[m+k, n+l]$$



Korelácia s nulovým priemerom

$$h[m,n] = \sum_{k,l} (g[k,l] - \bar{g})\,(f[m+k, n+l])$$



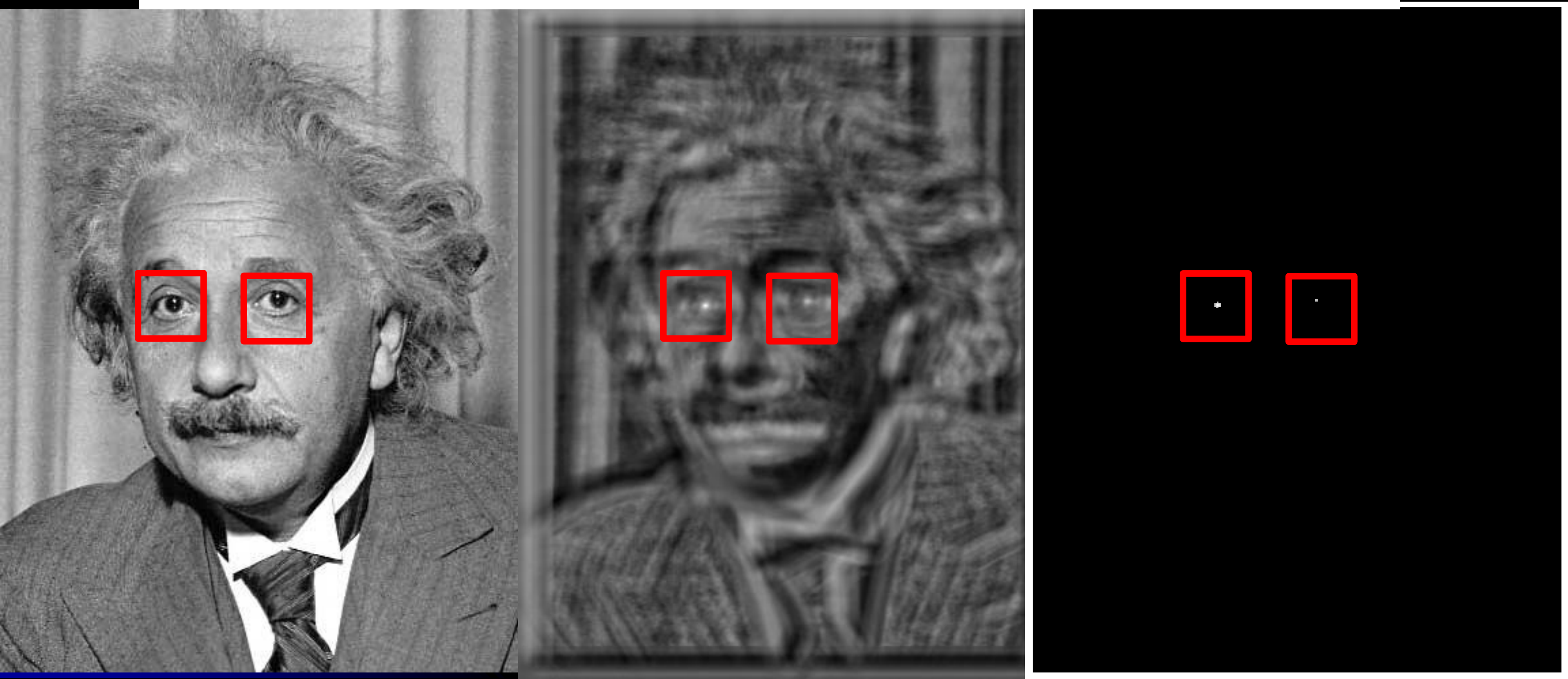
Suma štvorcov vzdialeností

$$h[m,n]=\sum_{k,l}(g[k,l]-f[m+k,n+l])^2$$

$$h[m,n] = \sum_{k,l} (g[k,l] - f[m+k, n+l])^2$$

Normalizovaná korelácia

$$h[m,n] = \frac{\sum_{k,l} (g[k,l]-\bar{g})(f[m+k,n+l]-\bar{f}_{m,n})}{\left(\sum_{k,l} (g[k,l]-\bar{g})^2 \sum_{k,l} (f[m+k,n+l]-\bar{f}_{m,n})^2\right)^{0.5}}$$



Ktorú mieru podobnosti použiť?

Korelácia – rýchla, znásobuje intenzity, nevhodná

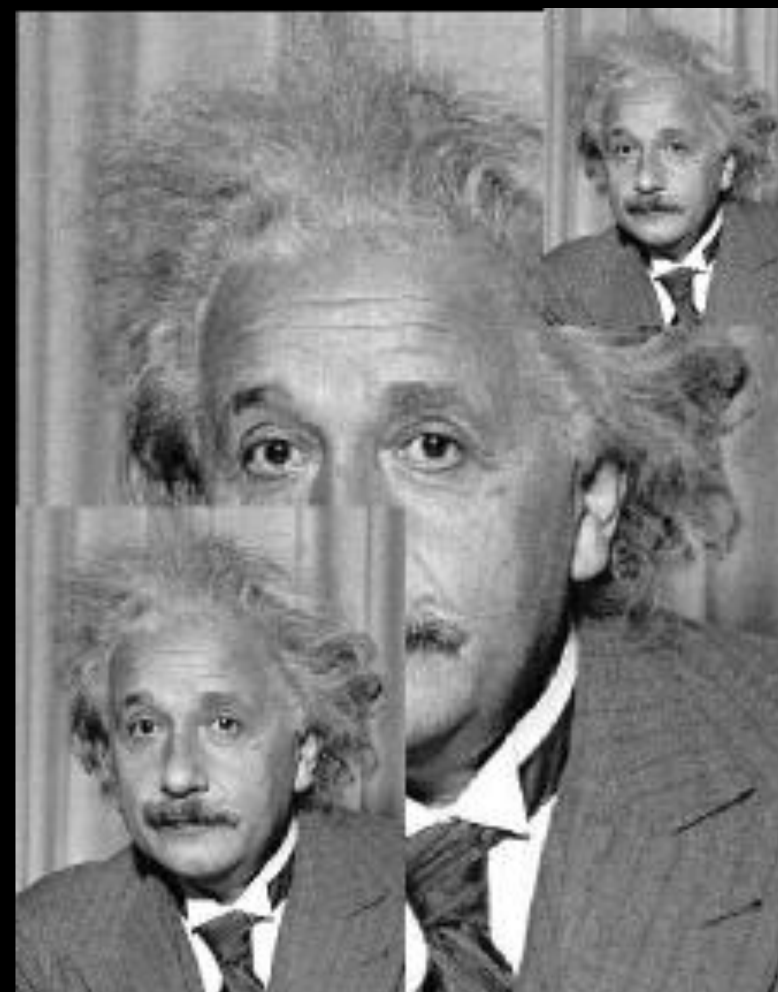
Korelácia s nulovým priemerom – rýchla, deteguje aj falošné výskyty

Suma štvorcov vzdialeností – pomalšia, citlivá na zmenu intenzity

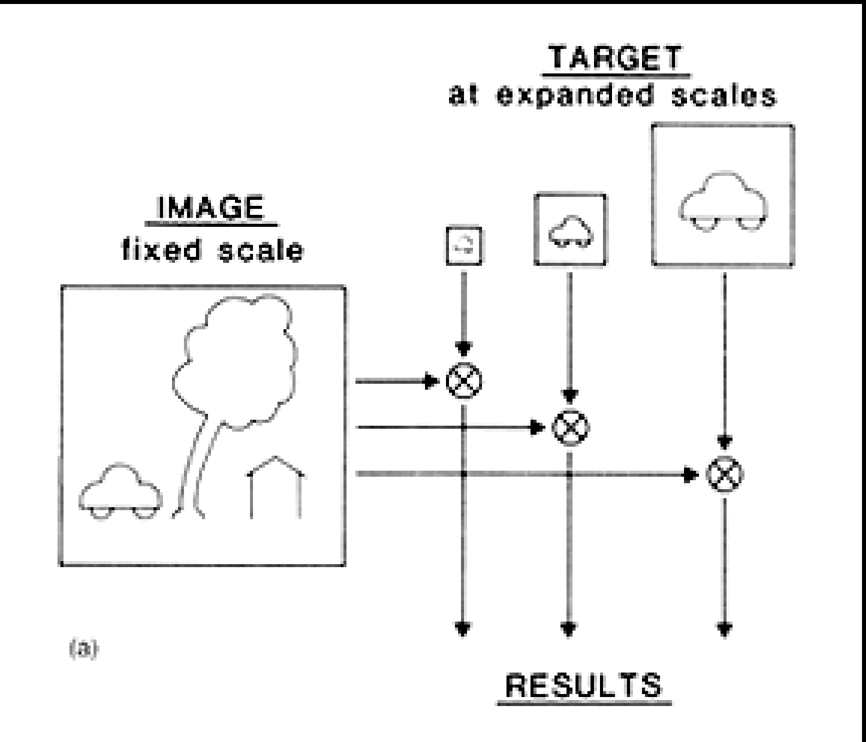
Normalizovaná korelácia – najpomalšia, invariantná voči zmene kontrastu a intenzity

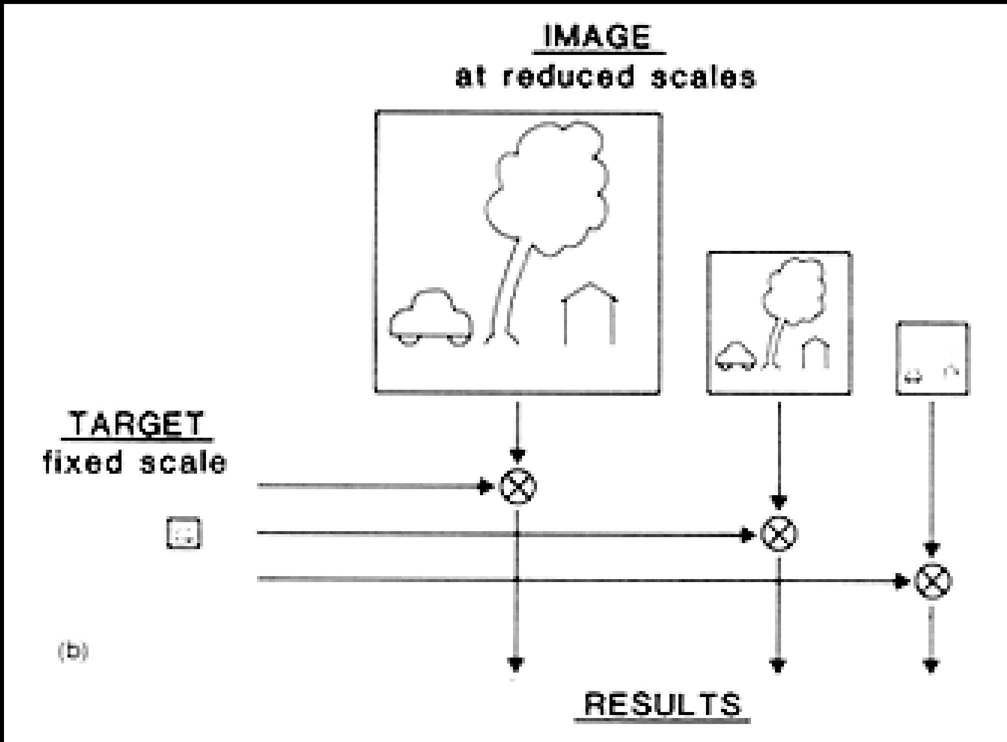
Nájdi  v obraze

?

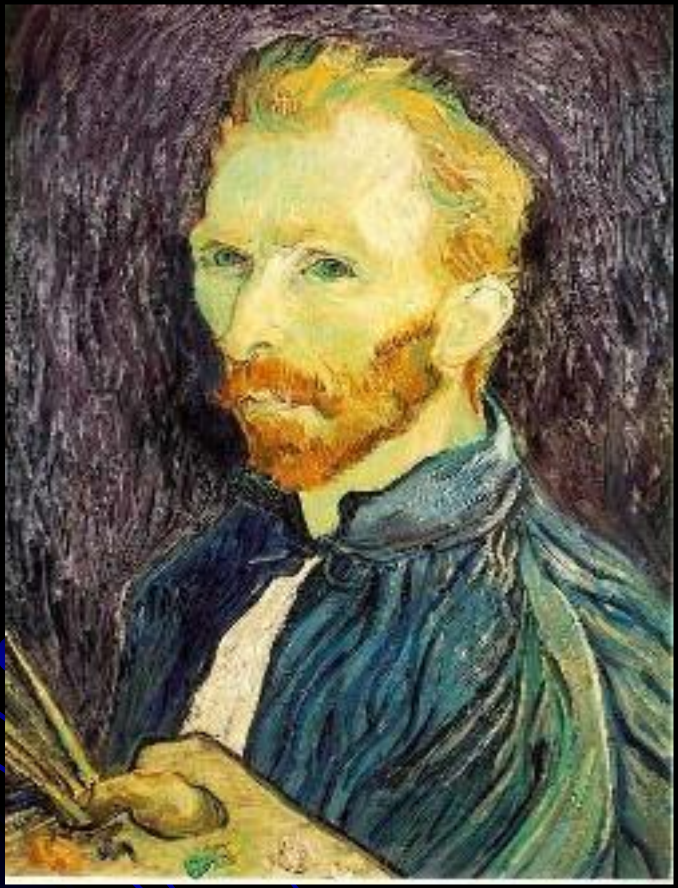


Hľadanie objektov rôznych veľkostí





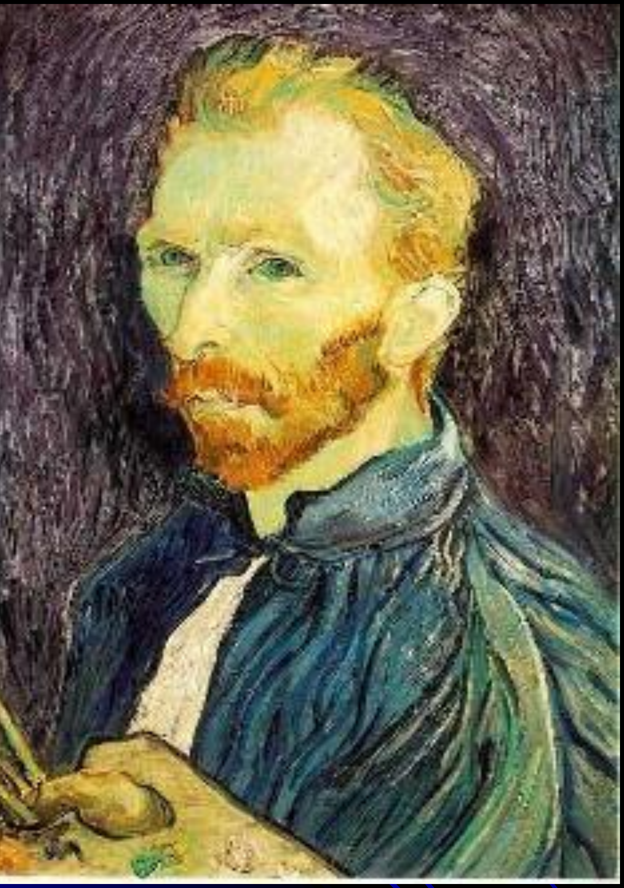
Škálovanie



1/4

1/16

Zahoď každý druhý riadok a stĺpec

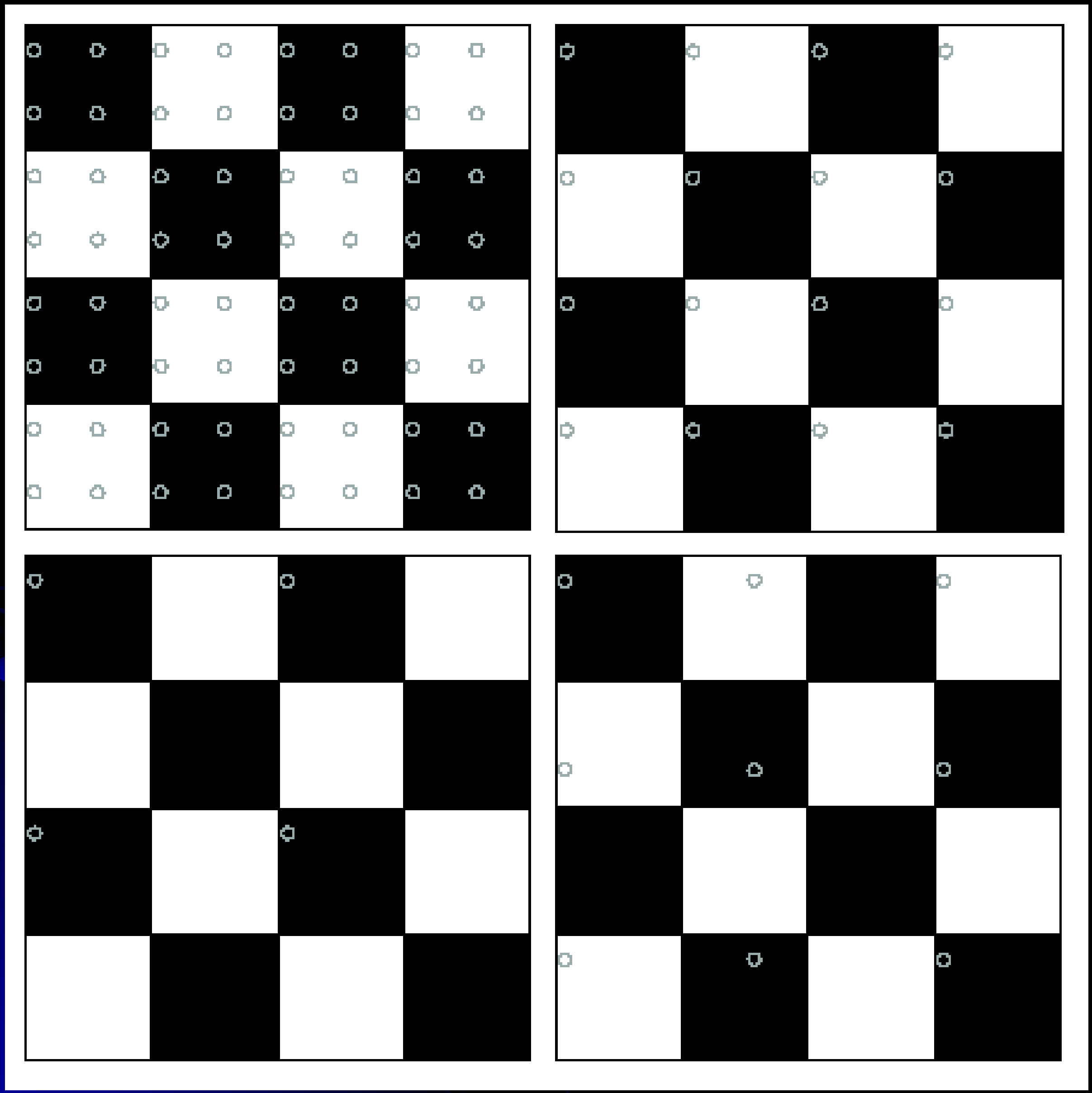


1/2

1/4 (2x zoom)

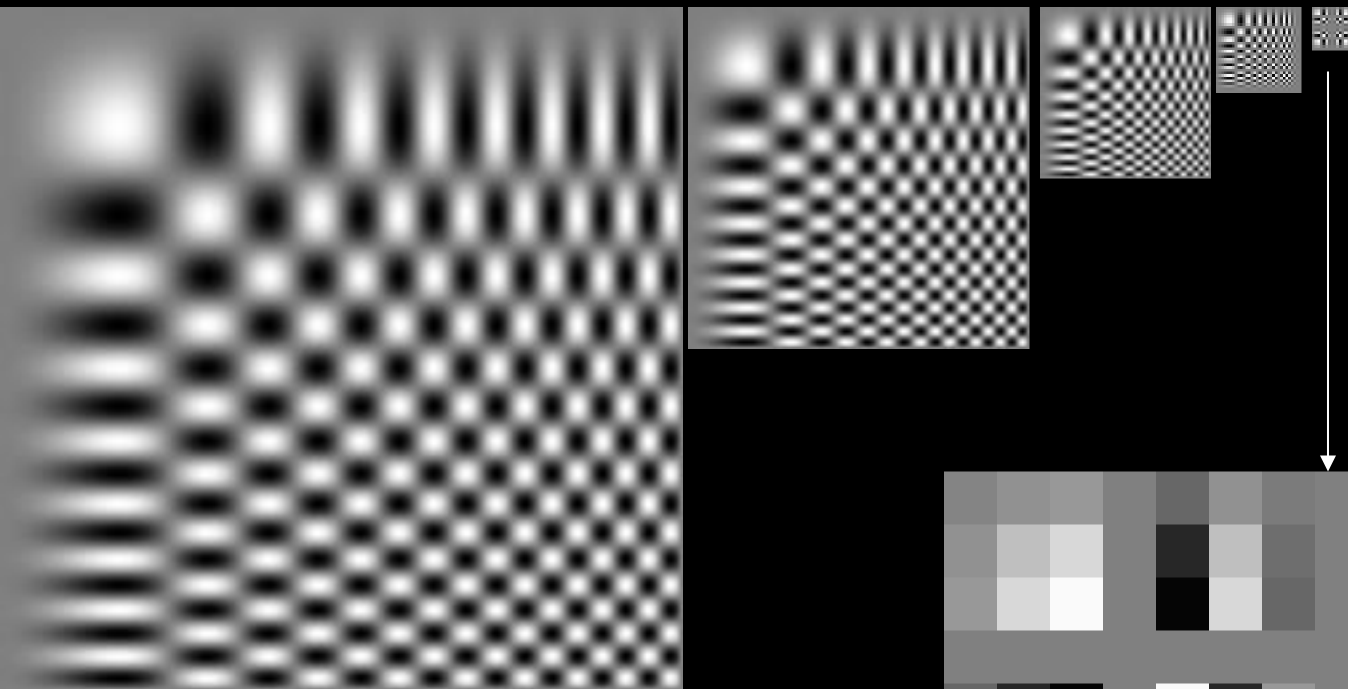
1/8 (4x zoom)

Dobré a zlé vzorkovanie

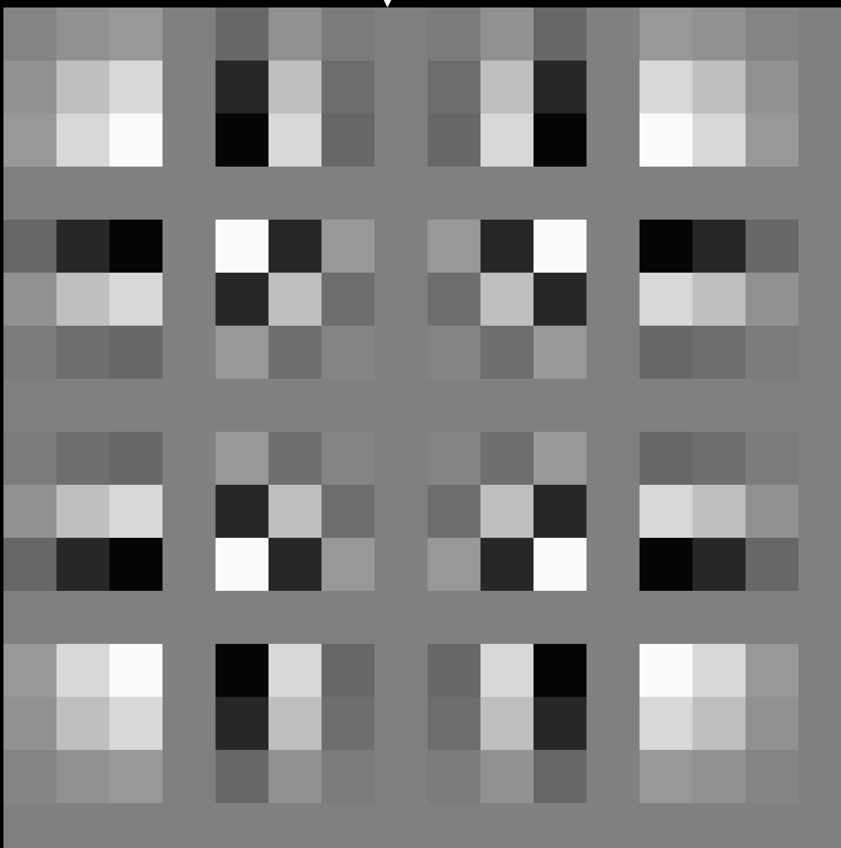


Dobré vzorkovanie:
Dostatočne veľa vzoriek, alebo „dobré“ vzorky

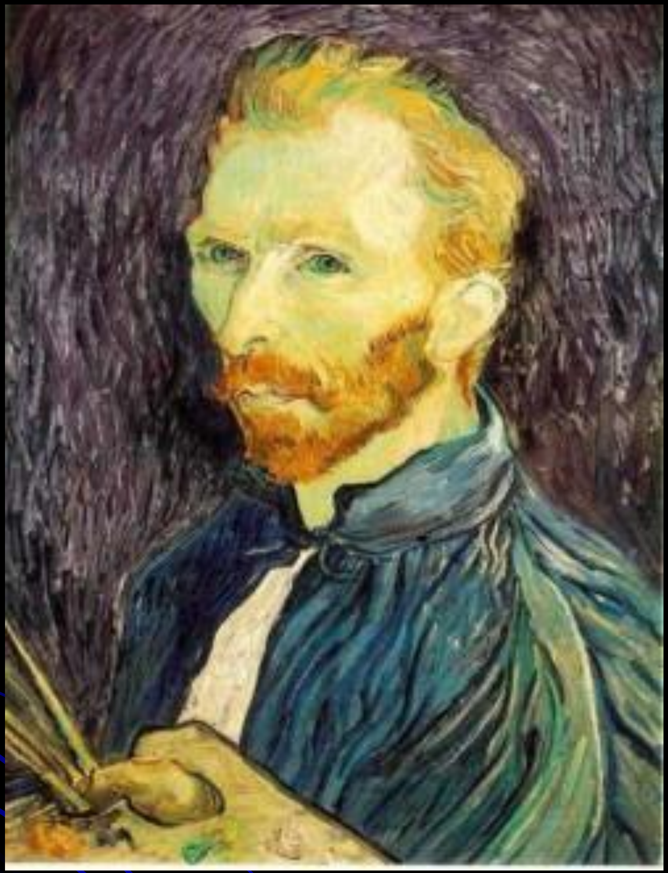
Zlé vzorkovanie:
Výsledkom je aliasing!



Zahoď každý druhý riadok a stĺpec



Škálovanie s rozostrením



Gauss a potom škálovanie

Gaussian 1/2

G 1/4

G 1/8

1/2

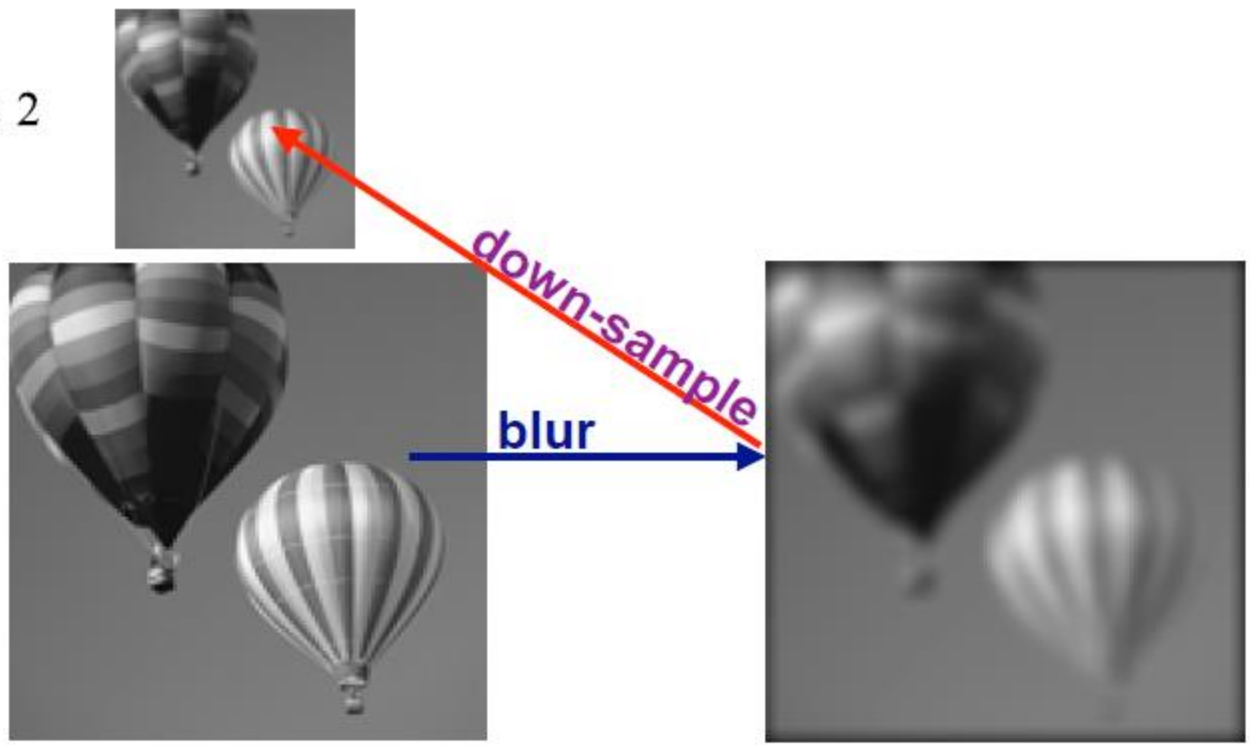
1/4 (2x zoom)

1/8 (4x zoom)

Gaussovská pyramída

$$G_1 = (G_0 * gaussian) \downarrow 2$$

$$G_0 = \textbf{Image}$$

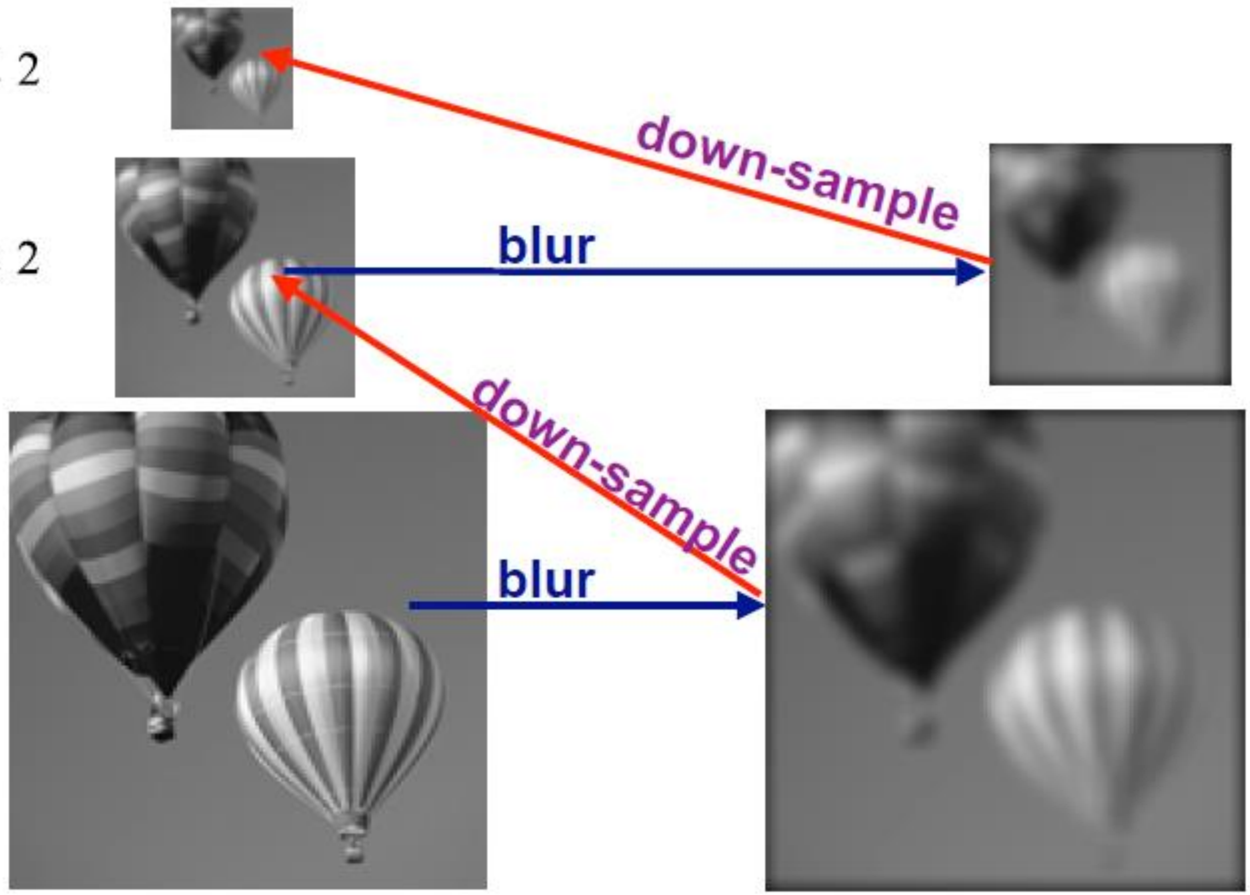


Gaussovská pyramída

$G_2 = (G_1 * gaussian) \downarrow 2$

$G_1 = (G_0 * gaussian) \downarrow 2$

$G_0 = \mathbf{Image}$



EECS 741: Computer Vision

Brian Potetz

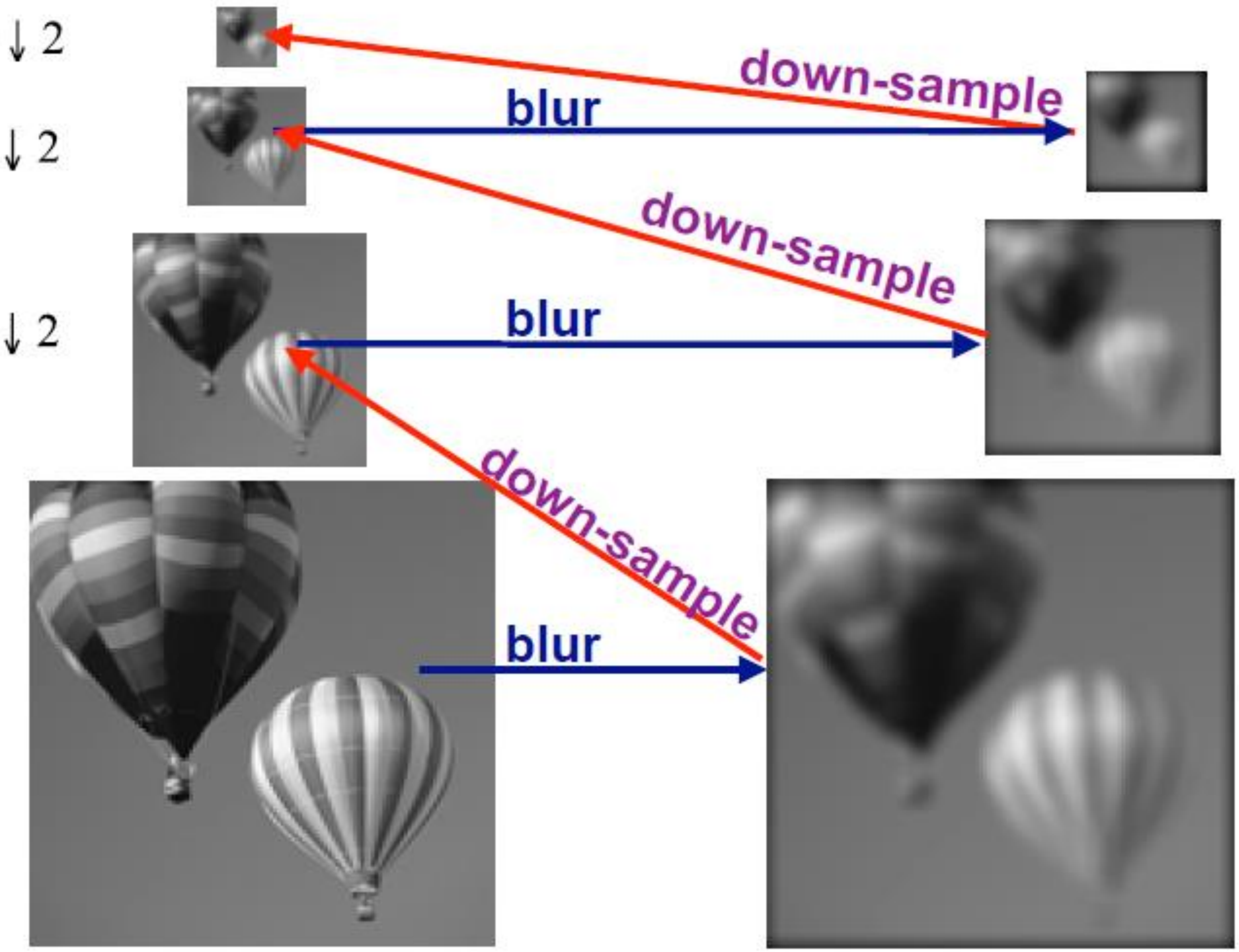
Gaussovská pyramída

$$G_3 = (G_2 * gaussian) \downarrow 2$$

$$G_2 = (G_1 * gaussian) \downarrow 2$$

$$G_1 = (G_0 * gaussian) \downarrow 2$$

$$G_0 = \mathbf{Image}$$



Gaussovská pyramída

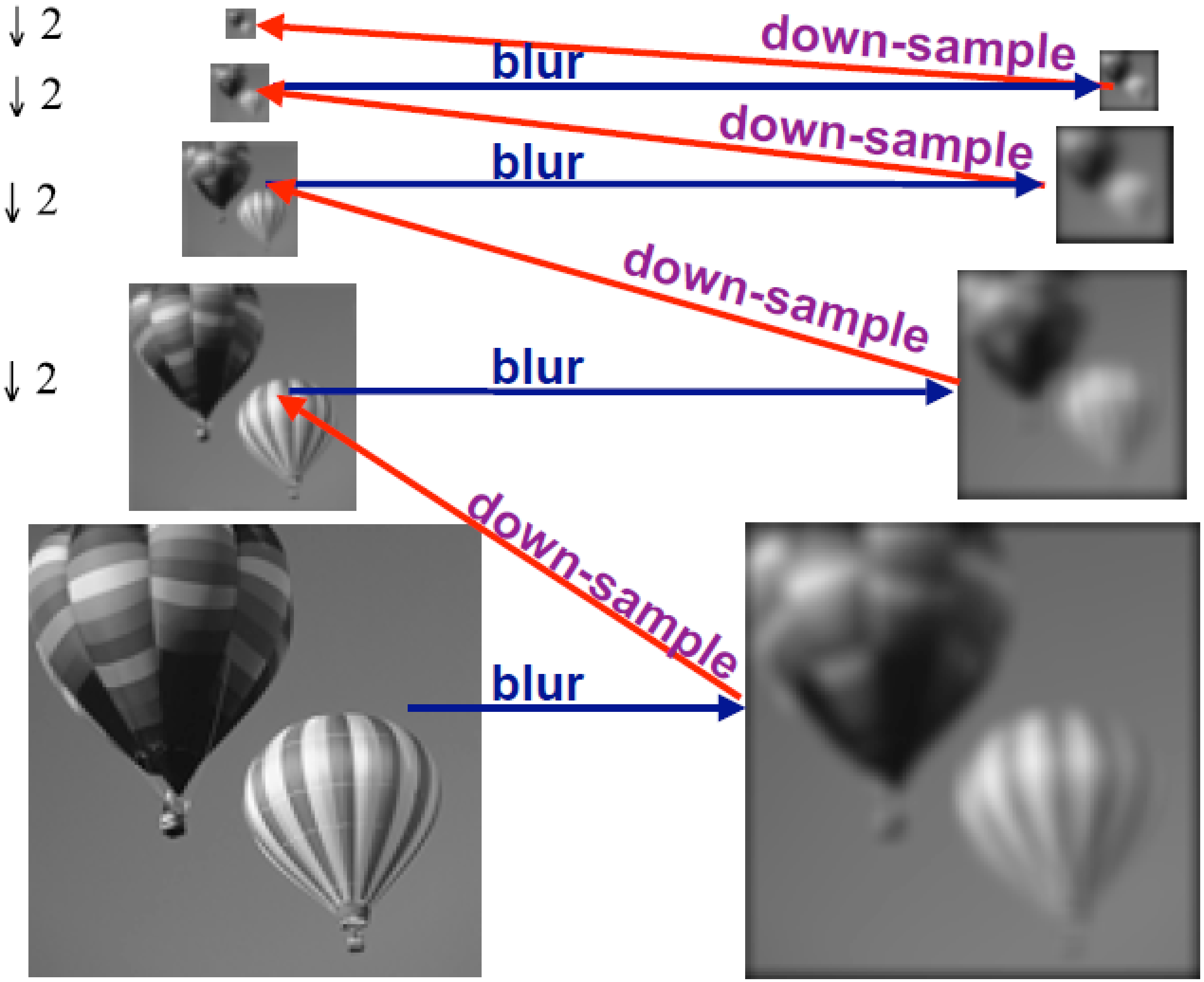
$$G_4 = (G_3 * gaussian) \downarrow 2$$

$$G_3 = (G_2 * gaussian) \downarrow 2$$

$$G_2 = (G_1 * gaussian) \downarrow 2$$

$$G_1 = (G_0 * gaussian) \downarrow 2$$

$$G_0 = \textbf{Image}$$



Priestorové prehľadávanie

Pyramídový prístup

Začneme najviac degradovanou verziou

Nájdeme kandidátne oblasti

Ďalej hľadáme len v týchto oblastiach

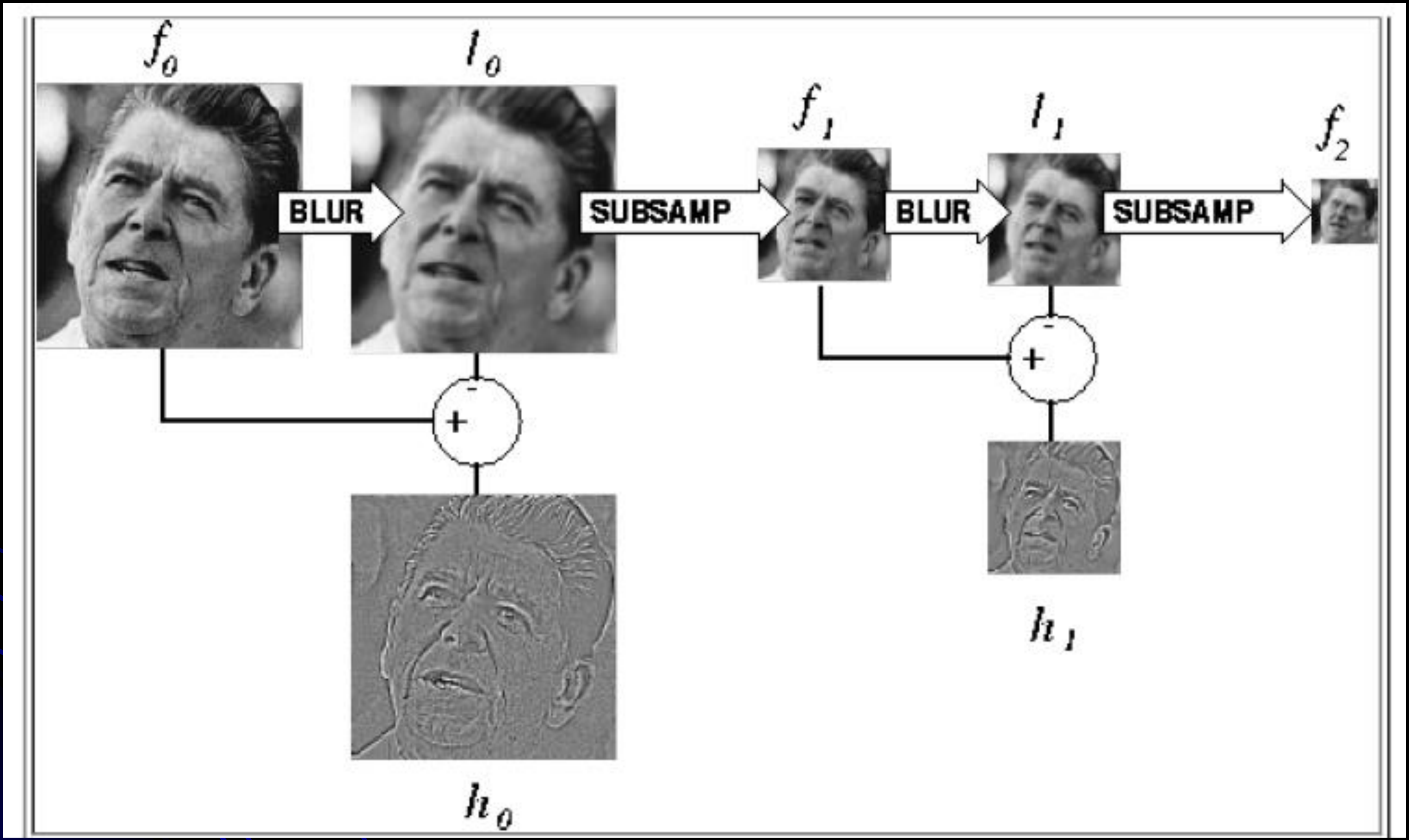
GP – vysoko redundantné údaje

Nízkopriepustný filter – najnižšie frekvencie sú v každom obraze

Nepotrebuje uložiť celý obraz, stačí chyba

Laplacovská pyramída

Laplacovská pyramída



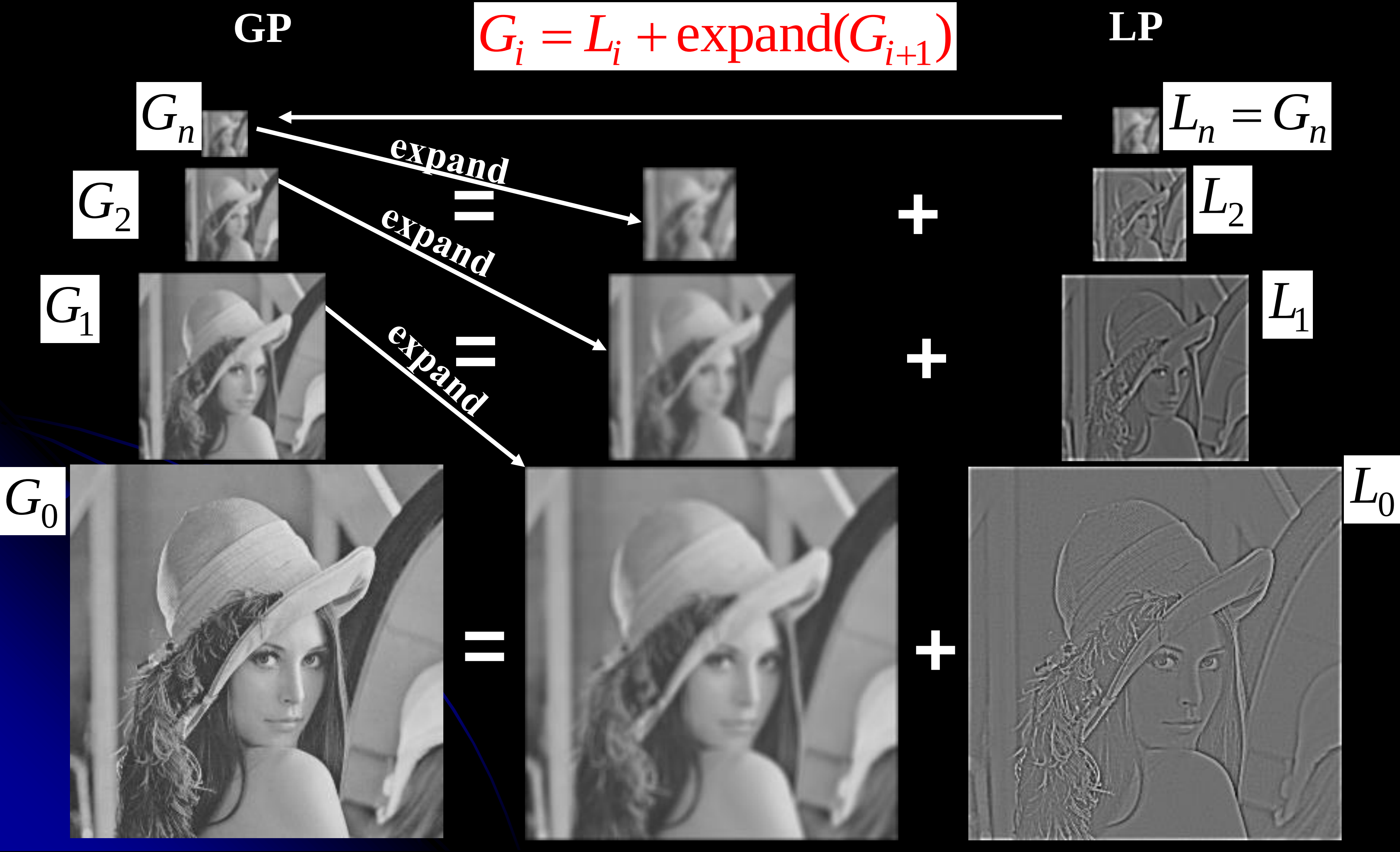
Pri výrobe GP, strácame info

Uložíme do LP

LP vs. GP

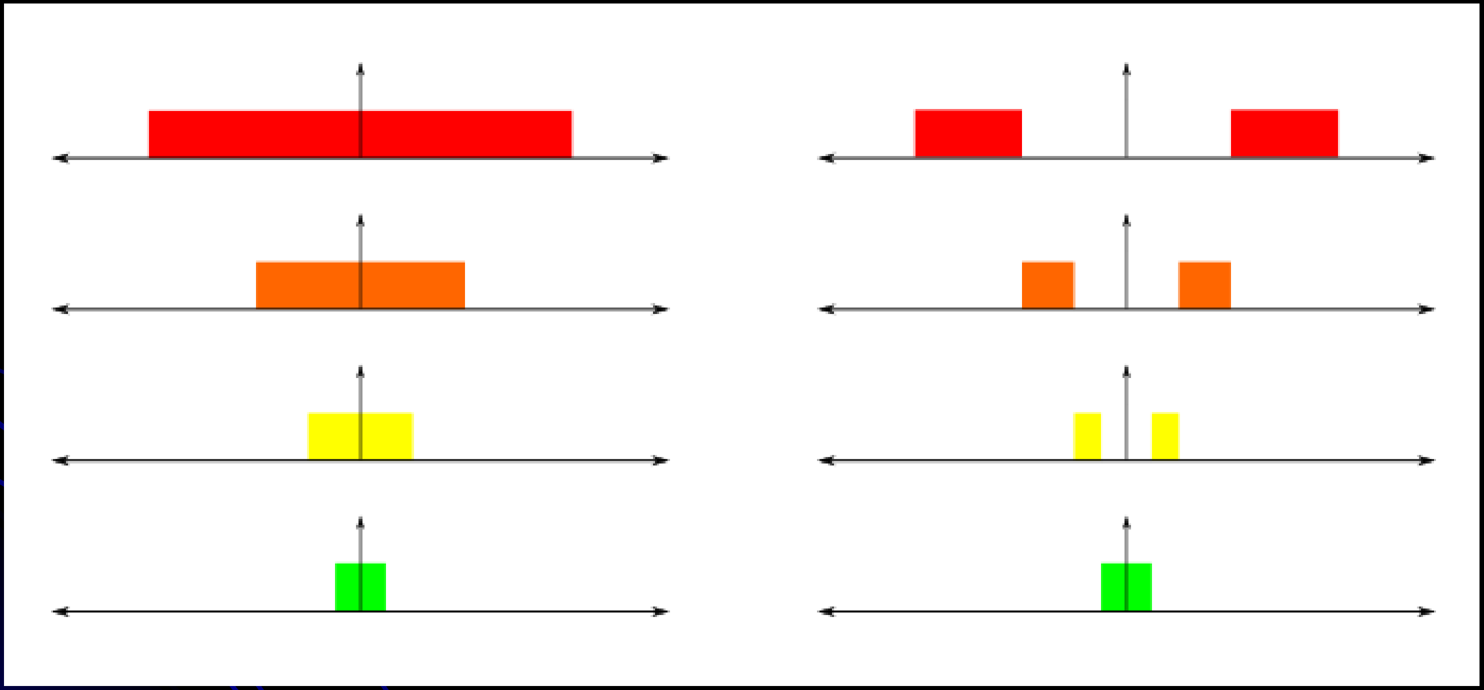
$$L_i = G_i - \text{expand}(G_{i+1})$$

$$G_i = L_i + \text{expand}(G_{i+1})$$

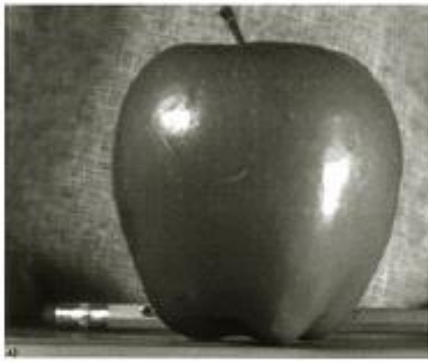


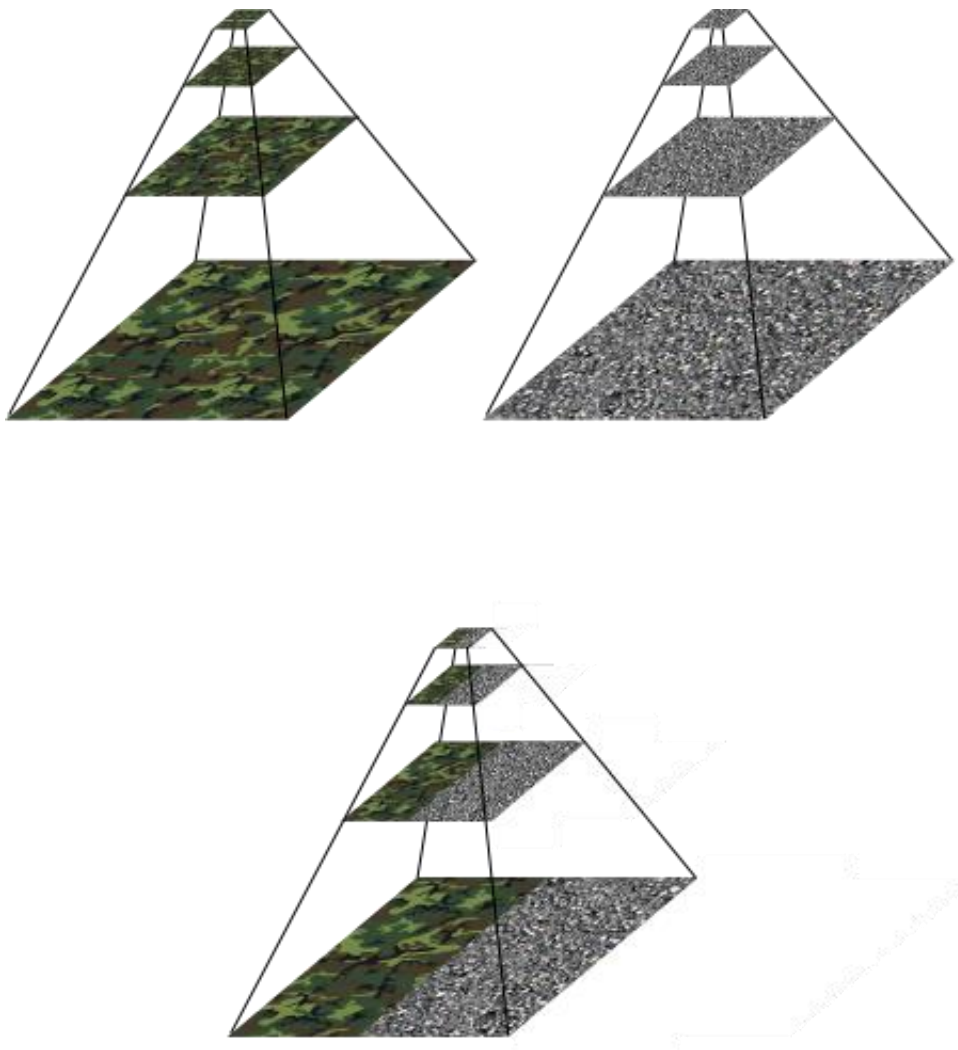
LP vs. GP

Frekvencie obsiahnuté v jednotlivých úrovniach

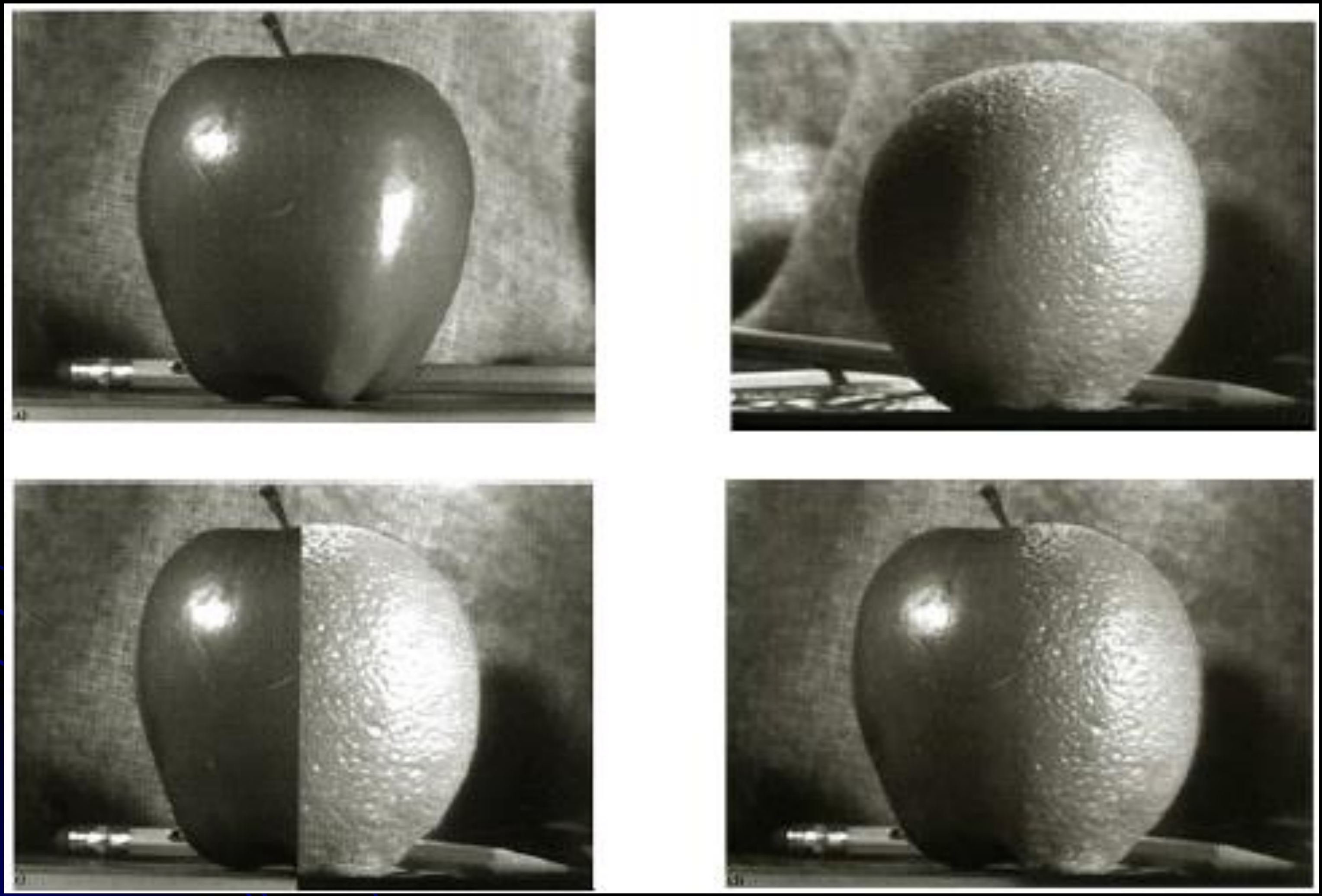


Kombinovanie obrazov





Jablranč



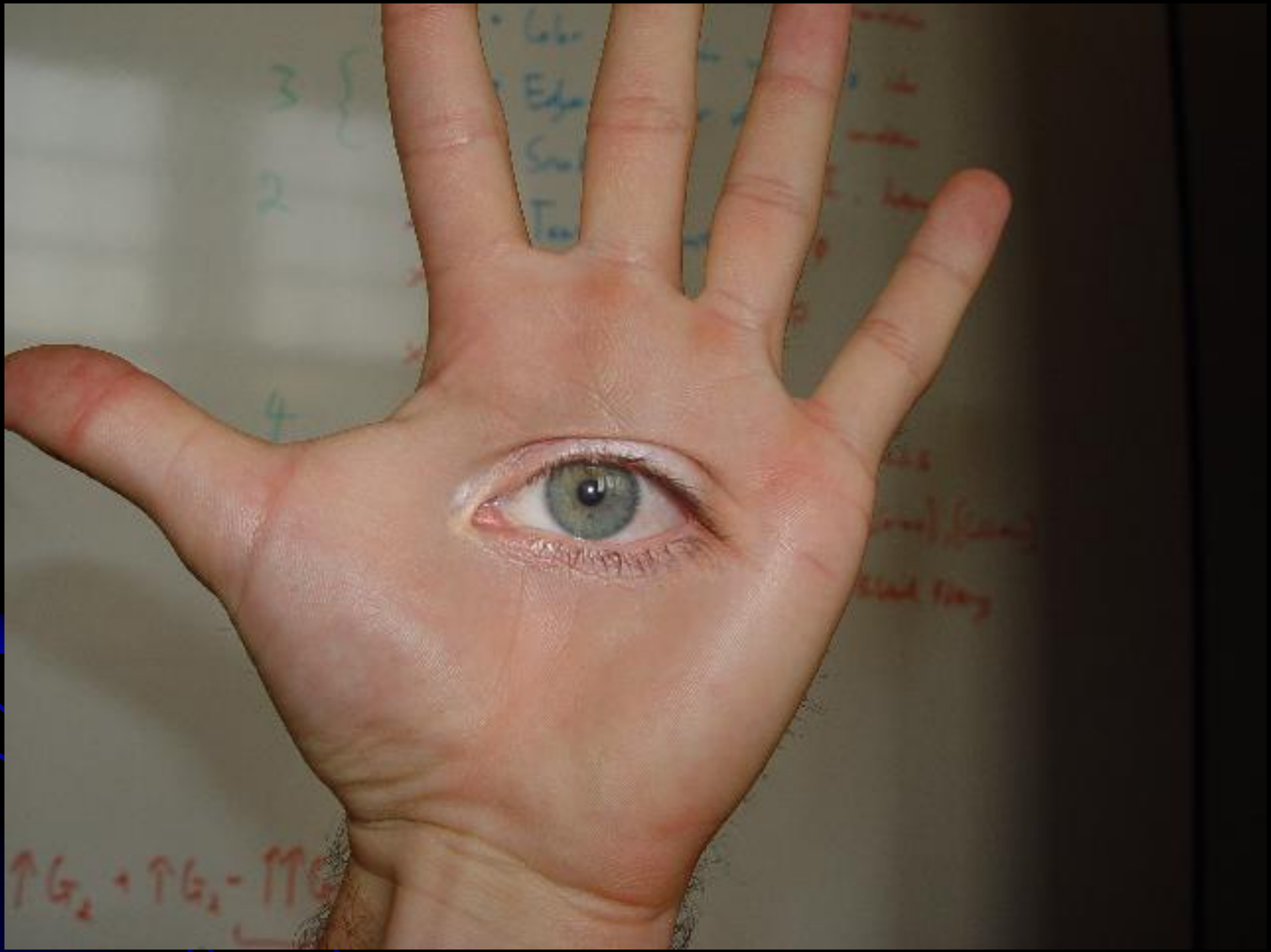
Kombinovanie regiónov

- Given two images A and B, and a mask M
- Construct Laplacian Pyramids L_a and L_b
- Construct a Gaussian Pyramid G_m
- Create a third Laplacian Pyramid L_c where for each level l

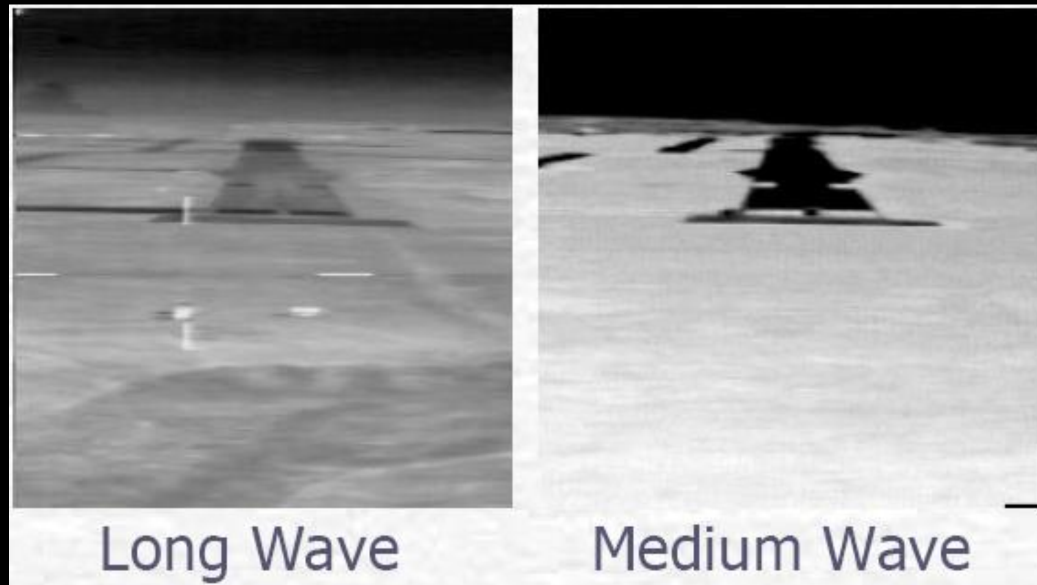
$$L_c(i,j) = G_m(i,j)L_a(i,j) + (1 - G_m(i,j))L_b(i,j)$$

- Sum all levels L_c in to get the blended image

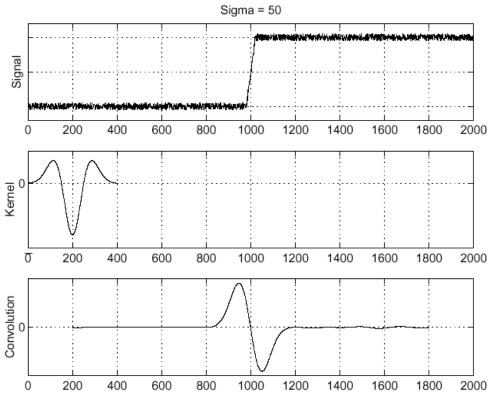
Horor foto

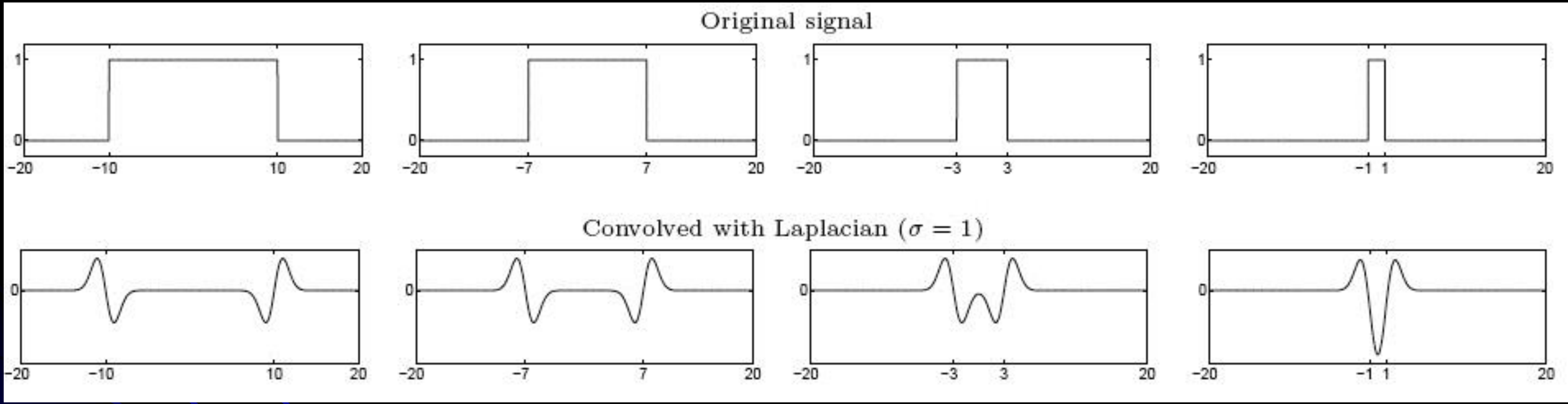


Multi-Sensor Fusion



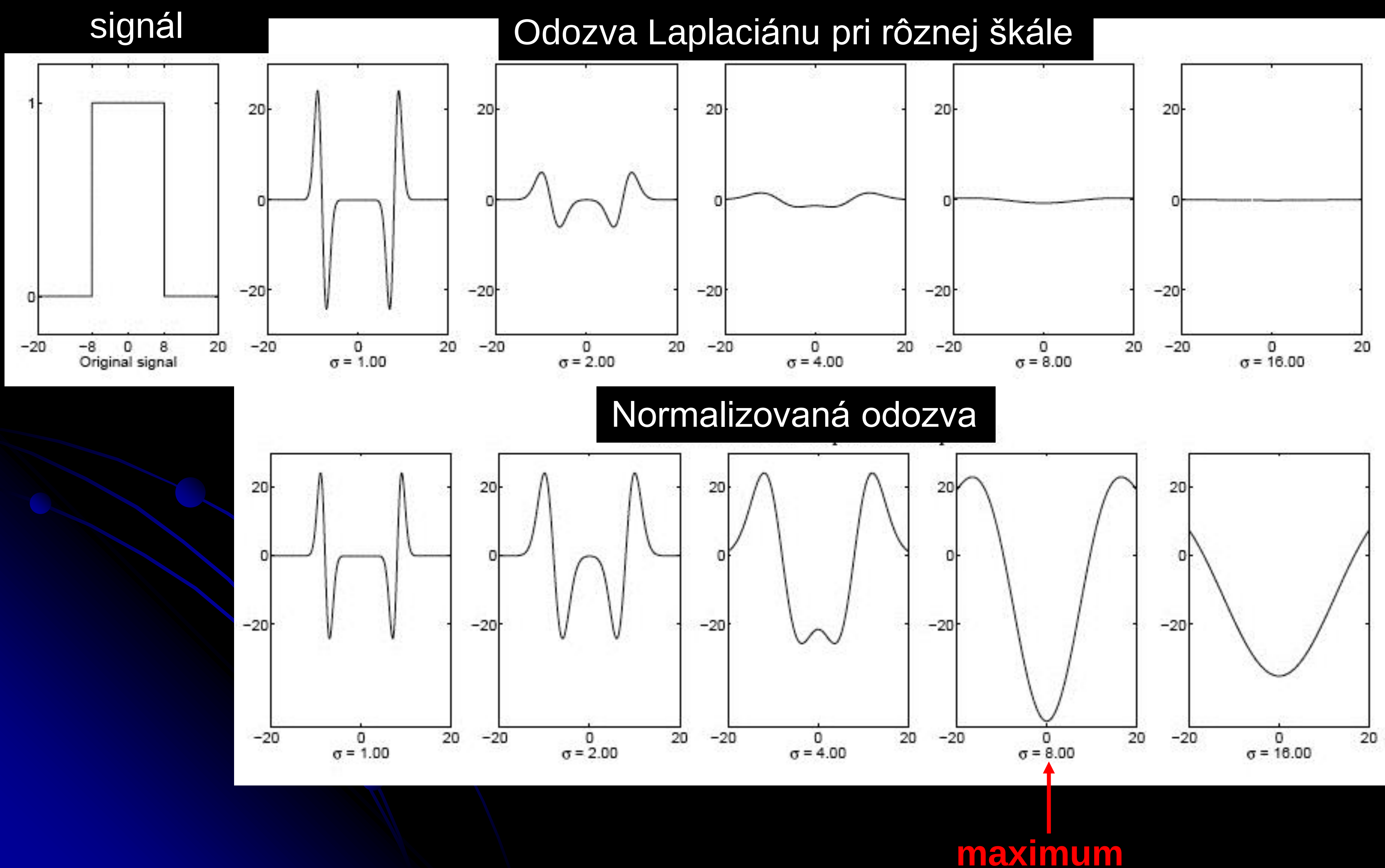
Škvrny



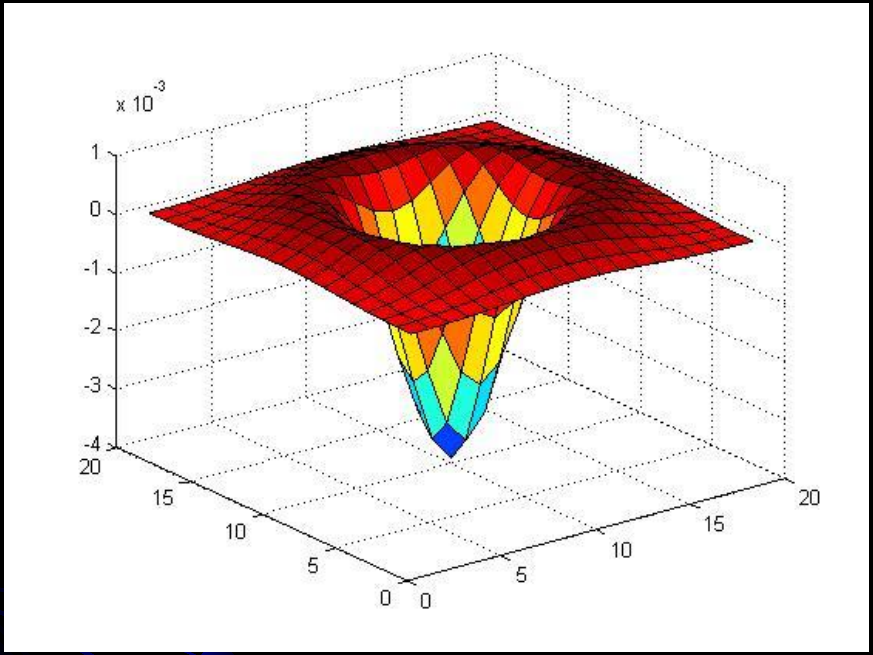


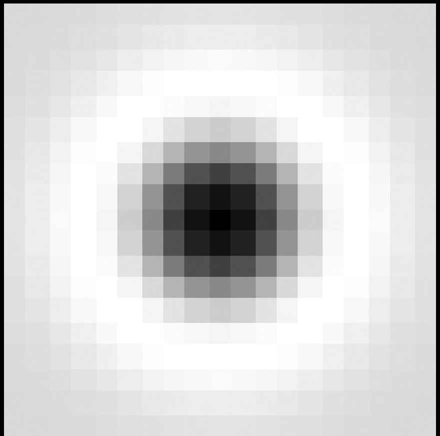
Odozva Laplaciánu bude maximálna v strede škvrny pri vhodnej škále

Normalizácia



2D LoG

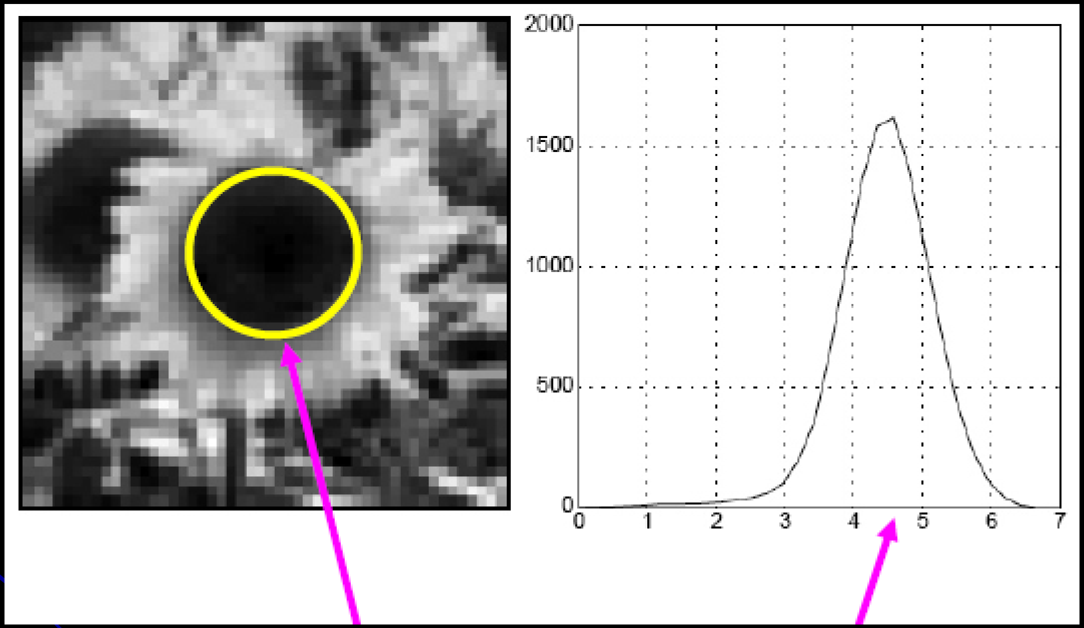




$$\nabla^2 G = \frac{\partial^2 G}{\partial x^2} + \frac{\partial^2 G}{\partial y^2}$$

normalizácia: $$\nabla^2_{\mathrm{norm}} G = \sigma^2 \left(\frac{\partial^2 G}{\partial x^2} + \frac{\partial^2 G}{\partial y^2} \right)$$

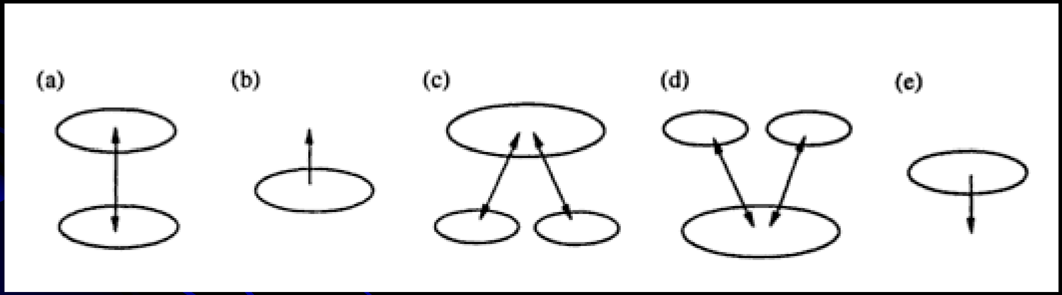
charakteristická škála škvrny
maximálna odpoveď Laplaciánu v strede škvrny

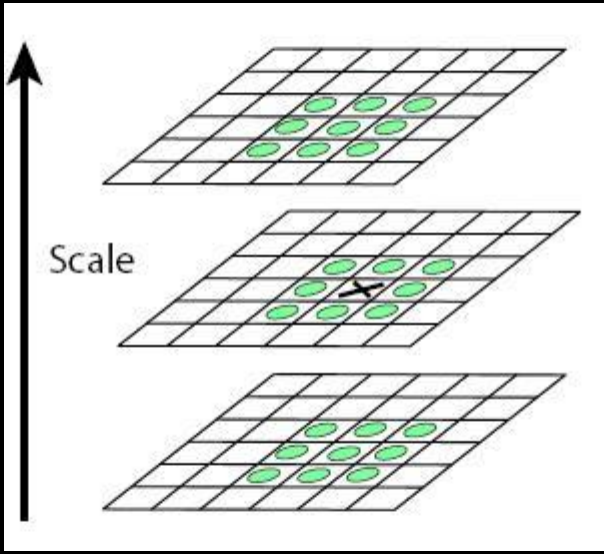


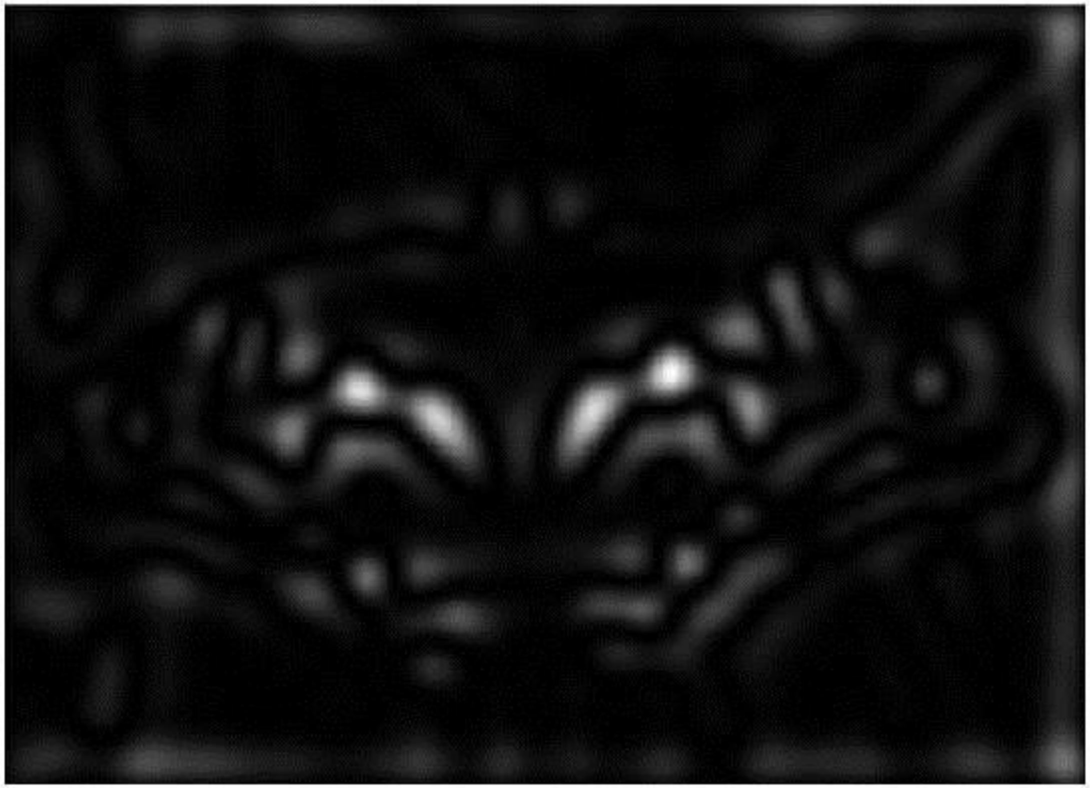
Detekcia škŕvn v ŠP

Odozva Laplacián obrazu pri rôznych škálach

Maximá v ŠP







sigma = 11.9912

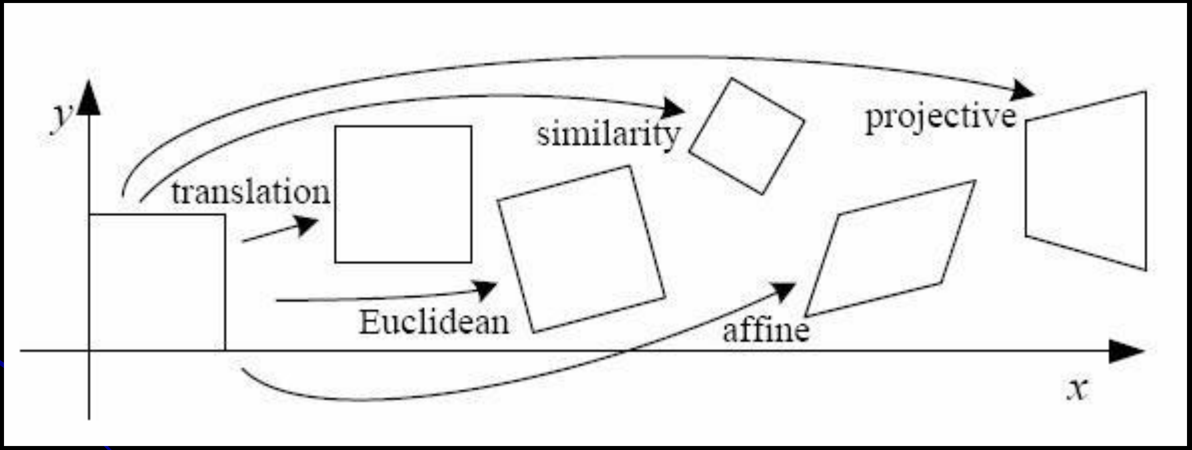
Lokálne príznaky

Skladajú sa z dvoch častí:
– Detektor na nájdenie zaujímavých bodov
– Deskriptor na ich popísanie

Porovnavanie
- Dôležitá je metrika!

Klasifikácia
- Obvykle počet zhôd

Invariantnosť



Výber zaujímavých bodov

Naivné:

Všetky body

Náhodné body

Rovnomerne rozmiestnené body

Detektory:

Harris corners

SUSAN

SIFT

SURF

FAST

SIFT

Figure 3. Example of a scale-space before the DoG computation.

Hľadá zaujímavé body v DoG priestore

DoG priestor

Rovnica prenosu tepla

$$\sigma \nabla^2 G = \frac{\partial G}{\partial \sigma}$$

$$\frac{\partial G}{\partial \sigma} \approx \frac{G(k\sigma) - G(\sigma)}{k\sigma - \sigma}$$

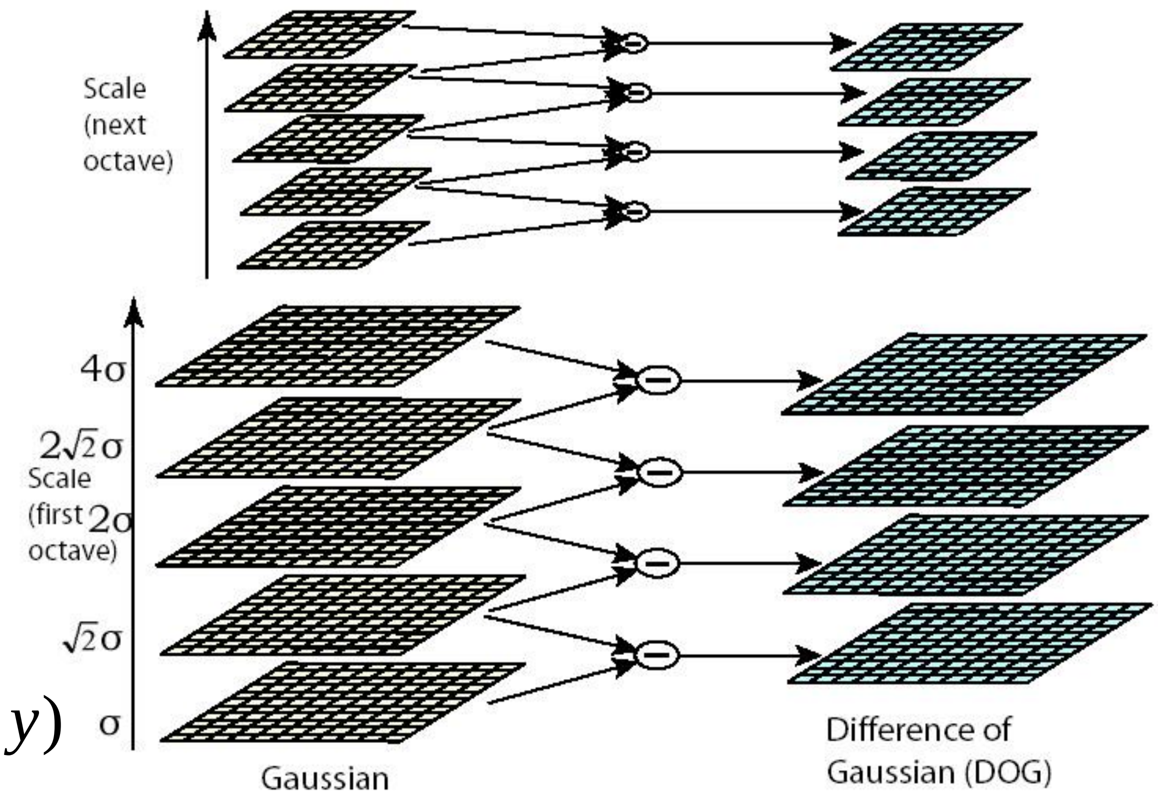
$$(k-1)\sigma^2 \nabla^2 G \approx G(k\sigma) - G(\sigma)$$

$$\nabla^2_{\text{norm}} G = \sigma^2 \nabla^2 G$$

$$D(x, y, \sigma) = \nabla^2_{\text{norm}} G(x, y, \sigma) * I(x, y)$$

DoG priestor

$$D(x,y,\sigma)=\sigma^2\nabla^2 G * I$$
$$\approx (G(k\sigma)-G(\sigma)) * I$$
$$\approx G(k\sigma) * I - G(\sigma) * I$$



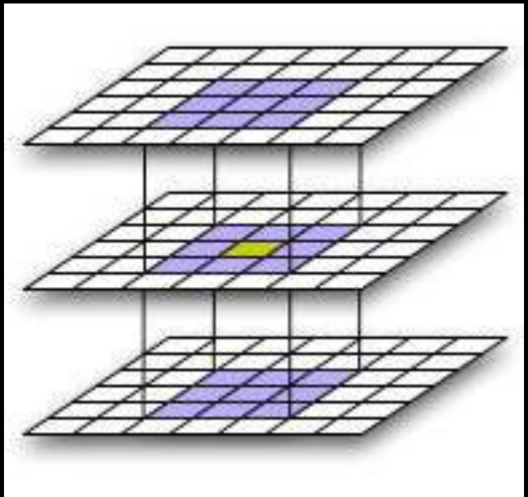
$$J(x,y,\sigma)=G(x,y,\sigma) * I(x,y)$$

SIFT

Zaujímavé body hľadá v 26 okolí v DoG

Hľadajú sa minimá a maximá

$\Rightarrow$ lokálne extrémy v 26 okolí



Určili sme pozíciu a škálu

Orientácia

$$\theta(x,y) = \arctan \frac{J(x,y+1) - J(x,y-1)}{J(x+1,y) - J(x-1,y)}$$

Odstránia sa

málo kontrastné body

body pozdĺž hrán

Hesseho matica druhých derivácií

$$\tilde{\mathbf{H}} = \begin{bmatrix} D_{xx} & D_{xy} \\ D_{xy} & D_{yy} \end{bmatrix}$$

$$Tr(\mathbf{H}) = D_{xx} + D_{yy} = \alpha + \beta$$

$$Det(\mathbf{H}) = D_{xx}D_{yy} - (D_{xy})^2 = \alpha\beta$$

$$\alpha = r\beta$$

$$\frac{Tr(\mathbf{H})^2}{Det(\mathbf{H})} = \frac{(\alpha+\beta)^2}{\alpha\beta} = \frac{(r\beta+\beta)^2}{r\beta^2} = \frac{(r+1)^2}{r}$$

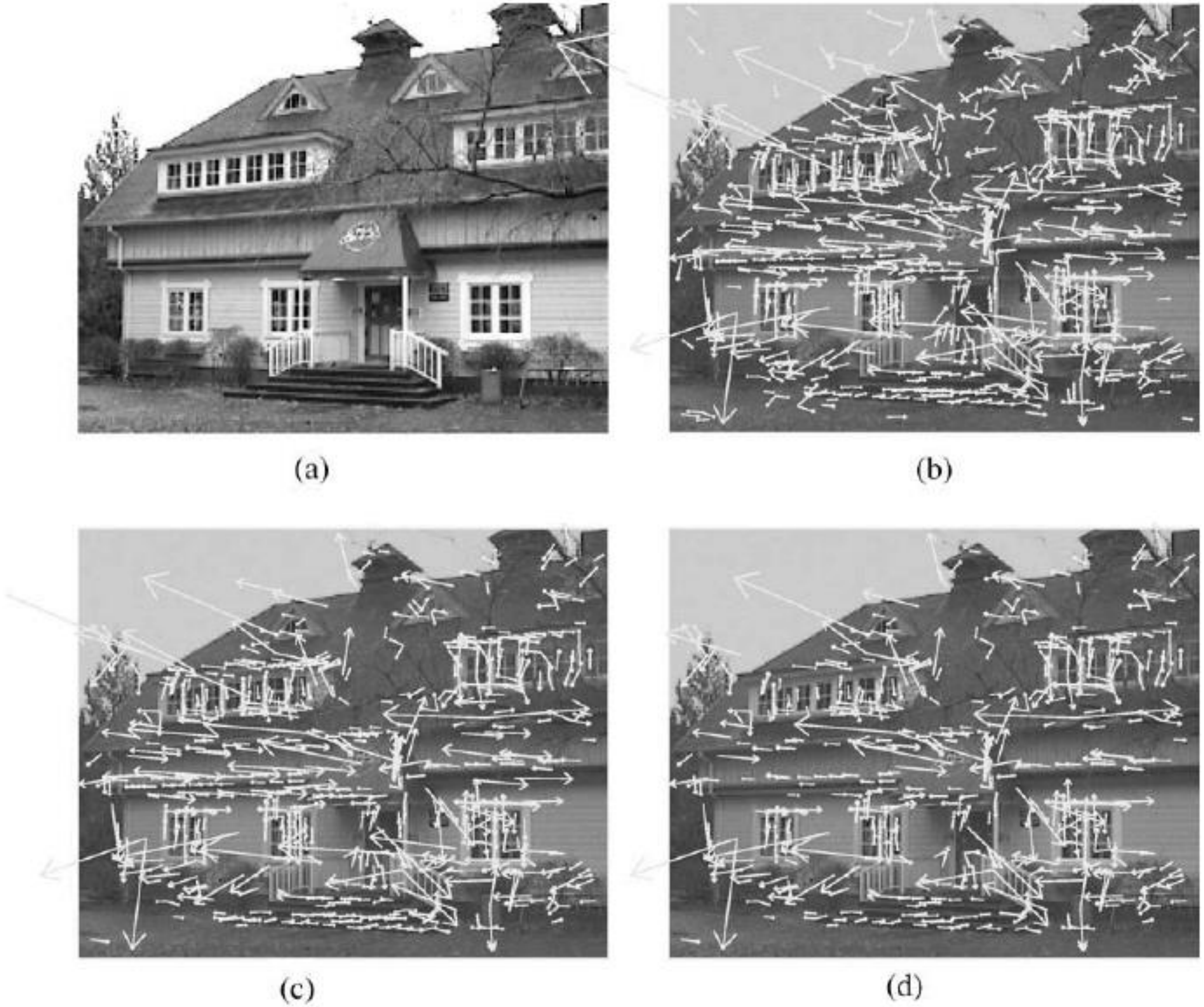


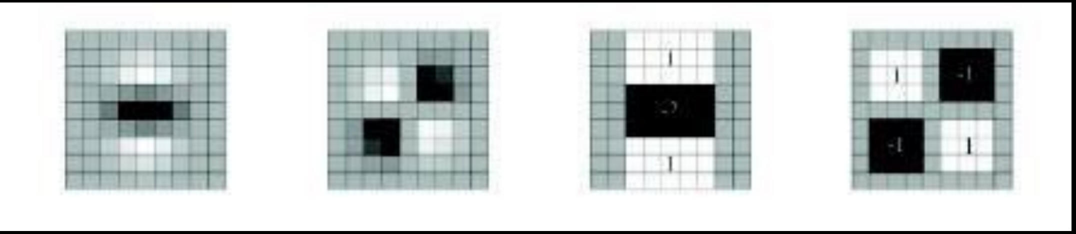
Figure 5. This figure shows the stages of keypoint selection. (a) The 233 × 189 pixel original image. (b) The initial 832 keypoints locations at maxima and minima of the difference-of-Gaussian function. Keypoints are displayed as vectors indicating scale, orientation, and location. (c) After applying a threshold on minimum contrast, 729 keypoints remain. (d) The final 536 keypoints that remain following an additional threshold on ratio of principal curvatures.

D.Lowe. “Distinctive Image Features from Scale-Invariant Keypoints”. IJCV 2004

SURF

Namiesto vytvárania Gaussovej pyramídy filtruje obrázok rôznymi veľkosťami filtrov

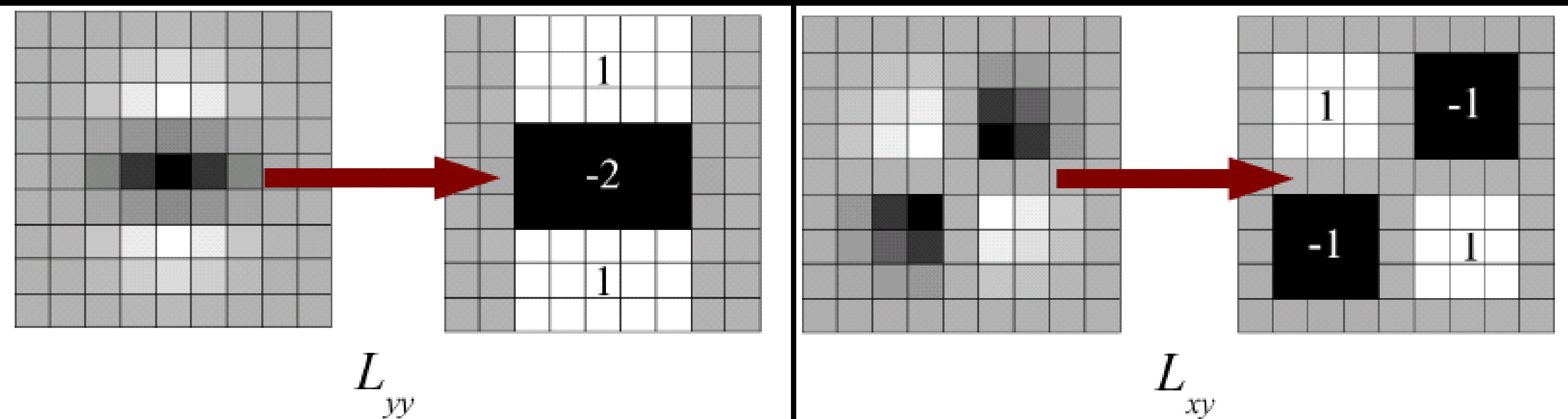
Filter = aproximácia druhých parciálnych derivácií Gausiánu



SURF: Speeded Up Robust Features
Herbert Bay, Tinne Tuytelaars, and Luc Van Gool, ECCV 2006

$$SIFT: \ H_{approx}^{SIFT} = \begin{bmatrix} D_{xx} & D_{xy} \\ D_{yx} & D_{yy} \end{bmatrix}$$

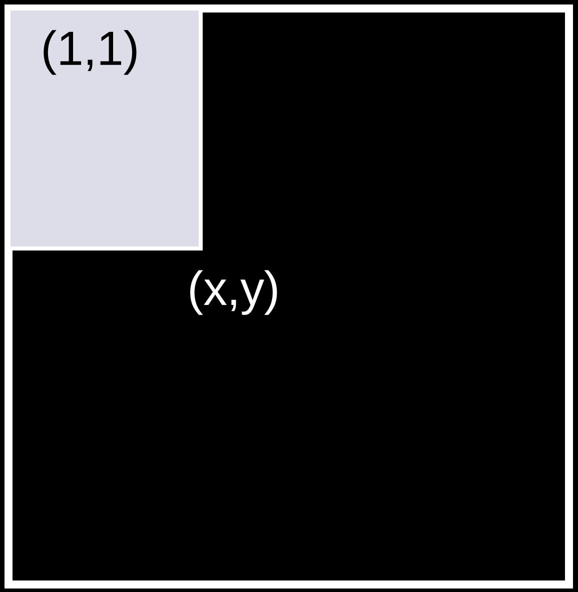
$$SURF: \ H_{approx}^{SURF} = \begin{bmatrix} \hat{L}_{xx} & \hat{L}_{xy} \\ \hat{L}_{yx} & \hat{L}_{yy} \end{bmatrix}$$



Integrálne obrazy

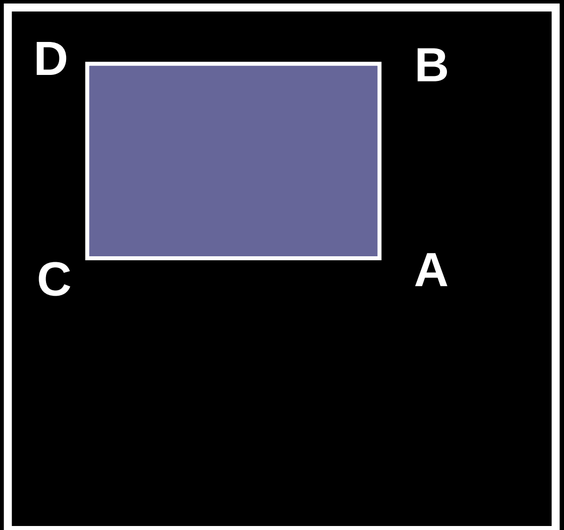
Suma bodov vľavo hore

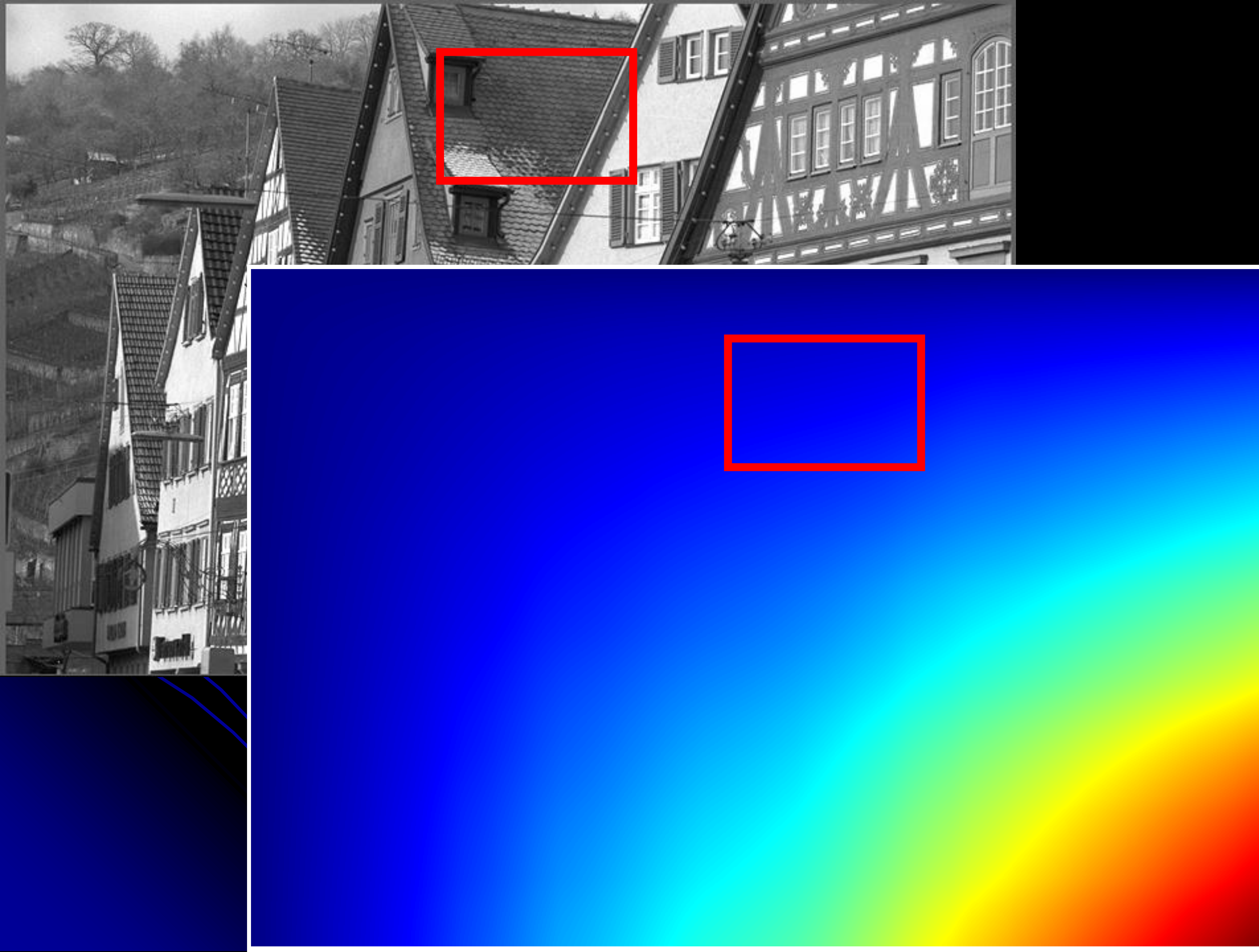
$$IO(x,y)=\sum_{i=1}^{x}\sum_{j=1}^{y} I(i,j)$$



Suma bodov v obdĺžnikovom okne (ABCD) pôvodného obrazu =

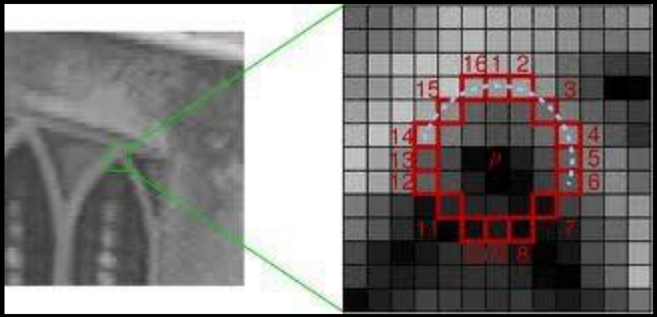
IO(A) – IO(B) – IO(C) + IO(D)





FAST

Porovnanie hodnoty intenzity bodu a jeho susedov na Bresenhamovej kružnici s polomerom r



E. Rosten and T. Drummond. "Machine learning for high-speed corner detection,". ECCV 2006

Popis zaujímavých bodov

Raw data

HOG

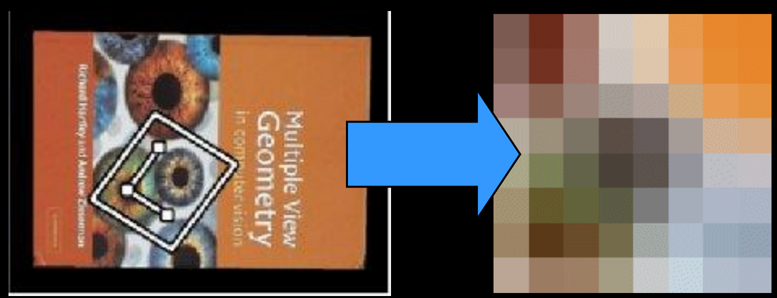
SIFT

SURF

BRIEF

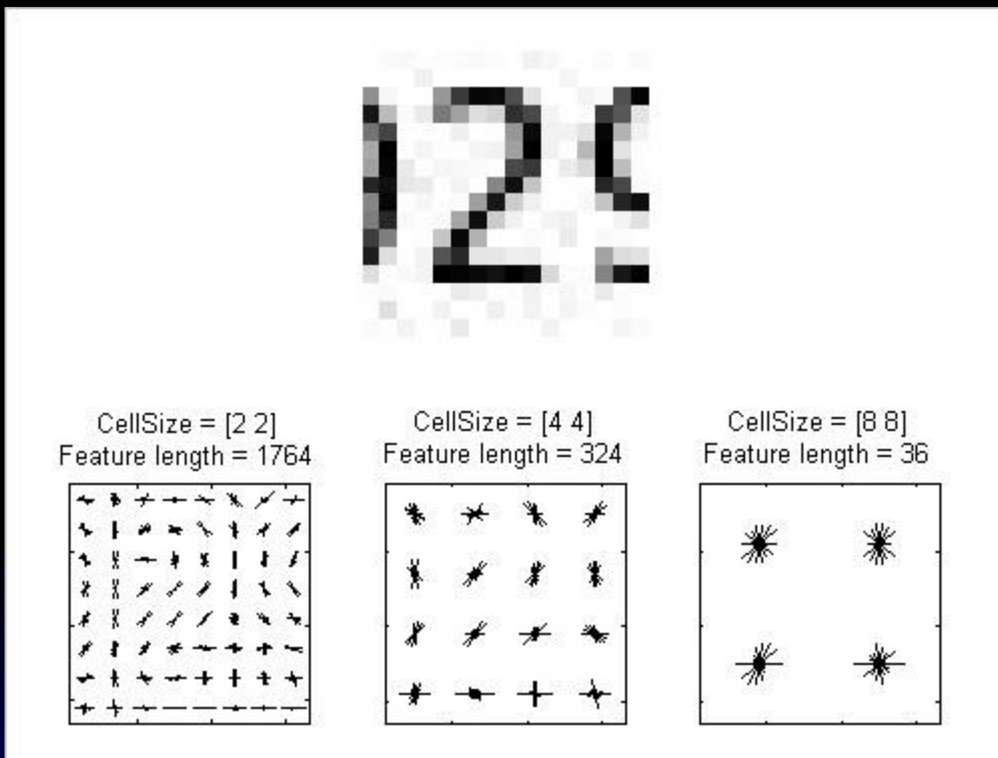
Raw data

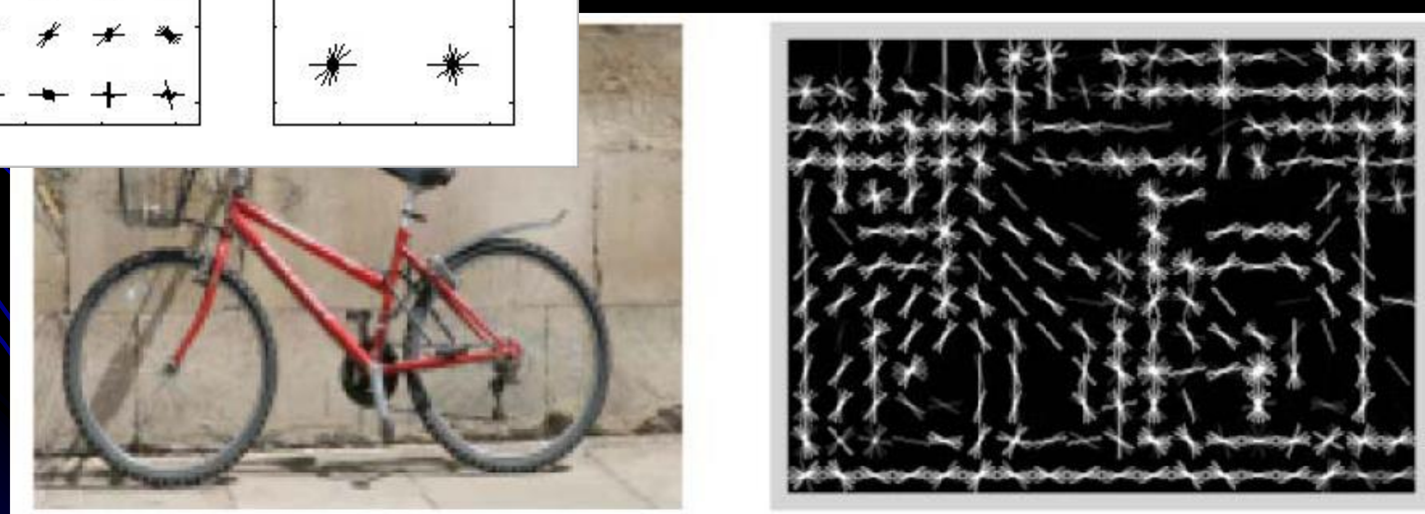
Vektor intenzít okna



HOG

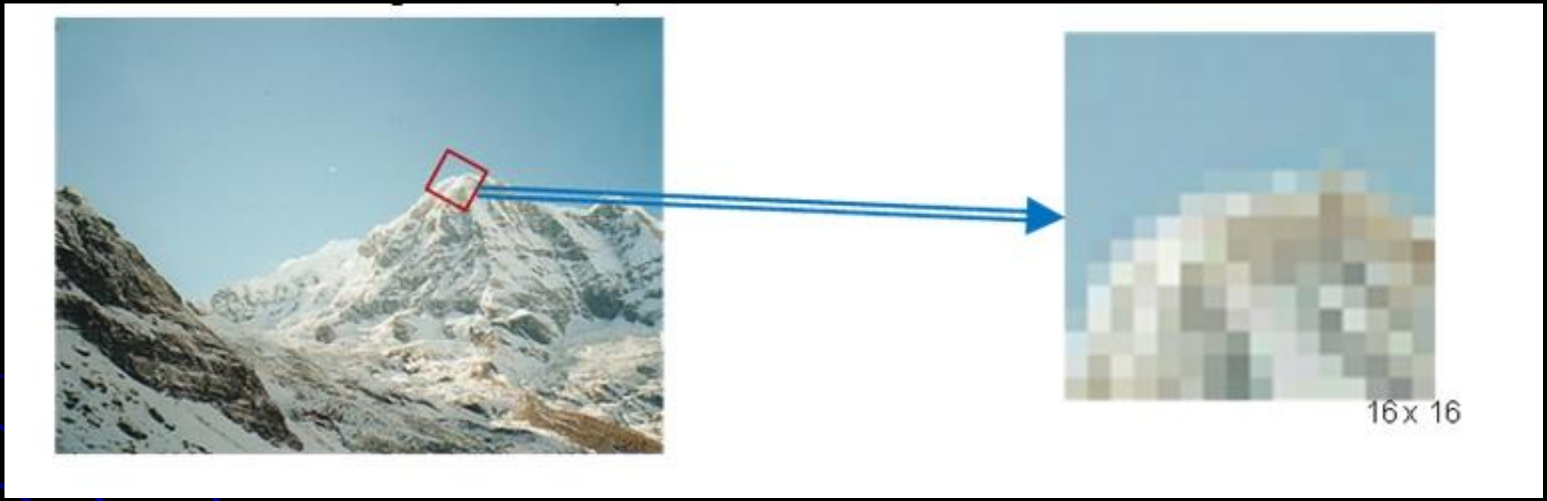
Histogam of Oriented Gradients





SIFT

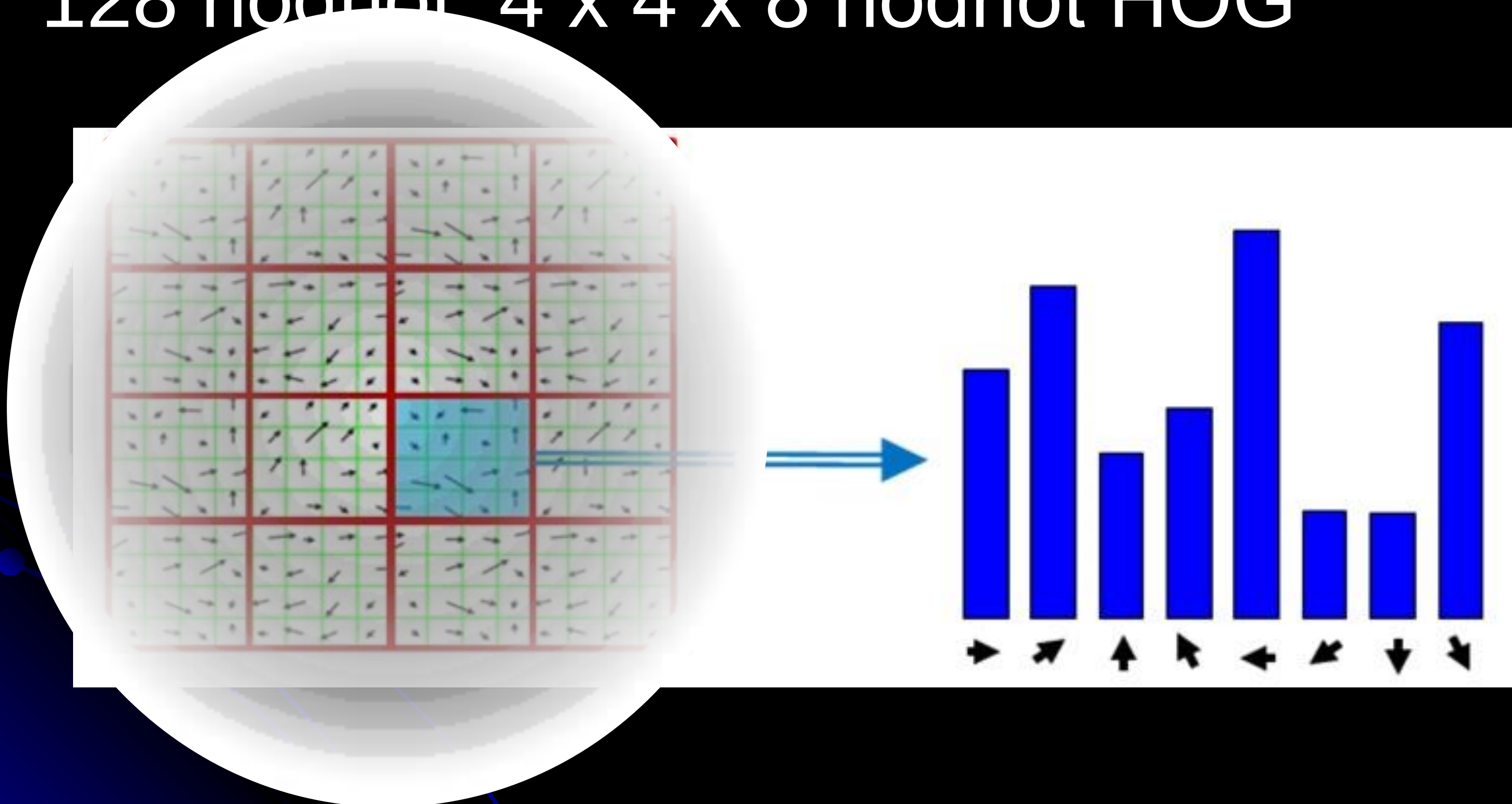
Používa HOG



Okno okolo zaujímavého bodu otočí podľa orientácie

SIFT

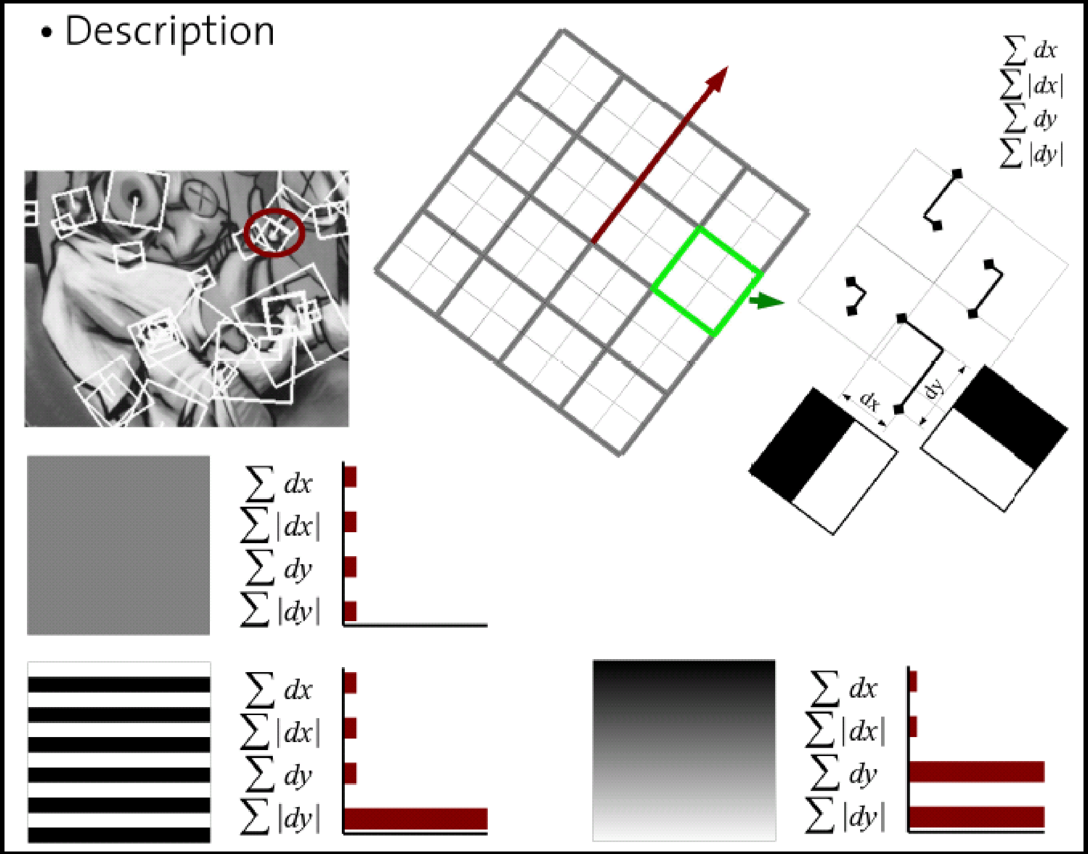
128 hodnôt: 4 x 4 x 8 hodnôt HOG



SURF

Haar wavelet odozvy vo vertikálnom smere a horizontálnom smere

4 príznaky x
16 oblastí =
64 hodnôt



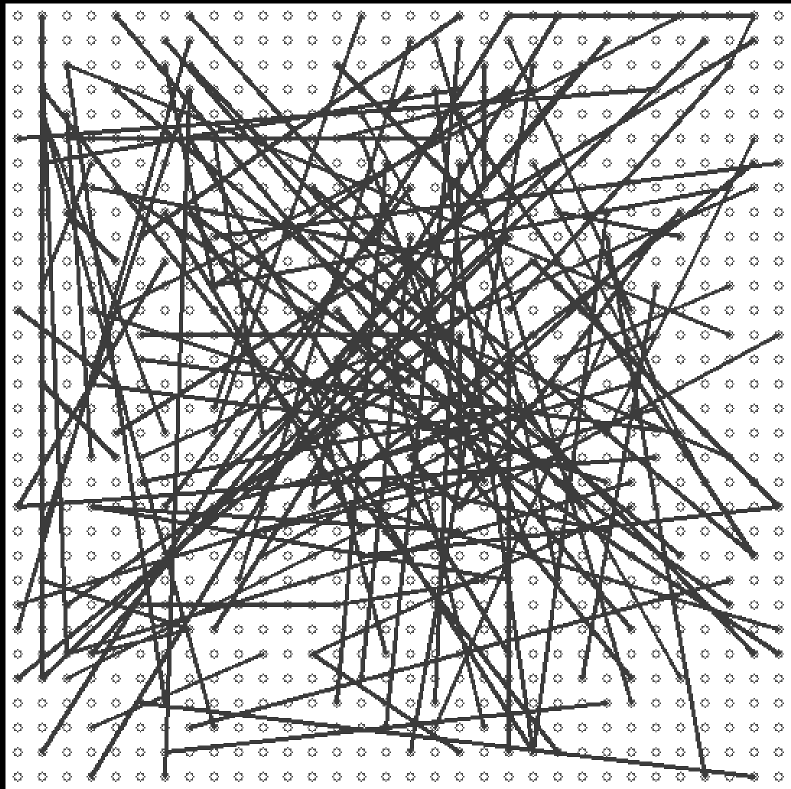
BRIEF

jeden z prvých binárnych deskriptorov

porovnáva intenzitu dvojíc pixlov v okolí zaujímavých bodov

=> bitový deskriptor

256 / 128 bitov



Porovnanie bodov

Euklidovská vzdialenosť

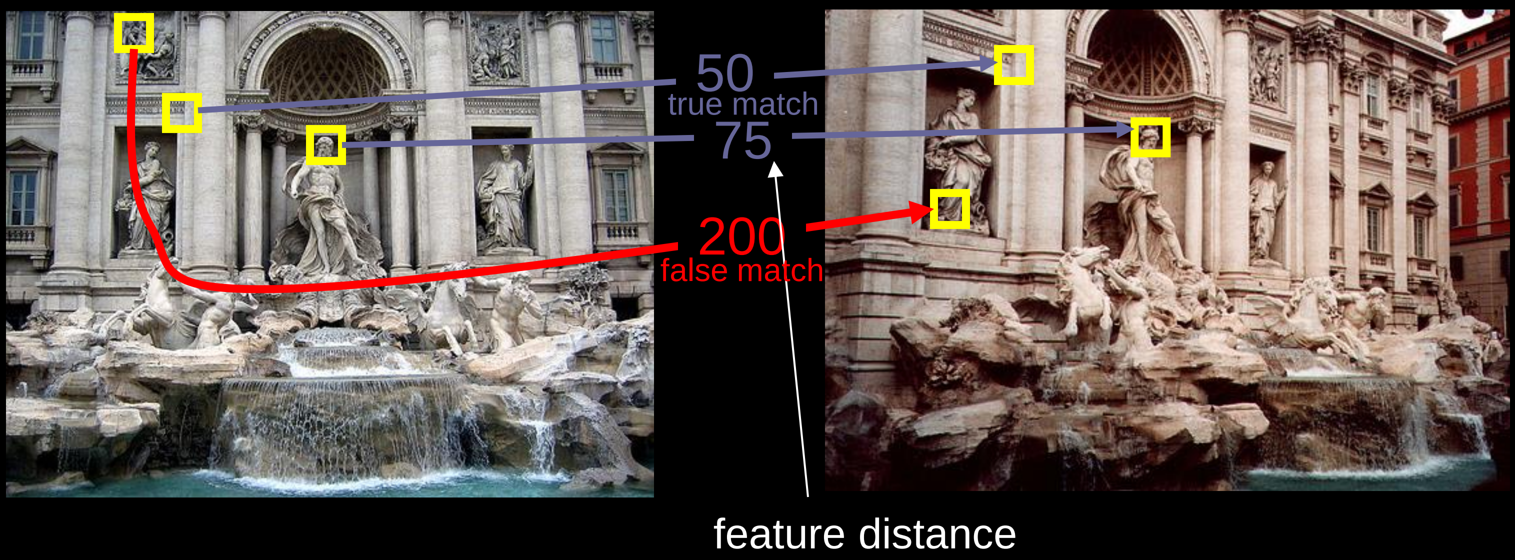
$$d_e(p,q) = \sqrt{\textstyle\sum_{i=1}^{n}(p_i - q_i)^2}.$$

Hammingova vzdialenosť

$$d_h(p,q) = \sum_{i=1}^{n} \delta(p_i,q_i)/n$$

where

$$\delta(p,q) = \begin{cases} 0 \text{ if } & = (x<0 \wedge y<0) \vee (x=0 \wedge y=0) \\ 1 \text{ if } & = otherwise \end{cases}.$$


50
true match
75
200
false match
feature distance