IMAGE FILTERING

Szeliski, Chapter 3.1-3.2, 4.2

内容

- 滤波的基本思想
- 均值（Box），高斯（Gaussian），中值（Median），双边（Bilateral）滤波处理图像后的效果
- Sobel边缘检测的基本原理
- OpenCV 实现

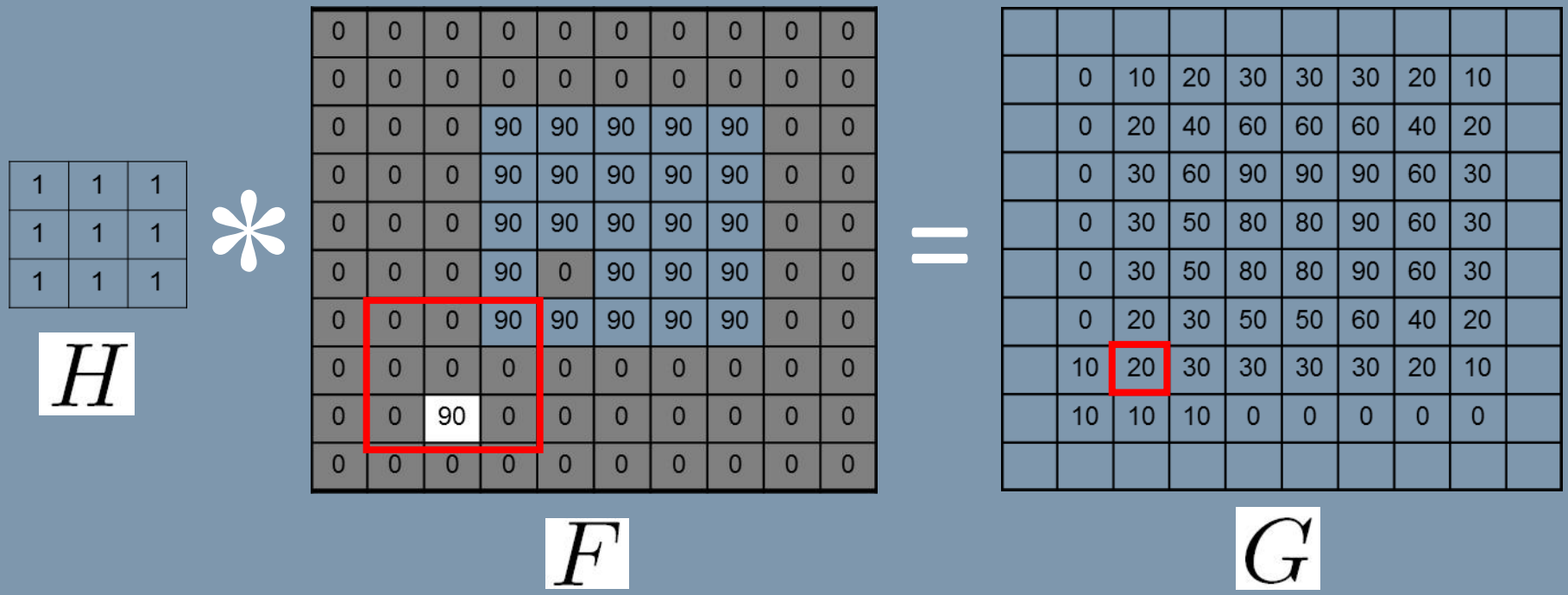
QUESTION: 去除噪音

- How?

IMAGE FILTERING（图像滤波）

- Modify the pixels in an image based on some function of a local neighborhood of each pixel
- Linear Filtering（线性滤波）
  - Replace each pixel by a linear combination (a weighted sum) of its neighbors
- The prescription for the linear combination is called the “kernel”（核）(or “mask”, “filter”)

MEAN FILTER（均值滤波）



Original

0	0	0
0	1	0
0	0	0

Filtered
(no change)

Original

0	0	0
0	0	1
0	0	0

?

Original

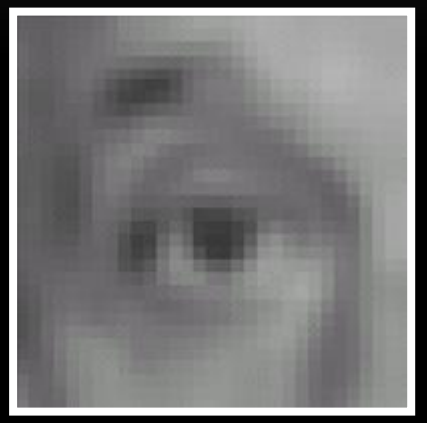
0	0	0
0	0	1
0	0	0

Shifted left
By 1 pixel

EXAMPLE，模糊

Original

1	1	1
1	1	1
1	1	1



Blur (with a box filter)

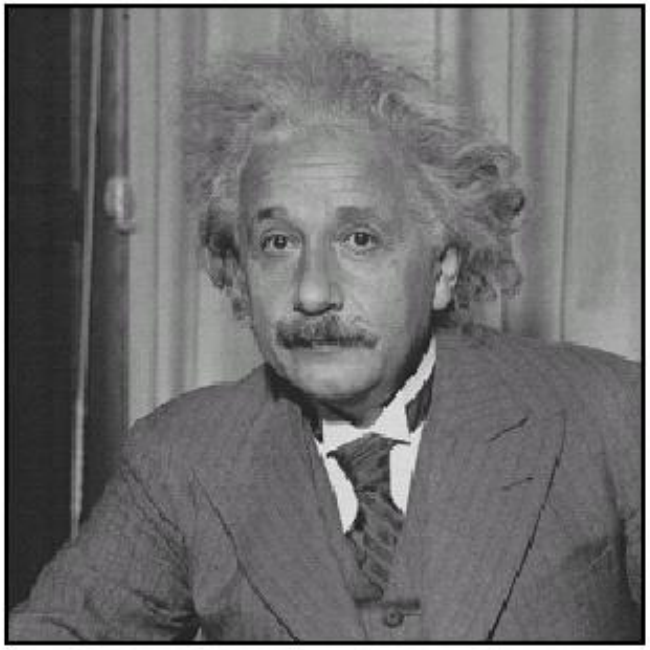
EXAMPLE，锐化

Original

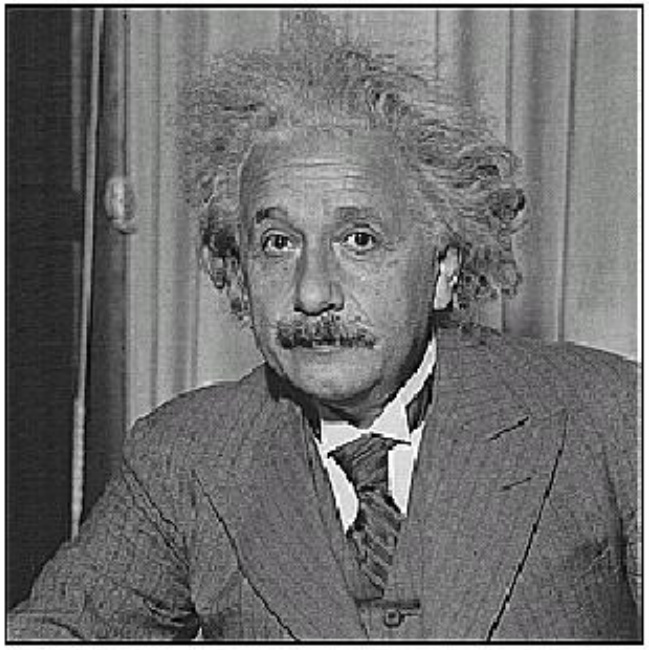
$$*\begin{bmatrix}0&0&0\\0&2&0\\0&0&0\end{bmatrix}-\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix}=$$

Sharpening filter
(accentuates edges)

SHAPENING 锐化

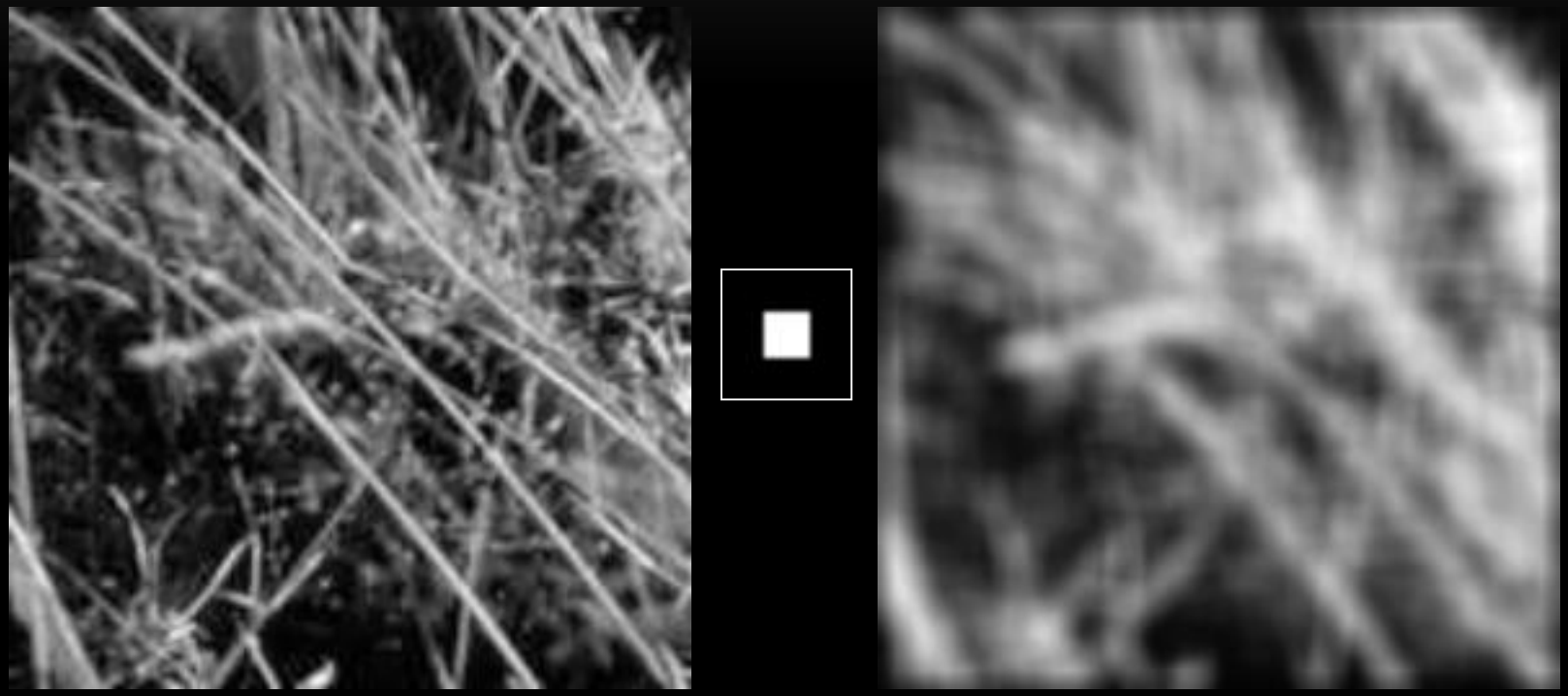


before

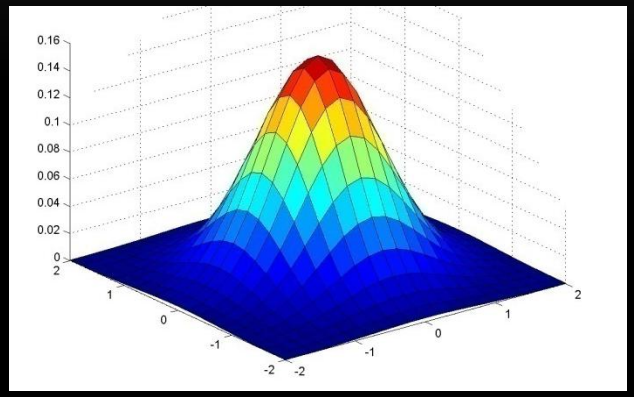


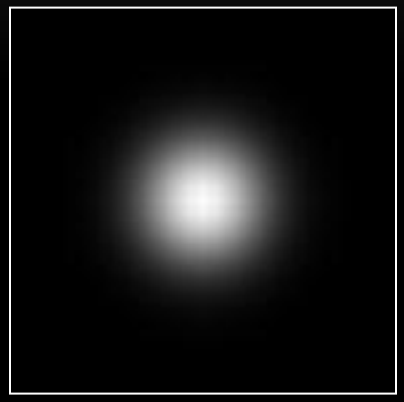
after

BOX FILTER



GAUSSIAN FILTER（高斯滤波）

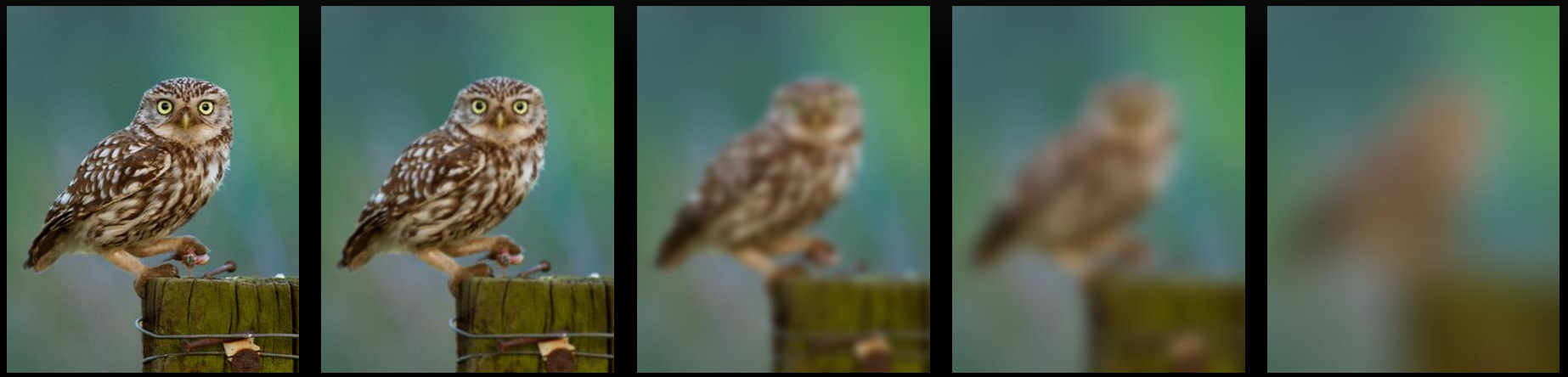




$$G_\sigma = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}$$

0.003	0.013	0.022	0.013	0.003
0.013	0.059	0.097	0.059	0.013
0.022	0.097	0.159	0.097	0.022
0.013	0.059	0.097	0.059	0.013
0.003	0.013	0.022	0.013	0.003

5 x 5, $\sigma = 1$



= 1 pixel = 5 pixels = 10 pixels = 30 pixels

APPLICATIONS 应用

−

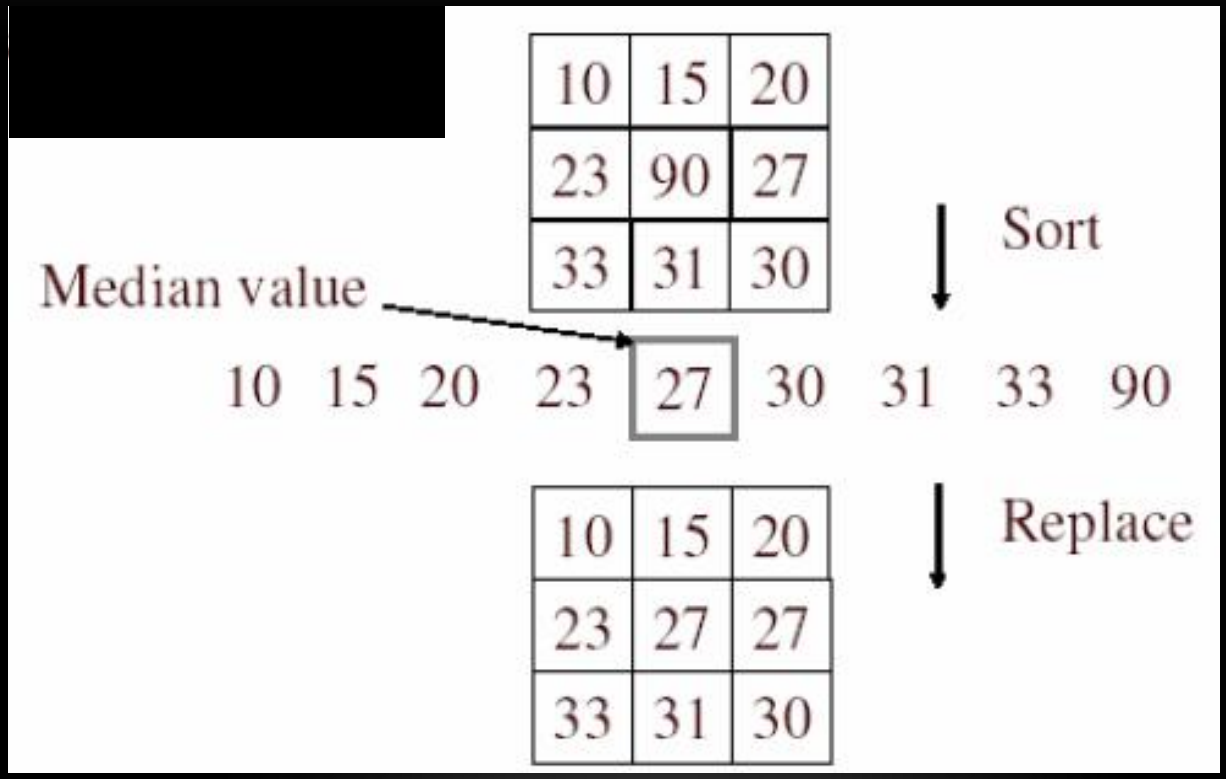
=

Let’s add it back:

+ α

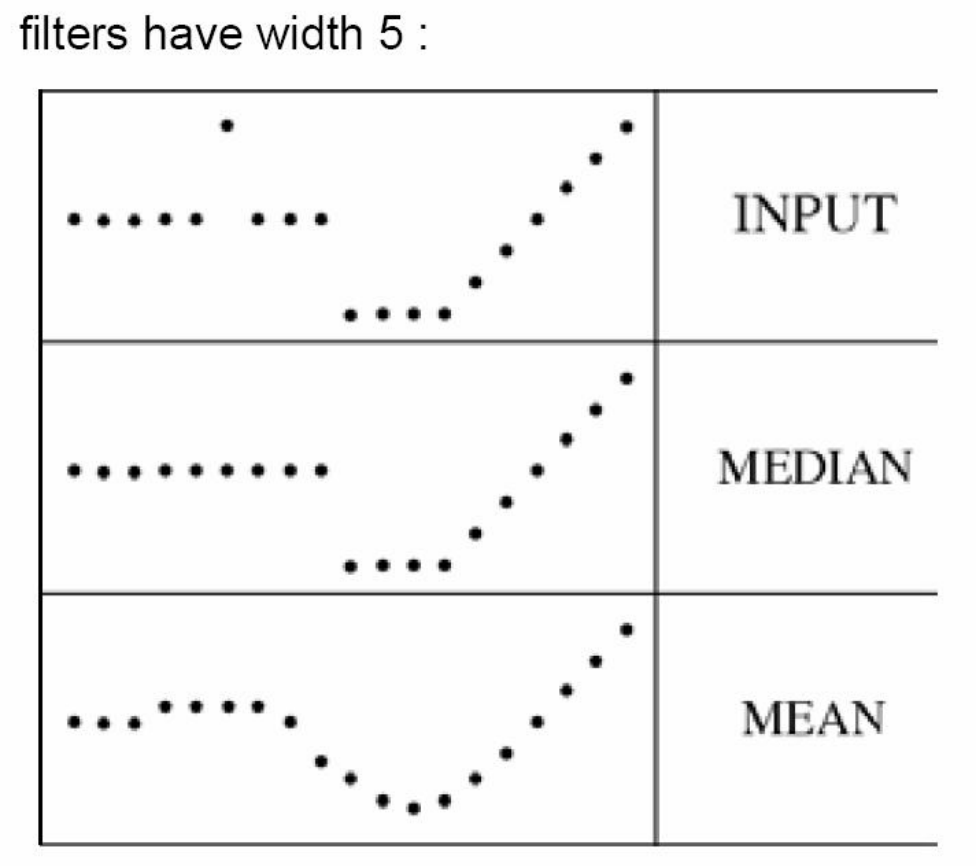
=

MEDIAN FILTER 中值滤波



- 是否线性滤波?

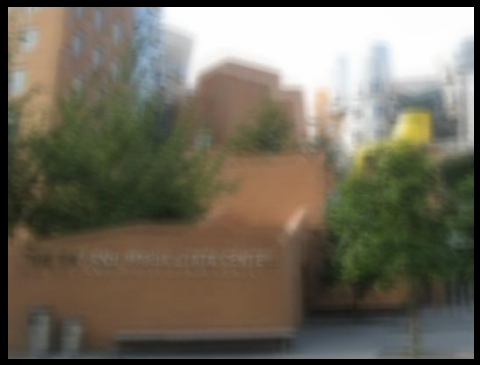
抗噪音




3x3
5x5
7x7
Gaussian
Median

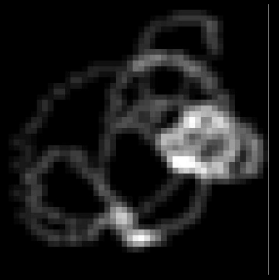
特殊的滤波核

Camera shake



=

*

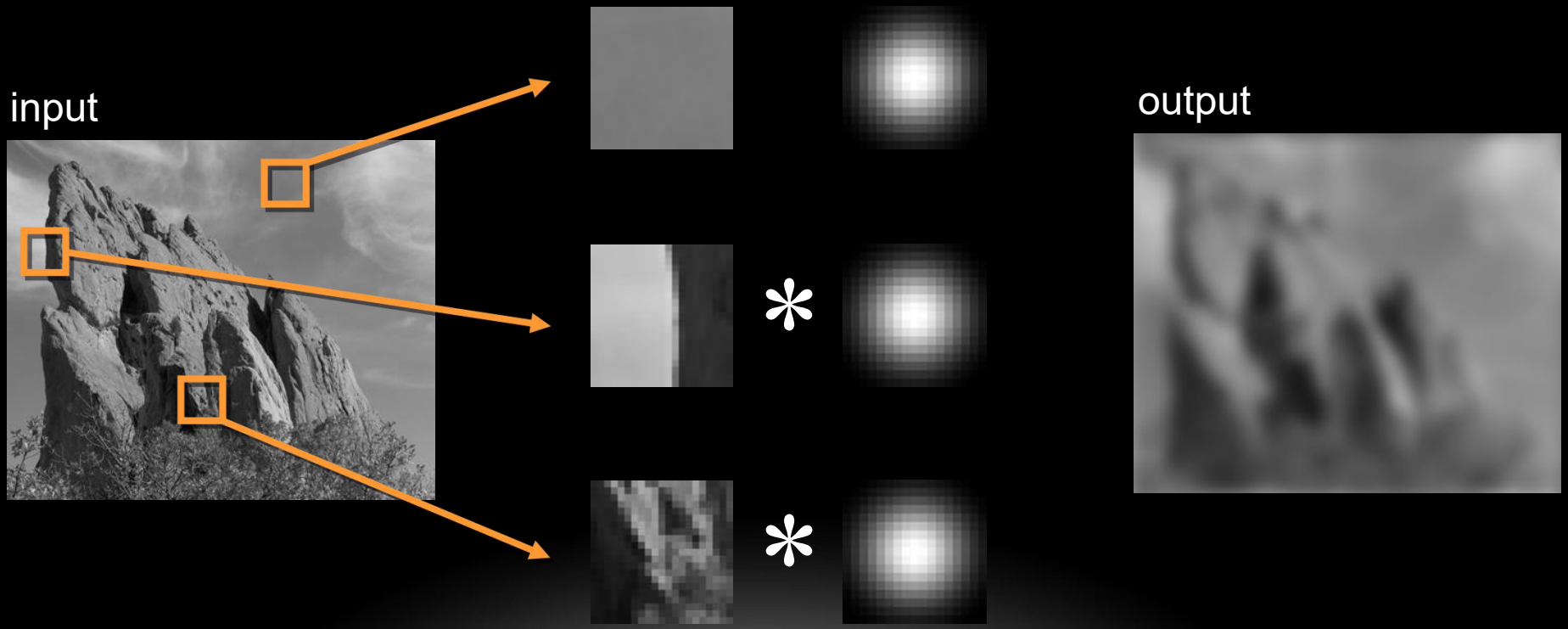


Source: Fergus, *et al.* "Removing Camera Shake from a Single Photograph", SIGGRAPH 2006

EDGE-AWARE FILTER（边缘保持滤波）

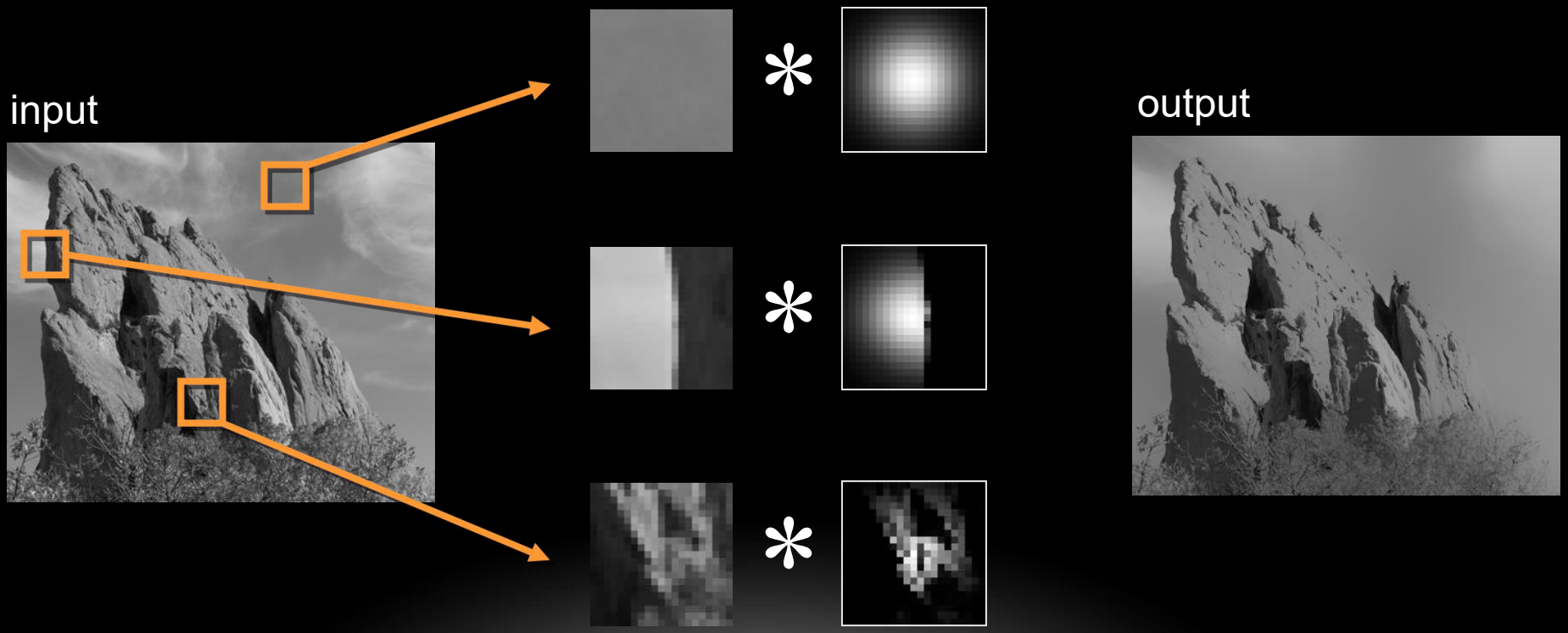
- Bilateral Filter（双边滤波）
- Guided Image Filter（导向图滤波）

高斯滤波



Same Gaussian kernel everywhere.

双边滤波



The kernel shape depends on the image content.

Same idea: **weighted average of pixels.**

new

not new

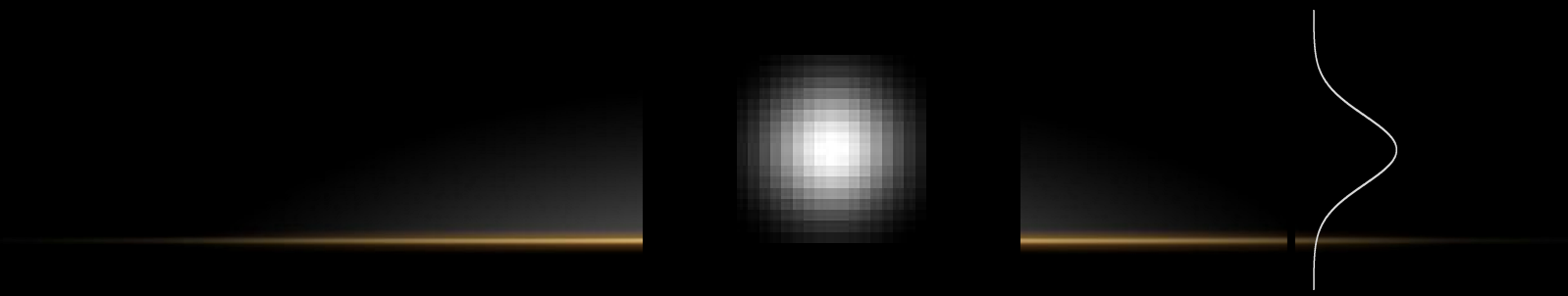
new

$$BF[I]_{\mathbf{p}} = \frac{1}{W_{\mathbf{p}}} \sum_{\mathbf{q} \in S} G_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|)\, G_{\sigma_r}(|I_{\mathbf{p}}-I_{\mathbf{q}}|)\, I_{\mathbf{q}}$$

normalization factor

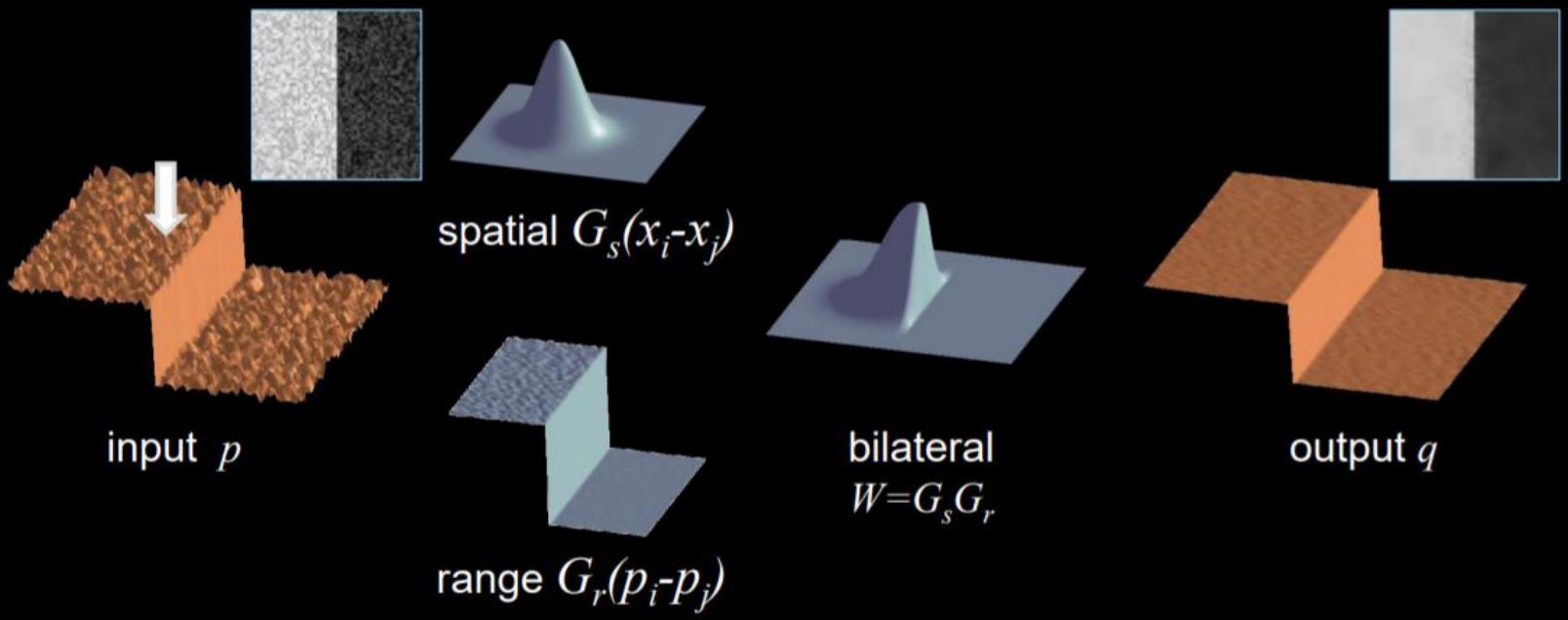
space weight

range weight



- Bilateral filter

$$q_i = \sum_{j \in N(i)} W_{ij}(p) p_j$$



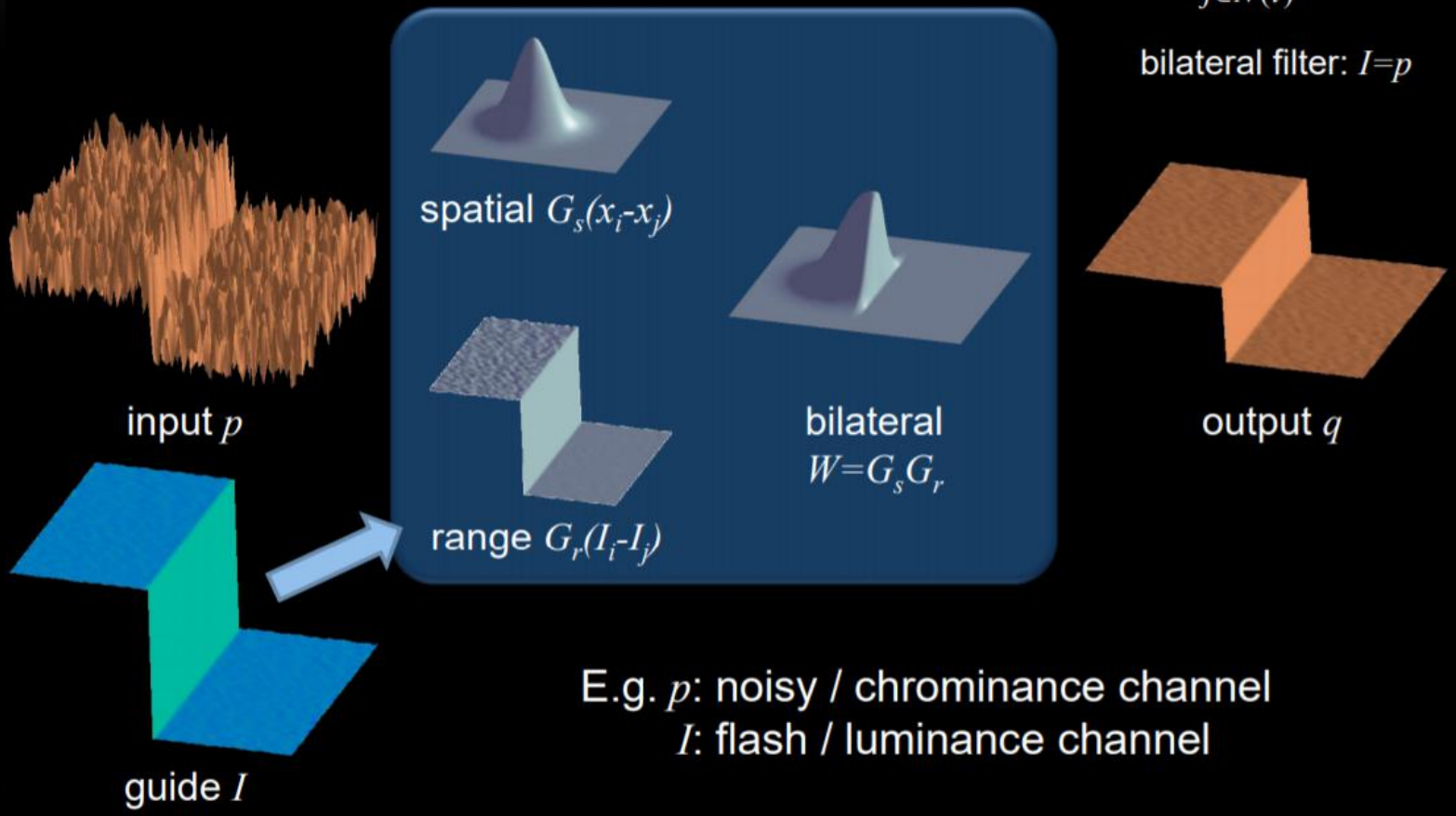
双边滤波的扩展

- 两个滤波核中，空间计算与图像无关，而颜色值计算与图像相关
- 能否利用其他图像的颜色值作为参考，处理双边滤波，会达到什么效果?

- Joint bilateral filter [Petschnigg et al. 2004]

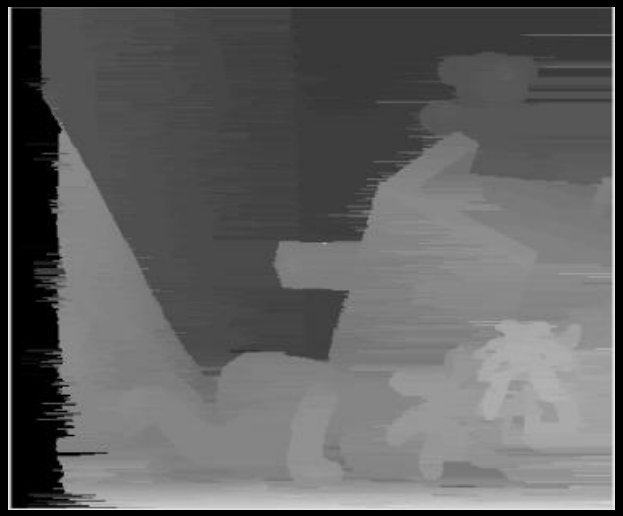
$$q_i = \sum_{j \in N(i)} W_{ij}(I) p_j$$

bilateral filter: $I=p$



E.g. p: noisy / chrominance channel
I: flash / luminance channel

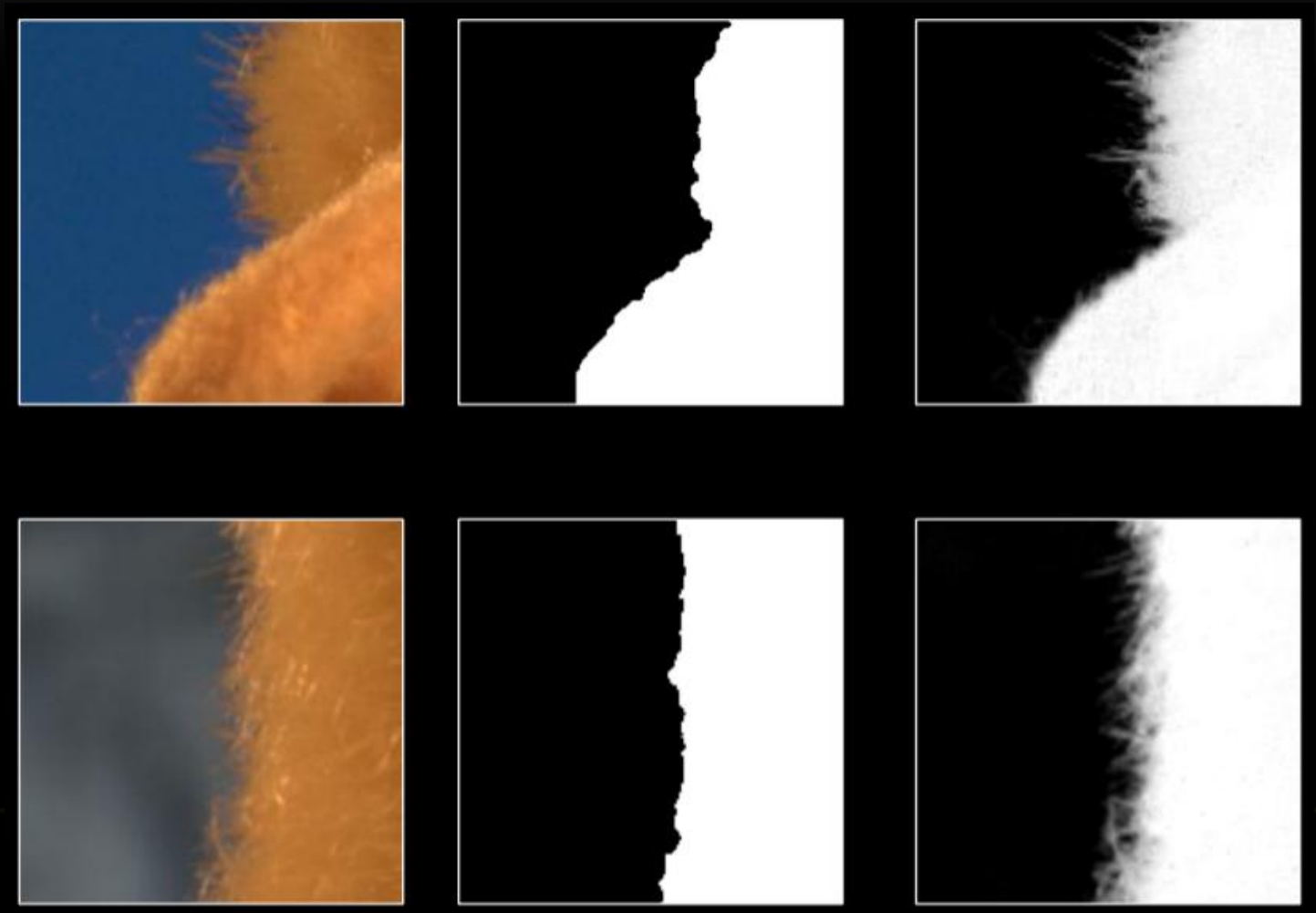
结果



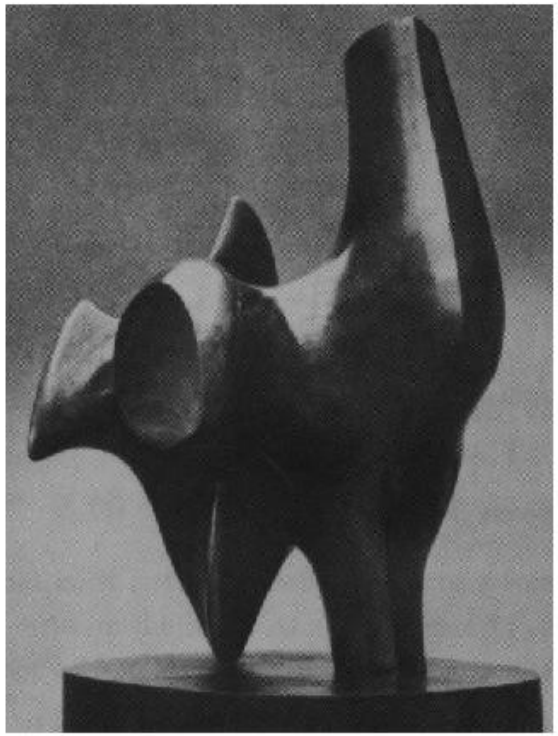
存在的问题

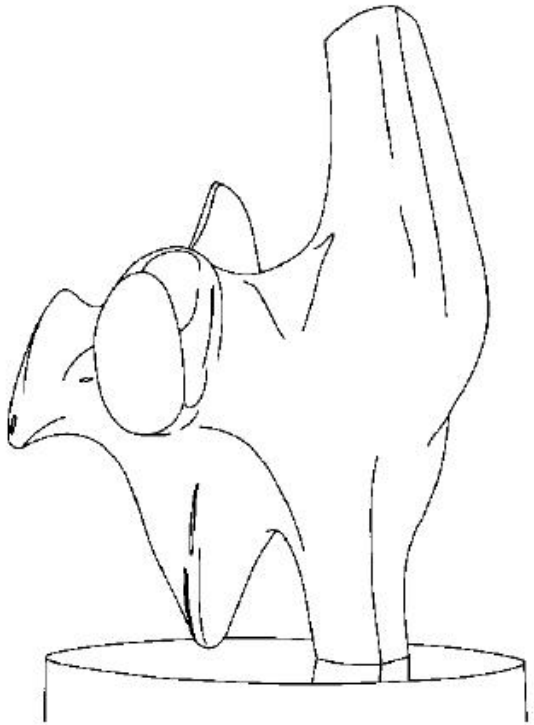
- 计算速度很慢
- 梯度变形

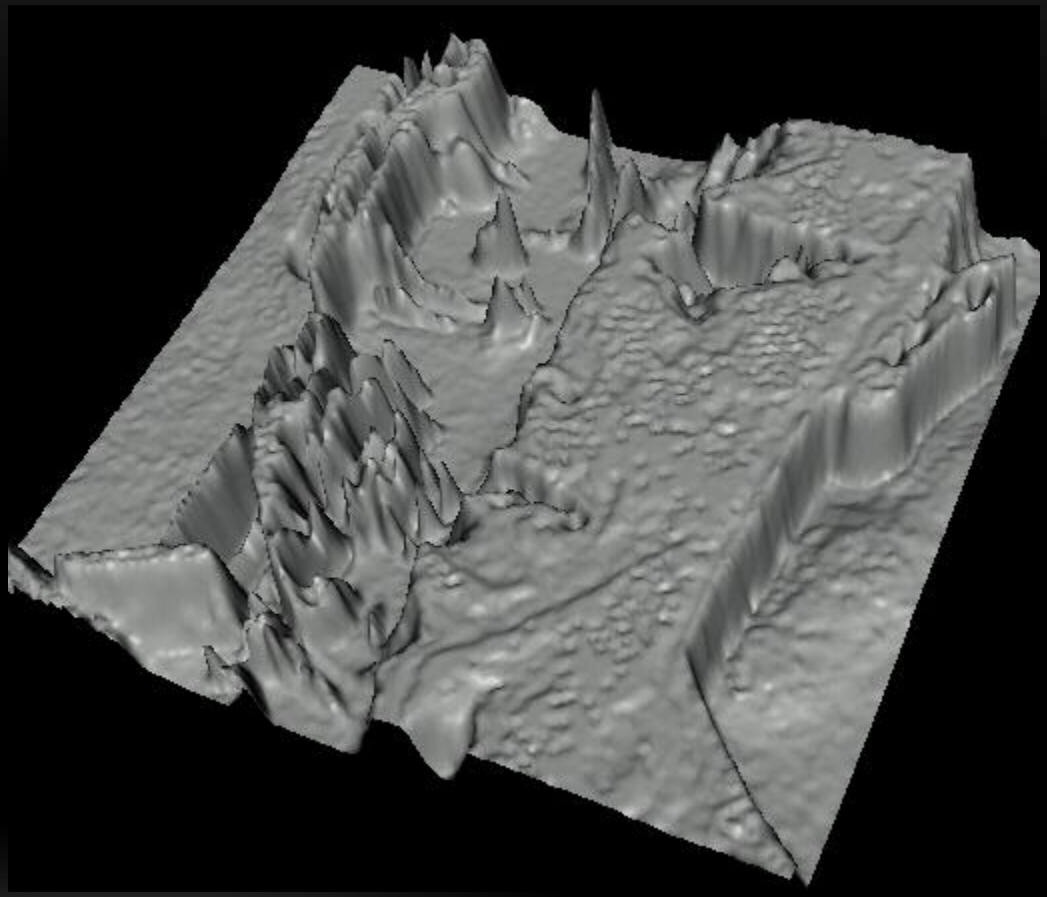
GUIDED IMAGE FILTER（导向图滤波）



EDGE DETECTOR（边缘检测）

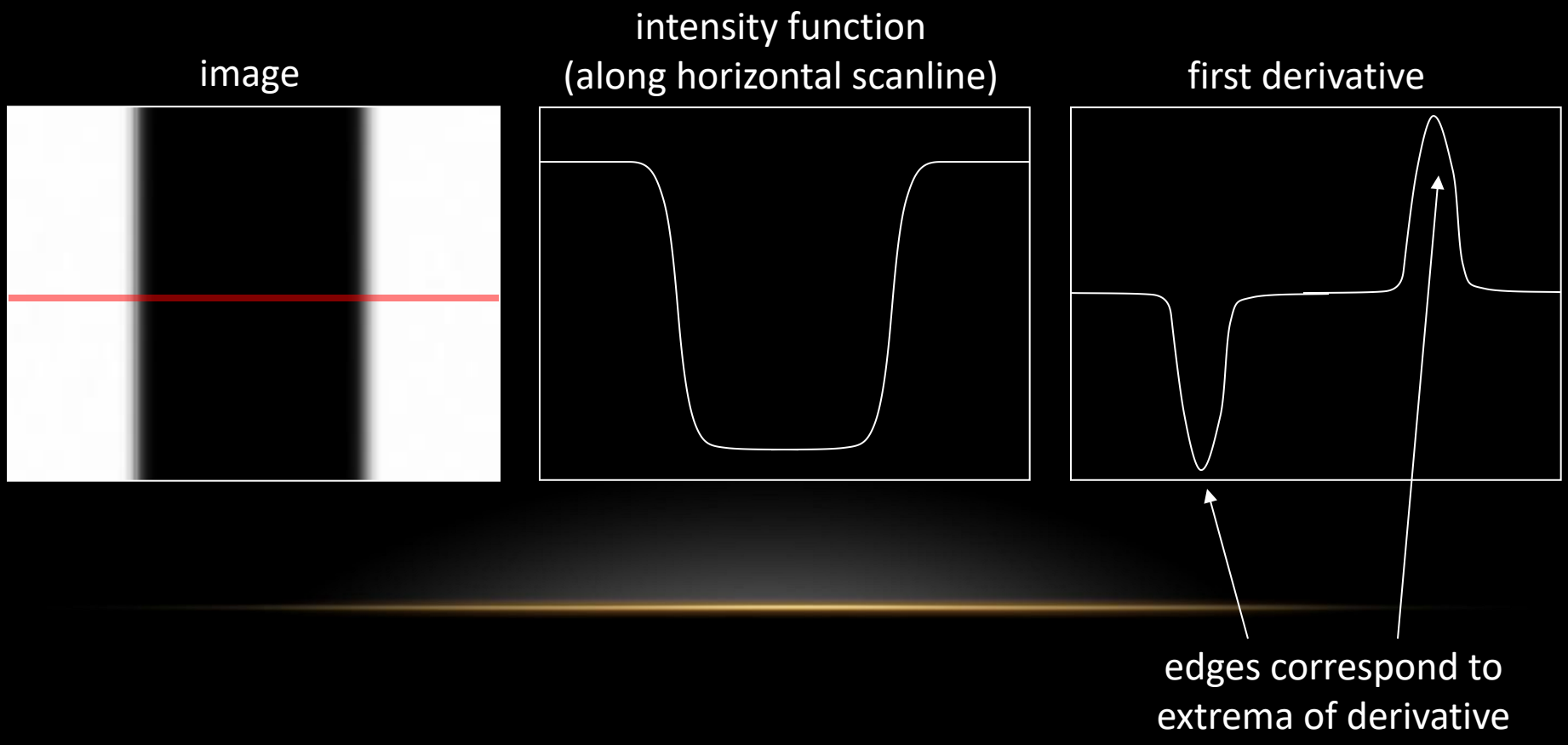






EDGE

- An edge is a place of *rapid change* in the image intensity function

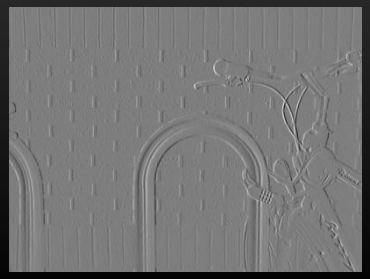
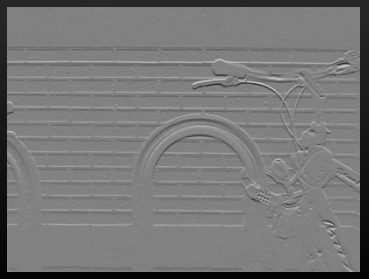


THE SOBEL OPERATOR

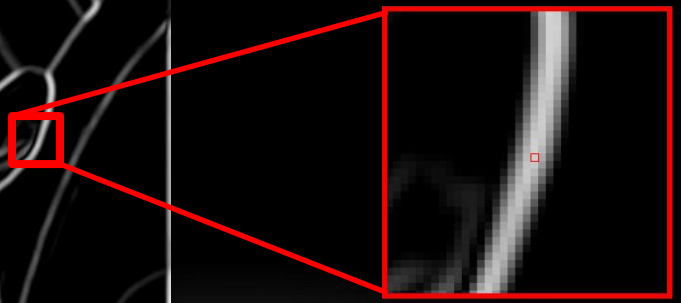
- The standard defn. of the Sobel operator omits the 1/8 term
  - doesn't make a difference for edge detection
  - the 1/8 term **is** needed to get the right gradient magnitude

$$\frac{1}{8}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad s_x$$

$$\frac{1}{8}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad s_y$$

Source: Wikipedia



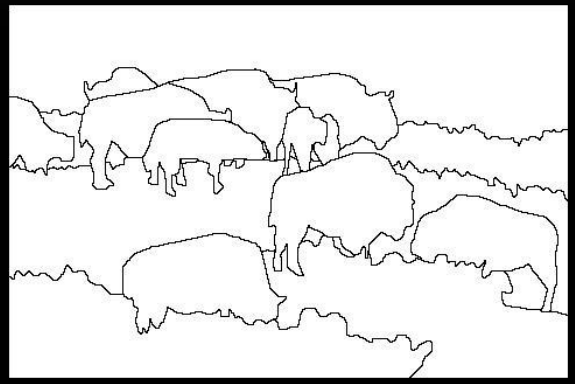
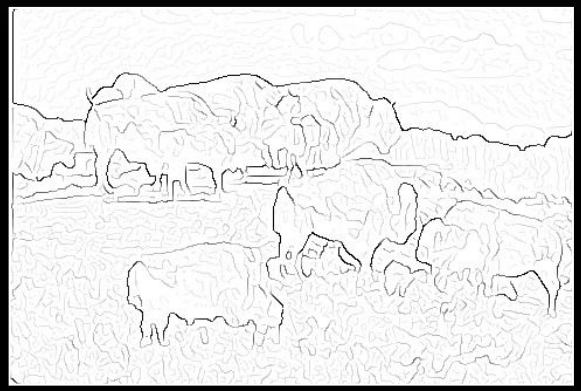
where is the edge?

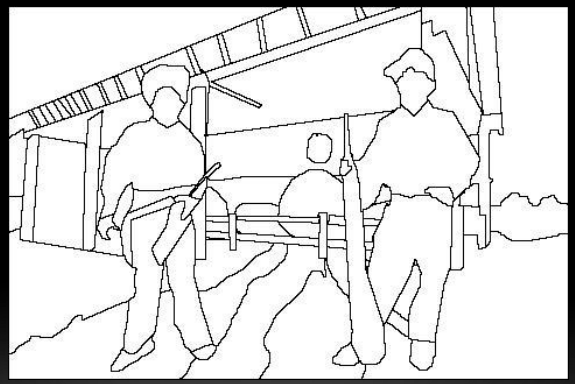
CANNY EDGE DETECTOR

- Good Detection, Localization
- Single Response（清晰的边界线）

简单的边缘检测远远不够

image | human segmentation | gradient magnitude


OPENCV EXAMPLES

- 上述方法均存在对应函数
- 作业
  - 使用OpenCV函数实现各种滤波计算
  - 根据方法思想实现对像素操作，完成上述滤波方法