Edge and Blob Detection by Image Filtering
Related to Chapters 3 and 4

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Examples 1

0	0	0
0	1	0
0	0	0

1/9 *

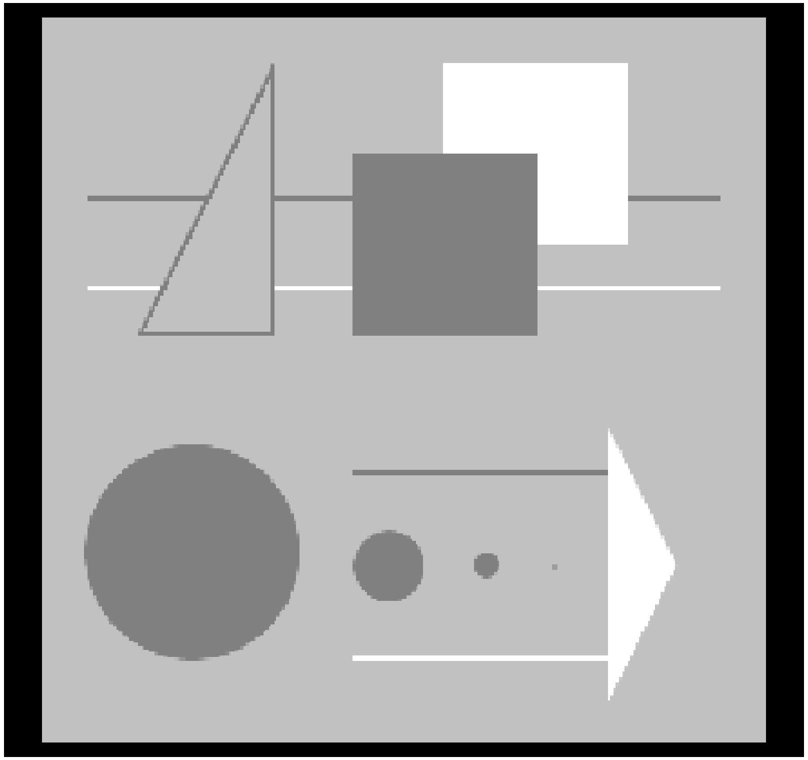
1	1	1
1	1	1
1	1	1

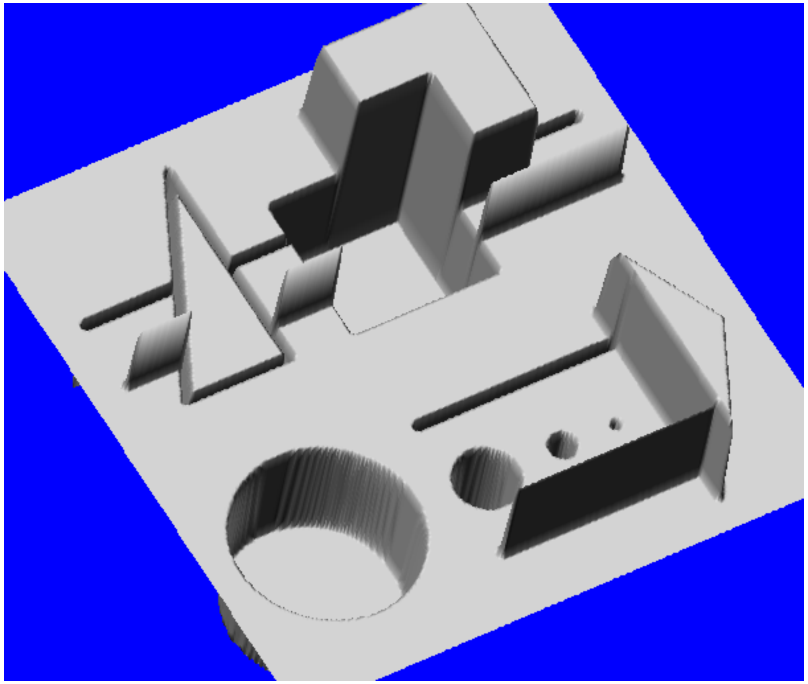
Examples 2

$$1/9 * \begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

$$1/25 * \begin{matrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{matrix}$$

Digital Images: Boundaries are “Lines” or “Discontinuities”





Example: Characterization of discontinuities?

Derivatives: Finite Differences

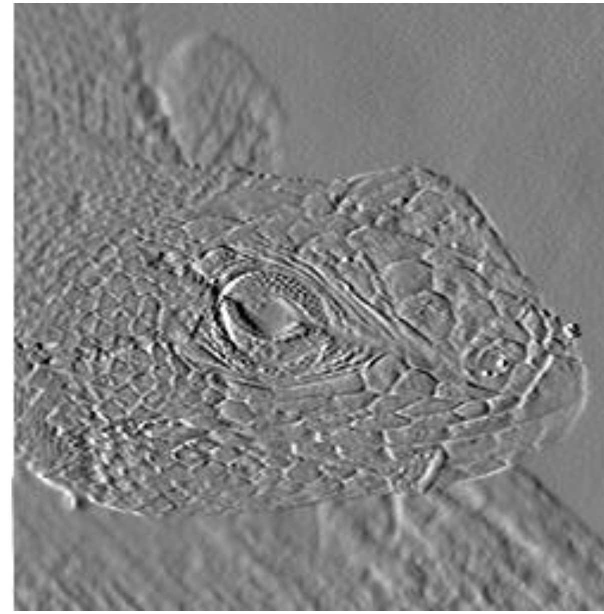
$$\frac{\partial f}{\partial x} \approx \frac{1}{2h} \left(f(x+1, y) - f(x-1, y) \right)$$

$$\frac{\partial f}{\partial x} \approx w_{dx} \circ f \qquad w_{dx} = \begin{array}{|c|c|c|} \hline -\frac{1}{2} & 0 & \frac{1}{2} \\ \hline \end{array}$$

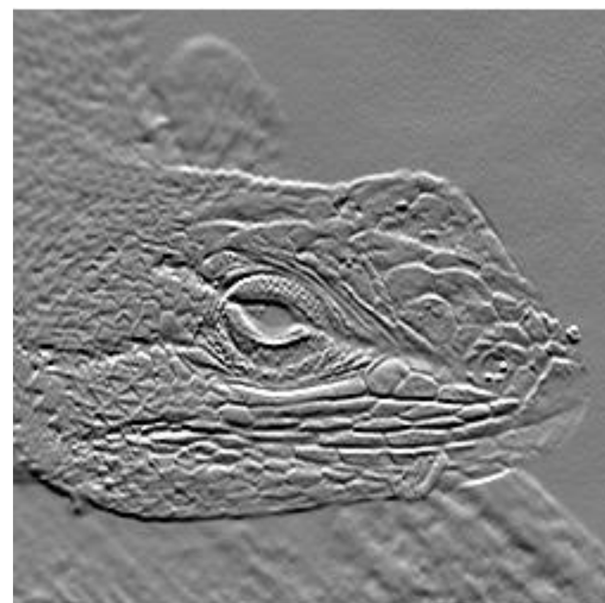
$$\frac{\partial f}{\partial y} \approx w_{dy} \circ f \qquad w_{dy} = \begin{array}{|c|} \hline -\frac{1}{2} \\ \hline 0 \\ \hline \frac{1}{2} \\ \hline \end{array}$$

Derivative Example

$$\begin{matrix} 0 & 0 & 0 \\ -1 & 0 & 1 \\ 0 & 0 & 0 \end{matrix}$$

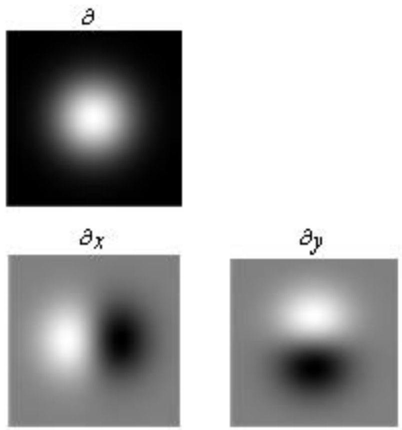


$$\begin{matrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{matrix}$$



Univ of Utah, CS6640 2010

2D Edge Filter: Output at different scales



1st order Gaussian Derivatives

Gradient Magnitude ($\sqrt{\frac{\partial I}{\partial x}^2 + \frac{\partial I}{\partial x}^2}$)

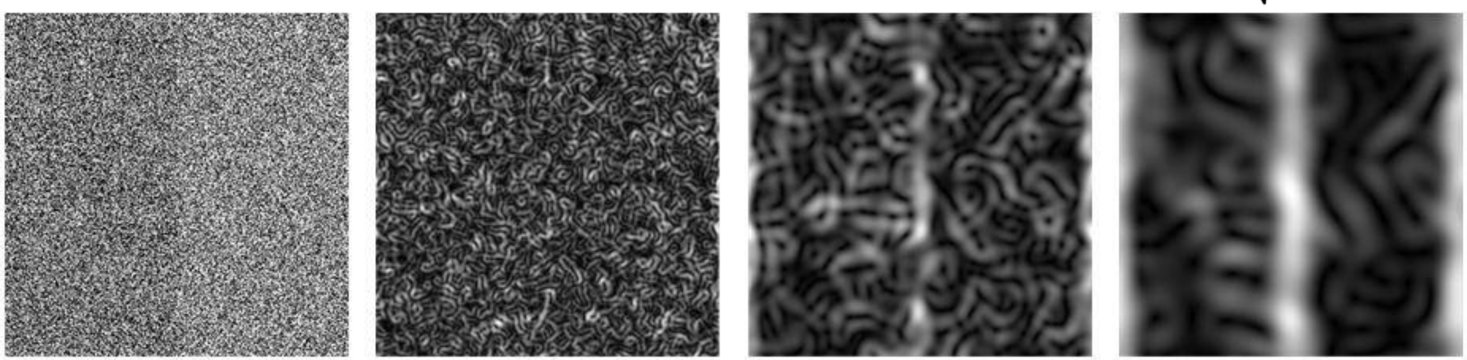
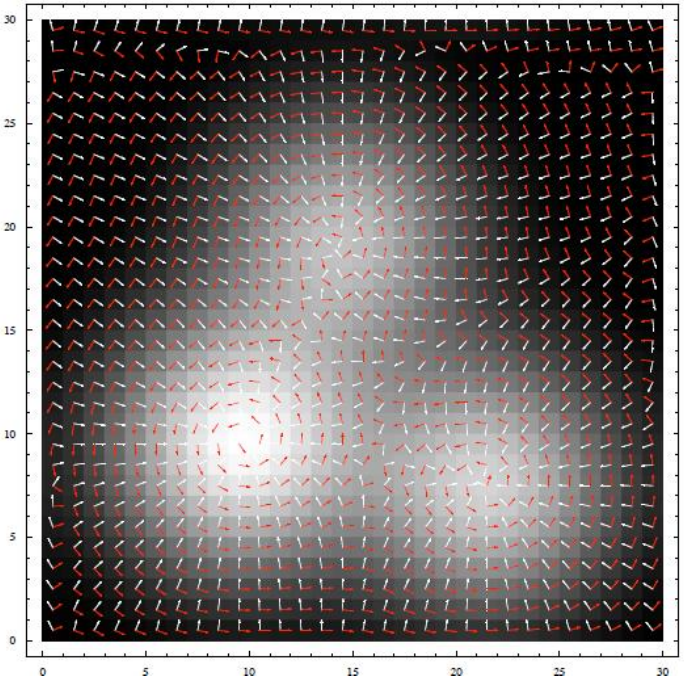


Figure 5.11 Detection of a very low contrast step-edge in noise. Left: original image, the step-edge is barely visible. At small scales (second image, $\sigma = 2$ pixels) the edge is not detected. We see the edges of the noise itself, cluttering the edge of the step-edge. Only at large scale (right, $\sigma = 12$ pixels) the edge is clearly found. At this scale the large scale structure of the edge emerges from the small scale structure of the noise.

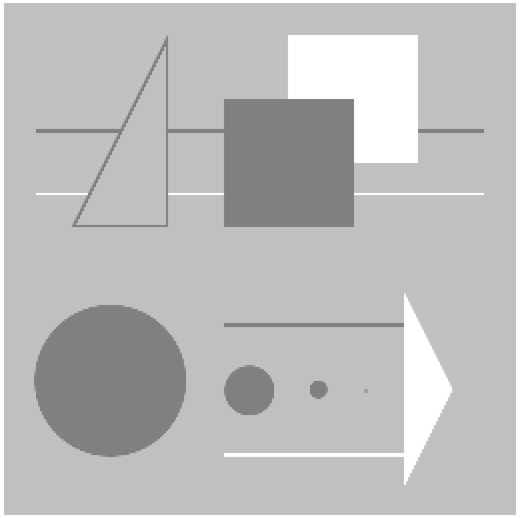
Response at different scales

Figure 5.11 Gradient edges detected at different scales ($\sigma = 0.5, 2, 5$ pixels resp.). '
coarser edges (right) indicate hierarchically more 'important' edges.

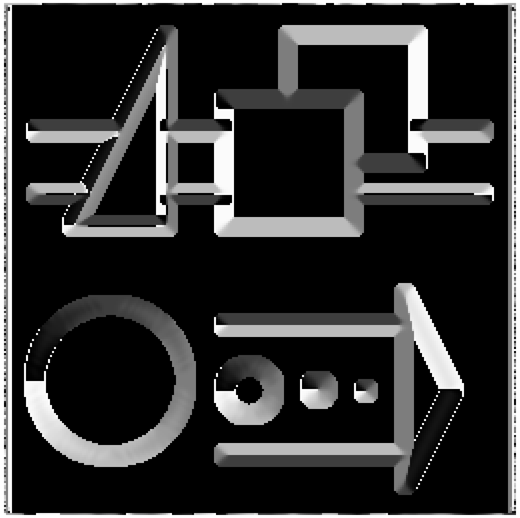
What about 2D?



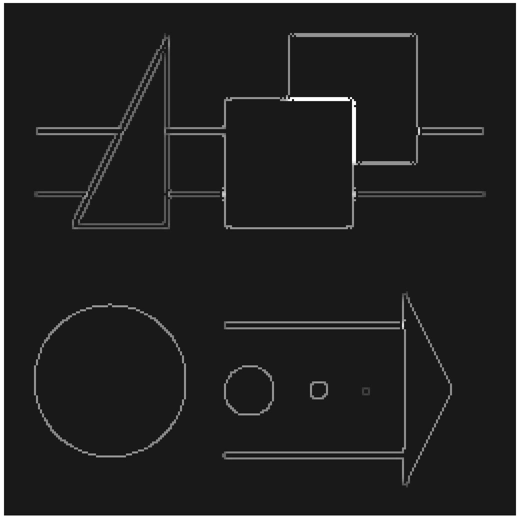
At every position in the edge-magnitude output, there is a coordinate system with normal and tangent.



original



edge orientation



edge positions coded by edge magnitude

Blob Detection for Point Features: Laplacian

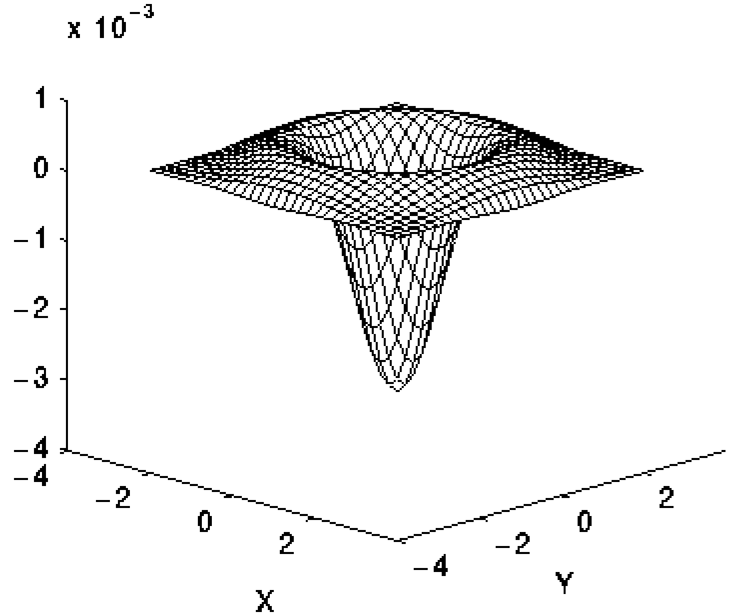
0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Local kernels

Laplacian of Gaussian LoG:

- Apply Laplacian at different image scales (images smoothed by Gaussian filtering).
- Implementation:
    - Smooth images by Gaussian with scale σ.
    - Apply 3x3 Laplacian kernel.



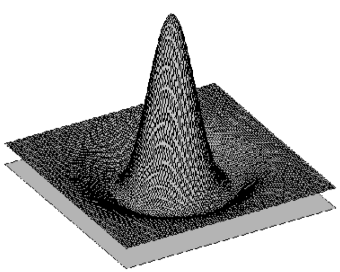
$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1-\frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Laplacian of 2D Gaussian kernel

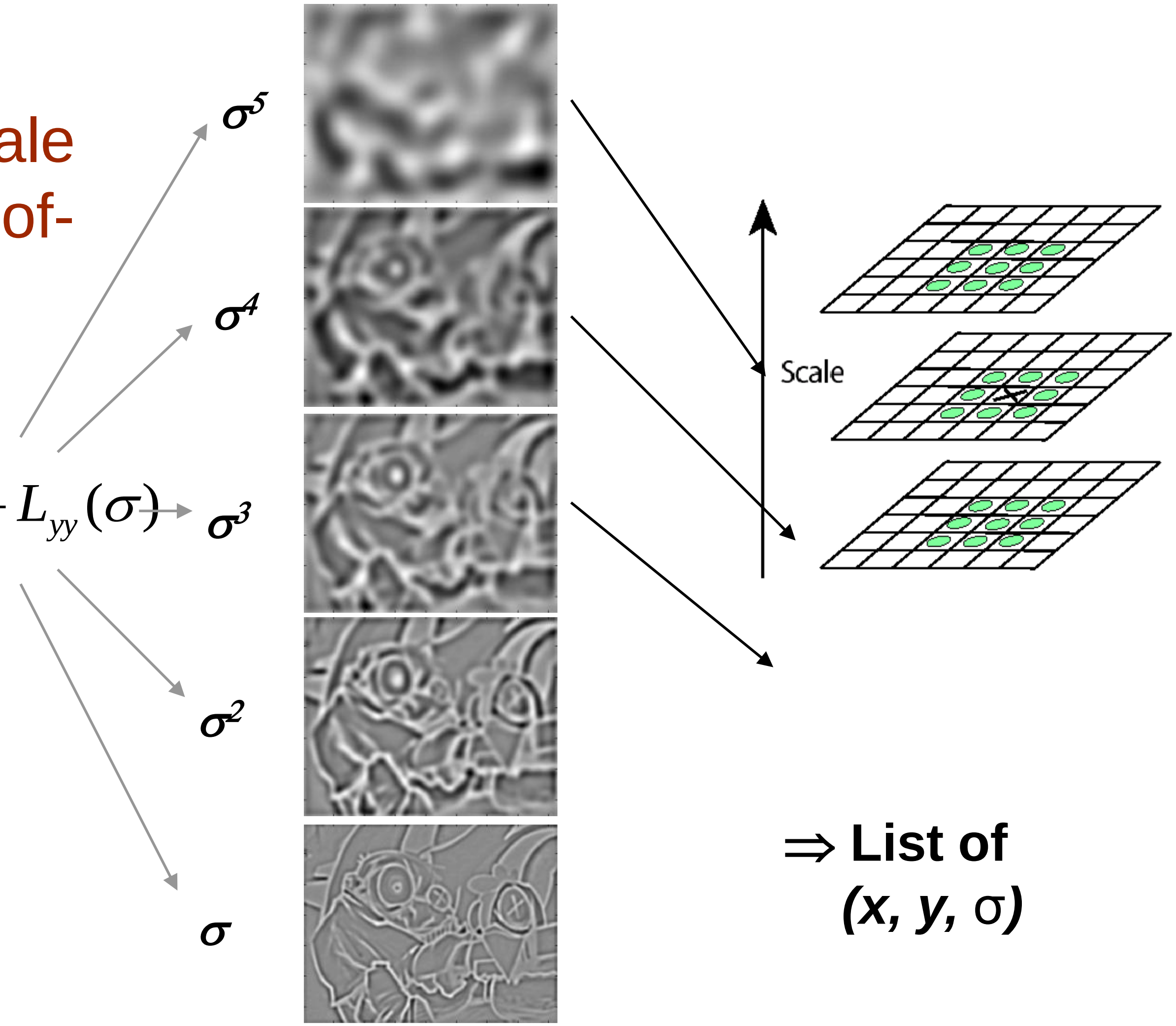
Laplacian-of-Gaussian (LoG)

- Interest points:

  Local maxima in scale space of Laplacian-of-Gaussian



$$L_{xx}(\sigma) + L_{yy}(\sigma)$$



⇒ List of *(x, y,* σ*)*

K. Grauman, B. Leibe

Scale-space blob detector: Example

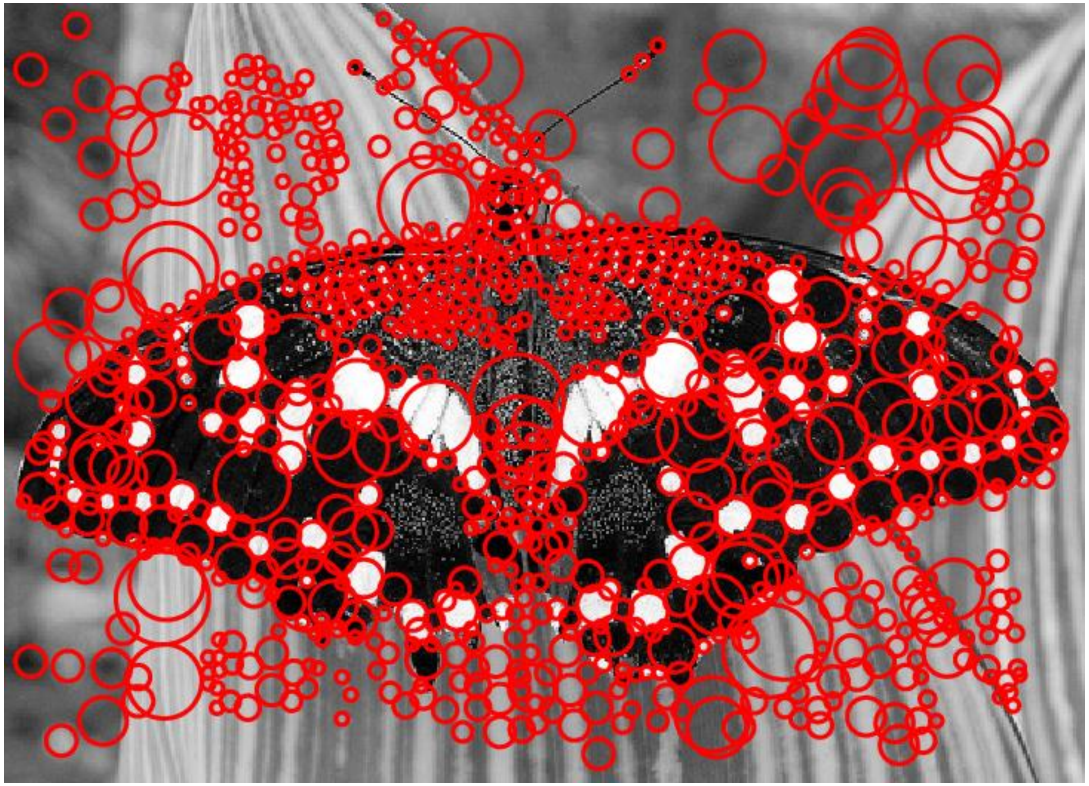
Source: Lana Lazebnik

Scale-space blob detector: Example

sigma = 11.9912

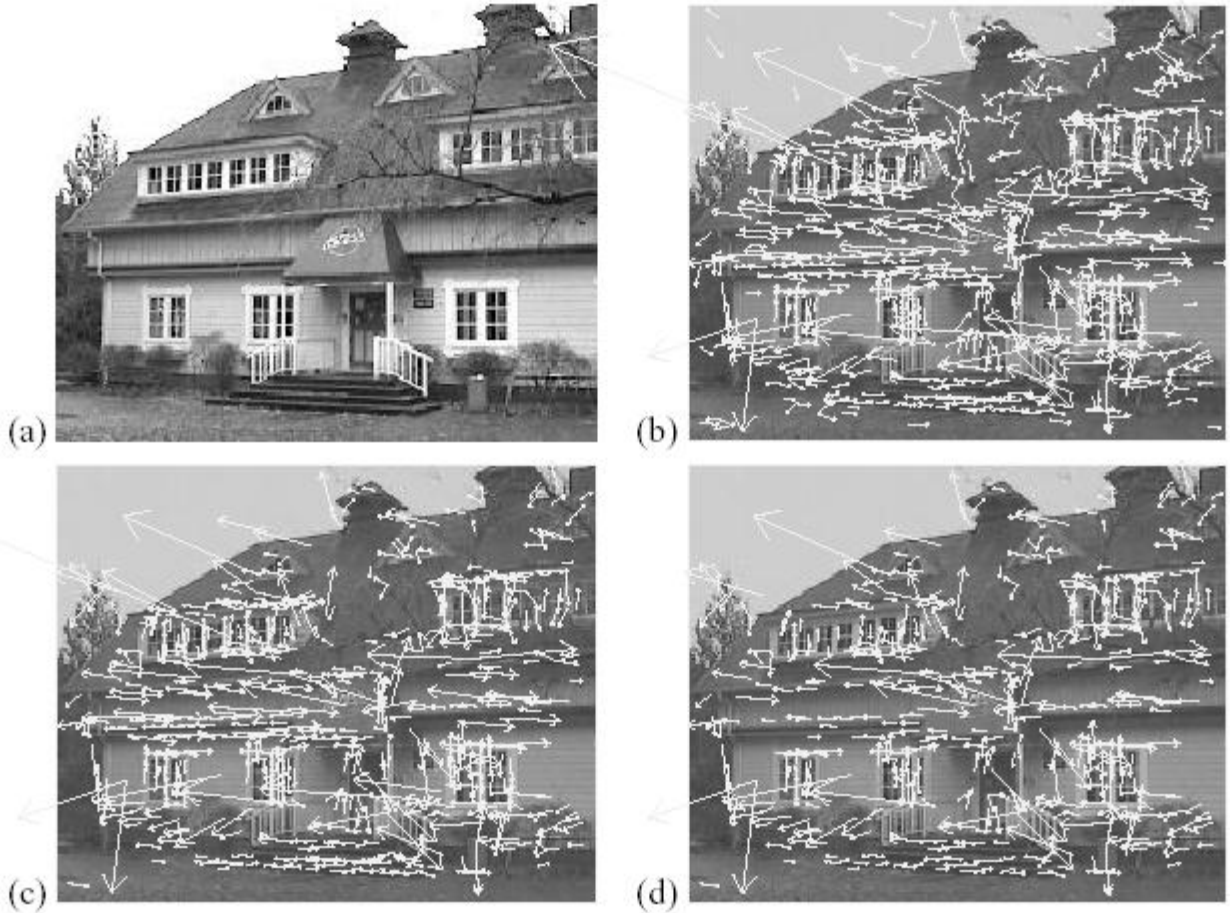
Source: Lana Lazebnik

Scale-space blob detector: Example



Source: Lana Lazebnik

Example of keypoint detection



(a) 233x189 image
(b) 832 DOG extrema
(c) 729 left after peak value threshold
(d) 536 left after testing ratio of principle curvatures (removing edge responses)