



COMPUTER VISION

Describing Interesting Points

Le Thanh Ha, Ph.D

Assoc. Prof. at University of Engineering and Technology,
Vietnam National University

ltha@vnu.edu.vn; lthavnu@gmail.com; 0983 692 592



- Scale and Rotation selection
- SIFT descriptor
- Texture descriptor

THIS CLASS

Automatic Scale Selection

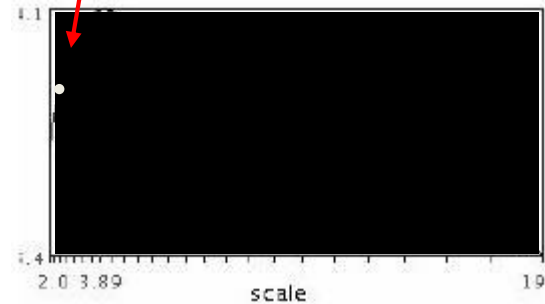


$$f(I_{i_1 \dots i_m}(x, \sigma)) = f(I_{i_1 \dots i_m}(x', \sigma'))$$

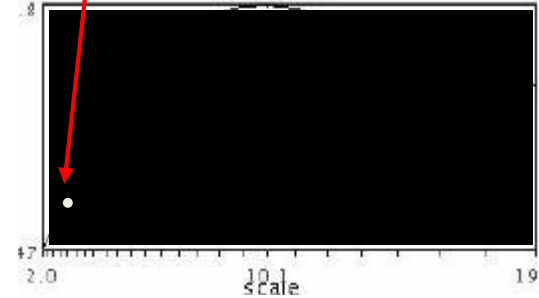
How to find corresponding patch sizes?

Automatic Scale Selection

- Function rescaled to unit interval (scale signature)



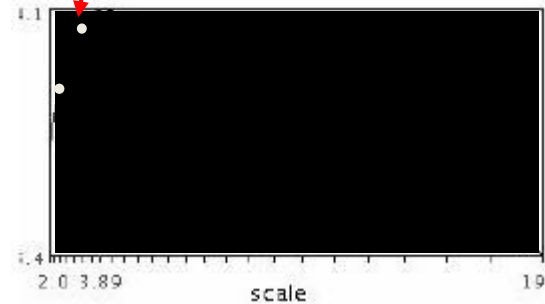
$$f(I_{i_1...i_m}(x, \sigma))$$



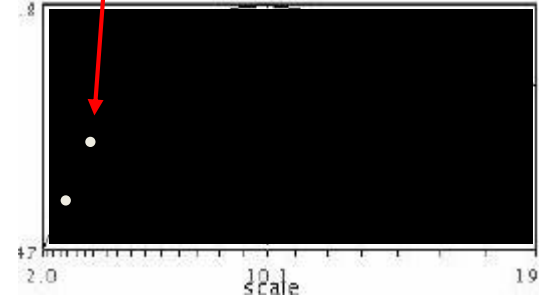
$$f(I_{i_1...i_m}(x', \sigma))$$

Automatic Scale Selection

- Function rescaled to unit interval (scale signature)



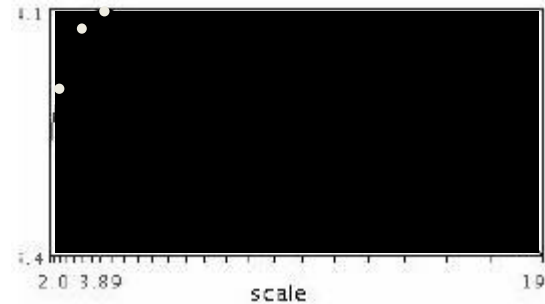
$$f(I_{i_1...i_m}(x, \sigma))$$



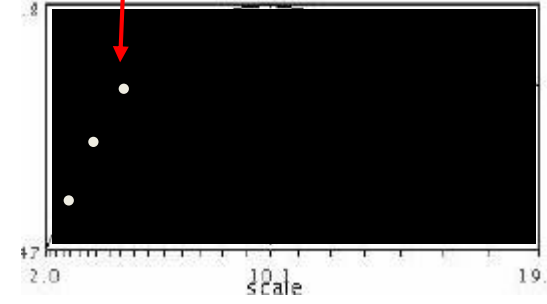
$$f(I_{i_1...i_m}(x', \sigma))$$

Automatic Scale Selection

- Function rescaled to unit interval (scale signature)



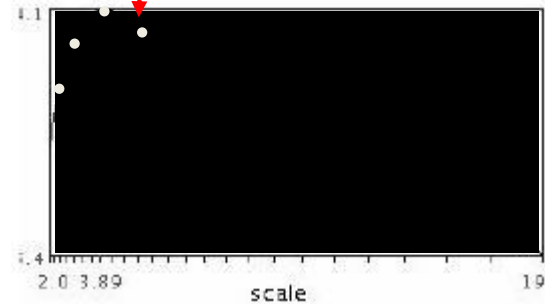
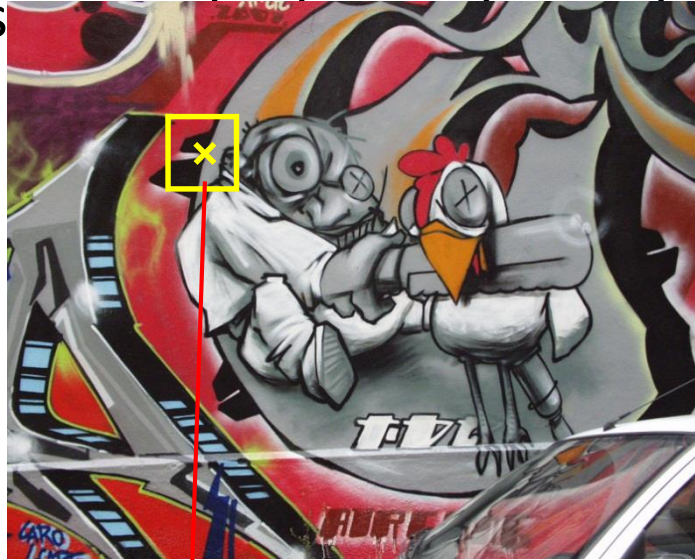
$$f(I_{i_1...i_m}(x, \sigma))$$



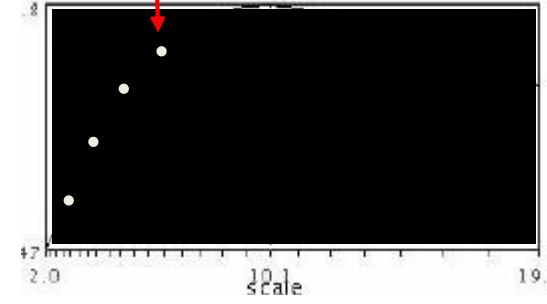
$$f(I_{i_1...i_m}(x', \sigma))$$

Automatic Scale Selection

- Function rescaled to unit interval (scale signature)



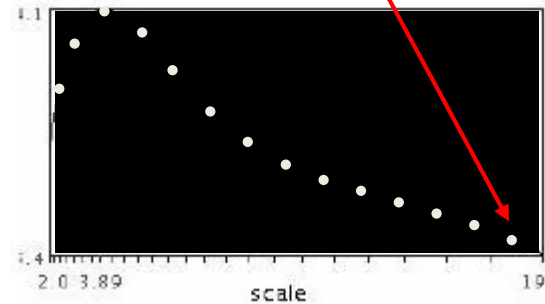
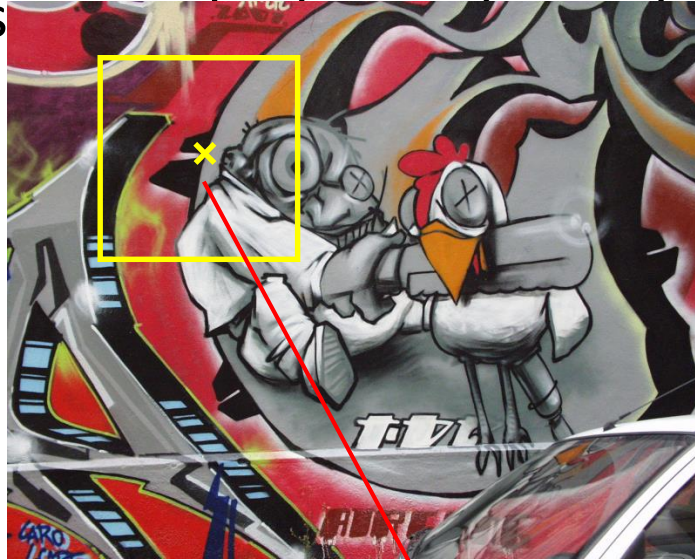
$$f(I_{i_1...i_m}(x, \sigma))$$



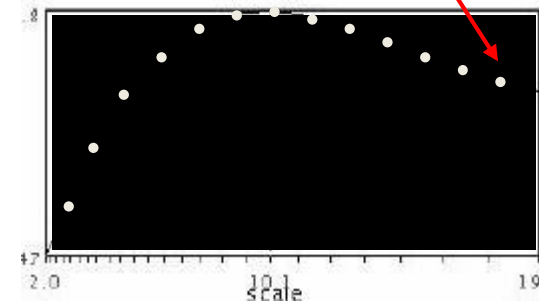
$$f(I_{i_1...i_m}(x', \sigma))$$

Automatic Scale Selection

- Function res (scale si



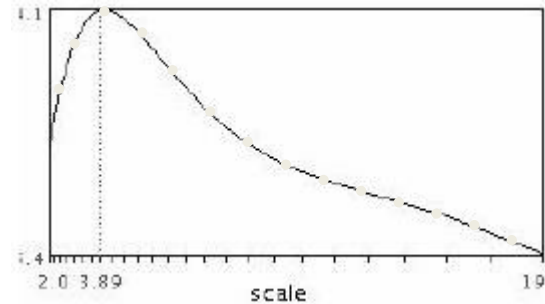
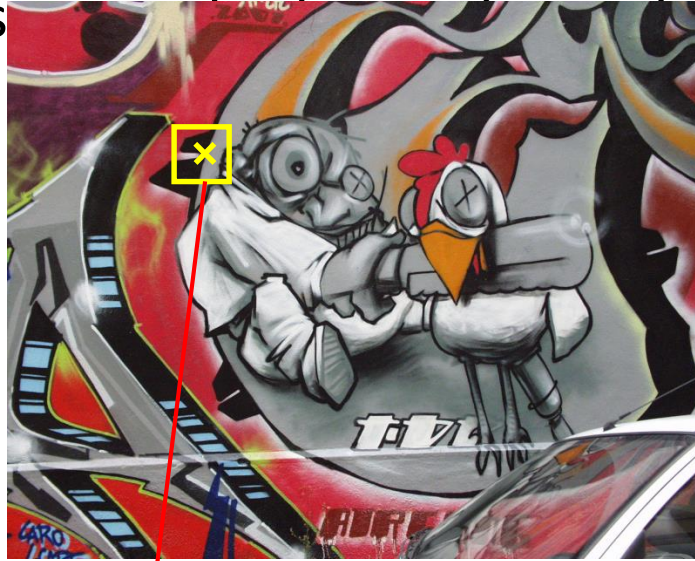
$$f(I_{i_1...i_m}(x, \sigma))$$



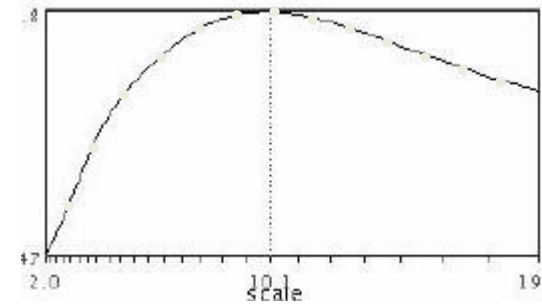
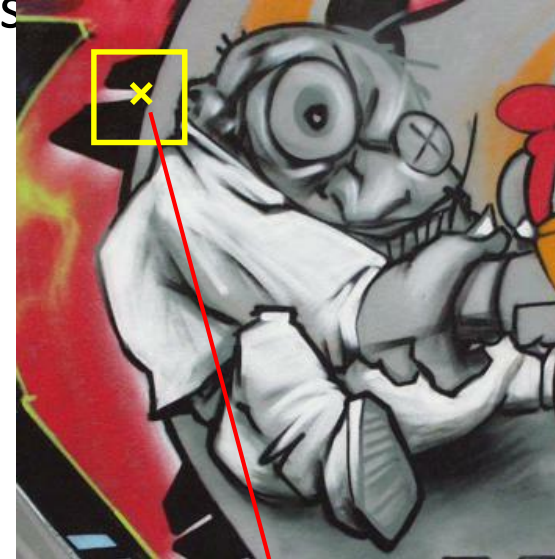
$$f(I_{i_1...i_m}(x', \sigma))$$

Automatic Scale Selection

- Function response $f(I_{i_1 \dots i_m}(x, \sigma))$ (scale signature)



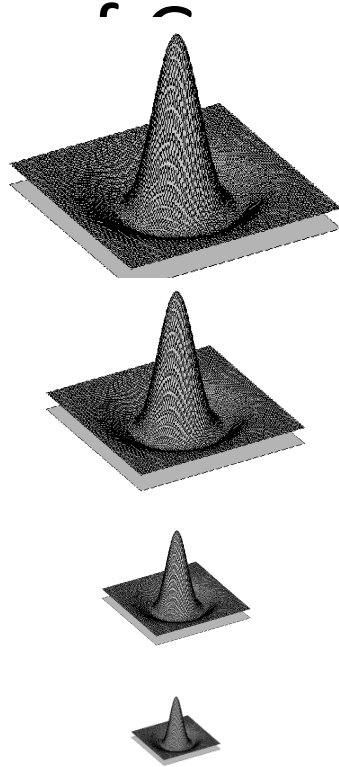
$$f(I_{i_1 \dots i_m}(x, \sigma))$$



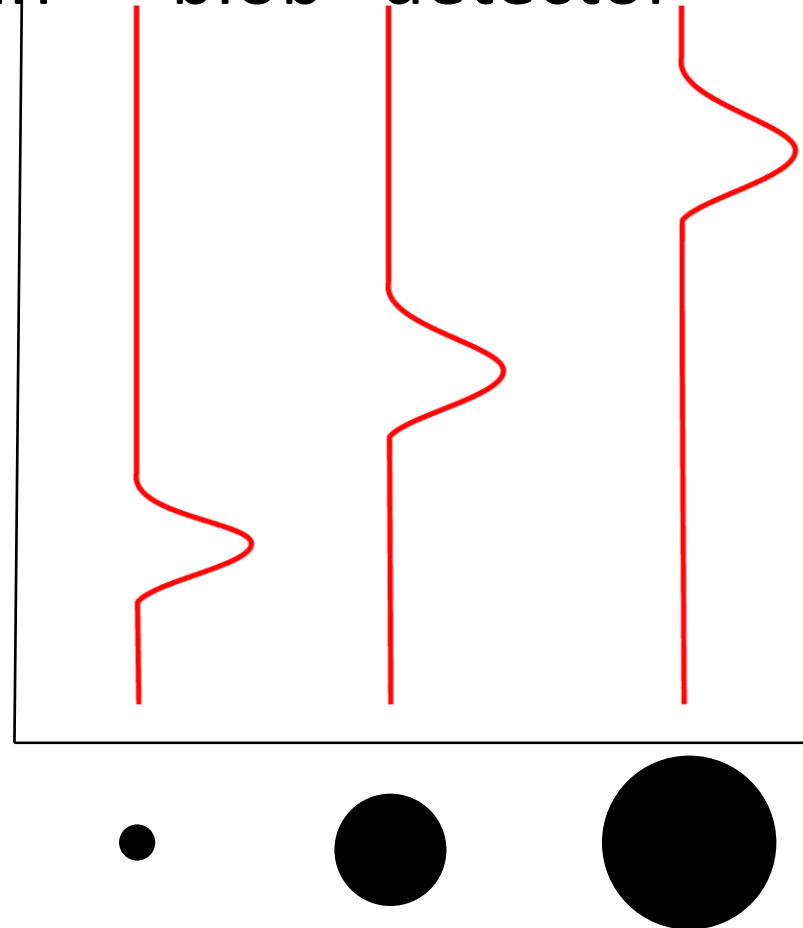
$$f(I_{i_1 \dots i_m}(x', \sigma'))$$

What Is A Useful Signature Function?

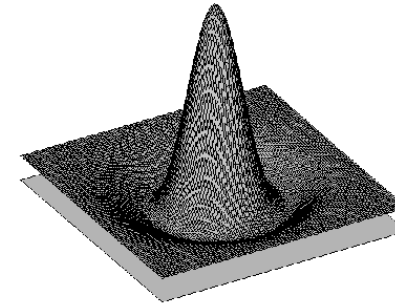
- Difference



ian = “blob” detector

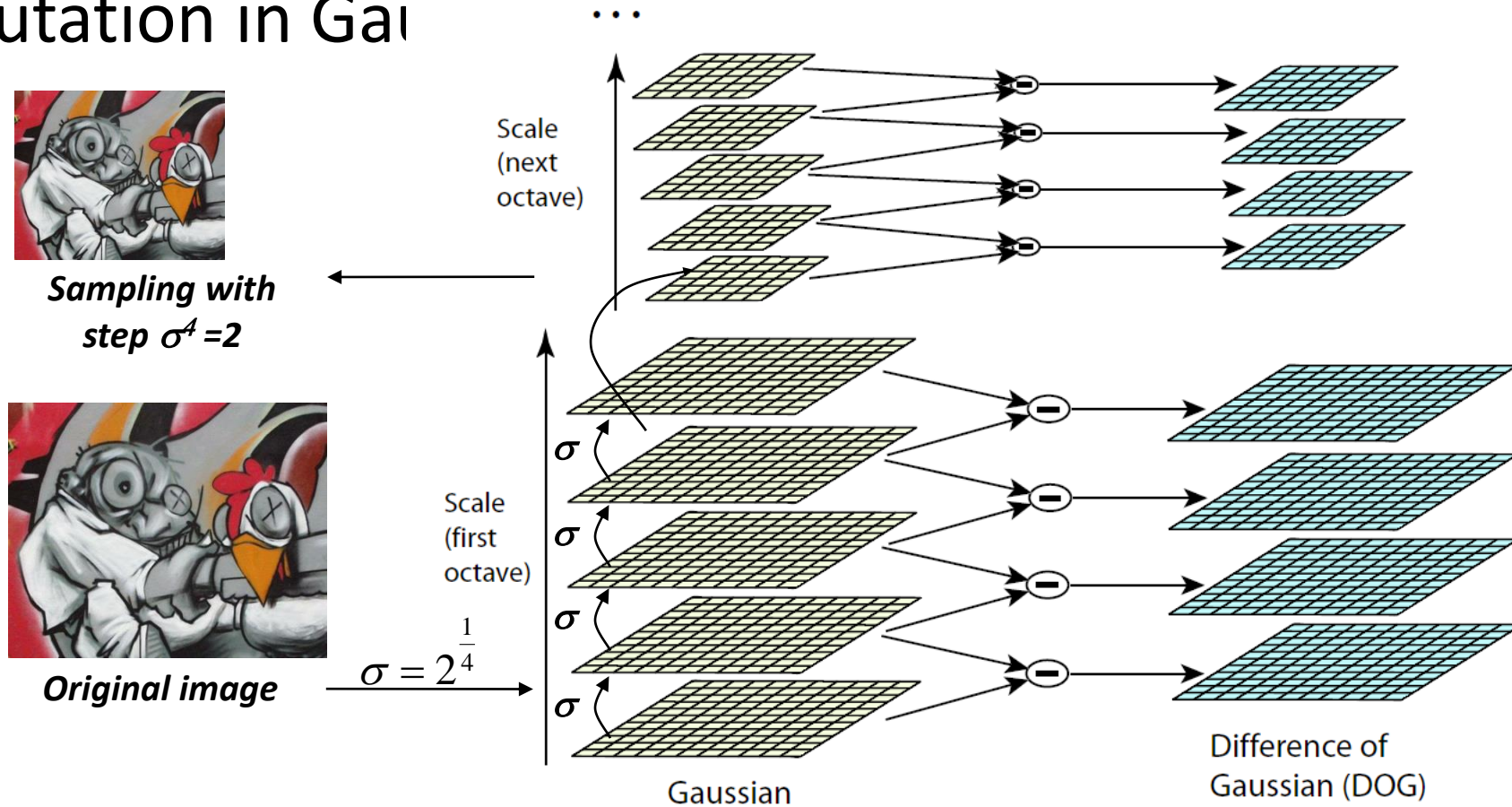


Difference-of-Gaussian (DoG)

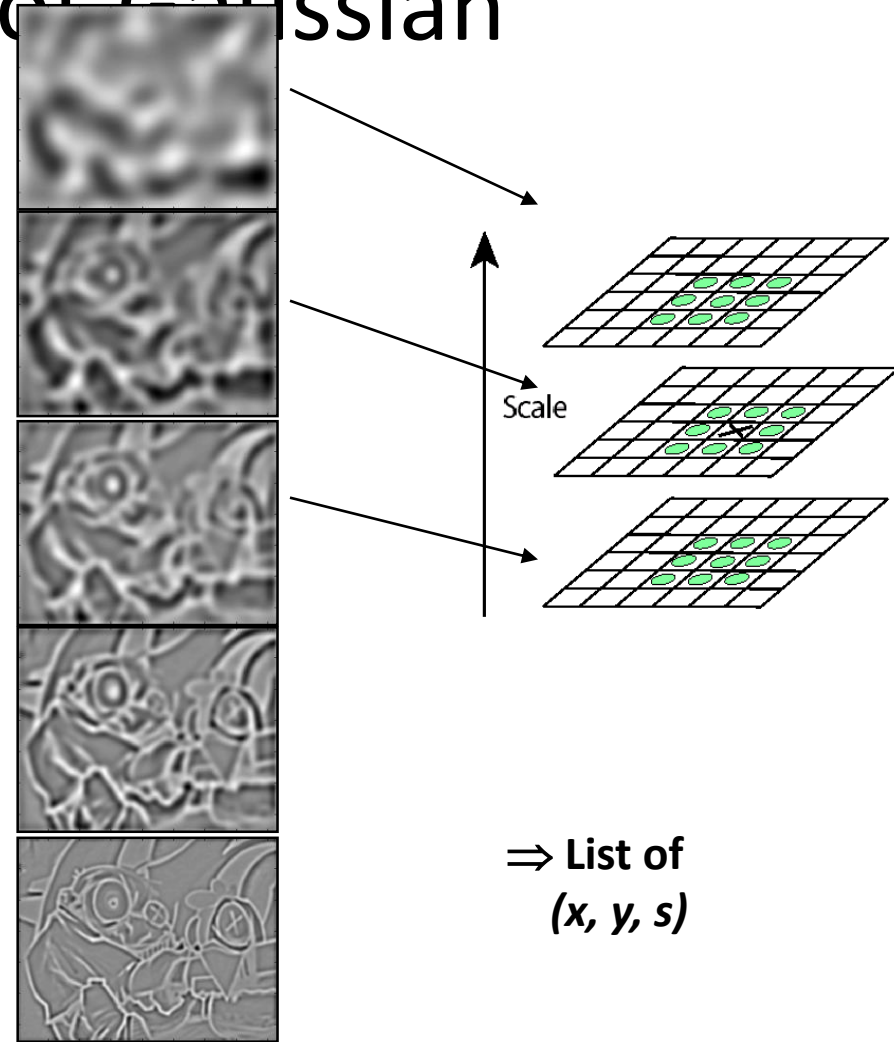
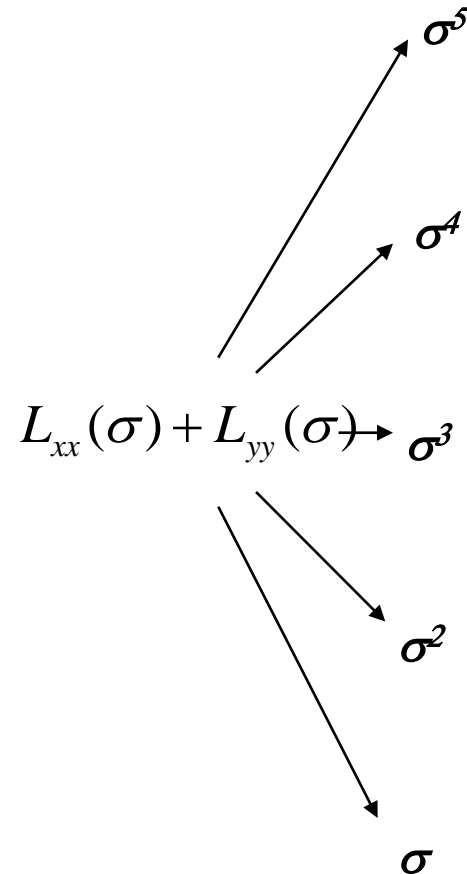
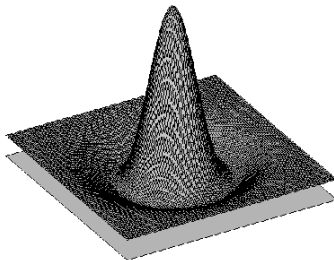


DoG – Efficient Computation

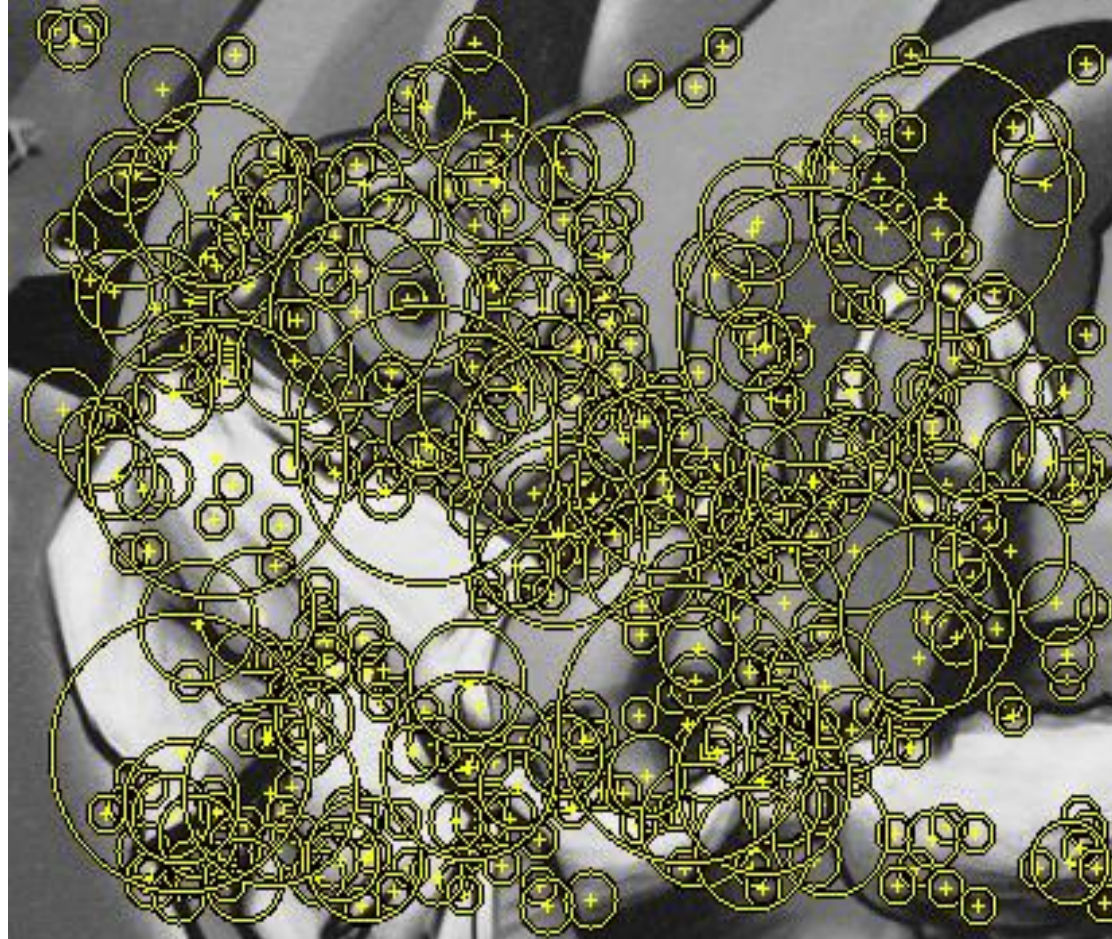
- Computation in Gai



Find local maxima in position-scale space of Difference-of-Gaussian



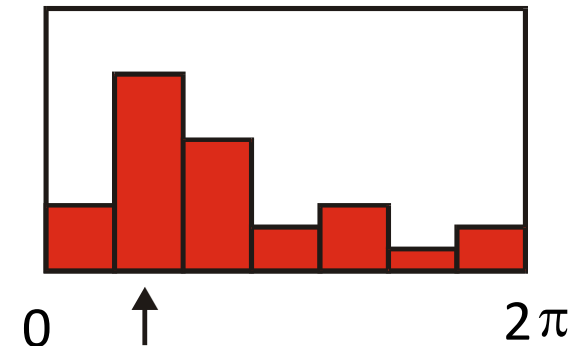
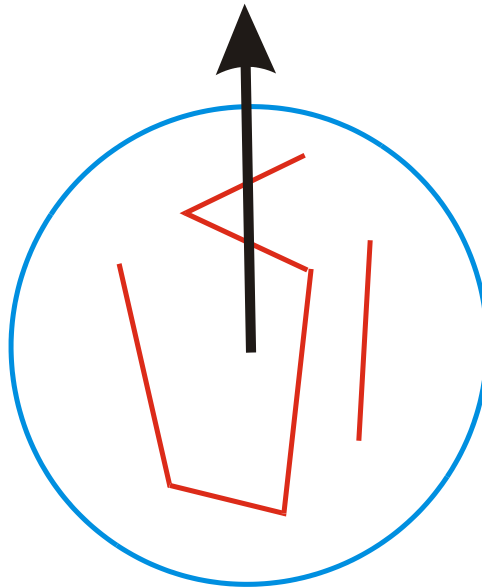
Results: Difference-of-Gaussian



Orientation Normalization

[Lowe, SIFT, 1999]

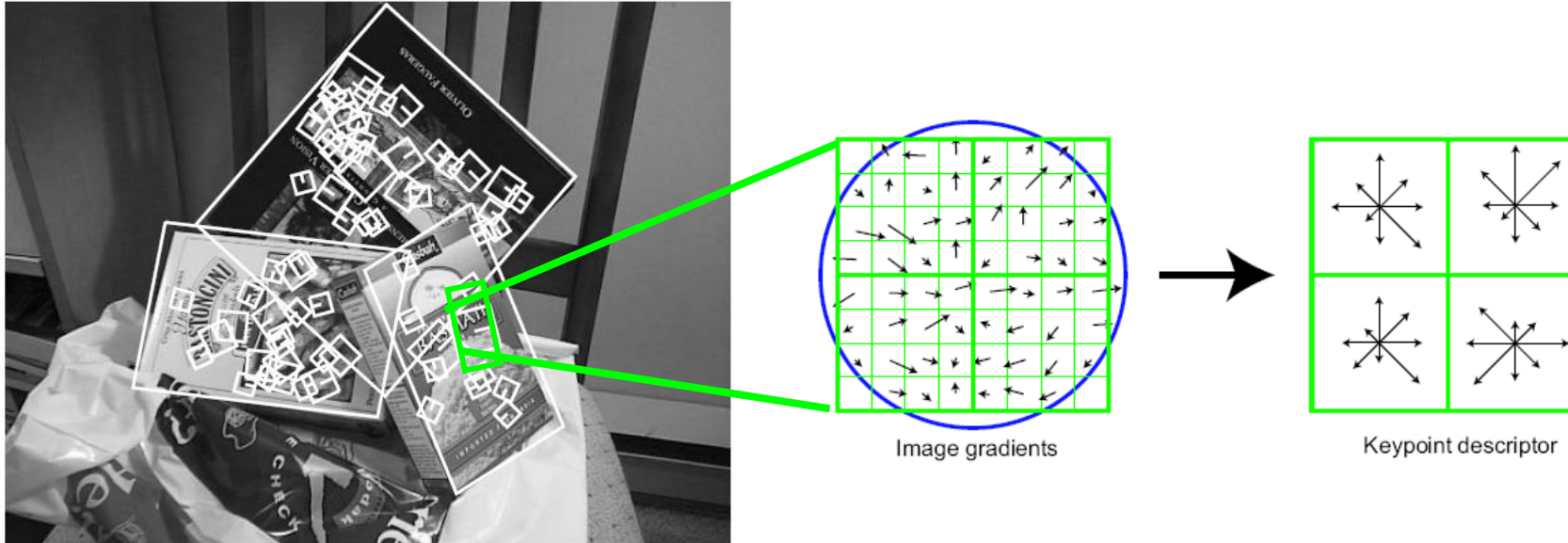
- Compute orientation histogram
- Select dominant orientation
- Normalize: rotate to fixed orientation



Local Descriptors

- The ideal descriptor should be
 - Robust
 - Distinctive
 - Compact
 - Efficient
- Most available descriptors focus on edge/gradient information
 - Capture texture information
 - Color rarely used

Local Descriptors: SIFT Descriptor



Histogram of oriented gradients

- Captures important texture information
- Robust to small translations / affine deformations

[Lowe, ICCV 1999]

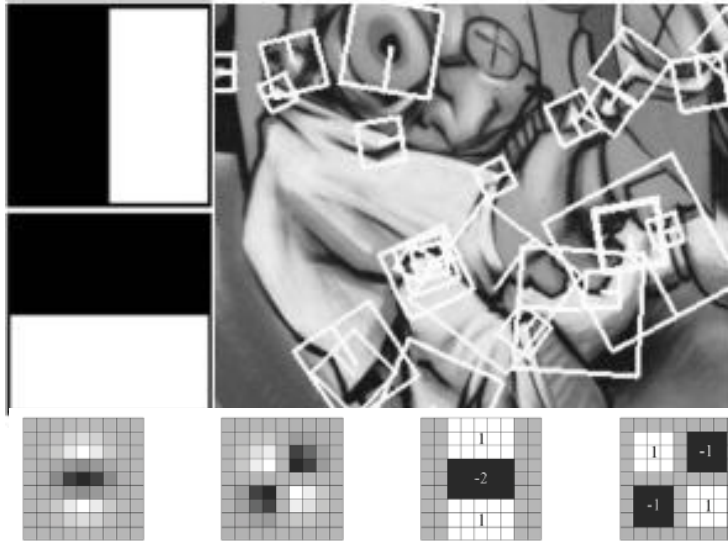
Details of Lowe's SIFT algorithm

- Run DoG detector
 - Find maxima in location/scale space
 - Remove edge points
- Find all major orientations
 - Bin orientations into 36 bin histogram
 - Weight by gradient magnitude
 - Weight by distance to center (Gaussian-weighted mean)
 - Return orientations within 0.8 of peak
 - Use parabola for better orientation fit
- For each (x,y,scale,orientation), create descriptor:
 - Sample 16x16 gradient mag. and rel. orientation
 - Bin 4x4 samples into 4x4 histograms
 - Threshold values to max of 0.2, divide by L2 norm
 - Final descriptor: 4x4x8 normalized histograms

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

$$\frac{\text{Tr}(\mathbf{H})^2}{\text{Det}(\mathbf{H})} < \frac{(r+1)^2}{r}$$

Local Descriptors: SURF



Fast approximation of SIFT idea

Efficient computation by 2D box filters & integral images

⇒ 6 times faster than SIFT

Equivalent quality for object identification

GPU implementation available

Feature extraction @ 200Hz

(detector + descriptor, 640×480 img)

<http://www.vision.ee.ethz.ch/~surf>

Things to remember

- Keypoint detection: repeatable and distinctive
 - Corners, blobs, stable regions
 - Harris, DoG
- Descriptors: robust and selective
 - spatial histograms of orientation
 - SIFT

