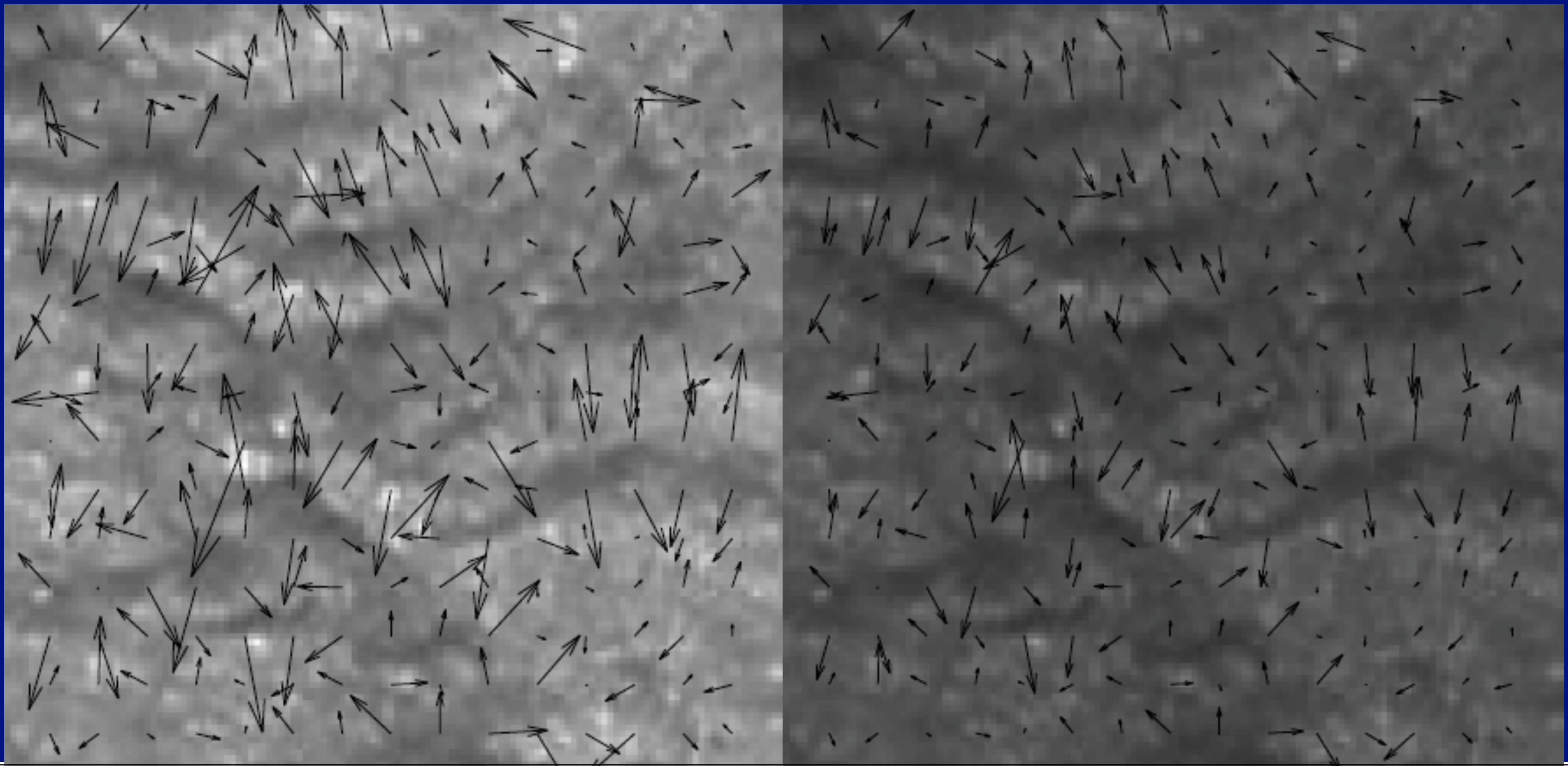
Orientation based descriptions

D.A. Forsyth

Orientation representations

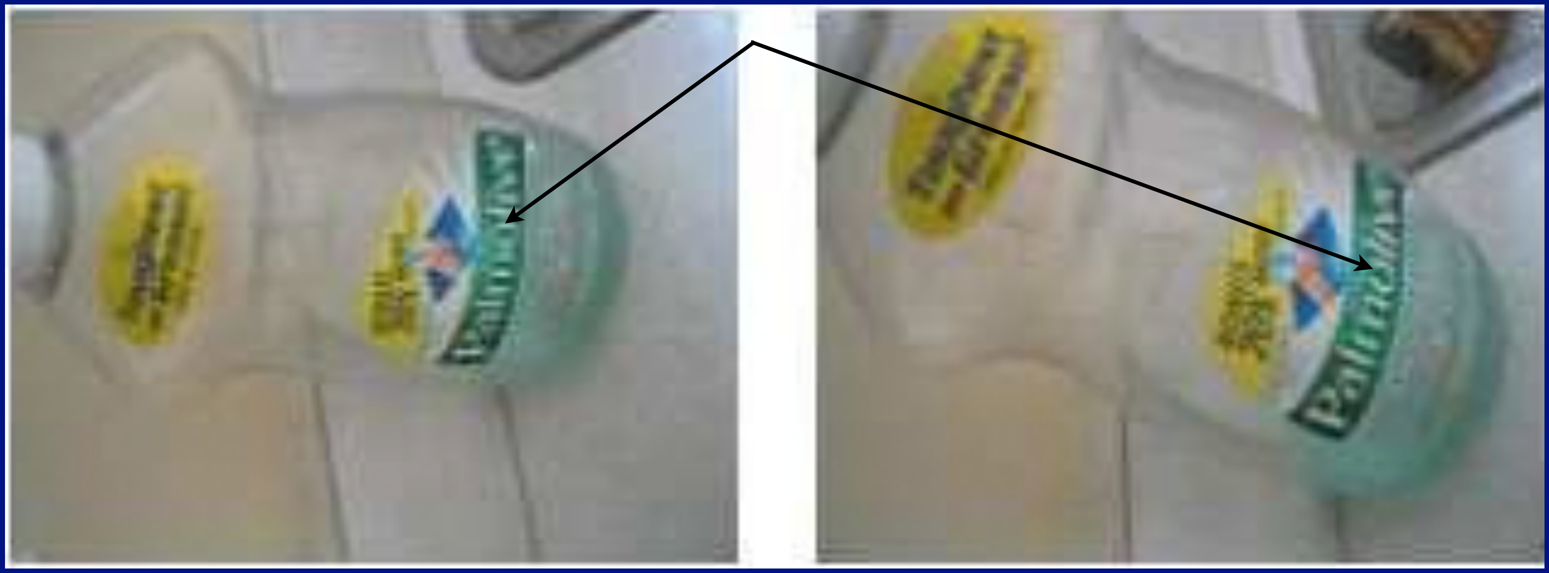
- Gradient magnitude is affected by illumination changes
  - but it’s direction isn’t
- Describe image patches by gradient direction



Orientation representations

- Goal: describe image patch so that
  - similar patches get similar descriptions
  - different patches get different descriptions

- Problem: patches may not be exactly lined up



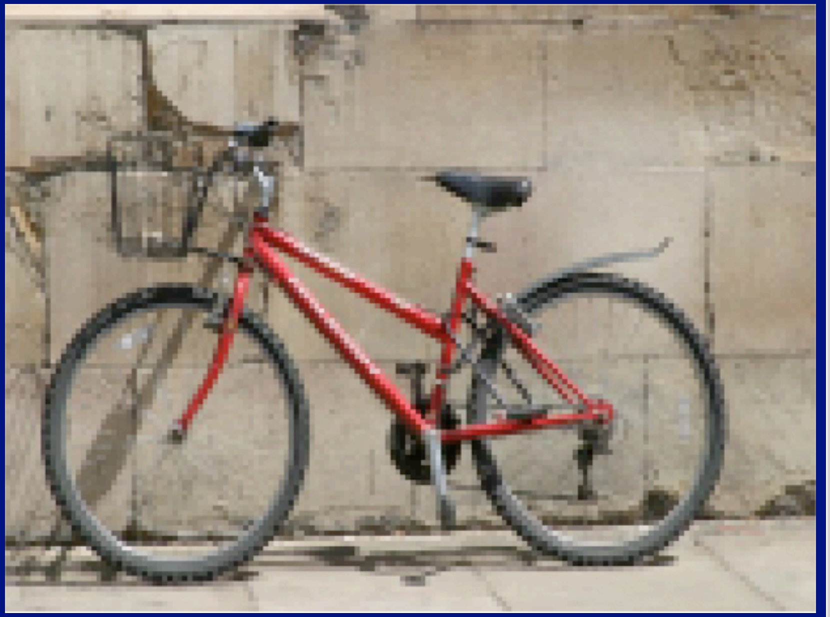
From Nister Stewenius 1996

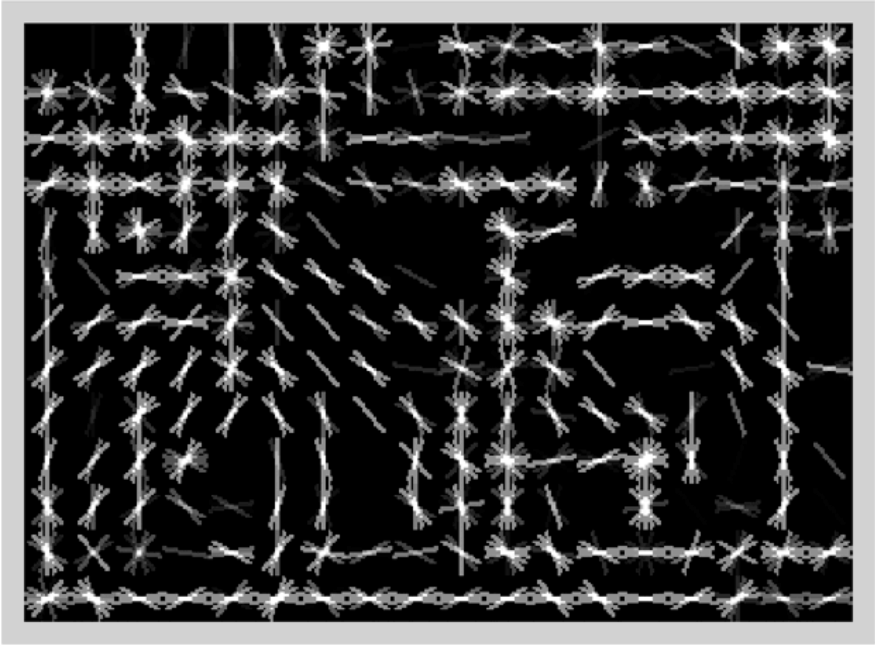
Orientation representations

Histograms of oriented gradients

- Strategy:
  - break patch up into blocks
  - construct histogram representing gradients in that block
    - which won’t change much if the patch moves slightly
- Variants
  - histogram of angles
  - histogram of gradient vectors, length normalized by block averages

Histograms of oriented gradients

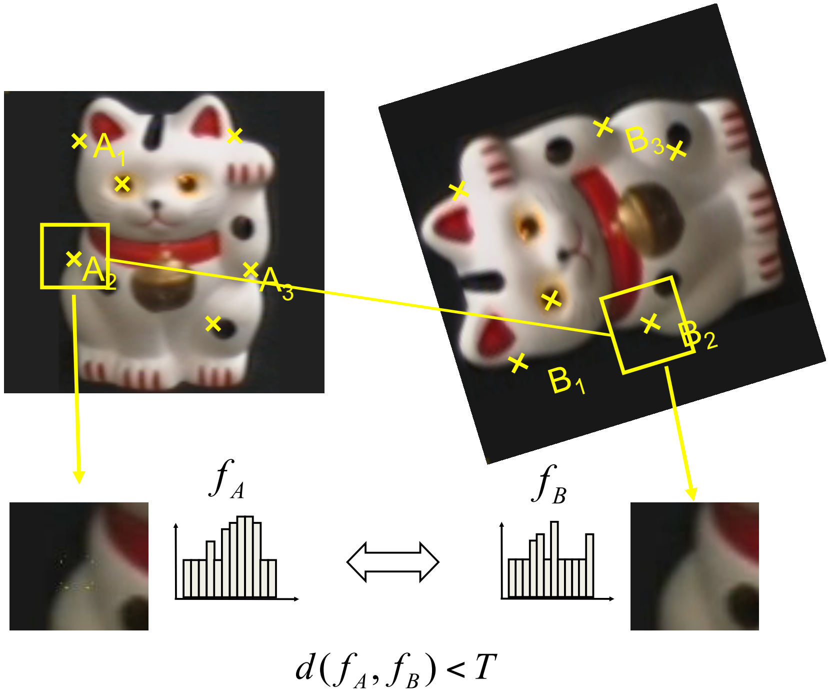




From Deva Ramanan's lake Como slides

Interest points

- Automatic patch construction
  - HOG works if we know the patch
    - but what patches should we use?
      - sliding windows
- We then
  - find patches
  - make descriptions
  - match patches
- Matches for
  - making mosaics
  - spotting near duplicates
  - detection
  - reconstruction



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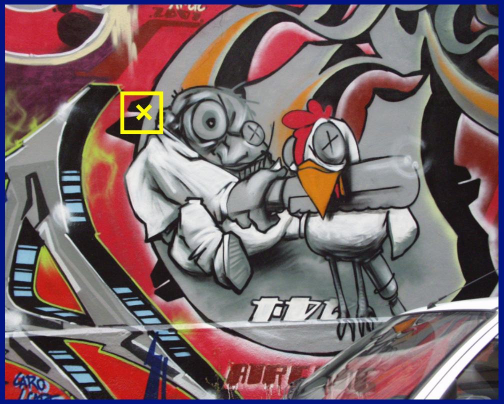
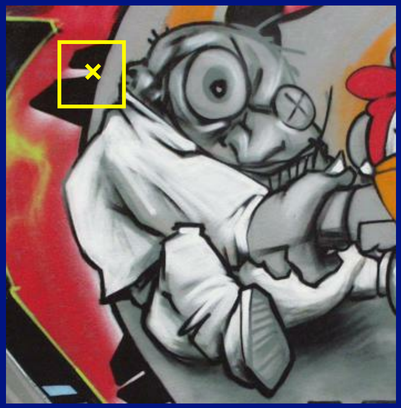
Interest points

- For image, find center/radius of circles “worth describing”
  - these should be “stable”
    - if the image is panned, the centers should pan
    - if the image is scaled, the centers should scale



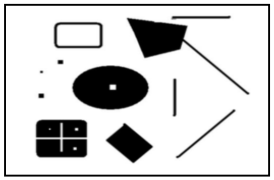


Interest points: locating centers

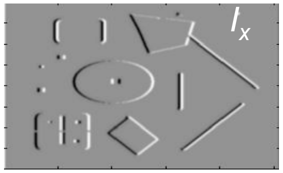
- We use a corner detector (Harris, 88)
  - at a corner there are
    - strong gradients
    - in different directions
- Use second moments of derivatives

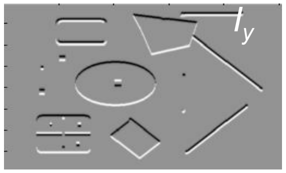
$$\mu(\sigma_I,\sigma_D) = g(\sigma_I) * \begin{bmatrix} I_x^2(\sigma_D) & I_xI_y(\sigma_D) \\ I_xI_y(\sigma_D) & I_y^2(\sigma_D) \end{bmatrix}$$

Interest points: locating centers

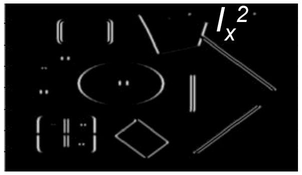


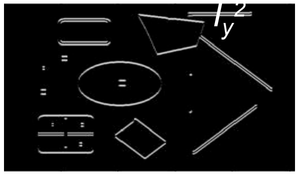
1. Image derivatives

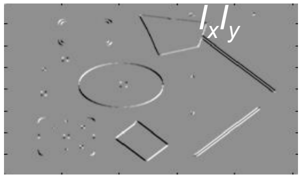




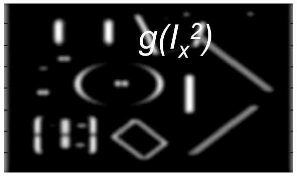
2. Square of derivatives

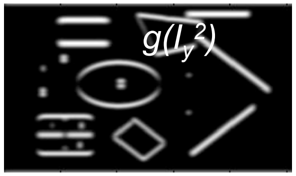


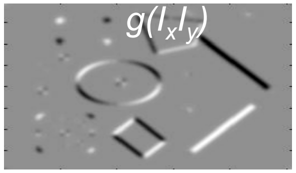




3. Gaussian filter $g(\sigma_I)$

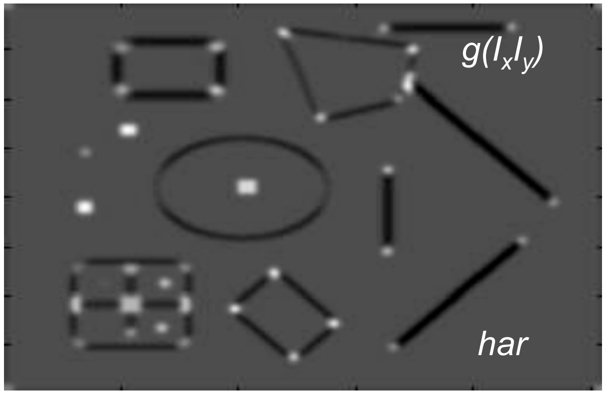




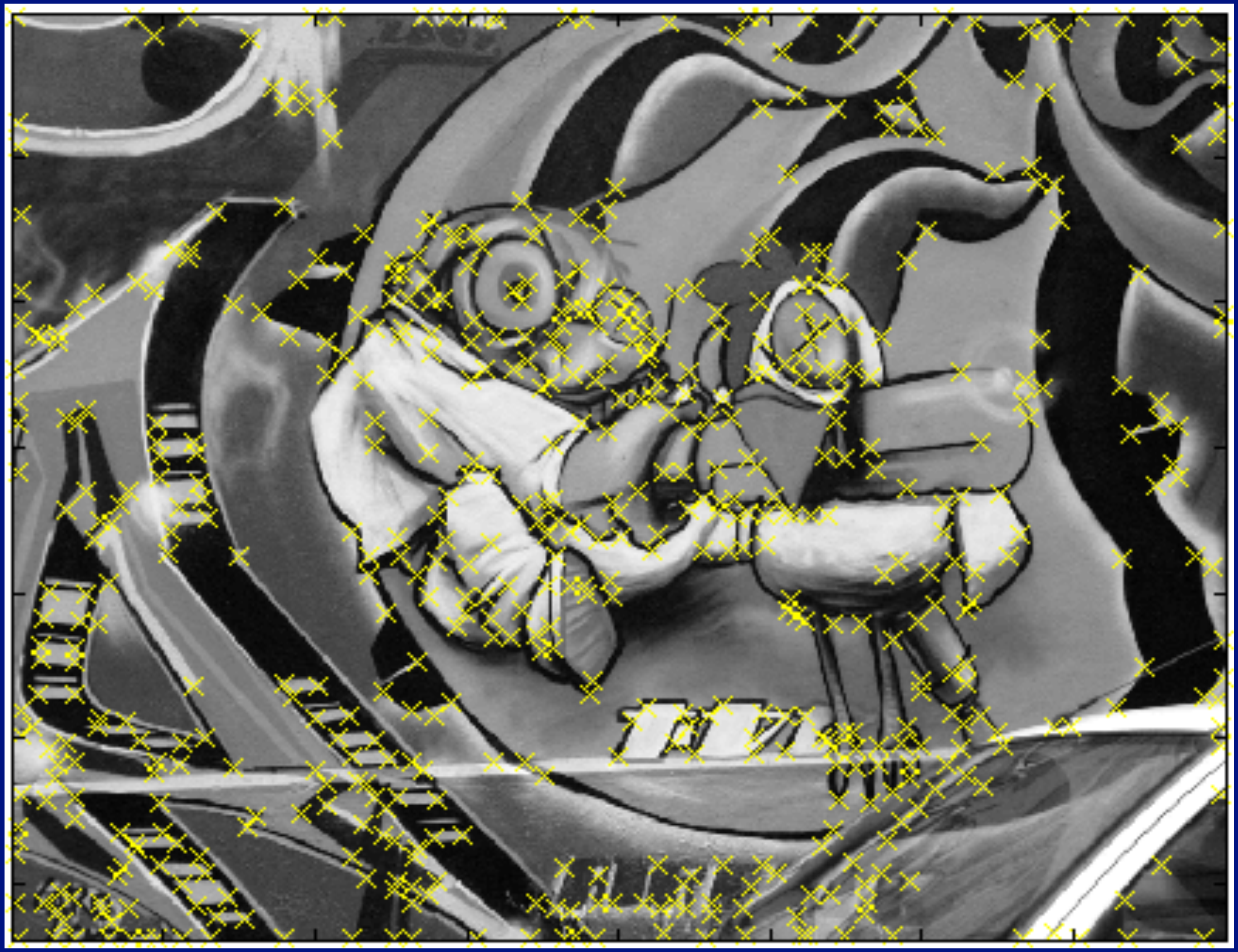


$$har = \det[\mu(\sigma_I,\sigma_D)] - \alpha[\mathrm{trace}(\mu(\sigma_I,\sigma_D))] =$$

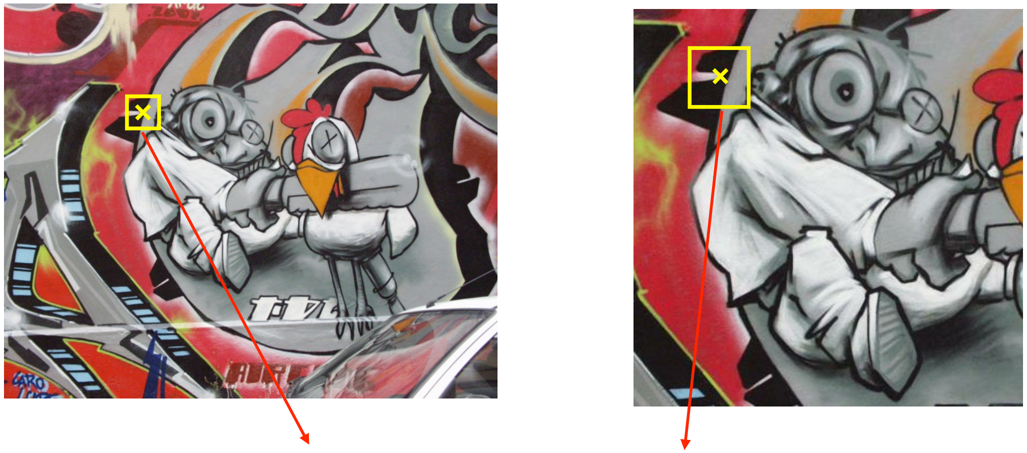
$$g(I_x^2)g(I_y^2) - [g(I_xI_y)]^2 - \alpha[g(I_x^2) + g(I_y^2)]^2$$



Interest points: locating centers



Interest points: finding the radius



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

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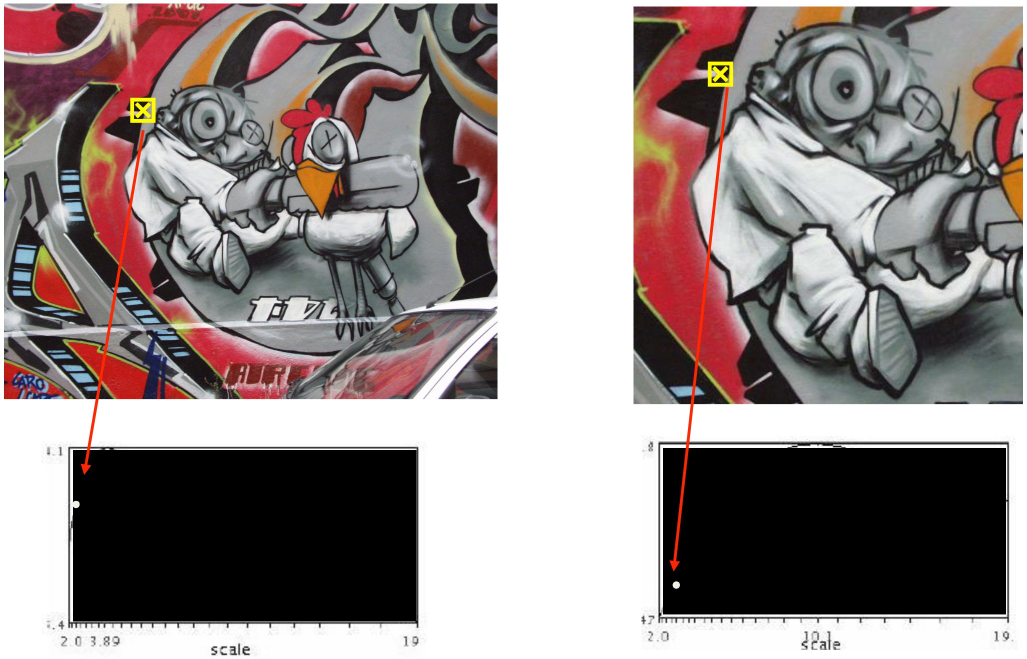
Interest points: finding the radius



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

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

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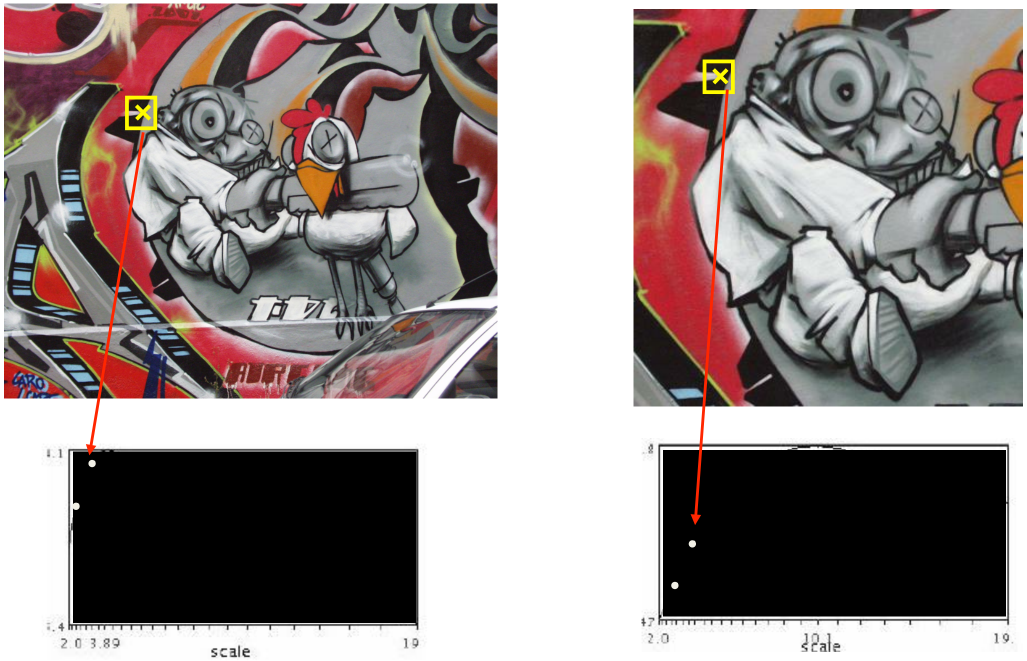
Interest points: finding the radius



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

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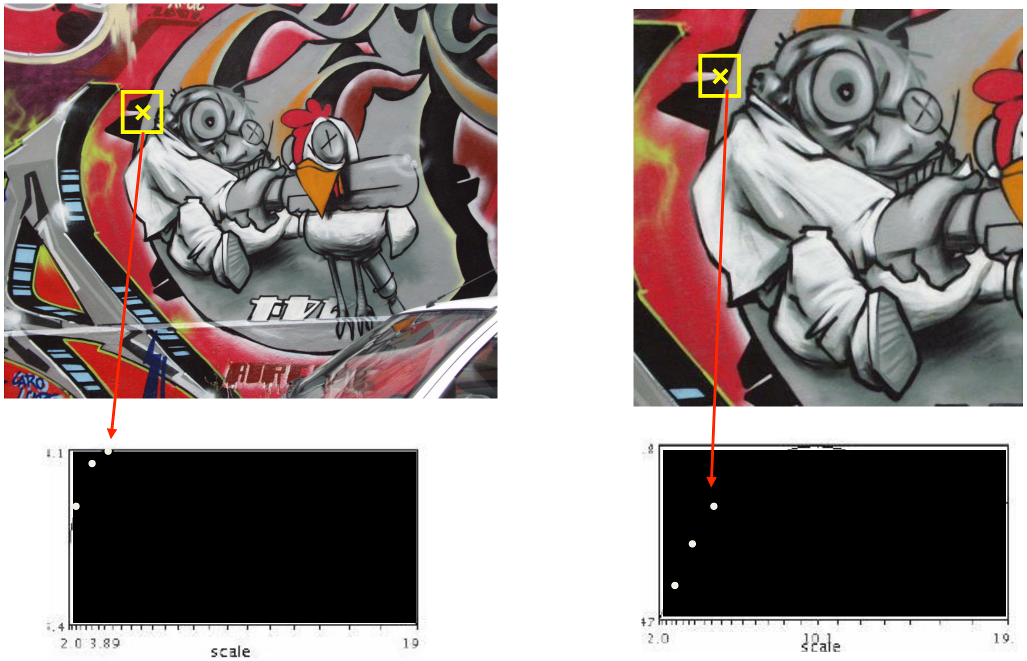
Interest points: finding the radius



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

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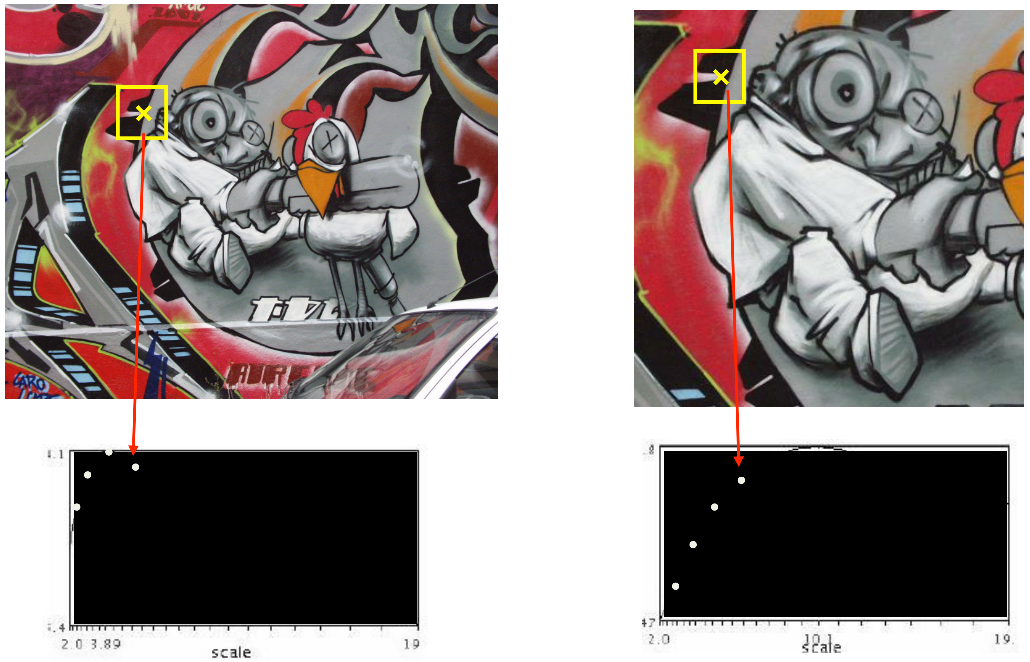

$f(I_{i_1 \ldots i_m}(x,\sigma))$

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

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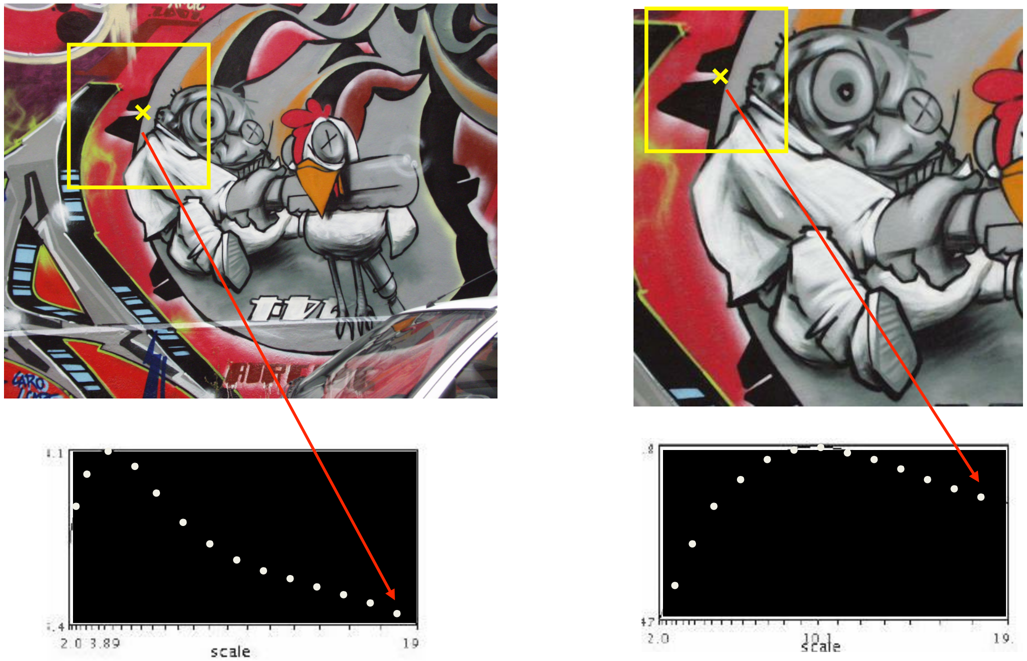

$f(I_{i_1 \ldots i_m}(x,\sigma))$ $f(I_{i_1 \ldots i_m}(x',\sigma))$

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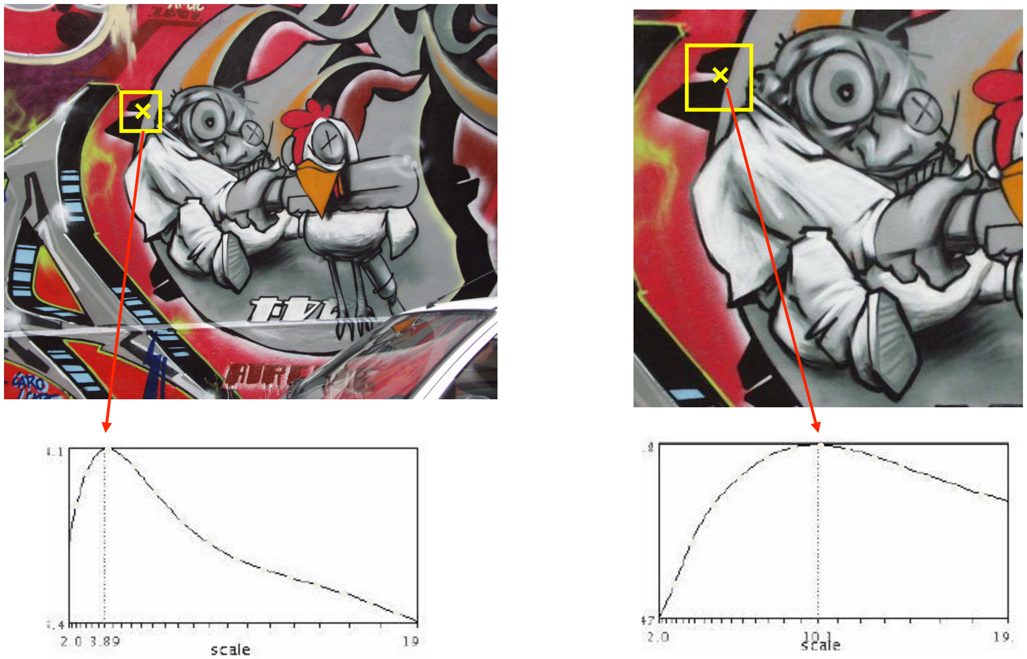

$f(I_{i_1 \ldots i_m}(x,\sigma))$

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

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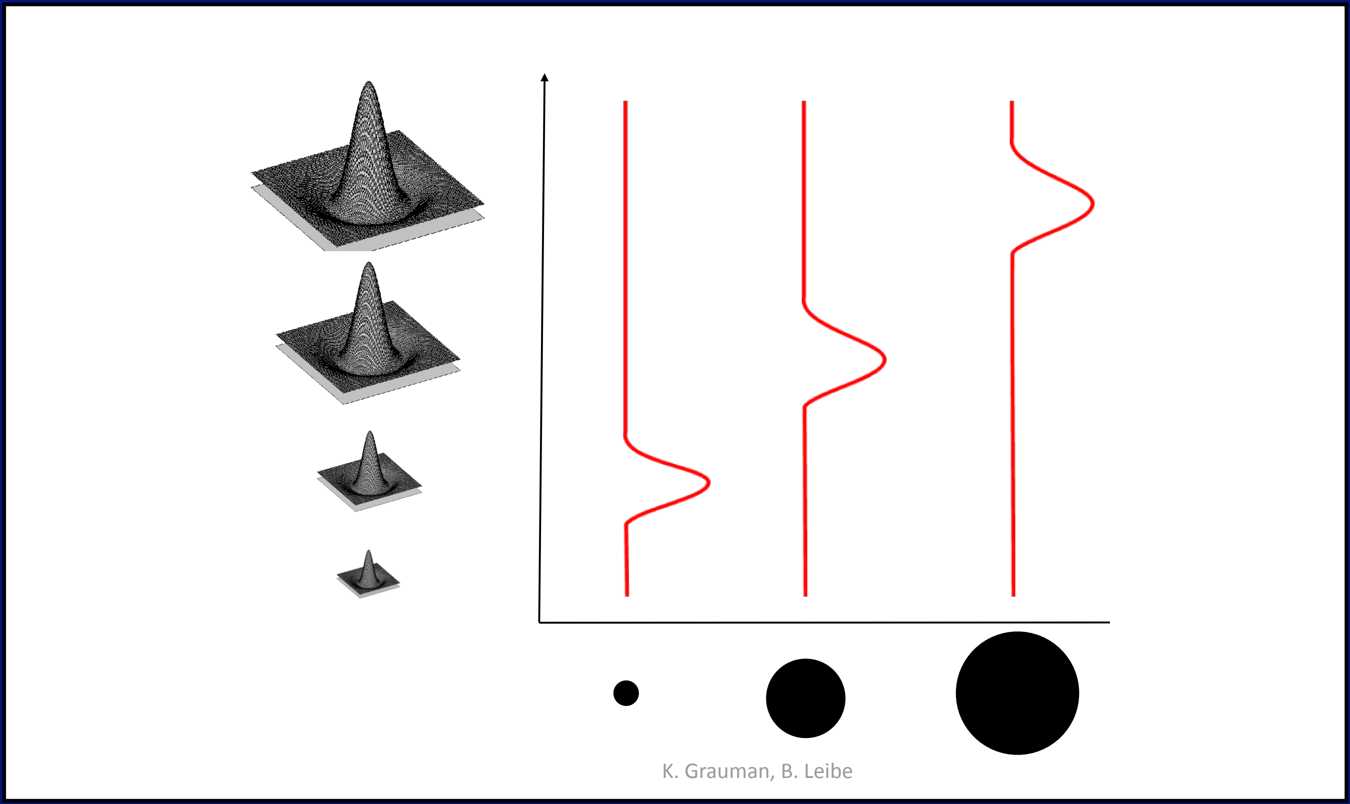
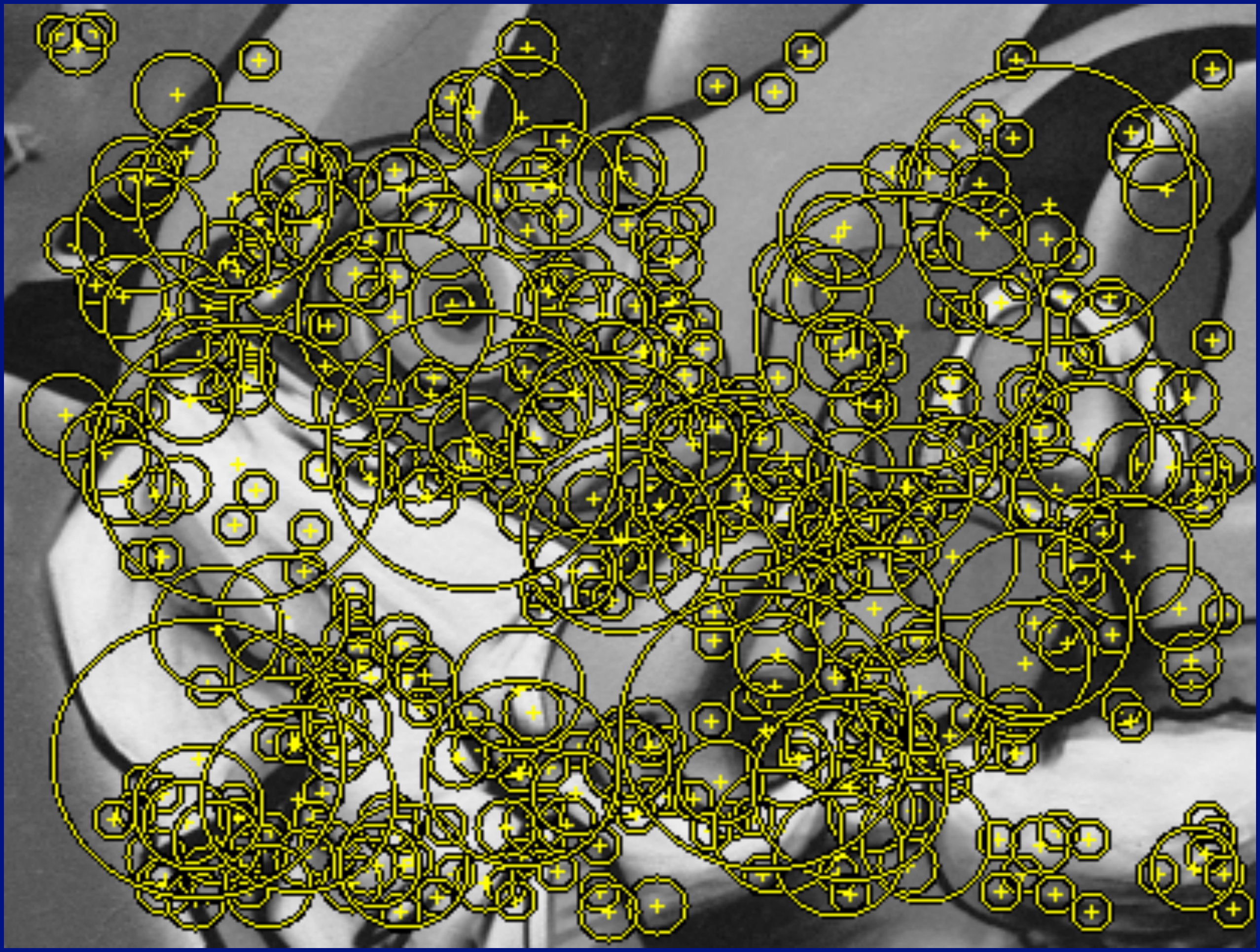
Interest points: finding the radius



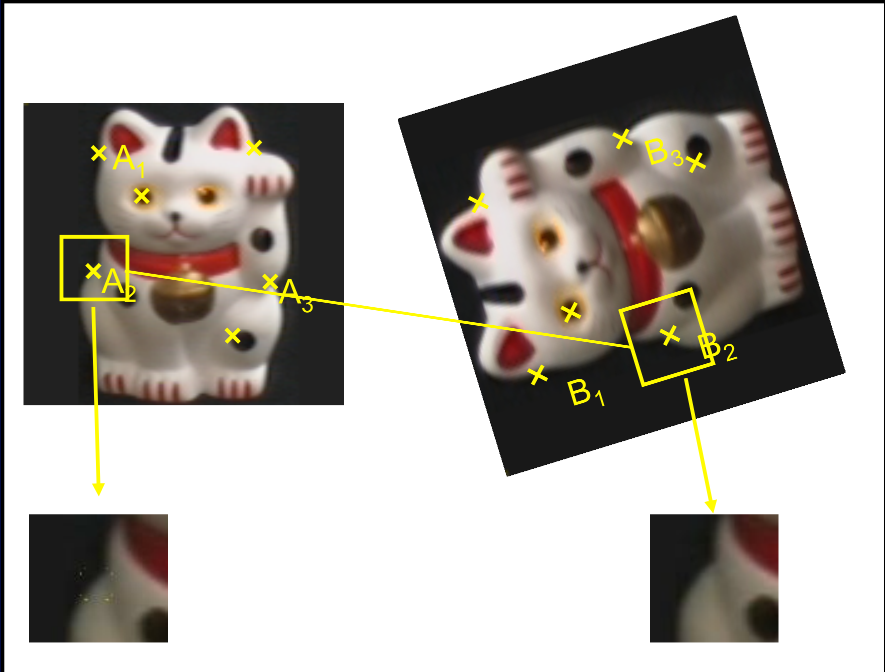
Laplacian of Gaussian: radius or blob detector

Interest points: finding the radius



Orientation of the patch

- We would like to know how the patch is rotated
  - to compare, compute features, etc.
- Strategy
  - compute orientation histogram
  - select most common orientation
    - this is 0 degrees



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Describing patches

- Various histograms of orientation
  - HOG
  - SIFT
  - SURF
  - etc.

Lowe's SIFT features

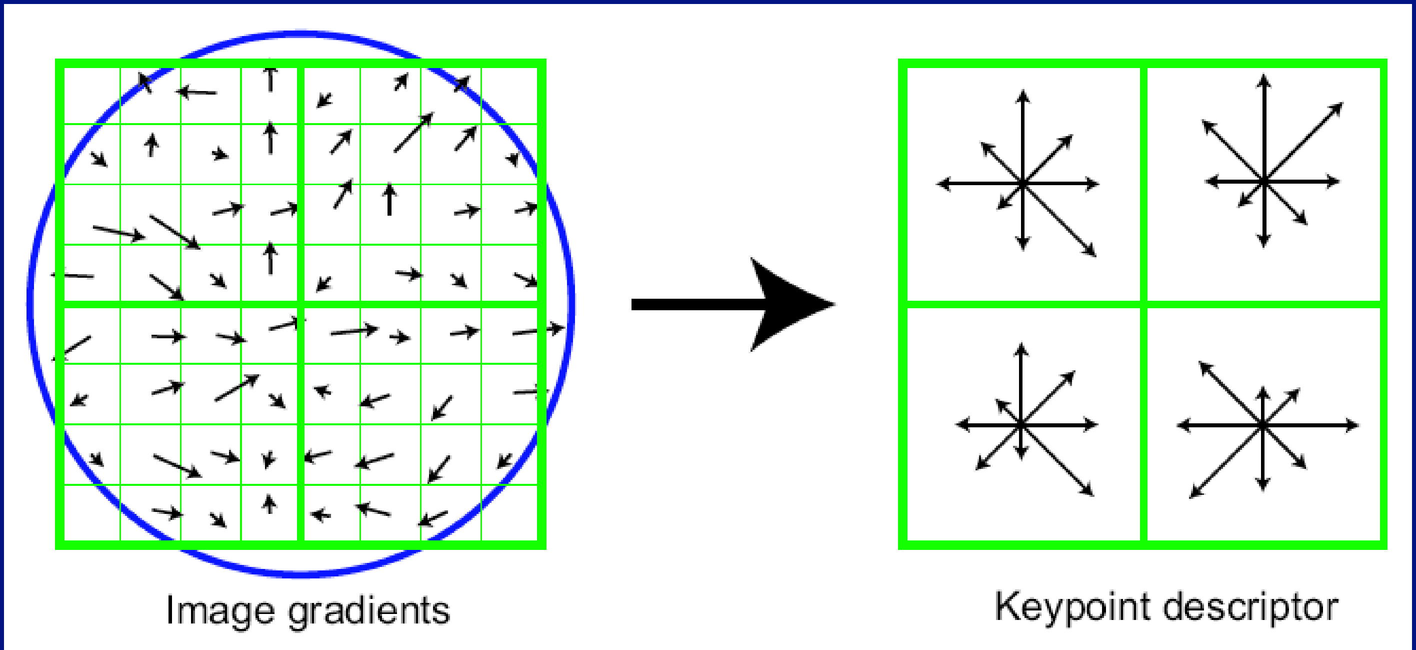
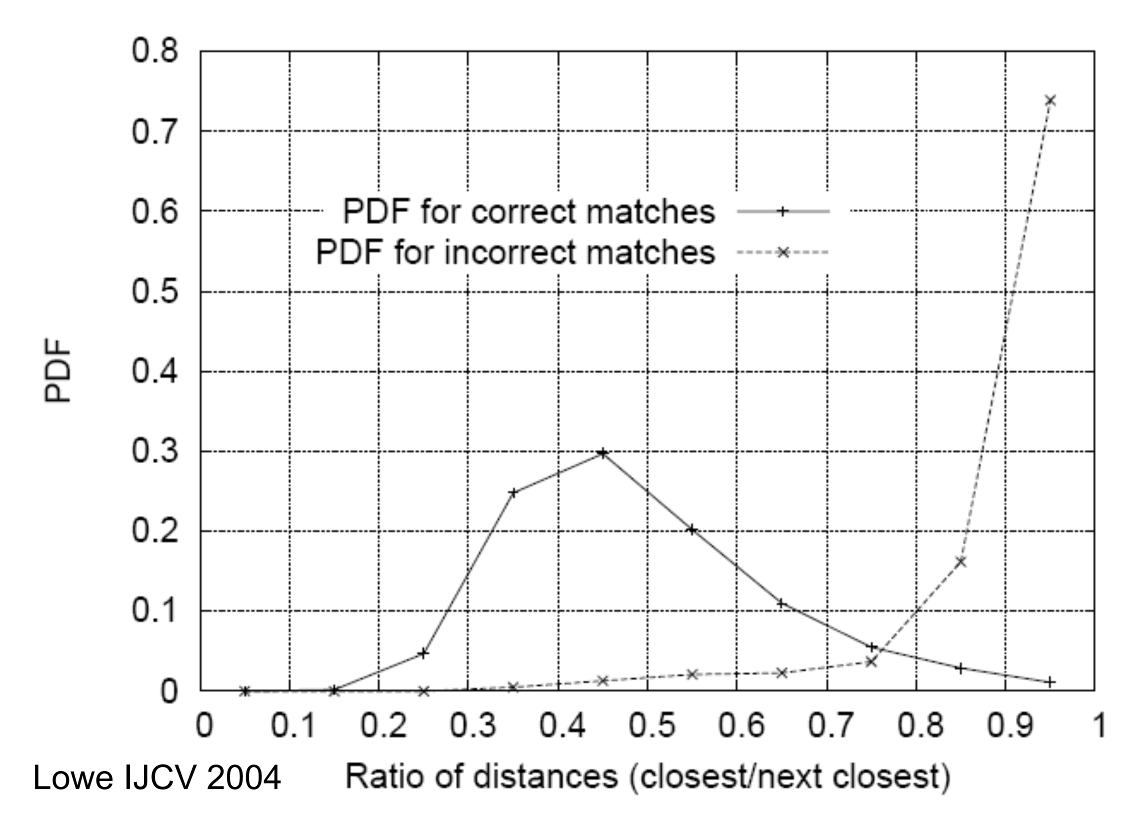


Fig 7 from:
Distinctive image features from scale-invariant keypoints
David G. Lowe, *International Journal of Computer Vision*, 60, 2 (2004), pp. 91-110.

Matching SIFT features

- Can be compared with Euclidean distance
  - test: (dist to closest)/(dist to second closest)



Lowe IJCV 2004

Crucial points

- Orientation based descriptors are very powerful
  - because robust to changes in brightness
- Procedure
  - find domain
    - window from search
    - patch center and radius
  - compute descriptor
    - histogram of orientations