Affine invariant interest points/regions

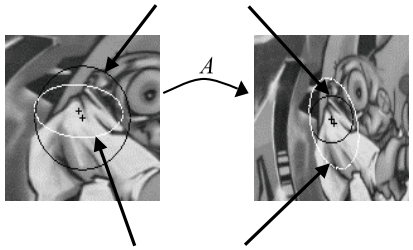
Overview

- Motivation
- Affine invariant points/regions detectors
  - Harris-Affine, Hessian-Affine, Laplacian-Affine
  - Maximally stable extremal regions
  - Intensity & edge based regions
  - Entropy-based regions

Affine invariant regions - Motivation

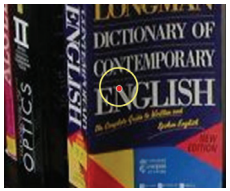
- Scale invariance is not sufficient for large baseline changes

detected scale invariant region

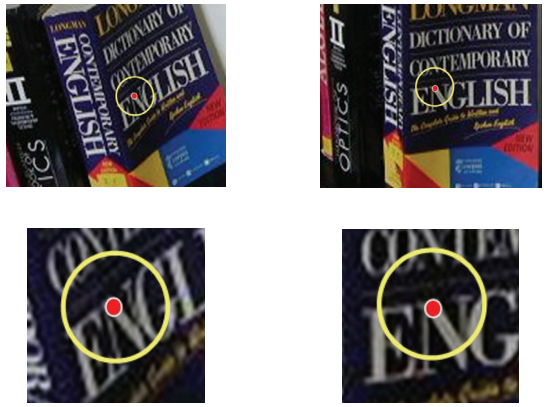


projected regions, viewpoint changes can locally be approximated by an affine transformation A

Affine invariant regions - Motivation



Affine invariant regions - Motivation



Affine invariant regions - Motivation

Affine invariant regions - Motivation

Affine invariant regions - Example

State of the art

- Harris-Affine *(Mikolajczyk and Schmid'02, Schaffalitzky and Zisserman'02)*
- Hessian-Affine / Laplacian-Affine *(Mikolajczyk and Schmid'02)*
- Maximally stable extremal regions (MSER) *(Matas et al.'02)*
- Intensity based regions (IBR) *(Tuytelaars and Van Gool'00)*
- Edge based regions (EBR) *(Tuytelaars and Van Gool'00)*
- Entropy-based regions (salient regions) *(Kadir et al.'04)*

Harris/Hessian/Laplacian-Affine

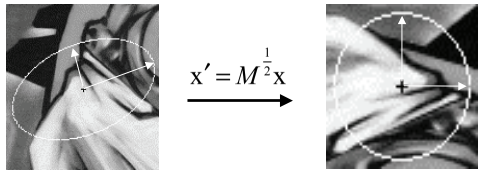
- Initialize with scale-invariant Harris/Hessian/Laplacian points
- Estimation of the affine neighbourhood with the second moment matrix
- Also possible to initialize with multi-scale points and estimate location, scale and affine region iteratively

Affine invariant regions - Theory

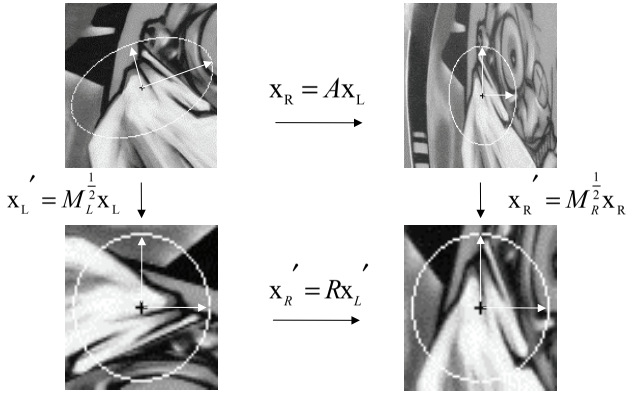
- Based on the second moment matrix (Lindeberg'94)

$$M = \mu(\mathbf{x}, \sigma_I, \sigma_D) = \sigma_D^2 G(\sigma_I) \otimes \begin{bmatrix} L_x^2(\mathbf{x}, \sigma_D) & L_x L_y(\mathbf{x}, \sigma_D) \\ L_x L_y(\mathbf{x}, \sigma_D) & L_y^2(\mathbf{x}, \sigma_D) \end{bmatrix}$$

- Normalization with eigenvalues/eigenvectors



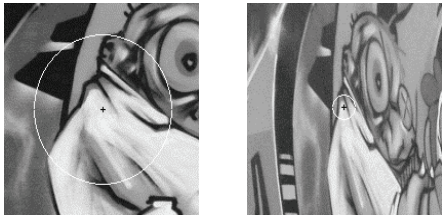
Affine invariant regions - Theory



Isotropic neighborhoods related by image rotation

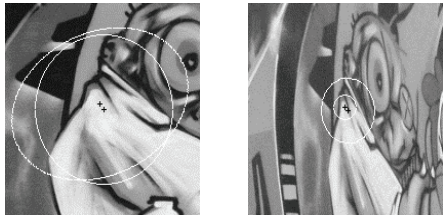
Affine invariant regions - Estimation

- Iterative estimation – initial points



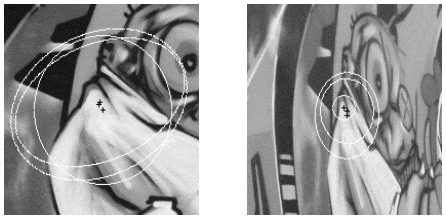
Affine invariant regions - Estimation

- Iterative estimation – iteration #1



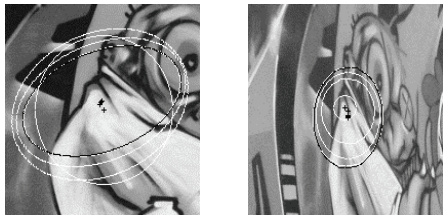
Affine invariant regions - Estimation

- Iterative estimation – iteration #2



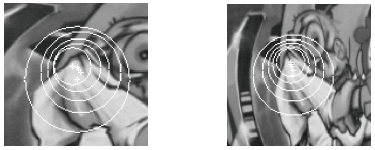
Affine invariant regions - Estimation

- Iterative estimation – iteration #3, #4

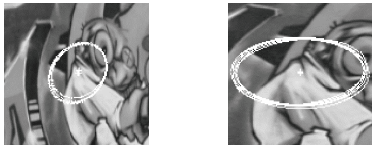


Harris-Affine

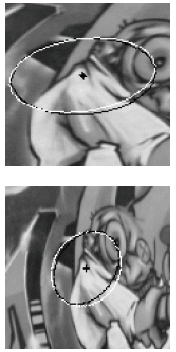
- Initialization with multi-scale interest points



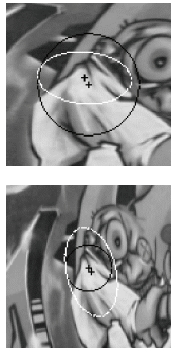
- Iterative modification of location, scale and neighborhood



Harris-Affine versus Harris-Laplace

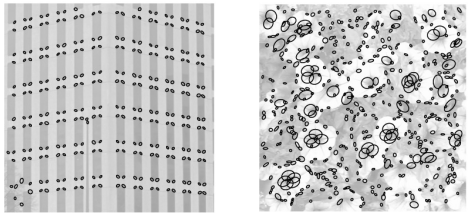


Harris-Affine

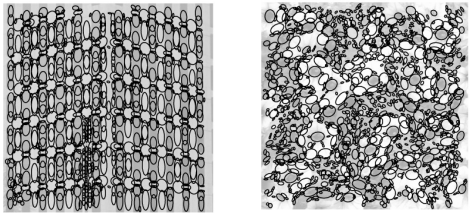


Harris-Laplace

Harris/Laplace-Affine

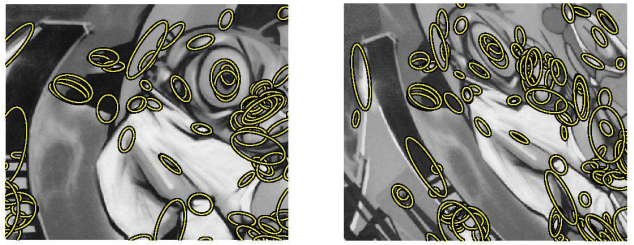


Harris-Affine



Laplace-Affine

Harris-Affine



Hessian-Affine


Image retrieval



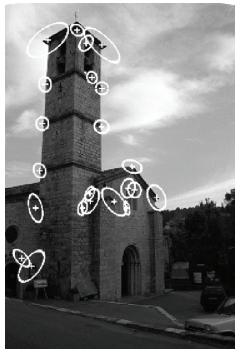




change in viewing angle

> 5000 images

Matches

22 correct matches

Image retrieval







change in viewing angle
+ scale change

> 5000 images

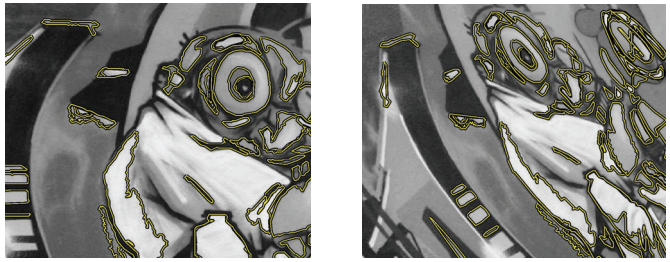
Matches

33 correct matches

Maximally stable extremal regions (MSER) [Matas'02]

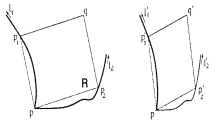
- Extremal regions: connected components in a thresholded image (all pixels above/below a threshold)
- Maximally stable: minimal change of the component (area) for a change of the threshold, i.e. region remains stable for a change of threshold

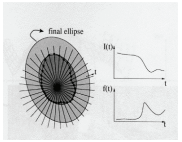
MSER



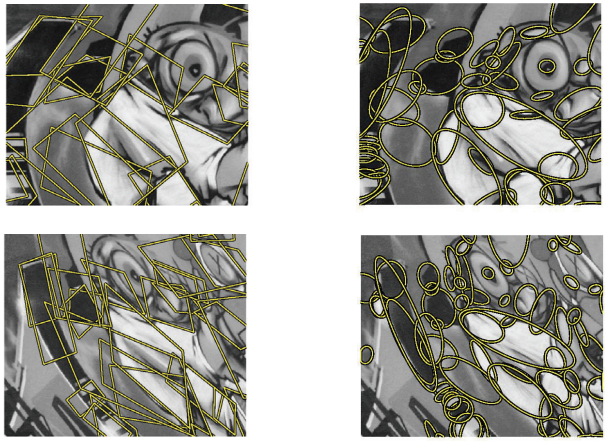
EBR & IBR affine invariant regions

- Edge-based regions (Tuytelaars et al.'00)
  - parallelogram formed by interest points and edges
- Intensity extrema-based regions (Tuytelaars et al.'00)
  - ellipses fitted to intensity maxima





EBR IBR



Salient regions [Kadir'04]

- Entropy of the distribution of the intensity values computed over an ellipse
- Extremal regions over three parameter family of ellipses
- Ordering by the derivative of the distribution with respect to scale

Salient regions