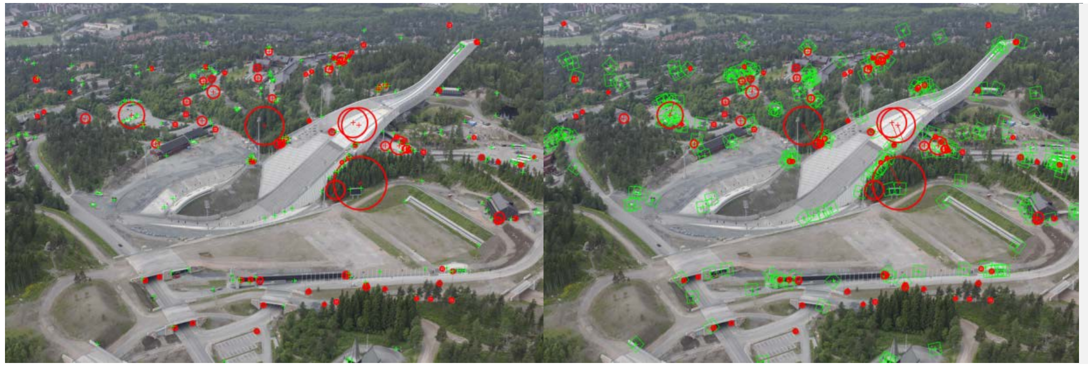
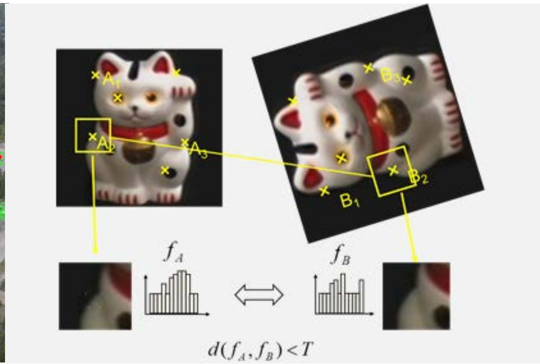


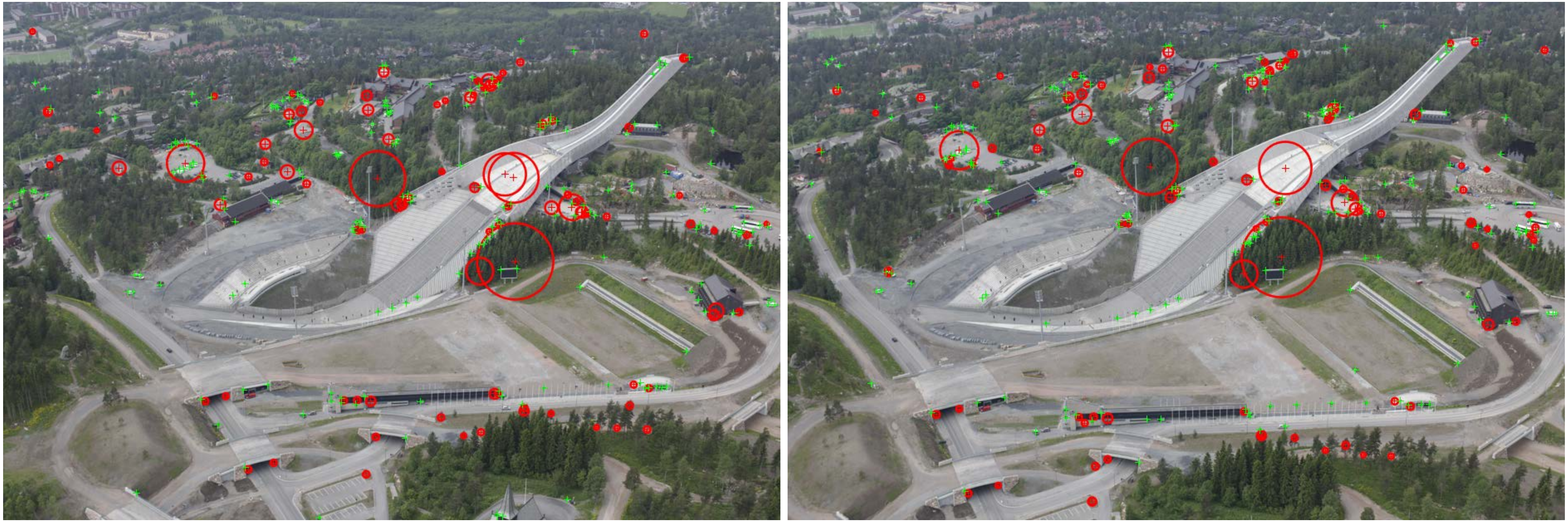


Lecture 4.0
From keypoints to correspondences

Trym Vegard Haavardsholm

Illustrations from K. Grauman, B. Leibe, Svetlana Lazebnik, David Lowe, Matthew Brown

Point correspondences from keypoints

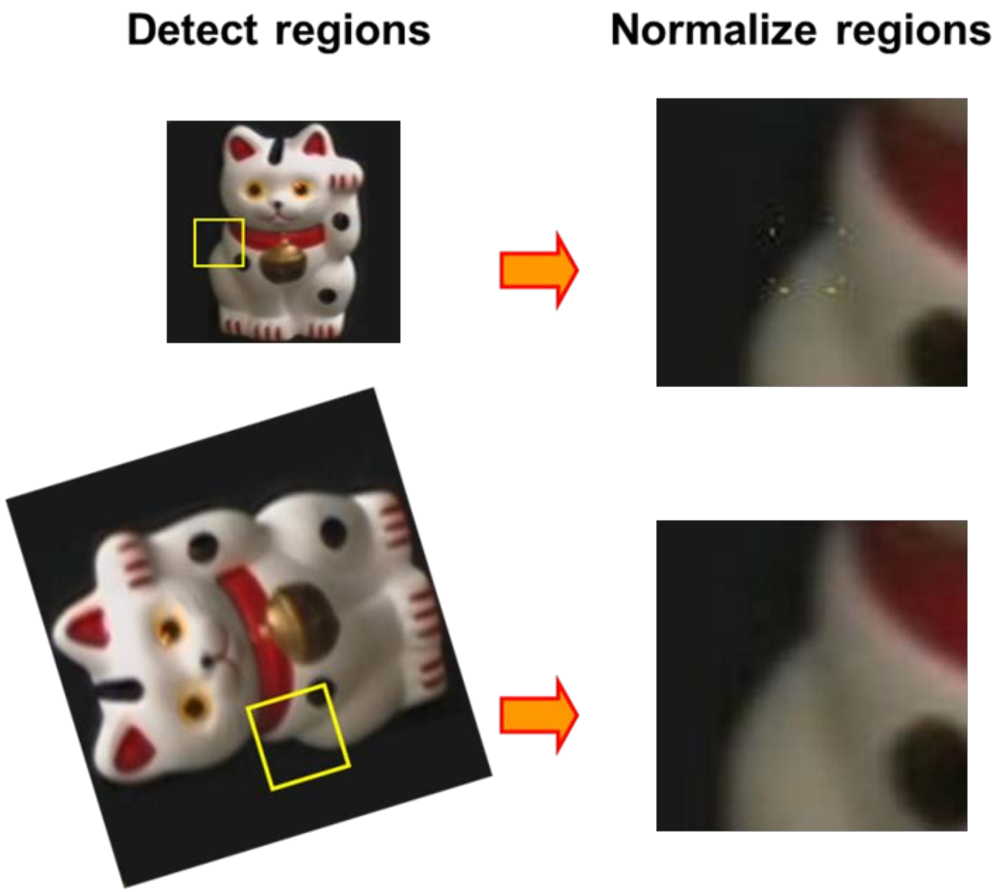


How do we match these keypoints?

Local patches

- Covariant feature point detectors
  - Location (x, y), scale σ and orientation θ.

- Normalize local patches surrounding keypoints
  - Canonical scale



Local patches

- Covariant feature point detectors
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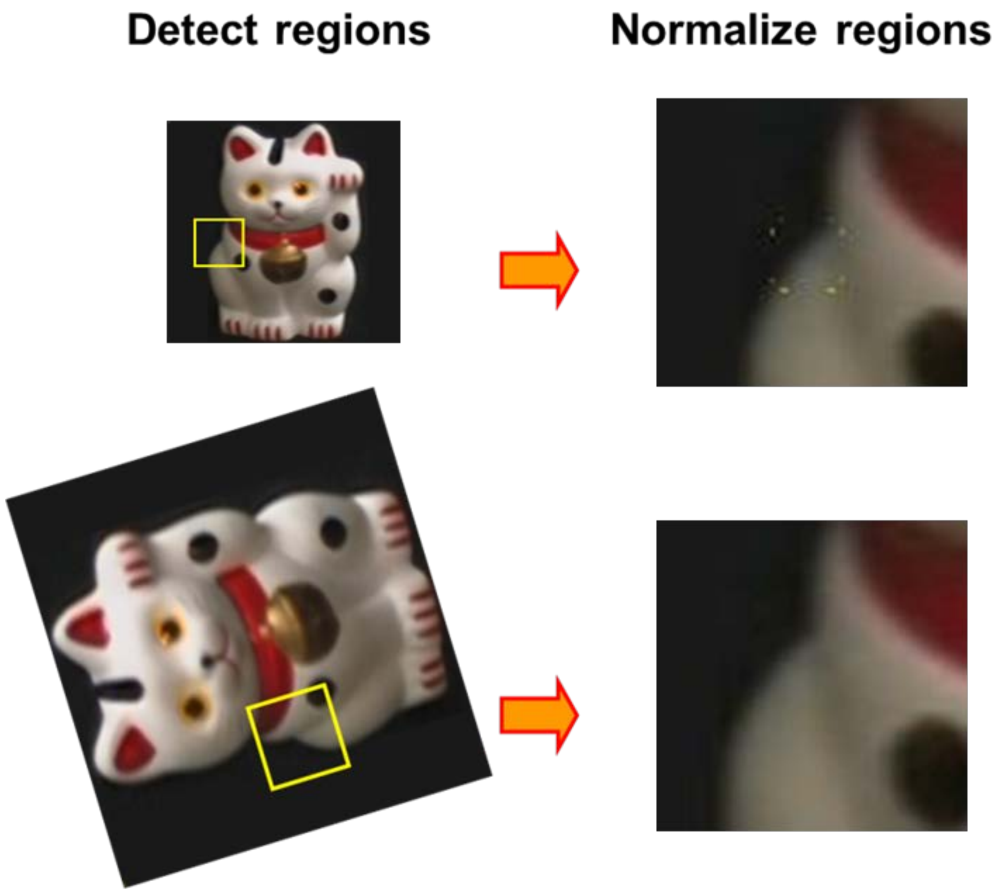
  - Canonical orientation



Estimating canonical orientation

- Find dominant orientation of the image patch
  - This is given by $\mathbf{x}_{\mathbf{max}}$, the eigenvector of $\mathbf{M}$ corresponding to λ_{max} (the *larger* eigenvalue)
  - Rotate the patch according to this angle

Estimating canonical orientation

- Orientation from Histogram of Gradients (HoG)

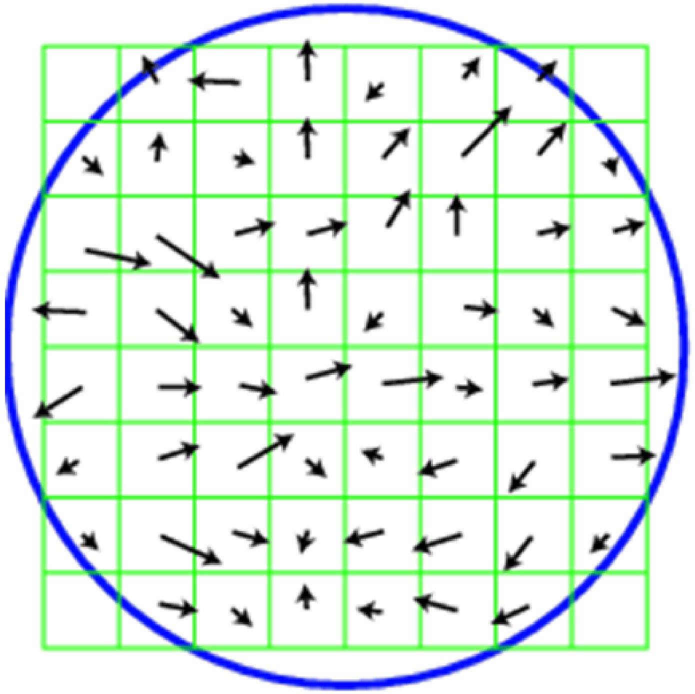
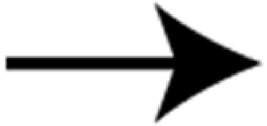
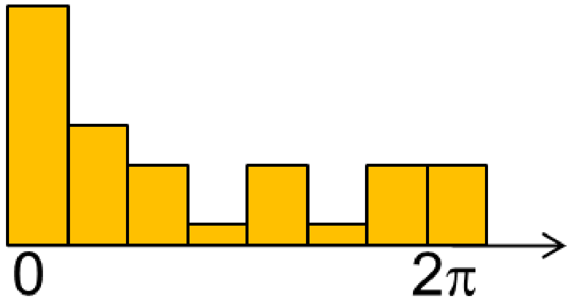
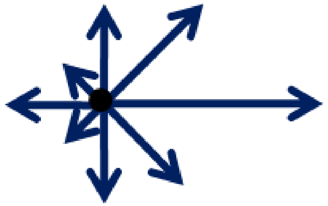


Image gradients

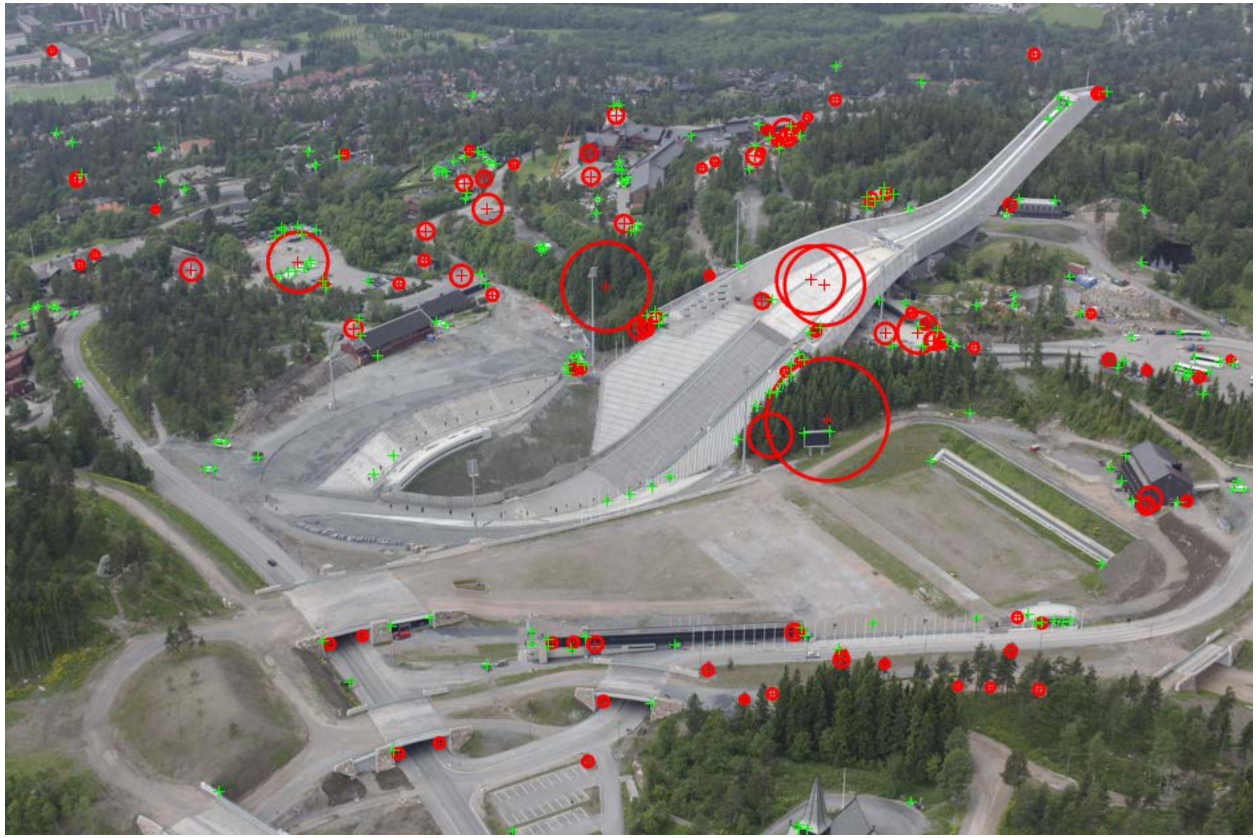


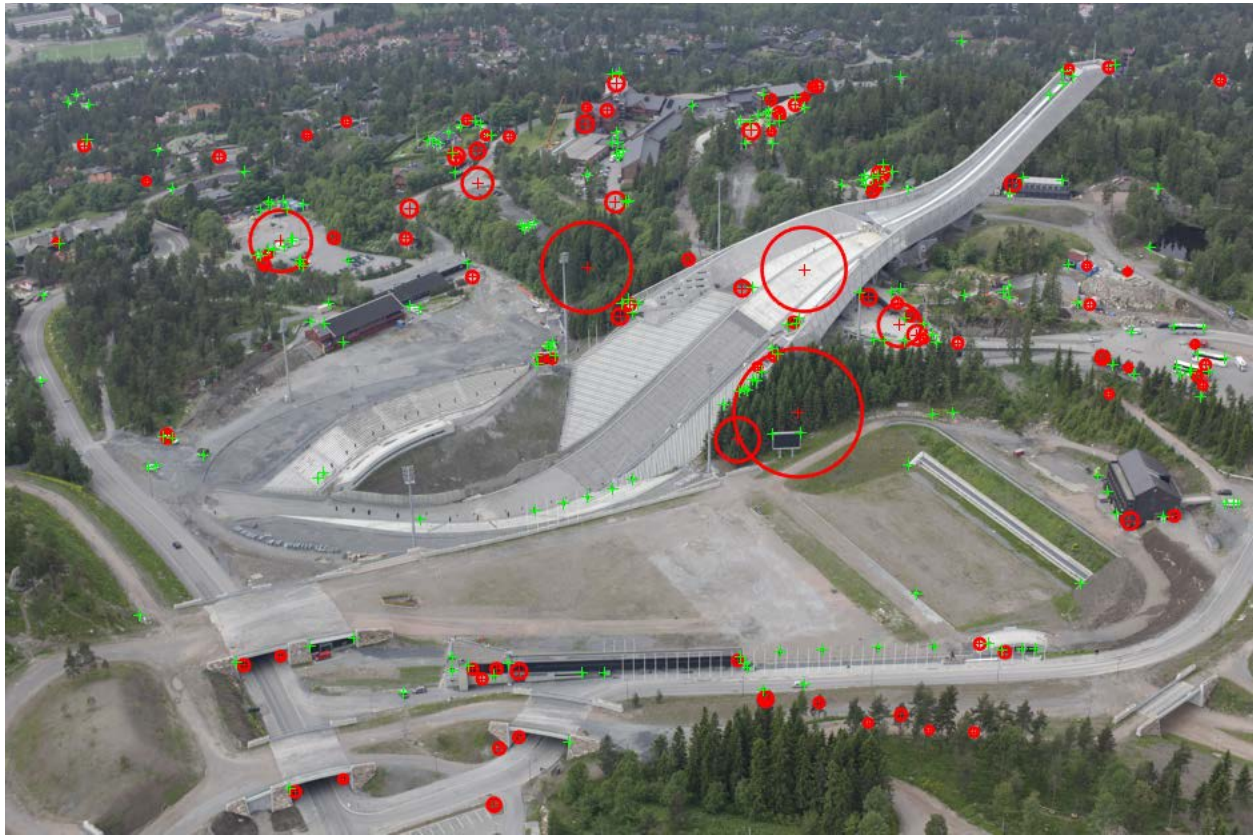


angle histogram

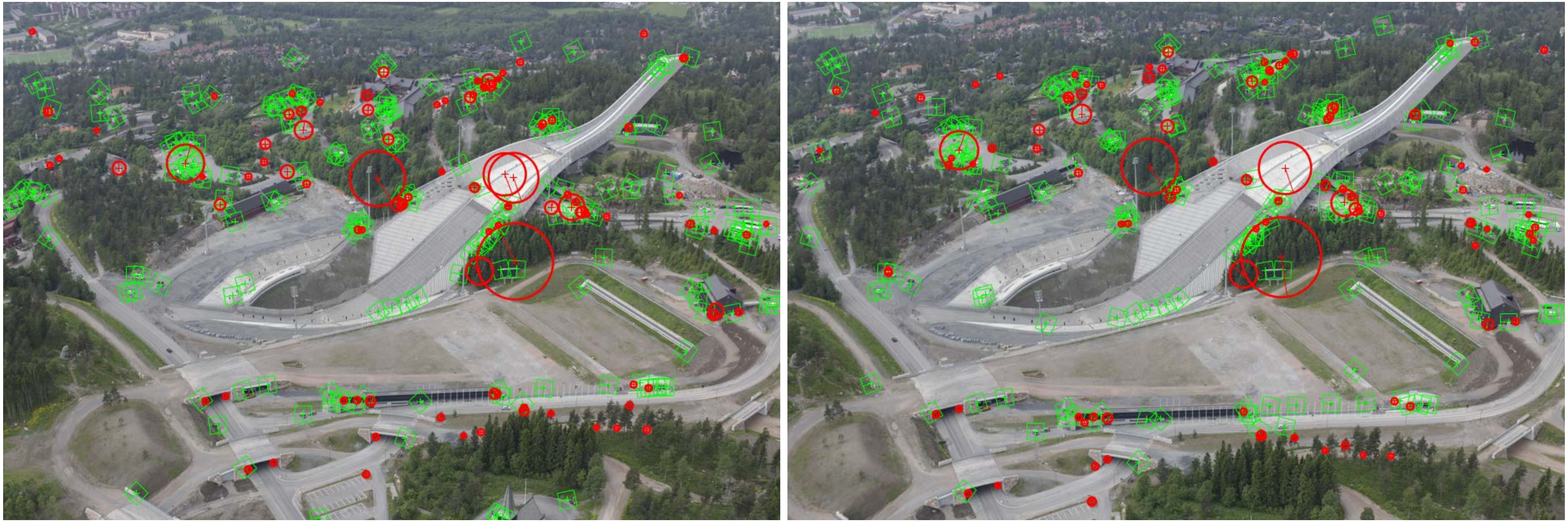


Estimating canonical orientation: Example





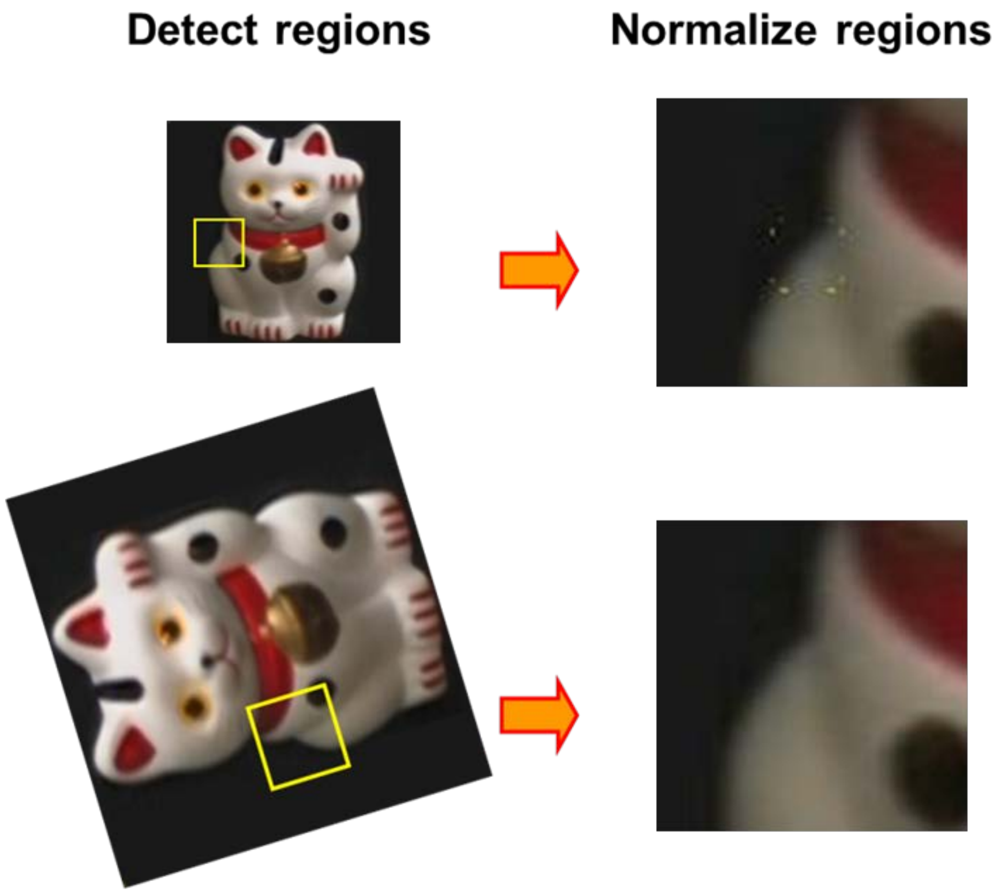
Estimating canonical orientation: Example



Local patches

- Covariant feature point detectors
  - Location (x, y), scale σ and orientation θ.

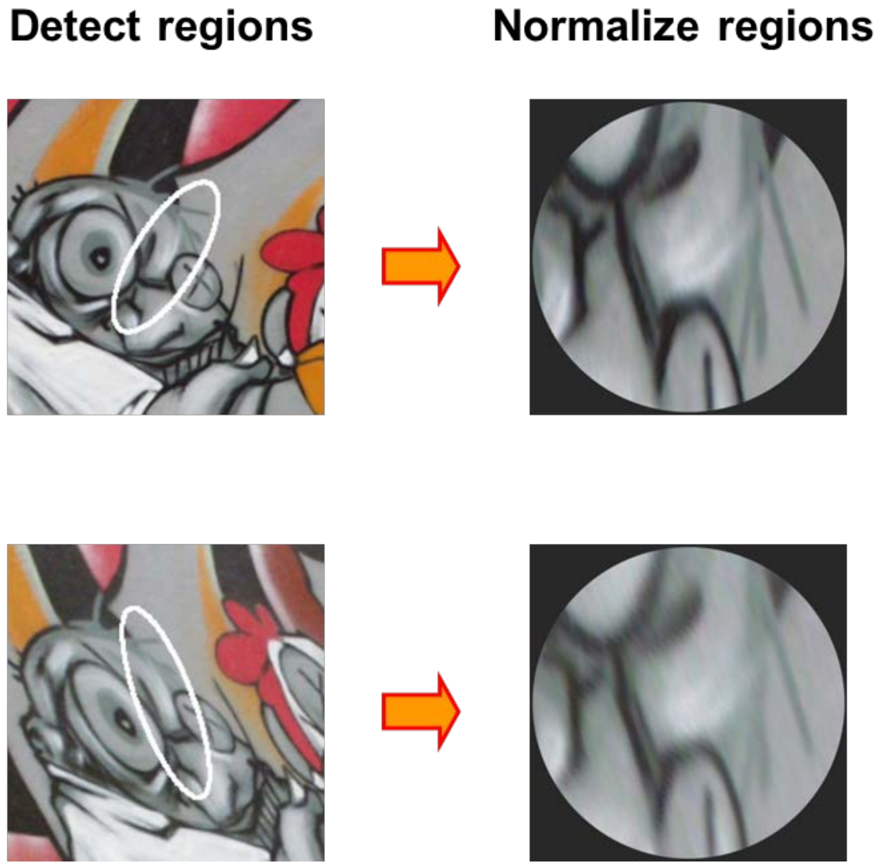
- Normalize local patches surrounding keypoints
  - Canonical scale
  - Canonical orientation



Local patches

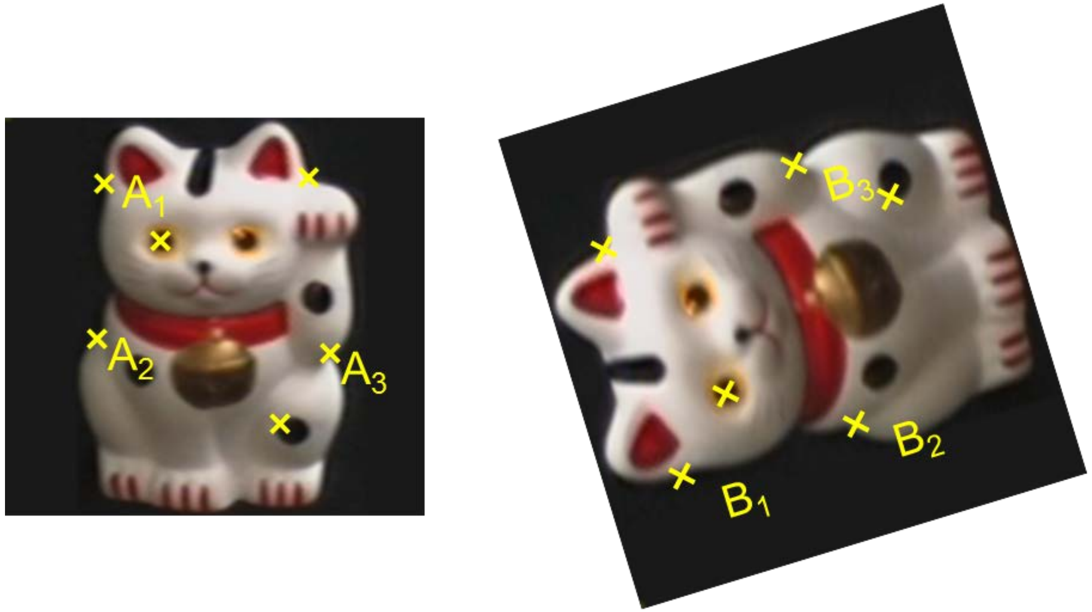
- Covariant feature point detectors
  - Affine transformation *A*

- Normalize local patches surrounding keypoints
  - Canonical affine transformation



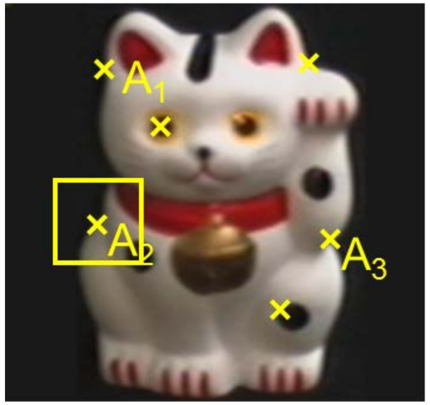
Overview of point feature matching

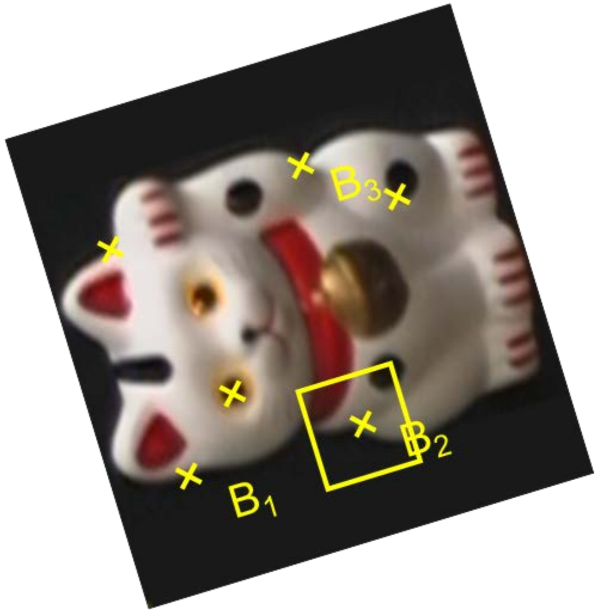
Overview of point feature matching



1. Detect a set of distinct feature points

Overview of point feature matching

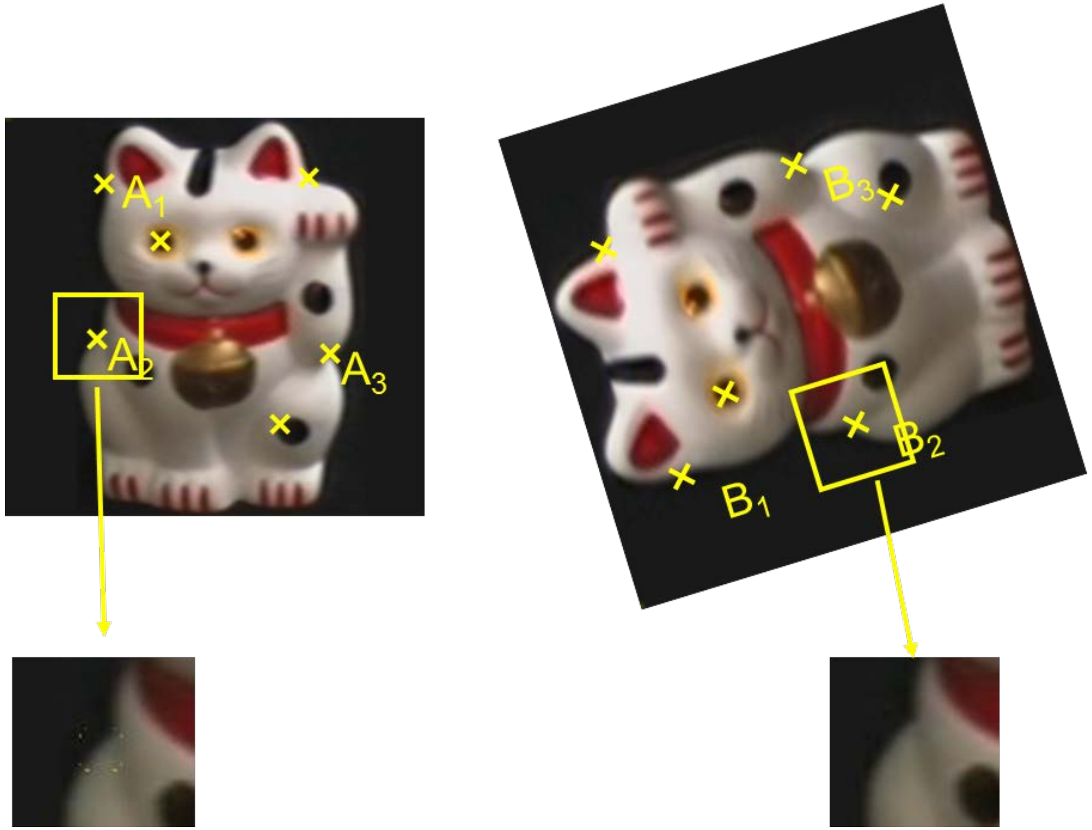




1. Detect a set of distinct feature points

2. Define a patch around each point

Overview of point feature matching

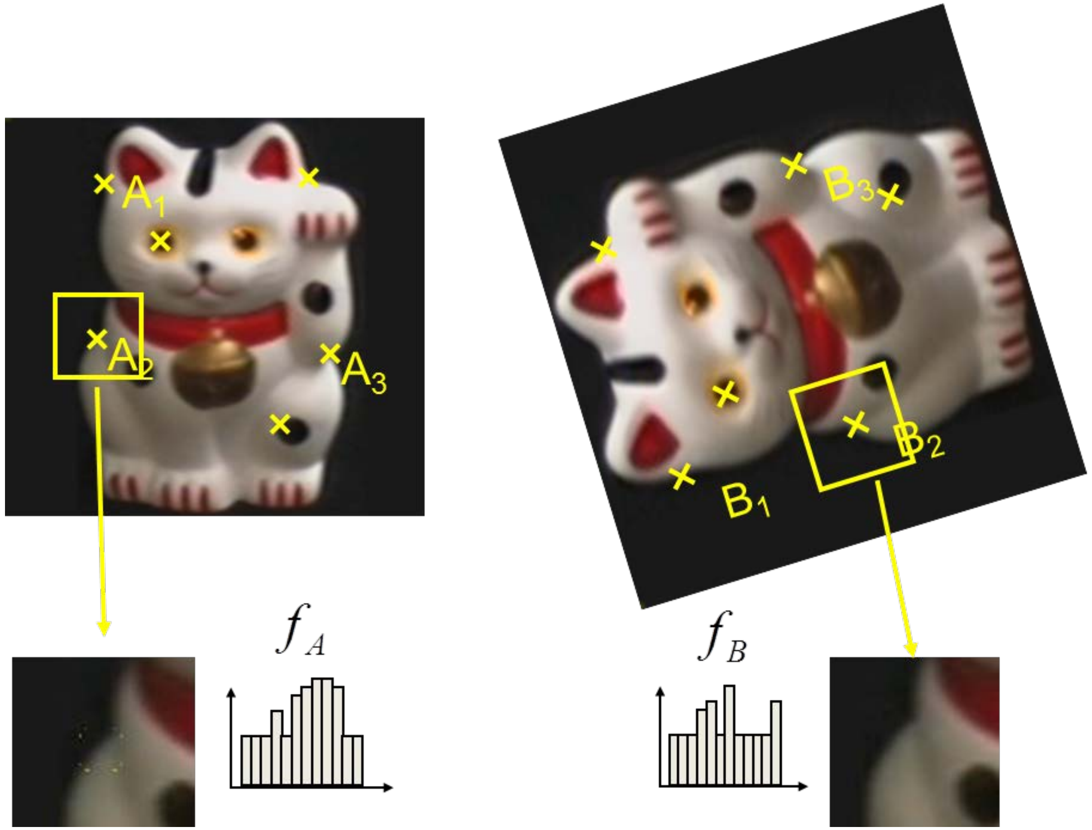


1. Detect a set of distinct feature points

2. Define a patch around each point

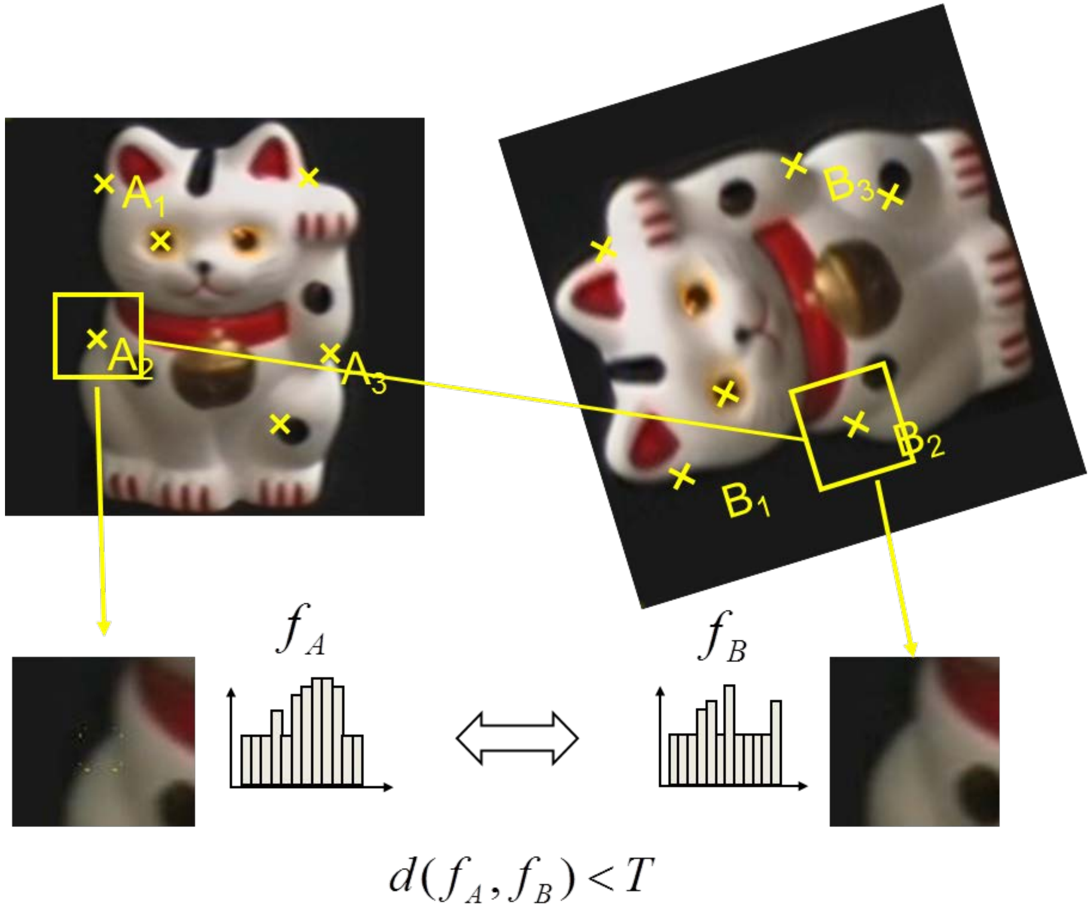
3. Extract and normalize the patch

Overview of point feature matching



1. Detect a set of distinct feature points
2. Define a patch around each point
3. Extract and normalize the patch
4. Compute a local descriptor

Overview of point feature matching

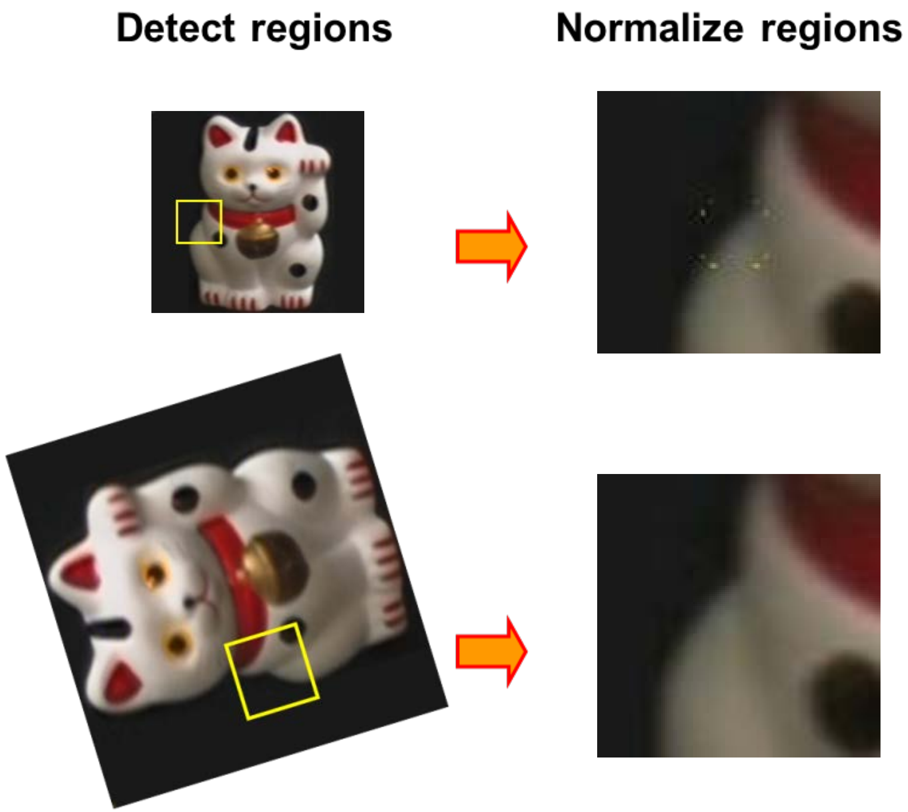


1. Detect a set of distinct feature points
2. Define a patch around each point
3. Extract and normalize the patch
4. Compute a local descriptor
5. Match local descriptors

Feature descriptors

- Simplest descriptor: Vector of raw intensity values

- How to compare two such vectors?

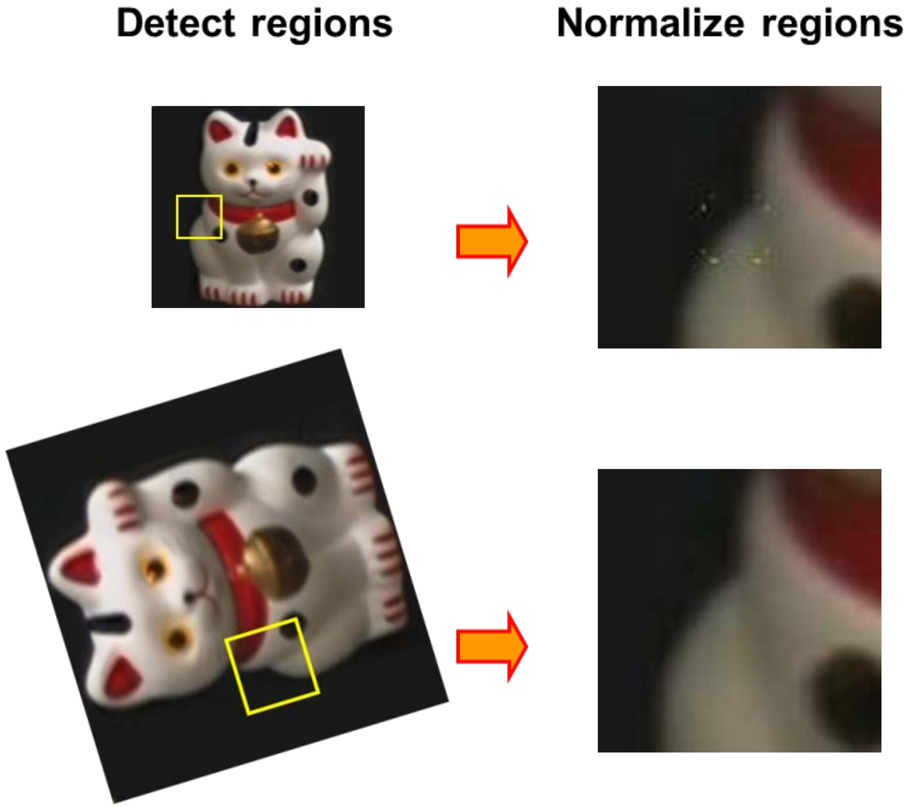


Feature descriptors

- Simplest descriptor: Vector of raw intensity values

- How to compare two such vectors?
  - Sum of squared differences (SSD)

$$\mathrm{SSD}(u,v) = \sum_i (u_i - v_i)^2$$



Feature descriptors

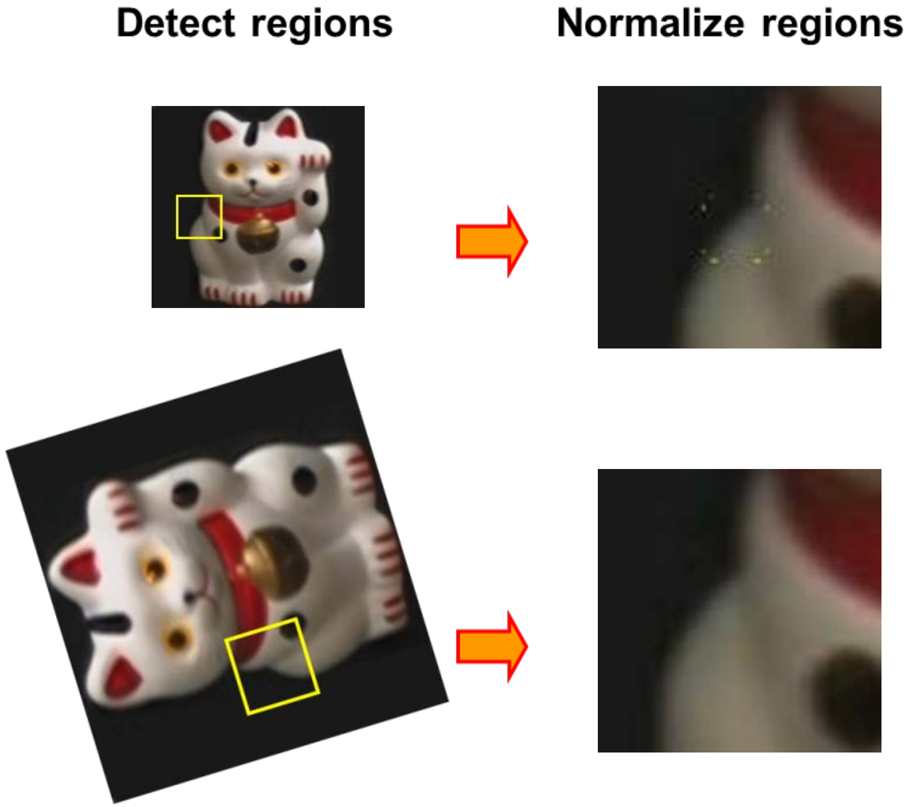
- Simplest descriptor: Vector of raw intensity values

- How to compare two such vectors?
  - Sum of squared differences (SSD)

$$\mathrm{SSD}(u,v) = \sum_i \left(u_i - v_i\right)^2$$

  - Normalized correlation

$$\rho(u,v) = \frac{\sum_i (u_i - \overline{u})(v_i - \overline{v})}{\sqrt{\left(\sum_j (u_j - \overline{u})^2\right)\left(\sum_j (v_j - \overline{v})^2\right)}}$$



A better descriptor

- Robust to small deformations

- Distinctive
- Fast to construct
- Fast to compare