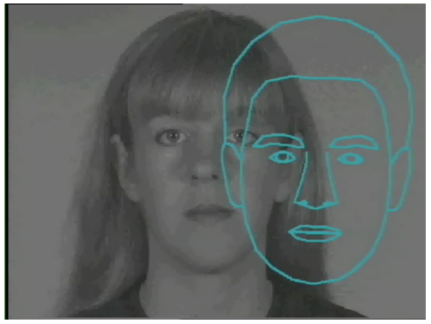
MANCHESTER 1824

The University of Manchester

Local Features (part 1)

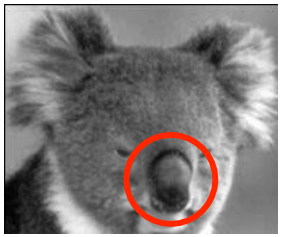
Motivation

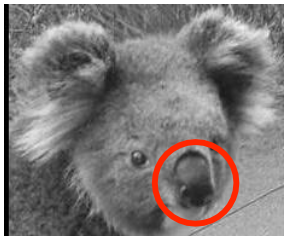
- Global representations have limitations



- Instead, describe and match only local regions
- Increased robustness to
  - Occlusions

  - Intra-category variations



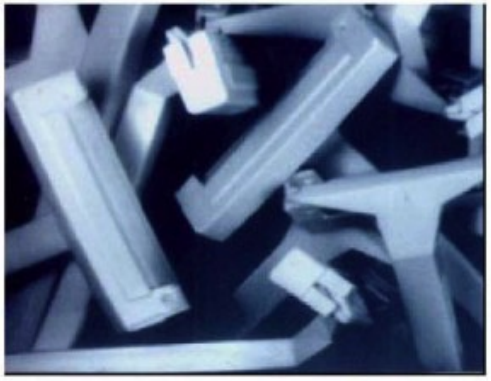


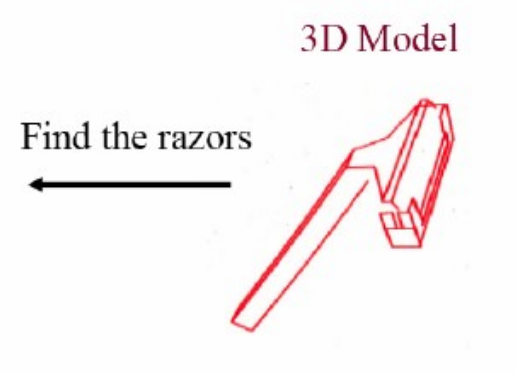
Topics of This Lecture

- **Local Invariant Descriptors (= Features) (part 1)**
  - Motivation
  - Requirements, Invariances
- **Local Interest Point Detection (Keypoint Localization)**
  - Harris detector (part 2)
- **Scale Invariant Region Selection (part 3)**
  - Automatic scale selection
  - Laplacian-of-Gaussian detector
  - Difference-of-Gaussian detector
- **Local Descriptors (part 4)**
  - Orientation normalization
  - SIFT

Another Example: Object Recognition

- Model Based Object Recognition





- Image Based Object Recognition

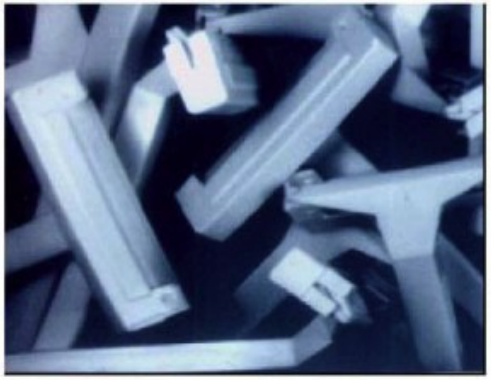
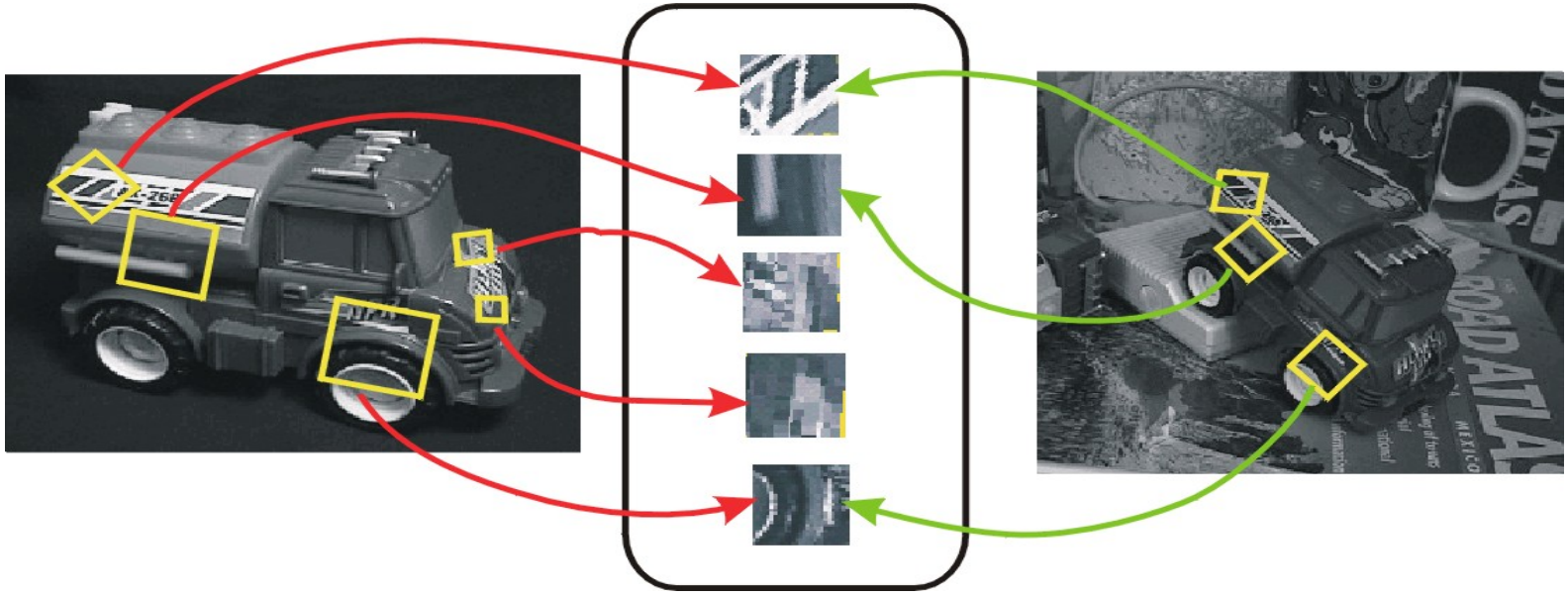


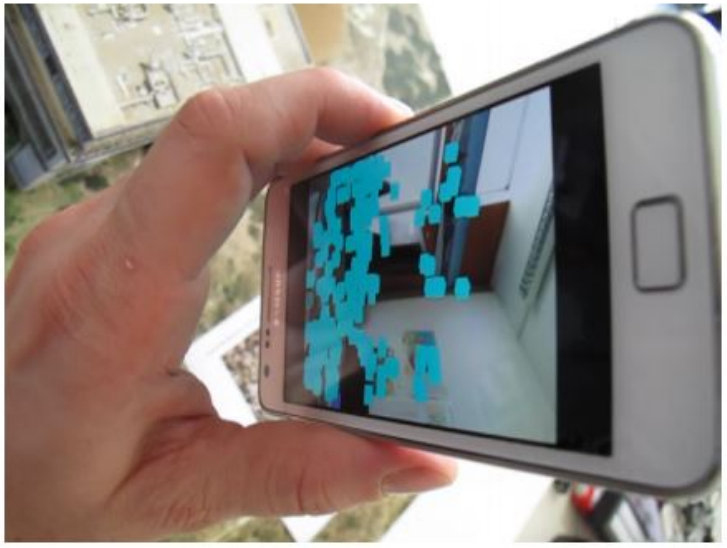
Image Features

- **What is a Feature in Computer Vision ?**
  - Local, meaningful, detectable parts of the image
  - Location of a sudden change
- **Why use features?**
  - Information Content High
  - Invariant to change of view point, illumination
  - Reduces computational burden



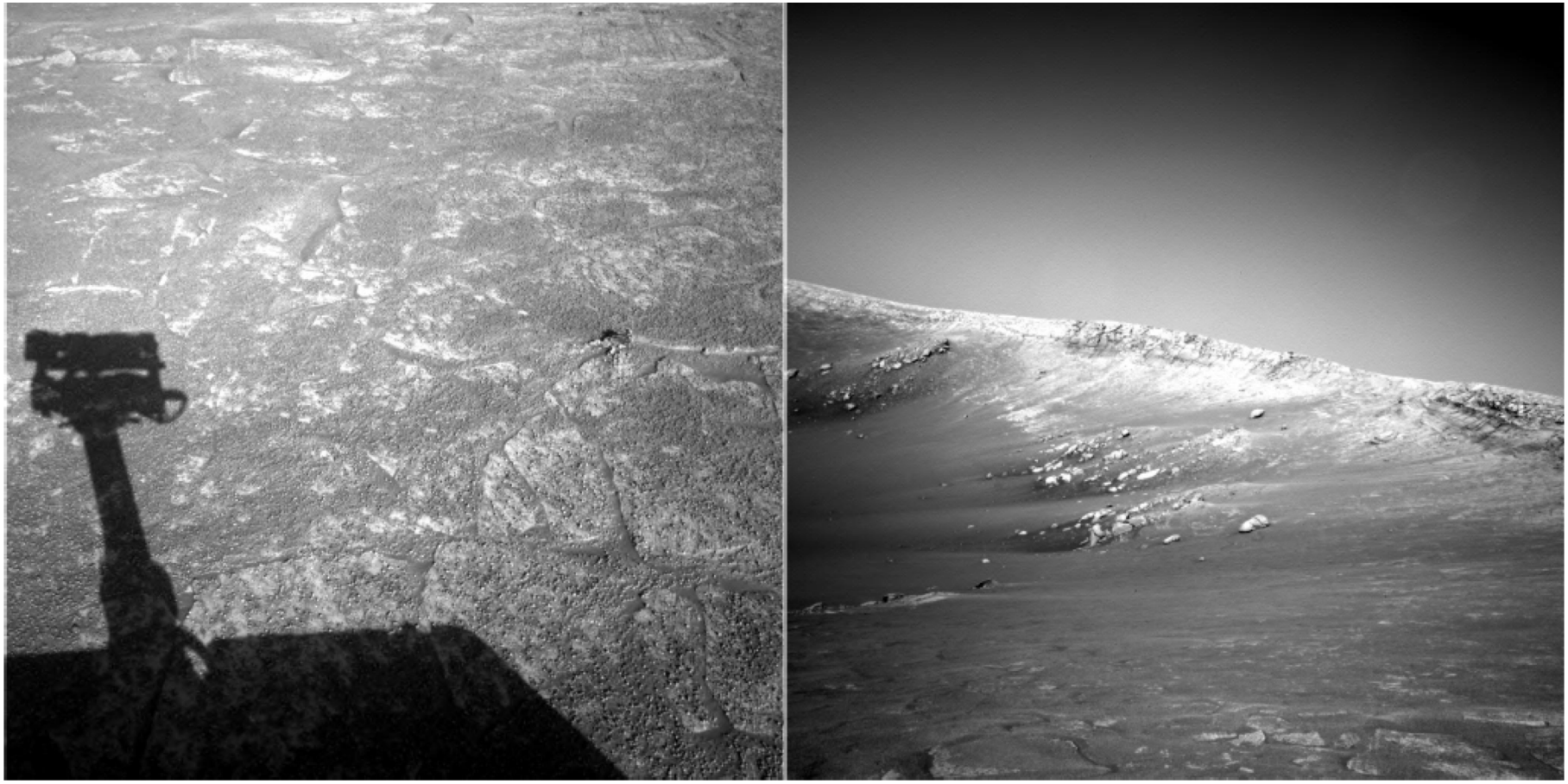
Application: Visual SLAM

(**S**imultaneous **L**ocalization **A**nd **M**apping)



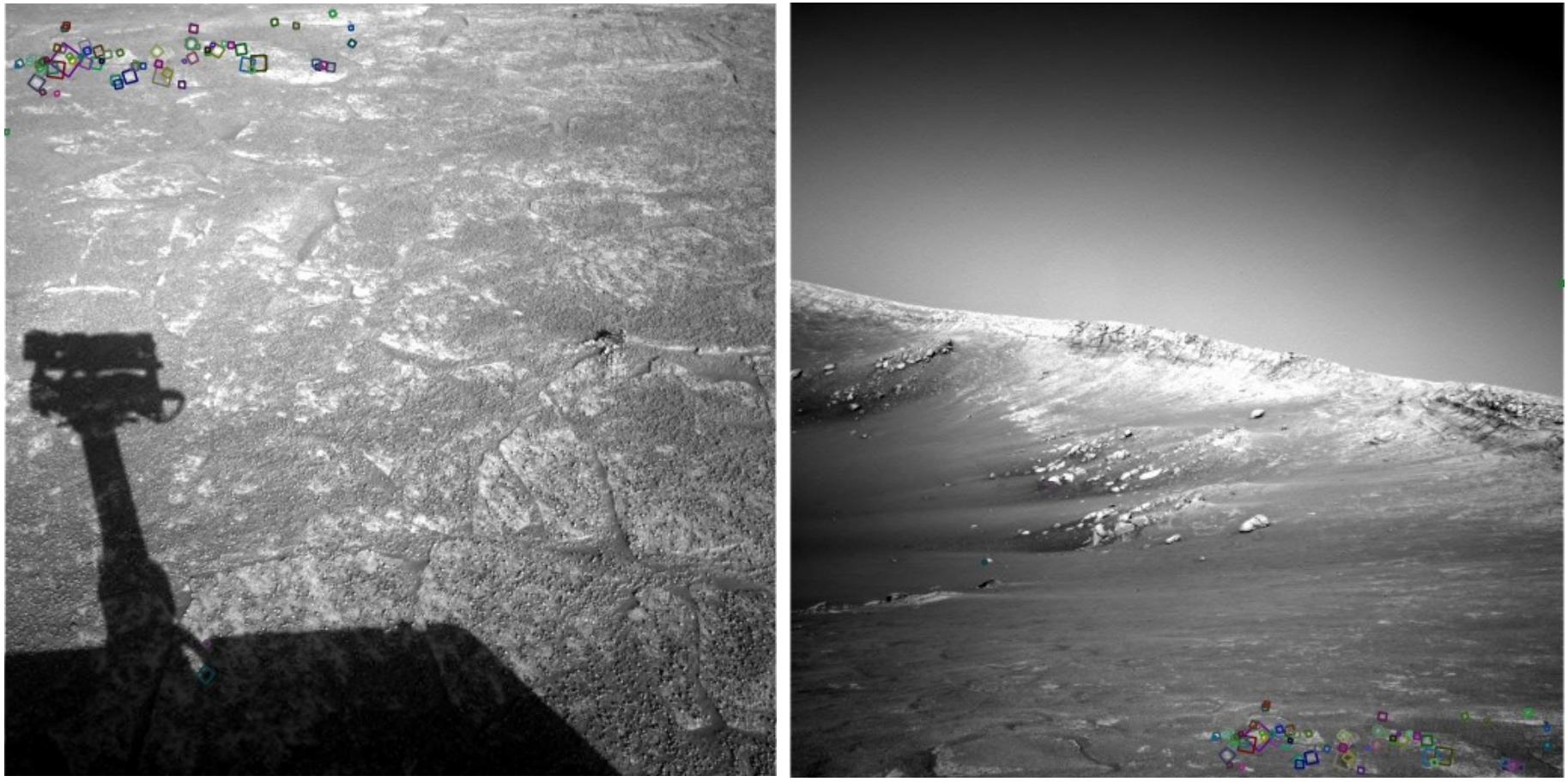
Application: Image Matching

Harder Still?



NASA Mars Rover images

Answer Below (Look for tiny colored squares)



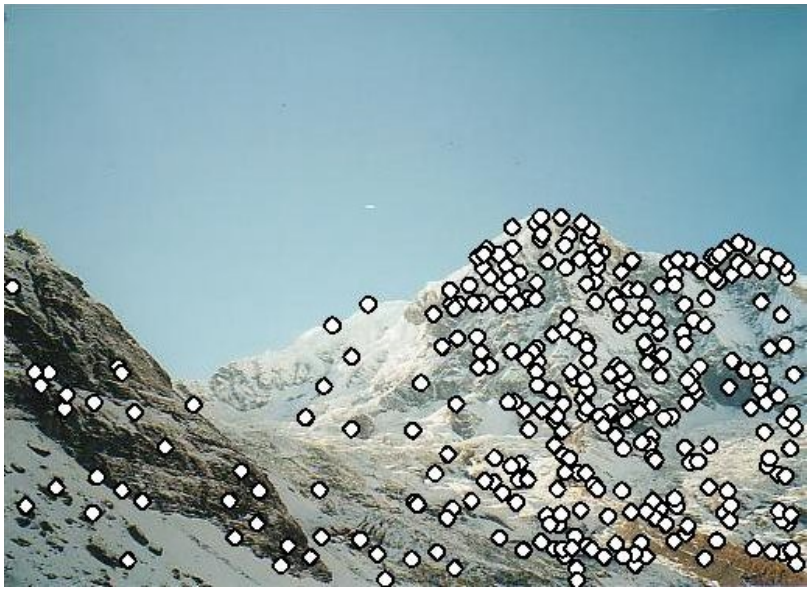
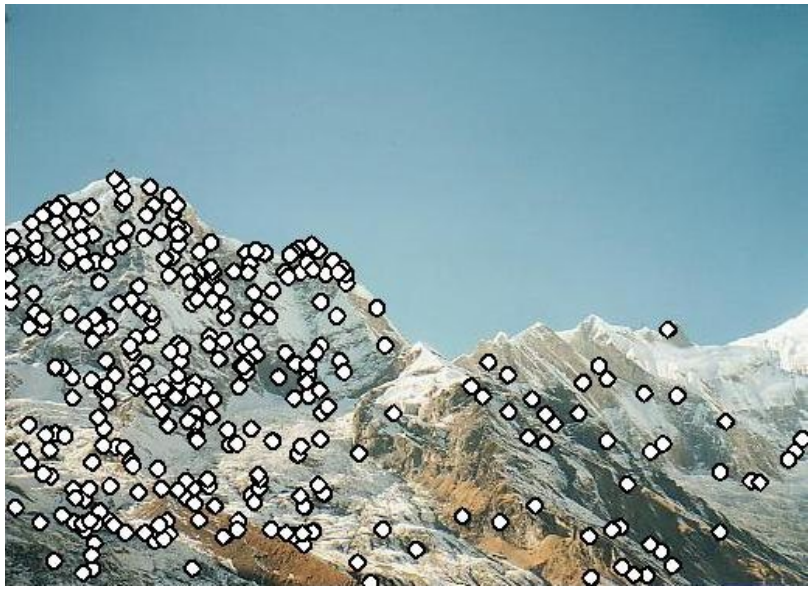
NASA Mars Rover images with SIFT feature matches (Figure by Noah Snavely)

More motivation…

- **Feature points are used also for:**
  - Image alignment (homography, fundamental matrix)
  - 3D reconstruction
  - Motion tracking
  - Indexing and database retrieval
  - Robot navigation
  - … other

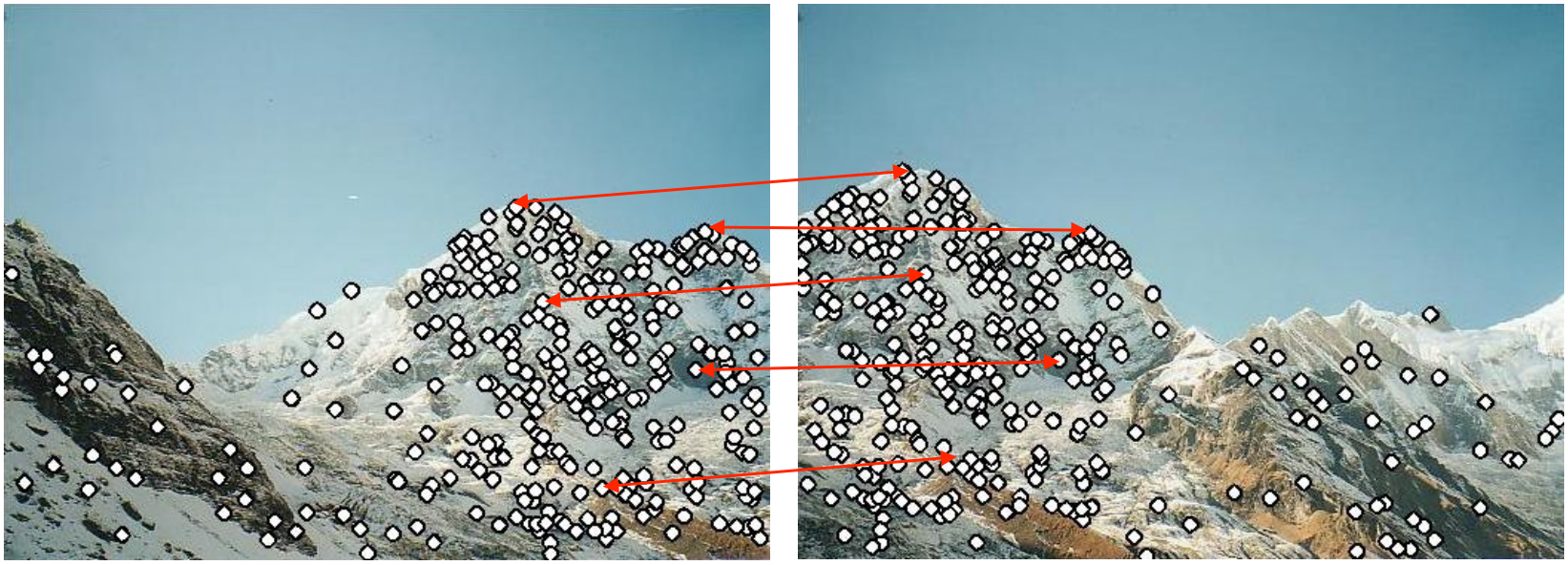
Application: Image Stitching

Application: Image Stitching

- **Procedure:**
  - Detect feature points in both images

Application: Image Stitching

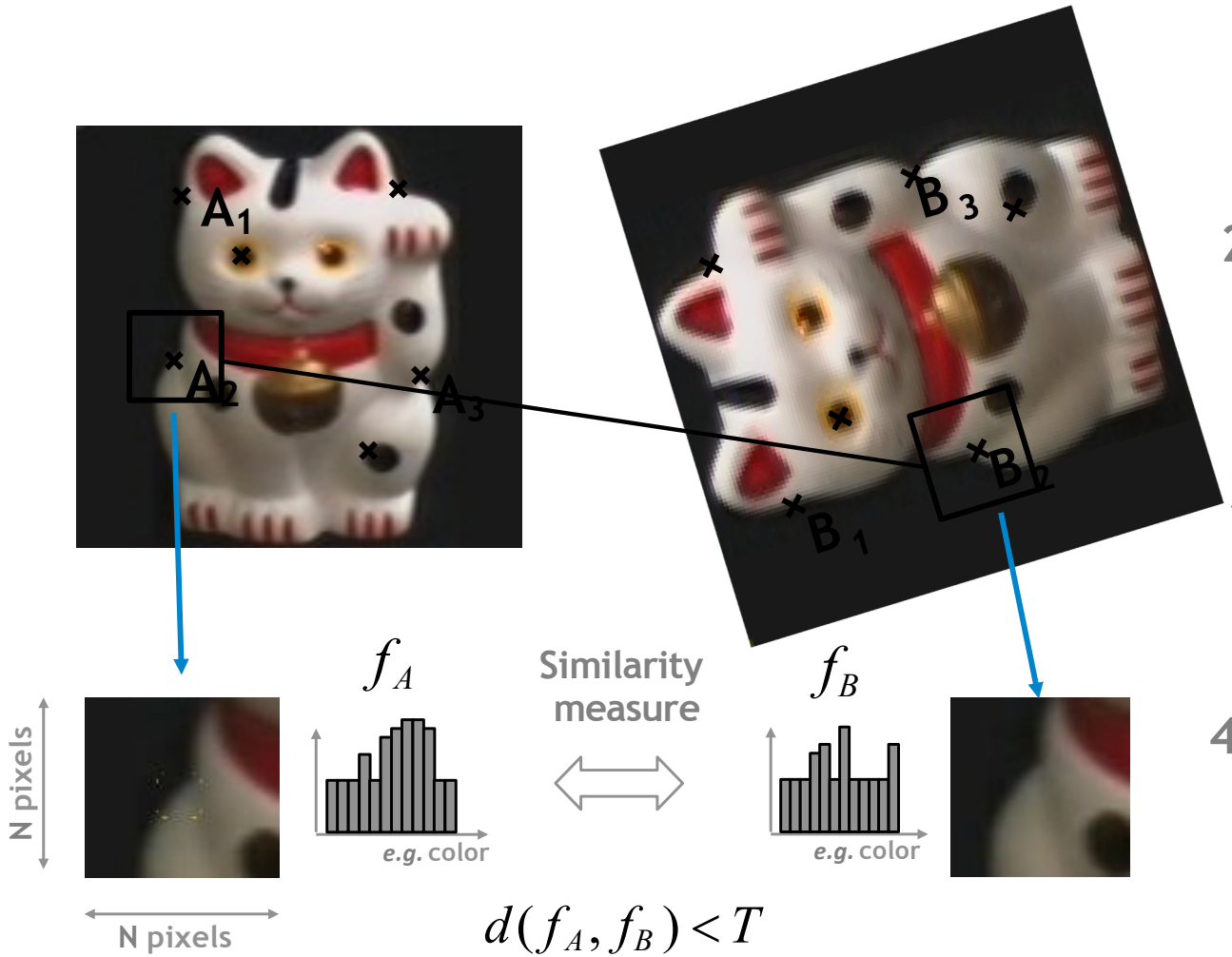


- **Procedure:**
  - Detect feature points in both images
  - Find corresponding pairs

Application: Image Stitching

- **Procedure:**
  - Detect feature points in both images
  - Find corresponding pairs
  - Use these pairs to align the images

General Approach



1. Find a set of distinctive keypoints (interest points)
2. Define a region around each keypoint (interest point)
3. Extract and normalize the region content
4. Compute a local descriptor from the normalized region
5. Match local descriptors

Common Requirements

- **Problem 1:**

  Detect the same point *independently* in both images

No chance to match!

We need a repeatable detector!

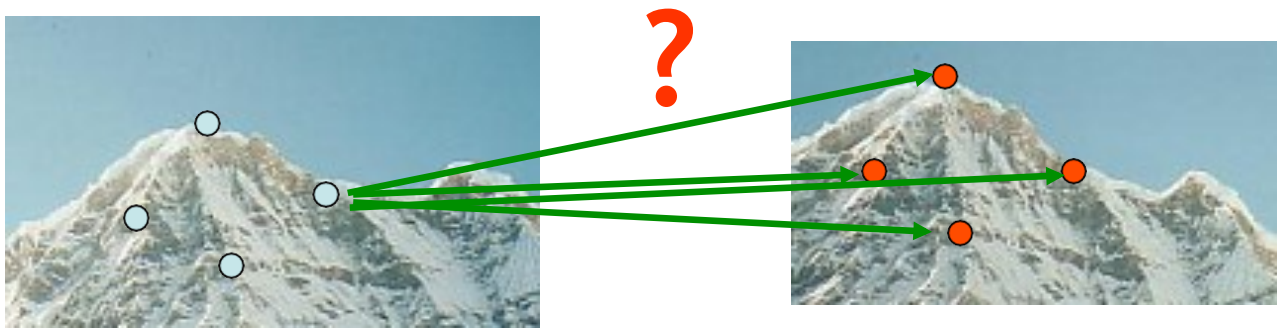
Common Requirements

- **Problem 1:**

  Detect the same point *independently* in both images

- **Problem 2:**

  For each point correctly recognize the corresponding one



We need a reliable and distinctive descriptor!

Local Feature Requirements

- **Region extraction needs to be repeatable and**
  - Invariant to translation, rotation, scale changes
  - Robust or covariant to out-of-plane (≈affine) transformations
  - Robust to lighting variations, noise, blur, quantization
- **Locality: Features are local, therefore robust to occlusion and clutter.**
- **Quantity: We need a sufficient number of regions to cover the object.**
- **Distinctiveness: The regions should contain "interesting" structure.**
- **Efficiency: Close to real-time performance.**

Many Detectors Available

Harris	[Harris '88]
Laplacian, DoG	[Lindeberg '98], [Lowe 1999]
Harris-/Hessian-Laplace	[Mikolajczyk & Schmid '01]
MSER	[Matas '02]
FAST	Rosten '10]
BRIEF	[Calonder '10]
ORB	[Rublee '12]
Others…	

These detectors have become a basic building block for many applications in Computer Vision.

Next Lecture

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