COLLEGE OF ENGINEERING
ELECTRICAL ENGINEERING & COMPUTER SCIENCE
UNIVERSITY OF MICHIGAN

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Case Study for Geometric Invariance
Local Image Features

EECS 442 Computer Vision

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Materials on these slides have come from many sources in addition to myself; specific sources are cited on each slide.

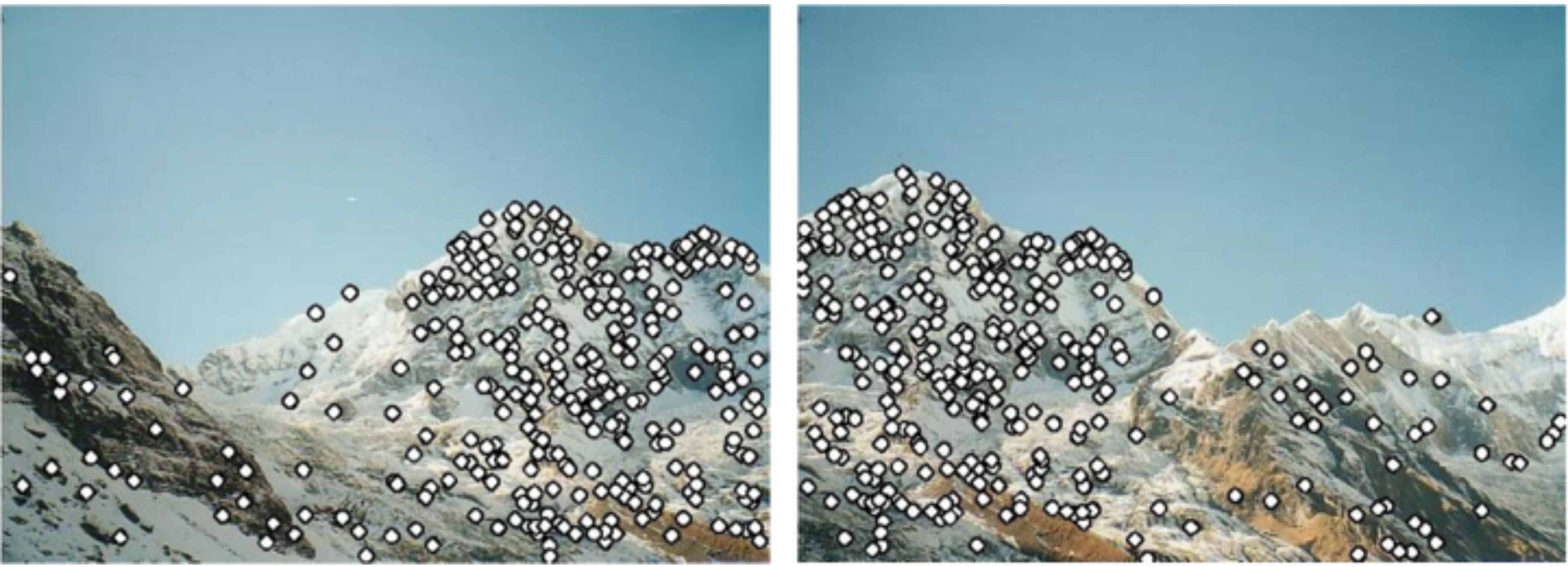
Plan

- What are local image features and why are they useful.
- Local Image Feature Detection
- Invariance
- Local Image Feature Description

Consider an Application: Image Stitching

Sources for this example: I. Kokkinos, D. Frolova, D. Simakov.

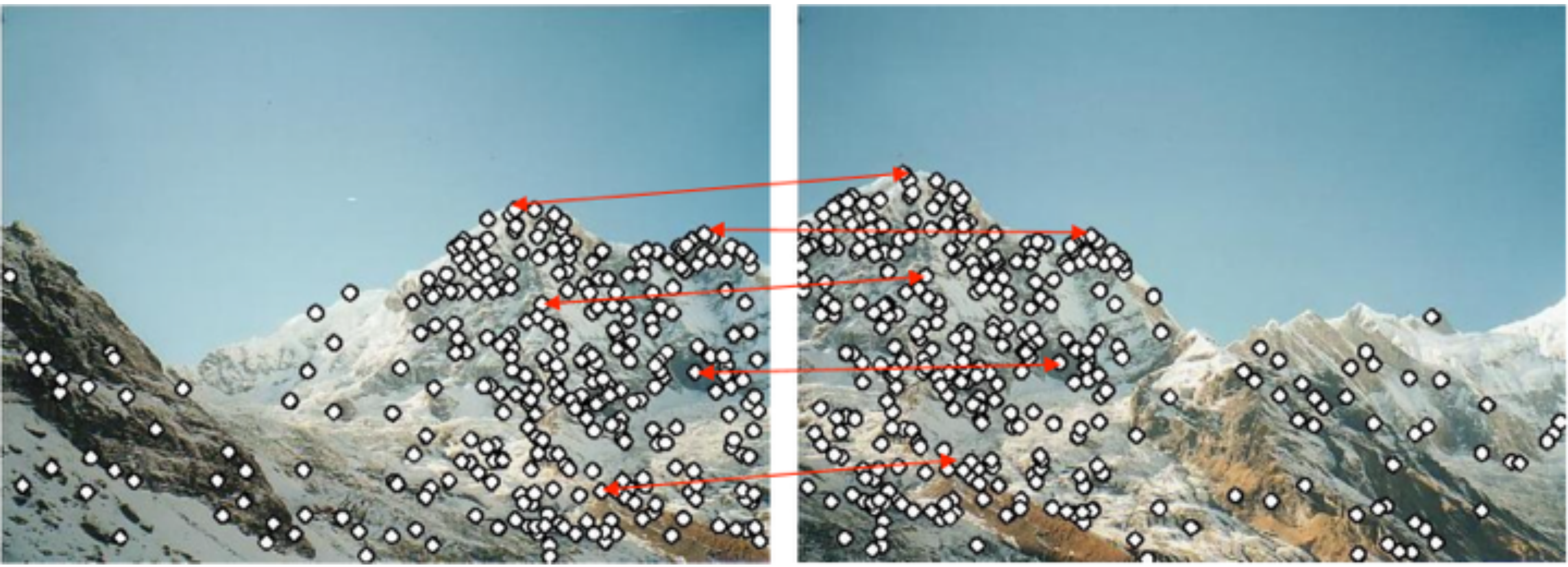
Consider an Application: Image Stitching



1. Detect feature points in both images.

Sources for this example: I. Kokkinos, D. Frolova, D. Simakov.

Consider an Application: Image Stitching



1. Detect feature points in both images.
2. Find corresponding pairs of feature points.

Sources for this example: I. Kokkinos, D. Frolova, D. Simakov.

Consider an Application: Image Stitching

1. Detect feature points in both images.
2. Find corresponding pairs of feature points.
3. Use the pairs to align the images.

Sources for this example: I. Kokkinos, D. Frolova, D. Simakov.

Consider an Application: Image Stitching

1. Detect feature points in both images. **Reduction**
2. Find corresponding pairs of feature points. **Matching**
3. Use the pairs to align the images. **Estimation**

Sources for this example: I. Kokkinos, D. Frolova, D. Simakov.

What invariants do we care about here?

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   1. Shift or Translation
   2. Scale? Rotation?
   3. Affine?
   4. Viewpoint?

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1. Geometric Invariants
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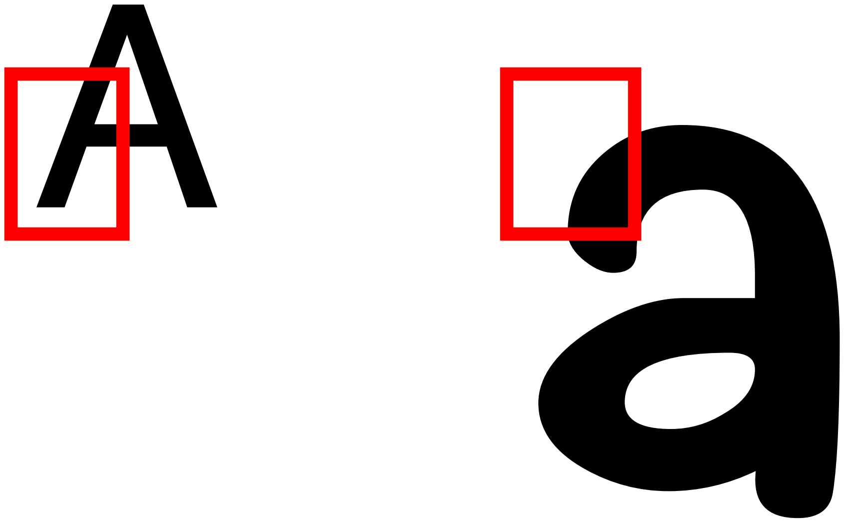
2. Scene layout?
3. Photometric invariants?

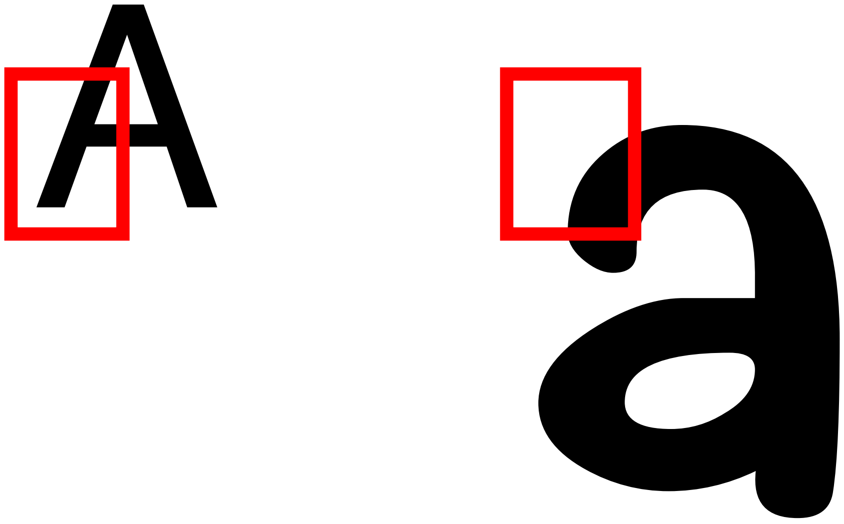
Consider an Application: Detect Object Instances



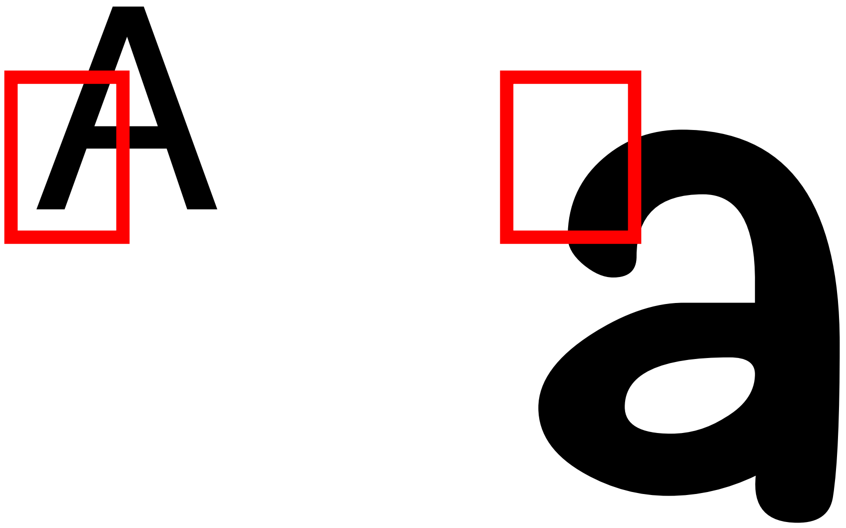
1. Detect feature points in both images.
2. Find corresponding pairs of feature points.
3. Use the pairs to match object instances.

Sources for this example: S. Savarese.

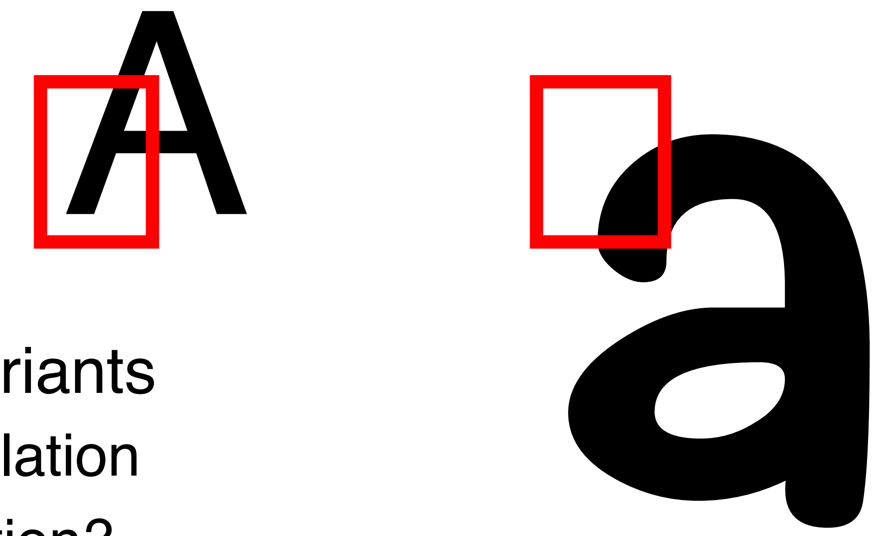
What invariants do we care about here?



What invariants do we care about here?



What invariants do we care about here?



1. Geometric Invariants
   1. Shift or Translation
   2. Scale? Rotation?
   3. Affine?
   4. Viewpoint?
2. Scene layout?
3. Photometric invariants?
4. Character shape invariance? “Font” invariance.

Case Study in Local Image Features

- Basic flow of applications in the case study

1. Detect feature points in both images.
2. Find corresponding pairs of feature points.
3. Use the pairs to solve objective function.

Case Study in Local Image Features

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1. Detect feature points in both images. **Reduction**
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Case Study in Local Image Features

- Basic flow of applications in the case study

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- Other applications of local image features
  - 3D reconstruction
  - Motion tracking
  - Object recognition
  - Indexing and database retrieval
  - Robot navigation

Advantages of local features

Locality

– features are local, so robust to occlusion and clutter

Distinctiveness:

– can differentiate a large database of objects

Quantity

– hundreds or thousands in a single image

Efficiency

– real-time performance achievable

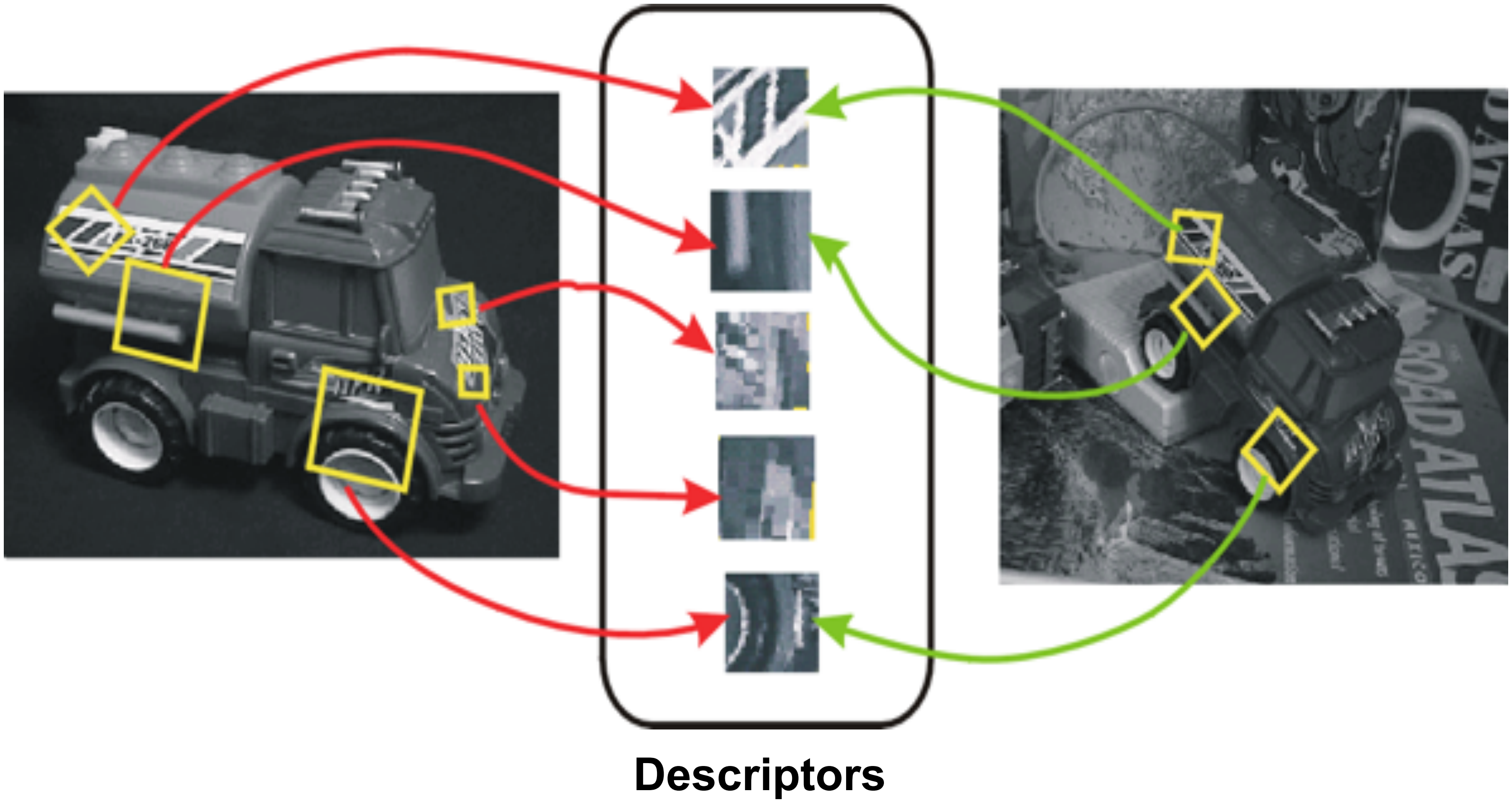
Generality

– exploit different types of features in different situations

Source: S. Seitz slides.

Challenges

- Repeatability
- Uniqueness
- Invariance w.r.t. Matching

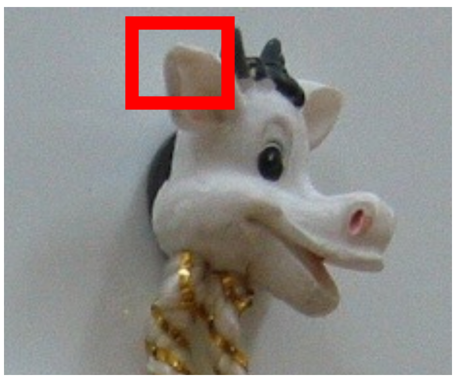


Sources for this example: I. Kokkinos, D. Frolova, D. Simakov, S. Seitz.

What makes a good feature?

Source for this example: S. Seitz.

Repeatability



Illumination invariance

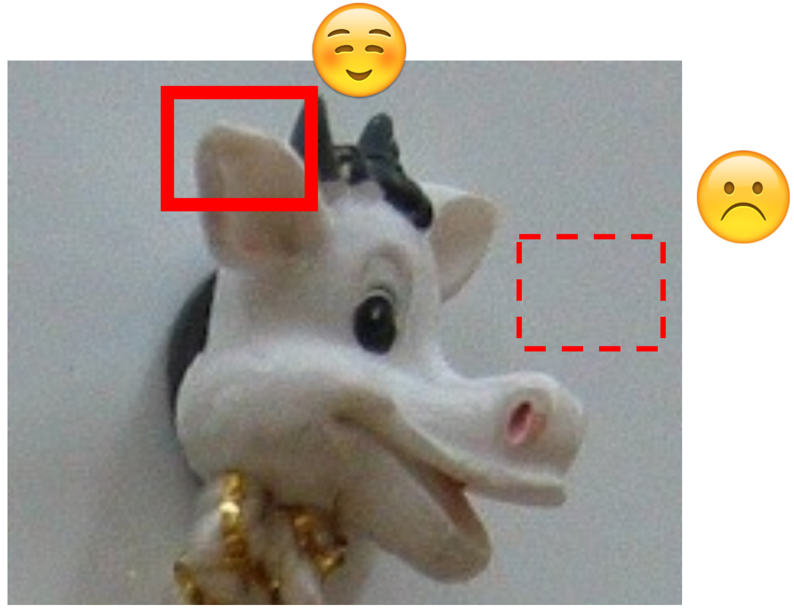
Scale invariance

Pose invariance

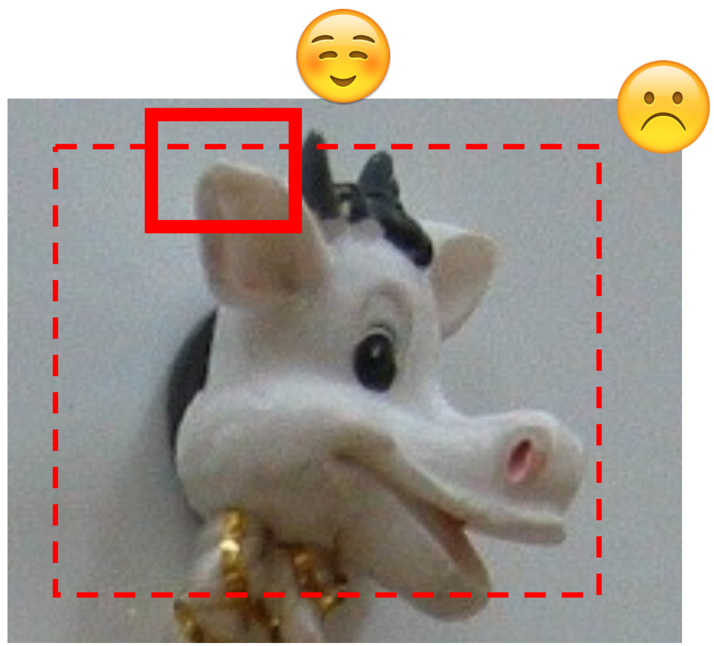
- Rotation
- Affine

Source for this example: Savarese.

- Saliency



- Locality



Source for this example: Savarese.

One criterion is uniqueness

Look for image regions that are unusual

– Lead to unambiguous matches in other images

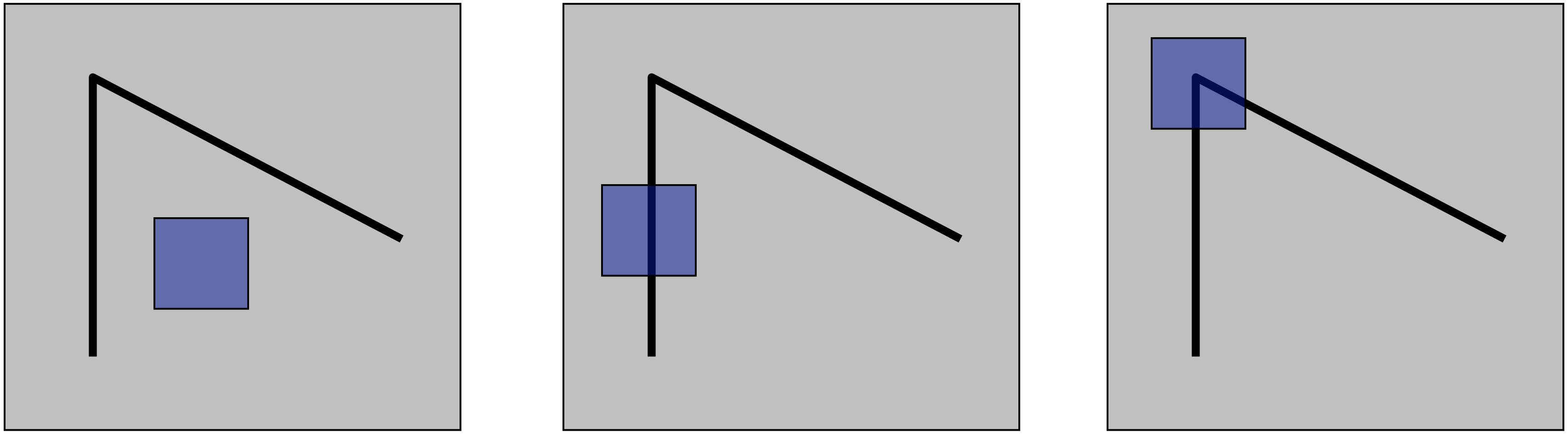
How to define “unusual”?

Source: S. Seitz.

Local measures of uniqueness

Suppose we only consider a small window of pixels

- What defines whether a feature is a good or bad candidate?

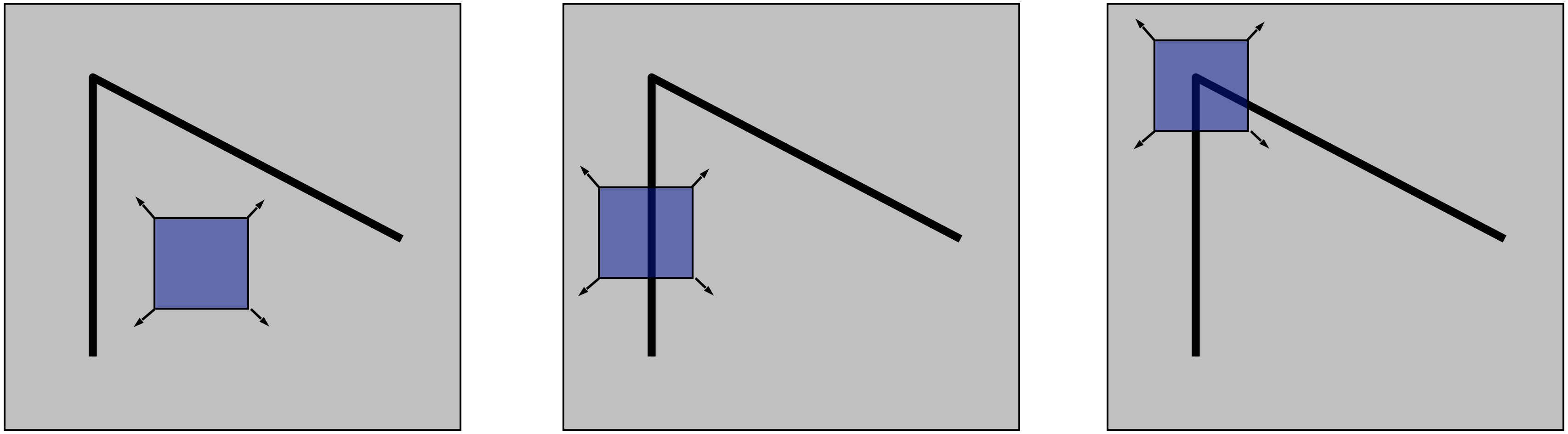


Sources: I. Kokkinos, D. Frolova, D. Simakov, S. Seitz.

Feature detection

Local measure of feature uniqueness

- How does the window change when you shift it?
- Shifting the window in *any direction* causes a *big change*



"flat" region:
no change in all directions

"edge":
no change along the edge direction

"corner":
significant change in all directions

Sources: I. Kokkinos, D. Frolova, D. Simakov, S. Seitz.

Stop Slides

See hand-written lecture notes for the mathematical derivation of the corner operator.