Recognizing objects

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CS1114

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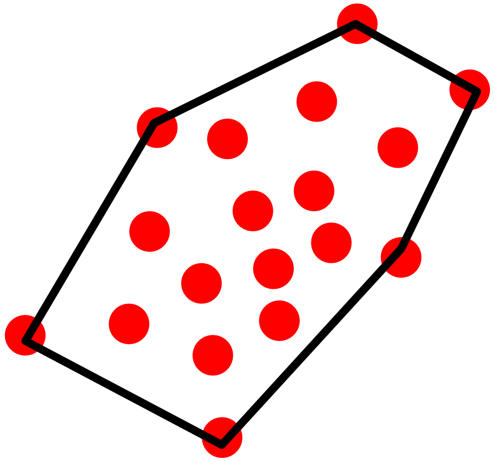
Cornell University
Computer Science

Administrivia

- Assignment 4 due on Friday
  - The first problem is tricky – please get started early!
- Quiz 4 next Tuesday, 3/31
- Prelim 2 in two weeks, 4/7 (in class)
  - Covers everything since Prelim 1
- Midterm course evaluations

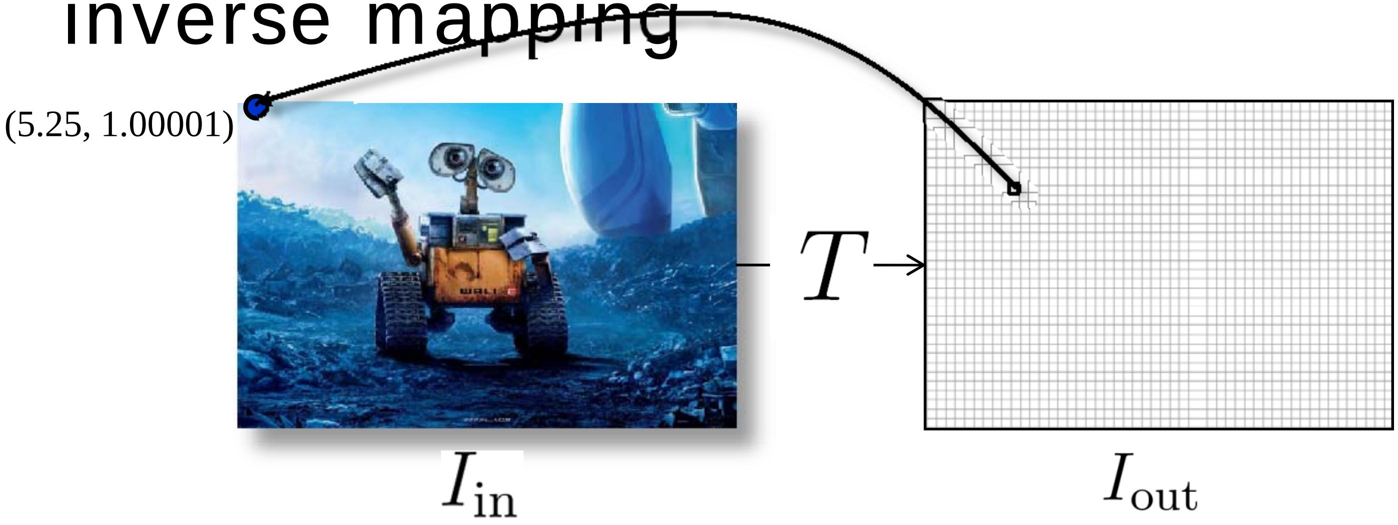
Convex hull

- The convex hull of a set of points is the *smallest* convex polygon that contains all of the points



Inverse mapping and bilinear interpolation

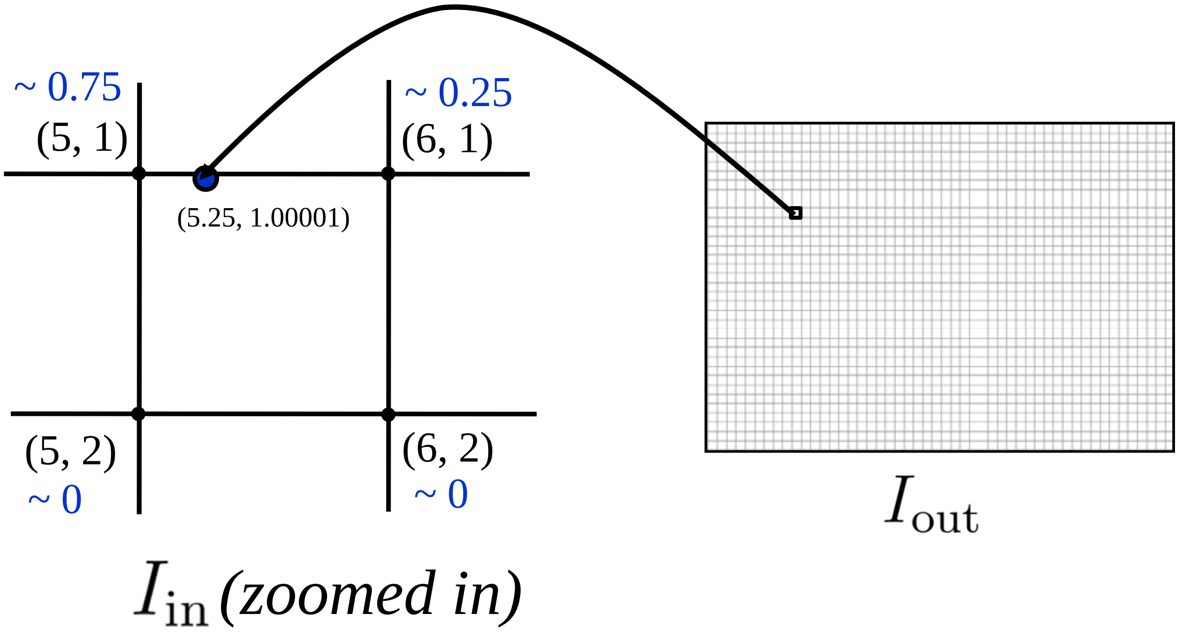
- Given an image I_{in} and a 2D transform T, compute the transformed image I_{out} using inverse mapping



- Given: $T^{-1}\begin{bmatrix} 10 \\ 10 \end{bmatrix} = \begin{bmatrix} 5.25 \\ 1.00001 \end{bmatrix}$

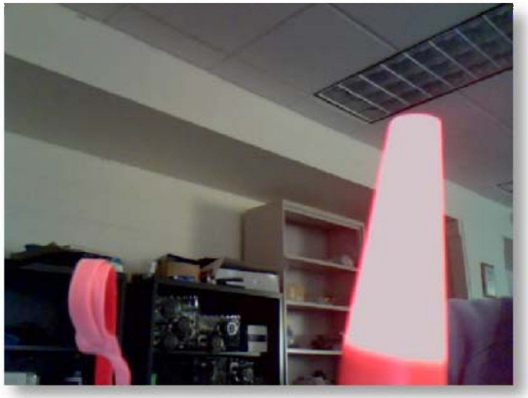
Inverse mapping and bilinear interpolation

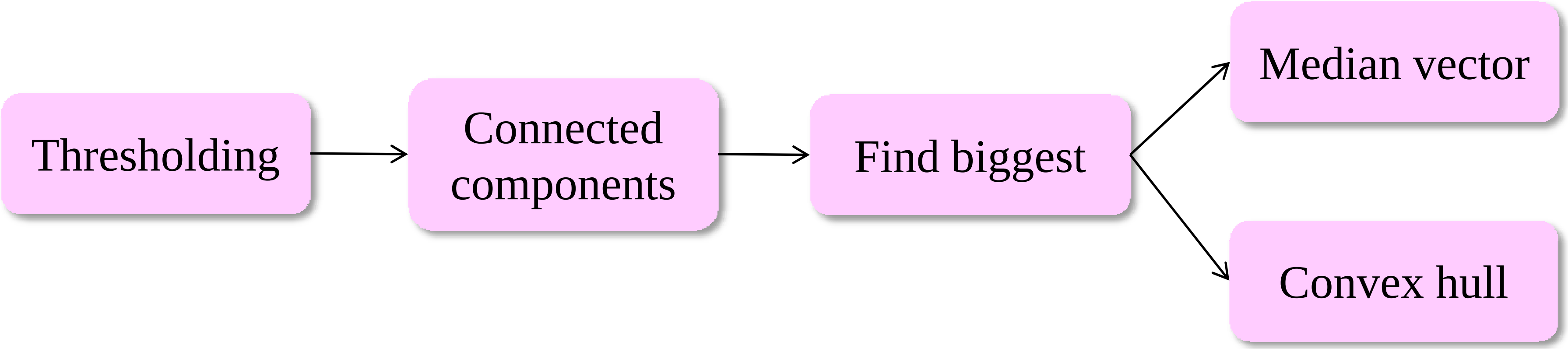
- Given: $T^{-1}\begin{bmatrix}10\\10\end{bmatrix}=\begin{bmatrix}5.25\\1.00001\end{bmatrix}$



Object recognition

- Our robots can now recognize this:





Thresholding

Connected components

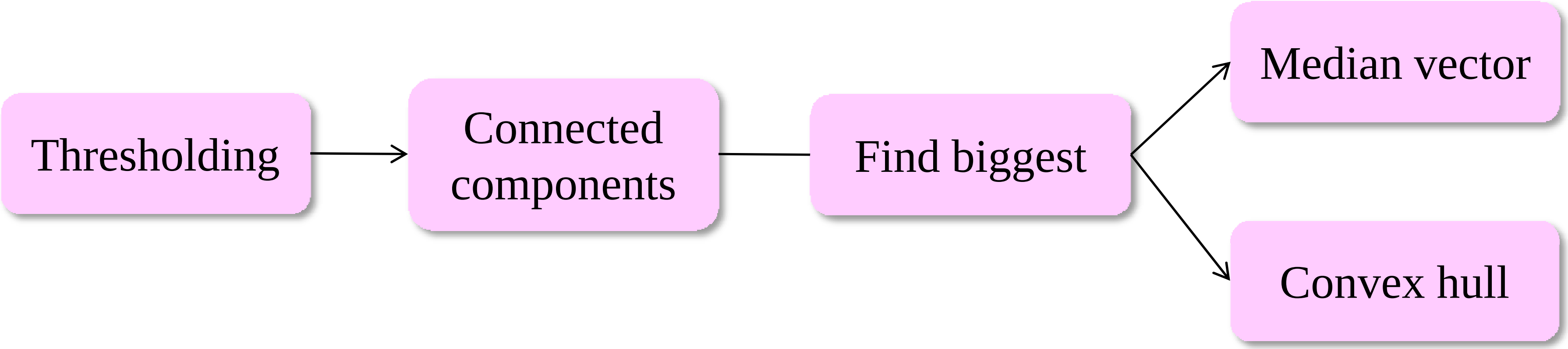
Find biggest

Median vector

Convex hull

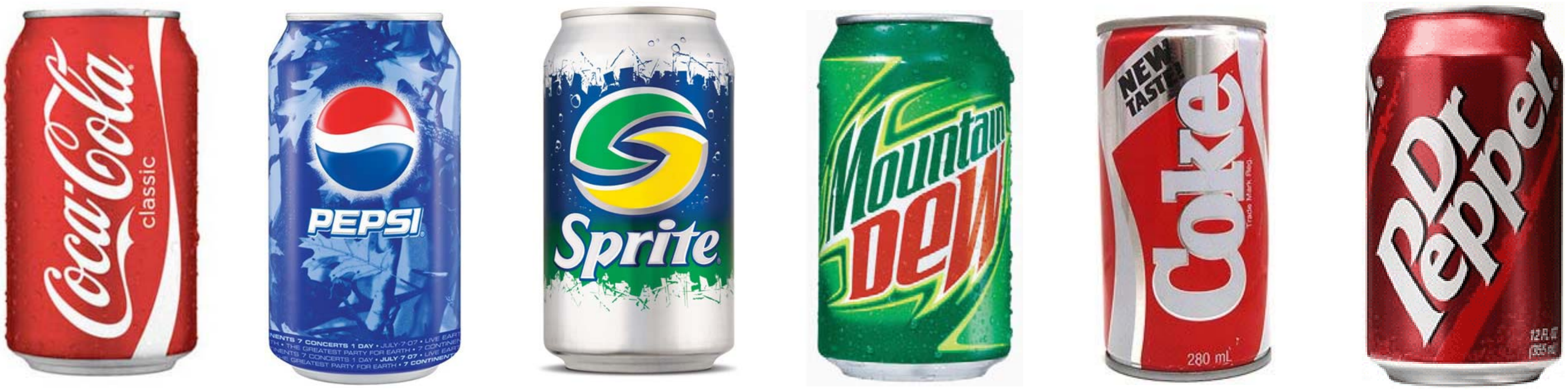
Object recognition

- What else can we recognize with this algorithm?



Object recognition

- Can we tell these objects apart?



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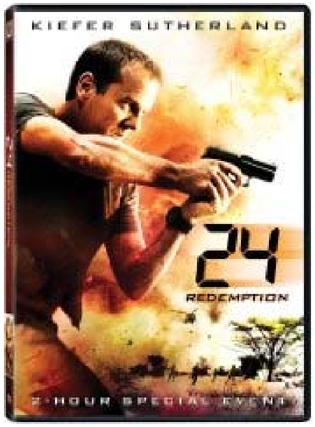
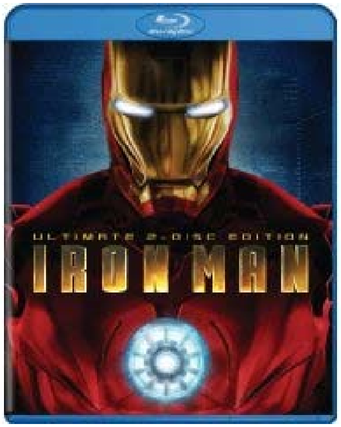
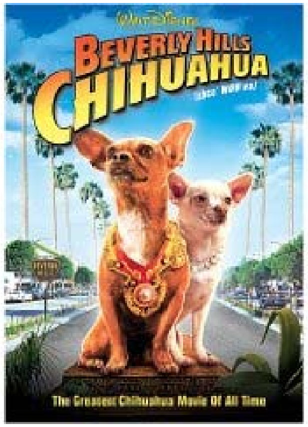
Object recognition

- How about these objects?







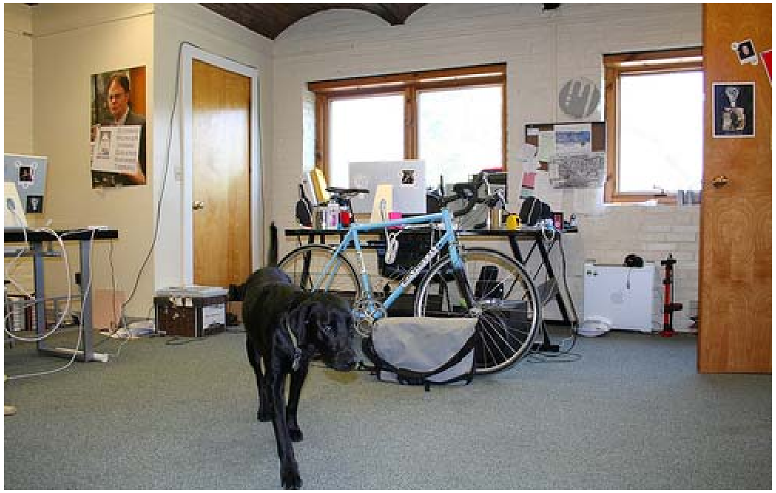
Object recognition

- For some objects **color** is a good feature to use for recognition
  - For instance, a bright red lightstick

- What other features might we use?

Object recognition

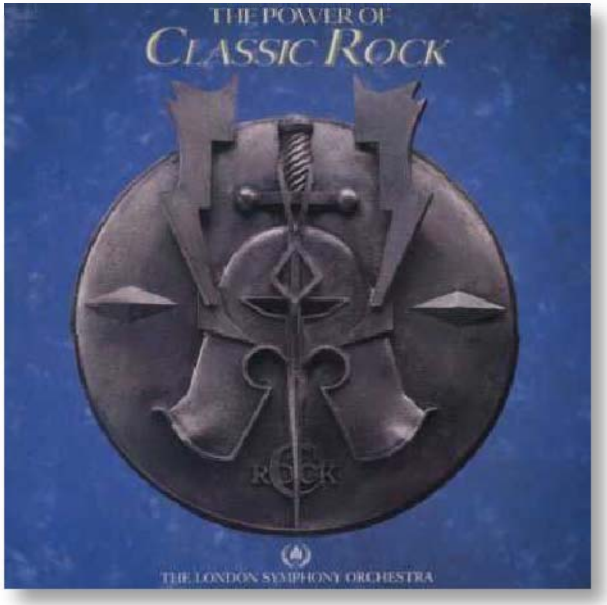
- The most general form involves recognizing all of the different *types* of objects in an image



- This problem is extremely difficult for computers

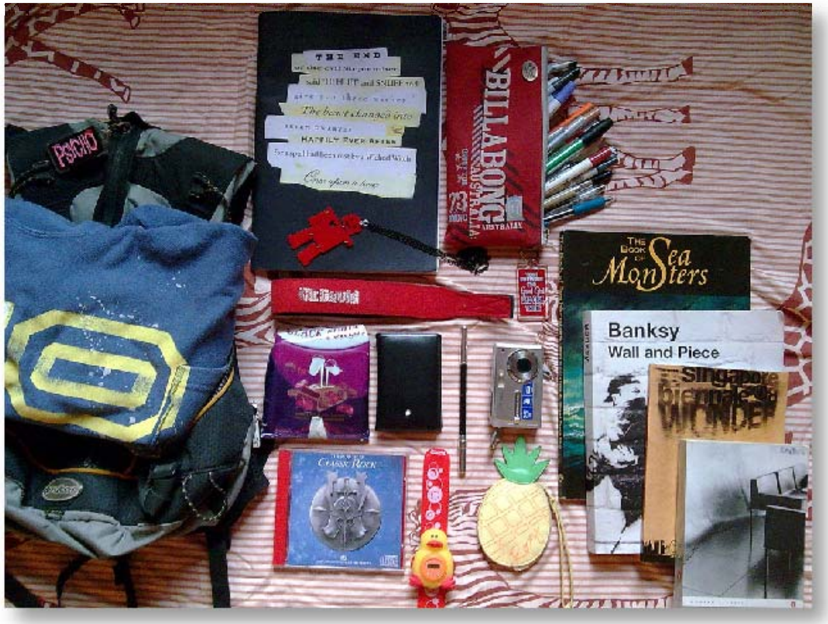
Easier problem

- Given an image of an object, can we find that object in another image?



template

?

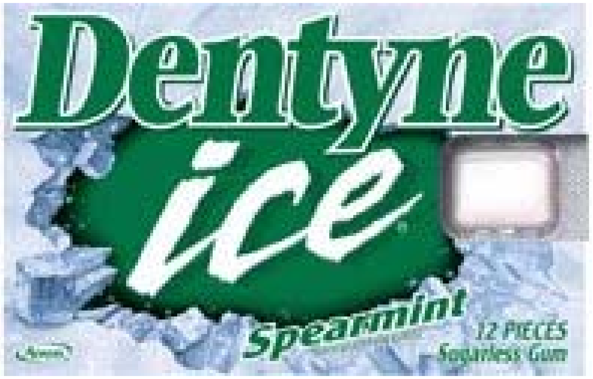


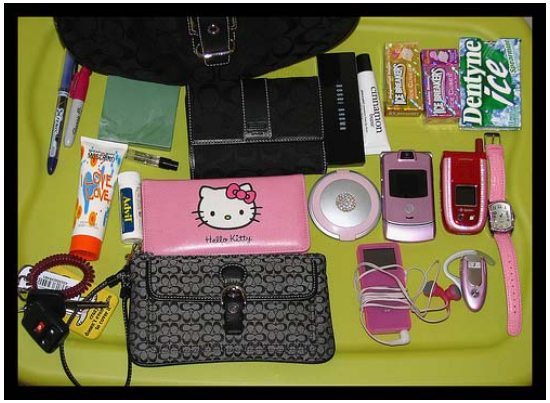
new image

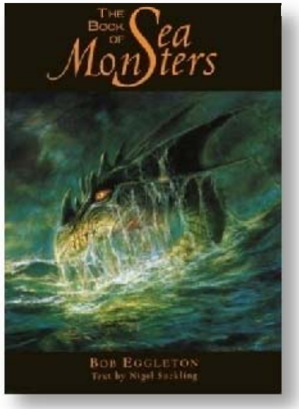
- How might we solve this problem?

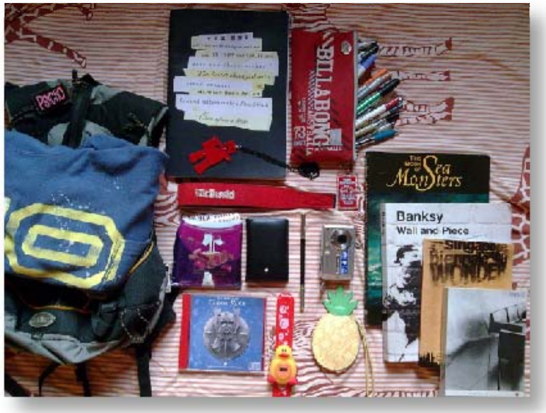
Finding specific objects

- What problems might come up?

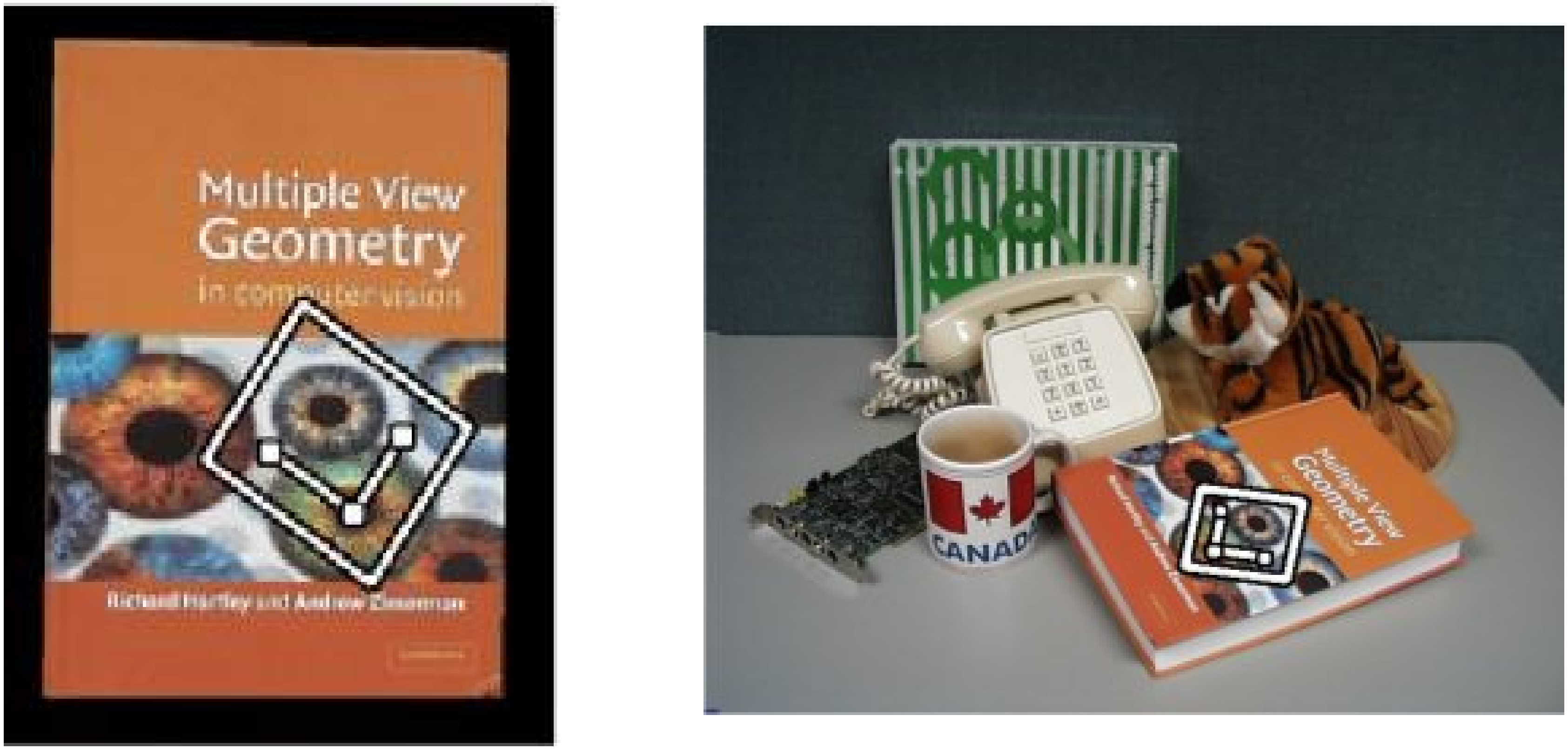






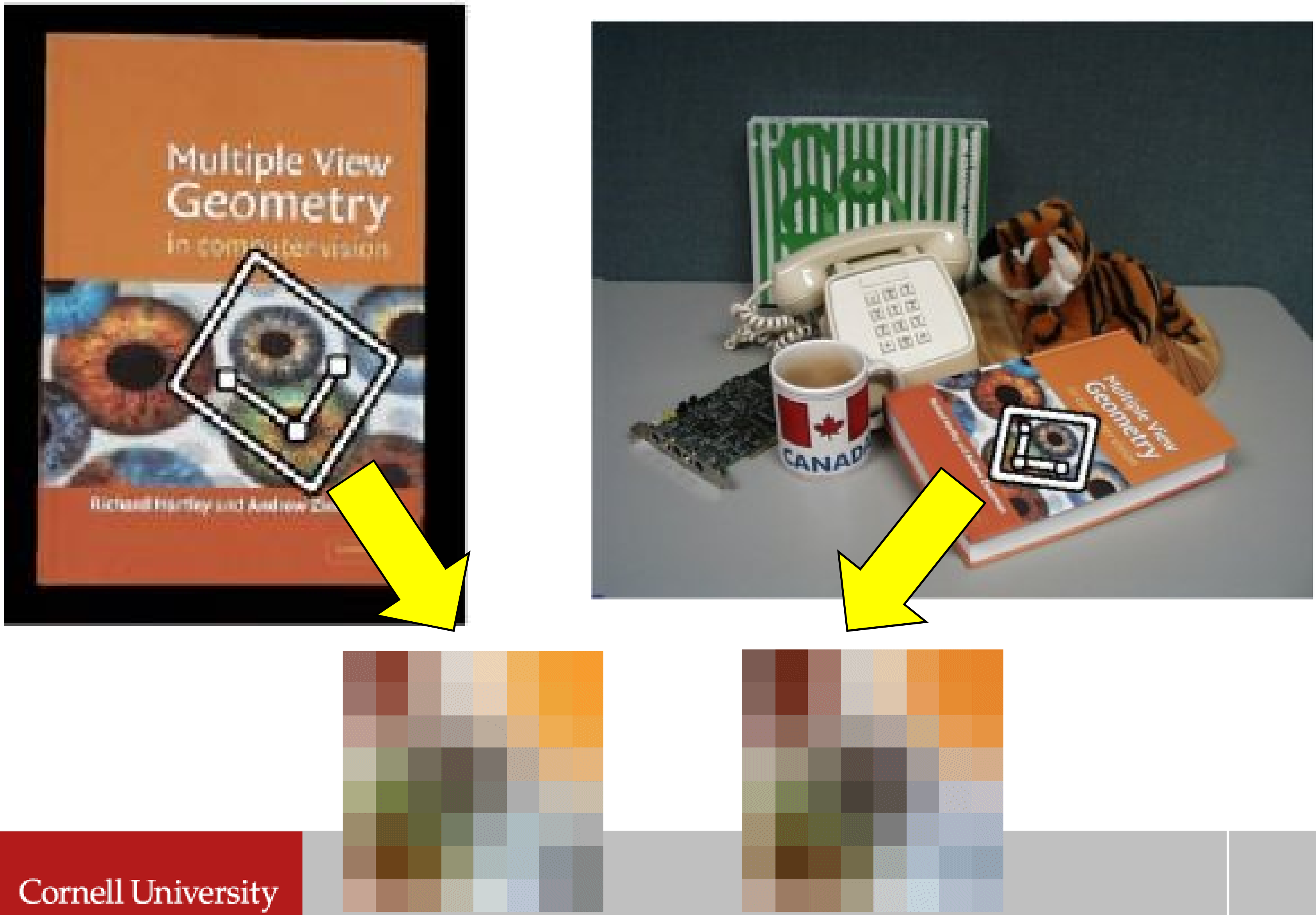


Feature-based image matching


Multiple View Geometry in computer vision
Richard Hartley and Andrew Zisserman
CANADA
Multiple View Geometry

(Slides courtesy Steve Seitz)

Feature-based image matching



What makes a good feature?

Snoop demo

(Slides courtesy Steve Seitz)

Want uniqueness

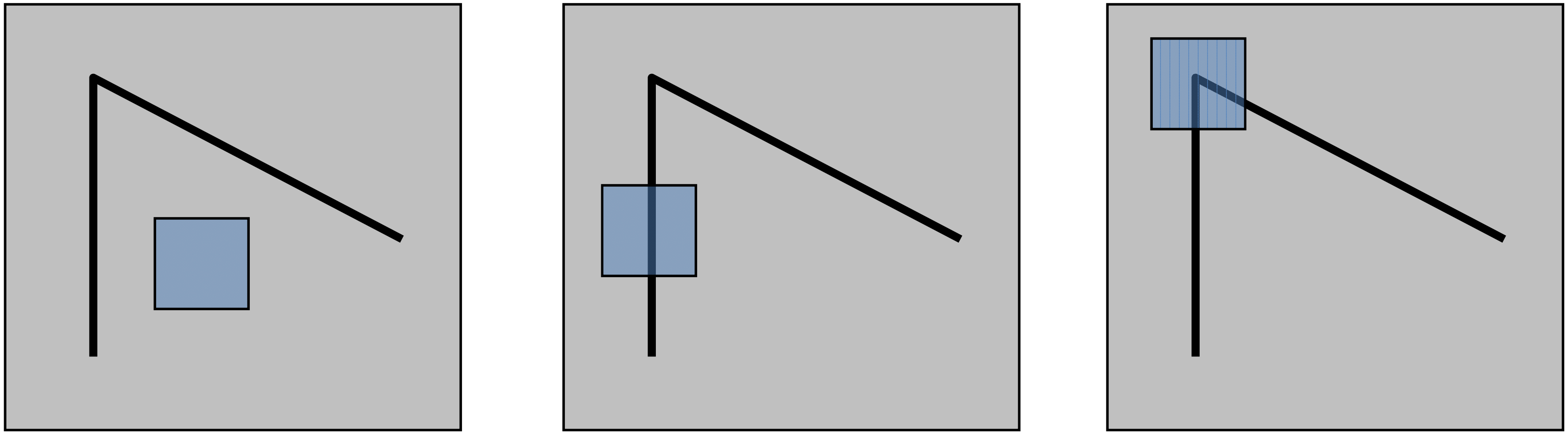
- Look for image regions that are unusual
  - Lead to unambiguous matches in other images

- How to define "unusual"?

(Slides courtesy Steve Seitz)

Local measures of uniqueness

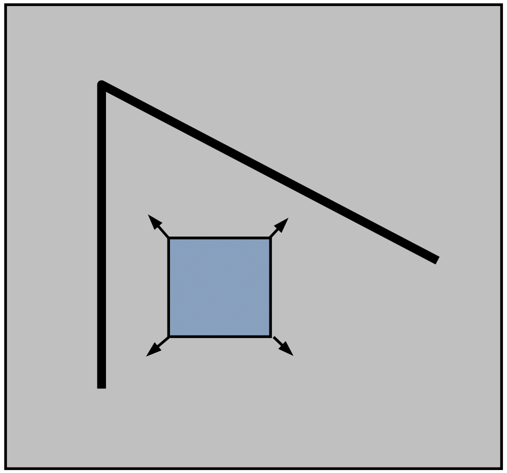
- Suppose we only consider a small window of pixels
  - What defines whether a feature is a good or bad candidate?



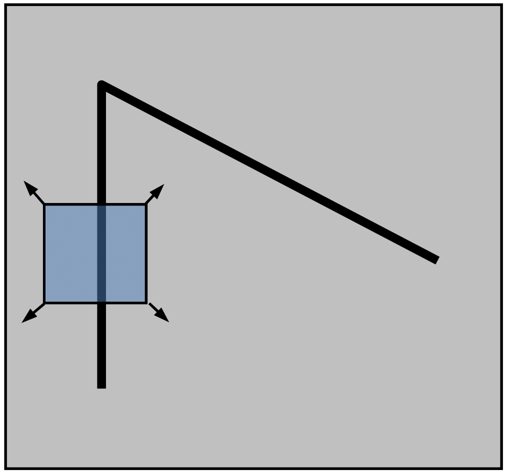
Slide adapted from Darya Frolova, Denis Simakov, Weizmann Institute.

Feature detection

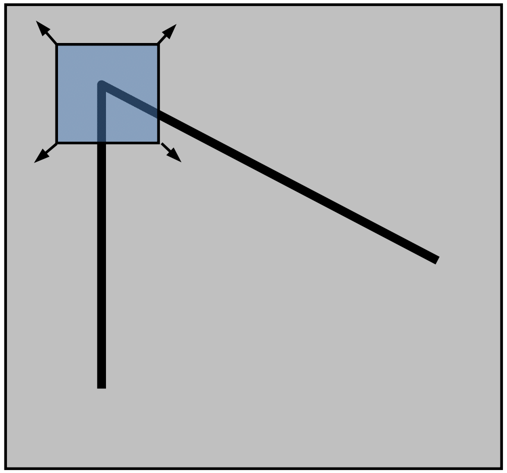
- Local measure of feature uniqueness
  - How does the window change when you shift it?
  - Shifting the window in *any direction* causes a *big change*



“flat” region:
no change in
all directions



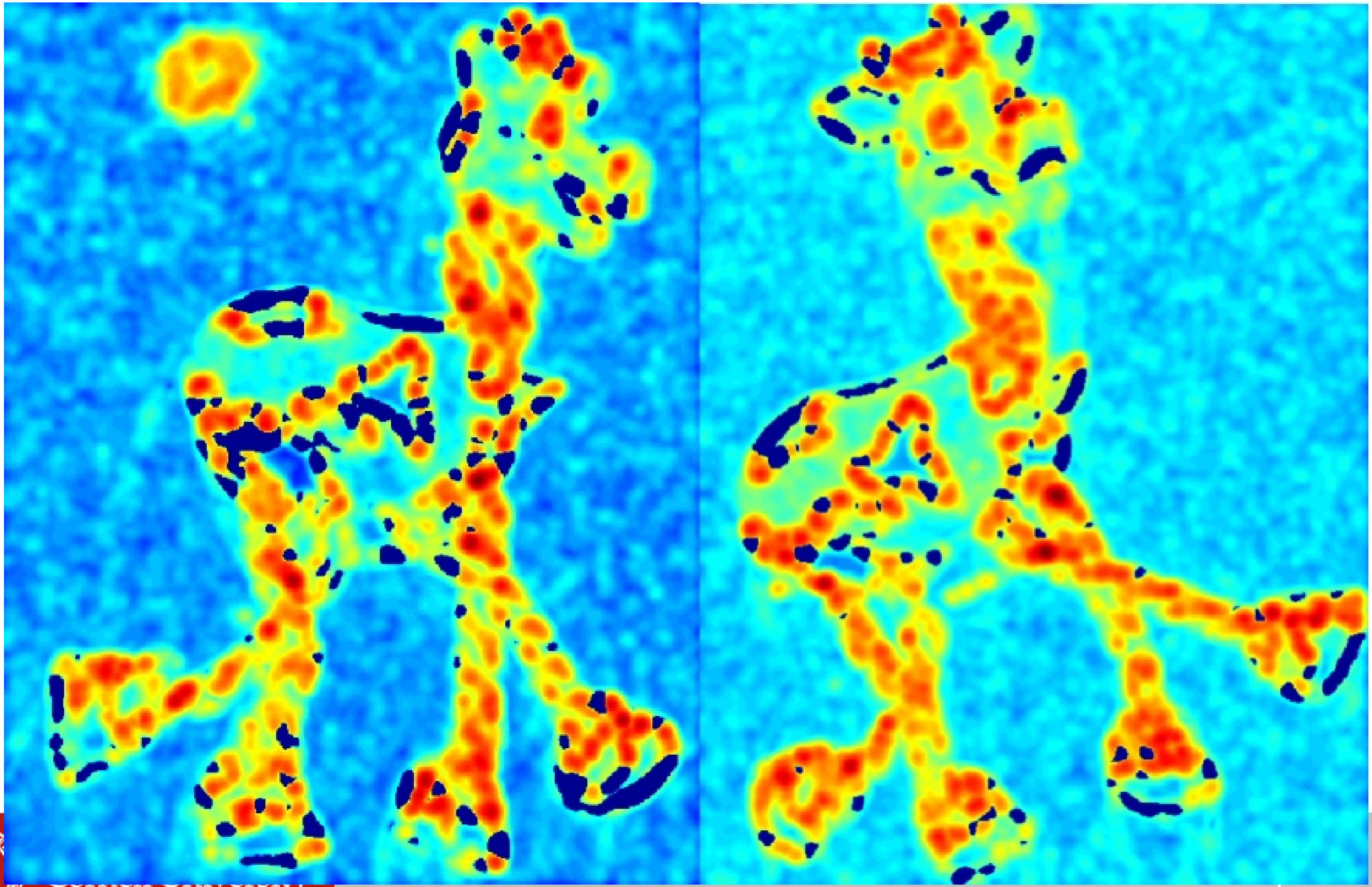
“edge”:
no change along
the edge direction



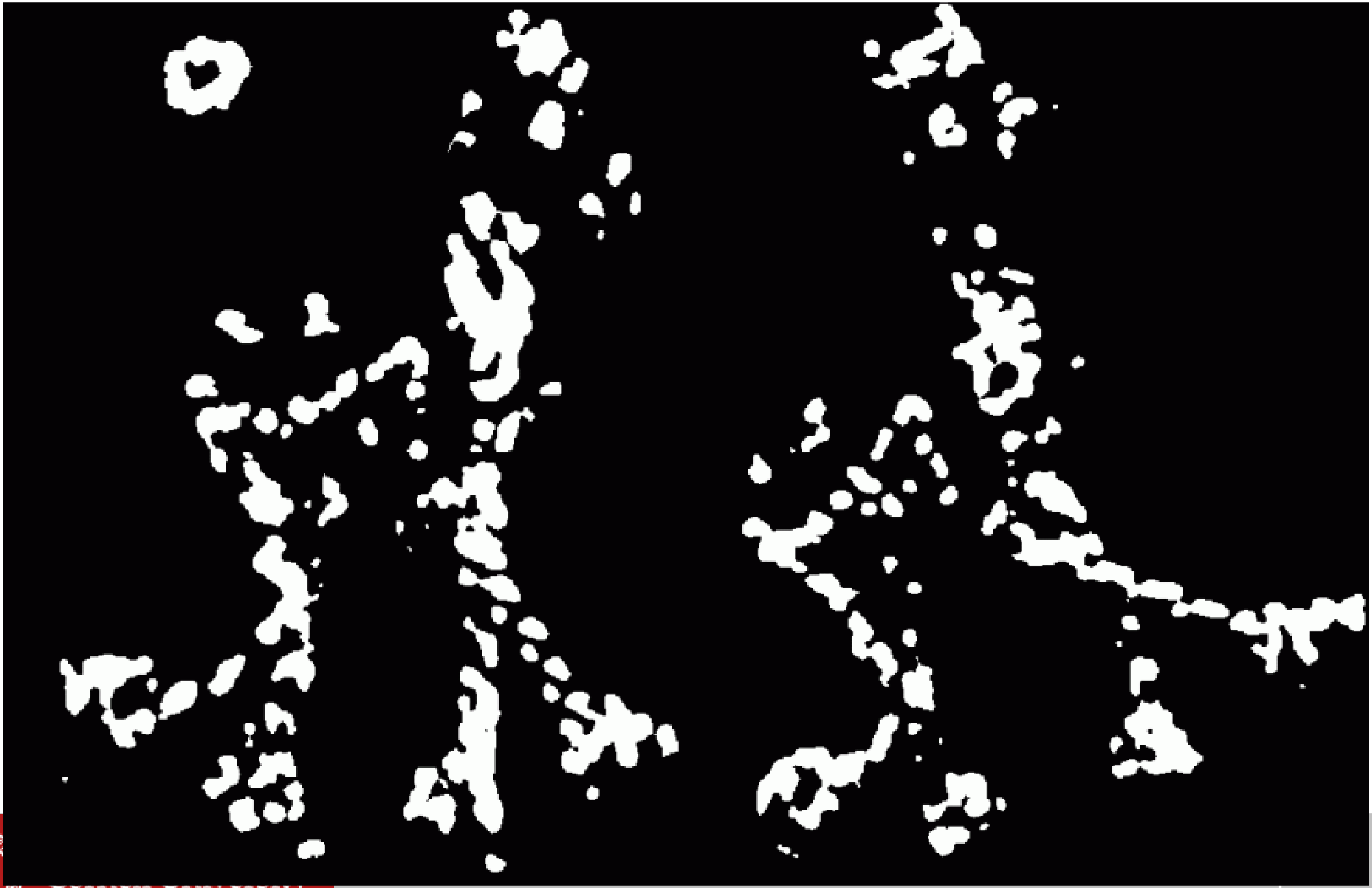
“corner”:
significant change
in all directions

Corner detector example

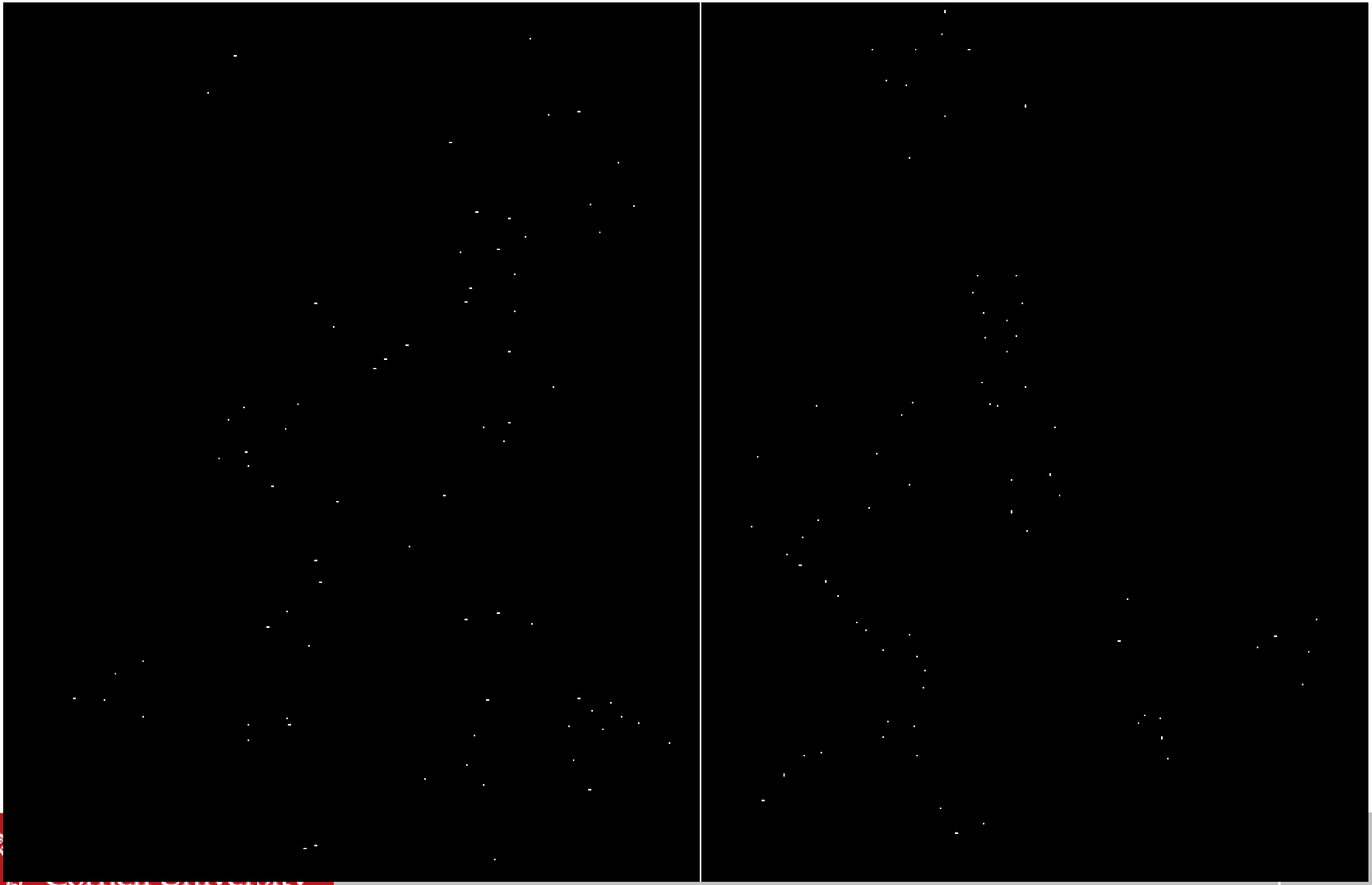
f value (red high, blue low)



Threshold (f > value)

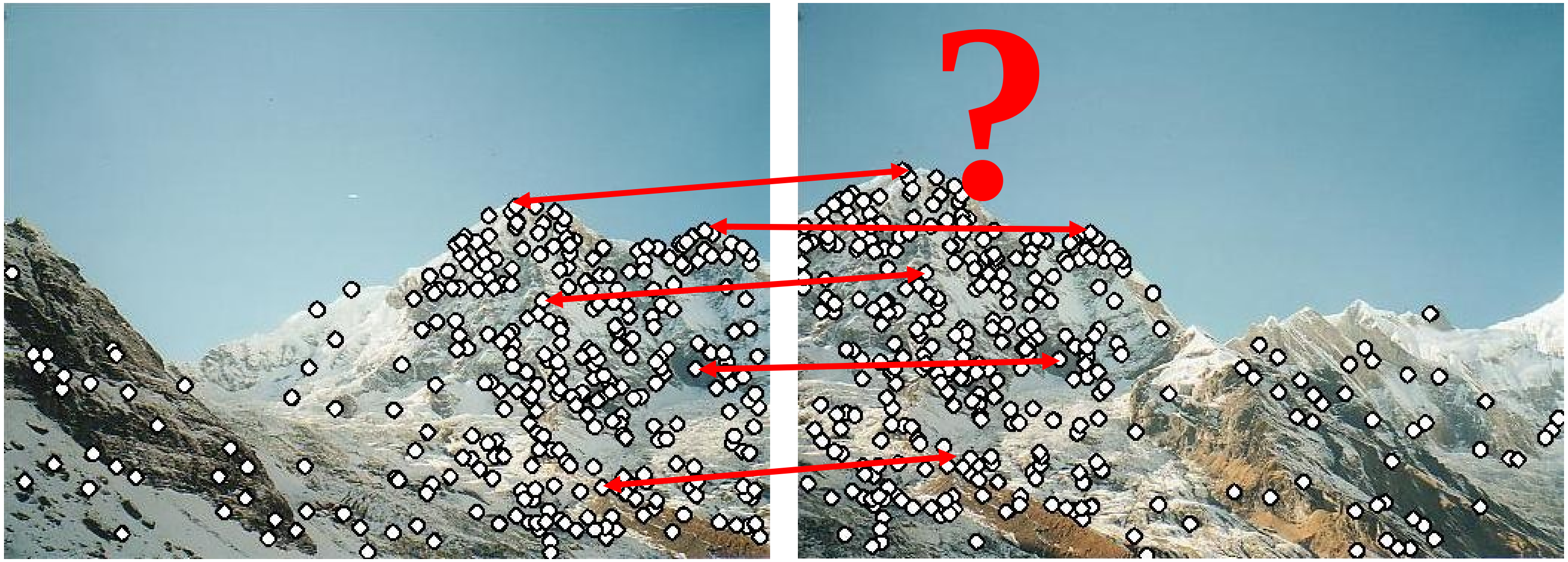


Find local maxima of f



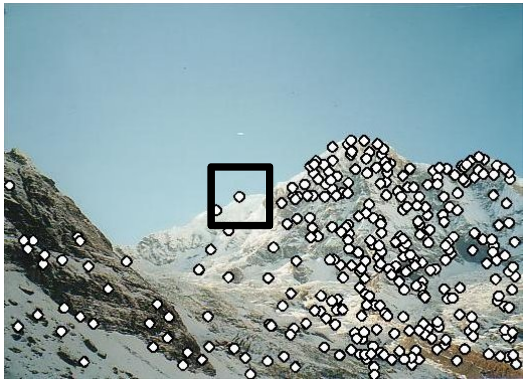
Feature descriptors

- We know how to detect good points
- Next question: **How do we match them?**



Matching feature points

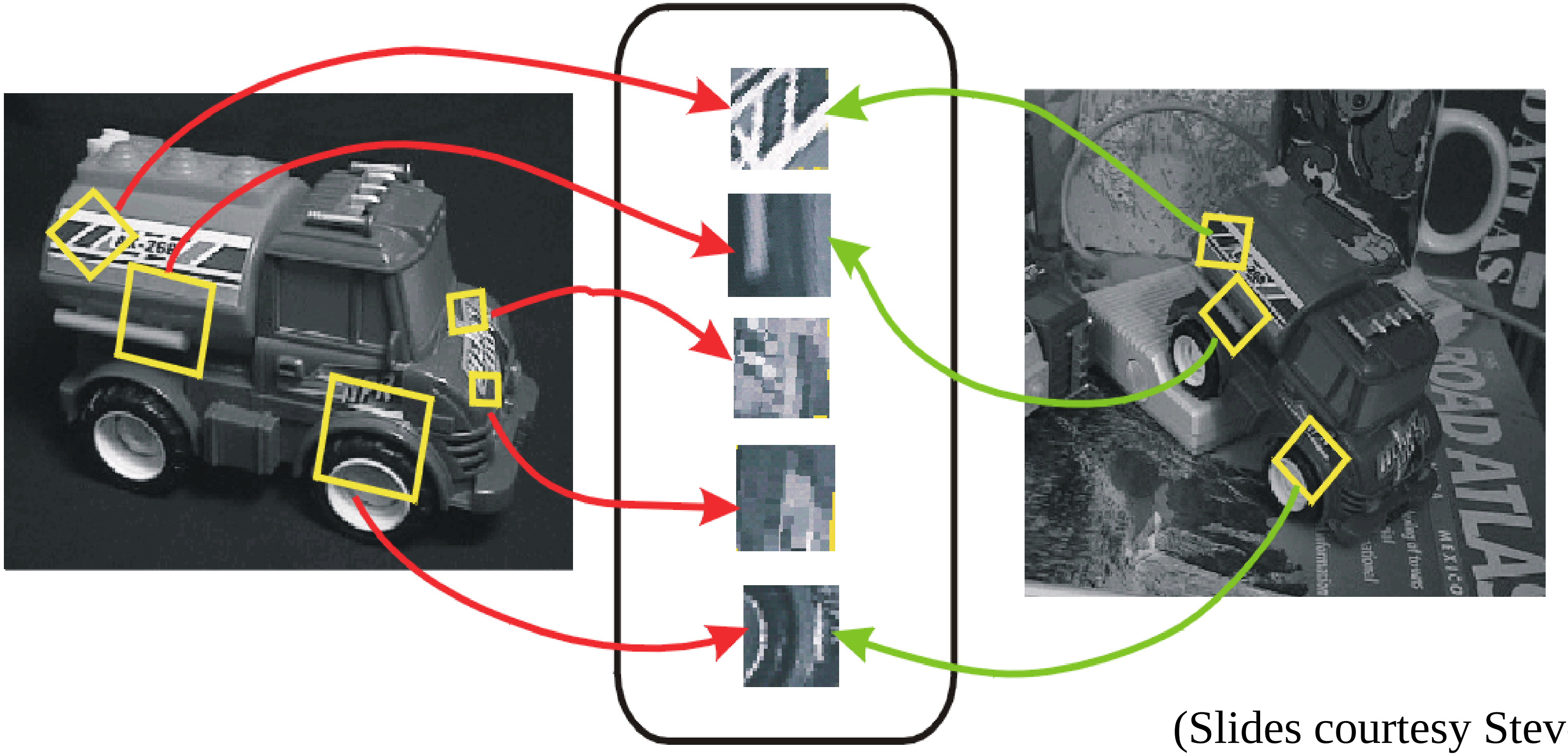
- How do we match features?
- Lots of possibilities
  - Simple option: match square windows around the point



  - State of the art approach: SIFT
    - David Lowe, UBC http://www.cs.ubc.ca/~lowe/keypoints/

Invariant local features

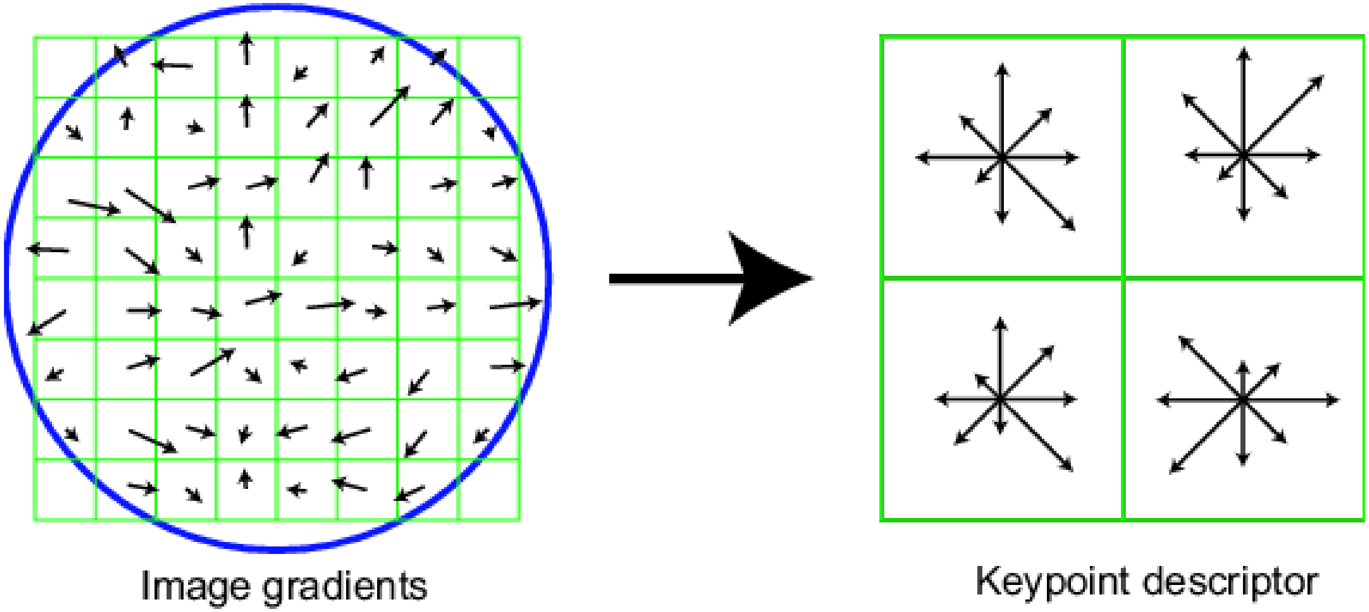
- Find features that are invariant to transformations
  - geometric invariance: translation, rotation, scale
  - photometric invariance: brightness, exposure, …



(Slides courtesy Steve Seitz)

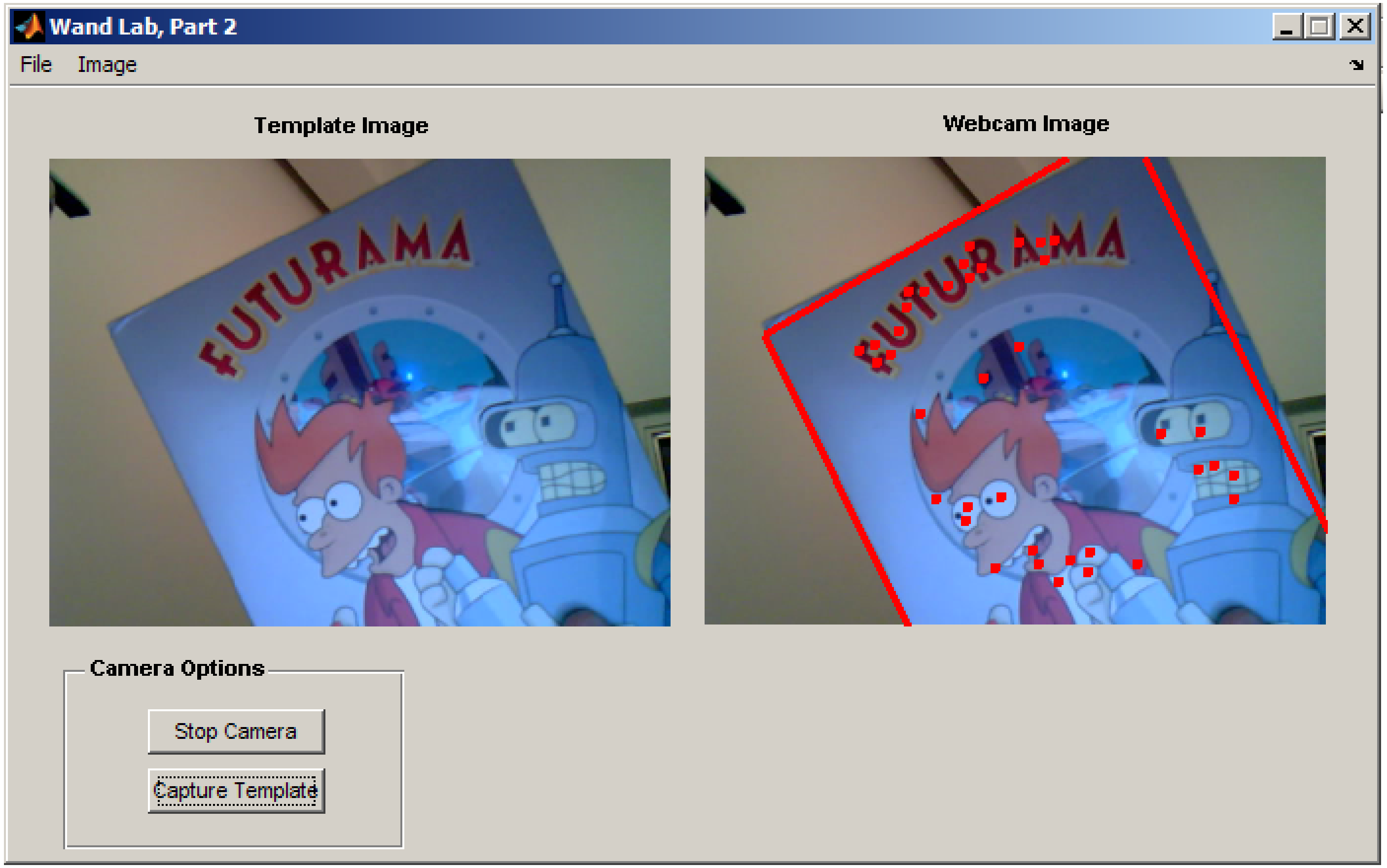
SIFT descriptor

- Very complicated, but very powerful
- (The details aren’t all that important for this class.)
- 128 dimensional descriptor



Adapted from a slide by David Lowe

SIFT demo



Wand Lab, Part 2
File
Image
Template Image
Webcam Image
FUTURAMA
Camera Options
Stop Camera
Capture Template