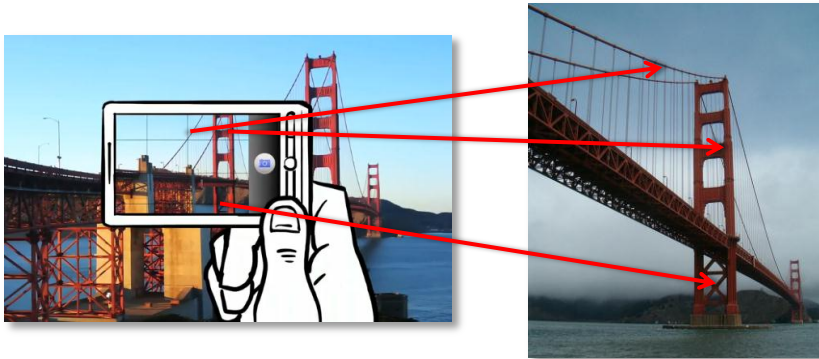


CS4670 / 5670: Computer Vision

Noah Snavely

Lecture 4: Feature matching



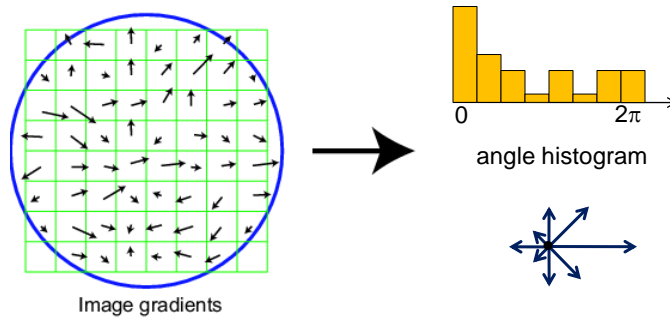
Announcements

- Project 1 artifact due tonight at 11:59pm (CMS)
- Quiz on Friday

Scale Invariant Feature Transform

Basic idea:

- Take 16x16 square window around detected feature
- Compute edge orientation (angle of the gradient - 90°) for each pixel
- Throw out weak edges (threshold gradient magnitude)
- Create histogram of surviving edge orientations

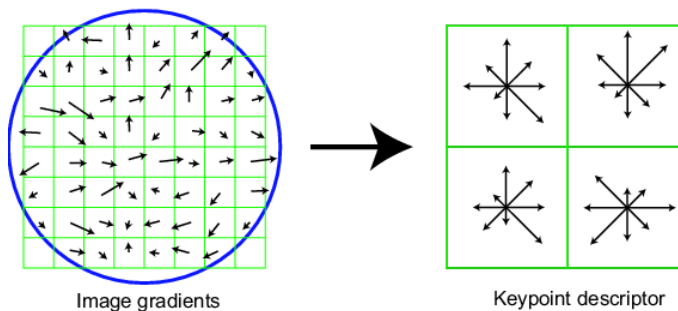


Adapted from slide by David Lowe

SIFT descriptor

Full version

- Divide the 16x16 window into a 4x4 grid of cells (2x2 case shown below)
- Compute an orientation histogram for each cell
- 16 cells * 8 orientations = 128 dimensional descriptor



Adapted from slide by David Lowe

Properties of SIFT

Extraordinarily robust matching technique

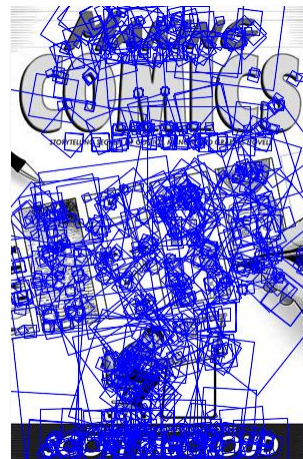
- Can handle changes in viewpoint
 - Up to about 60 degree out of plane rotation
- Can handle significant changes in illumination
 - Sometimes even day vs. night (below)
- Fast and efficient—can run in real time
- Lots of code available
 - http://people.csail.mit.edu/albert/ladypack/wiki/index.php/Known_implementations_of_SIFT



SIFT Example



sift



868 SIFT features

Feature matching

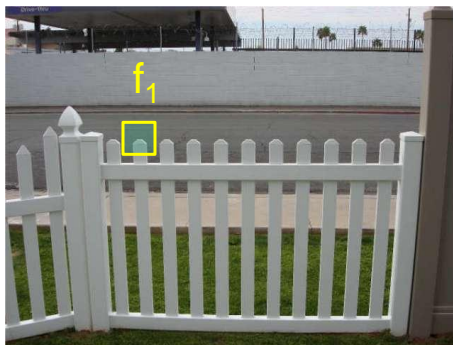
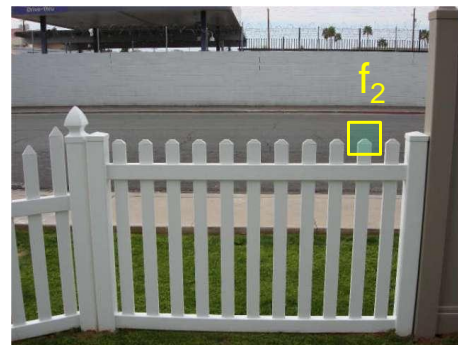
Given a feature in I_1 , how to find the best match in I_2 ?

1. Define distance function that compares two descriptors
2. Test all the features in I_2 , find the one with min distance

Feature distance

How to define the difference between two features f_1, f_2 ?

- Simple approach: L_2 distance, $\|f_1 - f_2\|$
- can give good scores to ambiguous (incorrect) matches

 I_1  I_2

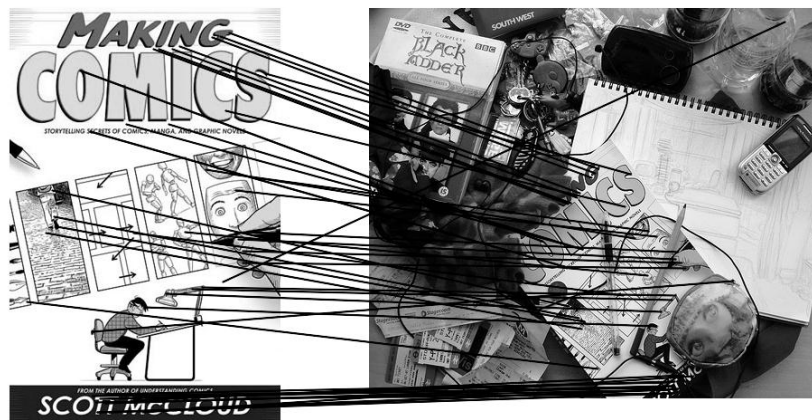
Feature distance

How to define the difference between two features f_1, f_2 ?

- Better approach: ratio distance = $\|f_1 - f_2\| / \|f_1 - f_2'\|$
 - f_2 is best SSD match to f_1 in I_2
 - f_2' is 2nd best SSD match to f_1 in I_2
 - gives large values for ambiguous matches

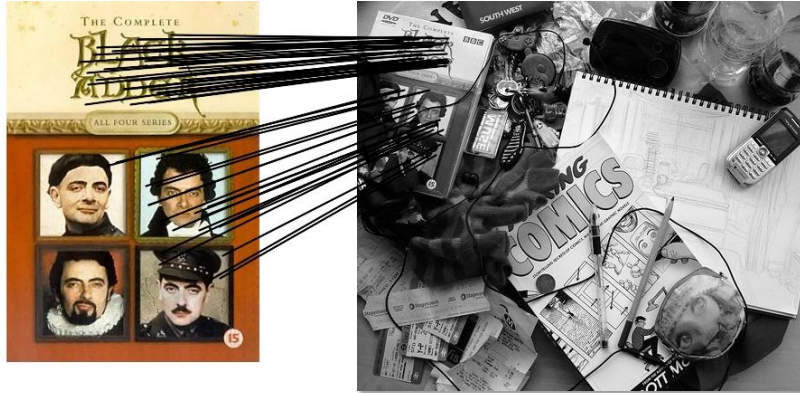


Feature matching example



51 matches

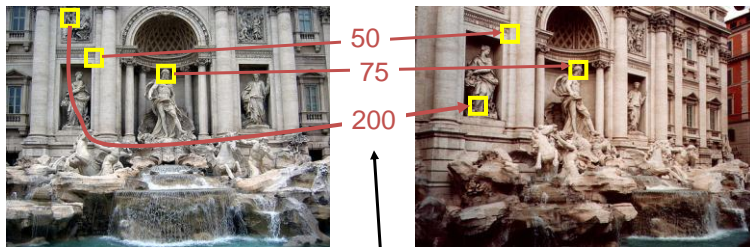
Feature matching example



58 matches

Evaluating the results

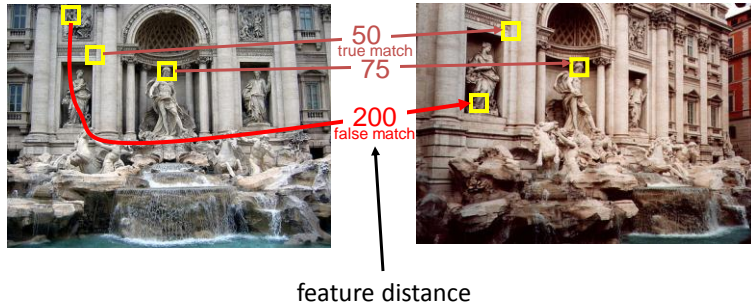
How can we measure the performance of a feature matcher?



feature distance

True/false positives

How can we measure the performance of a feature matcher?

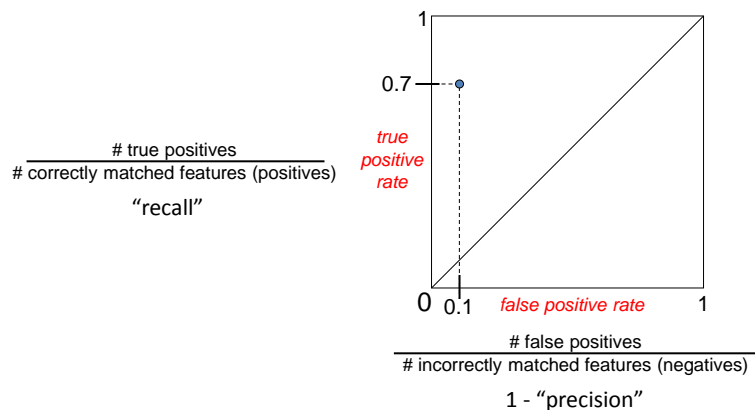


The distance threshold affects performance

- True positives = # of detected matches that are correct
 - Suppose we want to maximize these—how to choose threshold?
- False positives = # of detected matches that are incorrect
 - Suppose we want to minimize these—how to choose threshold?

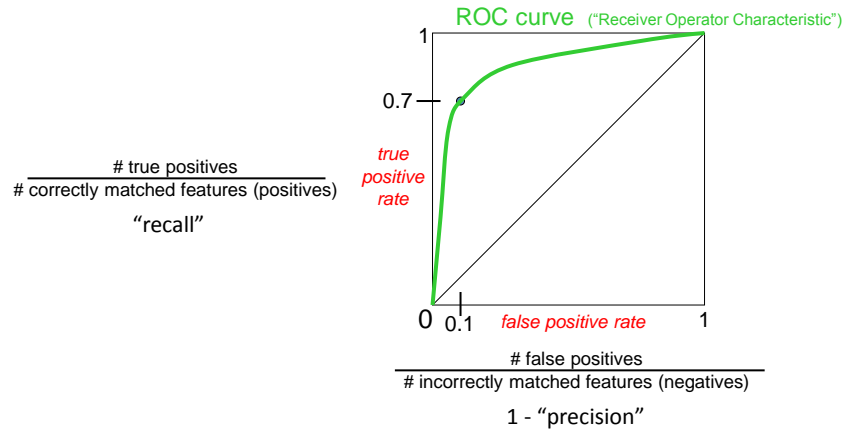
Evaluating the results

How can we measure the performance of a feature matcher?



Evaluating the results

How can we measure the performance of a feature matcher?

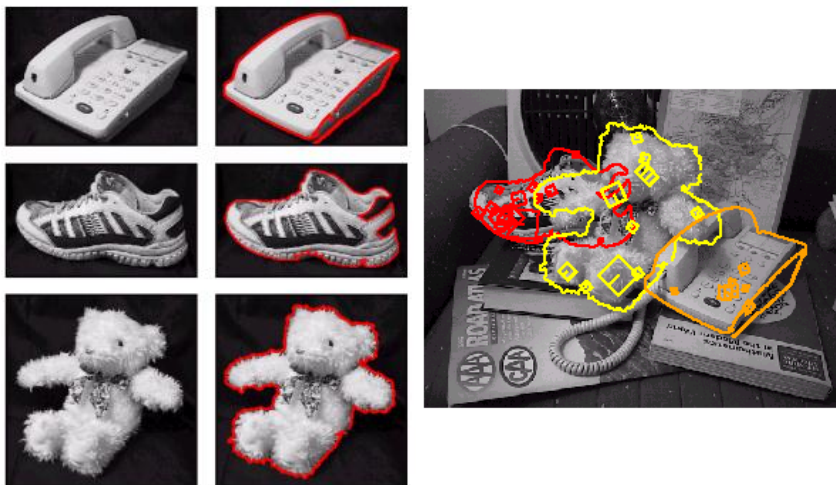


Lots of applications

Features are used for:

- Image alignment (e.g., mosaics)
- 3D reconstruction
- Motion tracking
- Object recognition (e.g., **Google Goggles**)
- Indexing and database retrieval
- Robot navigation
- ... other

Object recognition (David Lowe)



3D Reconstruction



Internet Photos ("Colosseum")



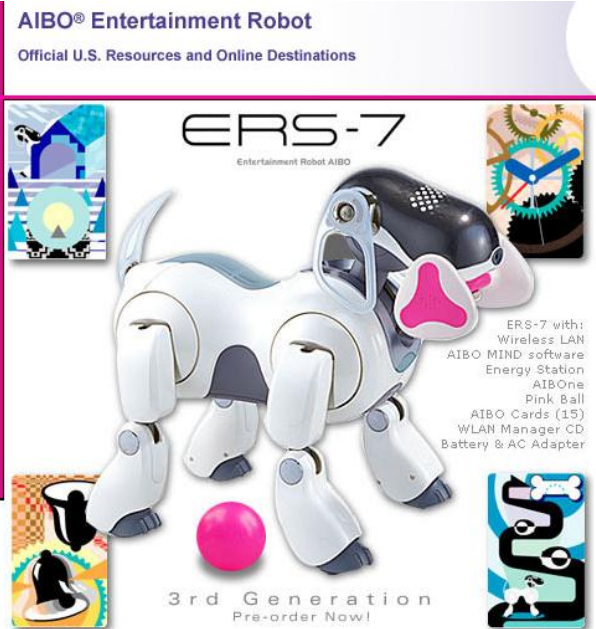
Reconstructed 3D cameras and points

Sony Aibo

SIFT usage:

- Recognize charging station
- Communicate with visual cards
- Teach object recognition

AIBO® Entertainment Robot
Official U.S. Resources and Online Destinations



The advertisement features a central image of the white and black AIBO Entertainment Robot ERS-7. The robot is shown in a three-quarter view, with its mouth open, revealing a pink tongue. A pink ball is positioned in front of its front legs. Surrounding the robot are four small, colorful cards: one at the top left showing a blue and white structure, one at the top right showing a gear and a clock, one at the bottom left showing a black silhouette of a person, and one at the bottom right showing a black silhouette of a person. The text 'ERS-7' is prominently displayed above the robot, with 'Entertainment Robot AIBO' in smaller text below it. At the bottom, it says '3rd Generation Pre-order Now!'. To the right of the robot, a list of included items is provided.

ERS-7 with:
Wireless LAN
AIBO MIND software
Energy Station
AIBOne
Pink Ball
AIBO Cards (15)
WLAN Manager CD
Battery & AC Adapter

Questions?

Image alignment



Why don't these images line up exactly?