CS 143: Introduction to Computer Vision

Instructor: James Hays

TAs: Hari Narayanan (HTA), Libin “Geoffrey” Sun, Greg Yauney, Bryce Aebi, Charles Yeh, Kurt Spindler

Image by kirkh.deviantart.com

Today’s Class

- Introductions
- What is Computer Vision?
- Computer Vision at Brown
- Specifics of this course
- Questions

A bit about me

Thesis: Large Scale Scene Matching for Graphics and Vision

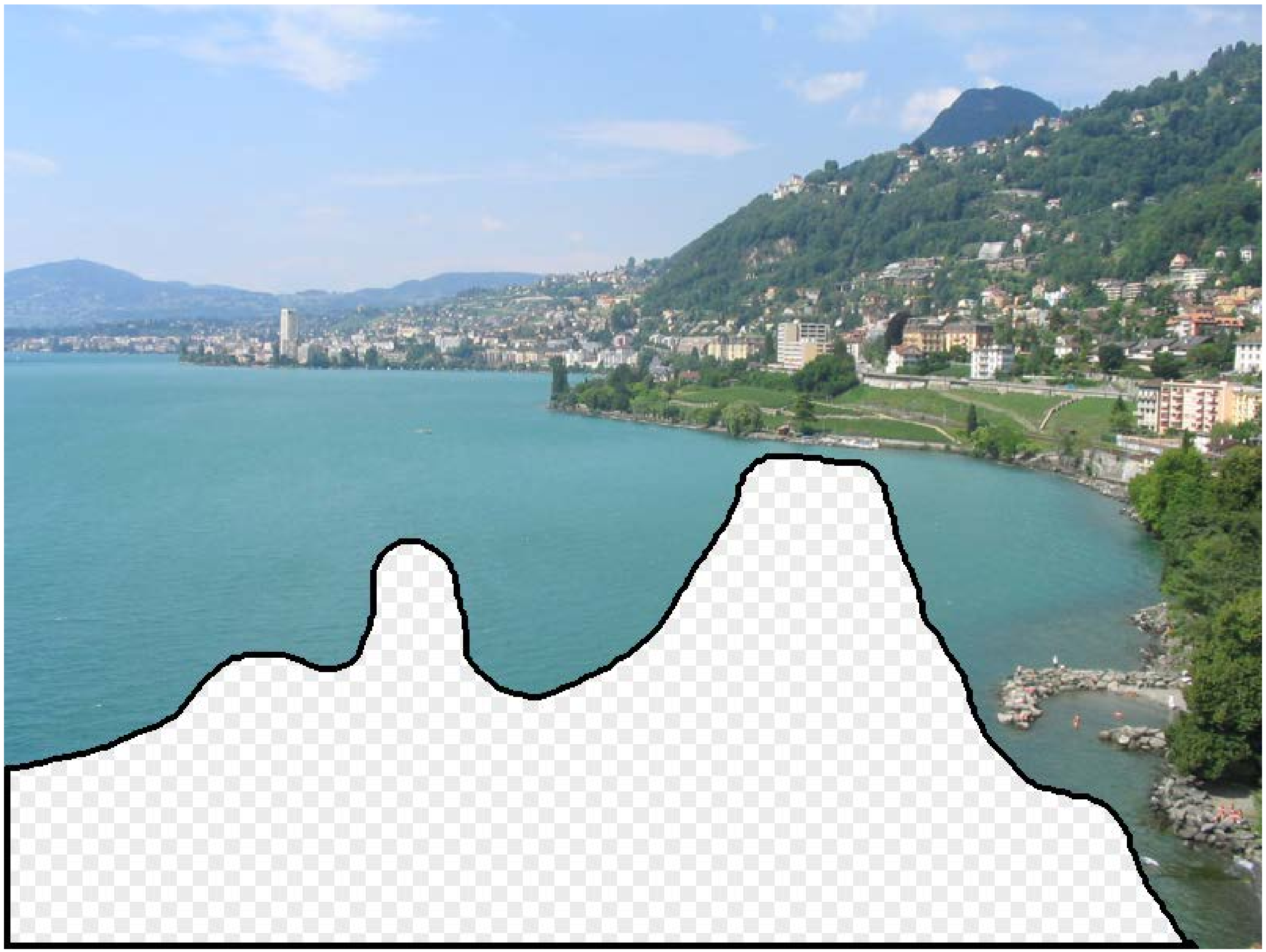
Thesis

hays_thesis.pdf, 107MB

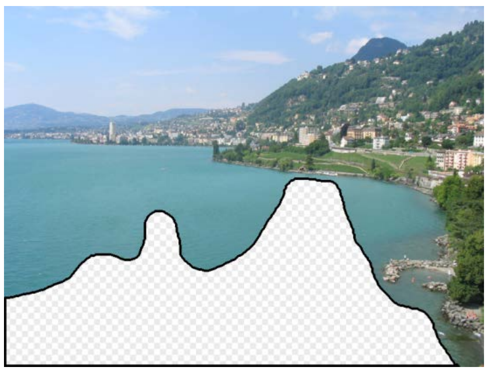
Committee

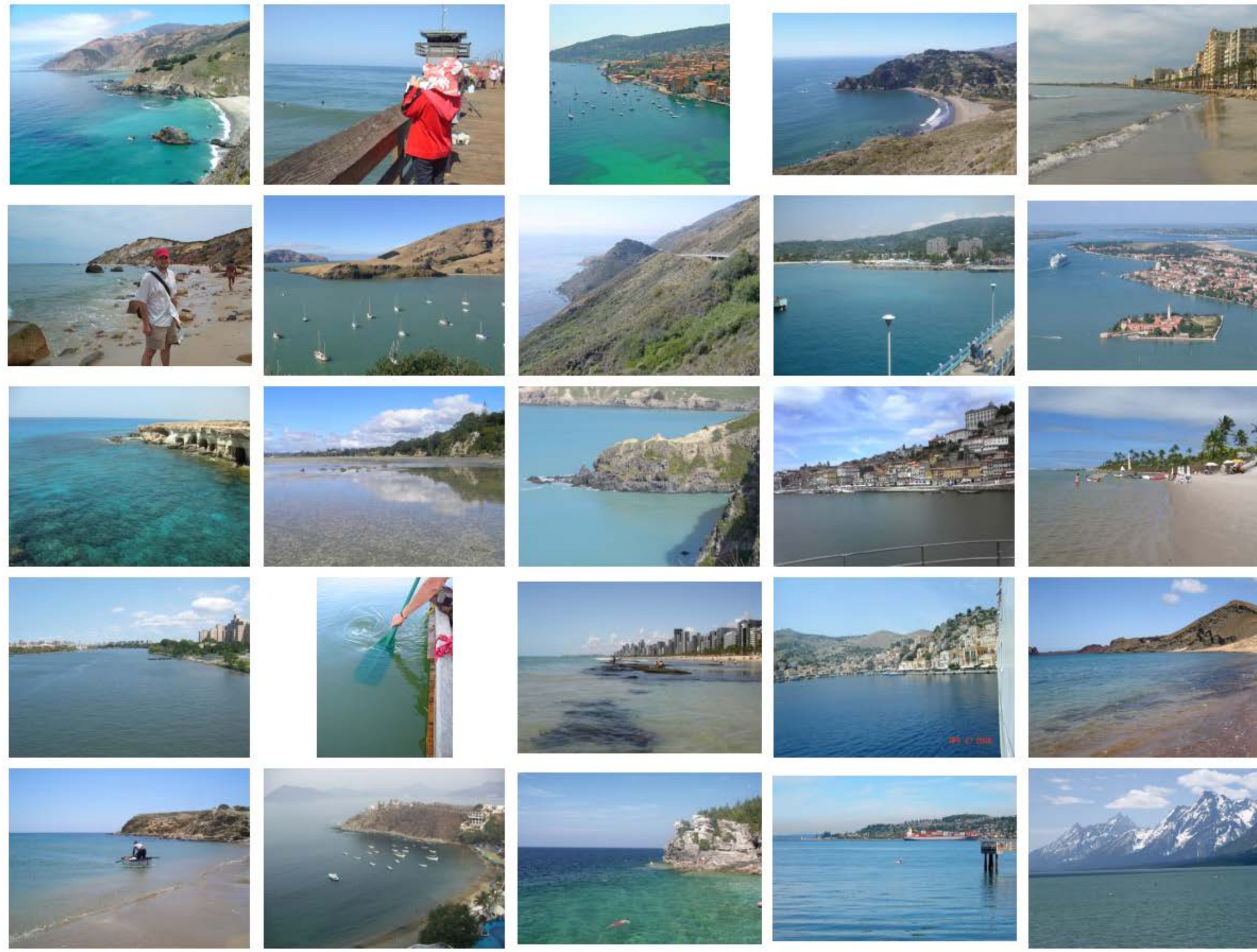
- **Alexei A. Efros** (chair)
- **Martial Hebert**
- **Jessica K. Hodgins**
- **Takeo Kanade**
- **Richard Szeliski**, Microsoft Research

Scene Completion



[Hays and Efros. Scene Completion Using Millions of Photographs. SIGGRAPH 2007 and CACM October 2008.]





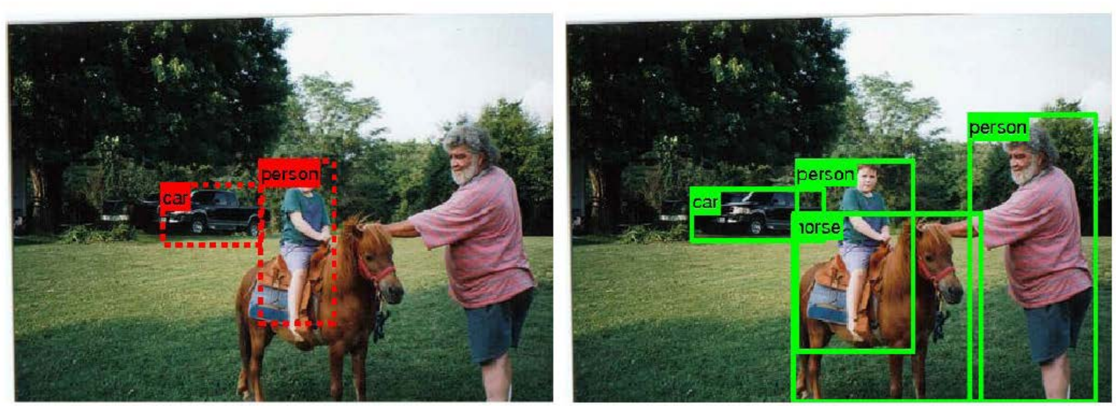
Nearest neighbor scenes from database of 2.3 million photos

Graph cut + Poisson blending

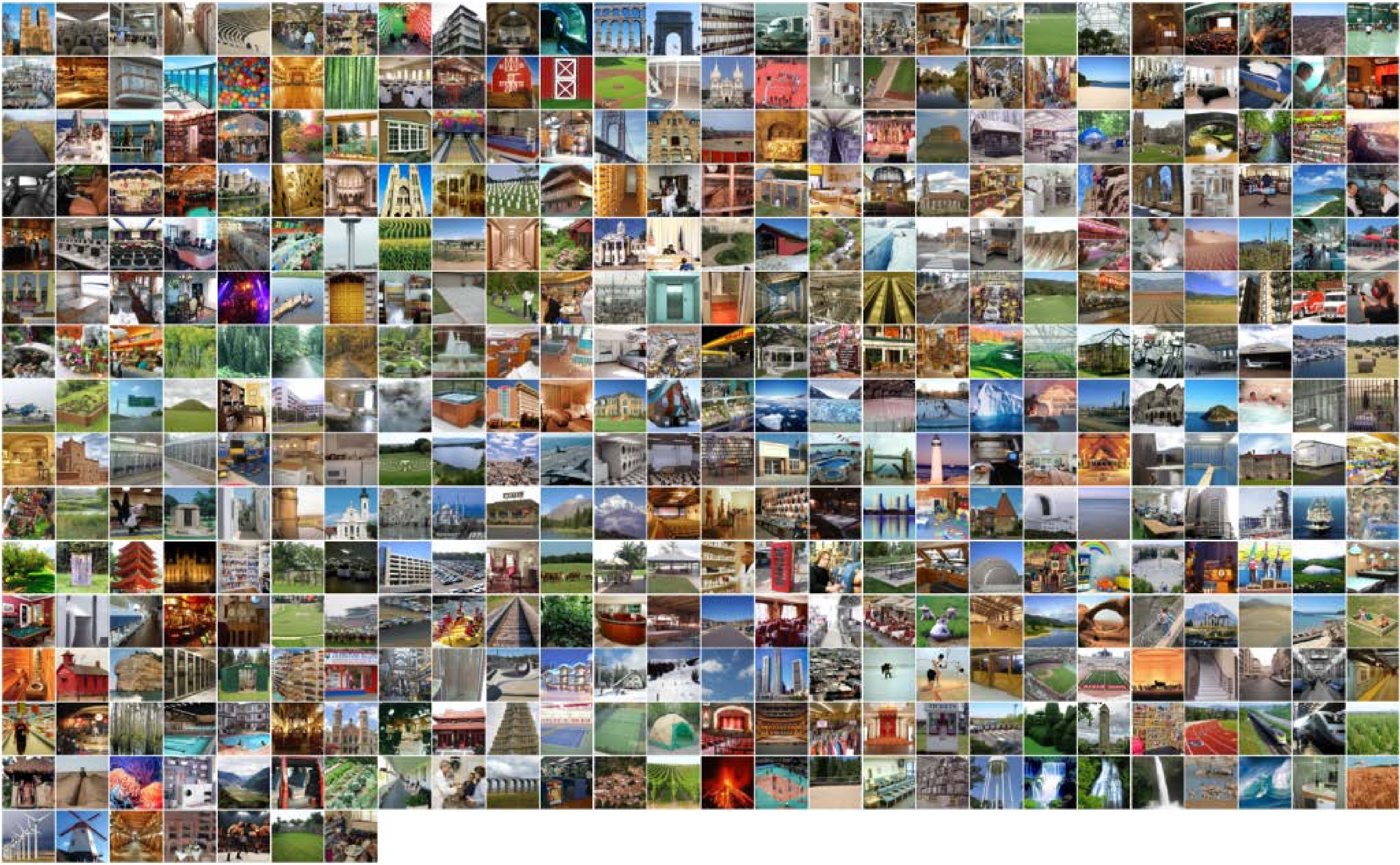
My Research

IM2GPS: estimating geographic information from a single image

An Empirical Study of Context in Object Detection



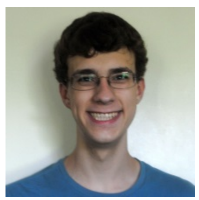
Categories of the SUN database



CS 143 TAs

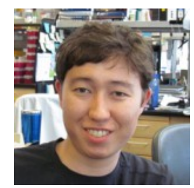
Hari Narayanan (HTA)

Libin “Geoffrey” Sun



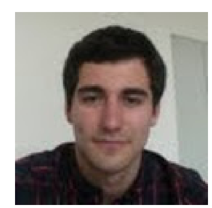
Greg Yauney

Bryce Aebi



Charles Yeh

Kurt Spindler



What is Computer Vision?

- What are examples of computer vision being used in the world?

Computer Vision

Make computers understand images and video.

What kind of scene?

Where are the cars?

How far is the building?

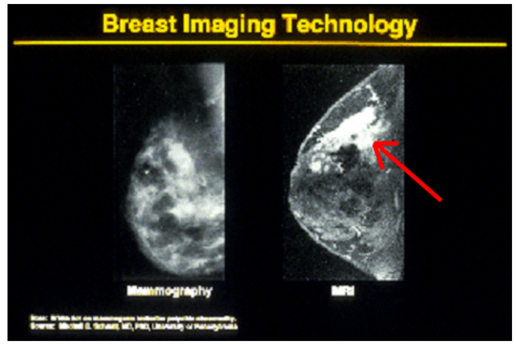
…

Vision is really hard

- Vision is an amazing feat of natural intelligence
  - Visual cortex occupies about 50% of Macaque brain
  - More human brain devoted to vision than anything else

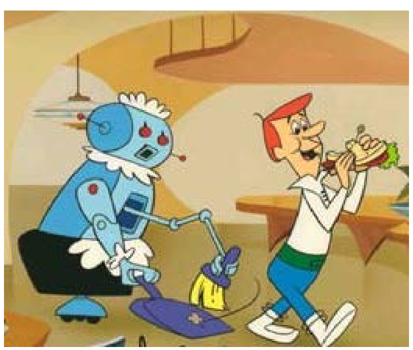
Why computer vision matters


Safety

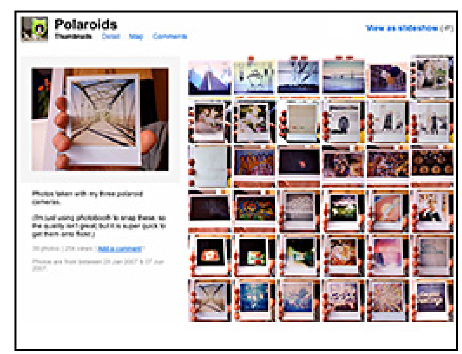


Health


Security


Comfort

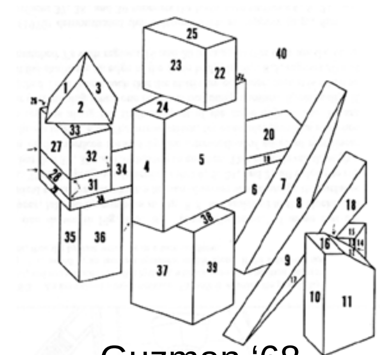

Fun



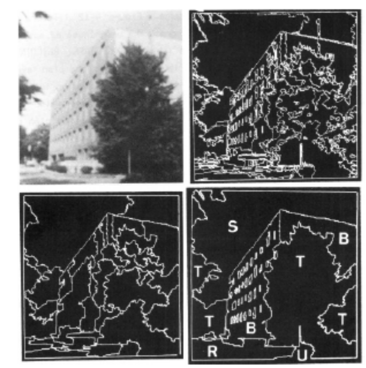
Access

Ridiculously brief history of computer vision

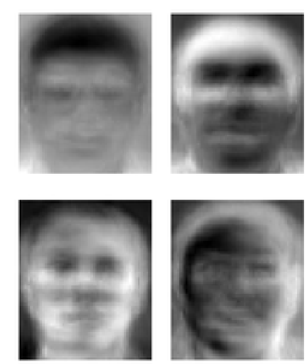
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960’s: interpretation of synthetic worlds
- 1970’s: some progress on interpreting selected images
- 1980’s: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990’s: face recognition; statistical analysis in vogue
- 2000’s: broader recognition; large annotated datasets available; video processing starts
- 2030’s: robot uprising?



Guzman ‘68



Ohta Kanade ‘78



Turk and Pentland ‘91

How vision is used now

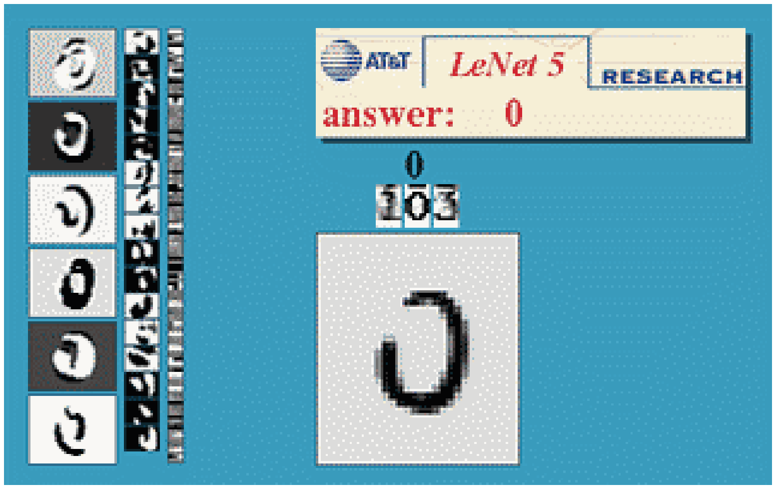
- Examples of state-of-the-art

Some of the following slides by Steve Seitz

Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

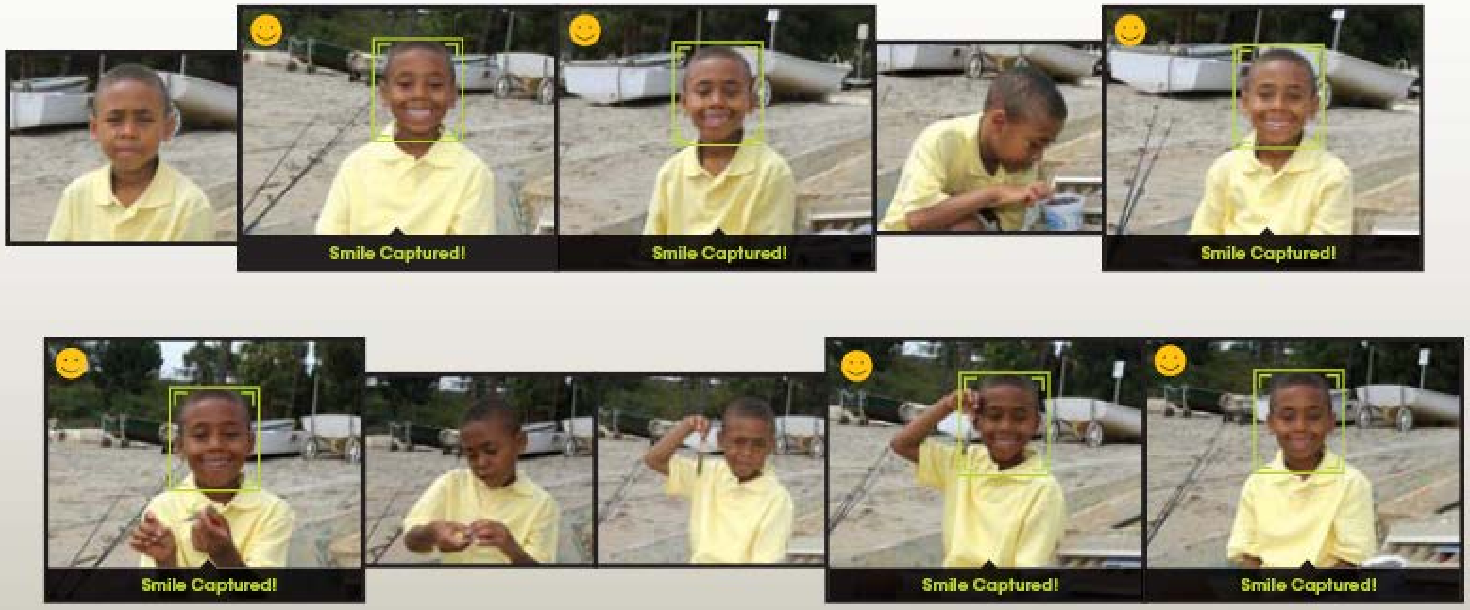
Face detection

- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, …

Smile detection

The Smile Shutter flow

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.



[Sony Cyber-shot® T70 Digital Still Camera](#)

3D from thousands of images

Building Rome in a Day: Agarwal et al. 2009

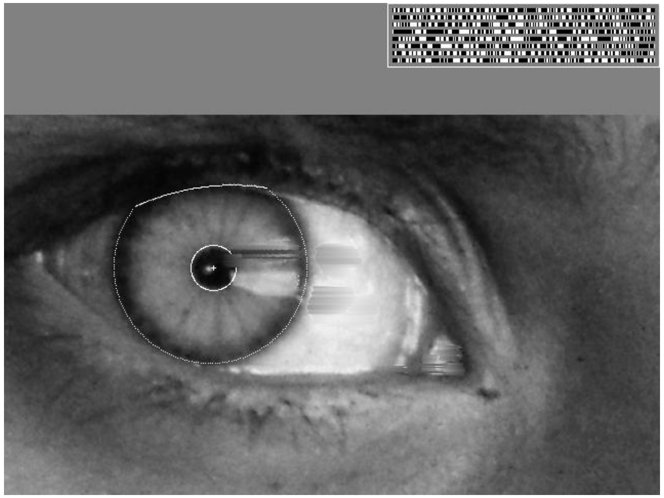
Object recognition (in supermarkets)

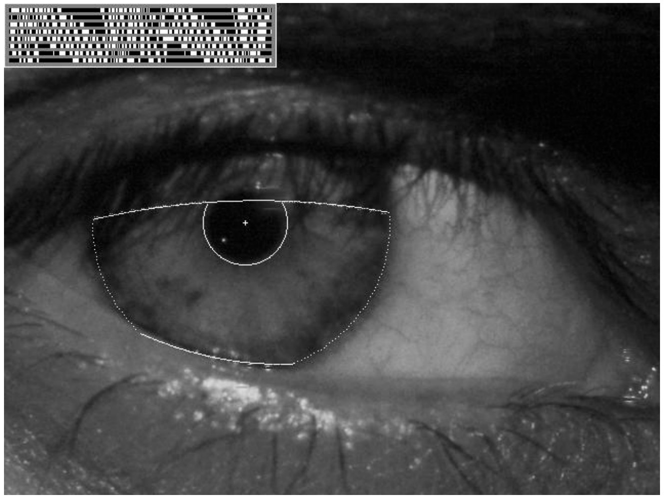
[LaneHawk by EvolutionRobotics]

“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk,you are assured to get paid for it… “

Vision-based biometrics

“*How the Afghan Girl was Identified by Her Iris Patterns*” Read the story
wikipedia





Login without a password…

Fingerprint scanners on
many new laptops,
other devices

Face recognition systems now
beginning to appear more widely
http://www.sensiblevision.com/

Object recognition (in mobile phones)

[Point & Find](), [Nokia]()

[Google Goggles]()

Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Special effects: motion capture

Pirates of the Carribean, Industrial Light and Magic

Sports

Sportvision first down line
Nice explanation on www.howstuffworks.com

http://www.sportvision.com/video.html

Smart cars

Slide content courtesy of Amnon Shashua

- Mobileye
  - Vision systems currently in high-end BMW, GM, Volvo models
  - By 2010: 70% of car manufacturers.

Google cars

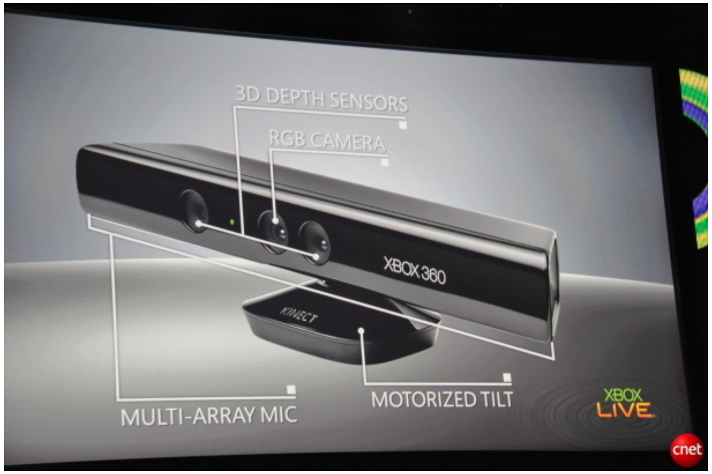
Oct 9, 2010. "Google Cars Drive Themselves, in Traffic". *The New York Times*. John Markoff

June 24, 2011. "Nevada state law paves the way for driverless cars". *Financial Post*. Christine Dobby

Aug 9, 2011, "Human error blamed after Google's driverless car sparks five-vehicle crash". *The Star* (Toronto)

Interactive Games: Kinect

- Object Recognition: http://www.youtube.com/watch?feature=iv&v=fQ59dXOo63o
- Mario: http://www.youtube.com/watch?v=8CTJL5lUjHg
- 3D: http://www.youtube.com/watch?v=7QrnwoO1-8A
- Robot: http://www.youtube.com/watch?v=w8BmgtMKFbY



Vision in space

NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

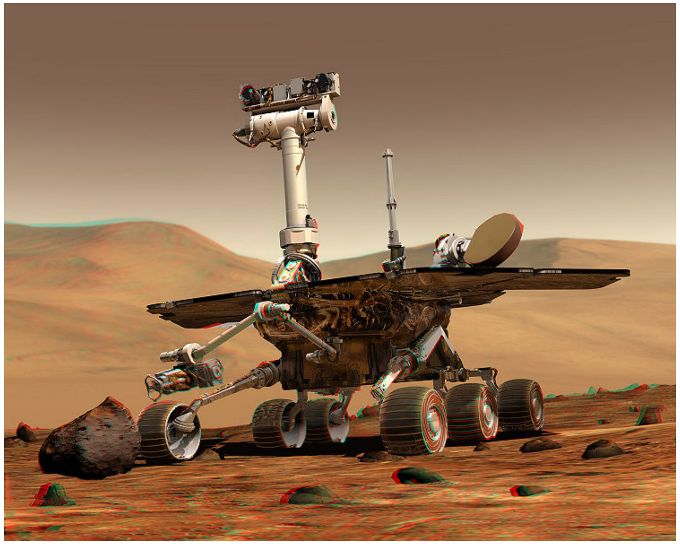
Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read “Computer Vision on Mars” by Matthies et al.

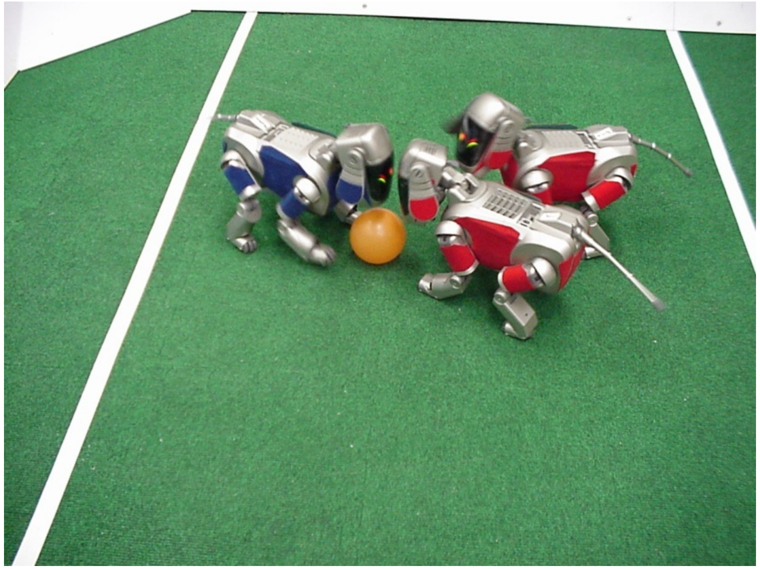
Industrial robots

Vision-guided robots position nut runners on wheels

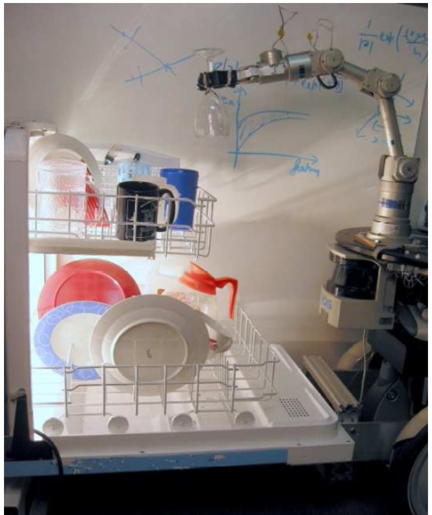
Mobile robots



NASA's Mars Spirit Rover
http://en.wikipedia.org/wiki/Spirit_rover

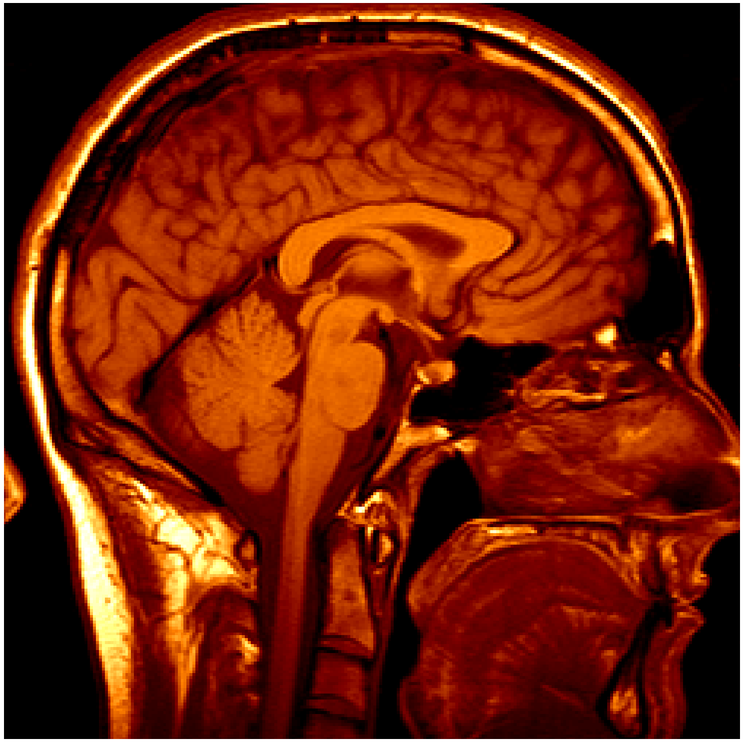


http://www.robocup.org/



Saxena et al. 2008
STAIR at Stanford

Medical imaging



3D imaging
MRI, CT

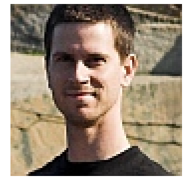
Image guided surgery
Grimson et al., MIT

Computer Vision and Nearby Fields

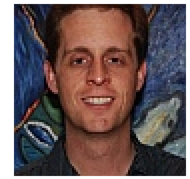
- Computer Graphics: Models to Images
- Comp. Photography: Images to Images
- Computer Vision: Images to Models

Computer Vision at Brown

Pedro Felzenszwalb

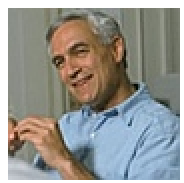


James Hays



Erik Sudderth

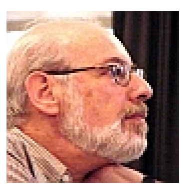
Thomas Serre



Stu Geman

David Mumford

Gabriel Taubin



David Cooper

Ben Kimia

Joe Mundy

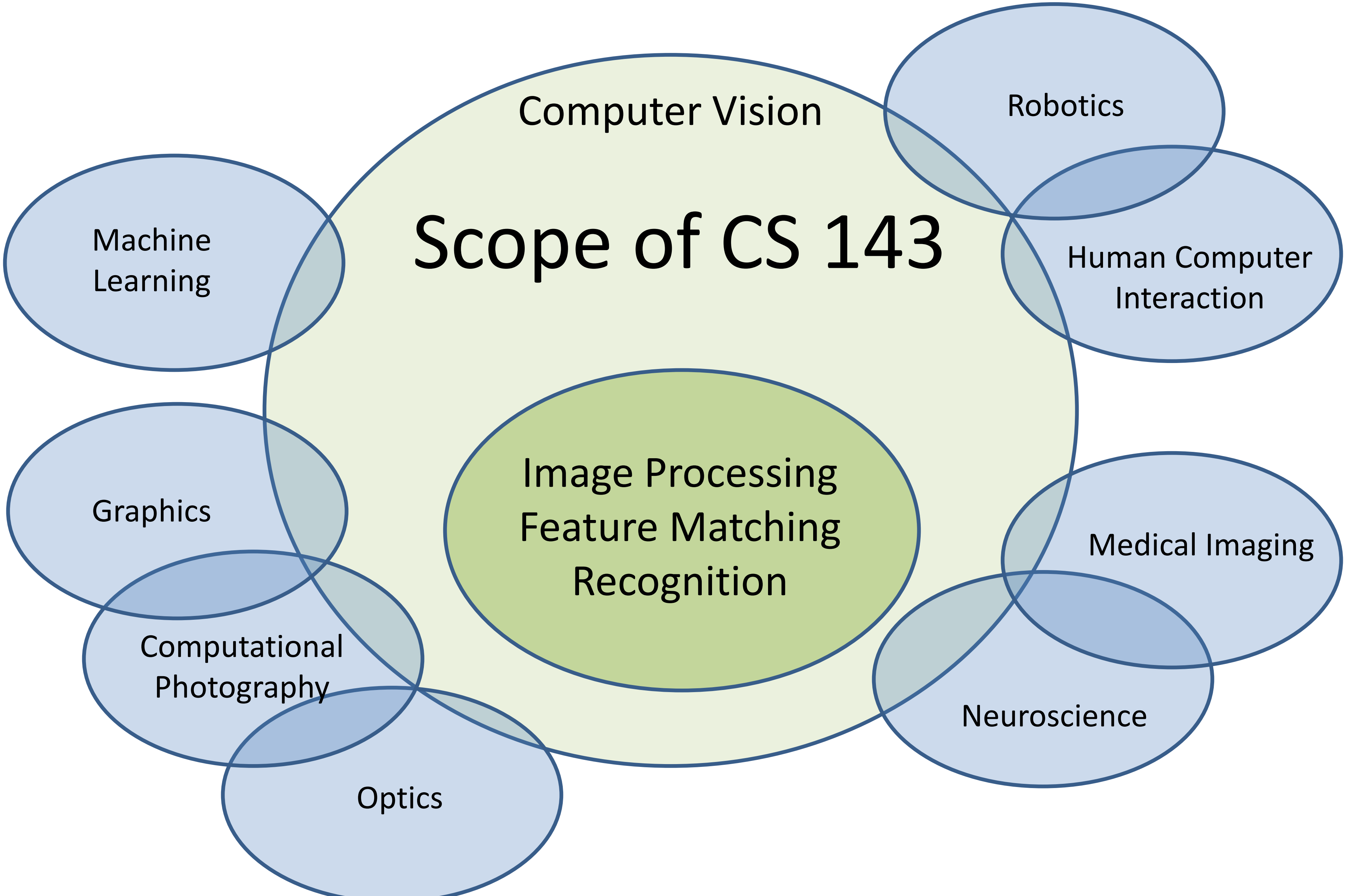
See also: [Brown Center for Vision Research (CVR)]

Course Syllabus (tentative)

- http://www.cs.brown.edu/courses/csci1430/

Grading

- 80% programming projects (5 total)
- 20% quizzes (2 total)


Computer Vision
Scope of CS 143
Robotics
Human Computer Interaction
Machine Learning
Graphics
Computational Photography
Optics
Image Processing
Feature Matching
Recognition
Medical Imaging
Neuroscience

Course Topics

- Interpreting Intensities
  - What determines the brightness and color of a pixel?
  - How can we use image filters to extract meaningful information from the image?
- Correspondence and Alignment
  - How can we find corresponding points in objects or scenes?
  - How can we estimate the transformation between them?
- Grouping and Segmentation
  - How can we group pixels into meaningful regions?
- Categorization and Object Recognition
  - How can we represent images and categorize them?
  - How can we recognize categories of objects?
- Advanced Topics
  - Action recognition, 3D scenes and context, human-in-the-loop vision…

Textbook

Computer Vision: Algorithms and Applications

© 2010 Richard Szeliski, Microsoft Research

http://szeliski.org/Book/

Prerequisites

- **Linear algebra**, basic calculus, and probability
- Experience with image processing or Matlab will help but is not necessary

Projects

- Image Filtering and Hybrid Images
- Local Feature Matching
- Scene Recognition with Bag of Words
- Object Detection with a Sliding Window
- Boundary Detection with Sketch Tokens

Proj1: Image Filtering and Hybrid Images

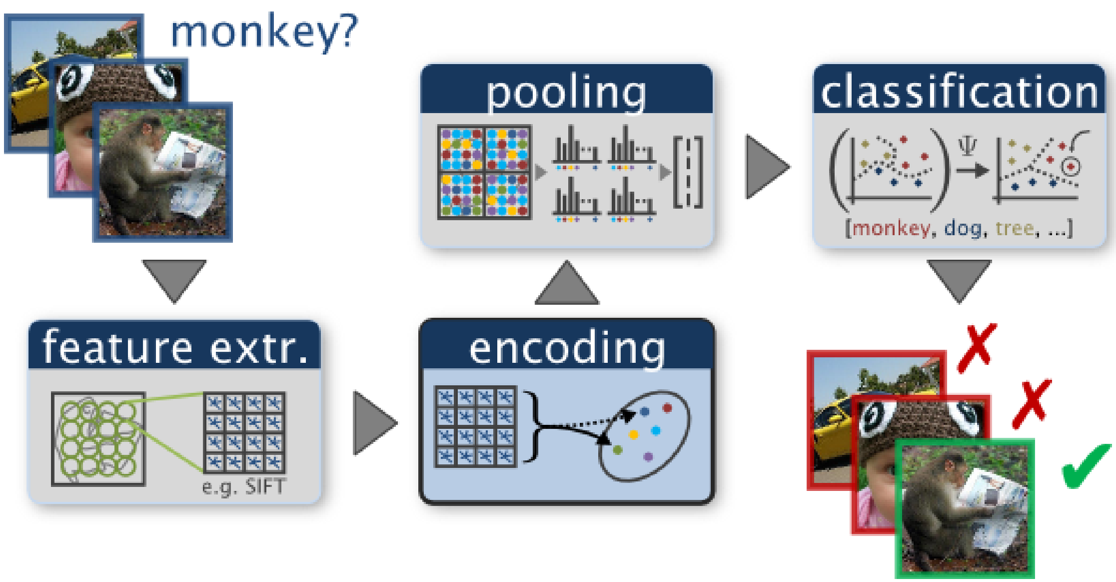
- Implement image filtering to separate high and low frequencies
- Combine high frequencies and low frequencies from different images to create an image with scale-dependent interpretation

Proj2: Local Feature Matching

- Implement interest point detector, SIFT-like local feature descriptor, and simple matching algorithm.
- Feed feature matches to a structure-from-motion system

Proj3: Scene Recognition with Bag of Words

- Quantize local features into a "vocabulary", describe images as histograms of "visual words", train classifiers to recognize scenes based on these histograms.



Proj4: Object Detection with a Sliding Window

- Train a face detector based on positive examples and “mined” hard negatives, detect faces at multiple scales and suppress duplicate detections.

Proj5: Boundary Detection with Sketch Tokens

- Quantize human-annotated boundaries into “sketch tokens”, train a multi-way classifier to recognize such tokens.