Computer Vision

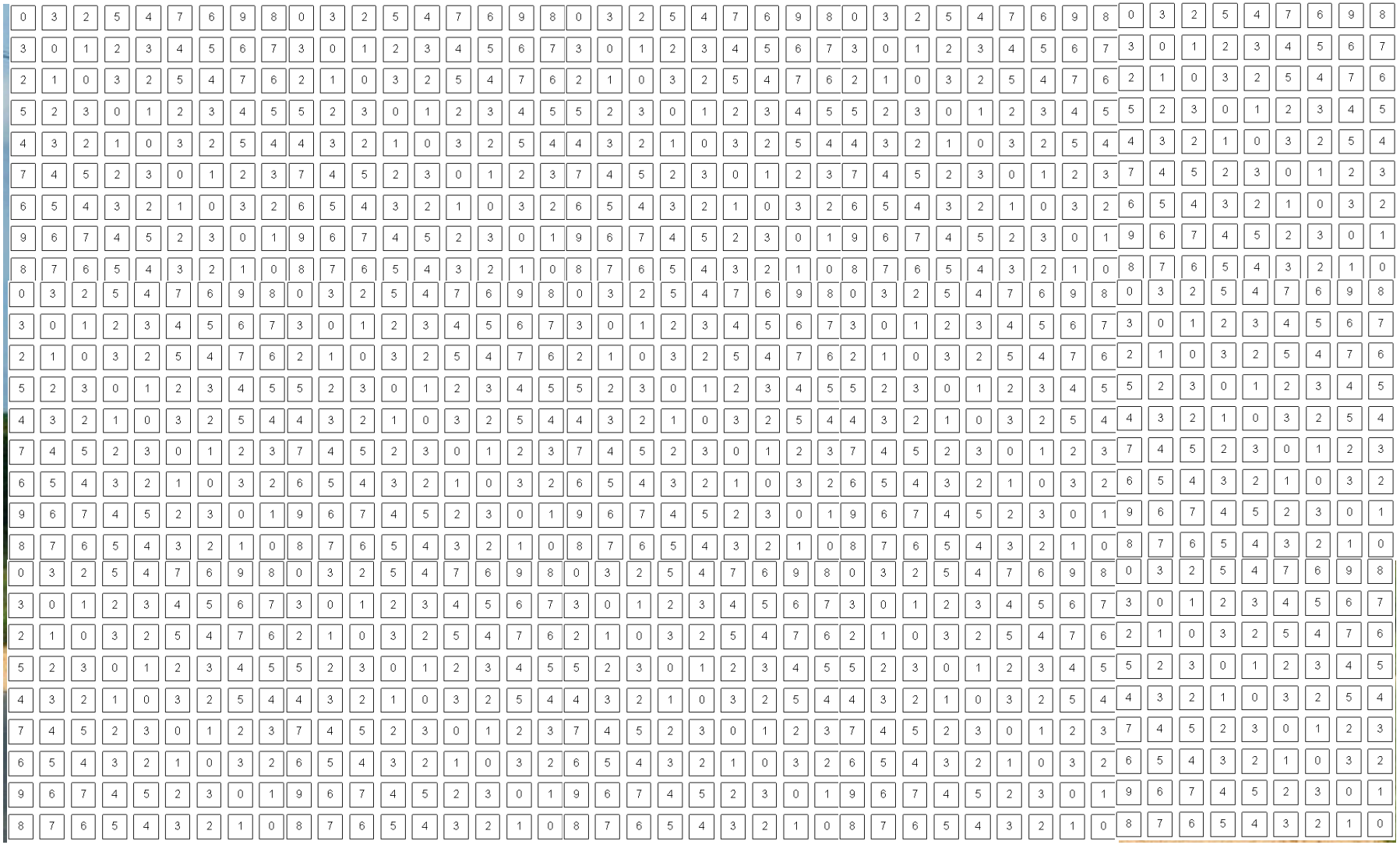
CSE 576
Ali Farhadi

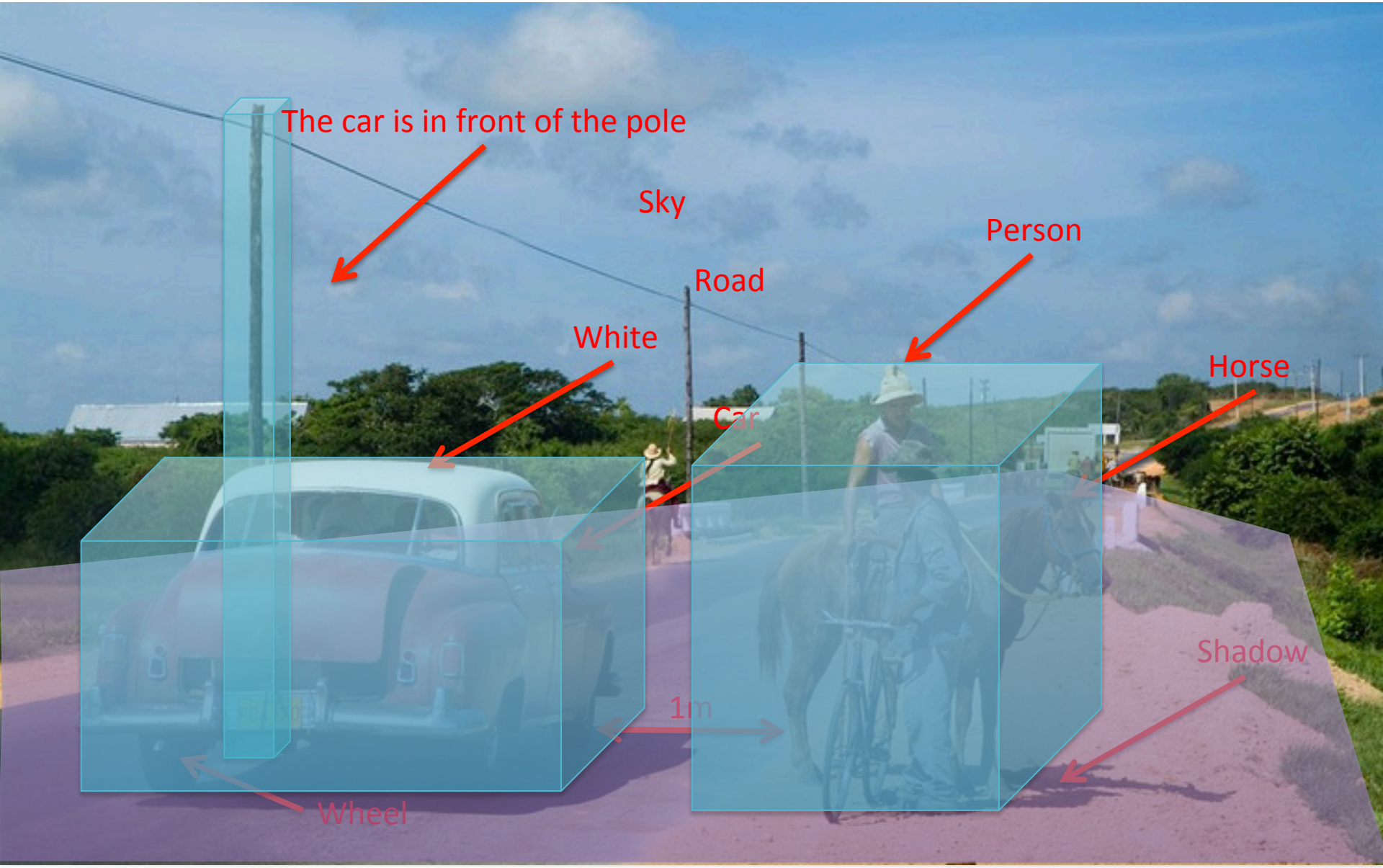
Many slides from Steve Seitz, Larry Zitnick, Yang Wang

Course Information

- Time:
  - Monday, Wednesday 1:30-2:50
- Location:
  - MGH 238
- Contact:
  - ali@cs.uw.edu , CSE 652
- TA:
  - Dun-Yu Hsiao
  - dyhsiao@cs.washington.edu
- Website:
  - http://www.cs.washington.edu/education/courses/cse576/15sp/

What does it mean to see?




The car is in front of the pole
Sky
Person
Road
White
Horse
Car
Shadow
1m
Wheel

Computer Vision

- Low Level Vision
  - Measurements
  - Enhancements
  - Region segmentation
  - Features
- Mid Level Vision
  - Reconstruction
  - Depth
  - Motion Estimation
- High Level Vision
  - Category detection
  - Activity recognition
  - Deep understandings

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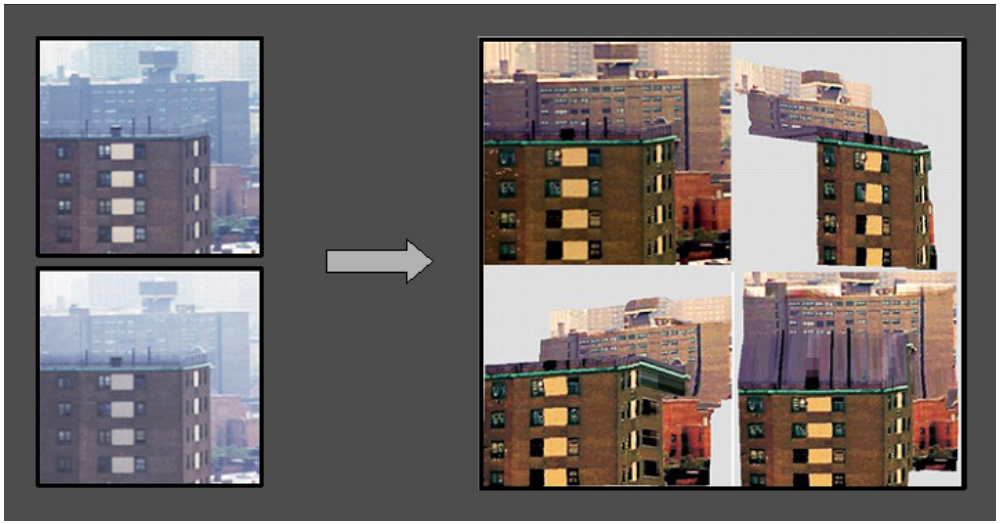
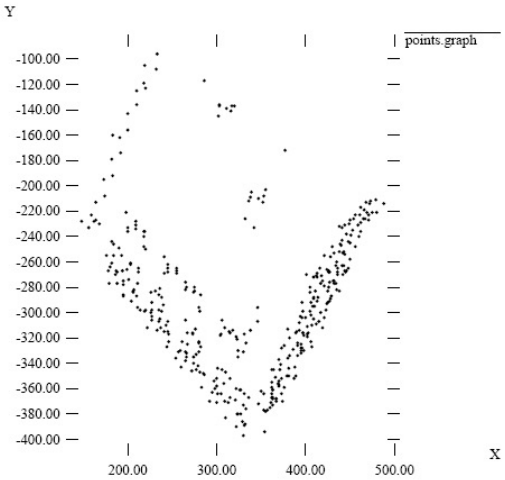
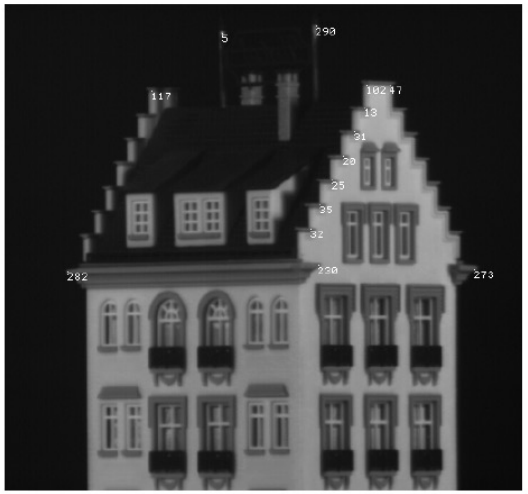
Vision as Measurement Device

Real-time stereo on Mars



Physics-based Vision





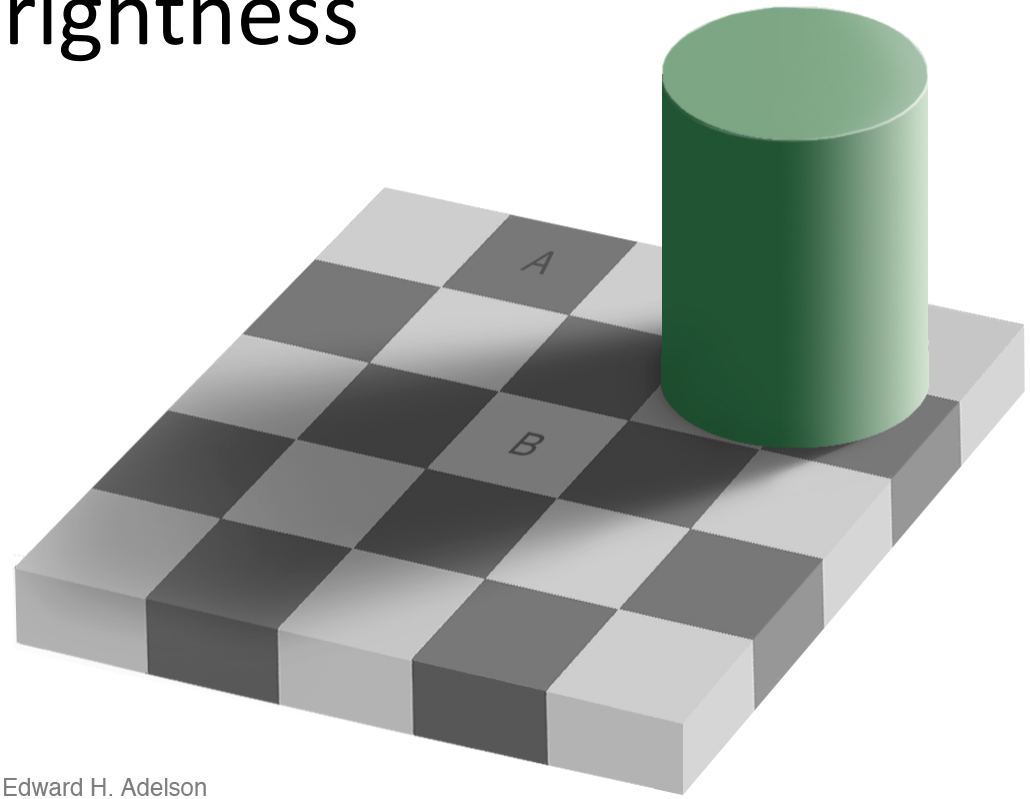
Structure from Motion

Virtualized Reality

Slide Credit: Alyosha Efros

Measurement

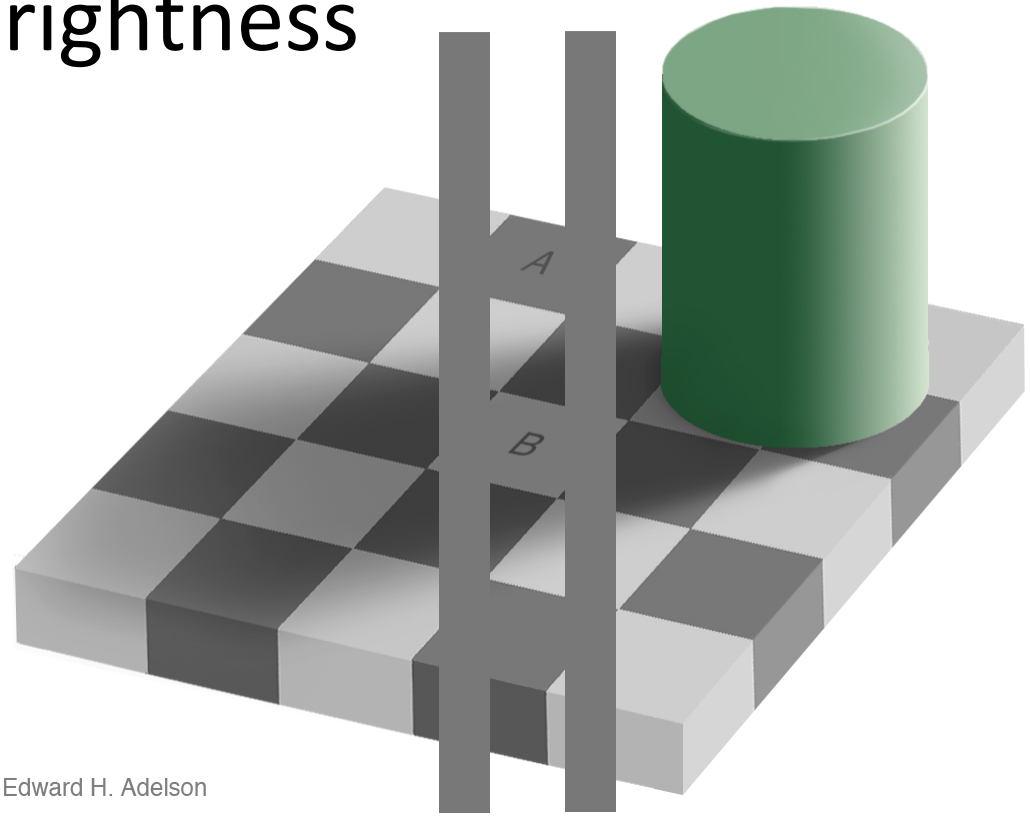
Brightness



Edward H. Adelson

Measurement

Brightness

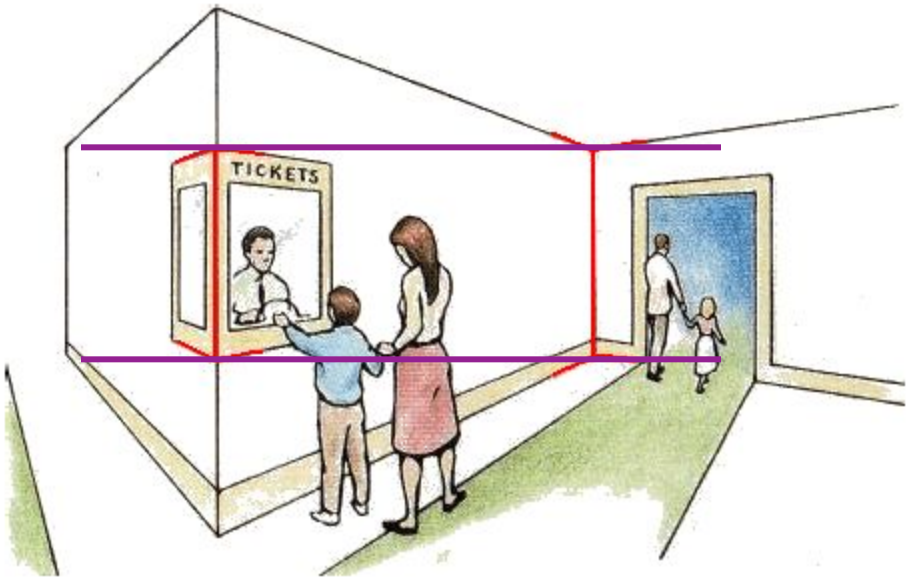


Edward H. Adelson

Slide Credit: Alyosha Efros

Measurement

Length



Müller-Lyer Illusion

http://www.michaelbach.de/ot/sze_muelue/index.html

Slide Credit: Alyosha Efros

Image Enhancement

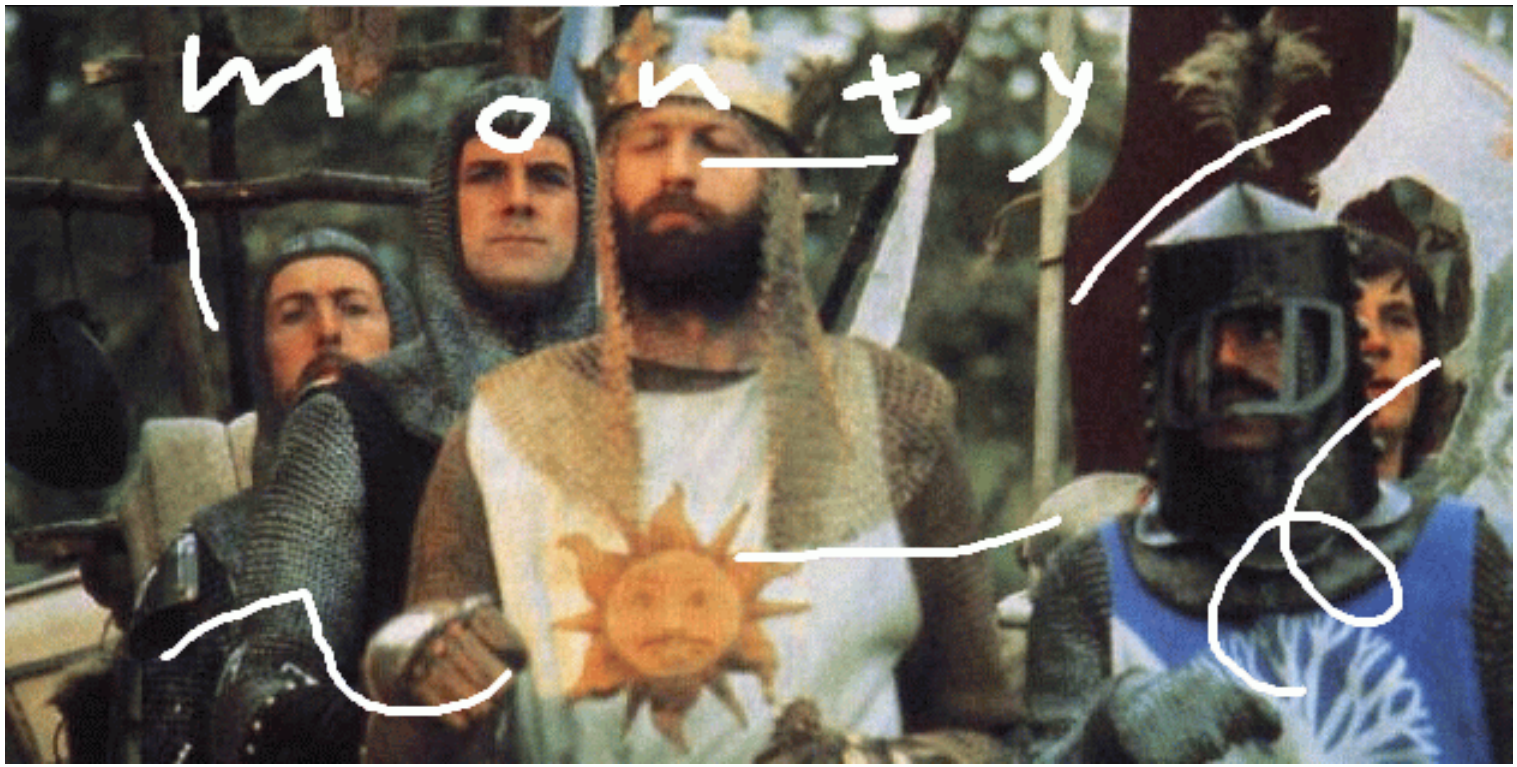
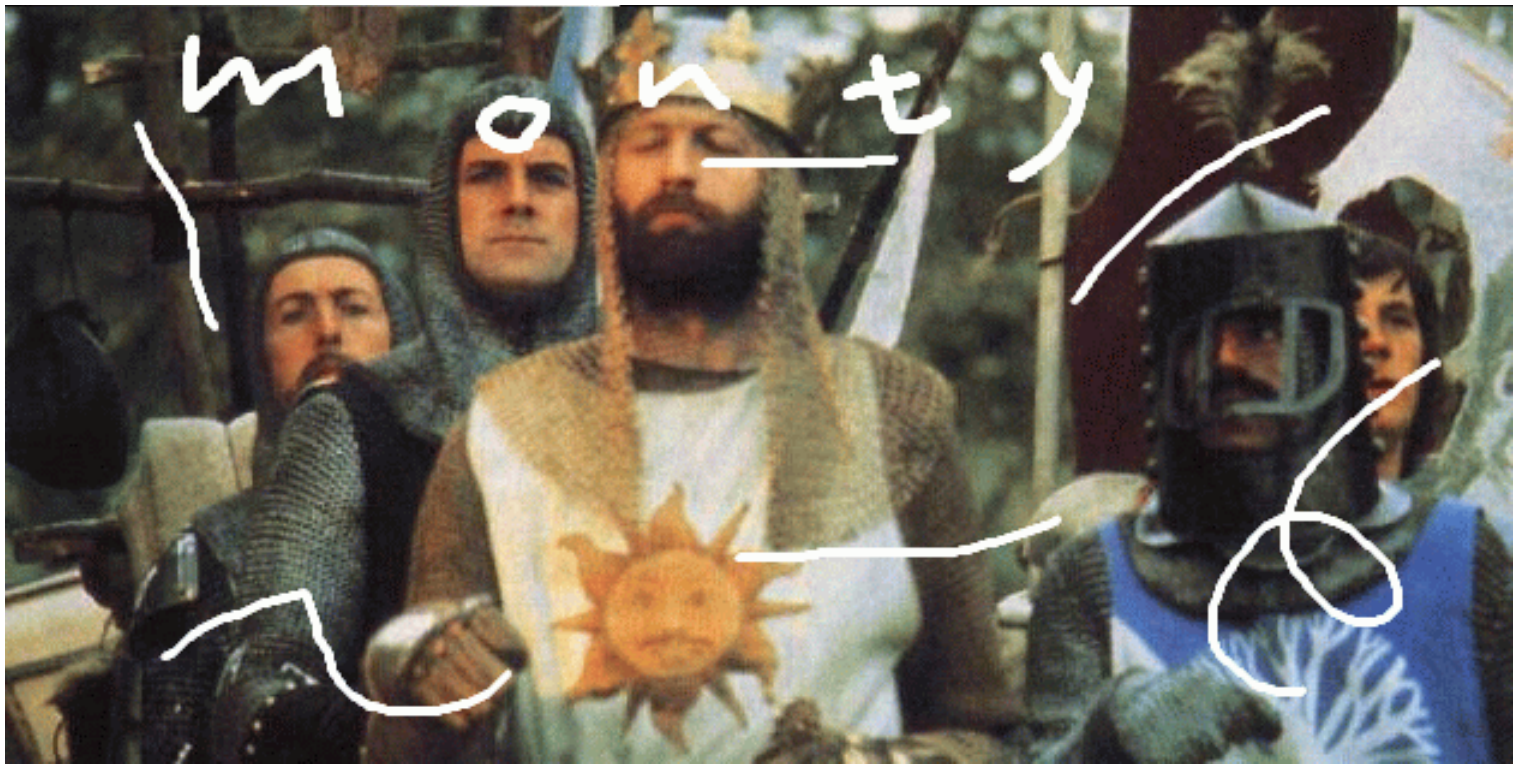


Image Inpainting, M. Bertalmío et al.
http://www.iua.upf.es/~mbertalmio//restoration.html

Image Enhancement



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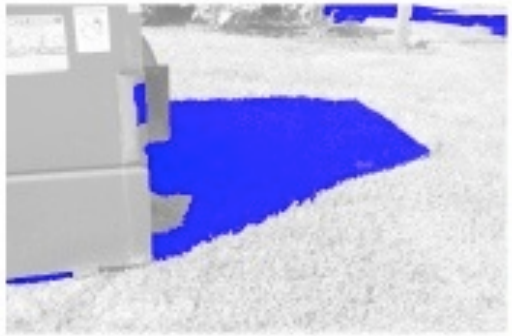
Seam Carving

[Shai & Avidan, SIGGRAPH 2007]

Traditional resizing

Content-aware resizing

[Shai & Avidan, SIGGRAPH 2007]



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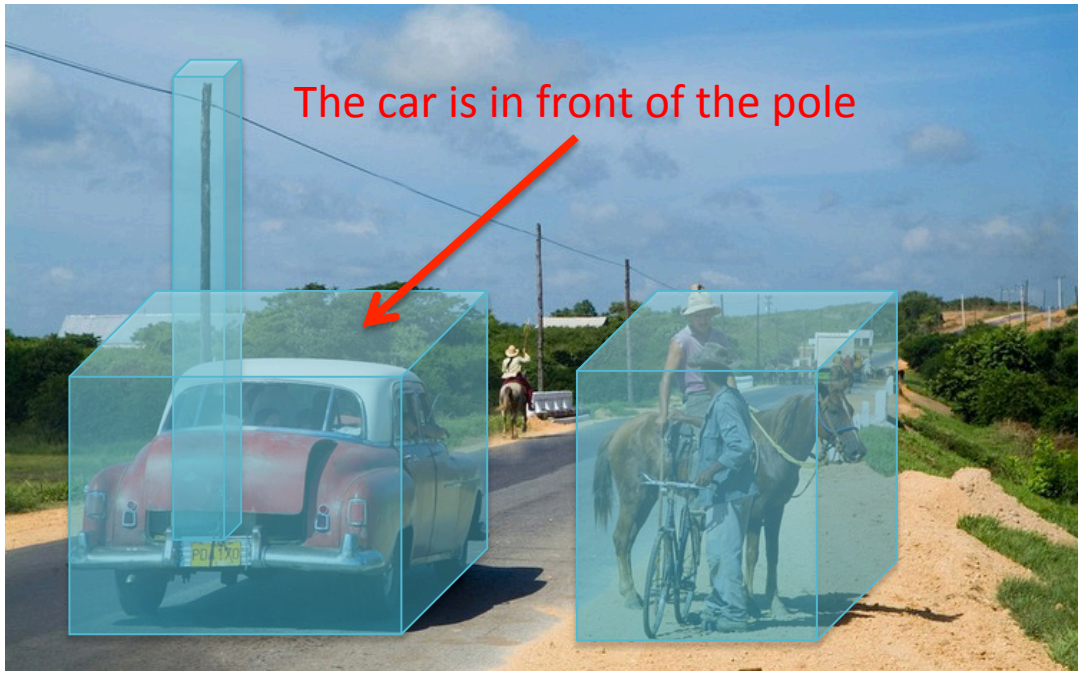
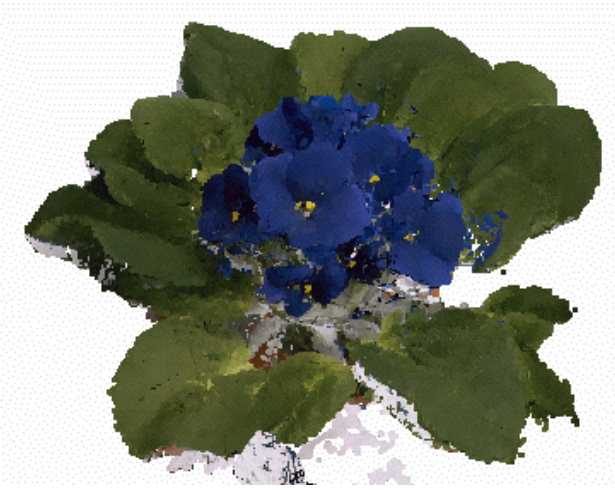
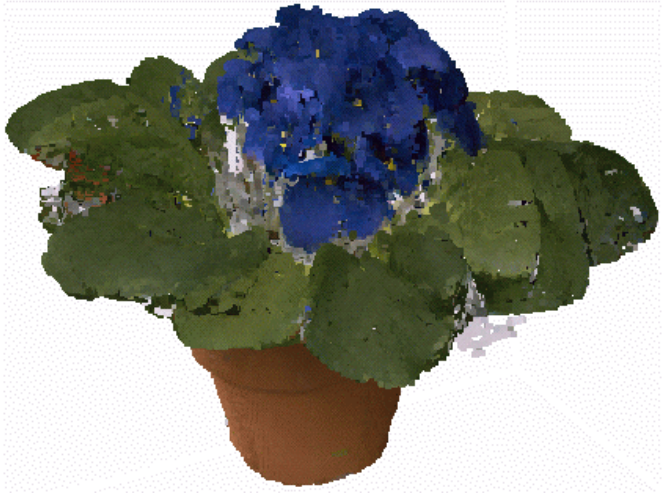


Input Image (1 of 45)

Reconstruction



Reconstruction



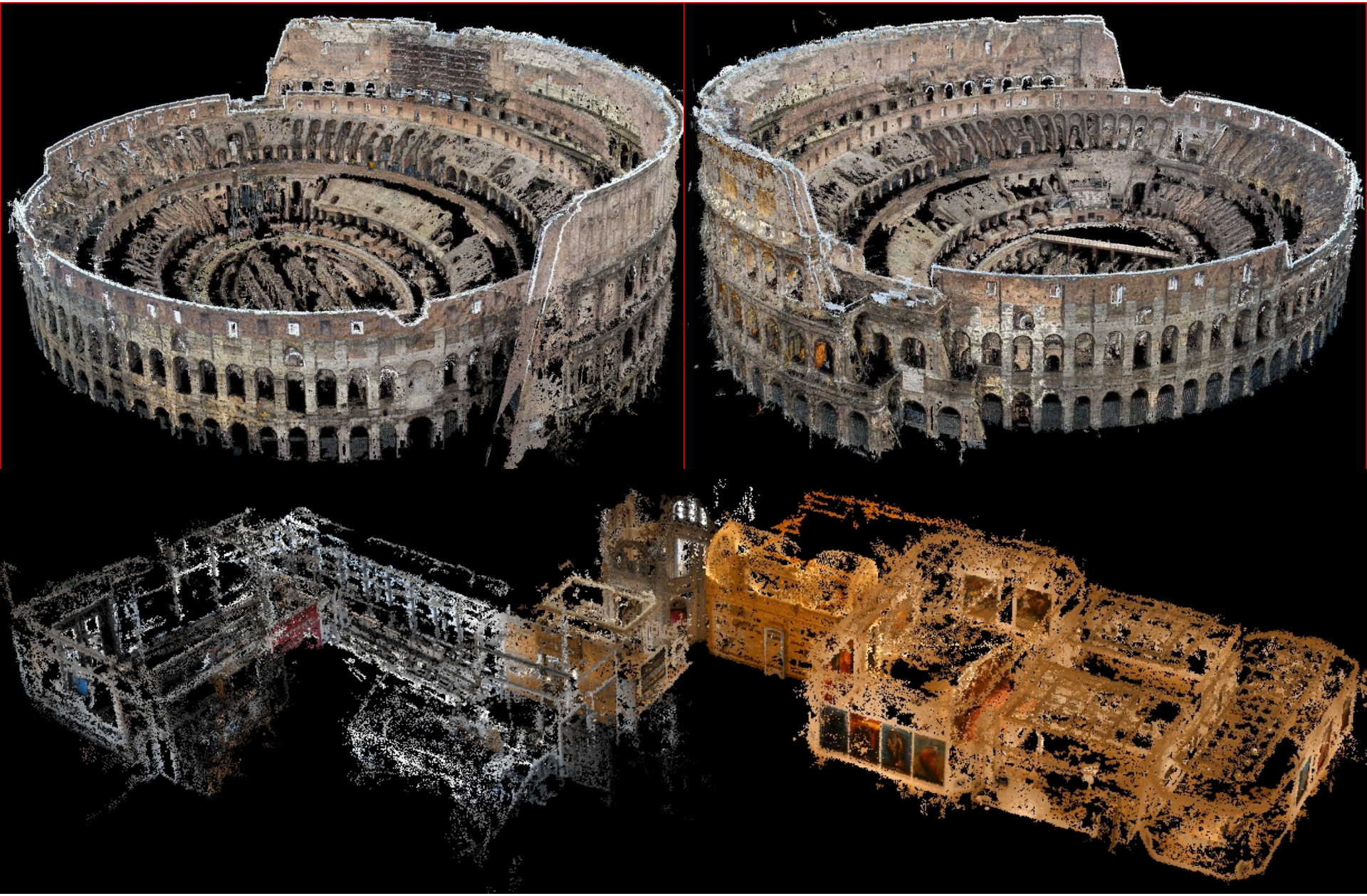
Reconstruction

Source: S. Seitz

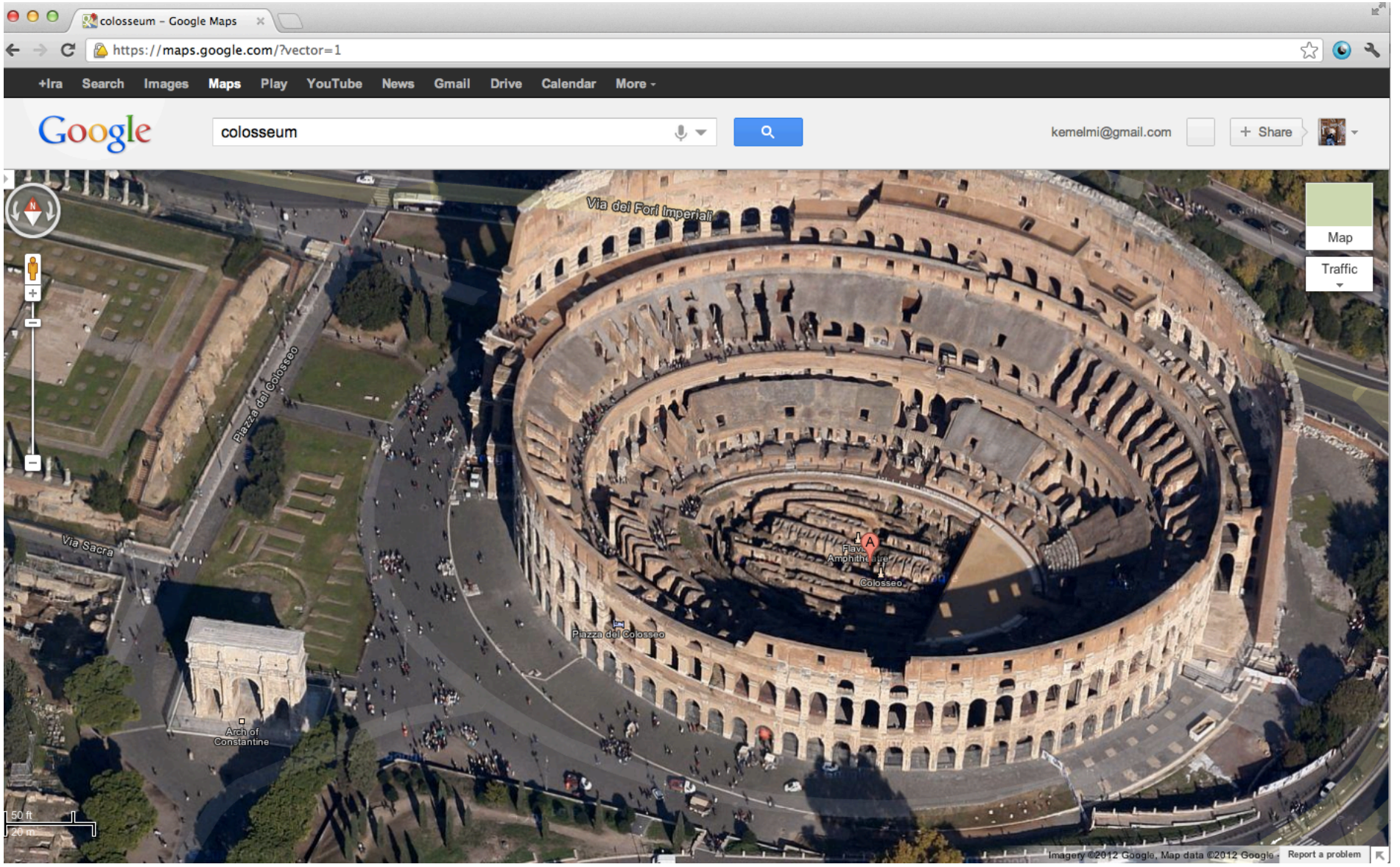
Input Image
(1 of 100)

Views of Reconstruction

Yasutaka Furukawa and Jean Ponce, **Carved Visual Hulls for Image-Based Modeling**, ECCV 2006.



Google's 3D Maps
Structure estimation from tourist photos



Apple’s 3D maps

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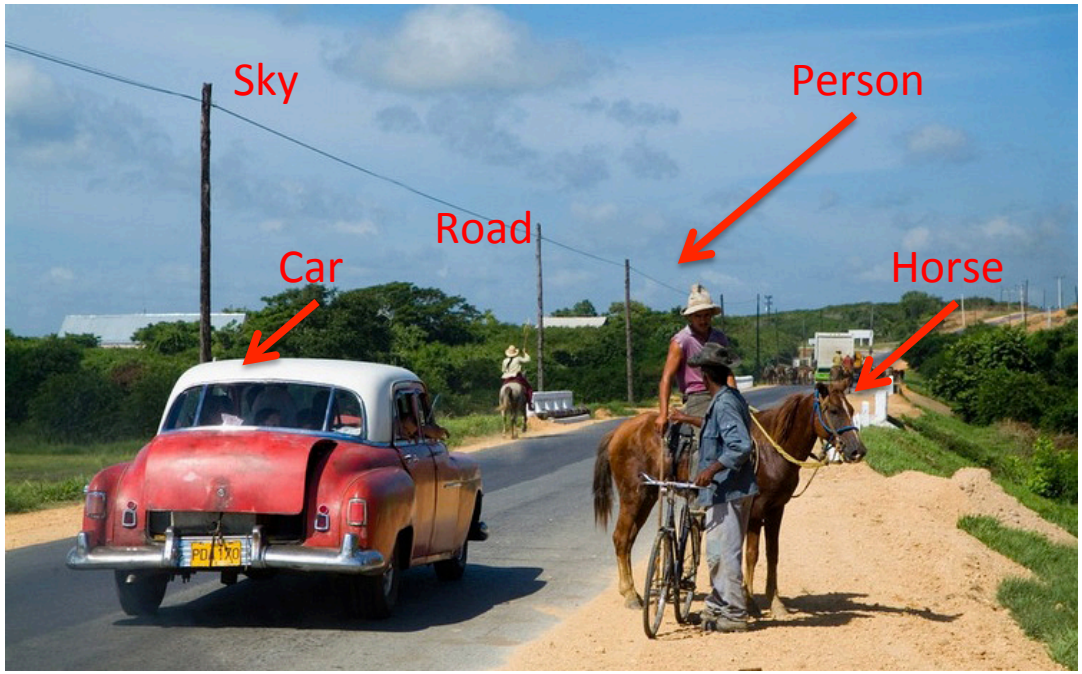
  - Pose estimation

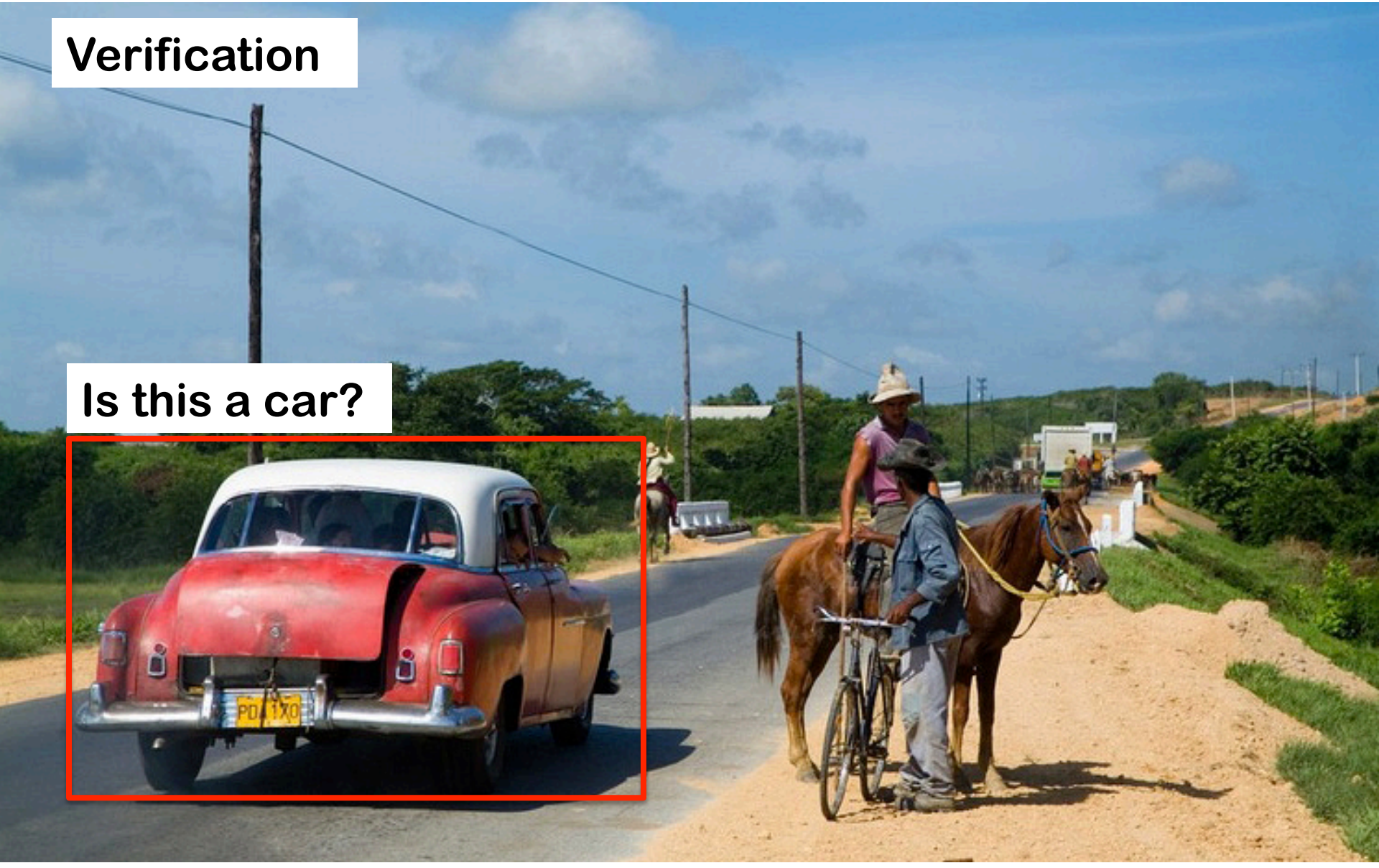


Visual Recognition?

- What does it mean to “see”?
  - “What” is “where”, Marr 1982

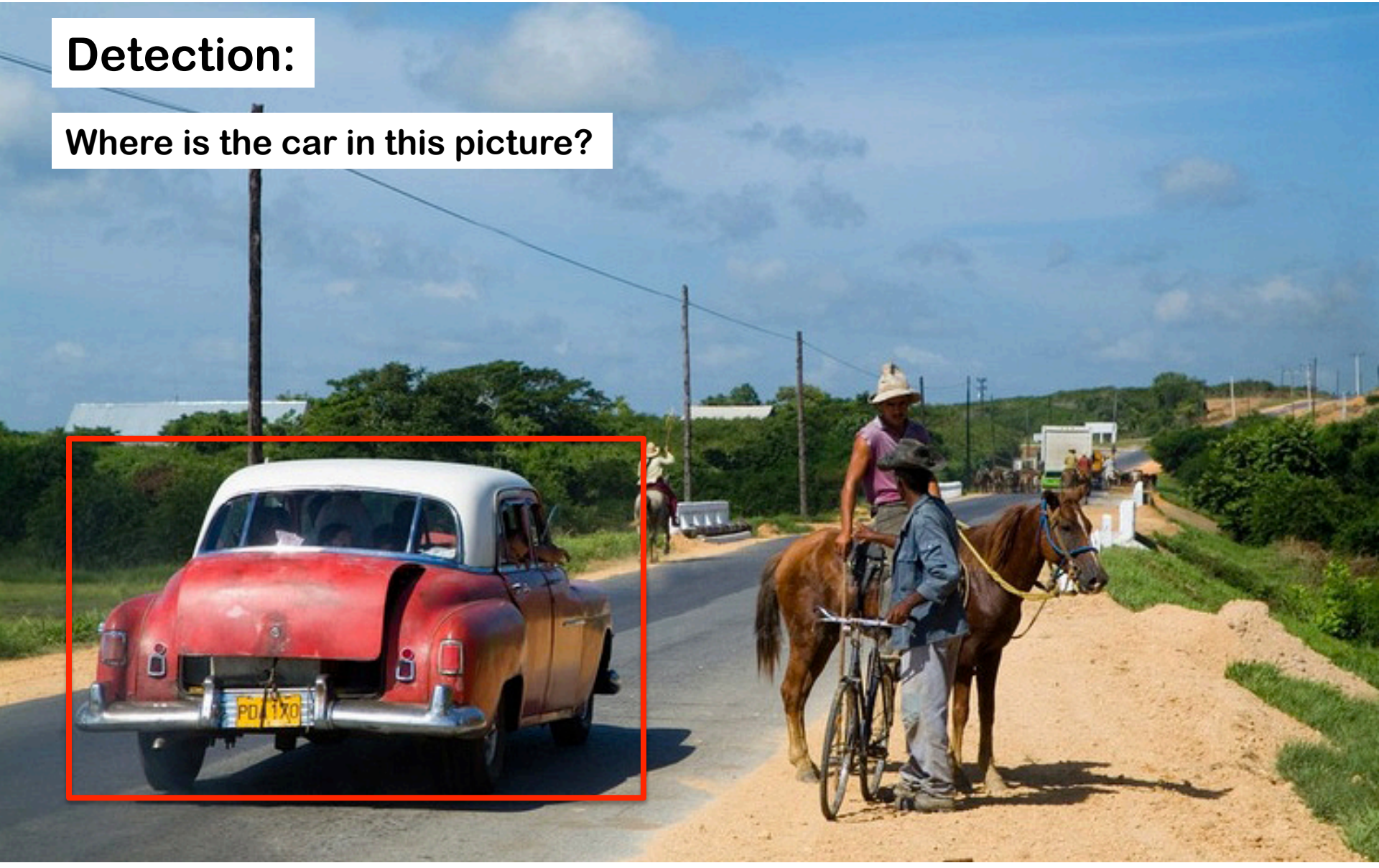
- Get computers to “see”

Visual Recognition



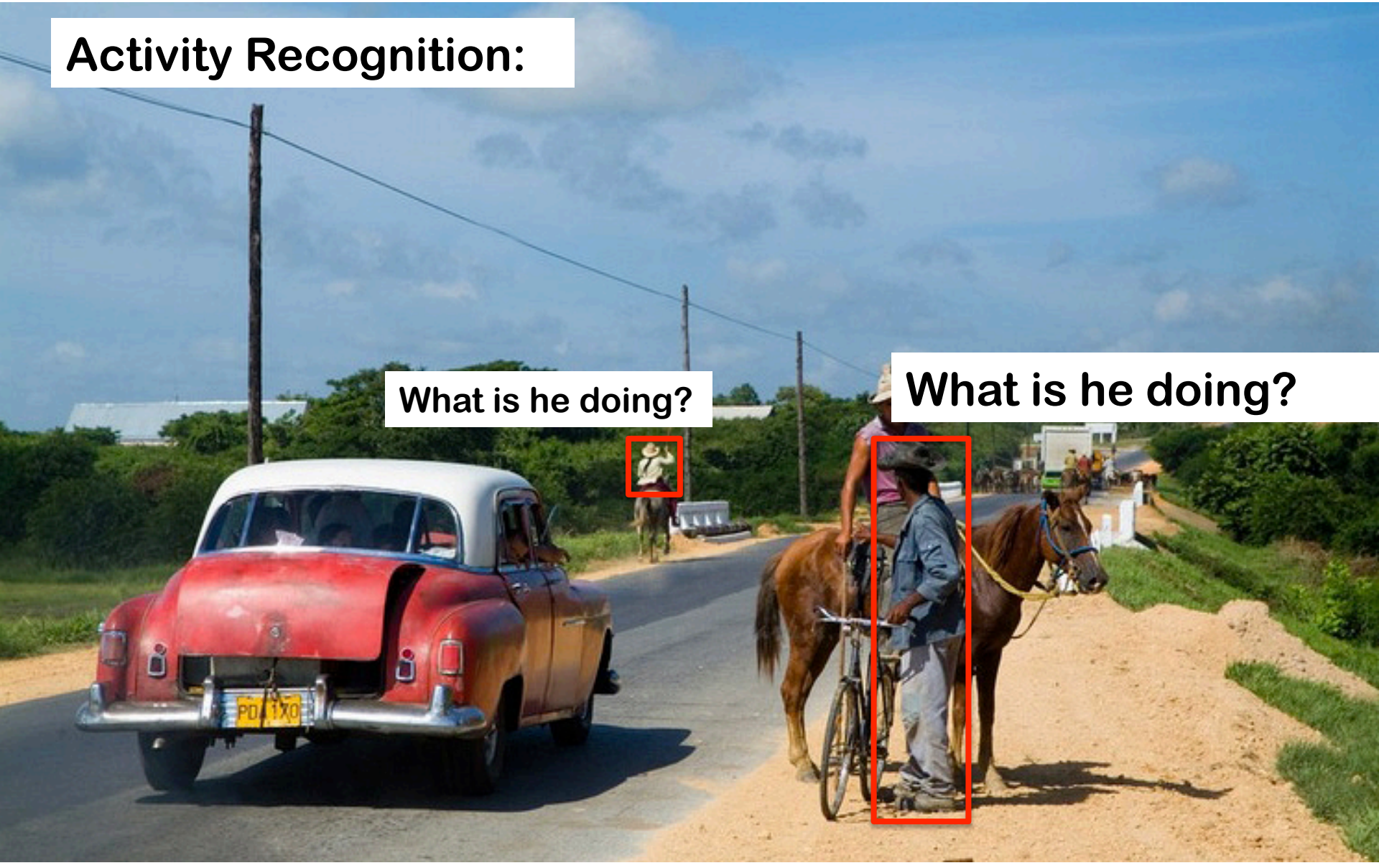
Visual Recognition

Visual Recognition

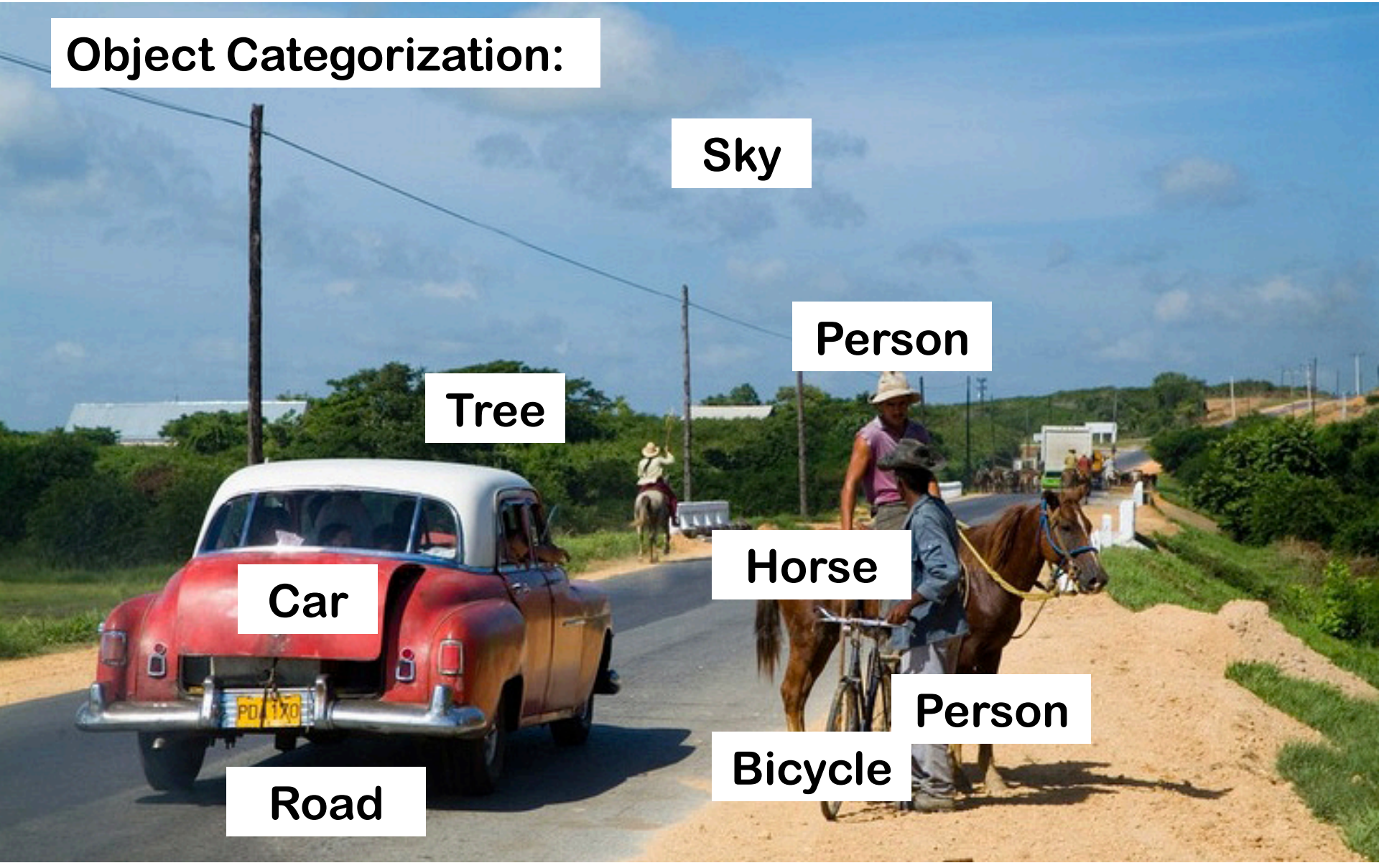


Visual Recognition

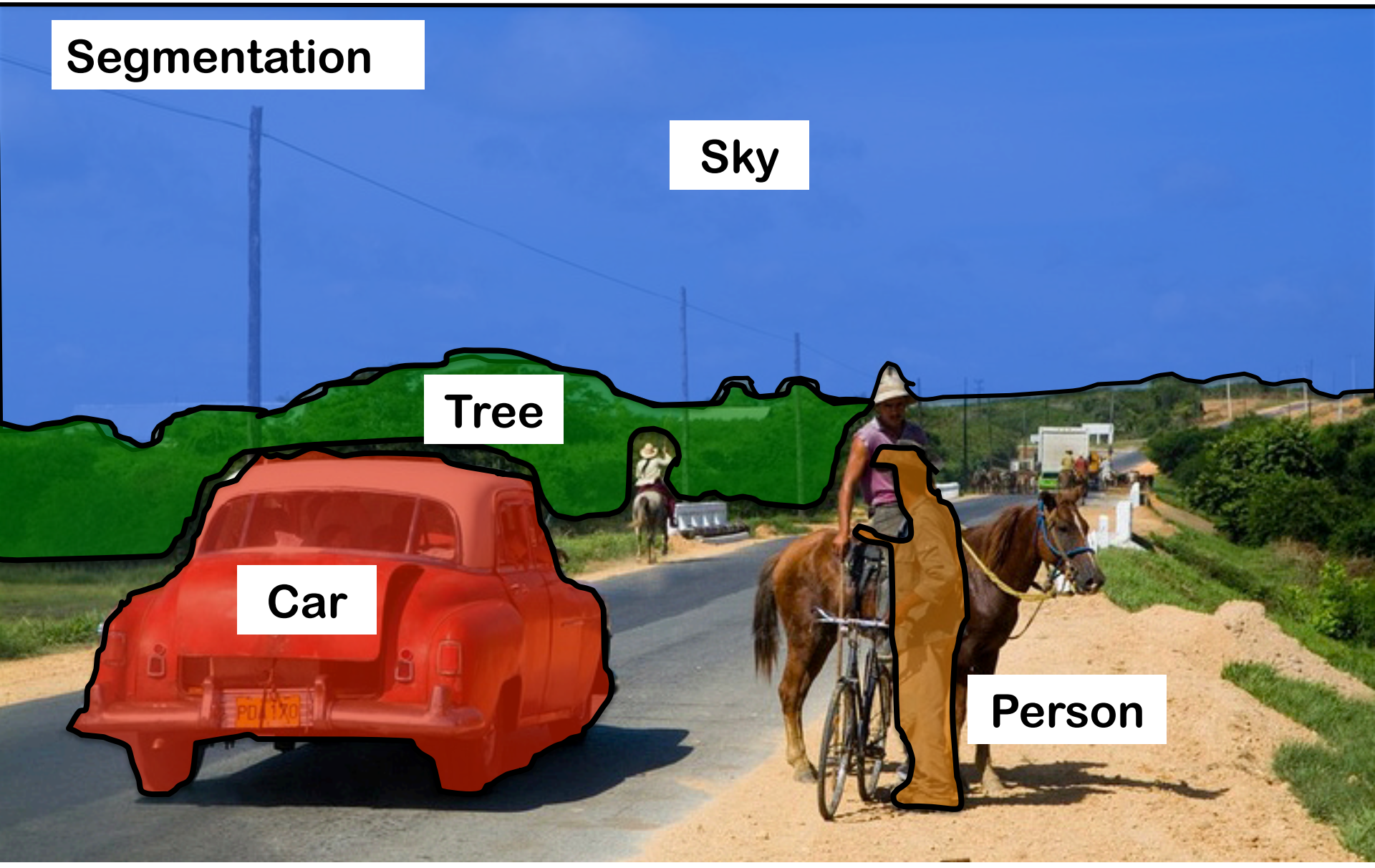
Visual Recognition



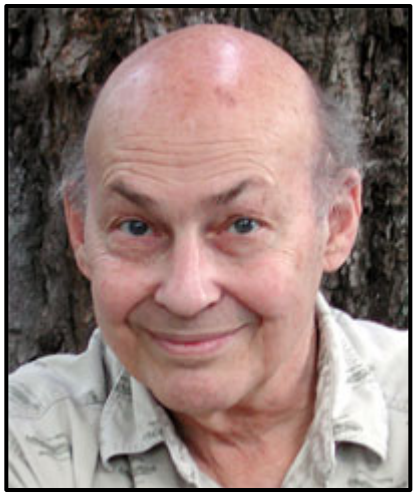
Visual Recognition



Visual Recognition



How hard is computer vision?



Marvin Minsky, MIT
Turing award,1969

"In 1966, Minsky hired a first-year undergraduate student and assigned him a problem to solve over the summer: connect a television camera to a computer and get the machine to describe what it sees."

Crevier 1993, pg. 88

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

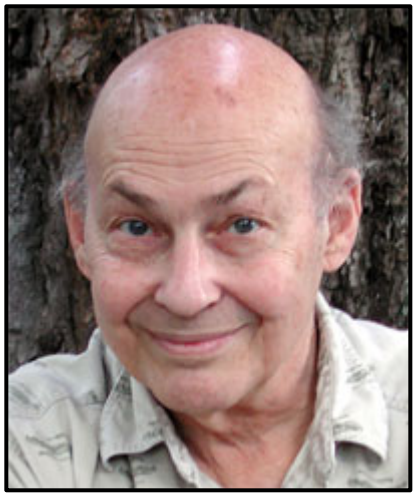
PROJECT MAC

Artificial Intelligence Group July 7, 1966
Vision Memo. No. 100.

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".



Marvin Minsky, MIT
Turing award,1969

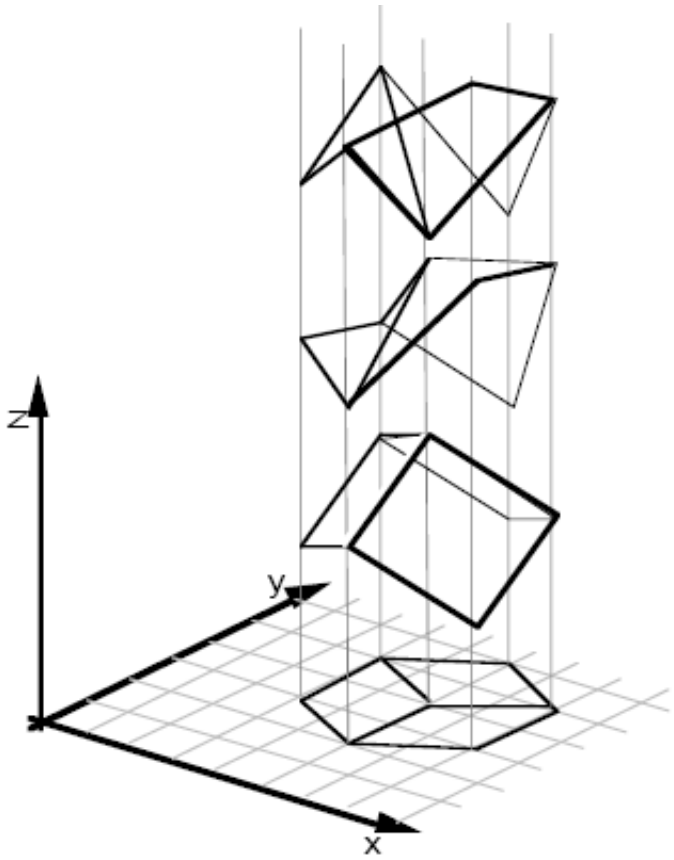
Gerald Sussman, MIT

"You'll notice that Sussman never worked in vision again!" – Berthold Horn

Why vision is so hard?

Why is vision so hard?

- Ill-posed problem



[Sinha and Adelson 1993]

Challenges 1: view point variation

Michelangelo 1475-1564

slide by Fei Fei, Fergus & Torralba

Challenges 2: illumination

slide credit: S. Ullman

Challenges 3: occlusion

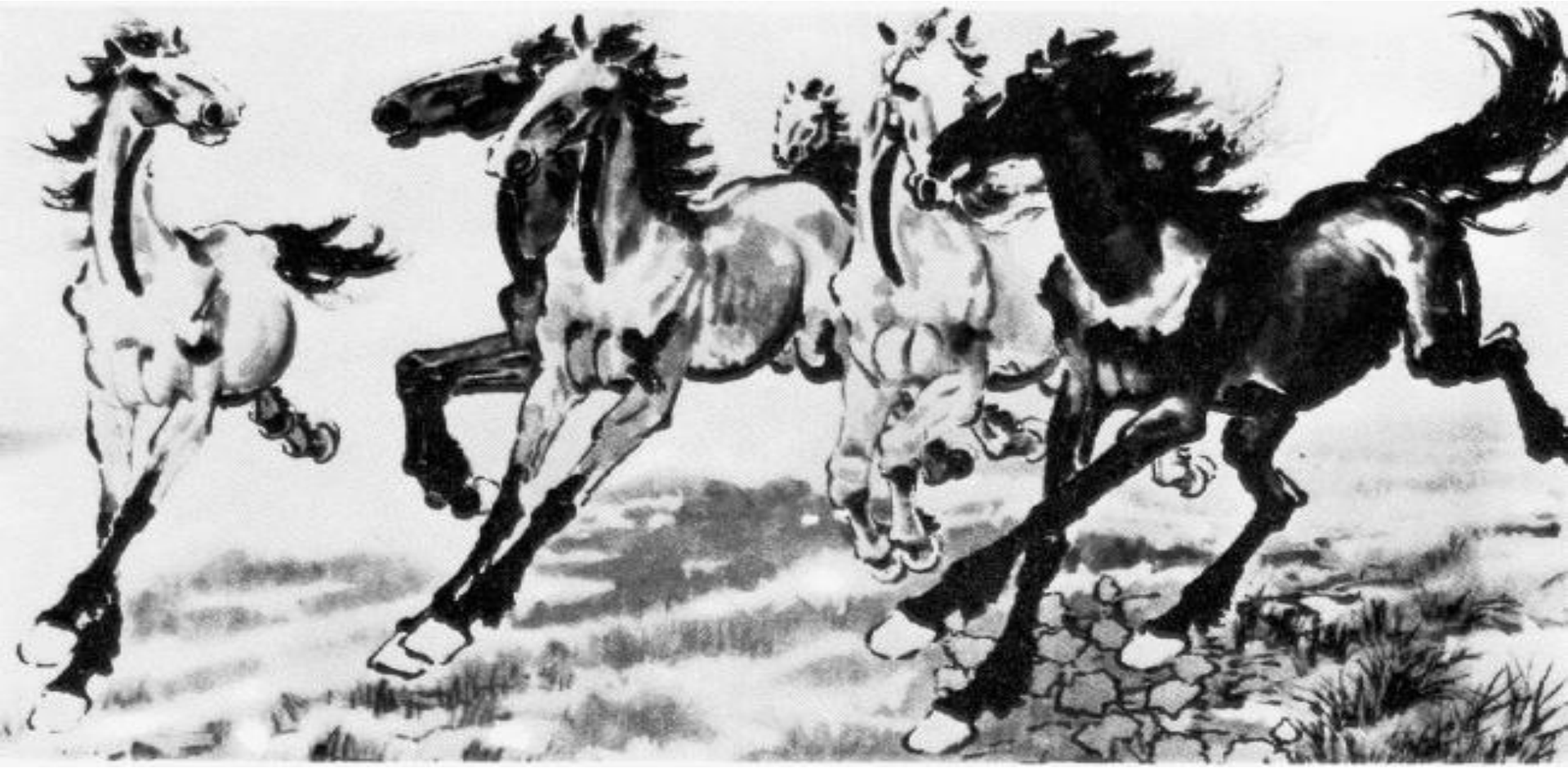
Magritte, 1957

slide by Fei Fei, Fergus & Torralba

Challenges 4: scale

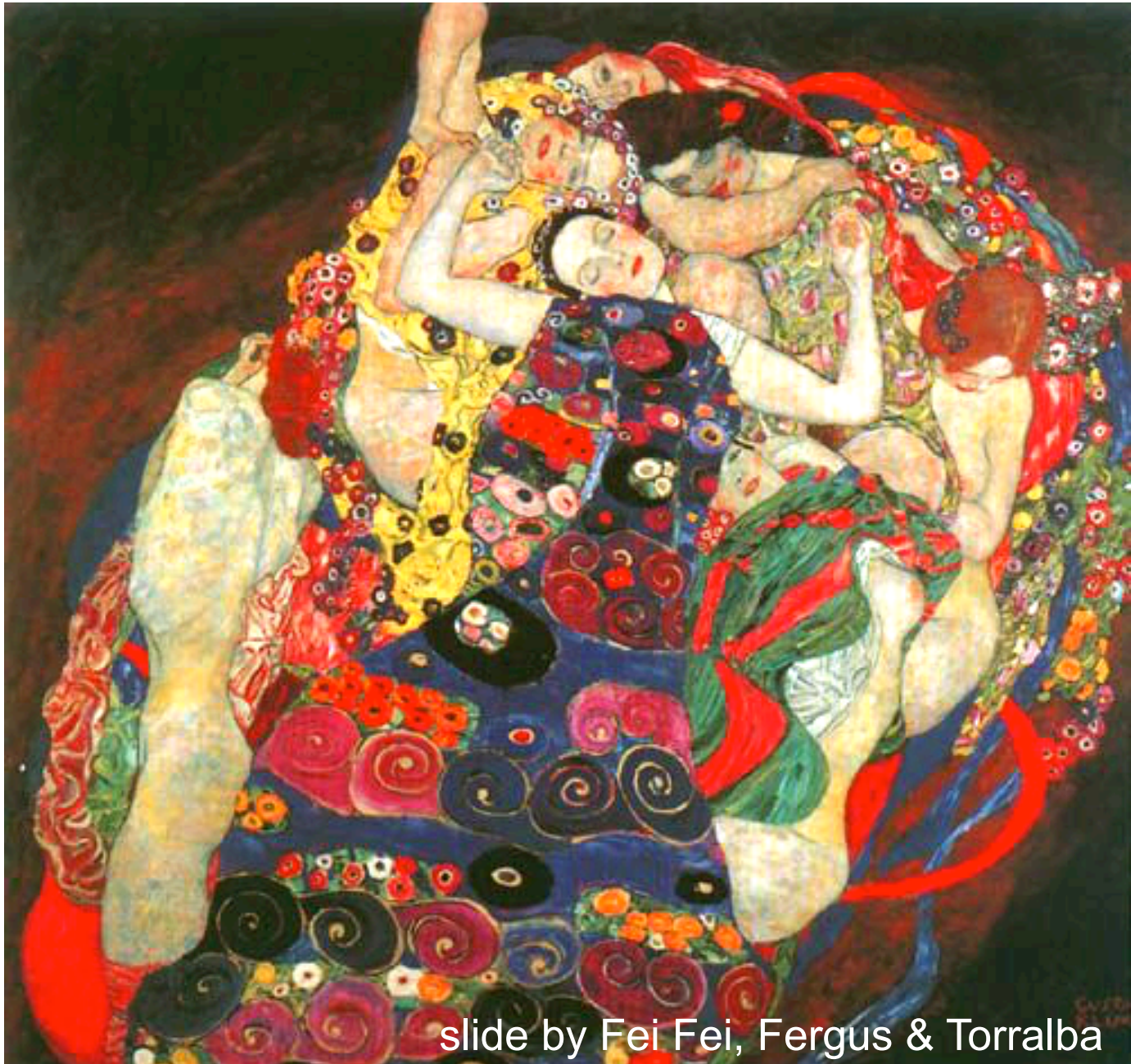
slide by Fei Fei, Fergus & Torralba

Challenges 5: deformation



Xu, Beihong 1943

Challenges 6: background clutter



Klimt, 1913

slide by Fei Fei, Fergus & Torralba

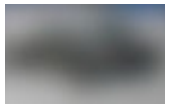
Challenges 7: object intra-class variation

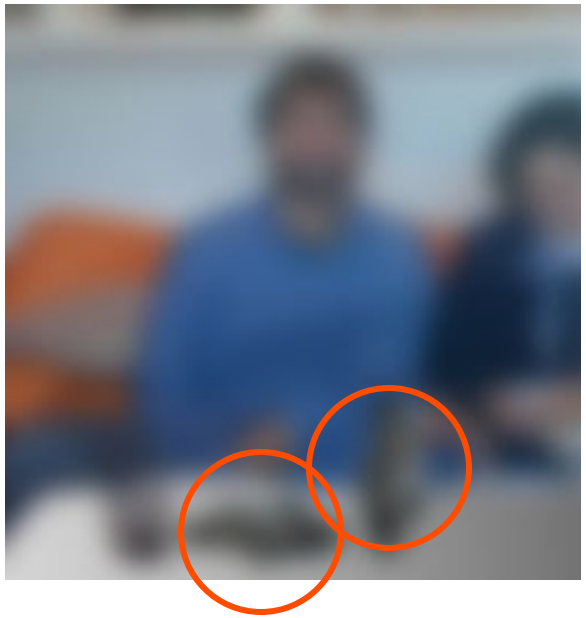


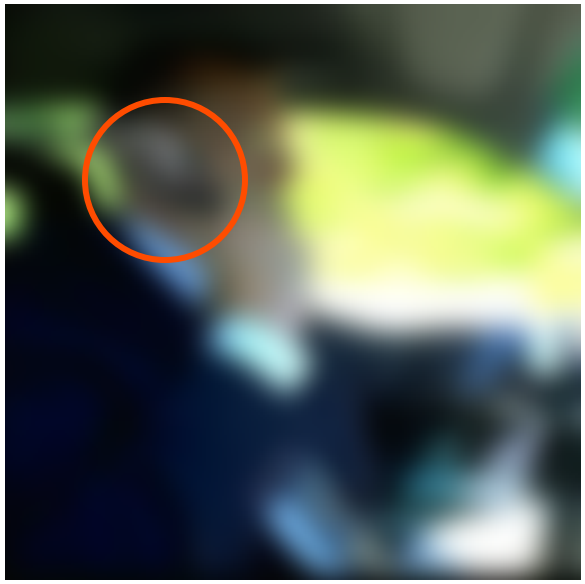


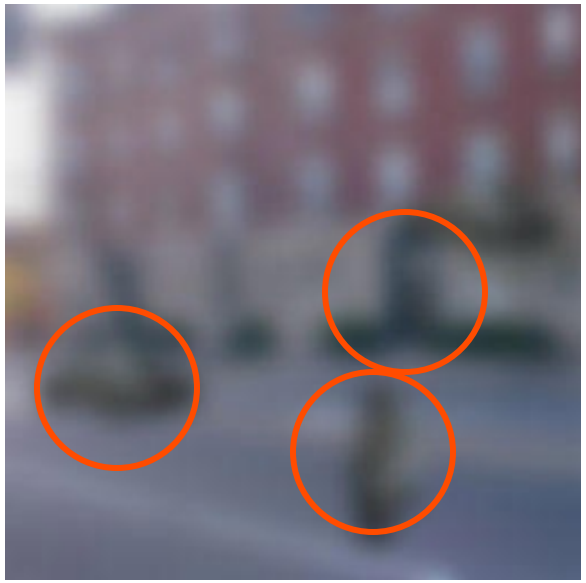

slide by Fei-Fei, Fergus & Torralba

Challenges 8: local ambiguity









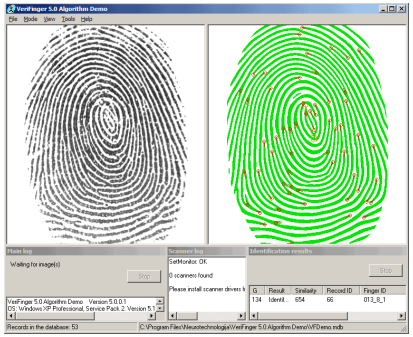
slide by Fei-Fei, Fergus & Torralba

Challenges 9: the world behind the image

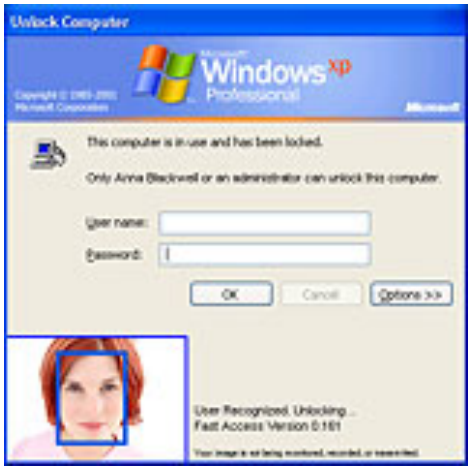
What Works Today?

- Reading license plates, zip codes, checks

Biometrics



Fingerprint scanners on many new laptops, other devices



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

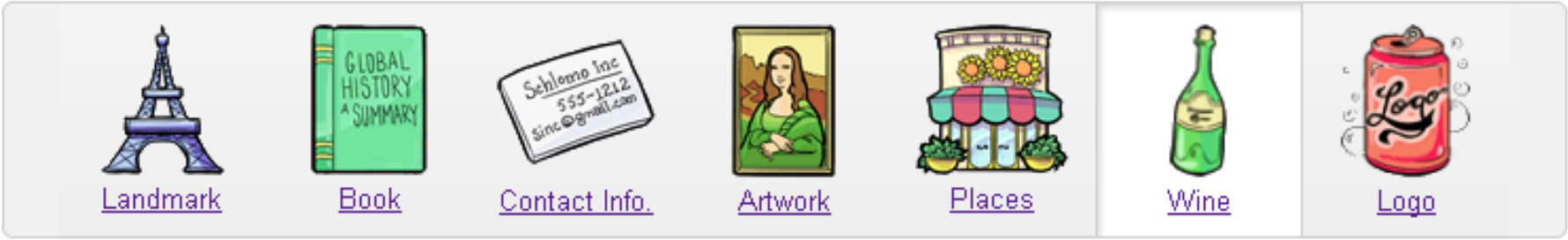
Source: S. Seitz

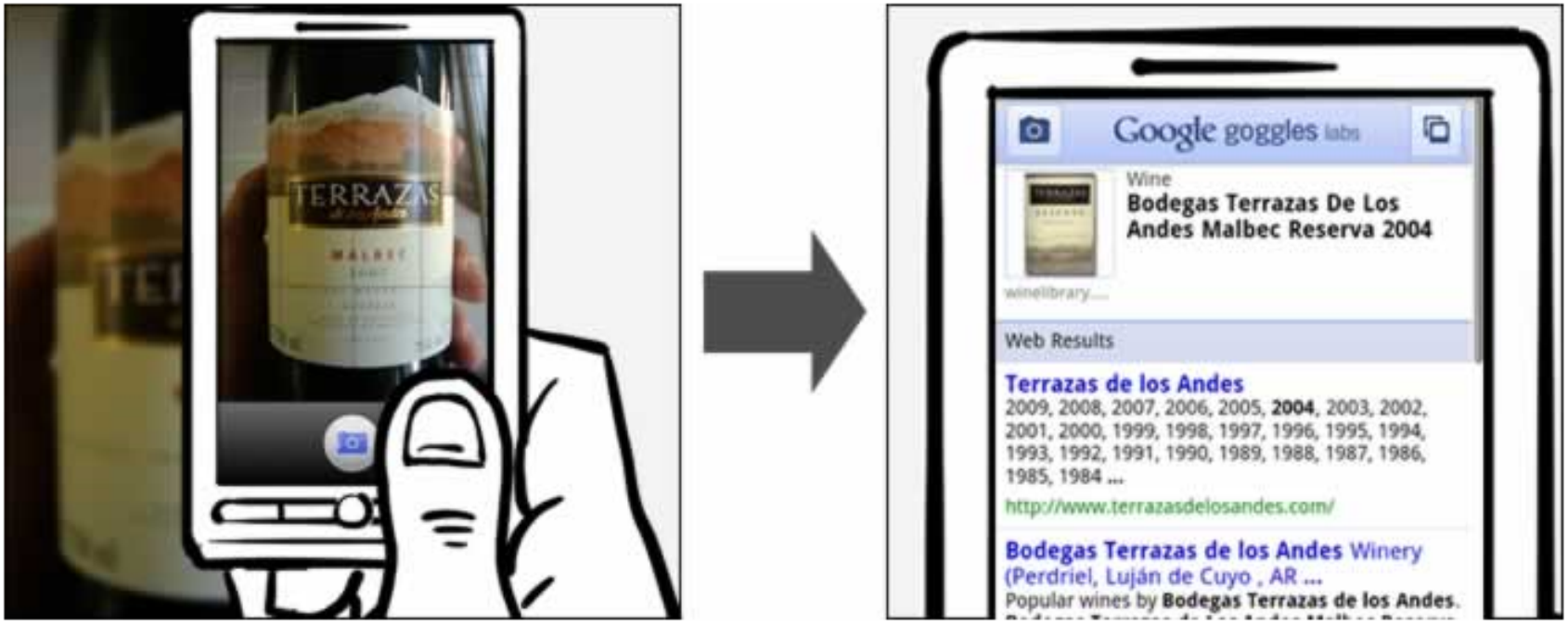
Mobile visual search: Google Goggles

Google Goggles in Action

Click the icons below to see the different ways Google Goggles can be used.

Google goggles labs



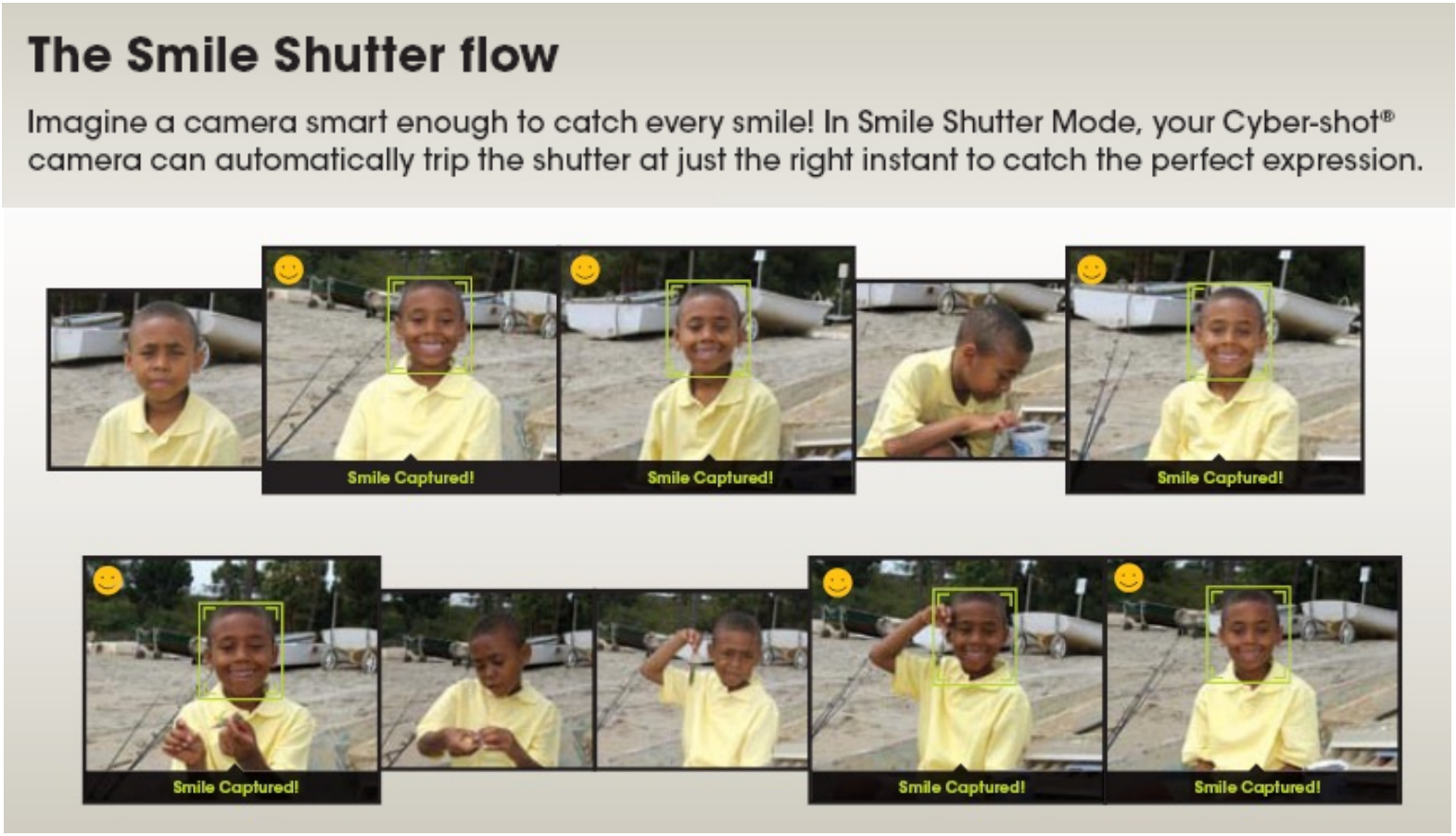


Face detection

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

Source: S. Seitz

Smile detection



Sony Cyber-shot® T70 Digital Still Camera

Source: S. Seitz

Face recognition: Apple iPhoto, Facebook, Google, etc

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… “

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Last Updated: Wednesday, 31 August 2005, 05:44 GMT 06:44 UK

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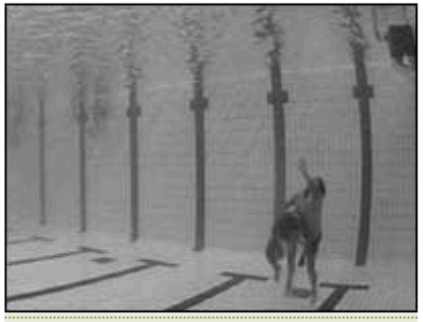
Computer alert for drowning girl

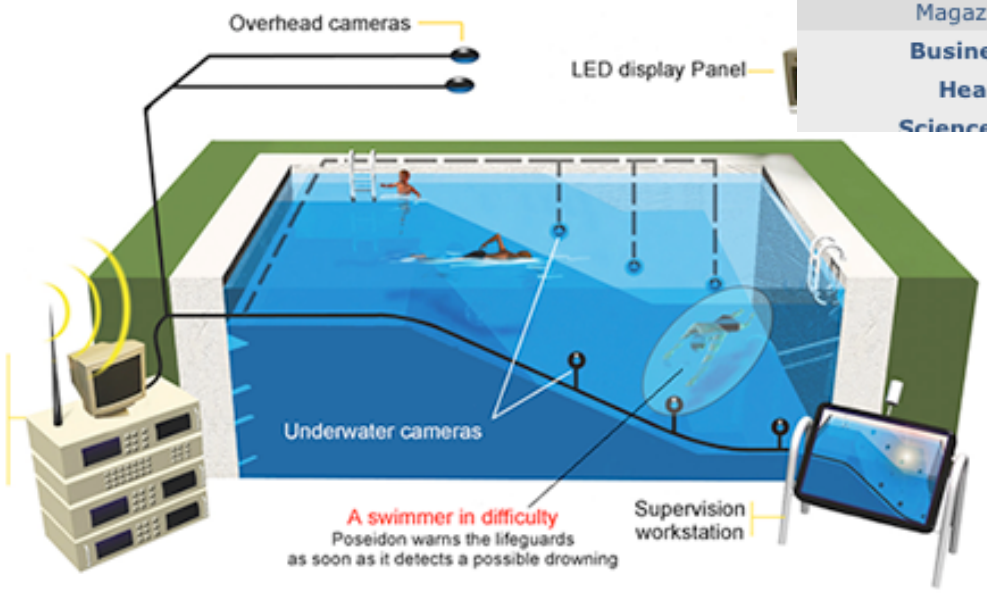
A 10-year-old girl has been saved from drowning by a computer system designed to raise the alarm when swimmers get into difficulties.



VIDEO Watch the rescue

The girl, from Rochdale, was at the deep end of the pool in Bangor, north Wales, when she sank to the bottom.

The £65,000 system, called Poseidon, detected her on the pool floor and sounded the alarm. A lifeguard pulled her out and she recovered in hospital.



Security

Local

Cameras help confirm Scott suicide ruling

Friday, December 04, 2009

TAGS: local, paul meincke

Comment Now Email Print Report a typo

Paul Meincke
More: Bio, News Team

December 4, 2009 (CHICAGO) (WLS) -- Chicago police have closed the case in the death of Chicago School Board President Michael Scott.

Police Supt. Jody Weis says investigators used police cameras in the city to trace Scott's last steps in the hours before his body was found in November.

Scott's death has been ruled a suicide. The medical examiner's office concluded --not long after Scott's body was found -- that he had committed suicide. Police did not dispute the finding but wanted to pursue all the investigative leads they could. They say they have done that and have now reached the same conclusion.

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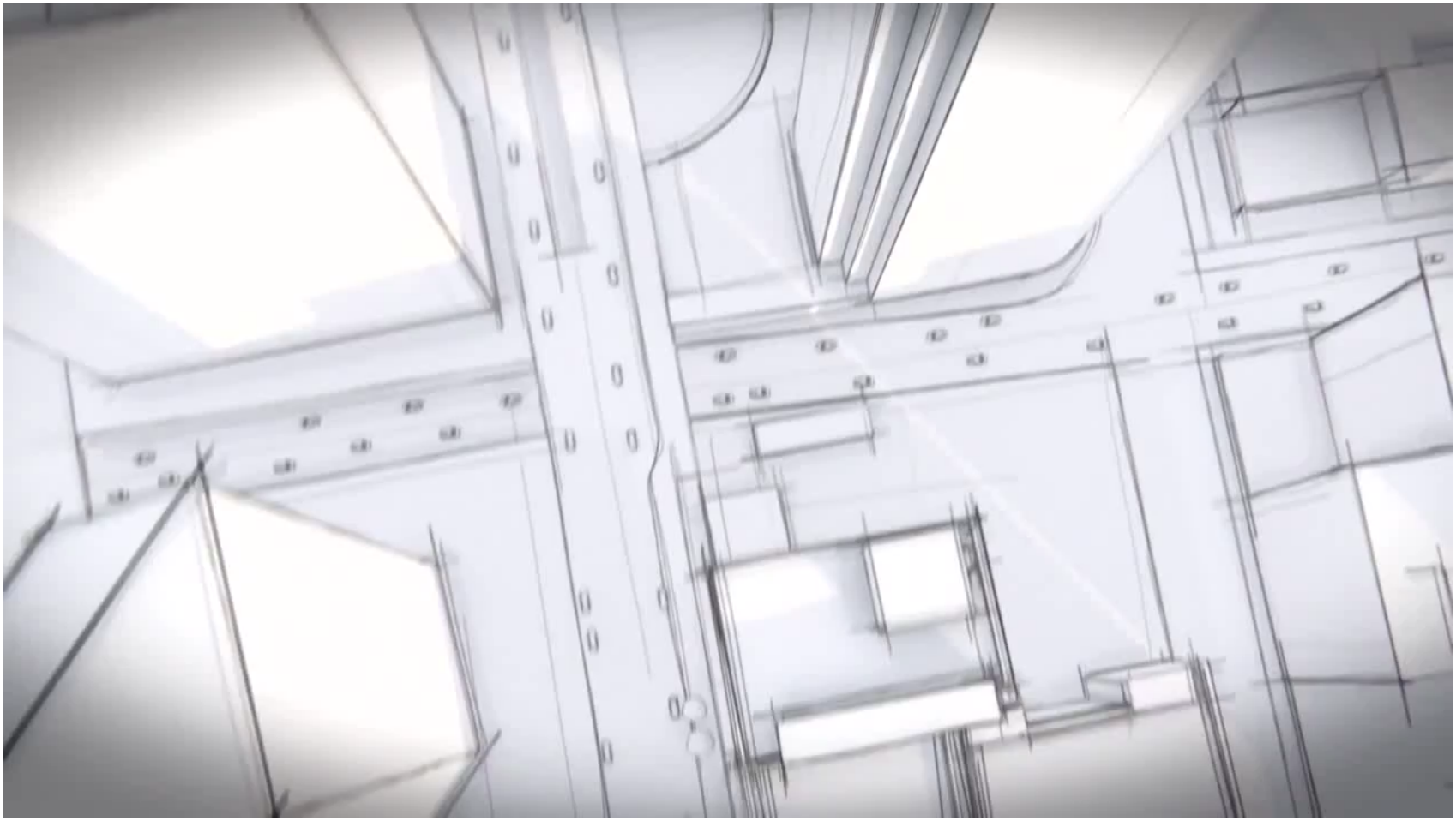
- BP Gas Recall: BP finds, fixes source of bad gas
- Teachers union, board resume negotiating
- Back to School
- 5 injured in South Side shooting 49 min ago
- Pastor: Stacy Peterson said she lied for Drew

Automotive safety

- Mobileye: Vision systems in high-end BMW, GM, Volvo models
  - Pedestrian collision warning
  - Forward collision warning
  - Lane departure warning
  - Headway monitoring and warning

Source: A. Shashua, S. Seitz



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)

Vision-based interaction: Xbox Kinect

Kinect Fusion

Augmented reality, consumer products

http://nconnex.com/wp/

Special effects: shape and motion capture

Source: S. Seitz

Vision for robotics, space exploration

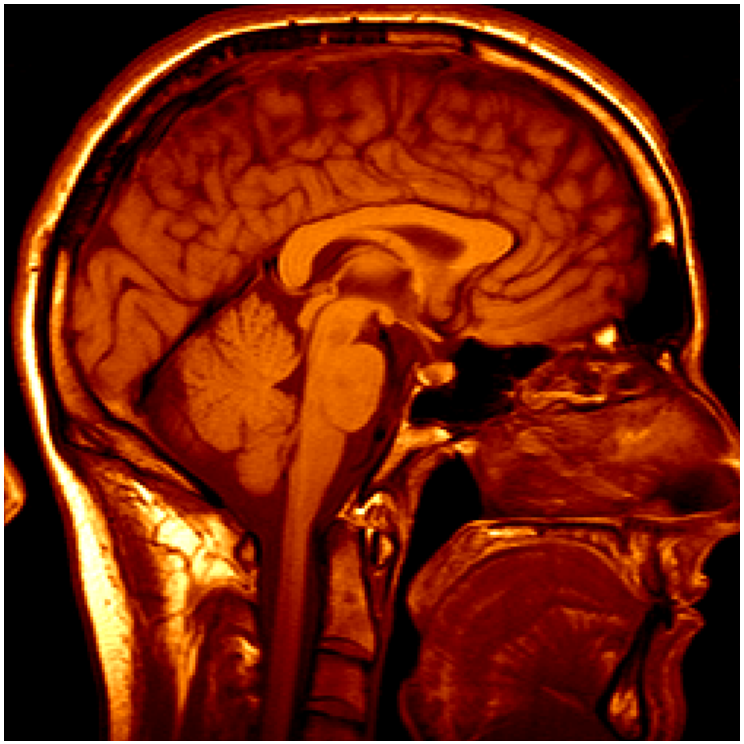
NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

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.

Source: S. Seitz

Medical imaging



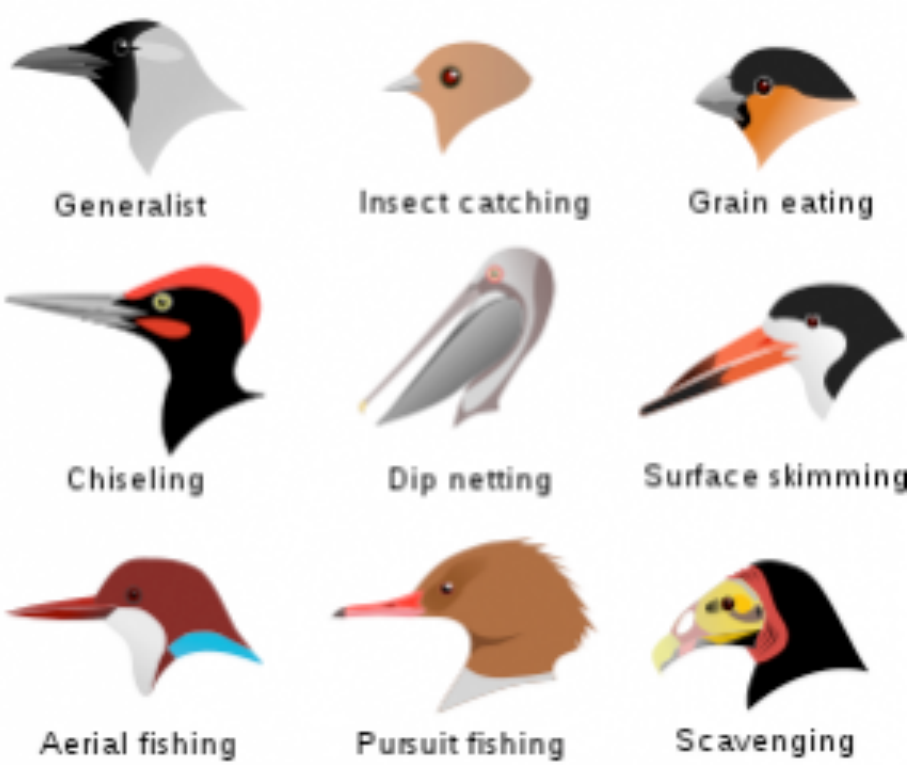
3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Computer vision in other scientific fields

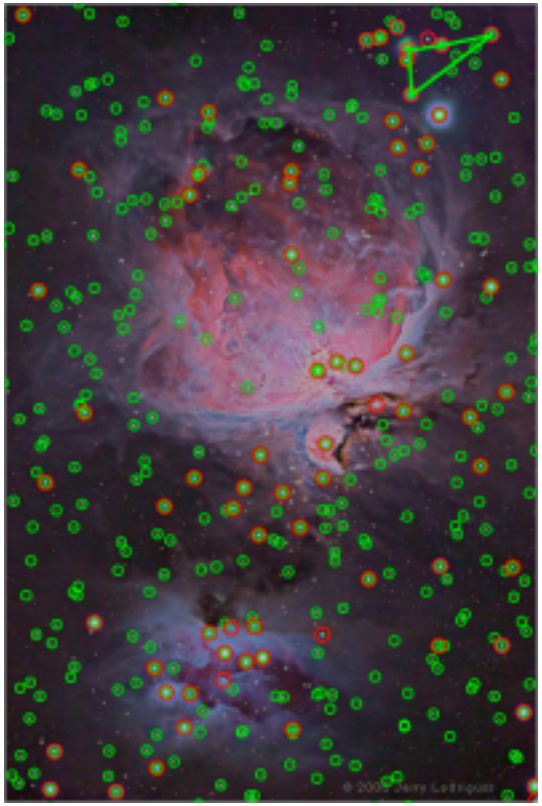
Computer vision research in biology

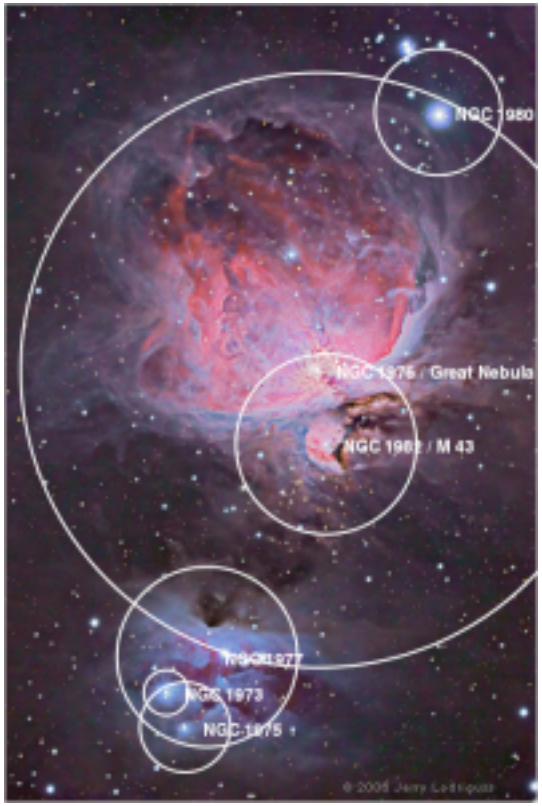
http://leafsnap.com/



http://www.vision.caltech.edu/visipedia/

Computer vision in cosmology





http://astrometry.net/

Computer vision research in healthcare

assisted living, patient monitoring
[Lan et al, PAMI 2012]

autism screening
http://www.gatech.edu/newsroom/release.html?nid=60509

Computer vision in the real-world

- Most examples are less than 5 years old
- Very active research area. Many new applications to come.
- A website of computer vision industries maintained by Prof. David Lowe (UBC):

http://www.cs.ubc.ca/~lowe/vision.html

Tentative Syllabus

- **Image Processing (2 weeks)**
- filtering, convolution
- image pyramids
- edge detection
- feature detection (corners, lines)
- hough transform

- **Image Transformation (2 weeks)**
- image warping (parametric transformations, texture mapping)
- image compositing (alpha blending, color mosaics)
- segmentation and matting (snakes, scissors)

- **Motion Estimation (1 week)**
- optical flow
- image alignment
- image mosaics
- feature tracking

Syllabus

3D Modeling (1 weeks)

- projective geometry
- camera modeling
- single view metrology
- camera calibration
- stereo

- **Computational Photography (1 week)**
- Super resolution
- Alpha Matting
- Blur removal
- Poisson Blending

- **Visual Recognition (3 week)**
- Eigenfaces
- Category Recognition
- Object Detection
- Kinect

Grading

- Four assignments (10 each+ extra points)
  - Mix of coding and written answers.
  - Using Qt (cross platform UI in c++) qt.nokia.com
  - Use of interactive UIs for exploring and gaining intuition
  1. Filters and edge detection
  2. Creating panoramas
  3. Computing depth from stereo
  4. Face detection
- **FINAL PROJECT (60 points + 20 extra points)**

Assignment 1: Image Filtering
10 Points

Assignment 2: Panorama Stitching
10 Points

Assignment 3: Stereo Reconstruction
10 Points

Assignment 4: Face Detection
10 Points

Final Project
60 Points + 20 Extra points

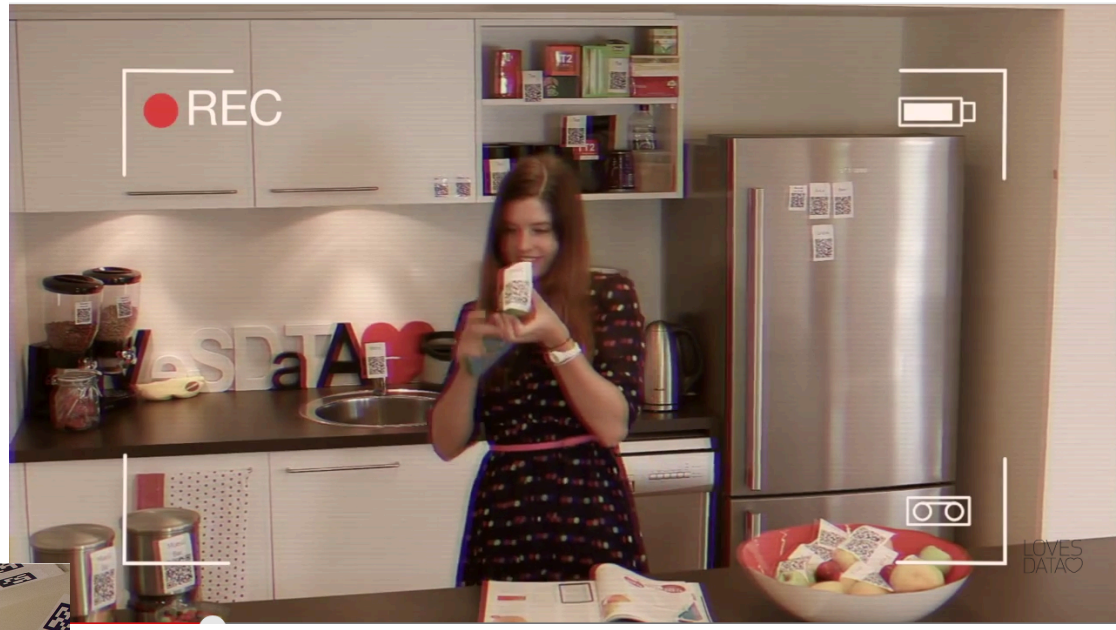
- Big Project
  - Better if related to your own research
  - Demo is a **BIG** plus

- Proposal is due on 4/6
  - One Paragraph,
  - Crisp final outcome/deliverable
- Progress Reports are due on
  - 4/15, 4/29,5/13,5/27
  - What has changed since last report
- Final Presentation will be on 6/3,
  - Demo/Posters @ CSE atrium

Sample Projects

From Taskar Center for Accessible Technology

Project: **My Kingdom**



Sample Projects

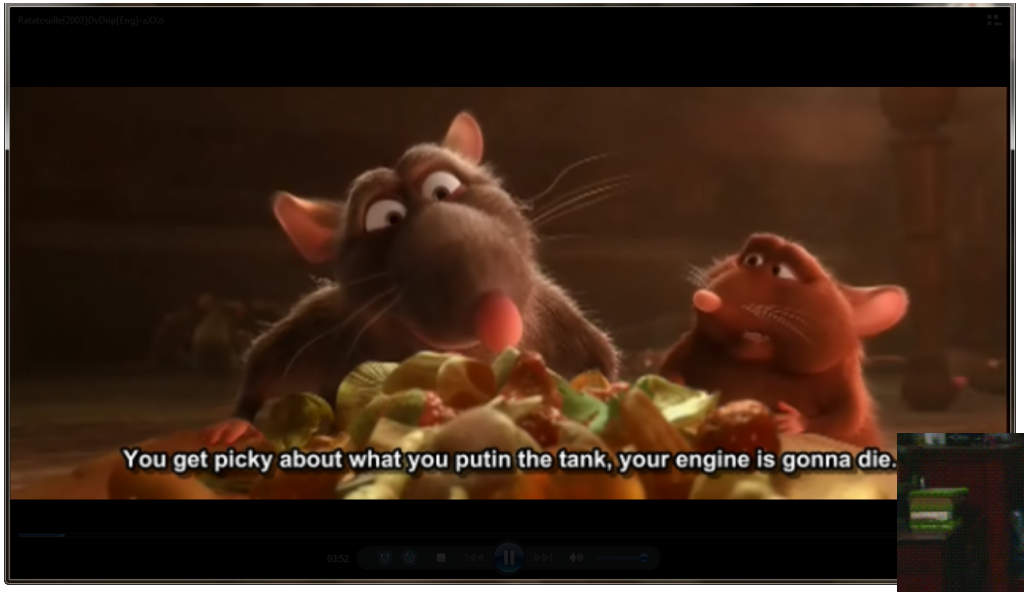
From Taskar Center for Accessible Technology

Project: **Curb Alert**

Sample Projects

From Taskar Center for Accessible Technology

Project: **Silent Movie**



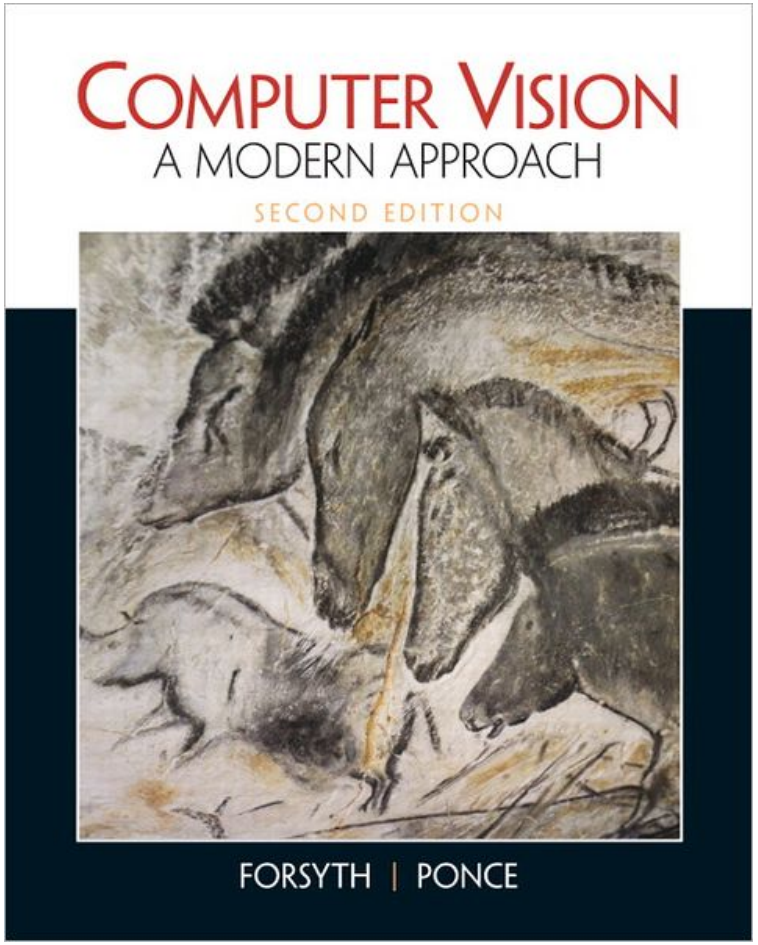
Samples of Previous Projects

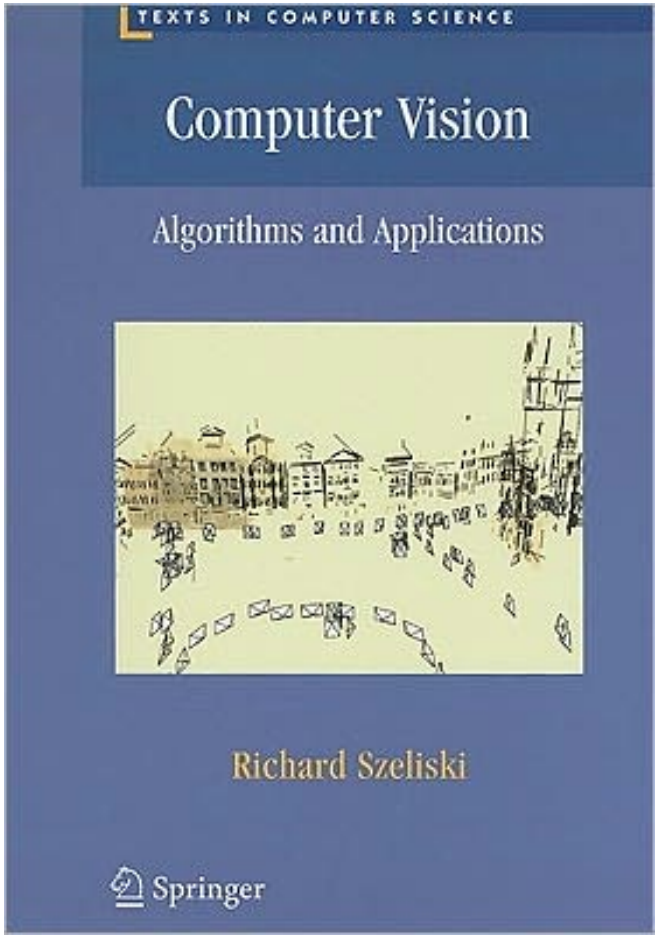
- Visual Calculator
- Seam Carving
- X-ray bone fracture detection
- Pipe leak detection
- Is it gonna be viral?
- Deep learning for object recognition
- …

Project Ideas

- Seam Carving
- Detecting Shadows
- Features
  - Learning Features
  - Features for regions
  - Comparison of features in the literature
- Action Recognition
  - Human pose
  - Objects and Interactions
  - Using Kinect
  - Detecting unattended luggages
  - Egocentric
- Grab cut
- Video Stabilization
- RGBD object Detection
- Object Detection in Videos
  - Video Google
- Matching Images and Videos in the wild
- Reading Street Signs
  - Wearable Cameras for visually impaired users
  - Auto Zooming
- Visual Odometer
  - Smart stop lights
- Language & Vision

Books


COMPUTER VISION
A MODERN APPROACH
SECOND EDITION
FORSYTH | PONCE


TEXTS IN COMPUTER SCIENCE
Computer Vision
Algorithms and Applications
Richard Szeliski
Springer

Calibration

- How many of you
  - have taken an undergrad vision course?
  - have taken an ML course?
  - have taken a Graphics course?
  - Remember your linear algebra course in your undergrad?
  - have any concerns about programming?

Do these words remind you of something?

Interest Point		SIFT	
Laplacian		Eigenvalue	
SVD		SVM	
MRF		STEREO	
Random Forest		Graph cut	

Preferences

- Low level vision?
- Mid level vision?
- High level vision?