CSC 391 Introduction to Computer Vision

V. Paul Pauca and Rongzhong Li

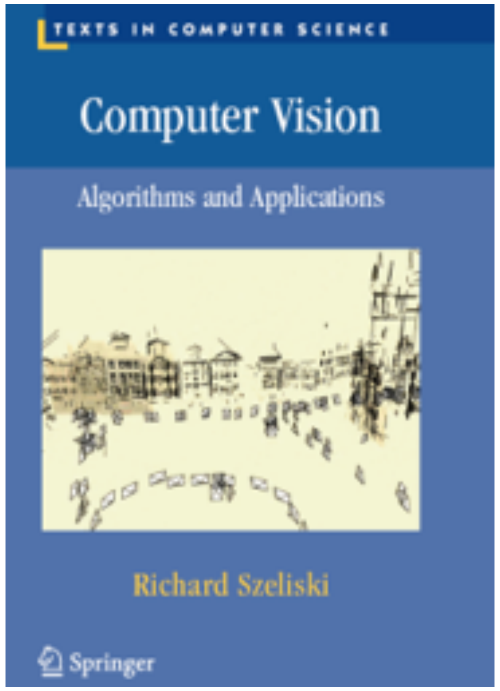
Fall 2016

Wake Forest University

Basic Info

- Instructors
  - V. Paul Pauca
  - Email: paucavp@wfu.edu
  - Office: Manchester Hall 235
  - Office hours: T-Th 9:00 - 11am
- Course webpage:
  - csweb.cs.wfu.edu/~pauca/CSC391-CV.html
- Textbook:

Computer vision: algorithms and applications by R. Szeliski



Course Details

- Grading
  - Programming projects: 40%
  - Final project: 20%
  - Midterm exam: 15%
  - Final exam: 20%
  - Attendance & participation: 5%
- Programming projects
  - OpenCV and Python
  - Weekly programming assignments
  - Turn in through Sakai

Course Details

- Final project
  - Individuals or up to groups of 2
  - Explore computer vision topics in robotics
  - Due on last week of class
- Midterm quiz and final
  - Test material comprehension as well as application
- Attendance and participation
  - Regular attendance required, participation helps a lot

Course Details

- Academic integrity
  - Can work with other students
  - But programming assignments are individual
  - Can use online resources as long as sources are credited

What is computer vision?

- *Automatic* understanding of images and video
  - Compute properties of the 3D world from visual data (measurement)
  - Algorithms and representations to allow a machine to recognize objects, people, scenes, and activities. (perception and interpretation)

Human vision

- Easily perceive 3-d structure of the world
  - Shape, translucency, segmentation, recognition, etc.
- *How does it work?*
- Can computers match or beat human vision?

Humans vs computers

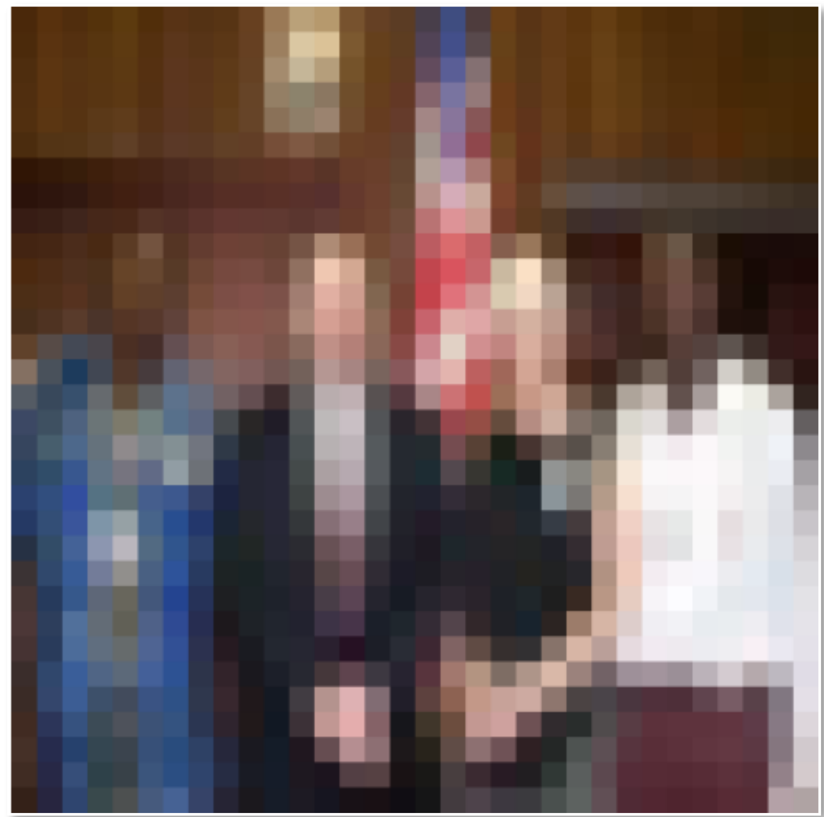
0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What we see   What a computer sees

- The goal in computer vision is to extract *meaning* from pixels

Source: S. Narasimhan via Lazebnik

Humans vs computers



Humans are remarkably good at extracting meaning from pixels

Source: “80 million tiny images” by Torralba et al.

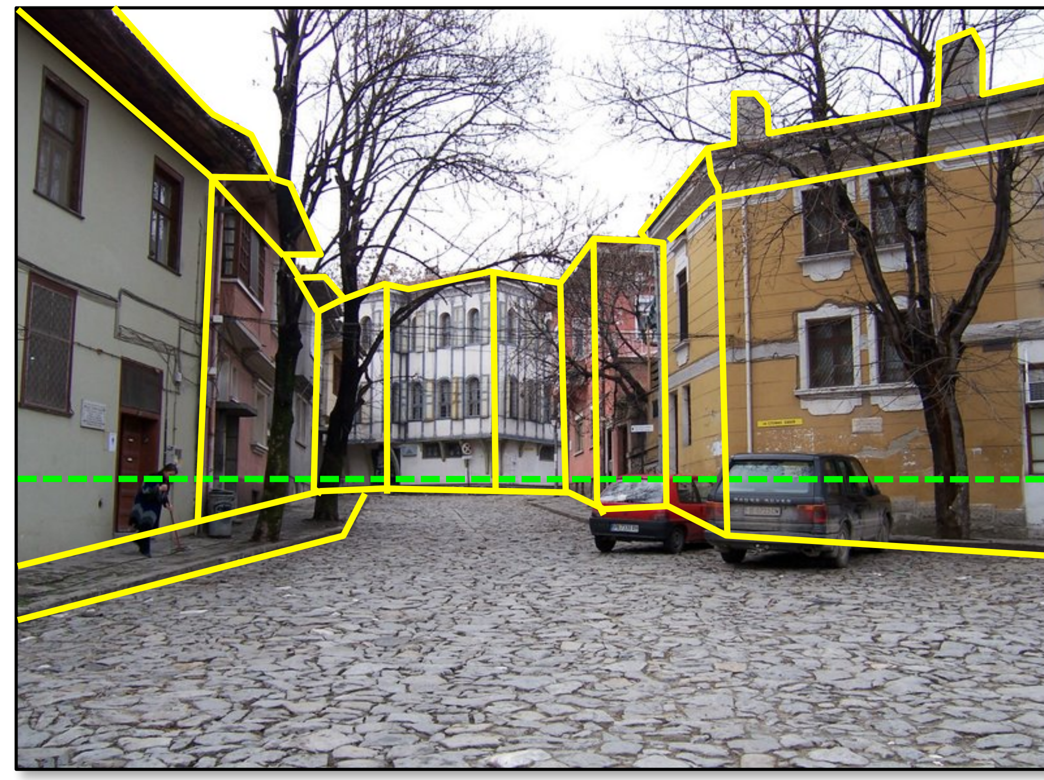
Human vs. computers

- But human perception has its shortcomings…

Sinha and Poggio, *Nature*, 1996

What kind of information can be extracted from an image?

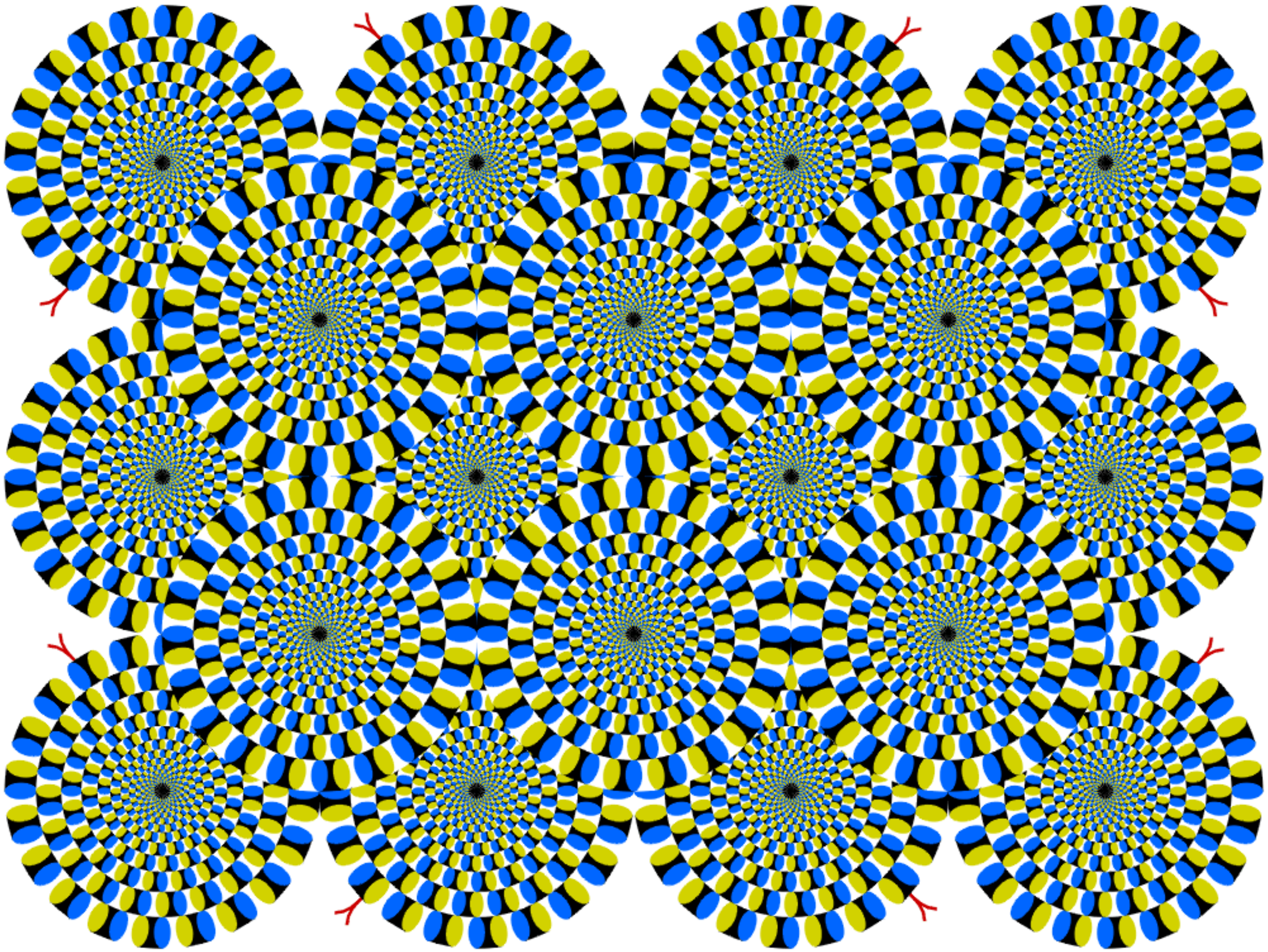
Semantic information



Geometric information

Source: S. Lazebnik

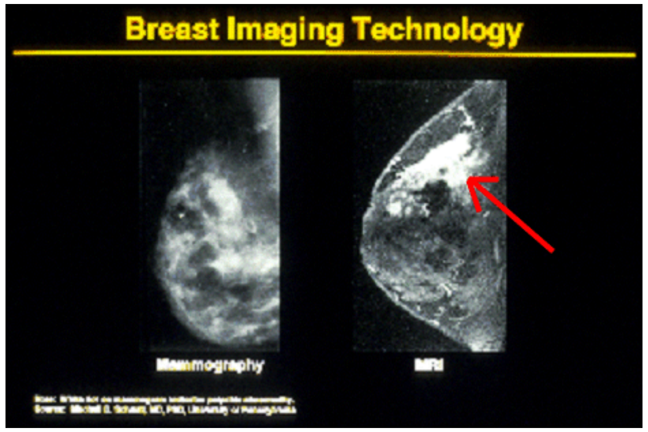
Humans vs. computers



Copyright A. Kitaoka 2003

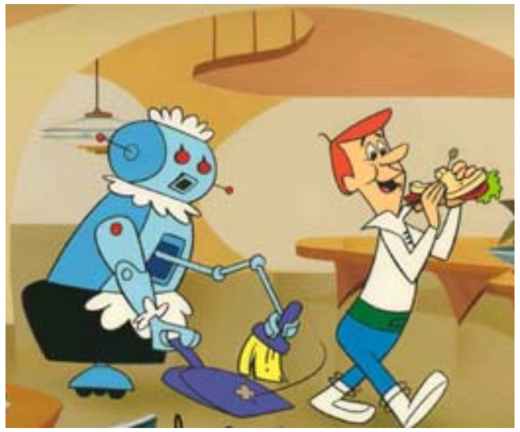
Why computer vision matters

Safety



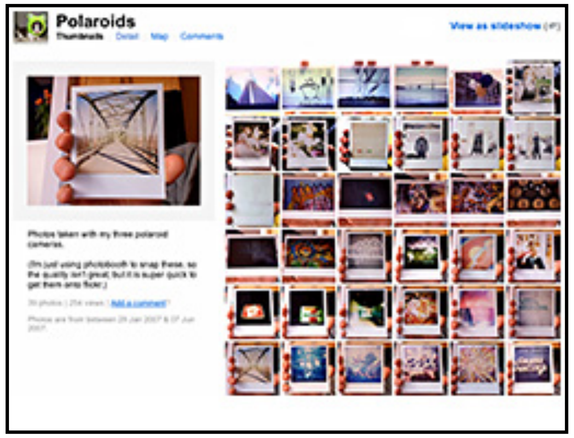
Health

Security



Comfort

Fun

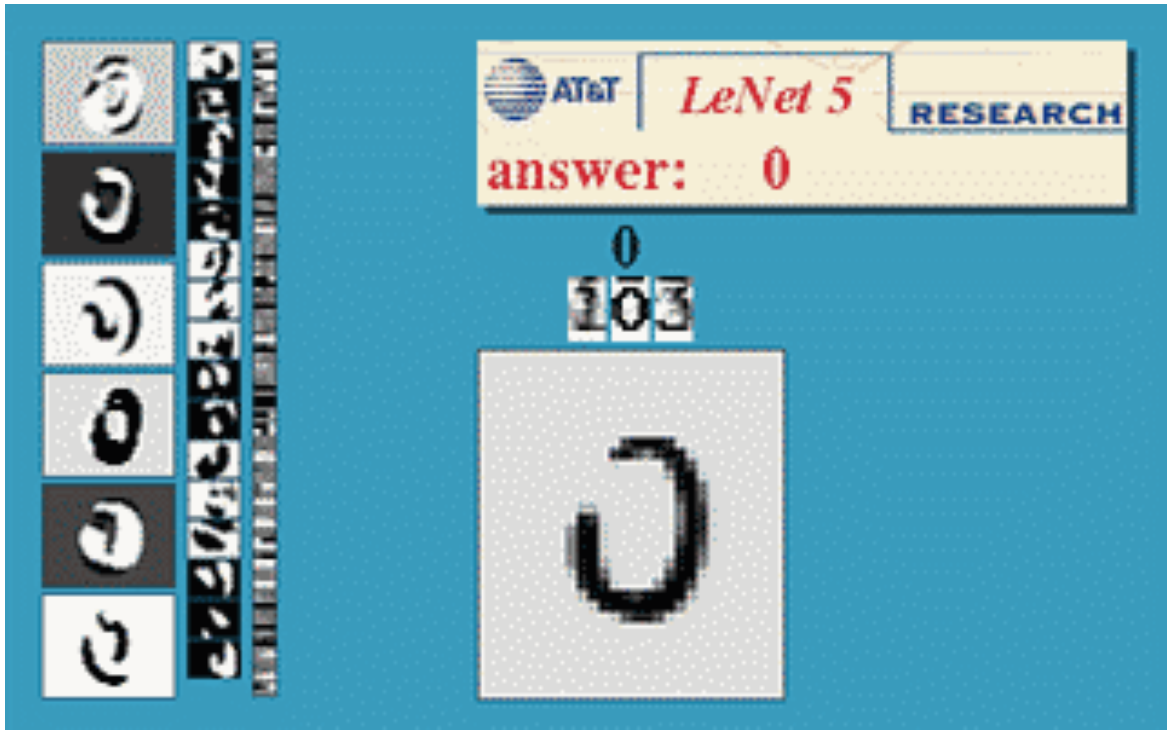


Access

Credit: J. Hays

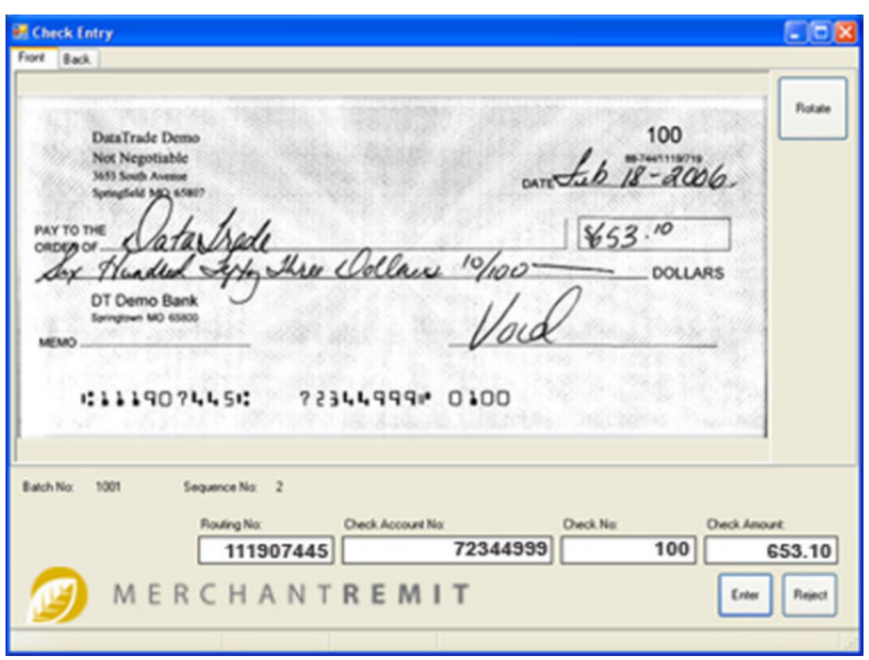
Success of CV to date

Optical character recognition (OCR)

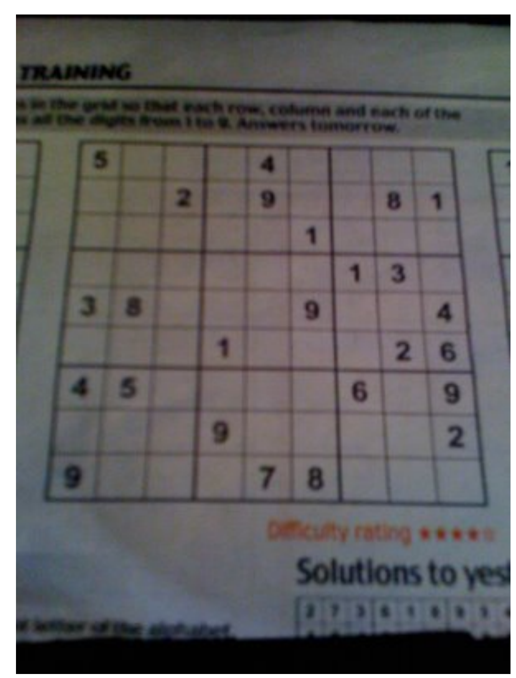


Digit recognition
yann.lecun.com

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



Automatic check processing



Sudoku grabber

http://sudokugrab.blogspot.com/

Source: S. Seitz, N. Snavely

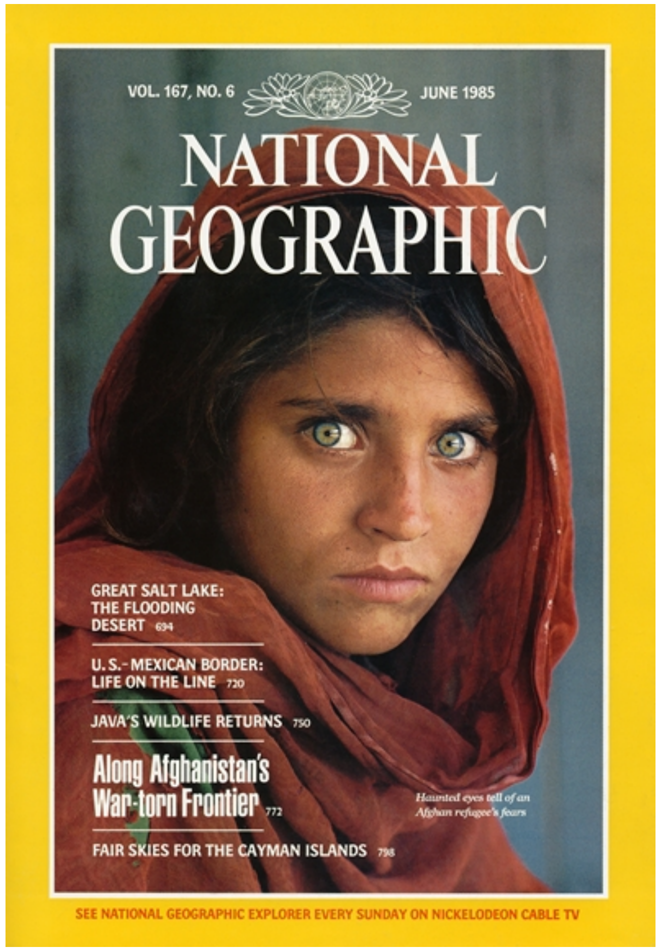
Biometrics

Fingerprint scanners on many new laptops, other devices

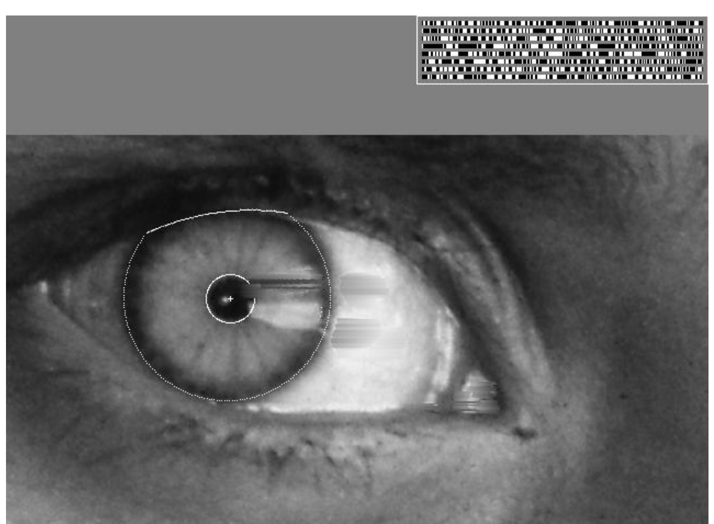
Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

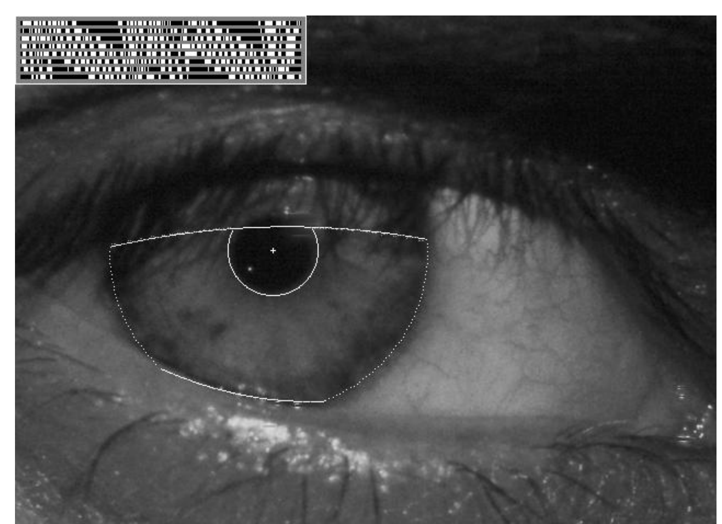
Source: S. Seitz

Biometrics



[How the Afghan Girl was Identified by Her Iris Patterns]





Source: S. Seitz

Face detection

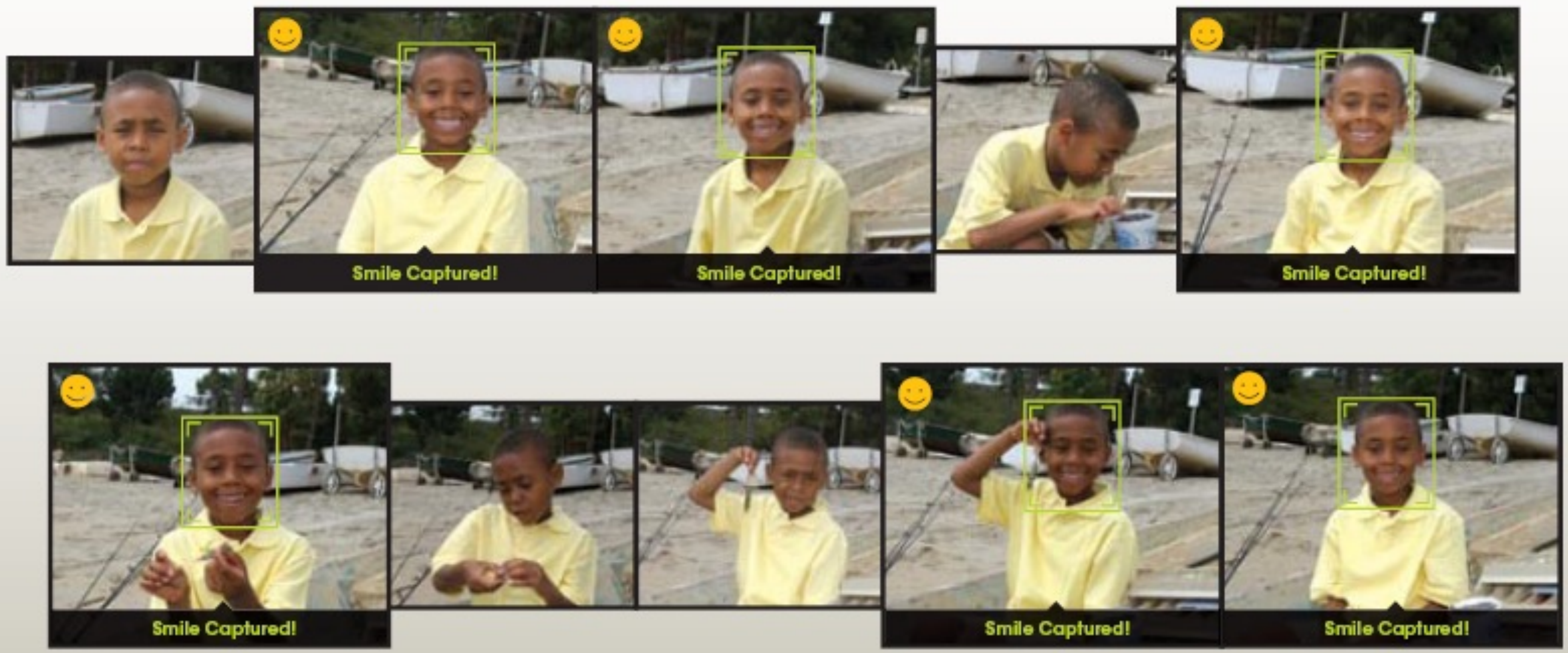
Many consumer digital cameras now detect faces

Source: S. Seitz

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.

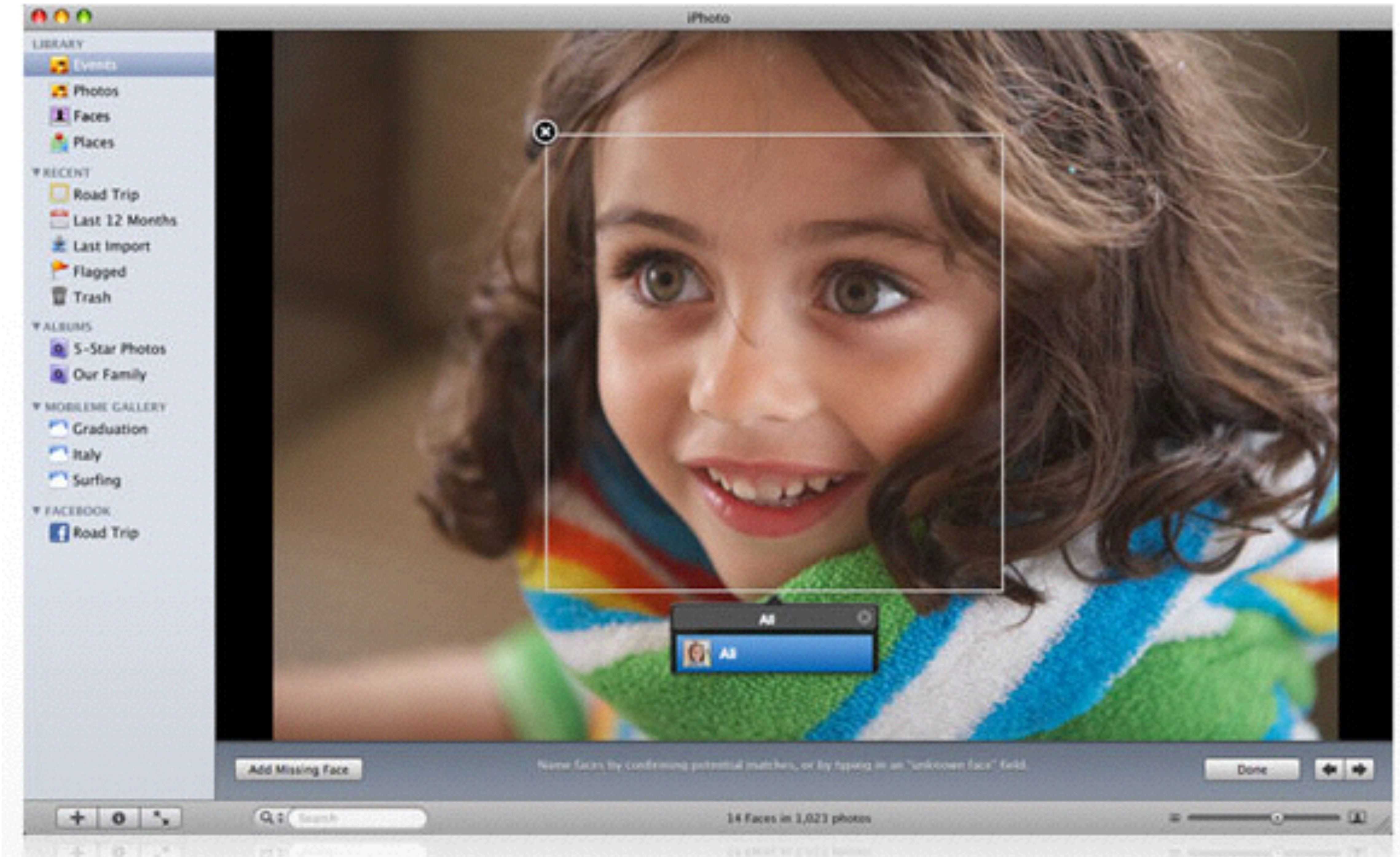


[Sony Cyber-shot® T70 Digital Still Camera](#)

Source: S. Seitz

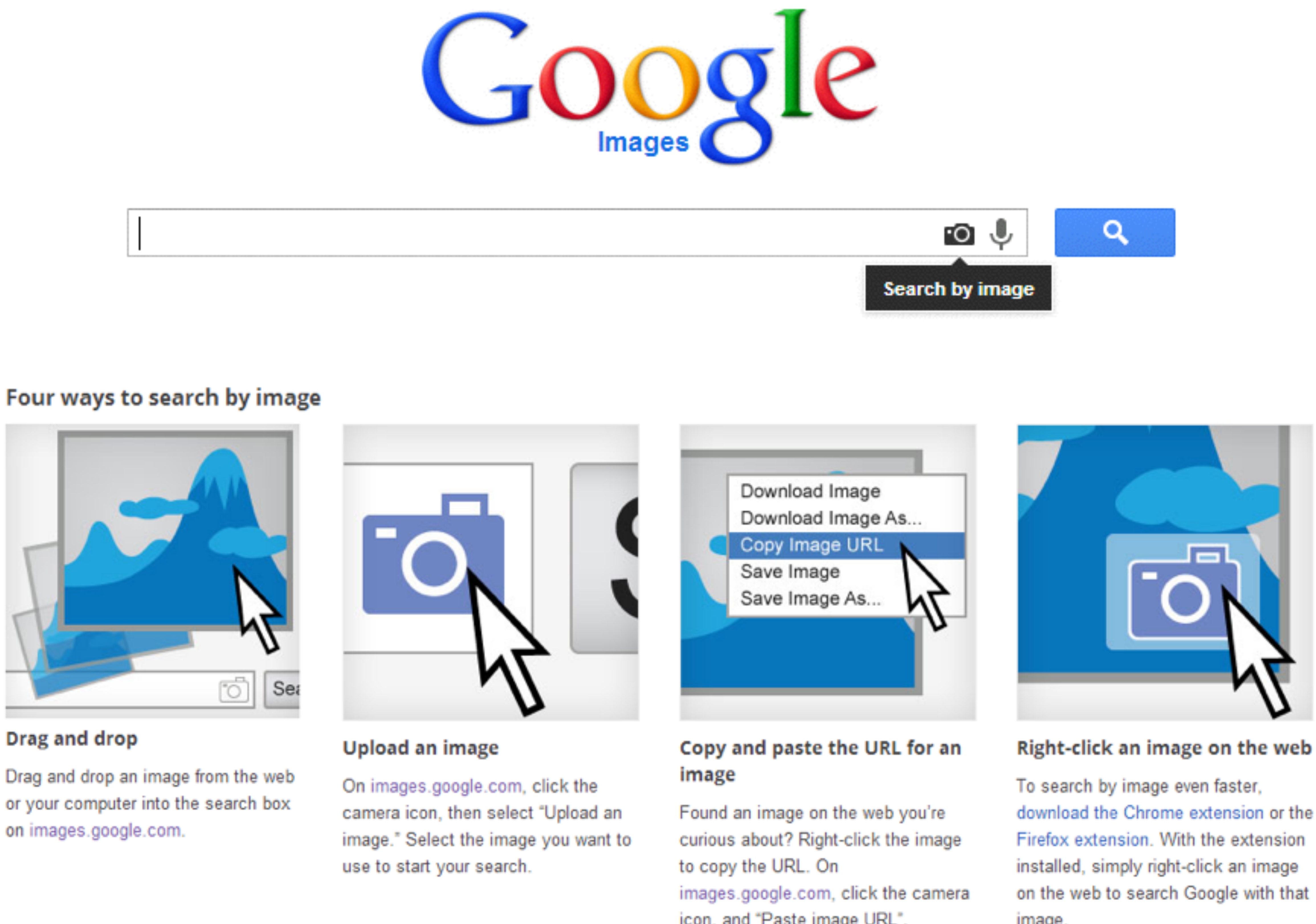
Privacy protection

Face recognition: Apple iPhoto software



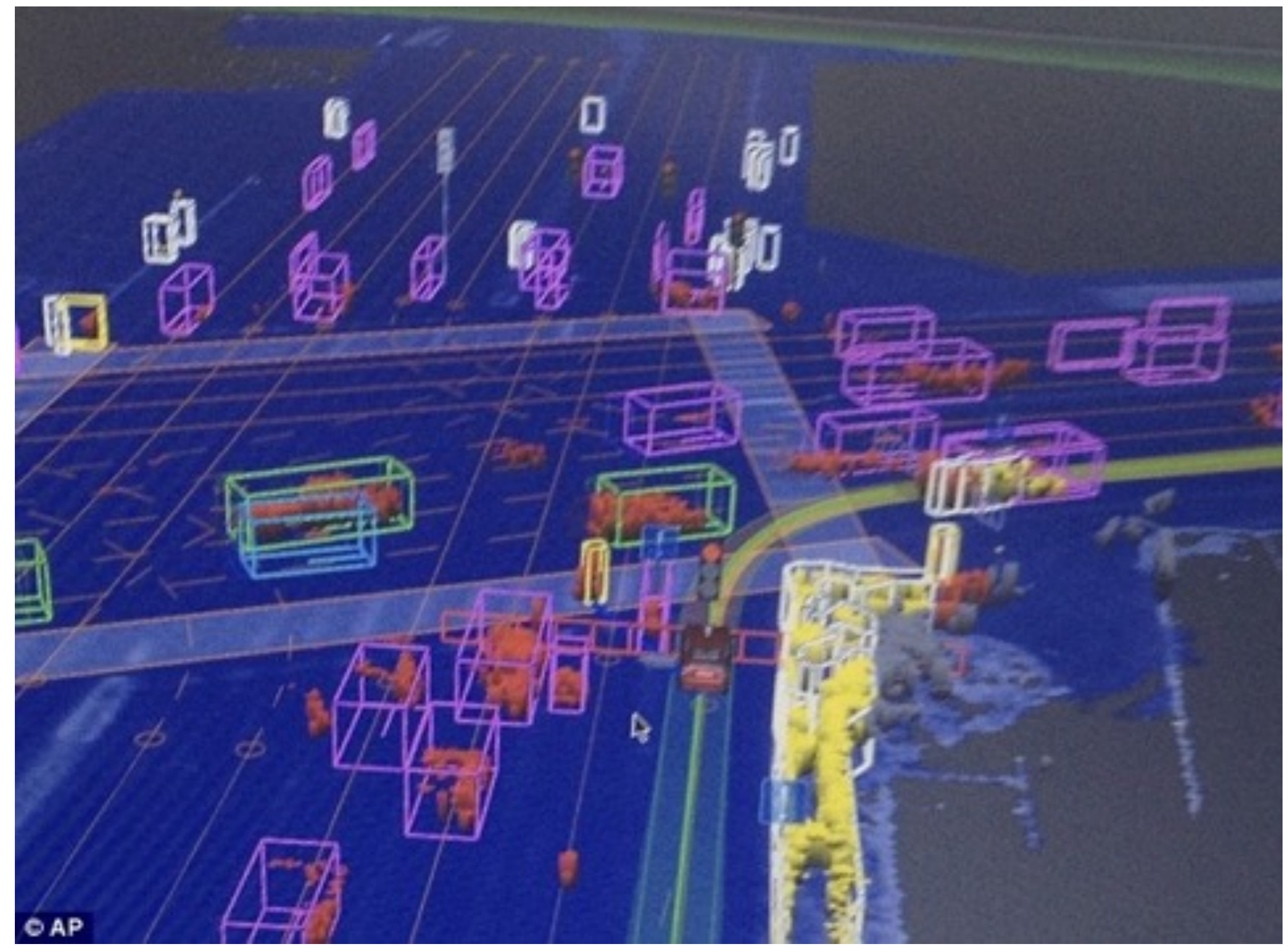
Source: S. Lazebnik

Visual search: Google search by image



Source: S. Lazebnik

Google self-driving cars



- [Google's self-driving car passes 1.5 million miles]
- [Nissan pledges affordable self-driving car models by 2020]
(CNET, 8/27/2013)

Source: S. Lazebnik

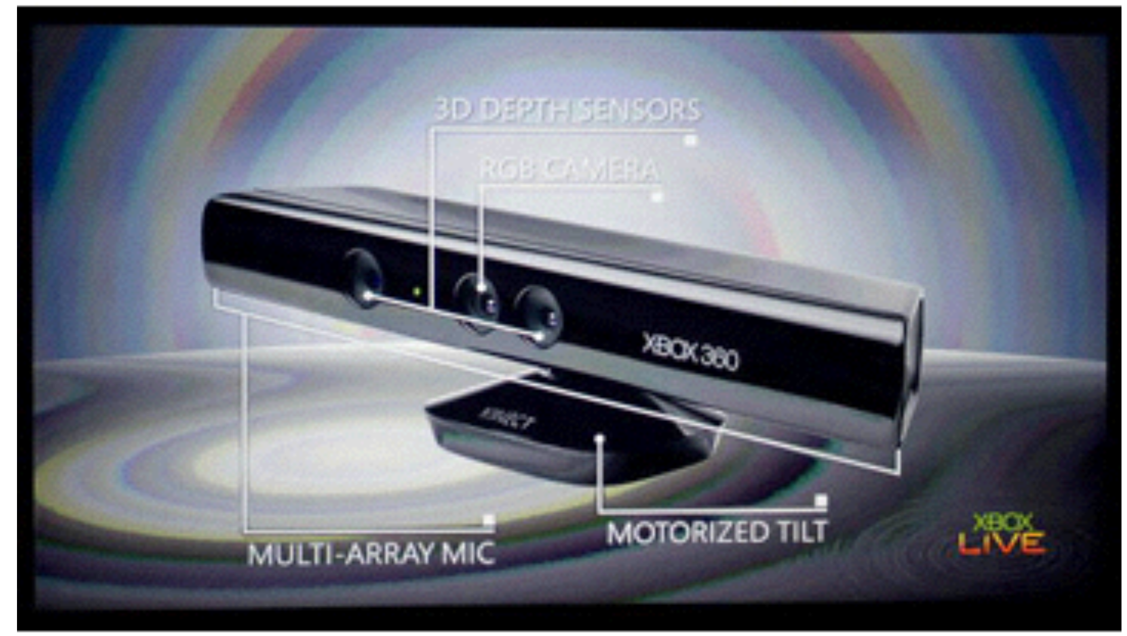
Automotive safety

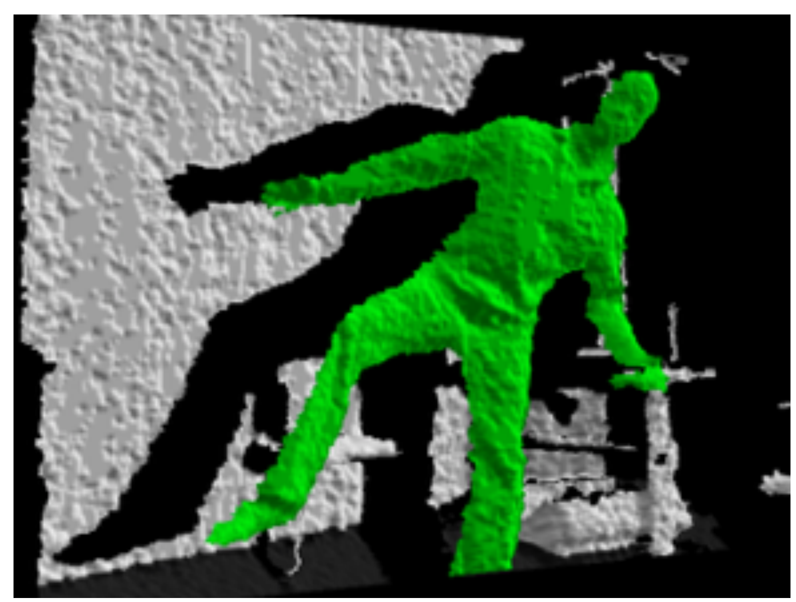
Mobileye: Vision systems in high-end BMW, GM, Volvo models

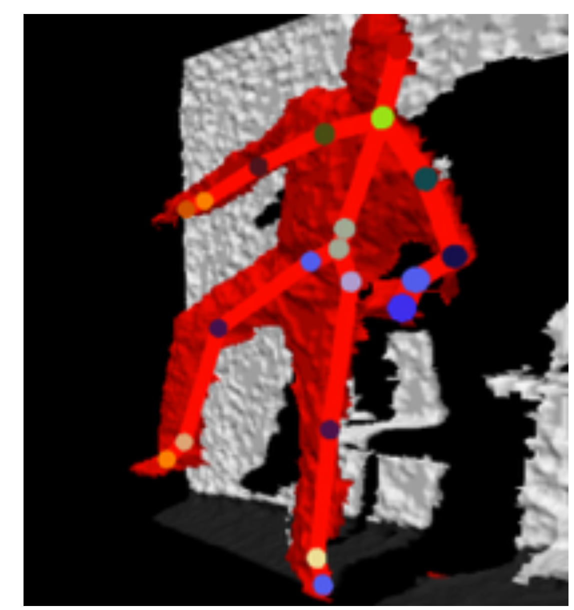
- Pedestrian collision warning
- Forward collision warning
- Lane departure warning
- Headway monitoring and warning

Source: A. Shashua, S. Seitz

Vision-based interaction: Xbox Kinect







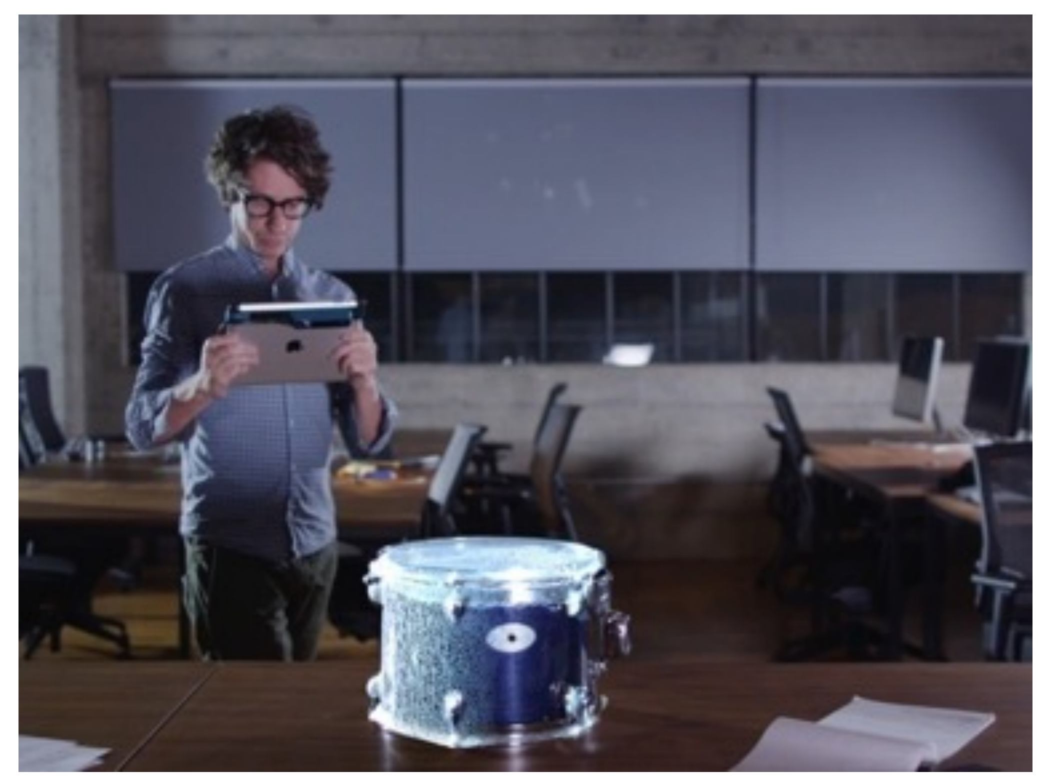
Source: S. Lazebnik

3D Reconstruction: Kinect Fusion

[YouTube Video]

Source: S. Lazebnik

Occipital: 3D structure sensor for iPad

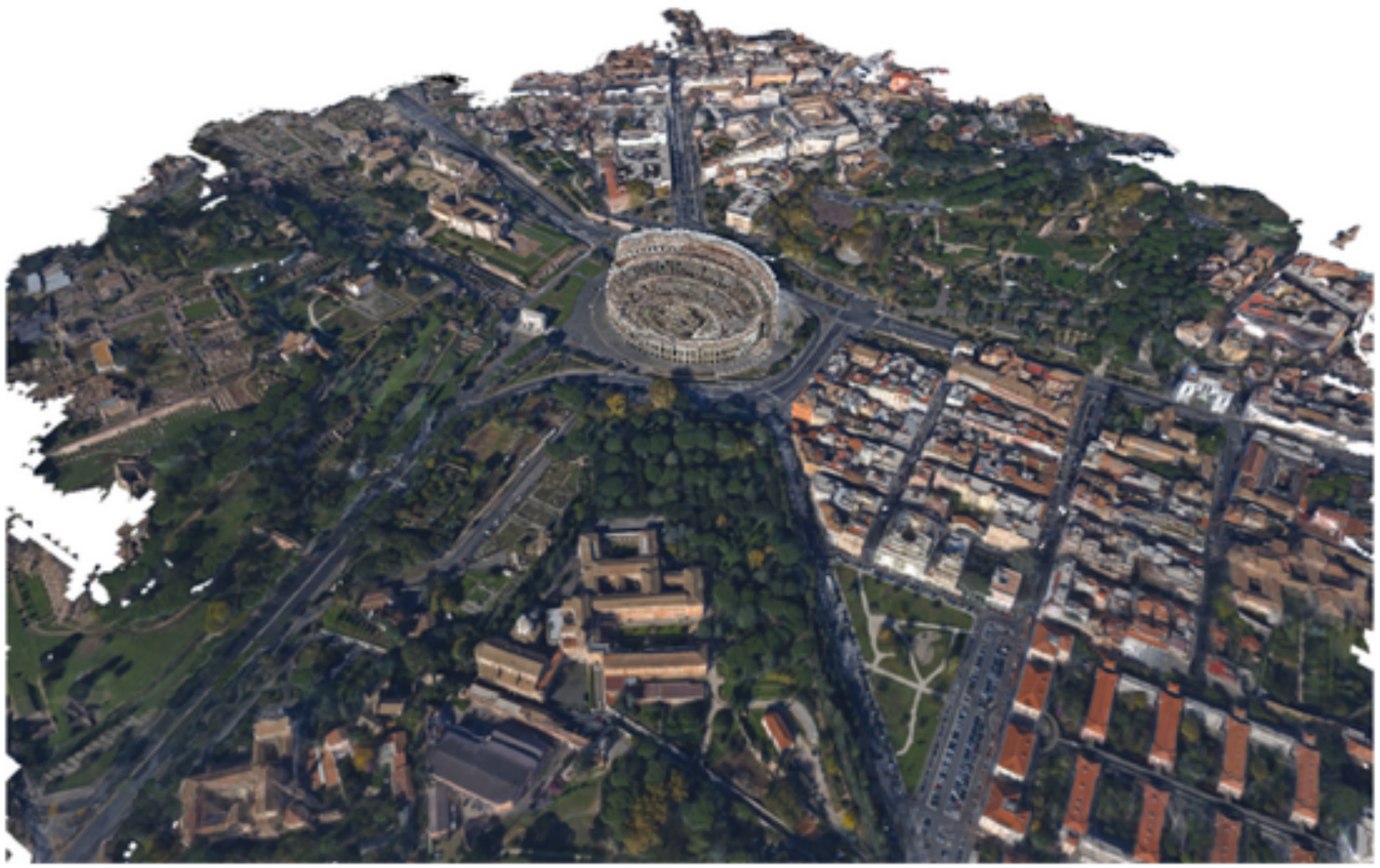


http://www.kickstarter.com/projects/occipital/structure-sensor-capture-the-world-in-3d

Source: S. Lazebnik

3D reconstruction from photo collections

Colosseum, Rome, Italy



San Marco Square, Venice, Italy

Q. Shan, R. Adams, B. Curless, Y. Furukawa, and S. Seitz, 3DV 2013

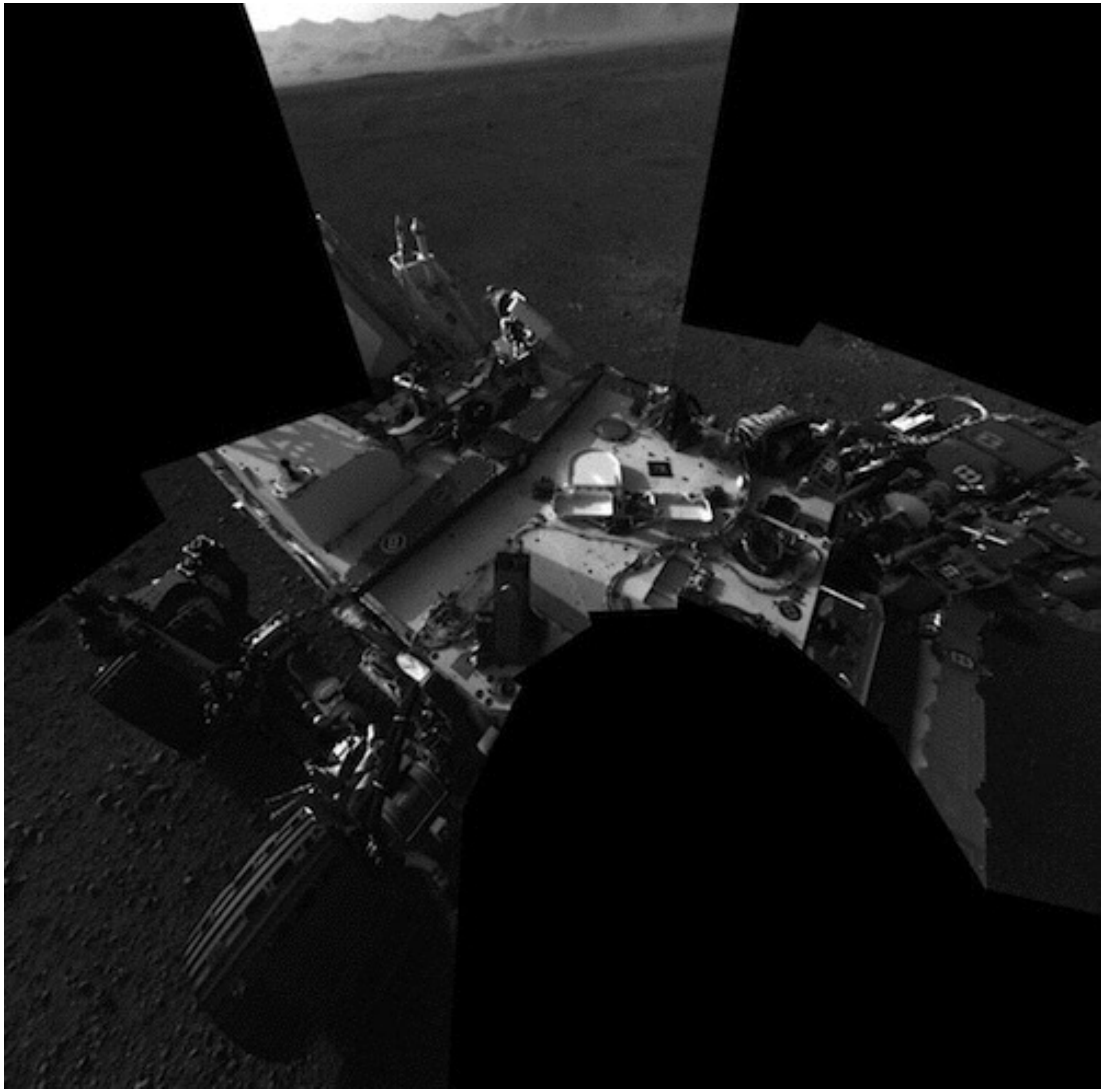
Source: S. Lazebnik

Special effects: shape and motion capture




Source: S. Seitz

Vision for robotics, space exploration



[NASA'S Curiosity Rover has a system consisting of 17 cameras]

Source: S. Lazebnik

Why is computer vision difficult?

Challenges: viewpoint variation

Michelangelo 1475-1564

Source: S. Lazebnik

slide credit: Fei-Fei, Fergus & Torralba

Challenges: illumination

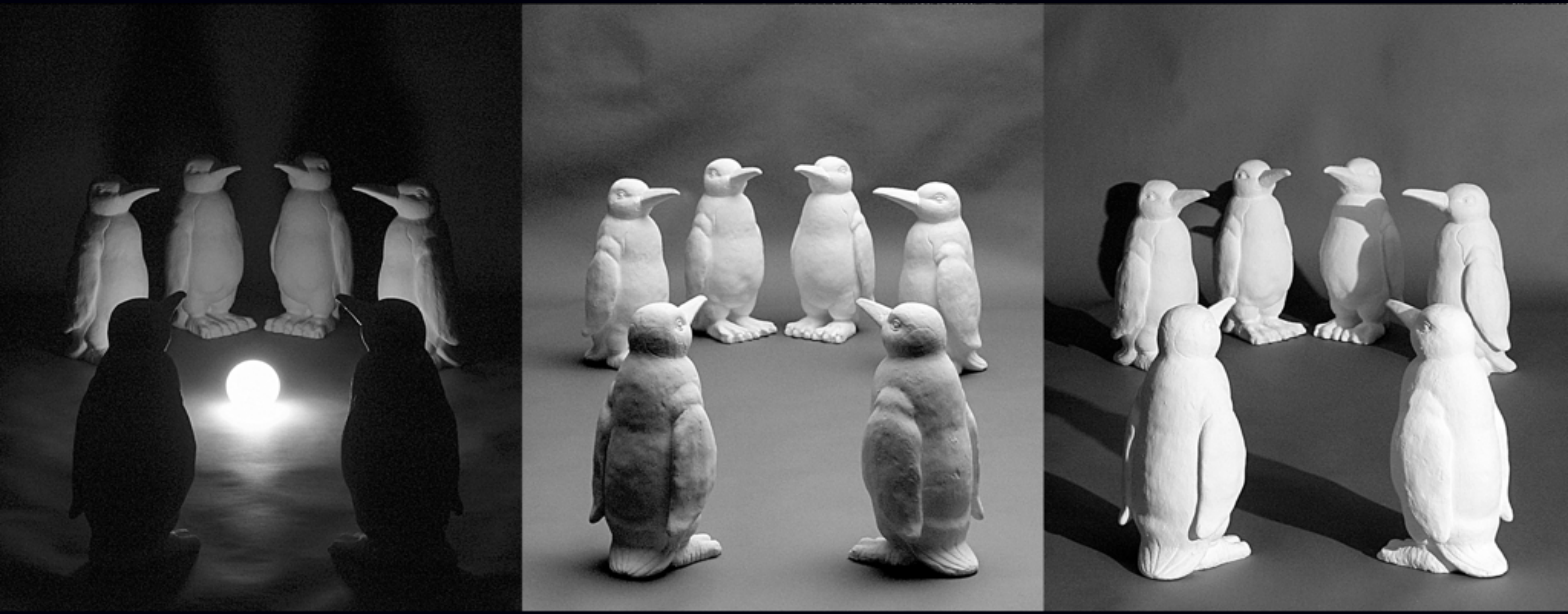
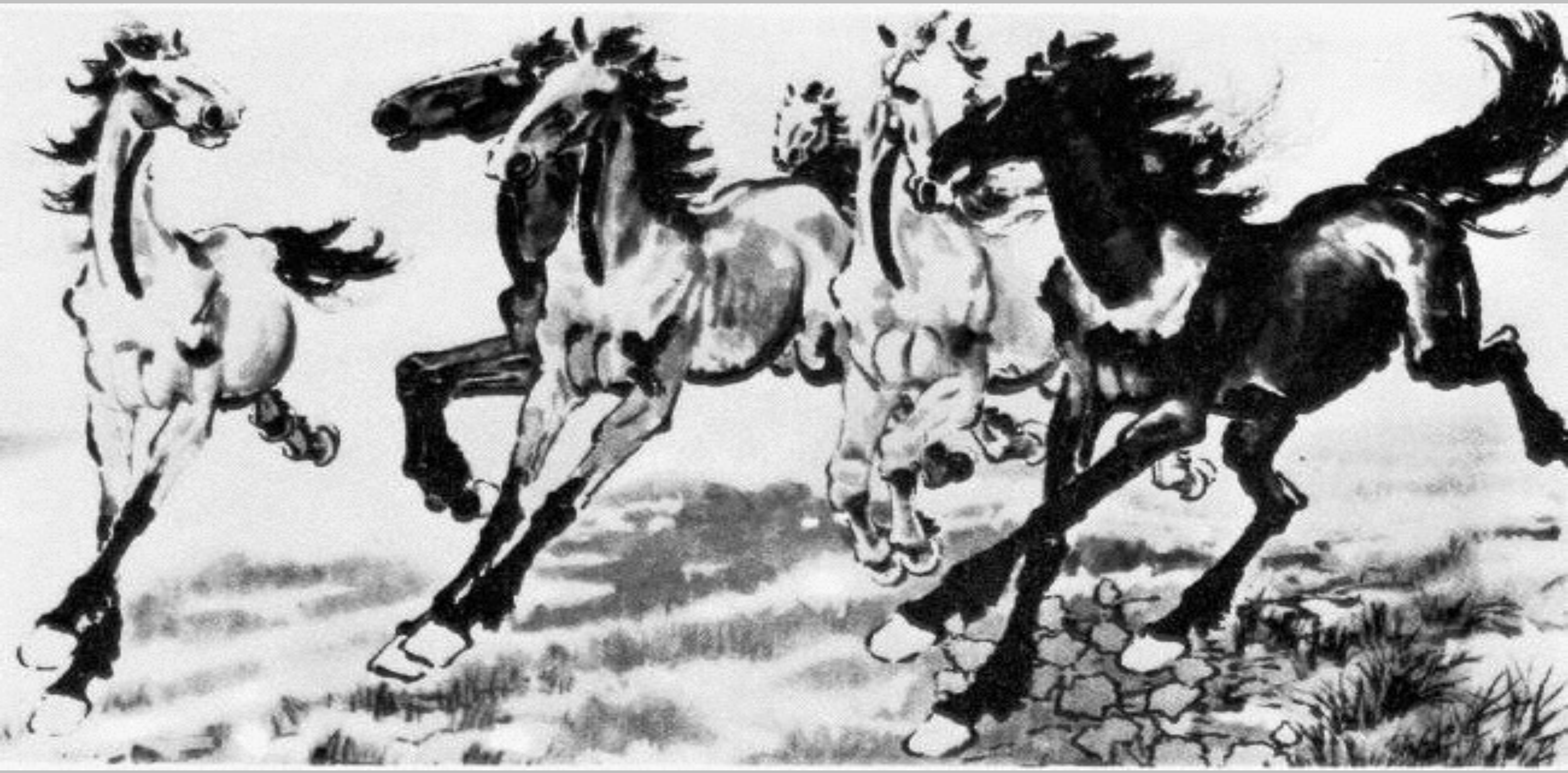


image credit: J. Koenderink

Challenges: scale

Source: S. Lazebnik
slide credit: Fei-Fei, Fergus & Torralba

Challenges: deformation



Xu, Beihong 1943

Source: S. Lazebnik

slide credit: Fei-Fei, Fergus & Torralba

Challenges: object intra-class variation

Source: S. Lazebnik

slide credit: Fei-Fei, Fergus & Torralba

Challenges: occlusion, clutter

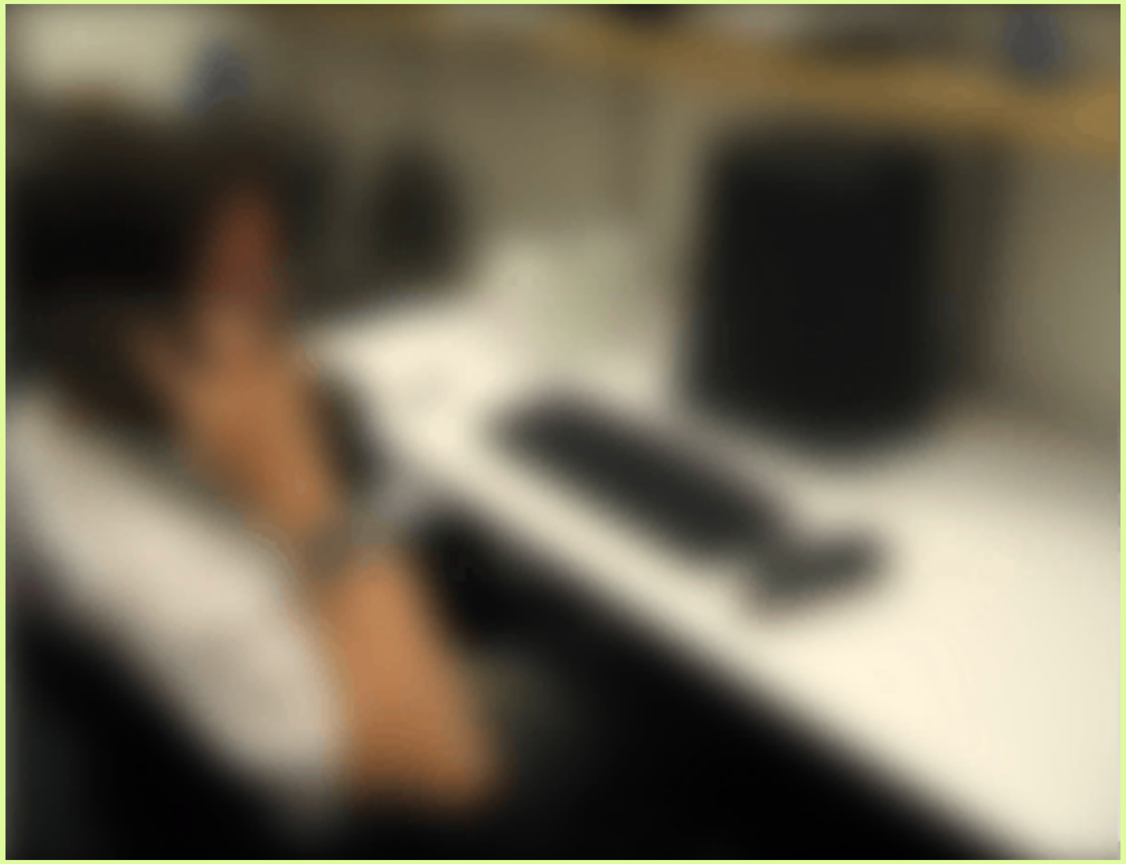
Image source: National Geographic

Source: S. Lazebnik

Challenges: Motion

Source: S. Lazebnik

Challenges: ambiguity



Source: Rob Fergus and Antonio Torralba

Challenges: ambiguity

Source: Rob Fergus and Antonio Torralba

Review: Intro to computer vision

- State-of-the-art applications

- Challenges of vision
  - Viewpoint and lighting variation
  - Intra-class variations: size, shape, deformation, etc.
  - Nuisances: motion, blur, noise, etc.
  - Intrinsic ambiguity

Source: S. Lazebnik

Challenges or opportunities?

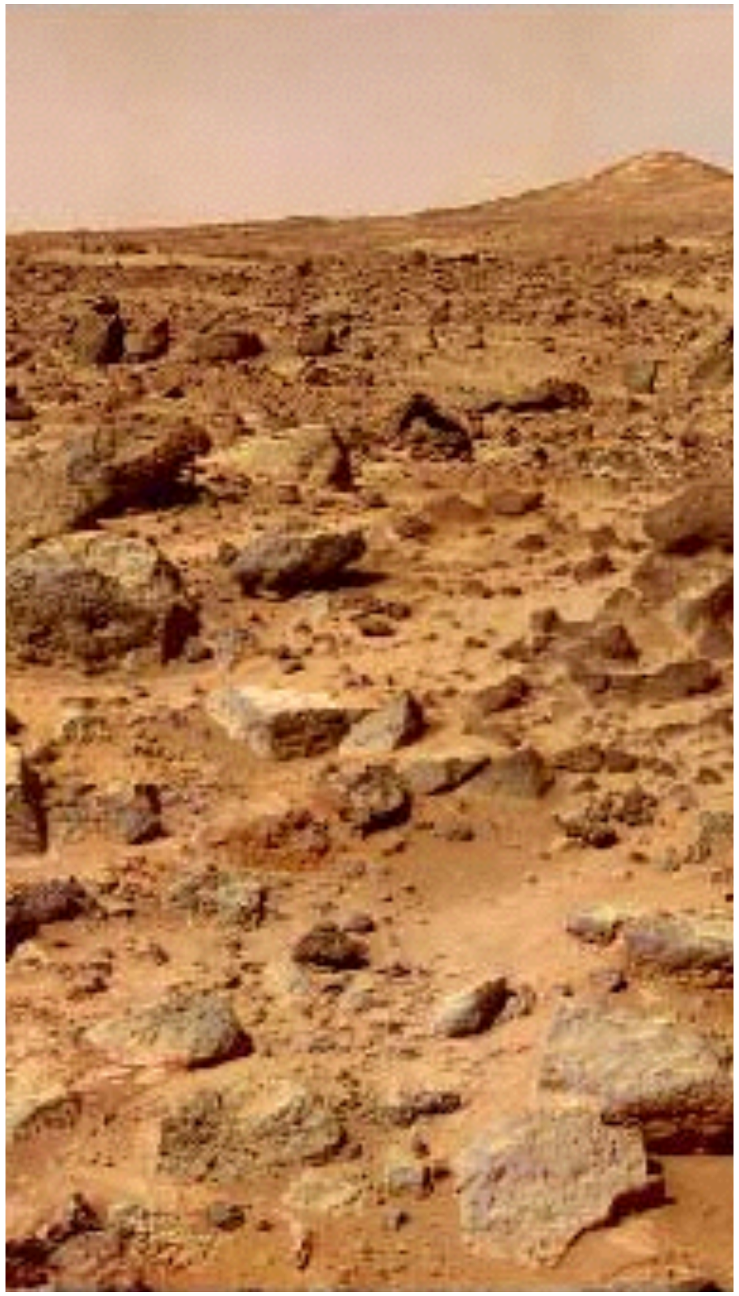
- Images are confusing, but they also reveal the structure of the world through numerous cues

Source: S. Lazebnik

Depth cues: Linear perspective

Source: S. Lazebnik

Depth cues: Parallax



Source: S. Lazebnik

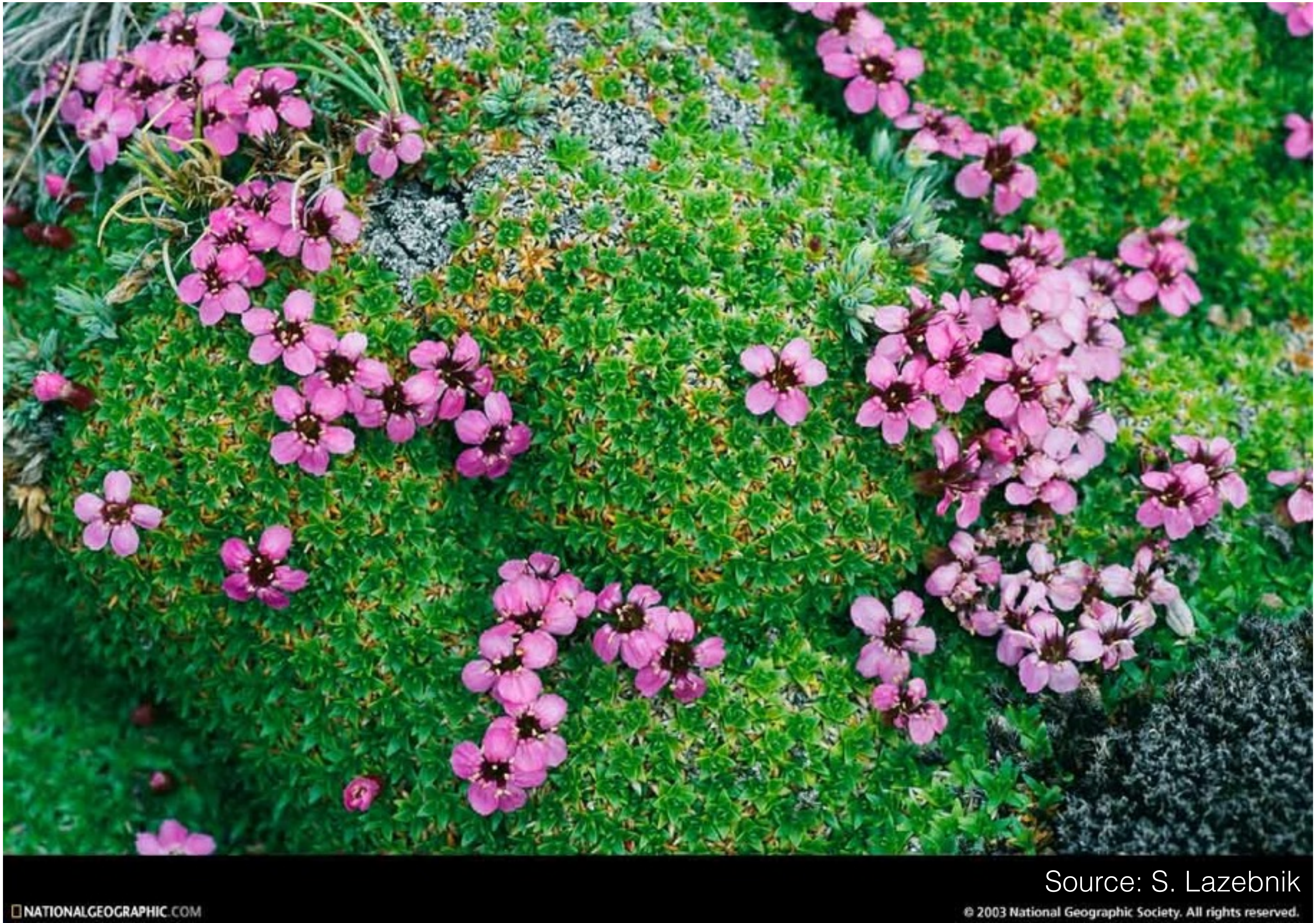
Shape cues: Texture gradient

Source: S. Lazebnik

Shape and lighting cues: Shading

Source: S. Lazebnik

Grouping cues: Similarity (color, texture, proximity)

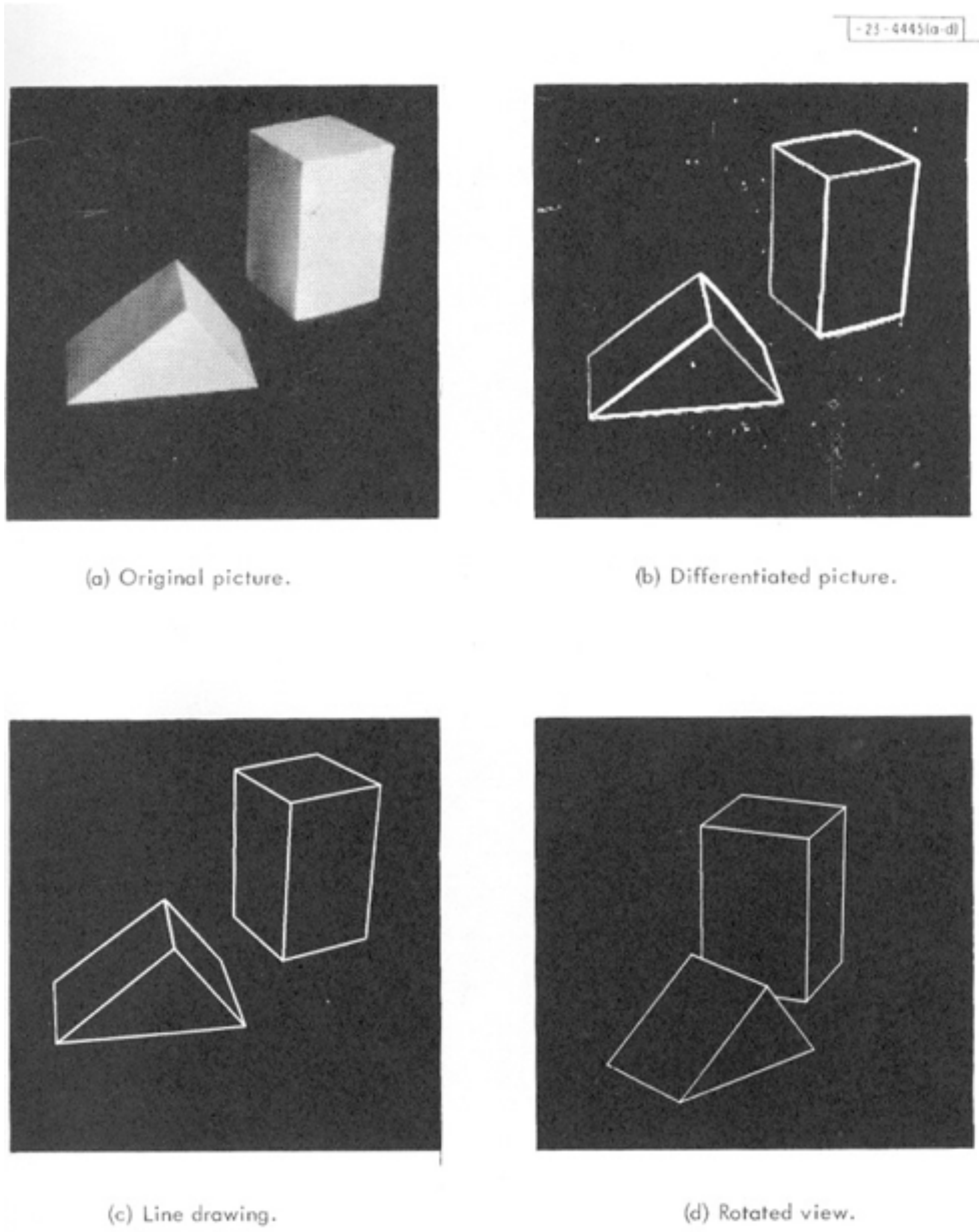


Source: S. Lazebnik

Grouping cues: "Common fate"

Source: S. Lazebnik

Origins of computer vision

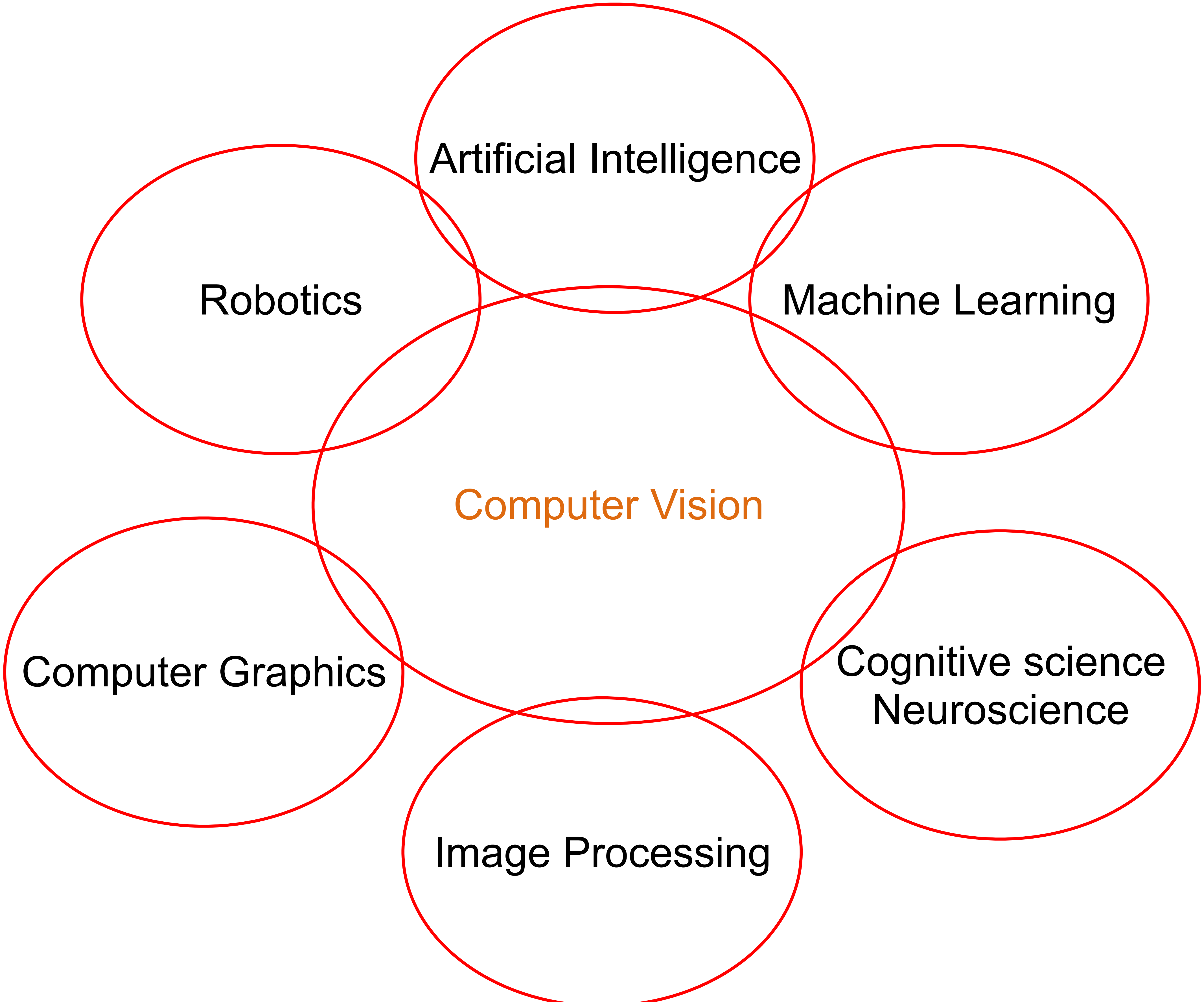


(a) Original picture.
(b) Differentiated picture.
(c) Line drawing.
(d) Rotated view.

L. G. Roberts *Machine Perception of Three Dimensional Solids*

Source: S. Lazebnik

Connections to other disciplines



Source: S. Lazebnik

The computer vision industry

- A list of companies here:

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