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Computer Vision

Contacts

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  - Tentatively: Tuesday Afternoon (>3:30 PM)

Course Objectives

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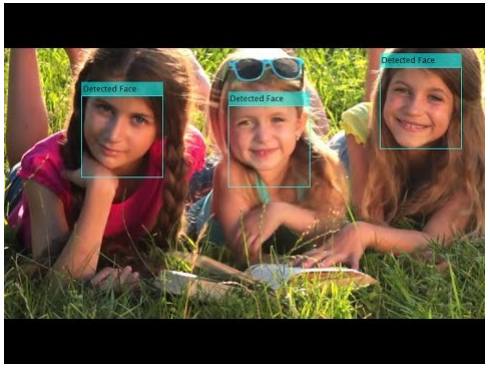
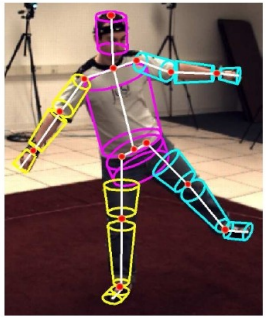
- Basic and Semi-advanced techniques for image processing & machine vision
- Computer vision is everywhere…





One Look Is Worth A Thousand Words--

One look at our line of Republic, Firestone, Miller and United States tires can tell you more than a hundred personal letters or advertisements.

WE WILL PROVE THEIR VALUE BEFORE YOU INVEST ONE DOLLAR IN THEM.

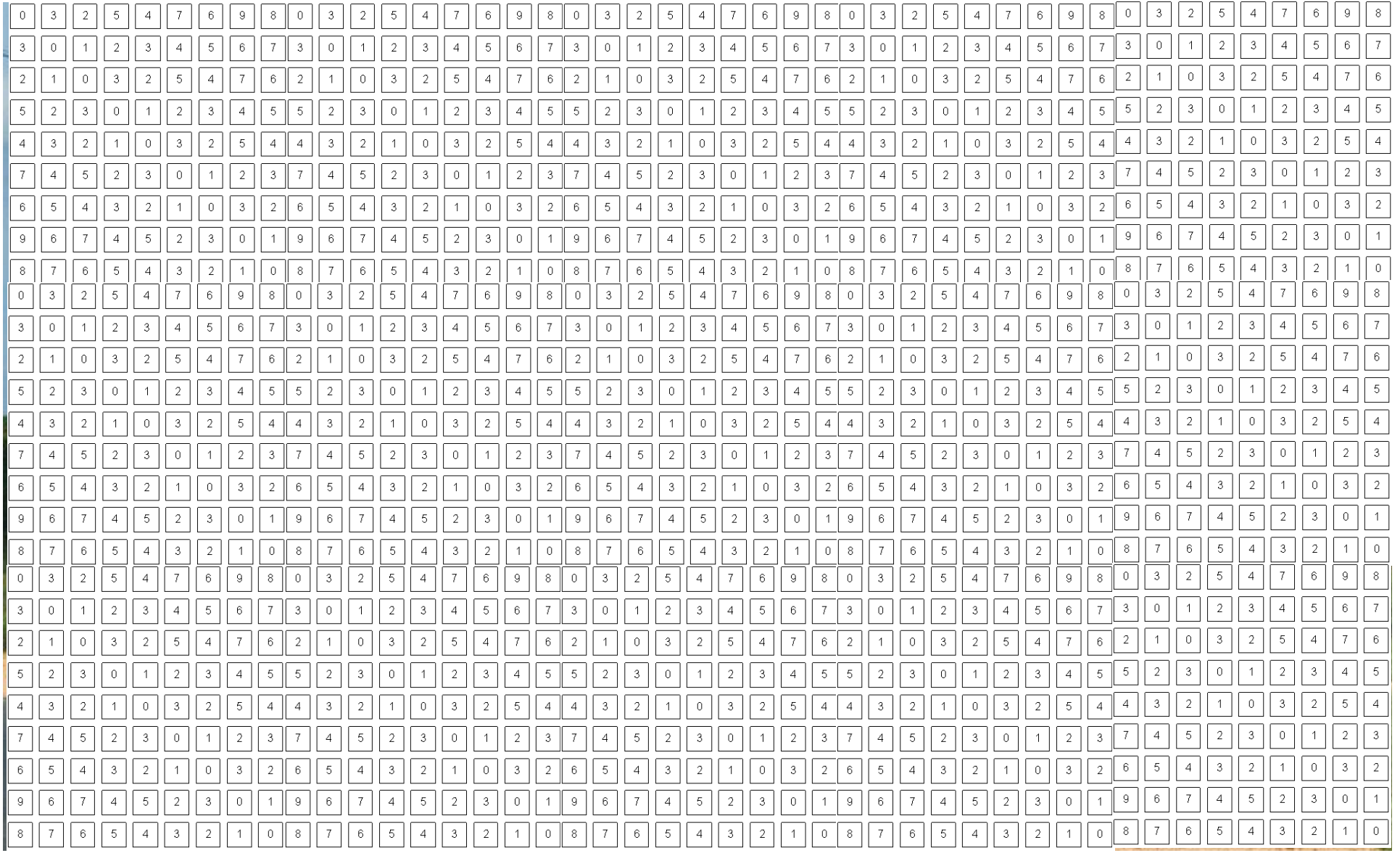
Ever consider buying Supplies from a catalog?

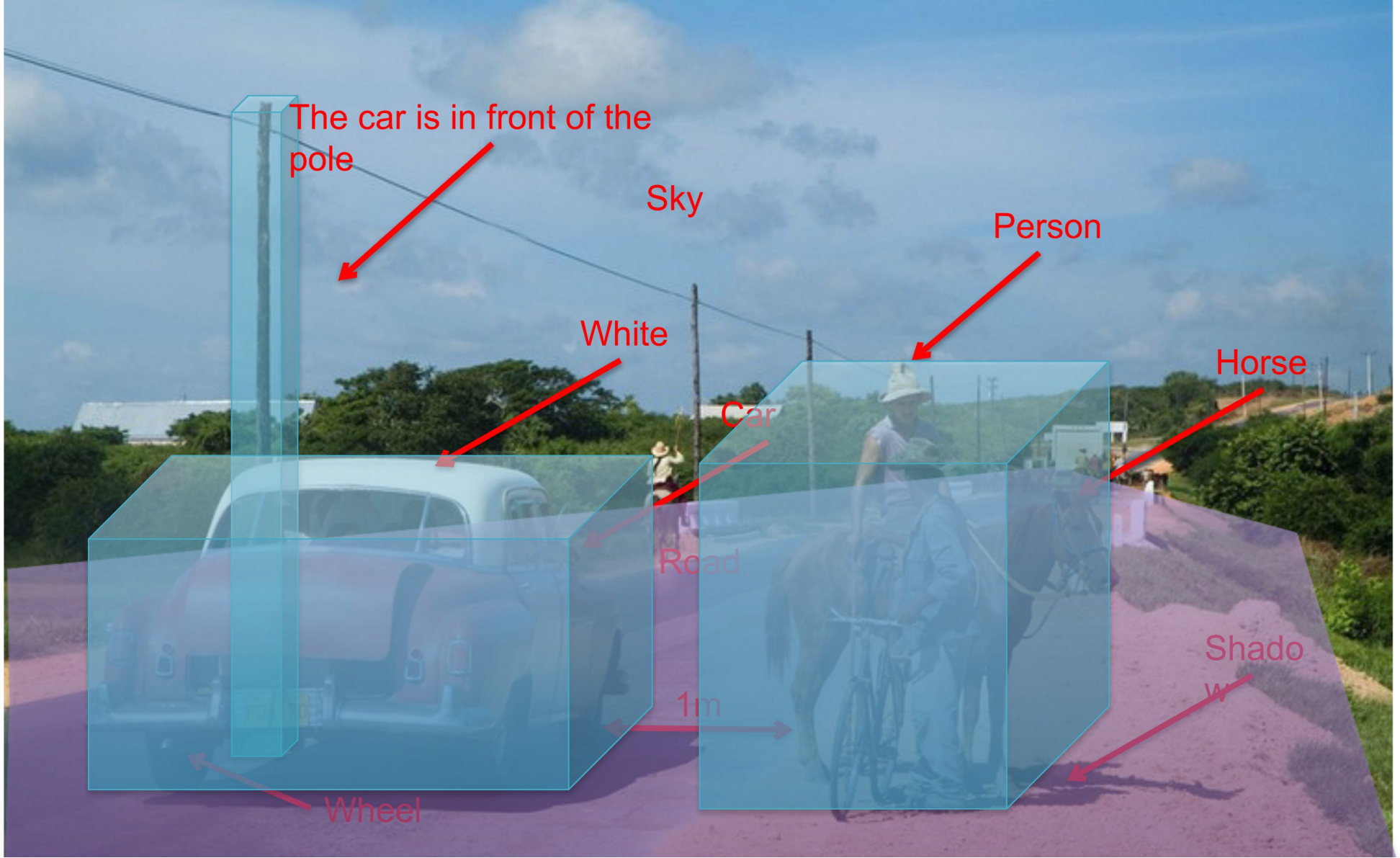
What's the use! Call and see what you are buying. One look at our display of automobile and motorcycle accessories will convince you of the fact.

THAT WE HAVE EVERYTHING FOR THE AUTO

Piqua Auto Supply House

133 N. Main St.—Piqua, O.




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

How hard is computer vision?

Some history...

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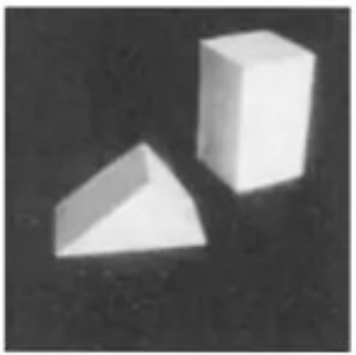
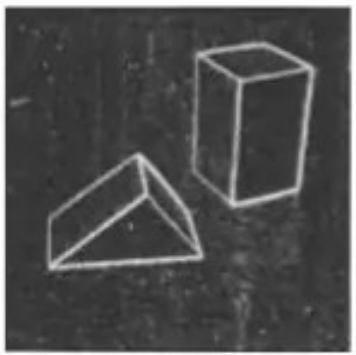
1960's: interpretation of synthetic worlds

Larry Roberts
"Father of Computer Vision"



Input image



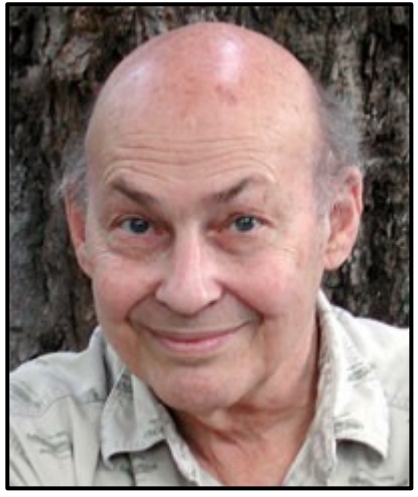
2x2 gradient operator

computed 3D model
rendered from new viewpoint

Larry Roberts PhD Thesis, MIT, 1963,
Machine Perception of Three-Dimensional Solids

Slide credit: Steve Seitz

Some history...



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
Vision Memo. No. 100.

July 7, 1966

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".

Some history...

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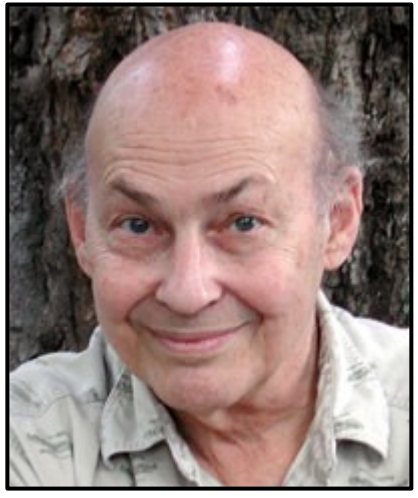
"You'll notice that Sussman never worked in vision again!" – Berthold Horn



Marvin Minsky, MIT
Turing award,1969

Gerald Sussman, MIT
(the undergraduate)

A little timeline...

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- 1959: The very first digital image scanner was invented that converted images into number grids.
- 1963: Larry Roberts described the process of deriving 3D information of solid objects from 2D pictures.
- 1966: Marvin Minsky instructed a graduate student to attach a camera to a computer and describe what it saw.
- 1980: Kunihiko Fukushima created the neocognitron. It's considered the precursor of the modern convolutional neural network (CNN).
- 1998: VisLab tested a >2000 km trip on Italian Highways using an autonomous vehicle
- 2001: Paul Viola and Michael Jones, two researchers at MIT, created the first face detection framework that works in real time.
- 2009: Google started the self-driving car project.
- 2010: Google released Google Goggles, an image recognition app useful for searches based on pictures captured by mobile devices. The same year, Facebook started using facial recognition to tag people on photos effectively.
- 2011: Facial recognition technology was used to confirm the identity of Osama Bin Laden after he was killed.
- 2012: Google Brain created a neural network consisting of 16,000 computer processors that could recognize the pictures of cats with the help of a deep learning algorithm. The same year, AlexNet, a convolutional neural network, attained a top-5 error of 15.3% in the ImageNet 2012 Challenge.
- 2013: BRAiVE, VisLab's most advanced autonomous car, drove in downtown Parma in a fully autonomous mode
- 2014: Tesla introduced Autopilot in its Model S electric cars. The self-driving system not only worked offline but also parked with precision.
- 2015: Google launched TensorFlow, which is an open-source and free software library for machine learning. The same year, Google introduced FaceNet for facial recognition.
- 2017: Apple released the iPhone X with the face recognition feature.
- 2019: The UK HighCourt permitted the use of automated facial recognition technology to search for people in crowds.
- 2019: Italy allows testing autonomous vehicles on public roads!

Credits: (partly) Amal Joby

Why vision is so hard?

Why vision is so hard?

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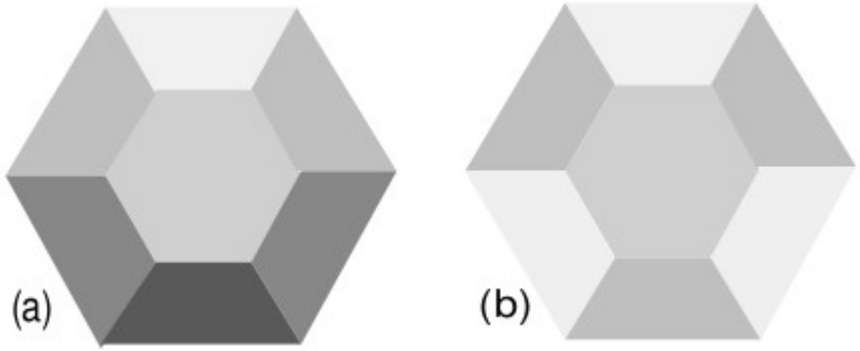
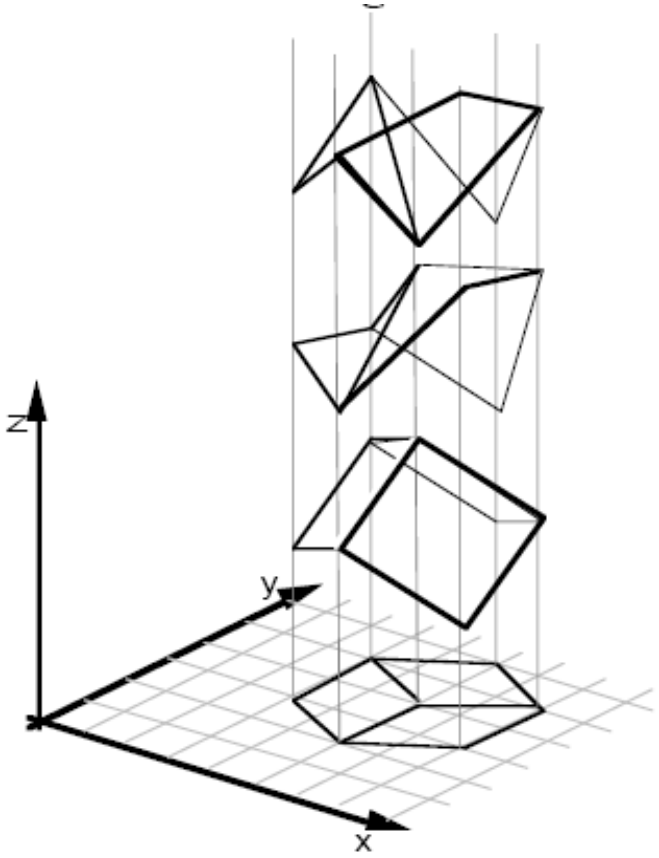
Ill-posed problem





[Sinha and Adelson 1993]

Challenges 1: view point variation

Michelangelo 1475-1564

slide by Fei Fei, Fergus & Torralba

Challenges 2: illumination

Challenges 3: occlusions

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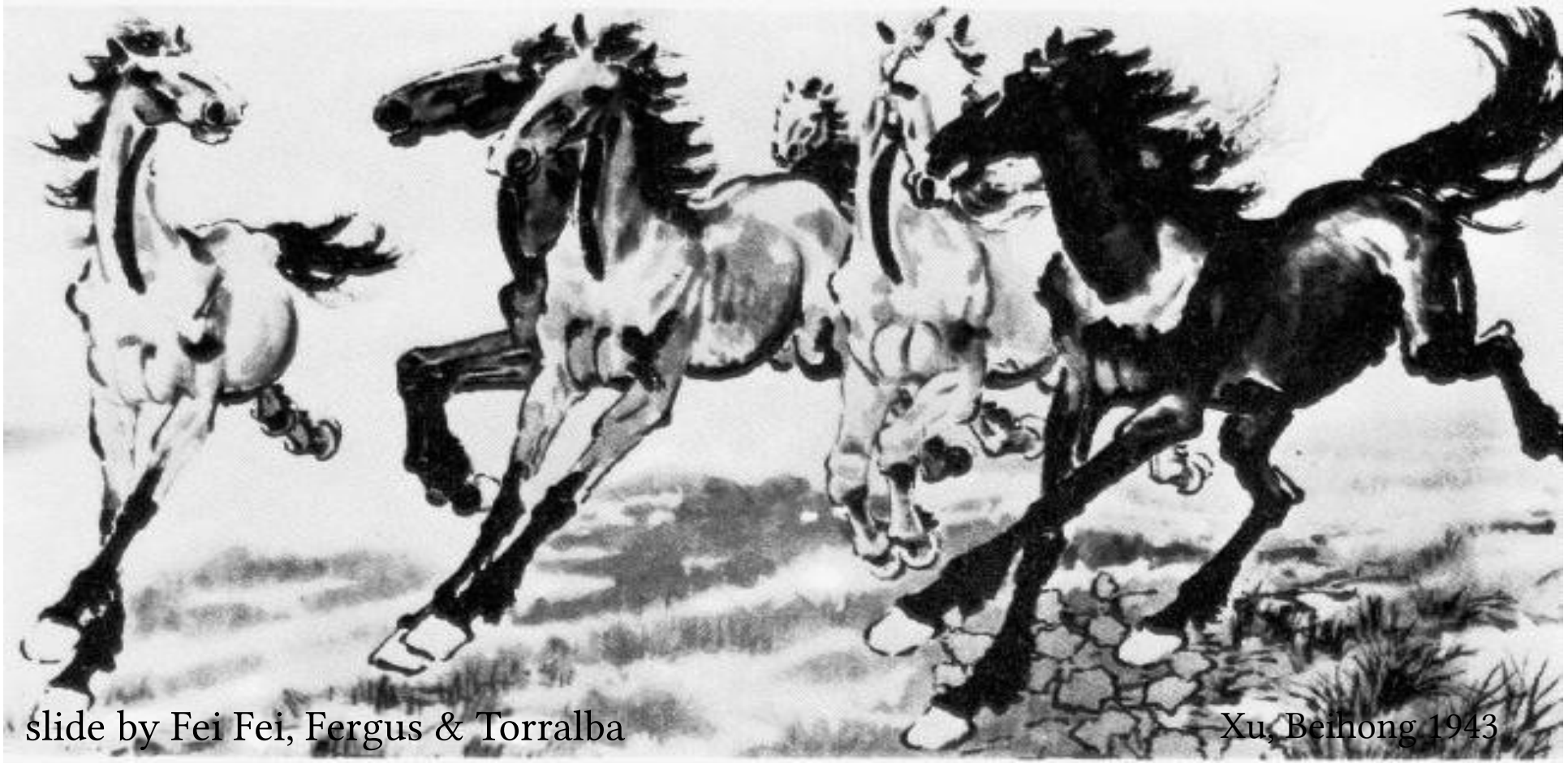
Magritte, 1957

slide by Fei Fei, Fergus & Torralba

Challenges 4: scale

slide by Fei Fei, Fergus & Torralba

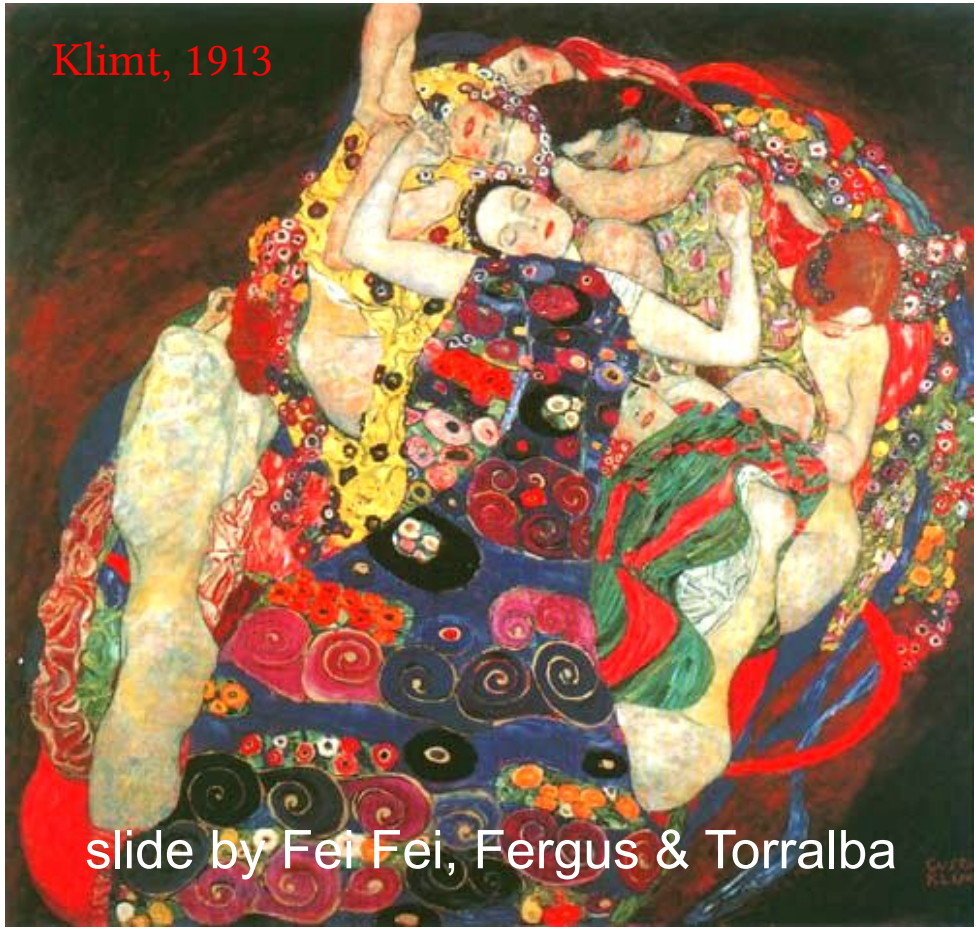
Challenges 5: deformation



slide by Fei Fei, Fergus & Torralba

Xu, Beihong 1943

Challenges 6: background



slide by Fei Fei, Fergus & Torralba

Challenges 7: intra class variation






slide by Fei-Fei, Fergus & Torralba

Challenges 8: local ambiguity

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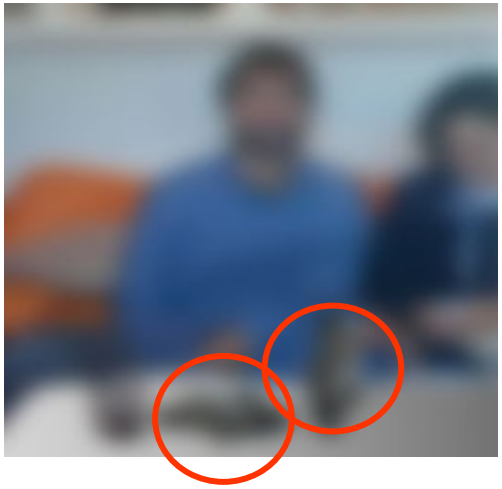
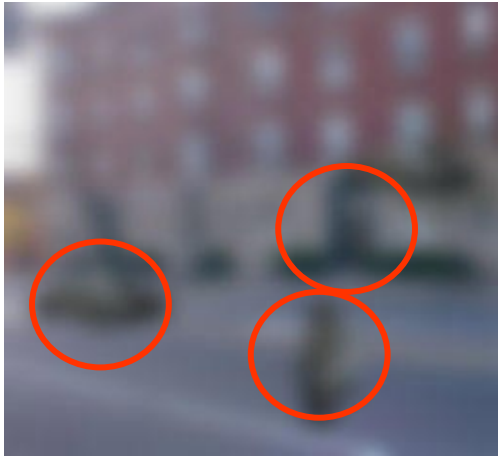
slide by Fei-Fei, Fergus & Torralba





Challenges 9: the world behind the image

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Slide Credit:
Alyosha Efros

What Works Today?

What works today: OCR

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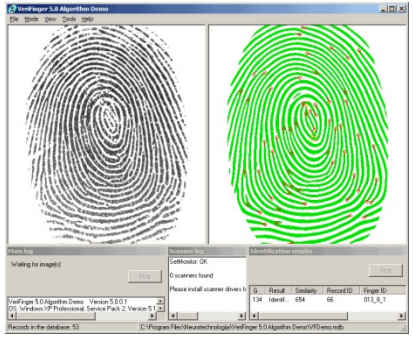
Reading license plates, zip codes, checks

What works today: biometrics



Fingerprint scanners on many new laptops, other devices

Source: S. Seitz

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

What works today: mobile visual search

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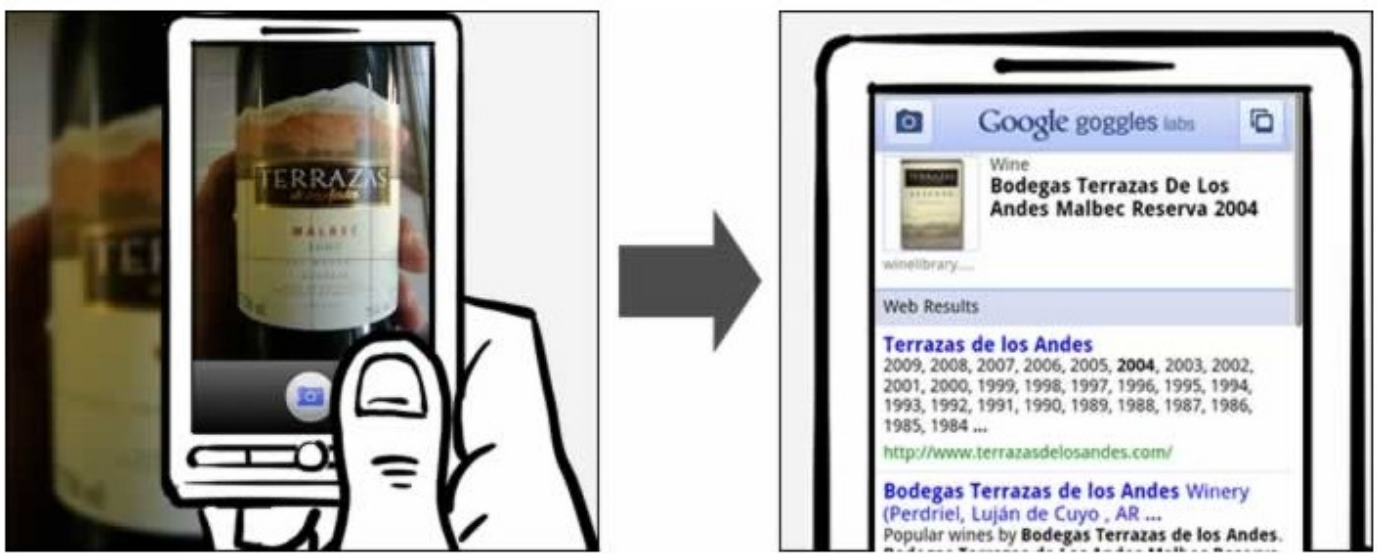
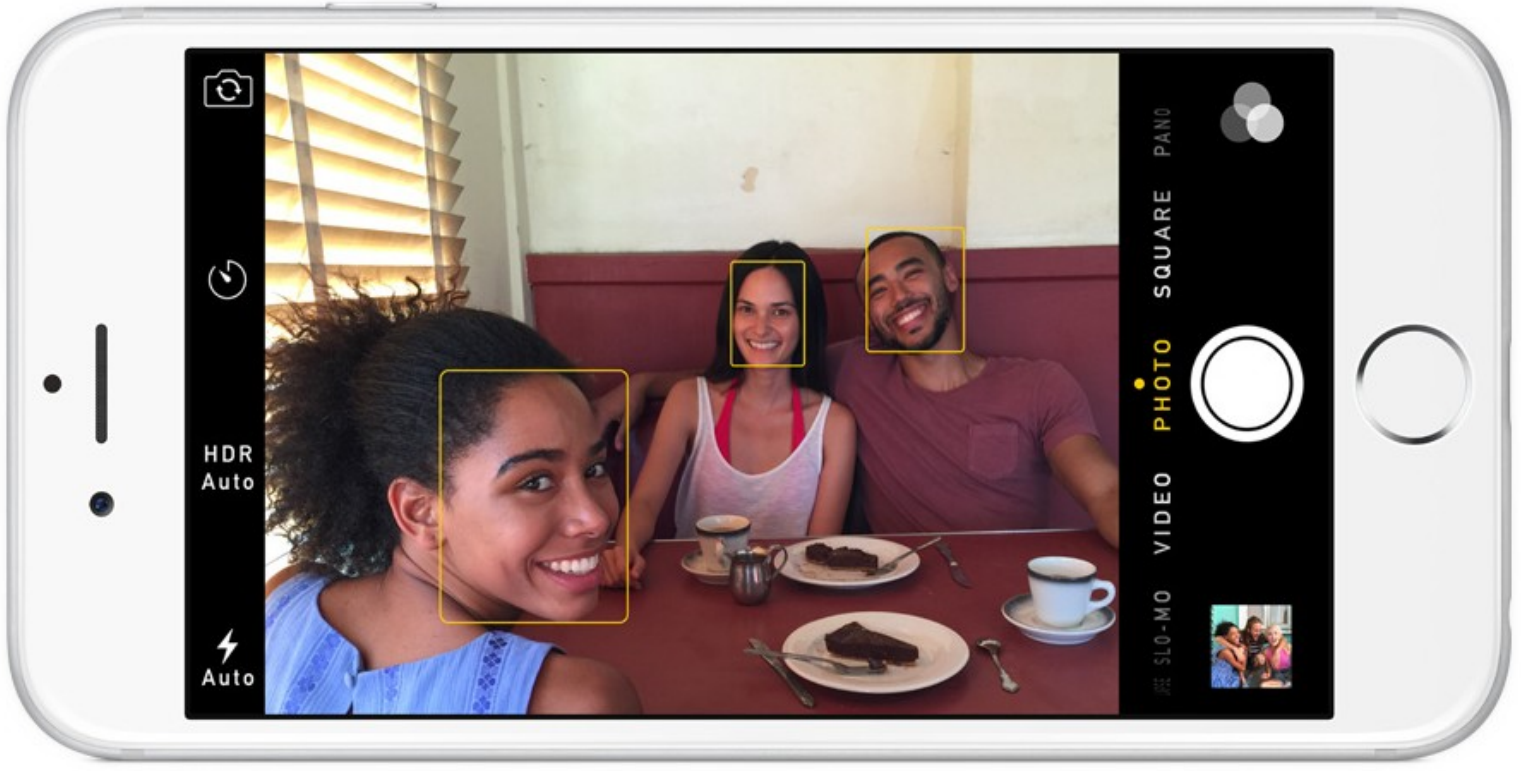
Google Goggles in Action

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

Google goggles labs



What works today: face detection



Many digital cameras now detect faces

What works today: smile detection

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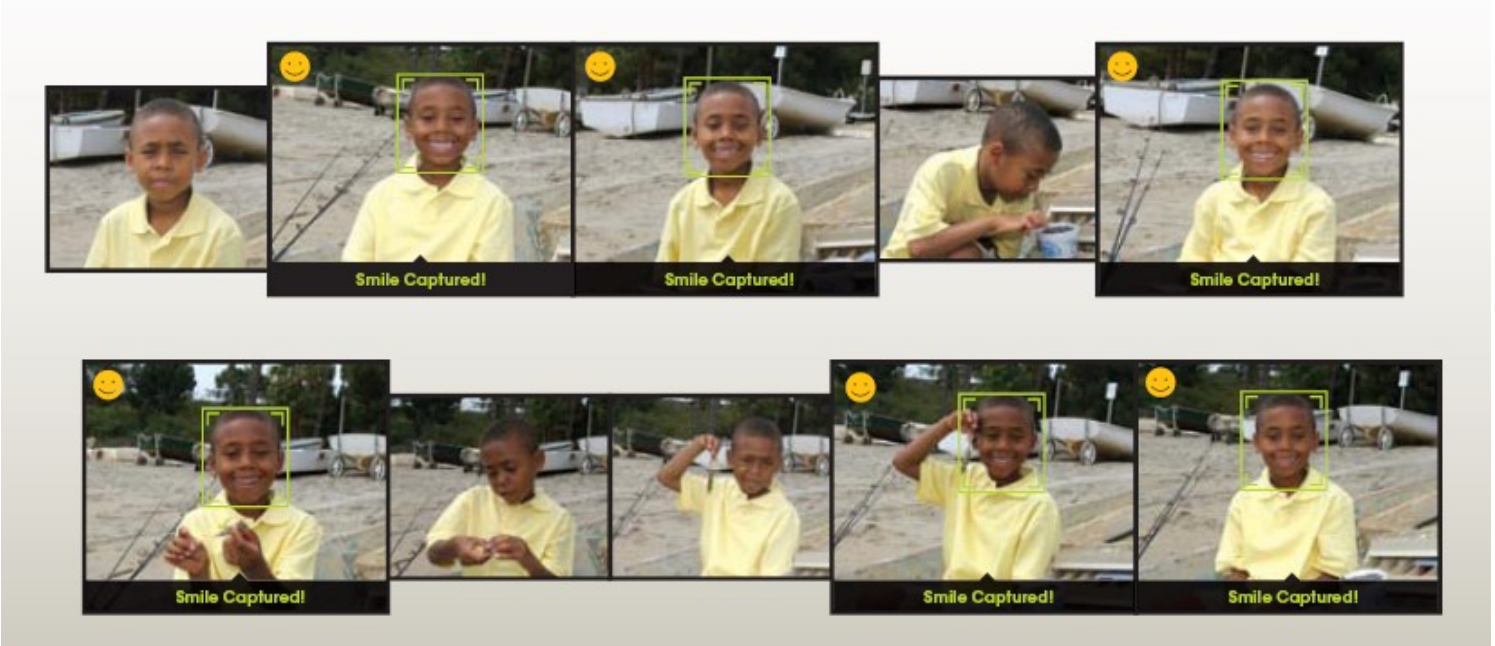
The Smile Shutter flow

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

What works today: supermarket object recognition

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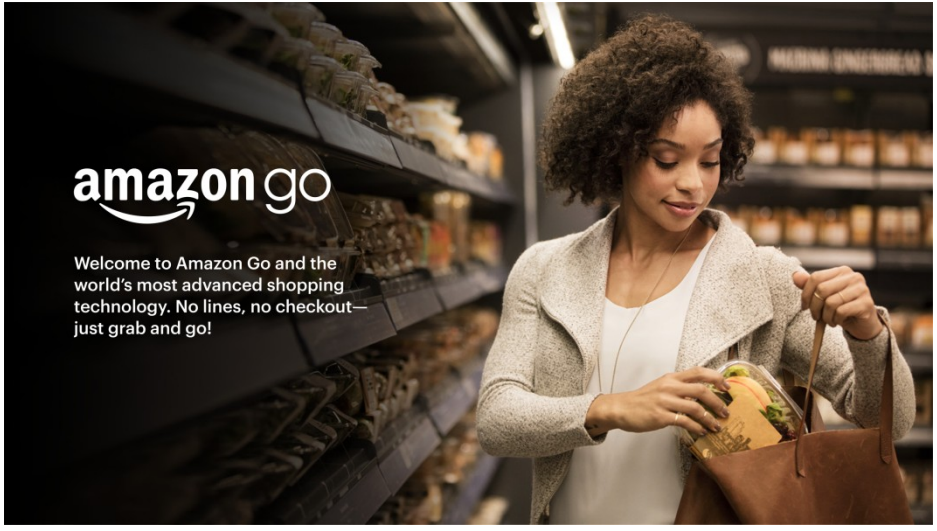
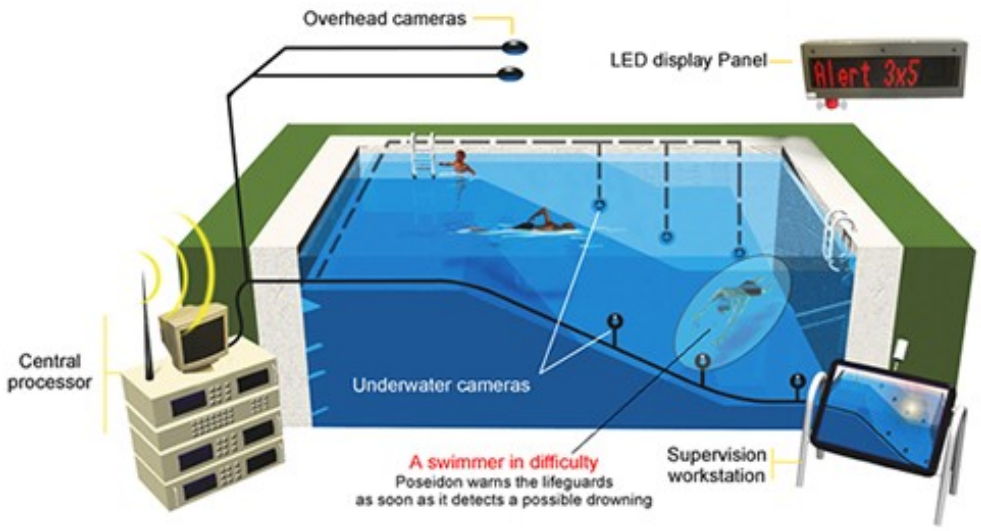


https://youtu.be/NrmMk1Myrxc

What works today: safety



BBC NEWS

Watch One-Minute World News

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

E-mail this to a friend Printable version

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.

What works today: security

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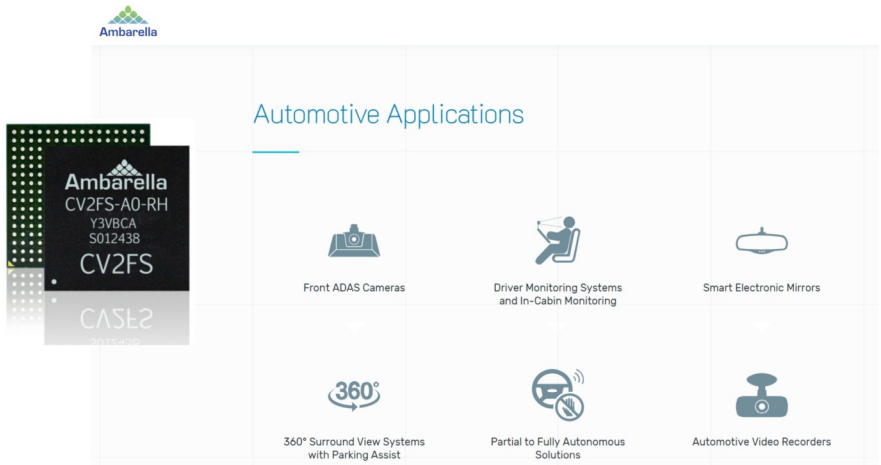
What works today: driving assistance/safety



Vision systems already in high-end car models

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

What works today: GOOGLE, Tesla, UBER, Lyft, VisLab...

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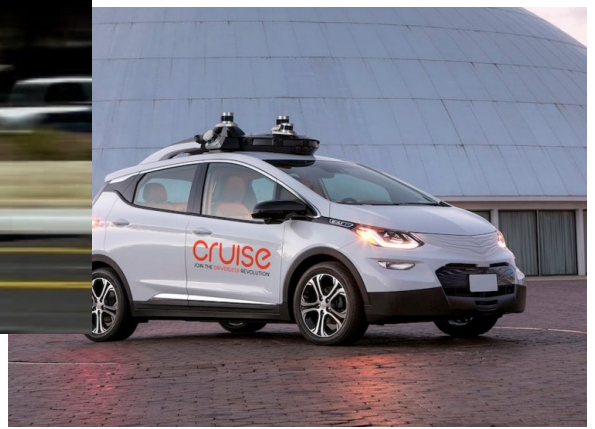

What works today: vision interaction

Microsoft Kinect

What works today: augmented reality

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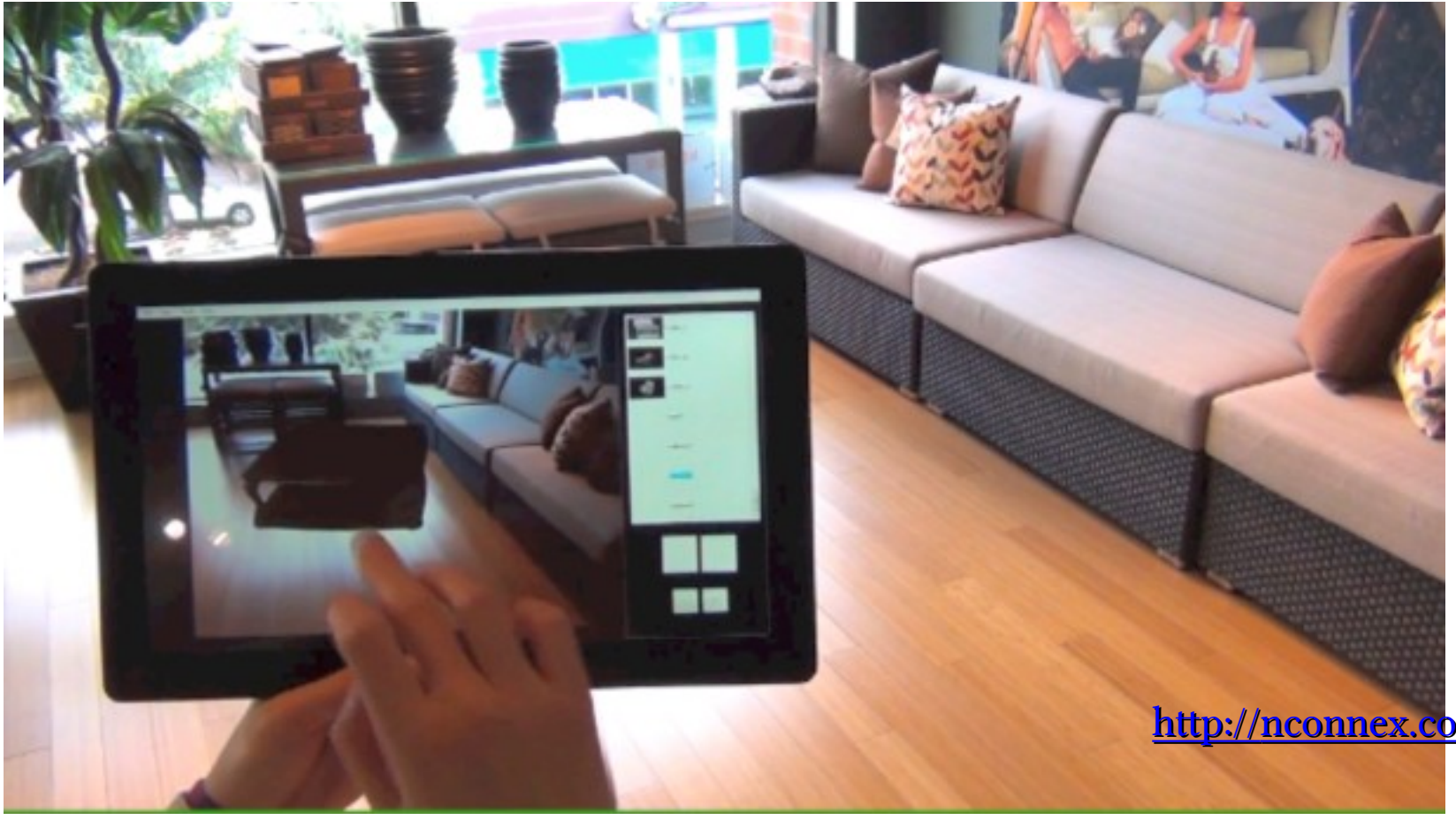

http://nconnex.com/wp/

What works today: special effects (shape/motion capture)

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Source: S. Seitz

What works today: robotics

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.

What works today: medical imaging

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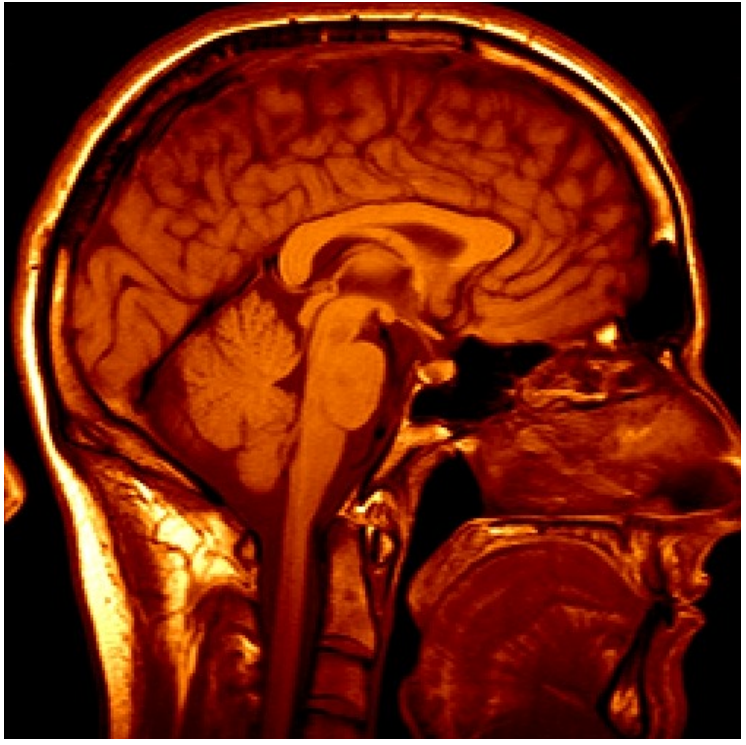
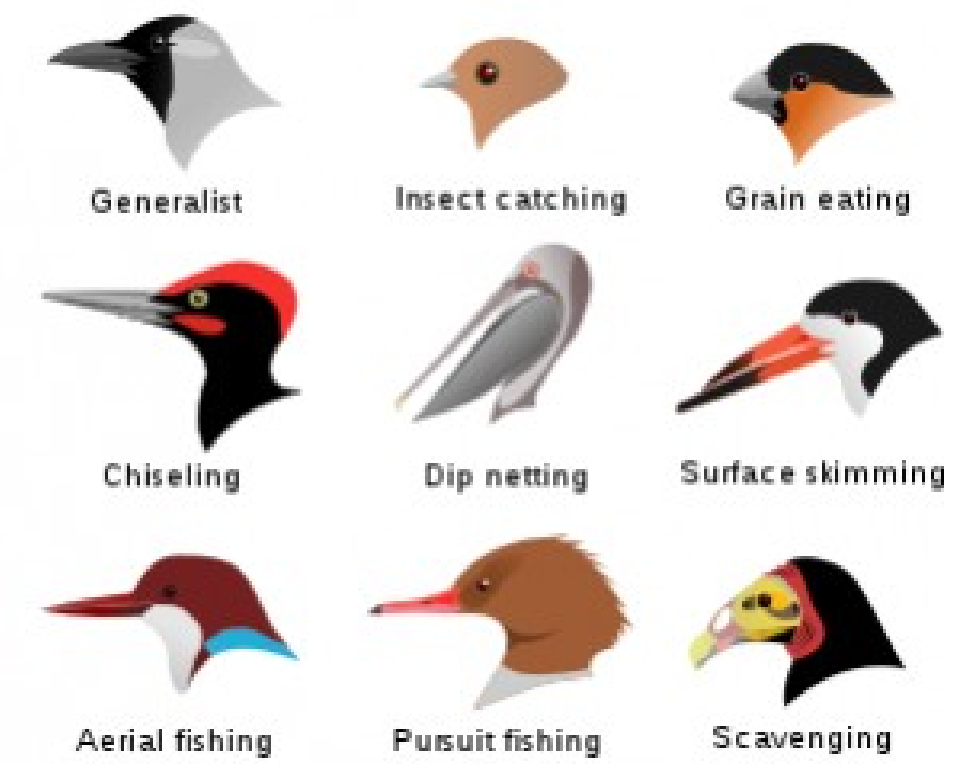


3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

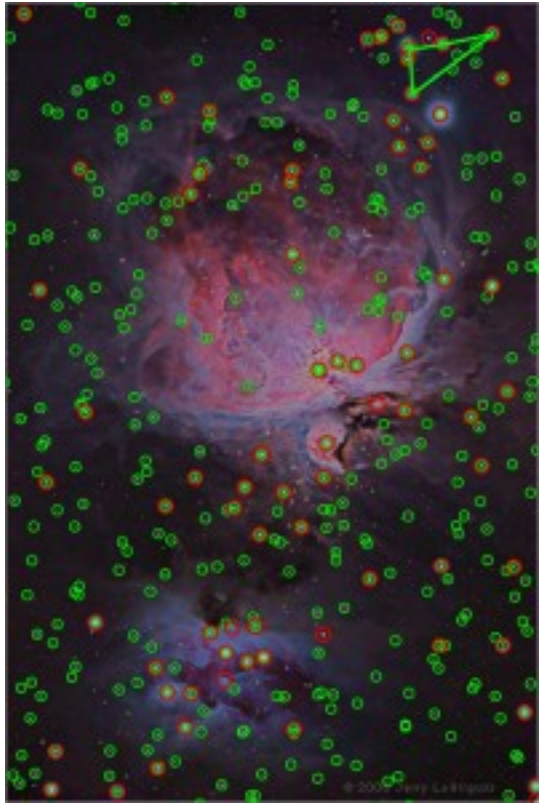
What works today: biology

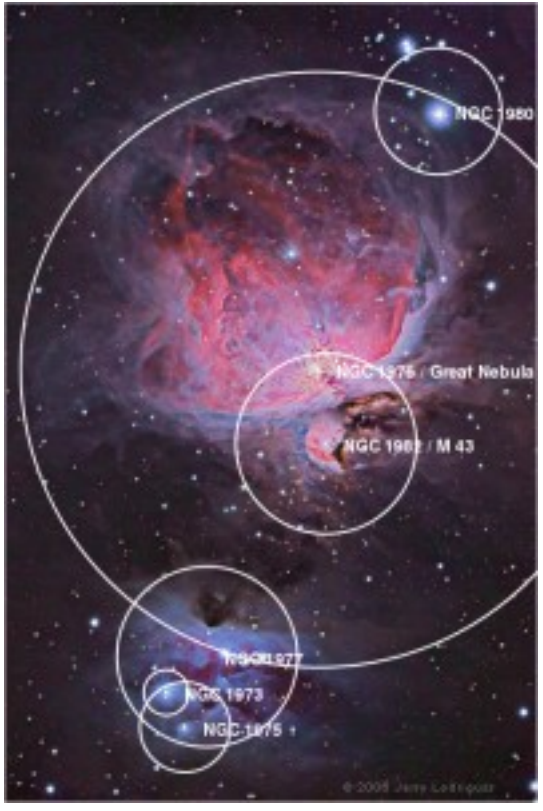


Pl@ntNet

www.visipedia.org

What works today: cosmology





http://astrometry.net/

What works today: healthcare

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

autism screening

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

Deep Learning vs *traditional* machine vision

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- DL still not superseded traditional MV
- DL is not going to better solve all CV problems
- Sometime DL is a overkill
  - SIFT, coulor thersholding, not class specific operations
  - Image stitching
  - 3D mesh reconstruction
  - Always when the problem can be easily formalized
    - (!)

Deep Learning vs *traditional* machine vision

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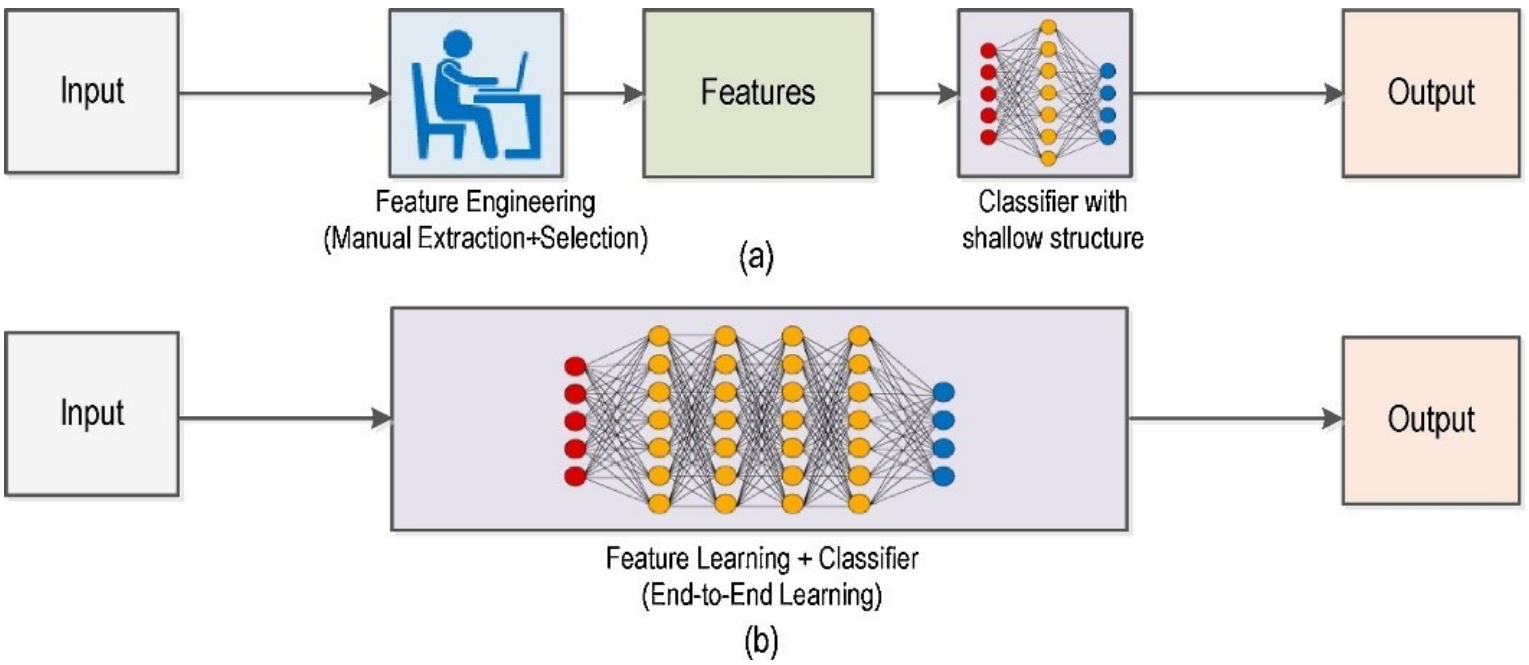
- Often MV + Machine Learning classification



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Practical Information

Requirements

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- Expertise on what you should already study in:
  - Calcolatori Elettronici
  - Fondamenti di Informatica
  - Sistemi Operativi
- For projects/code we will use C++
  - OpenCV, Eigen
  - Ubuntu/Linux knowledge

Topics

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- Images & their formats
- Image processing
  - Linear filtering
  - Non linear filtering
  - Binary images & Mathematical Morphology
  - Edges/Lines detection
- Machine vision
  - Pin hole model
  - Single view geometry
  - Stereo vision
  - Features extraction & matching
  - (Model fitting)
  - Segmentation

Exams

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- Theory
  - Written
  - 2 hours
  - Max 25 points, min 15 points
- Practical
  - Computer (YOUR laptop/notebook)
  - 2 hours
  - Max 5 points, min 3 points
- Assignements
  - Not mandatory but alternative to practical test
  - During laboratory
  - 5 points

Calendar & other infos

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- Slides, material & news: always look in elly
  - https://elly2024.didattica.unipr.it → git
  - Please note that slides are for personal use only!
    - Many images/formulas/… are from copyrighted material…

Books and other info sources

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- Machine vision and image processing books:
  - D.A. Forsyth and J. Ponce. Computer Vision: A Modern Approach (2° edition). Prentice Hall, 2011
  - R. Hartley and A. Zisserman. Multi View Geometry in Computer Vision. Cambridge University Press, 2003
  - Richard Szeliski. Computer Vision: Algorithms and Applications. Link
  - Shapiro and Stockman, Computer Vision, Prentice-Hall, 2001. Original chapters available at this URL link
- C++/OpenCV guides:
  - C++ Complete Reference
  - C++ STD Quick Reference
  - OpenCV Reference Manual
  - OpenCV Cheat Sheet link

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