



Lecture: Introduction to Computer Vision

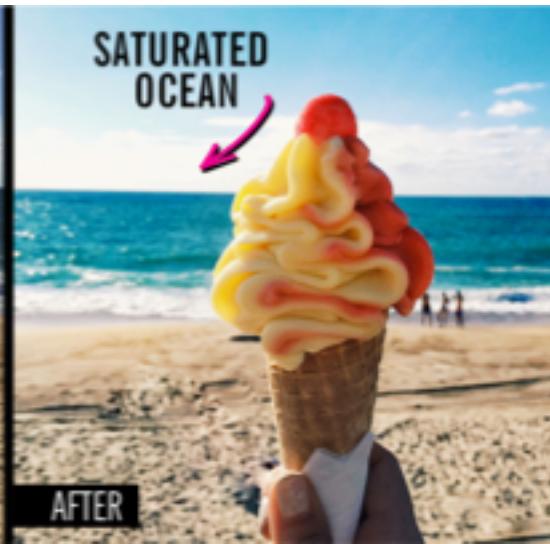
Juan Carlos Niebles and Ranjay Krishna
Stanford Vision and Learning Lab



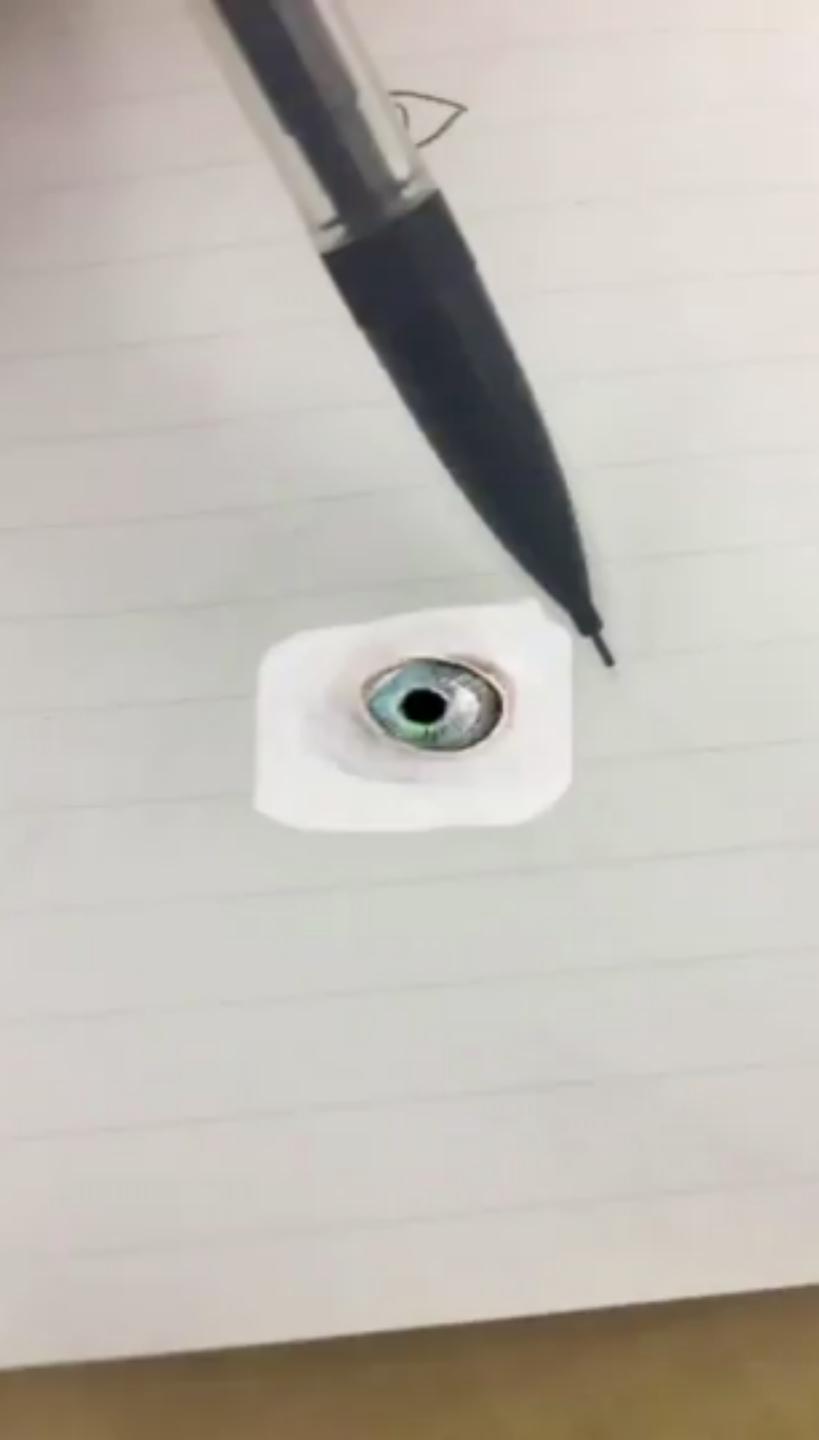
Introduction

25-Sep-2018

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Welcome to CS131



Jason Salavon
GAN experiment on Twitter



Mario Klingemann, GAN experiment on Twitter

Main device 0





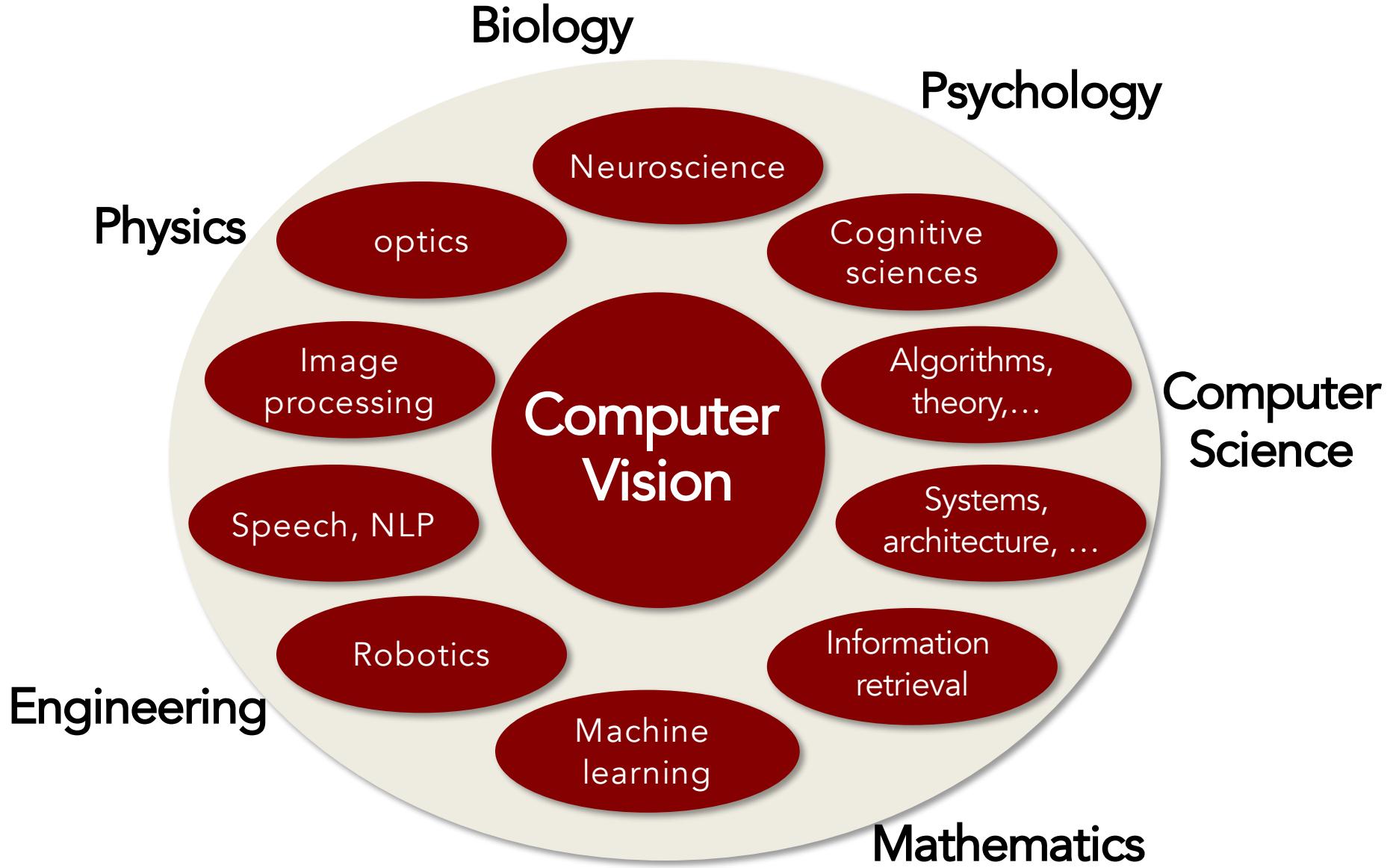
What you should expect to learn in this class.

- What is computer vision?
- Which problems fall under this umbrella?
- Which applications are possible today and in the near future?
- What are common research questions?
- What is the history behind these problems and how did it lead to deep learning?
- What tools will help you develop a framework to solve these problems?



CS131 is the introductory course for computer vision

- CS131 (fall, 2017):
 - Overview of computer vision and all its applications
 - Will prepare you for an industry job in vision
- CS231a (winter, 2018, Prof. Silvio Savarese)
 - Advanced Computer Vision
 - focusing on 3D vision
- CS231n (spring, 2018):
 - Convolutional Neural Networks





Today's agenda

- Introduction to computer vision
- Course overview



Quiz?

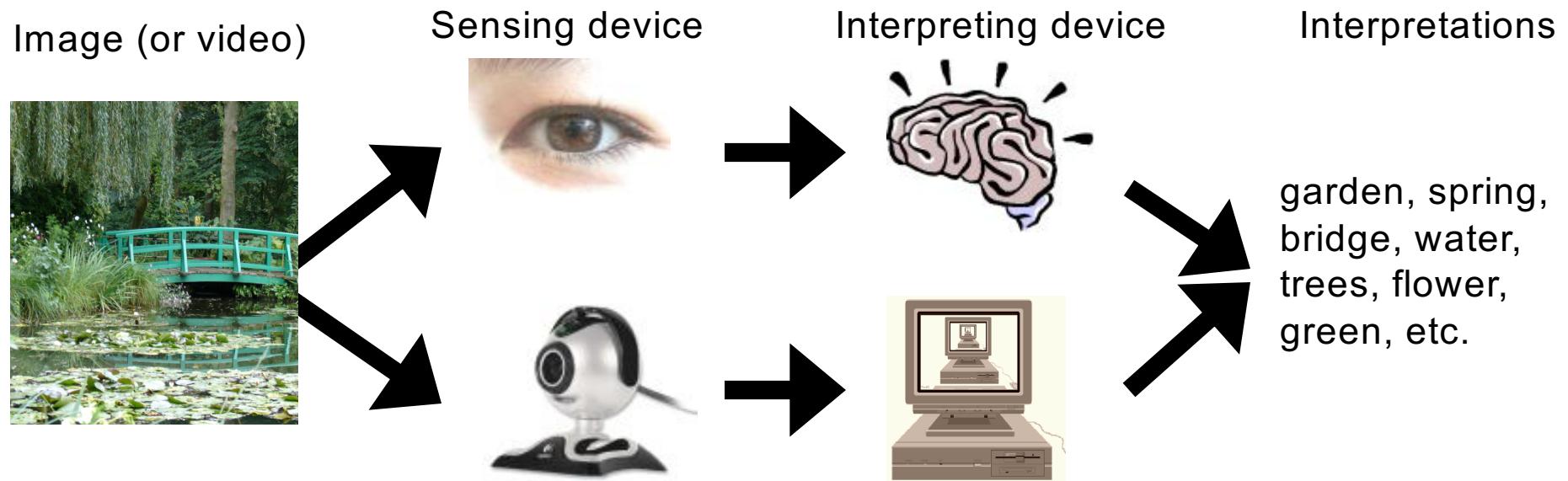




What about this?



What is (computer) vision?





The goal of computer vision

- To bridge the gap between pixels and “meaning”



What we see

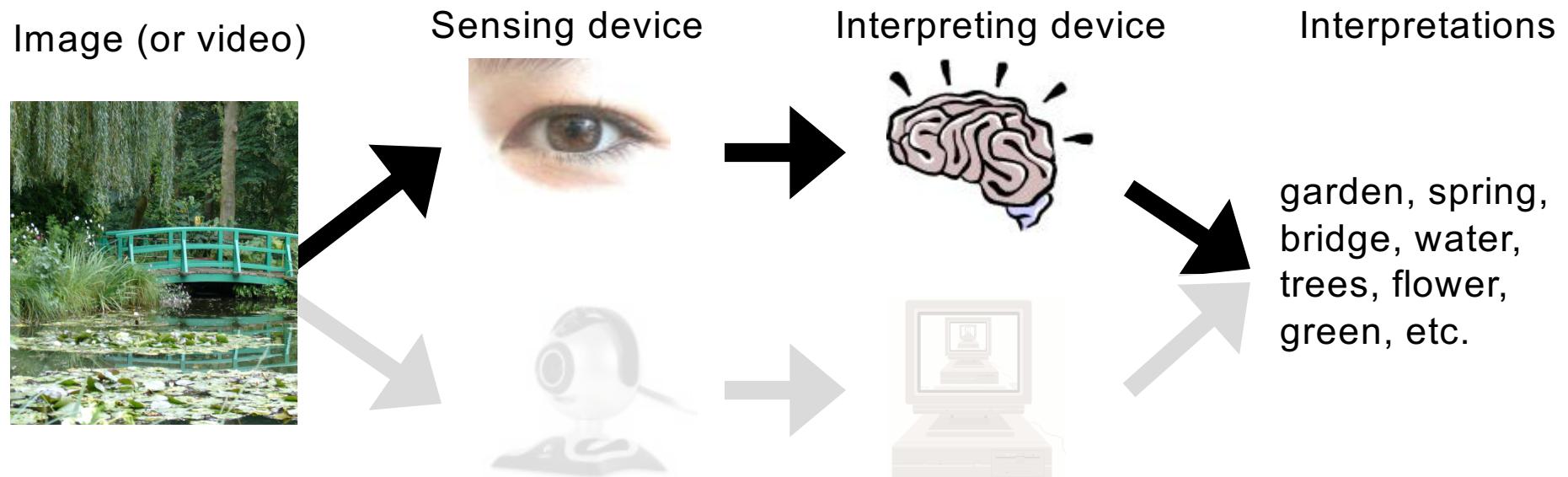
0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

Source: S. Narasimhan



What is (computer) vision?





1981: Nobel Prize in medicine



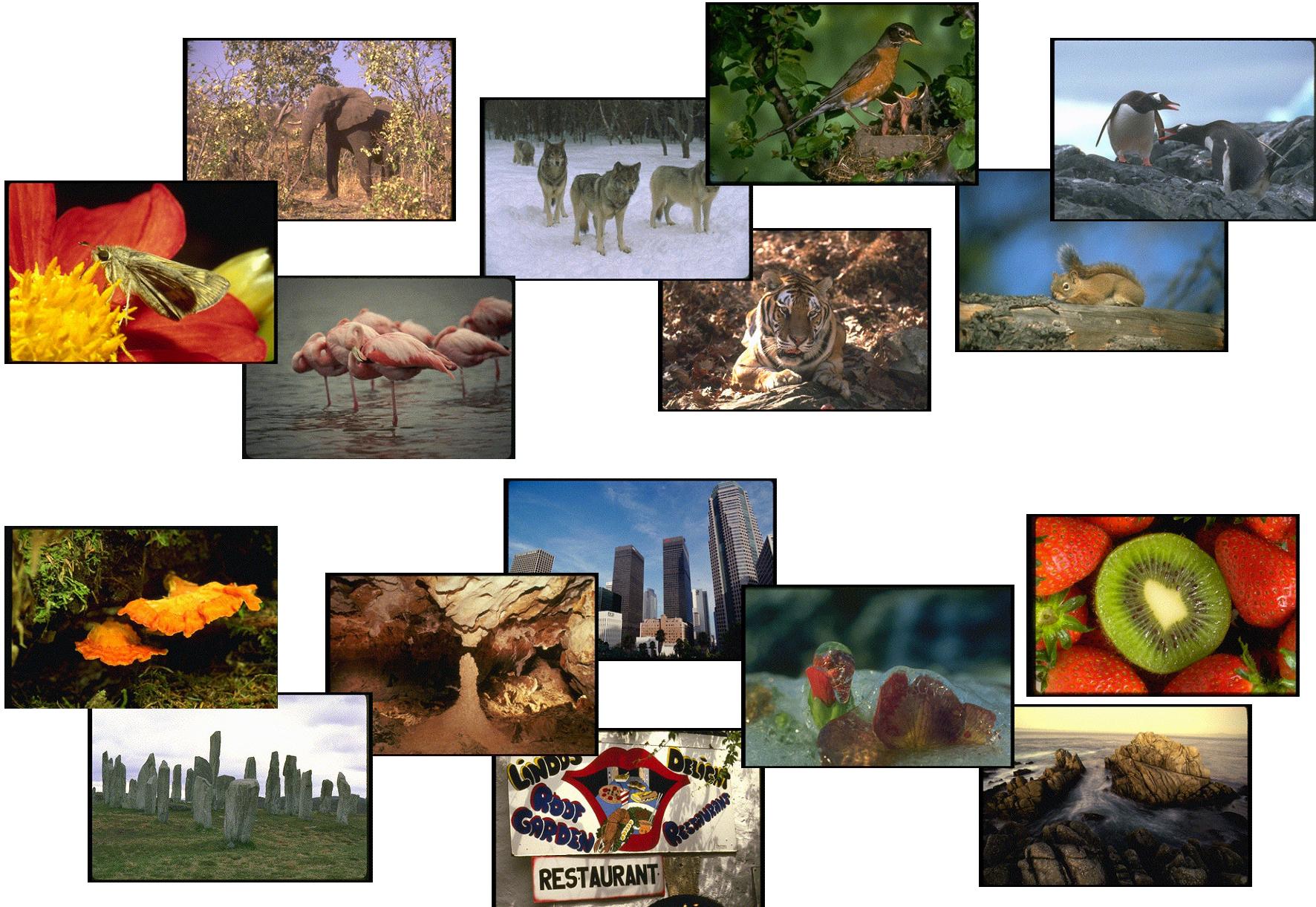
Hubel & Wiesel



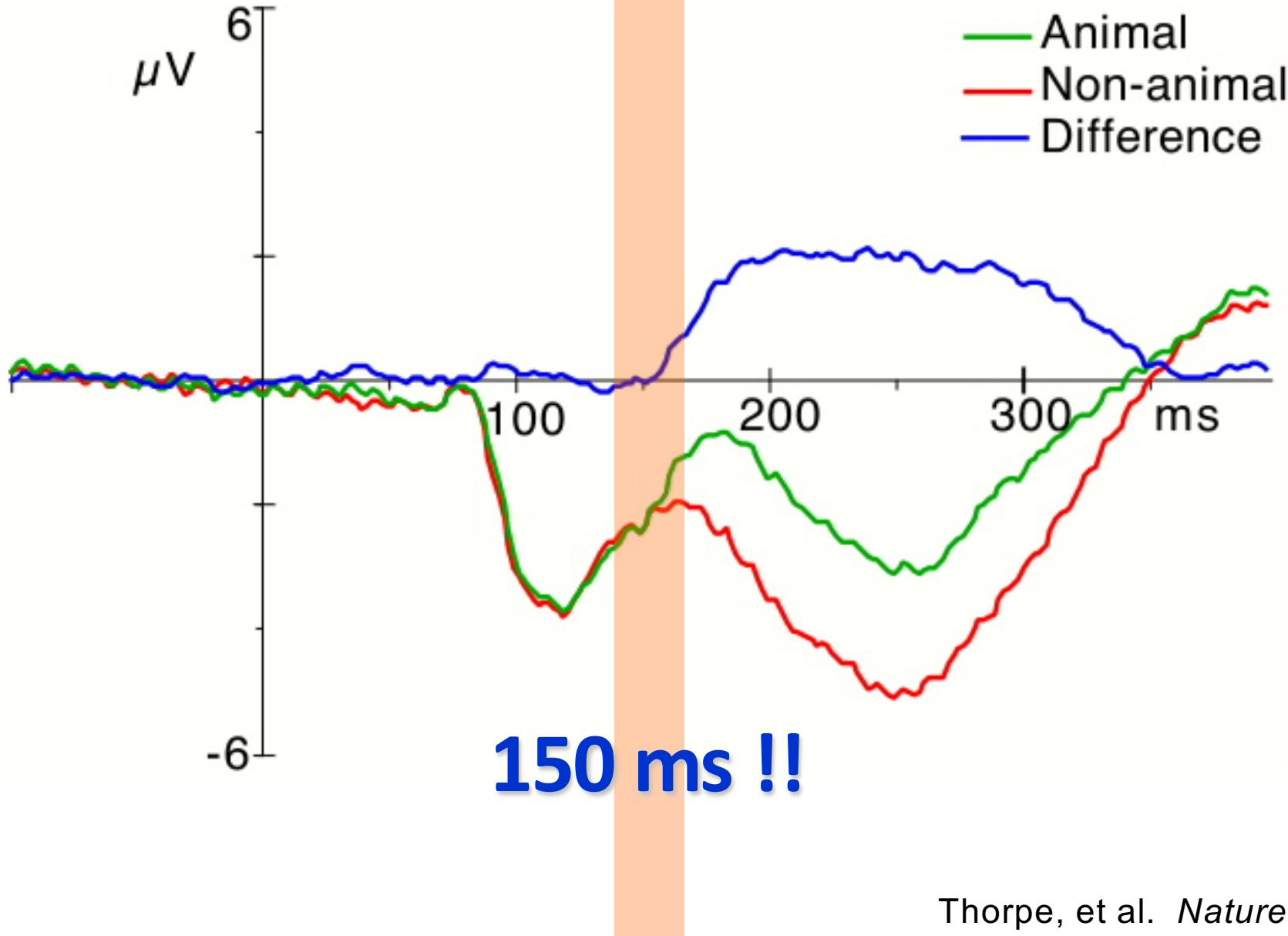
Human vision is superbly efficient



Potter, Biederman, etc. 1970s



Thorpe, et al. *Nature*, 1996



Change Blindness



Rensink, O'regan, Simon, etc.



Change Blindness



Rensink, O'regan, Simon, etc.

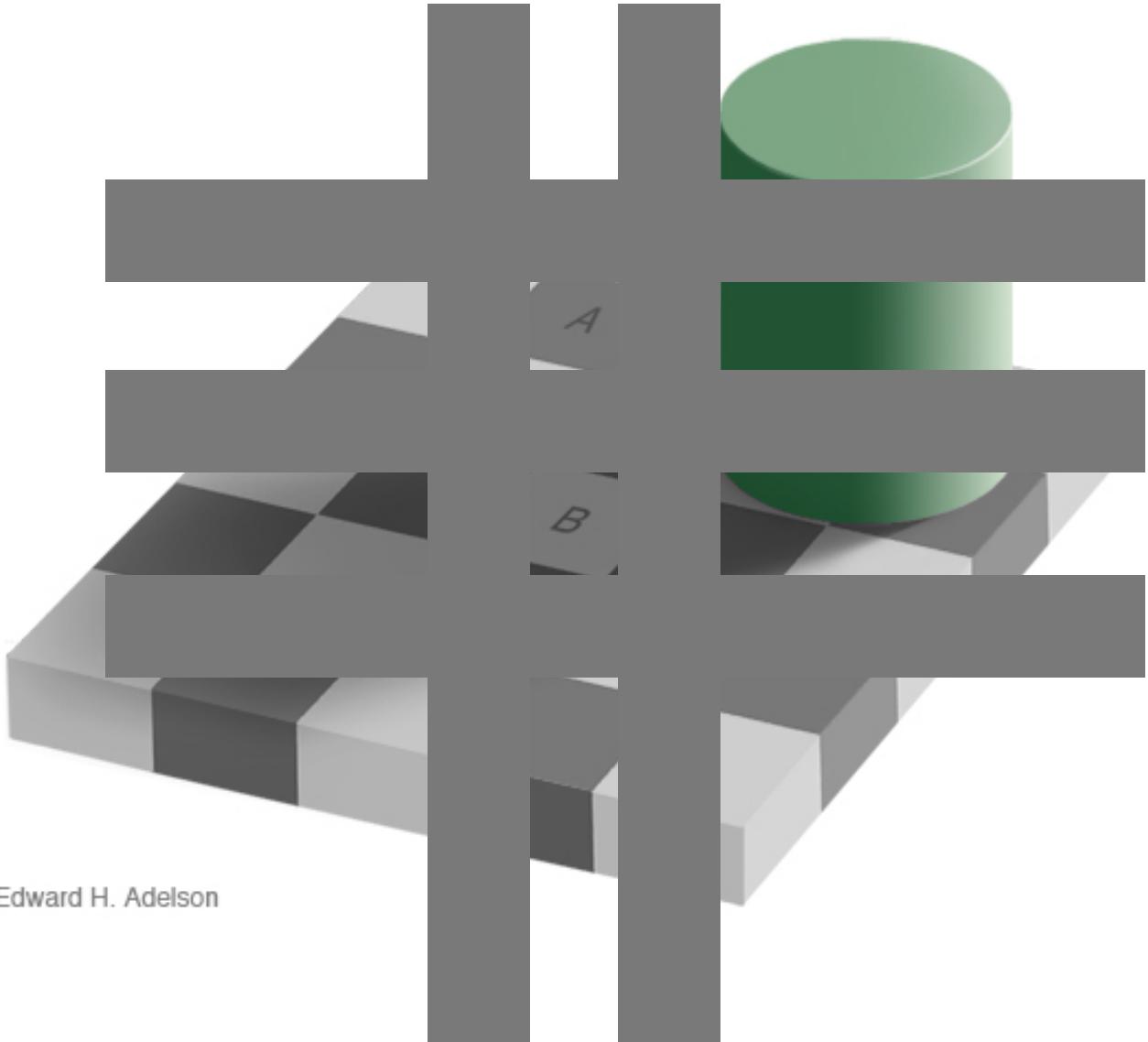
Segmentation





Perception



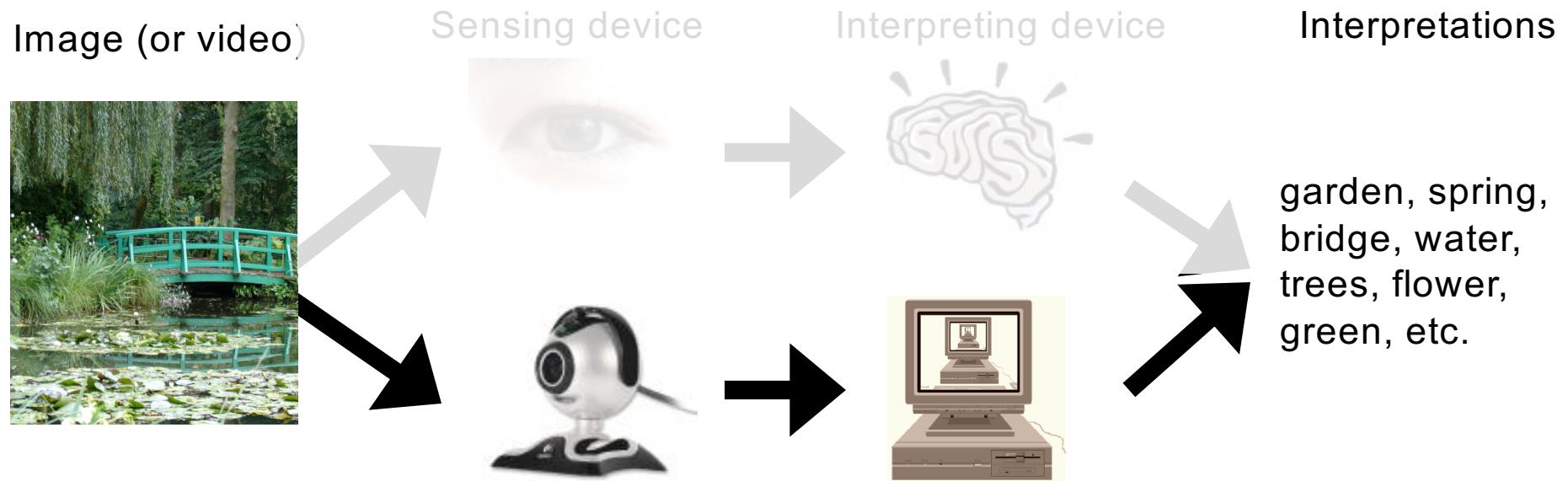


Edward H. Adelson





What is (computer) vision?





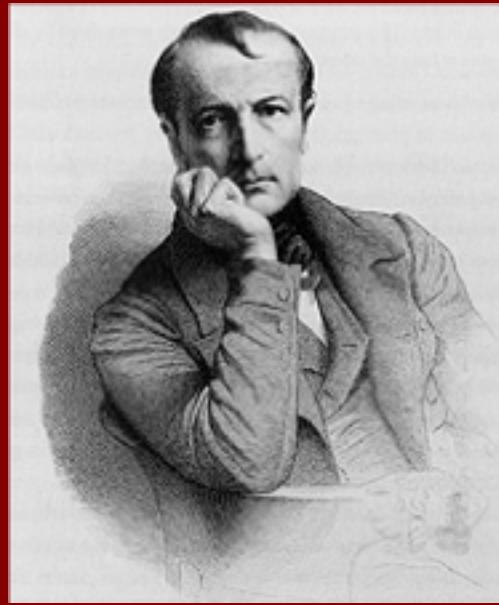
Paintings in 1838



1812: Jacques-Louis-David
The Emperor Napoleon at his Study at the Tuileries



1808: Ingres, *La grande baigneuse*



“From today, painting is dead”
— painter Paul Delaroche
at a demonstration of the Daguerreotype,
1839



1837: Niépce, First photo of one's meal



1838: Boulevard du Temple, Daguerre



1838: First selfie, Robert Cornelius



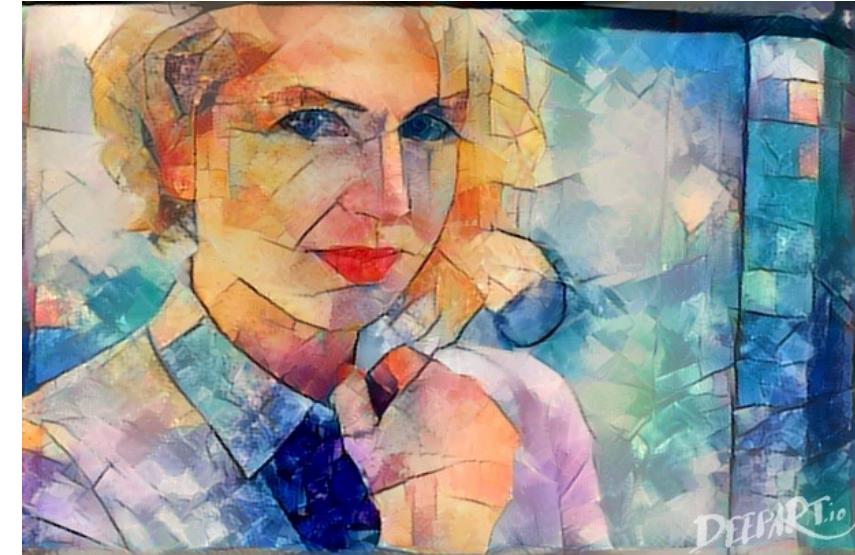
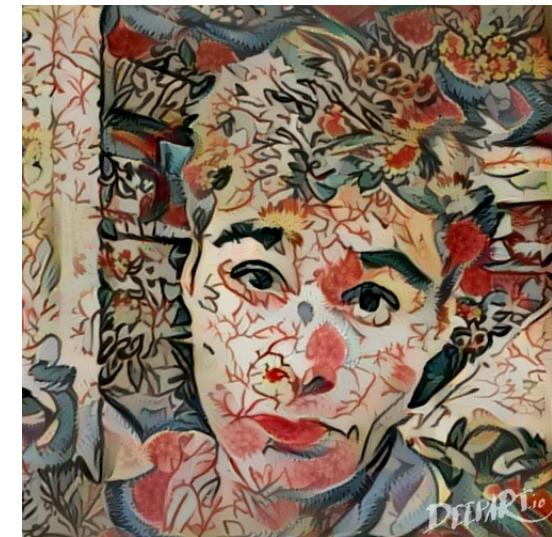
DeepDreams
[Mordvintsev et al. 2015]



Neural Style Transfer
[Gatys et al. 2015]



DEEPART.io



Neural Style Transfer
[Gatys et al. 2015]

Monet \curvearrowright PhotosMonet \rightarrow photoZebras \curvearrowright Horseszebra \rightarrow horseSummer \curvearrowright Wintersummer \rightarrow winterphoto \rightarrow Monethorse \rightarrow zebrawinter \rightarrow summer

Photograph



Monet



Van Gogh



Cezanne



Ukiyo-e

CycleGAN [Zhu et al. 2017]



The goal of computer vision

- To bridge the gap between pixels and “meaning”



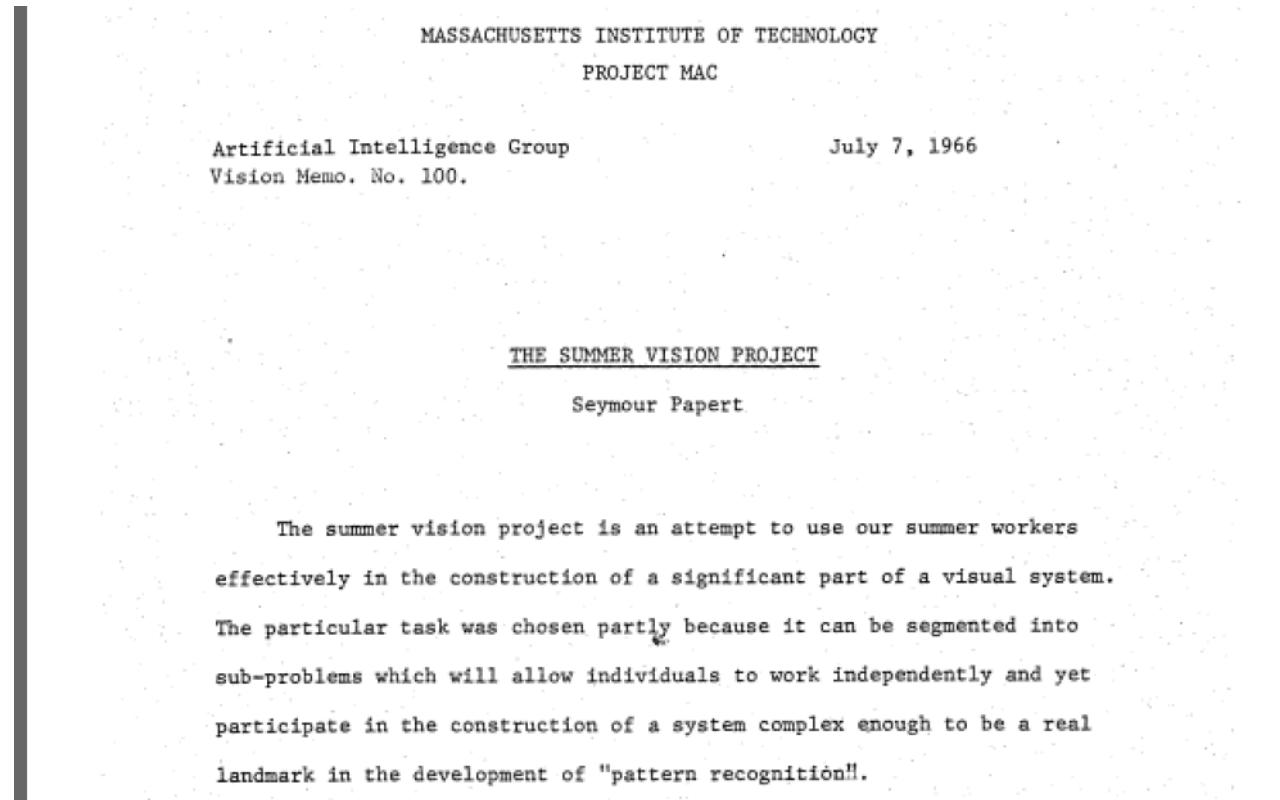
What we see

0	3	2	5	4	7	6	9	8
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6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
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What a computer sees



Origins of computer vision: an MIT undergraduate summer project

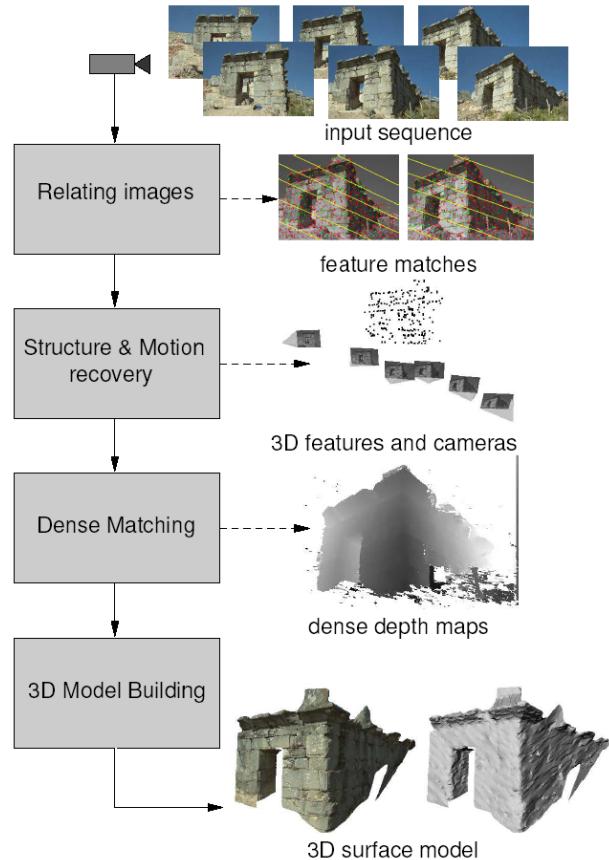




What kind of information can we extract from an image?

- Metric 3D information
- Semantic information

Vision as measurement device



Pollefeys et al.



Goesele et al.



amusement park

sky

The Wicked Twister

ride

Lake Erie

tree

deck

bench

Cedar Point

Ferris wheel

water

tree

ride

12 E

-12 E-

Objects
Activities
Scenes
Locations
Text / writing
Faces
Gestures
Motions
Emotions...

Vision as a source of semantic information

people waiting in line

people sitting on ride

umbrellas

carousel

tree

pedestrians

maxair



Why study computer vision?

- Vision is useful: Images and video are everywhere!



Google
Image Search

Google Photos

flickr^{GAMMA}

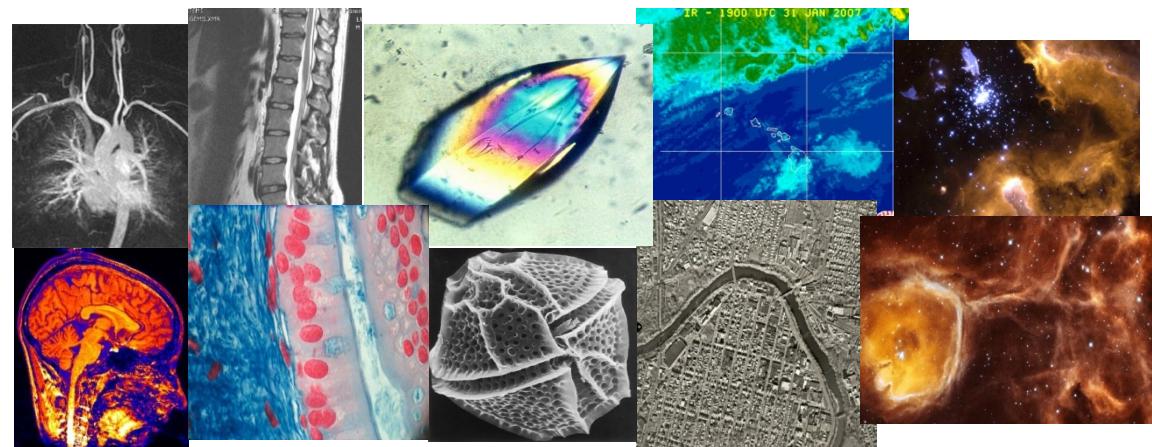
webshots^{beta}

picsearch™

YouTube
Broadcast Yourself™



Surveillance and security



Medical and scientific images

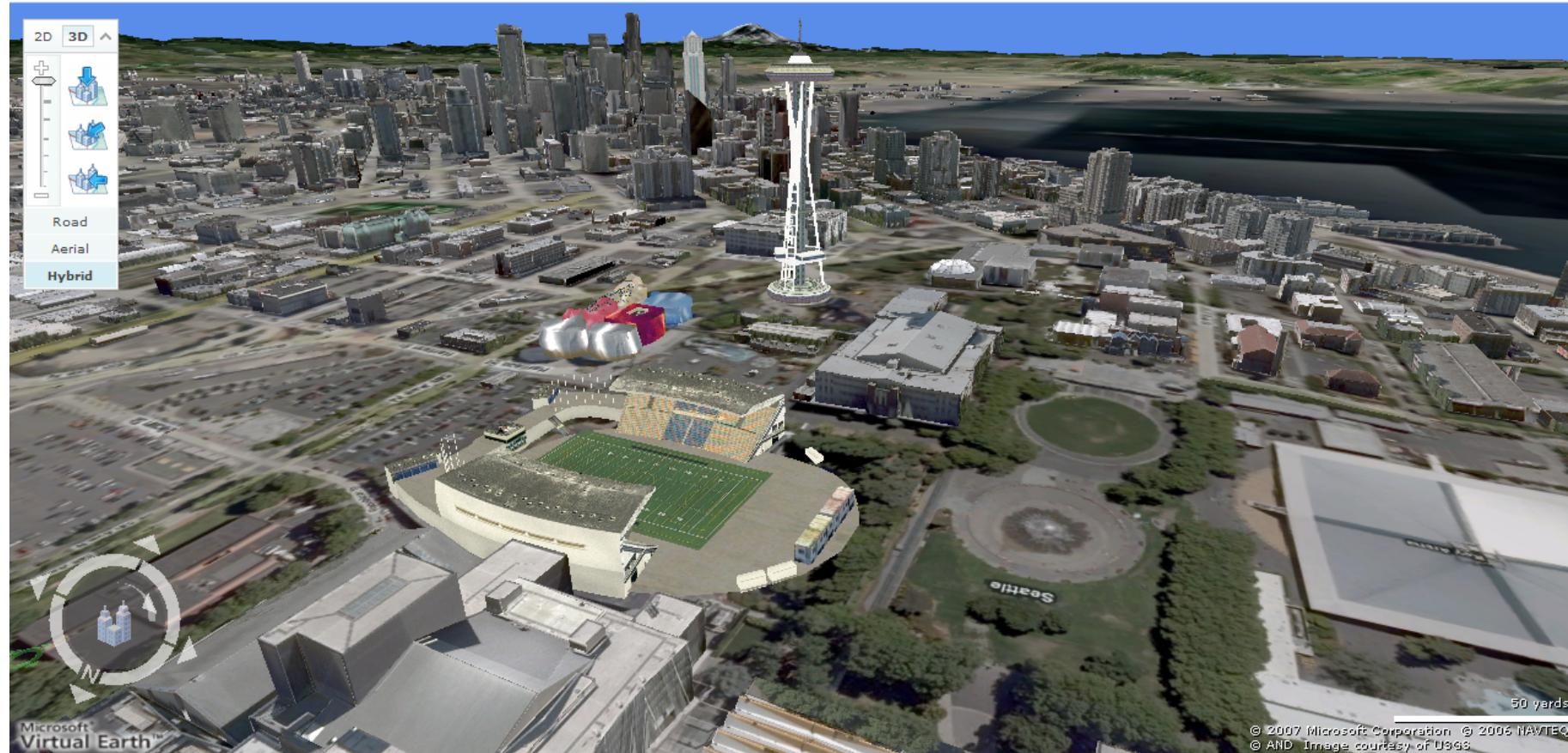
Special effects: shape and motion capture



Source: S. Seitz



3D urban modeling



Bing maps, Google Streetview



3D urban modeling: Microsoft Photosynth



<http://photosynth.net>

Face detection



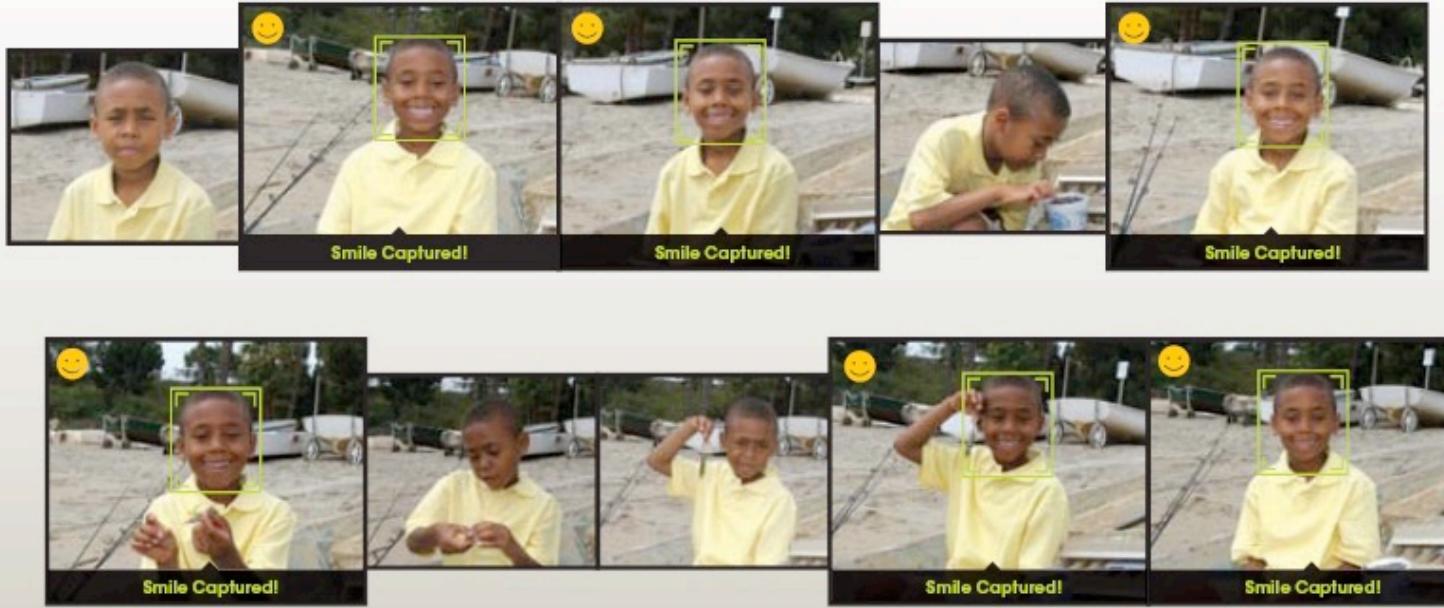
- Many digital cameras now detect faces
 - Canon, Sony, Fuji, ...



Smile detection

The Smile Shutter flow

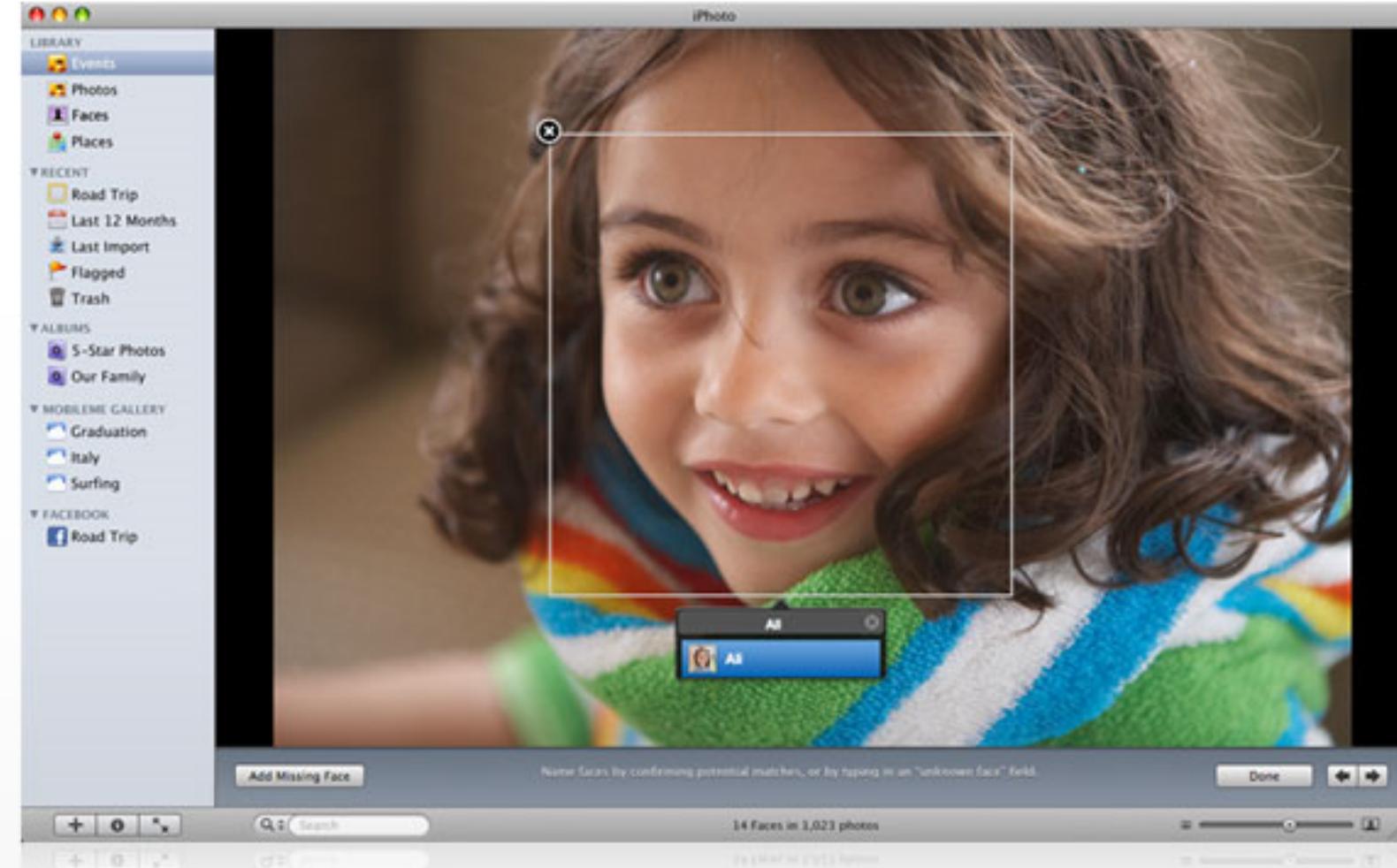
Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.



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



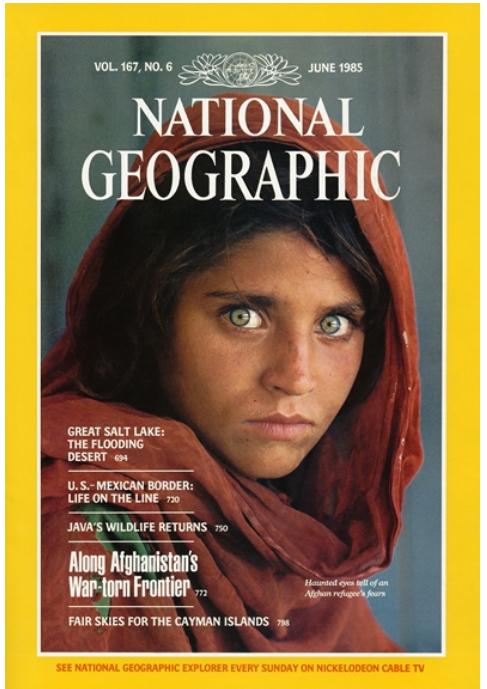
Face recognition: Apple iPhoto software



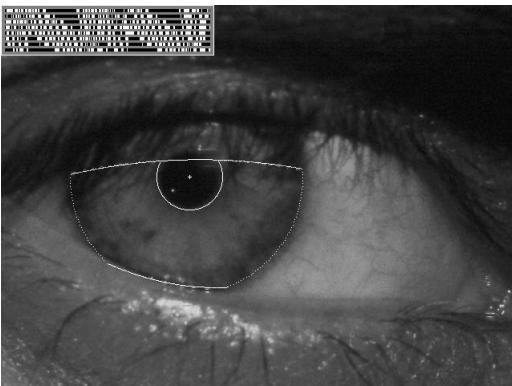
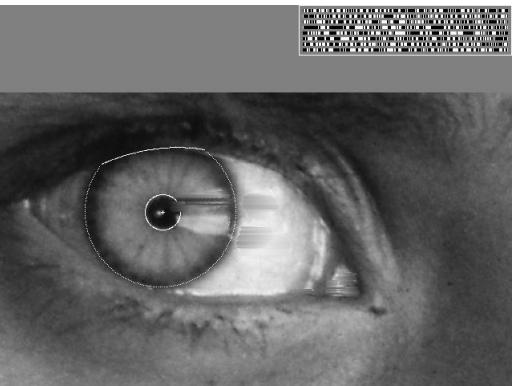
<http://www.apple.com/ilife/iphoto/>



Biometrics



How the Afghan Girl was Identified by Her Iris Patterns



Source: S. Seitz



Biometrics



Fingerprint scanners on
many new laptops,
other devices



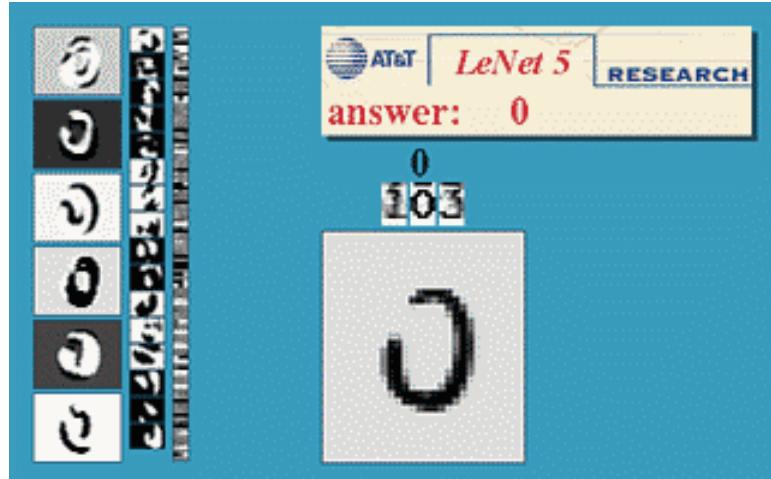
Face recognition systems now beginning
to appear more widely
iphone X just introduced face recognition



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



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

Source: S. Seitz



Google maps: Annotate all houses and streets



Avenue des Sapins



Toys and Robots





Mobile visual search: iPhone Apps

snaptell

kooaba

Query Images



Perspective



Zoom



Rotation



Coverage



Lighting



Logos



Occlusion



Blur



Zoom

Matched Image



Snapstacles and Google glasses

spectacles



- That's Ranjay in undergrad ->



Automotive safety

► manufacturer products consumer products ◀◀

Our Vision. Your Safety.

rear looking camera forward looking camera
side looking camera

EyeQ Vision on a Chip

Vision Applications

Road, Vehicle, Pedestrian Protection and more

AWS Advance Warning System

News

- Mobileye Advanced Technologies Power Volvo Cars World First Collision Warning With Auto Brake System
- Volvo: New Collision Warning with Auto Brake Helps Prevent Rear-end

Events

- Mobileye at Equip Auto, Paris, France
- Mobileye at SEMA, Las Vegas, NV

- Mobileye: Vision systems in high-end BMW, GM, Volvo models
 - “In mid 2010 Mobileye will launch a world's first application of full emergency braking for collision mitigation for pedestrians where vision is the key technology for detecting pedestrians.”



Vision 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...”



Amazon Go



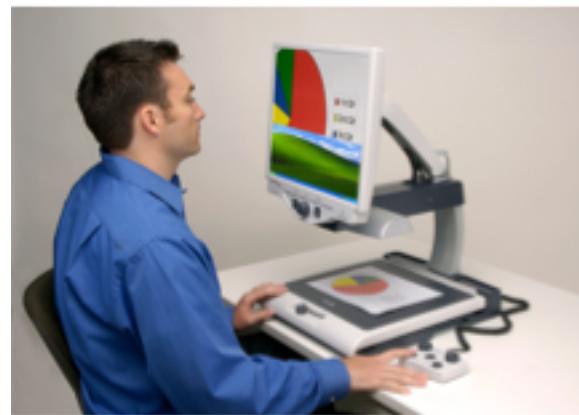
Vision-based interaction (and games)



Microsoft's Kinect



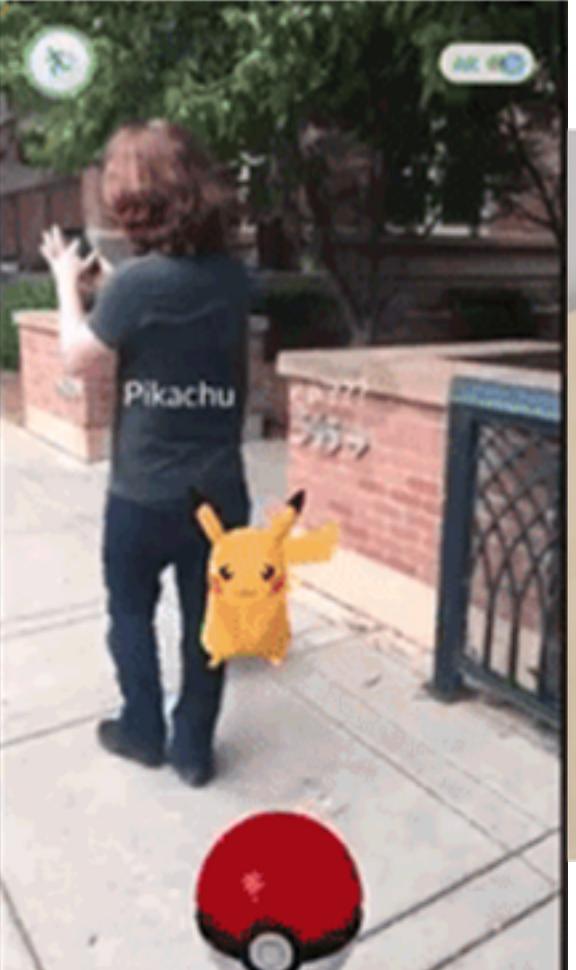
Sony EyeToy



Assistive technologies



Augmented Reality





Virtual Reality



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.



MGMT "When You Die"