Machine Vision Technology

School of Computer Science
Beijing University of Posts and Telecommunications

1

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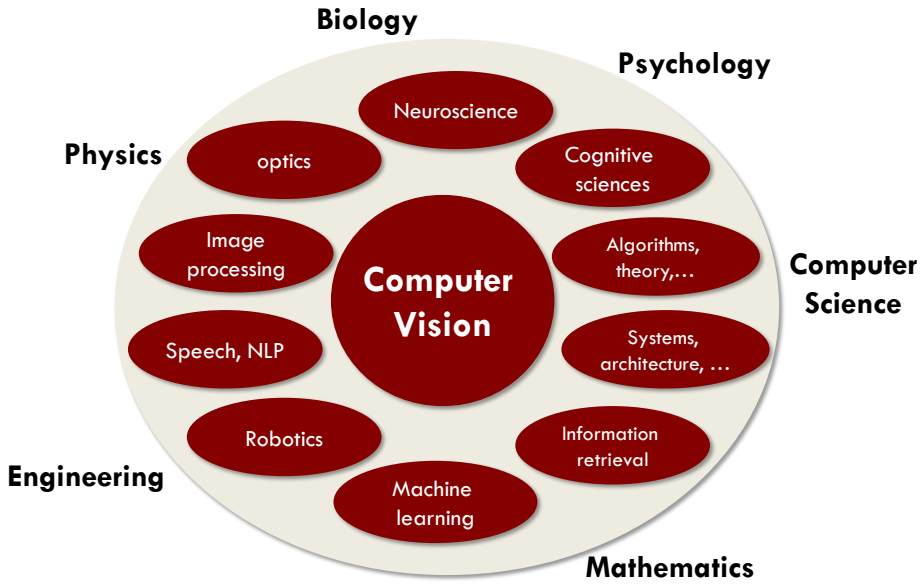

3

Today's agenda

- Introduction to computer vision
- Course overview

4

Quiz?

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What about this?

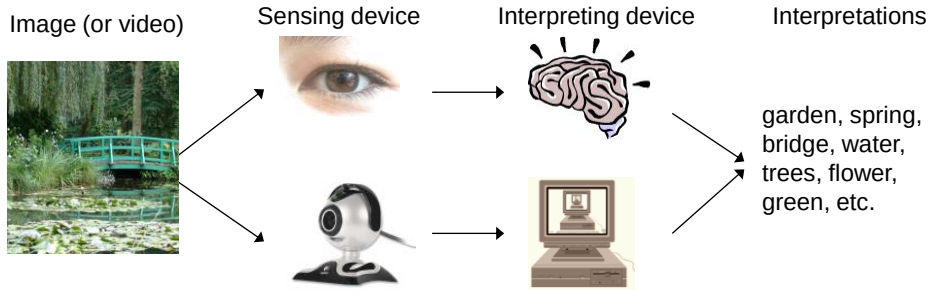
3D Reconstruction

Michaelangelo's David

Recognizing chairs

6

What is (computer) vision?

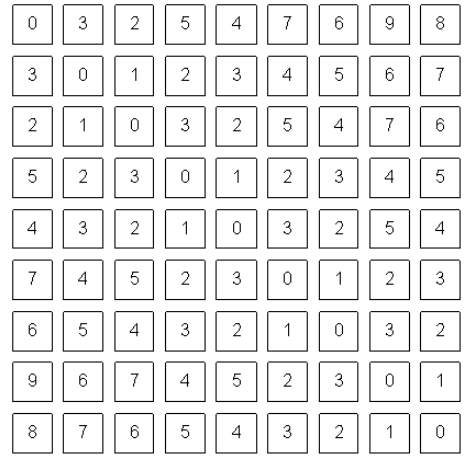


7

The goal of computer vision

- To bridge the gap between pixels and “meaning”

What we see

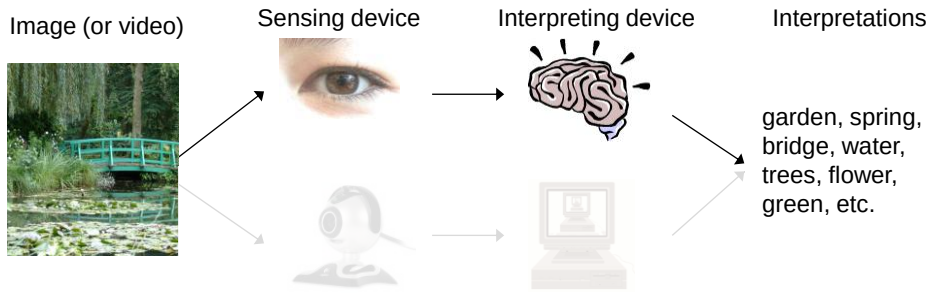


What a computer sees

Source: S. Narasimhan

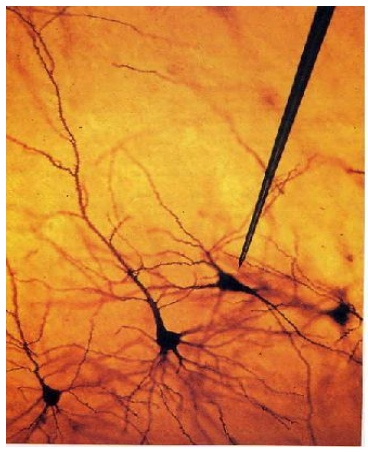
8

What is ~~(computer)~~ vision?



9

1981: Nobel Prize in medicine



Hubel & Wiesel

Dr. Hubel said:

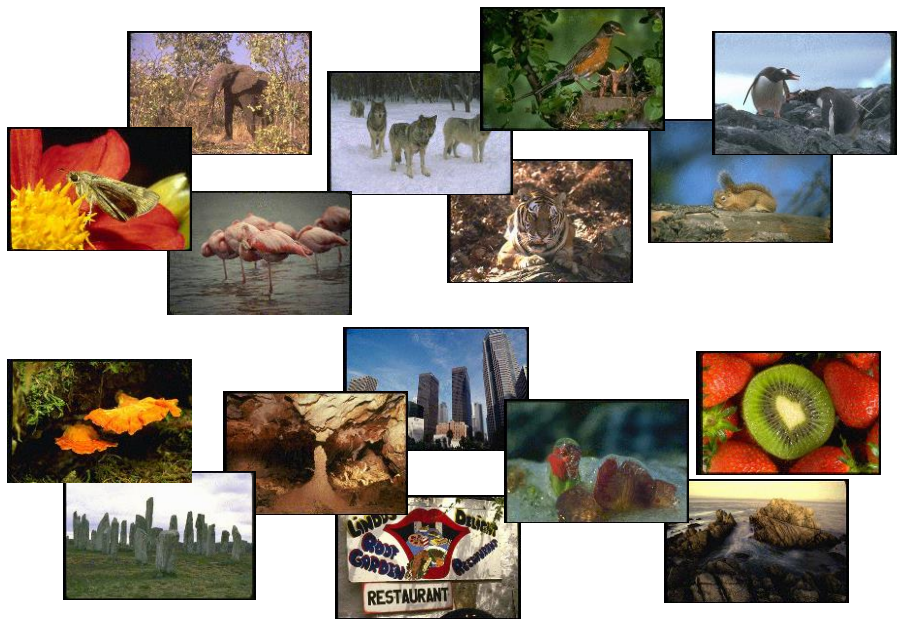
There has been a myth that the brain cannot understand itself. It is compared to a man trying to lift himself by his own bootstraps. We feel that is nonsense. The brain can be studied just as the kidney can.

10

Human vision is superbly efficient

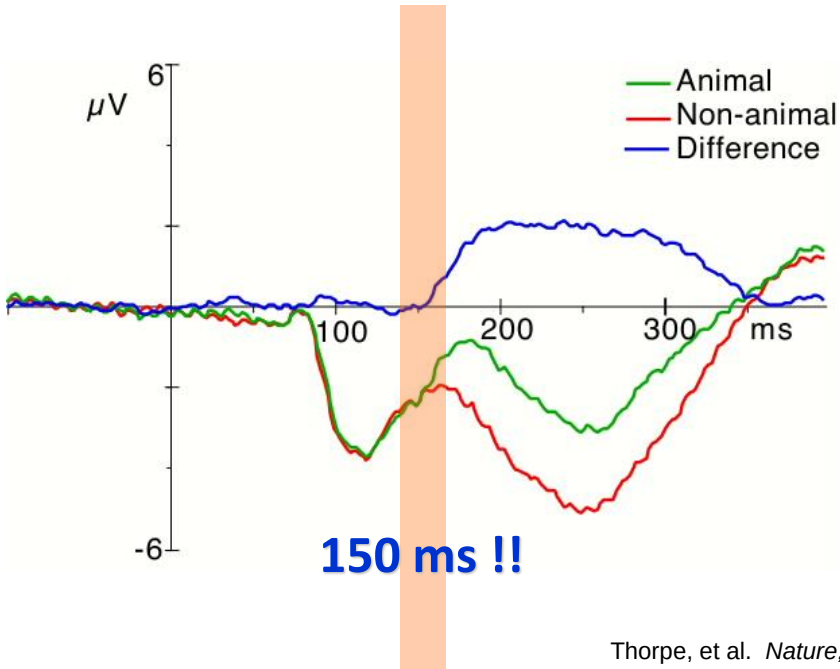
Potter, Biederman, etc. 1970s

11



Thorpe, et al. *Nature,* 1996

12



Thorpe, et al. *Nature,* 1996

13

Change Blindness

Rensink, O'regan, Simon, etc.

14

Change Blindness

Rensink, O'regan, Simon, etc.

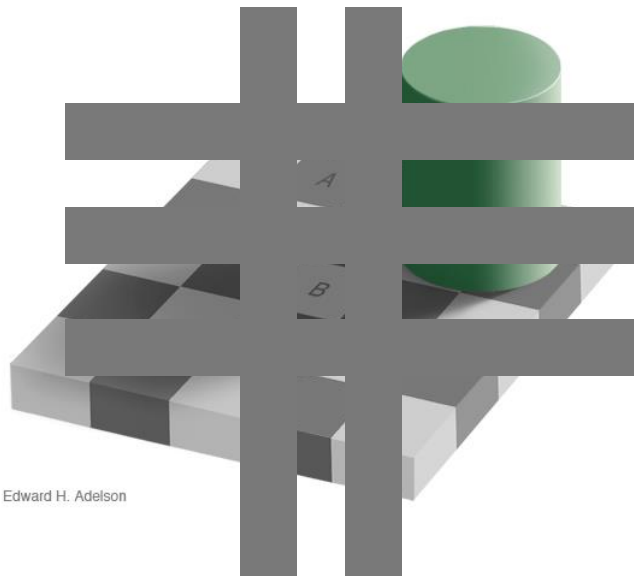
15

Segmentation

16

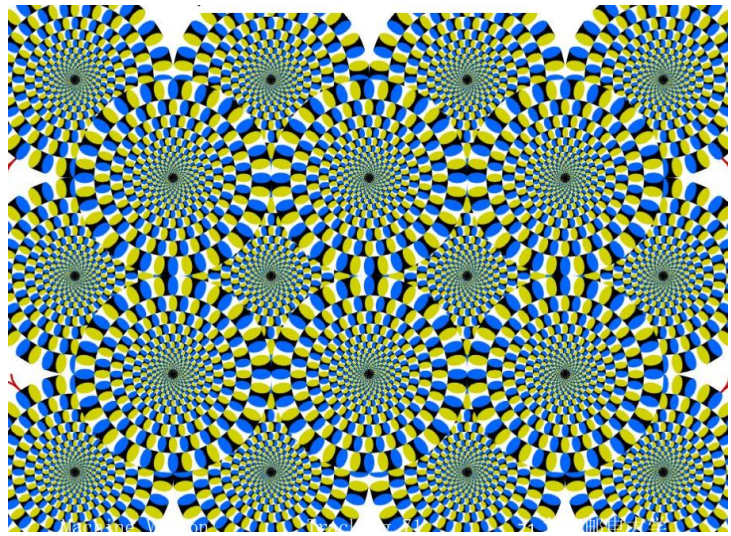
Perception

17



18

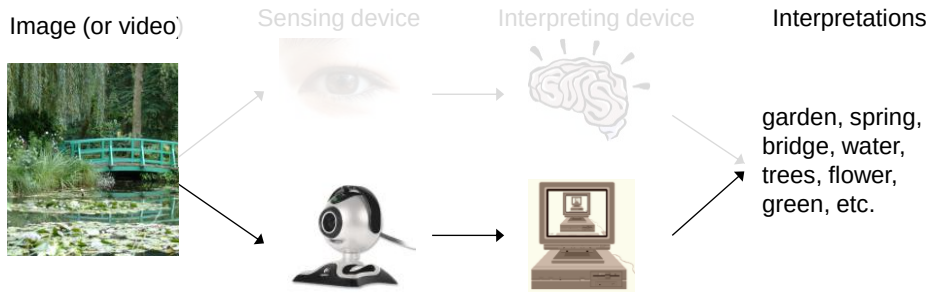
Motion without movement



19

20

What is (computer) vision?



21

The goal of computer vision

- To bridge the gap between pixels and “meaning”

What we see

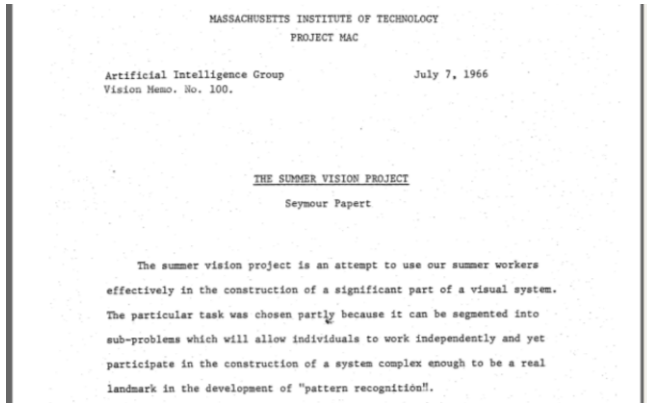
0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

Source: S. Narasimhan

22

Origins of computer vision: an MIT undergraduate summer project



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".

23

Pioneer in the field： David Marr (1945-1980)

Computational theory: What is the goal of the computation (task) and what are the constraints that are known or can be brought to bear on the problem?

Representations and algorithms: How are the input, output, and intermediate information represented, and which algorithms are used to calculate the desired result?

Hardware implementation: How are the representations and algorithms mapped onto actual hardware, e.g., a biological vision system or a specialized piece of silicon? Conversely, how can hardware constraints be used to guide the choice of representation and algorithm?

《Vision：A Computational Investigation into the Human Representation and Processing of Visual Information》

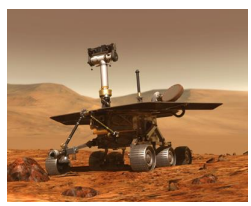
24

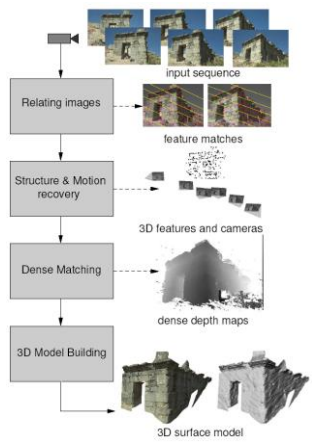
What kind of information can we extract from an image?

- Metric 3D information
- Semantic information

25

Vision as measurement device

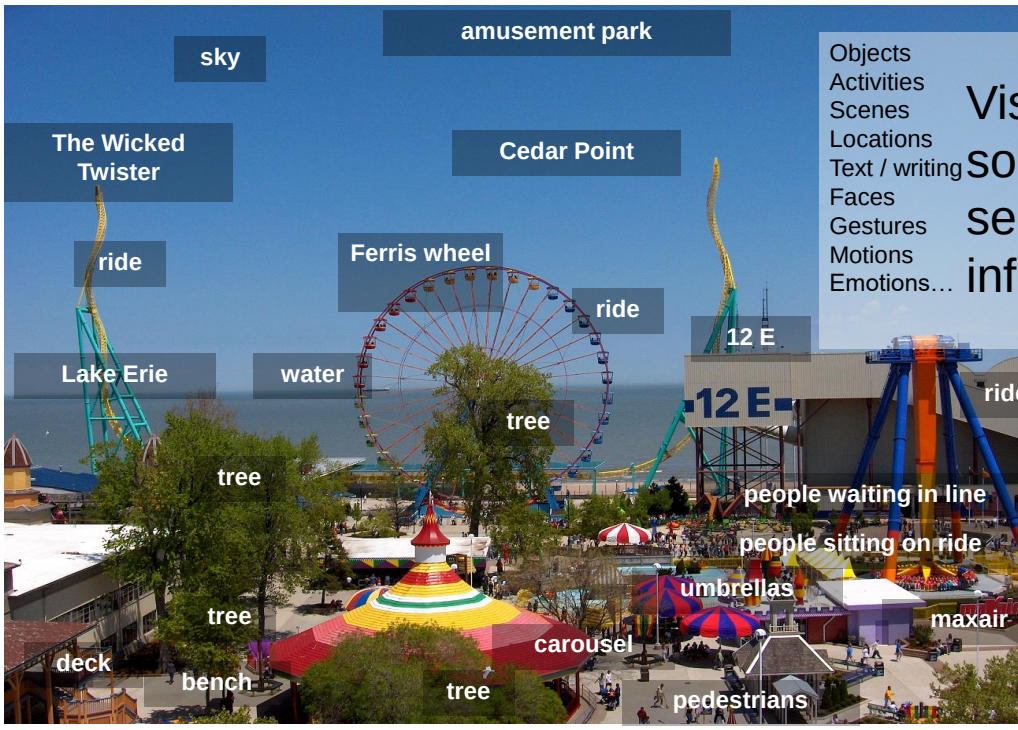




Pollefeys et al.

Goesele et al.

26

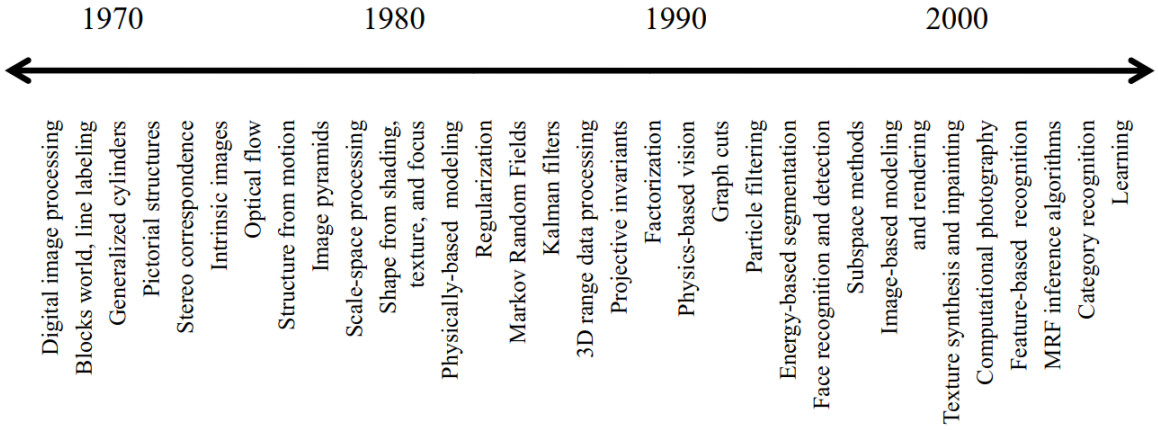


Vision as a source of semantic information

Slide credit: Kristen Grauman

27

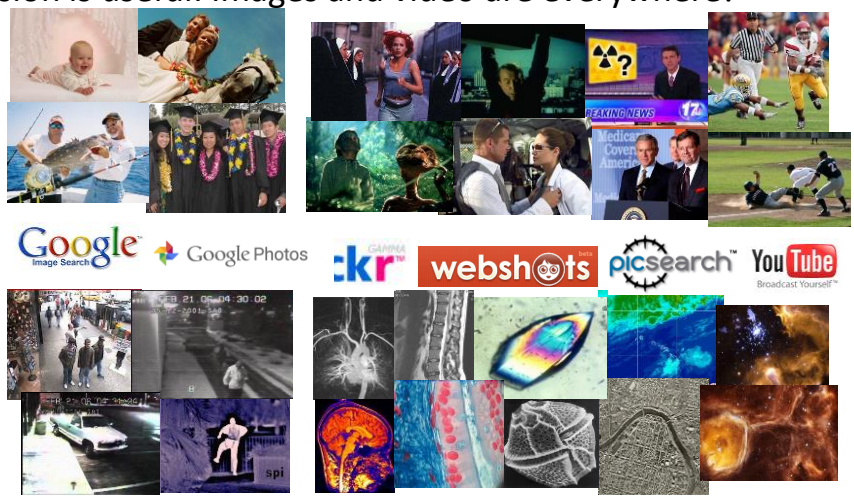
Most active topics of research in computer vision



28

Why study computer vision?

- Vision is useful: Images and video are everywhere!



Surveillance and security

Medical and scientific images

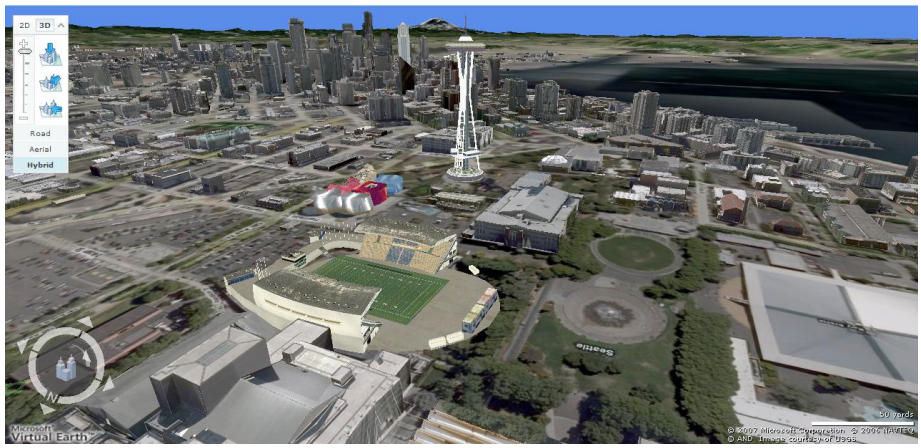
29

Special effects: shape and motion capture

Source: S. Seitz

30

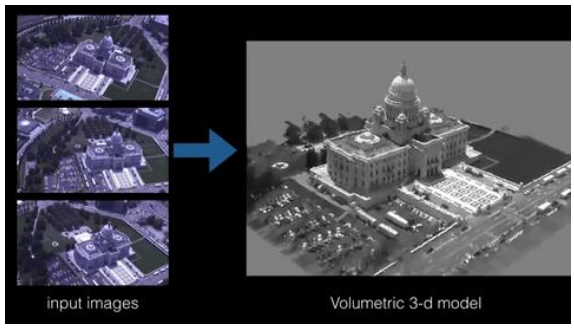
3D urban modeling

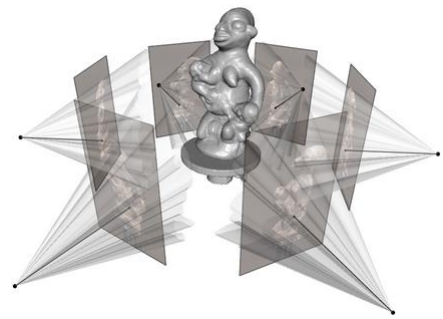


Bing maps, Google Streetview

31

3D modeling





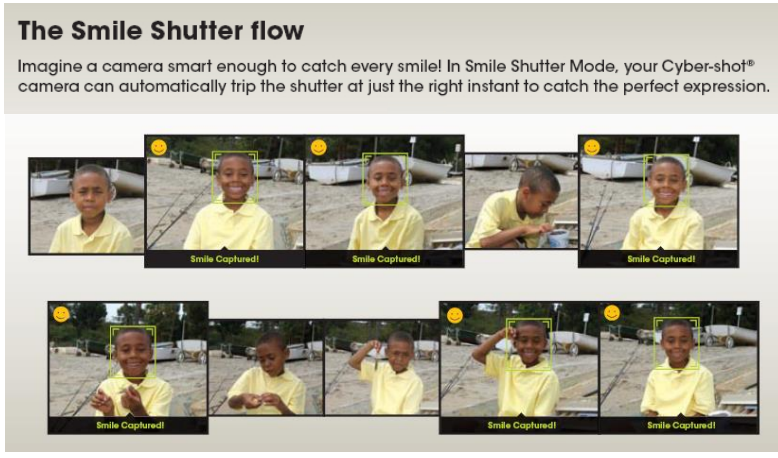
32

Face detection

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

33

Smile detection



Sony Cyber-shot® T70 Digital Still Camera

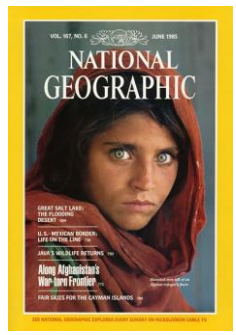
34

Face recognition: Apple iPhoto software

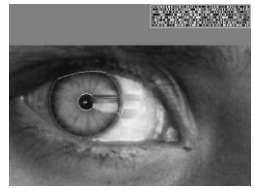
http://www.apple.com/ilife/iphoto/

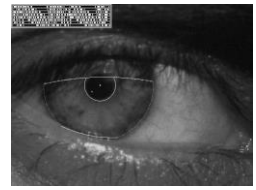
35

Biometrics



How the Afghan Girl was Identified by Her Iris Patterns





Source: S. Seitz

36

Biometrics

Fingerprint scanners on many new laptops, other devices

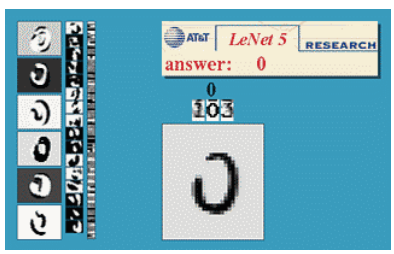
Face recognition systems now beginning to appear more widely
iphone X just introduced face recognition

37

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

38

Google maps: Annotate all houses and streets

Avenue des Sapins

Goodfellow et al. 2014

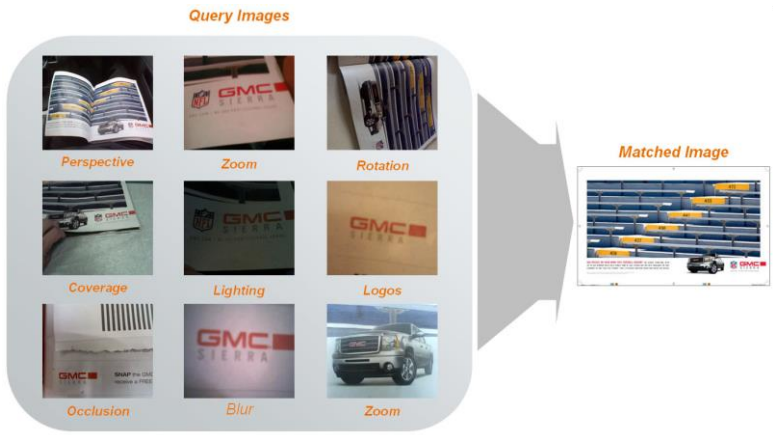
39

Toys and Robots

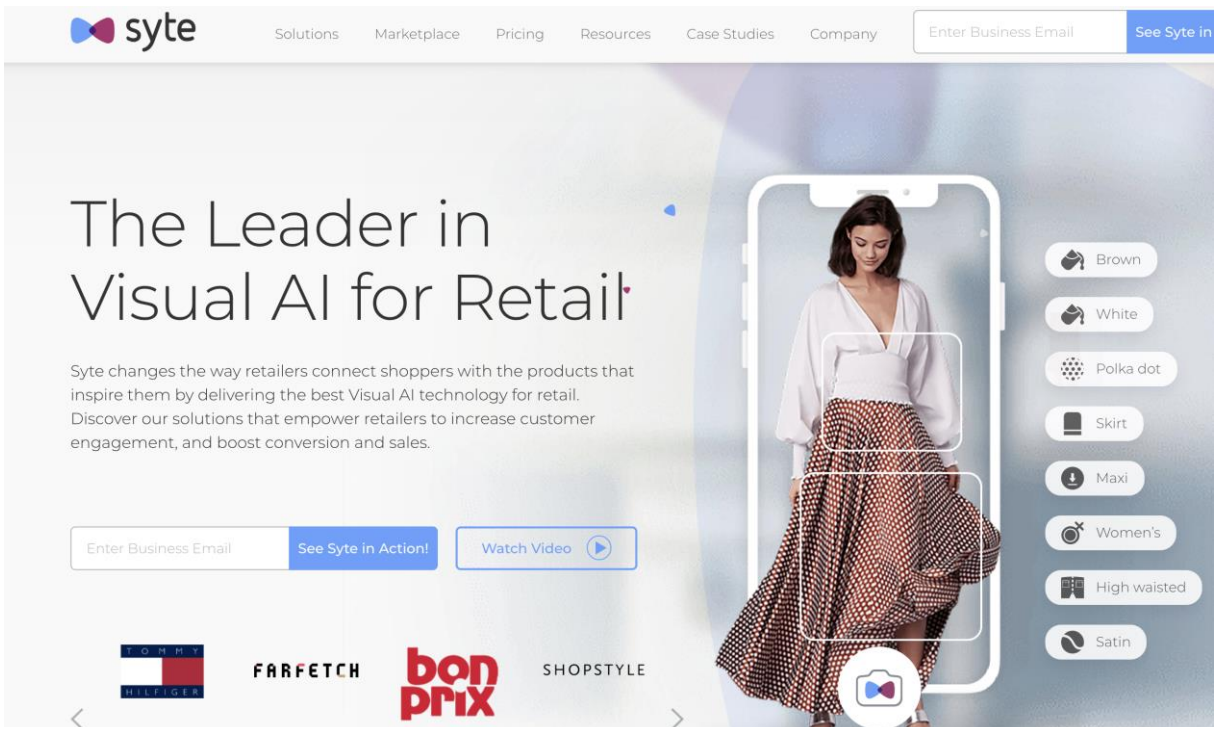
40

Mobile visual search: iPhone Apps

snaptell kooaba

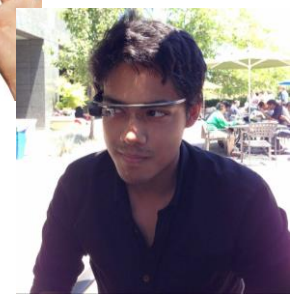


41



42

Snapstacles and Google glasses



- That's Ranjay in undergrad ->

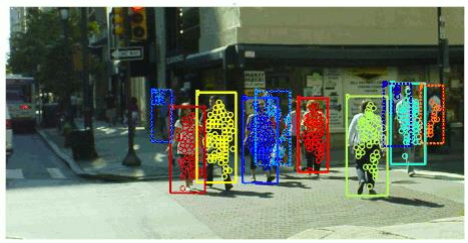
43

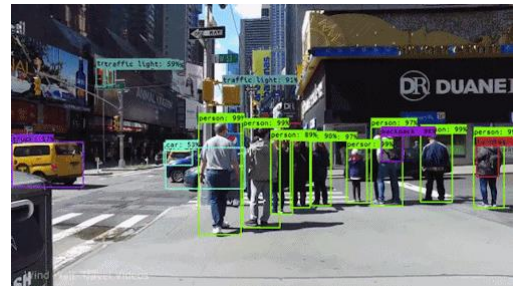
Automotive safety

- Mobileye

44

Detection and tracking





45

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… "

46

Amazon Go

47

Vision-based interaction (and games)

Microsoft's Kinect

Sony EyeToy

Assistive technologies

48

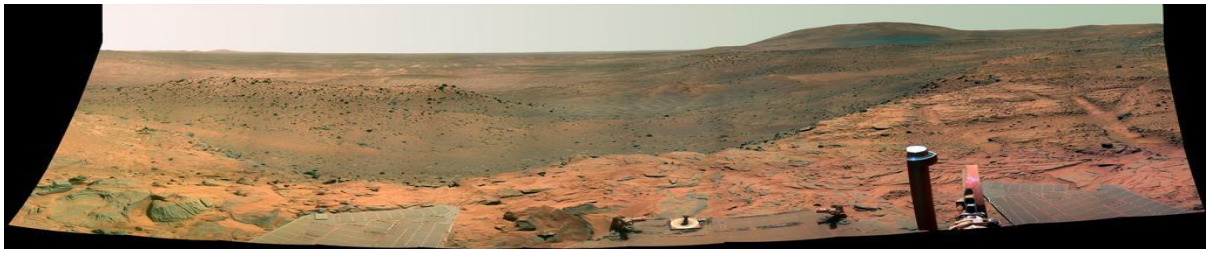
Augmented Reality

49

Virtual Reality

50

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.

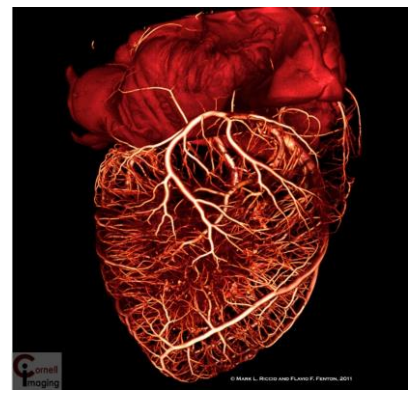
Vision systems (JPL) used for several tasks

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

Source: S. Seitz

51

Medical image recognition



52

Vision for meteorology

53

Course Overview

54

Syllabus organized from

- **CS131 Computer Vision: Foundations and Applications**

  http://vision.stanford.edu/teaching/cs131_fall1920/index.html
- **CS231A: Computer Vision, From 3D Reconstruction to Recognition**

  http://web.stanford.edu/class/cs231a/
- **CS 543/ECE 549: Computer Vision** http://slazebni.cs.illinois.edu/spring19/
- **CS 376: Computer Vision** http://vision.cs.utexas.edu/376-spring2018/

55

Grading policy

- Attendance: 10%
- Homework 1: 15%
- Homework 2: 15%
- Classroom test(open-book): 60%

56

Why should you take the class?

- Become a vision researcher
  - CVPR 2020 conference
  - ICCV 2020 conference
- Become a vision engineer in industry
  - Perception team at Google AI
  - Vision at Google Cloud
  - Vision at Facebook AI
  - Vision at SenseTime
  - Vision at MEGVII
  - Vision at Tencent AI Lab
- General interest

58

Overall Philosophy

Breadth

- Computer vision is a huge field
- It can impact every aspect of life and society
- It will drive the next information and AI revolution
- Pixels are everywhere in our lives and cyber space
- This course is meant as an broad overview course, we will not cover all topics of CV
- Lectures are mixture of detailed techniques and high level ideas
- Speak our “language”

Depth

- Computer vision is a highly technical field, i.e. know your math!
- Master bread-and-butter techniques: face recognition, corners, lines, features, optical flows, clustering and segmentation

59

Roadmap

Machine Vision Technology							
Semantic information					**Metric 3D information**		
Pixels	Segments	Images	Videos		Camera		Multi-view Geometry	
Convolutions Edges & Fitting Local features Texture	Segmentation Clustering	Recognition Detection	Motion Tracking		Camera Model	Camera Calibration	Epipolar Geometry	SFM
10	4	4	2		2	2	2	2

60