Lecture : 01

Computer Vision: Algorithms and Applications

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Course Syllabus

- Introduction.
- Image Morphology.
- Image Segmentation & Color Spaces.
- Feature Detection.
- Feature Matching.
- Image Clustering.
- Image Classification.
- Face Detection & Recognition.
- Image Stitching.
- Scene Detection.
- Video Shot Detection.
- Object Tracking.

Chapter 1: Introduction

1.1 What is computer vision?

- As humans, we perceive the three-dimensional structure of the world around us with apparent ease.

- Think of how vivid the three-dimensional percept is when you look at a vase of flowers sitting on the table next to you.

- You can tell the shape and translucency of each petal through the subtle patterns of light and shading that play across its surface and effortlessly segment each flower from the background of the scene (Figure 1.1).

Figure 1.1 The human visual system has no problem interpreting the subtle variations in translucency and shading in this photograph and correctly segmenting the object from its background.

Computer Vision

- What are examples of computer vision being used in the world?

Cont..

Computer Vision

Make computers understand
images and video.

What kind of scene?

What includes in the image?

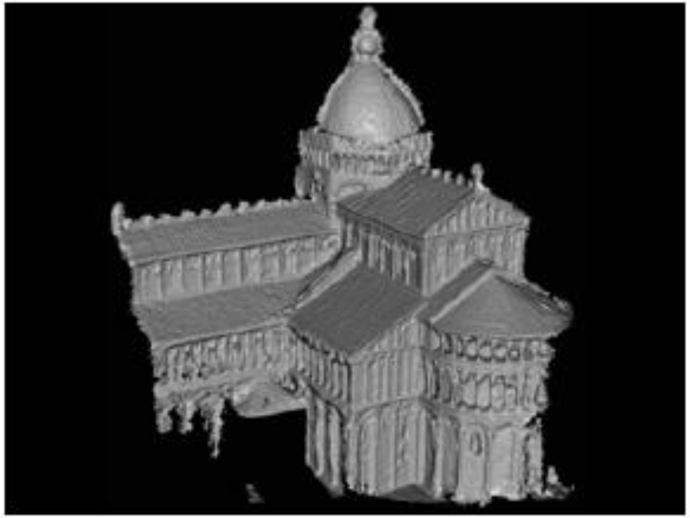
Where are the cars?

How far is the building?

…

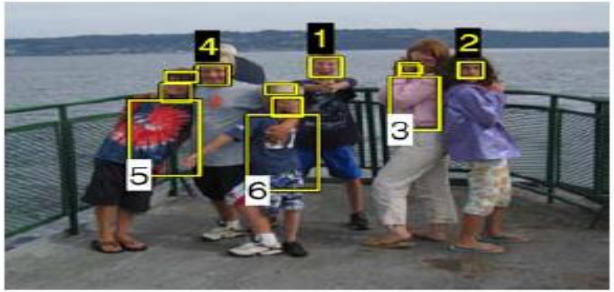
Researchers in computer vision have been developing, in parallel, mathematical techniques for recovering the three-dimensional shape and appearance of objects in imagery. We now have reliable techniques for accurately computing a partial 3D model of an environment from thousands of partially overlapping photographs.

Given a large enough set of views of a particular object or facade, we can create accurate dense 3D surface models using stereo matching



We can track a person moving against a complex Background as you can see in this fig.

We can even, with moderate success, attempt to find and name all of the people in a photograph using a combination of face, clothing, and hair detection and recognition as you can see in this fig.



Why is vision so difficult?

Cont..

Computer Vision

- The part of the human brain devoted to **vision** is bigger than any other operations.
- Vision is an amazing action of **natural intelligence**.

Vision is really hard

"One picture is worth more than ten thousand words"

Why is this hard?

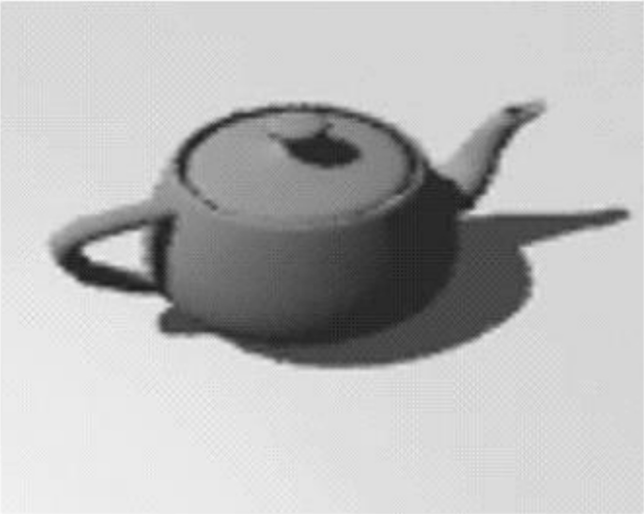
What is in this image?

1. A hand holding a man?
2. A hand holding a mirrored sphere?
3. An Escher drawing?
4. A 1935 self portrait of Escher

- Interpretations are ambiguous
- The forward problem (graphics) is well-posed
- The "inverse problem" (vision) is not

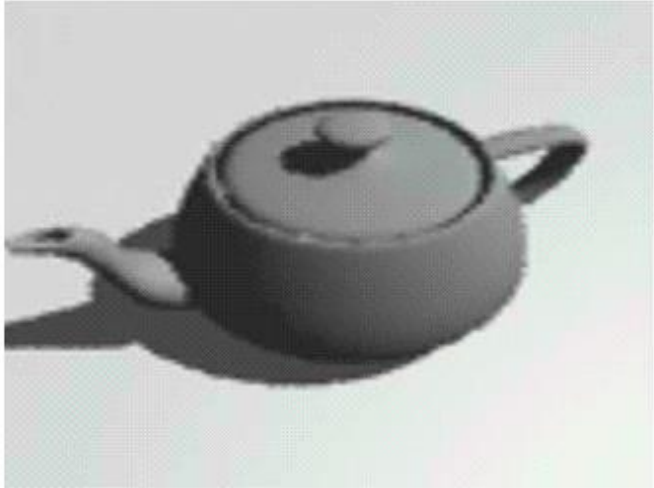
What do you see?

- Changing viewpoint
- Moving light source
- Deforming shape



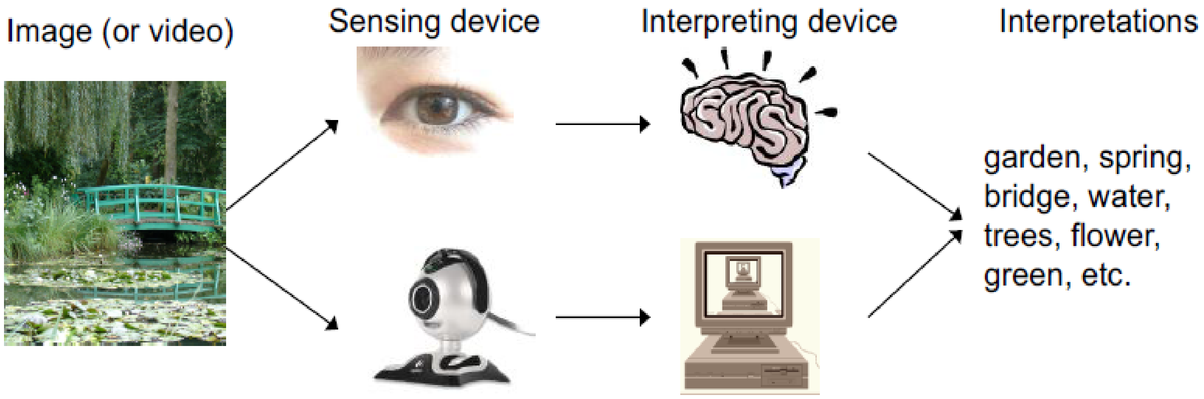
What was happening

- ☐ Changing viewpoint
- ☐ Moving light source
- ☑ Deforming shape

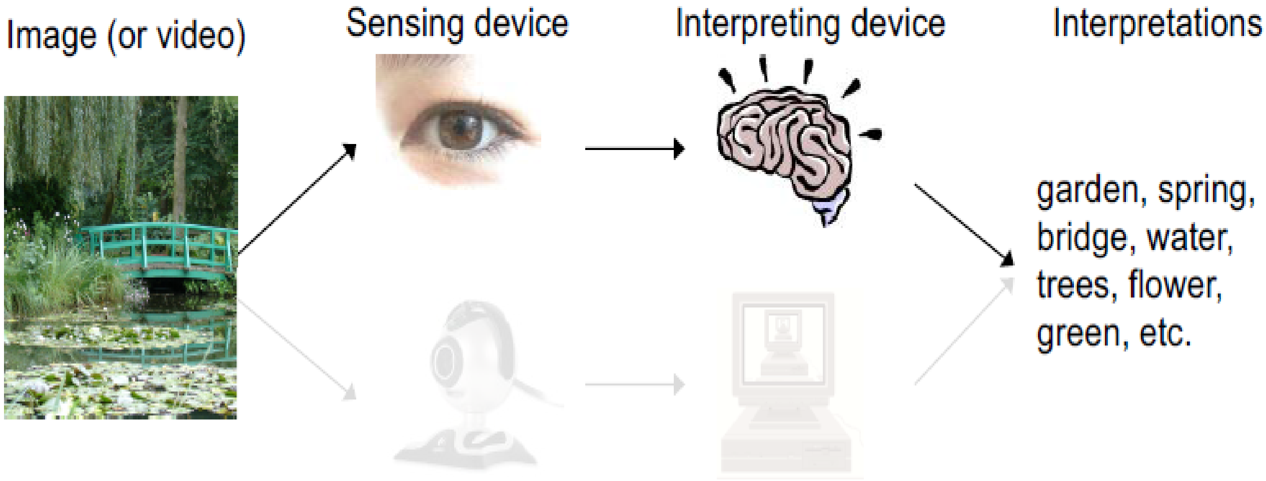


What is the Computer Vision

What is (computer) vision?



What is (computer) vision?



What is Computer Vision?

- Szeliski (Text): “In computer vision, we are trying to...describe the world that we see in one or more images and to reconstruct its properties.”
- Trucco and Verri (secondary text): Computing properties of the 3-D world from one or more digital images
- Sockman and Shapiro: To make useful decisions about real physical objects and scenes based on sensed images
- Ballard and Brown: The construction of explicit, meaningful description of physical objects from images.
- Forsyth and Ponce: Extracting descriptions of the world from pictures or sequences of pictures”

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

Question???

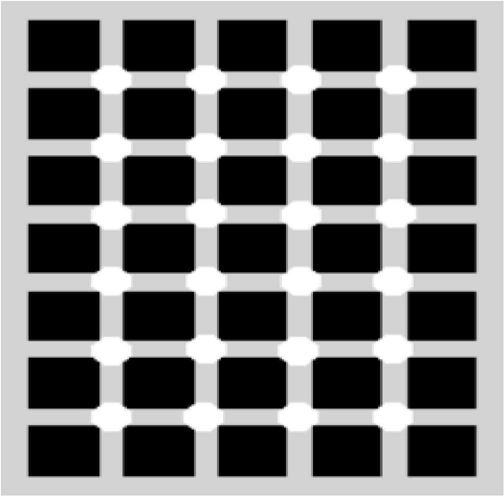
Should computer vision follow from our understanding of human vision?

Yes & No

1. Who would ever be crazy enough to even try creating machine vision?
2. Human vision "works", and copying is easier than creating.
3. Secondary benefit – in trying to mimic human vision, we learn about it.

1. Why limit oneself to human vision when there is even greater diversity in biological vision
2. Why limit oneself to biological when there may be greater diversity in sensing mechanism?
3. Biological vision systems evolved to provide functions for "specific" tasks and "specific" environments. These may differ for machine systems
4. Implementation – hardware is different, and synthetic vision systems may use different techniques/methodologies that are more appropriate to computational mechanisms

Hermann Grid

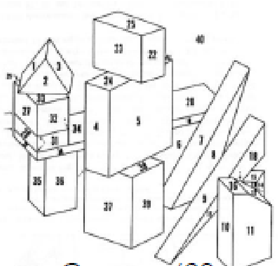


Scan your eyes over the figure. Do you see the gray spots at the intersections? Stare at one of them and it will disappear.

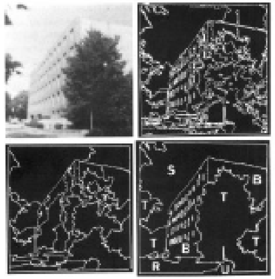
Why does this happen? Is it useful? Eye does not seem be acting like a camera an faith fully capturing scene?

Brief about Computer Vision

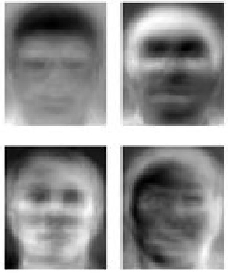
- 1960's: interpretation of artificial worlds
- 1970's: some progress on interpreting selected images
- 1980's: artificial neural networks (ANNs); shift toward geometry and increased mathematical model
- 1990's: face recognition; statistical analysis
- 2000's: broader recognition; large annotated datasets available; **video processing** starts
- 2030's: **robot revolution**



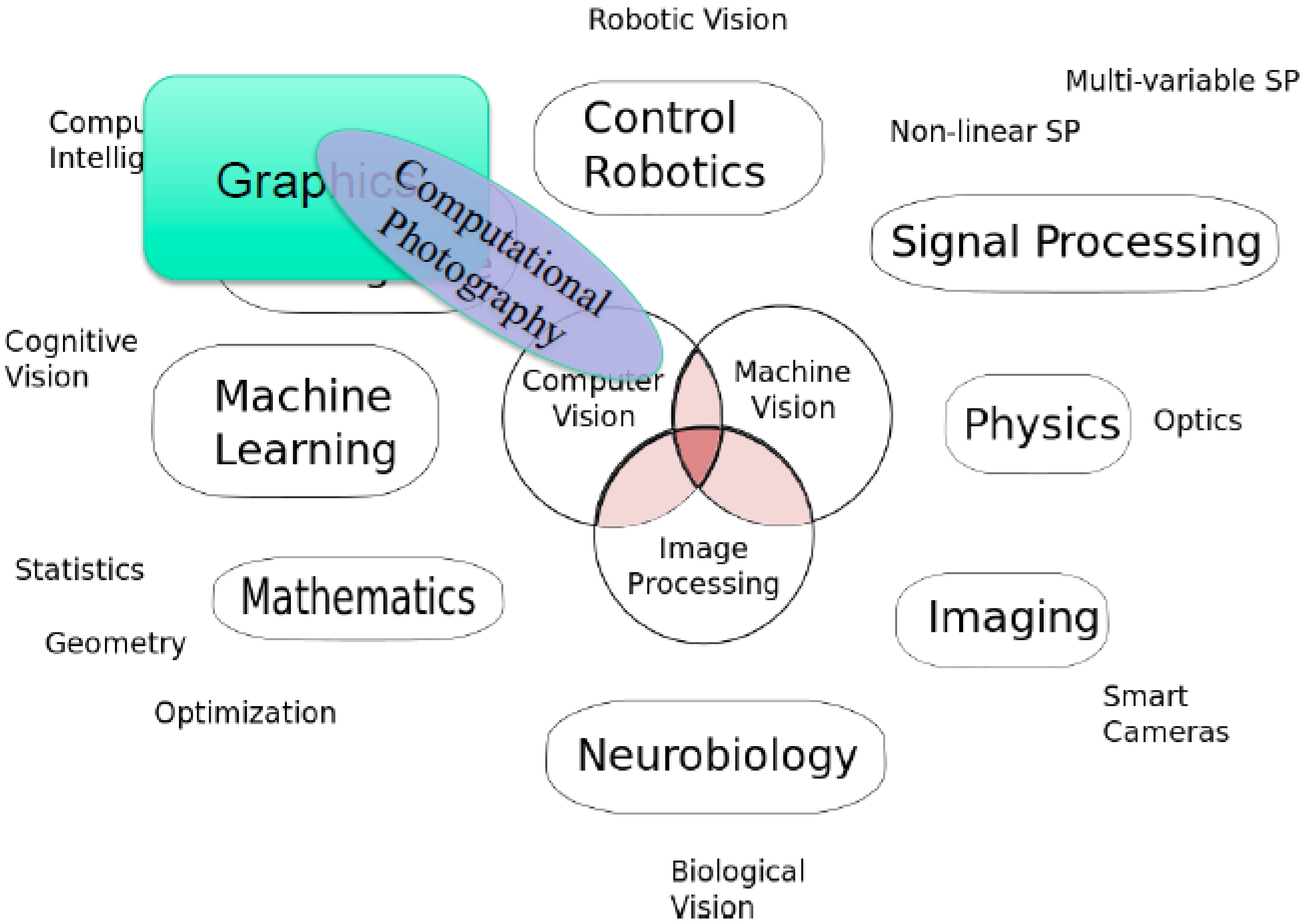
Guzman '68



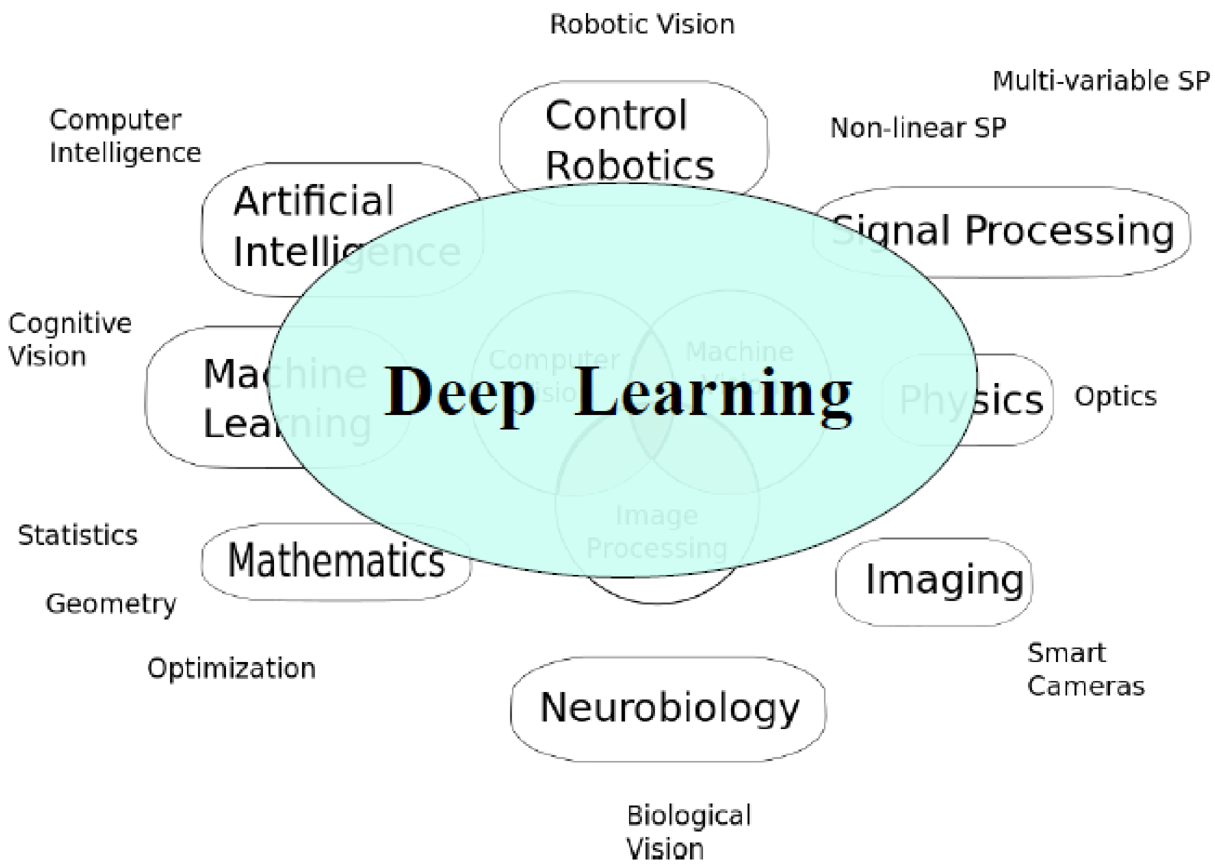
Ohta Kanade '78



Related Fields



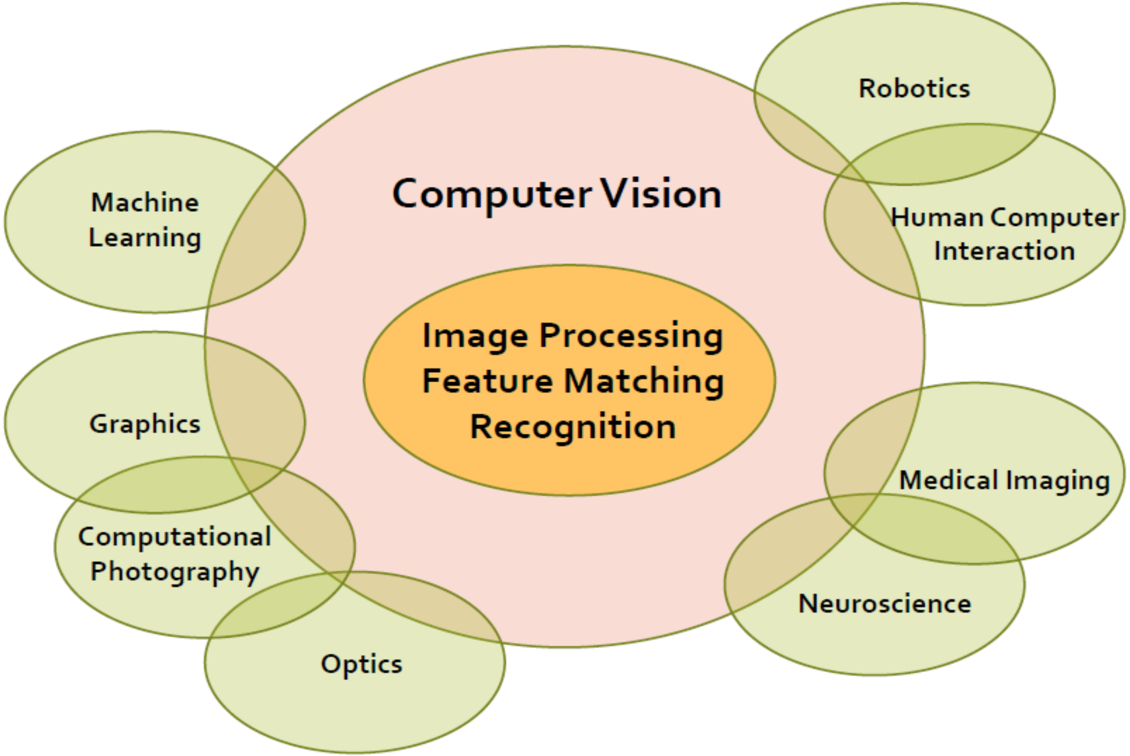
Related Fields



Computer Vision and Nearby Fields

- Computer Graphics: Models to Images
- Computer Photography: Images to Images
- Computer Vision: Images to Models

Computer Vision Applications



Computer Vision Applications

Safety

Health

Security

Comfort

Fun

Access

Applications: touching your life

- Optical Character Recognition
- Football
- Movies
- Surveillance
- HCI – hand gestures
- Aids to the blind
- Face recognition & biometrics
- Road monitoring
- Industrial inspection
- Virtual Earth; street view
- Robotic control
- Autonomous driving
- Space: planetary exploration, docking
- Medicine – pathology, surgery, diagnosis
- Microscopy
- Military
- Remote Sensing
- Digital photography
- Google Goggles
- Video games

Examples of state-of-the-art
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
http://www.research.att.com/~yann/

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

Examples of state-of-the-art
Face detection

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

Examples of state-of-the-art
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](#)

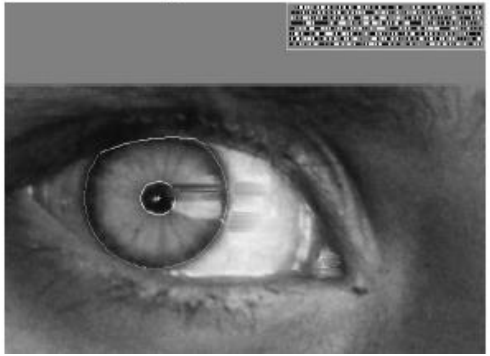
Examples of state-of-the-art
Object recognition (in supermarkets)

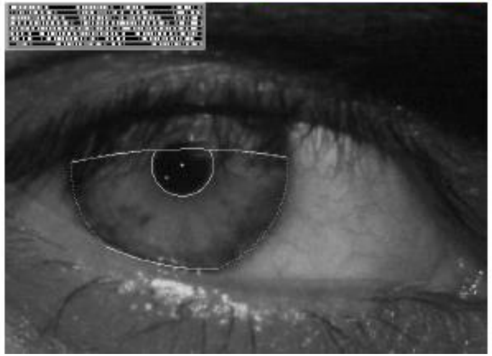
Lane Hawk by Evolution Robotics

"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 Lane Hawk, you are assured to get paid for it… "

Examples of state-of-the-art
Vision-based biometrics

“How the Afghan Girl was Identified by Her Iris Patterns” Read the story wikipedia





Examples of state-of-the-art
Login with your biometrics

Fingerprint scanners on many new laptops, other devices

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

Examples of state-of-the-art
Object recognition

Examples of state-of-the-art
Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Examples of state-of-the-art
Sports

Sports vision explanation on

http://www.sportvision.com/video.html

Examples of state-of-the-art
Smart cars

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

Examples of state-of-the-art
Google cars

Oct 9, 2010. "Google Cars Drive Themselves, in Traffic". *The New York Times*. John Markoff

Aug 9, 2011, "Human error blamed after Google's driverless car sparks five-vehicle crash". *The Star* (Toronto)

Examples of state-of-the-art
Vision in space

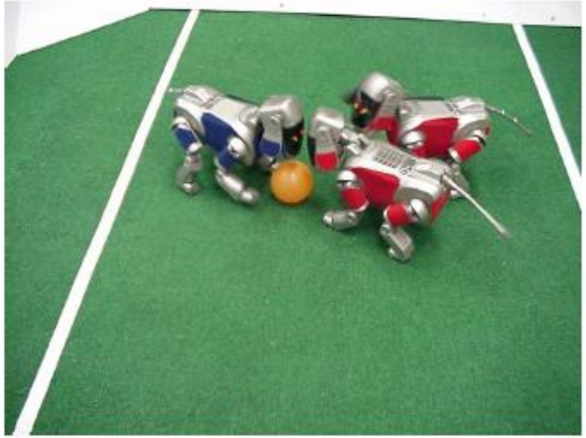
NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Vision systems used for several tasks

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

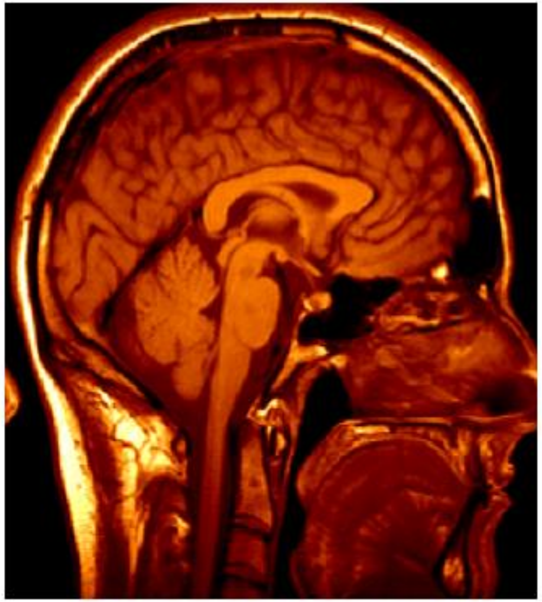
Examples of state-of-the-art
Robots

NASA's Mars Spirit Rover
http://en.wikipedia.org/wiki/Spirit_rover



http://www.robocup.org/

Examples of state-of-the-art
Medical imaging

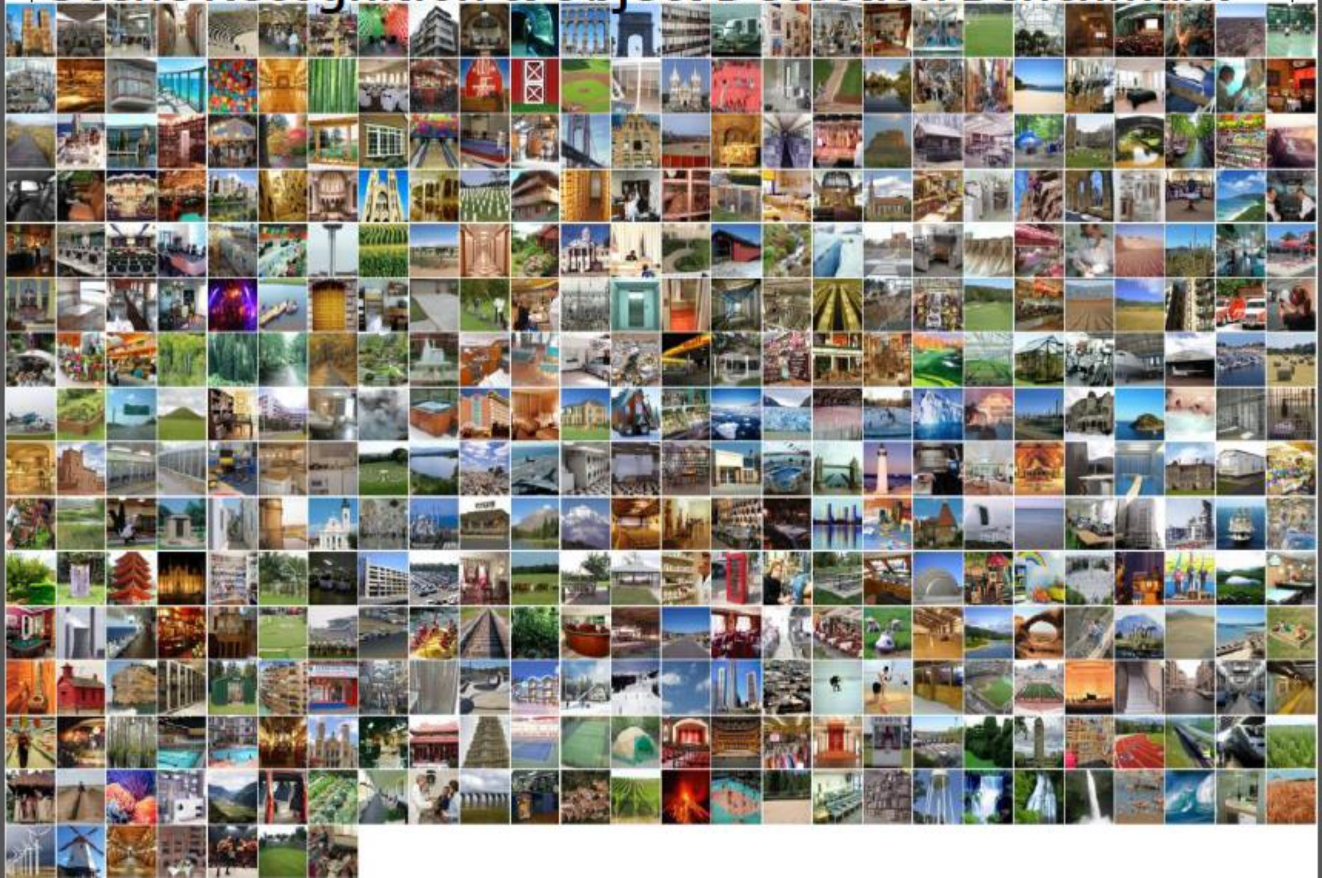


3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

SUN database

Scene Recognition & Object Detection Benchmark



Computer Vision & Image processing software

- CVIPtools (Computer Vision and Image Processing tools)
- Intel Open Computer Vision Library (OpenCV)
- Microsoft Vision SDL Library
- **Matlab**

- For more information, see
  - http://www.cs.unr.edu/~bebis/CS791E
  - http://www.cs.unr.edu/CRCD/ComputerVision/cv_resources.html

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How do we solve computer vision problems?

1. Build mathematical/physical model of the problem and implement algorithm with provably correct properties.
2. Craft a solution using software libraries of established methods and tailor them to the particulars of the problem.
3. Gather image data, potentially label it, and use machine learning to provide solution.

- In computer vision, we are trying to do the inverse, i.e., to describe the world that we see in one or more images and to reconstruct its properties, such as shape, illumination, and color distributions.

- It is amazing that humans and animals do this so effortlessly, while computer vision algorithms are so error prone.

- People who have not worked in the field often underestimate the difficulty of the problem.

Aim of our Research Group:

The aim of our Scientific Innovation research Group (SIRG) to evaluate the IOT performance by propose a secure architecture for the IoT security issues for Education.

Thank you