



# Computer Vision: Algorithms and Applications



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# Course Syllabus

2

- **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

3



- 1.1 What is computer vision? ..... 3
- 1.2 A brief history ..... 10
- 1.3 Book overview ..... 19
- 1.4 Sample syllabus ..... 26
- 1.5 A note on notation ..... 27
- 1.6 Additional reading ..... 28

# 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..

7

# Computer Vision

**Make computers understand  
images and video.**



What kind of scene?

What includes in the image?

Where are the cars?

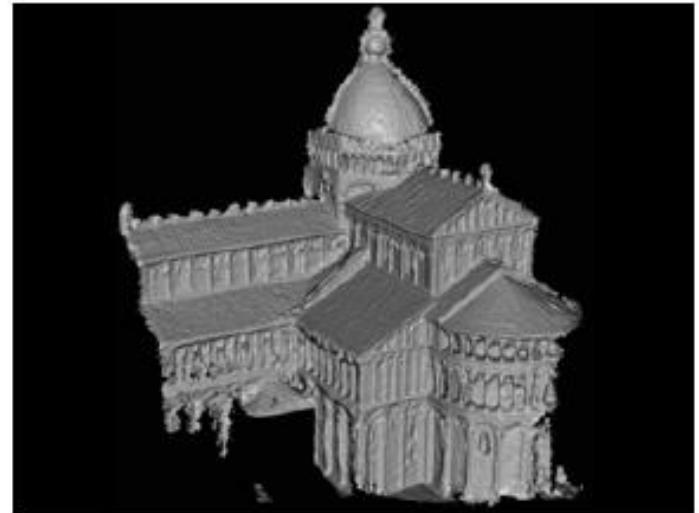
How far is the building?

...

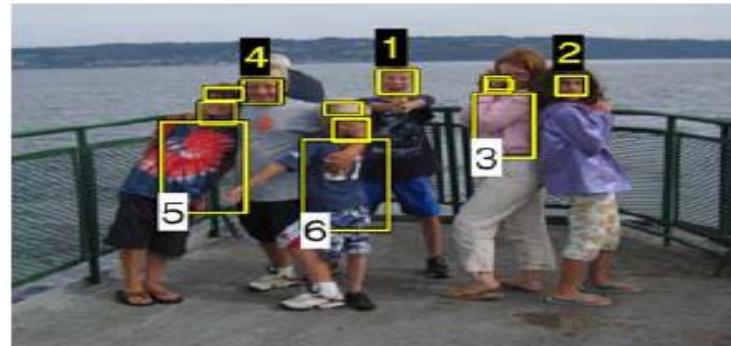
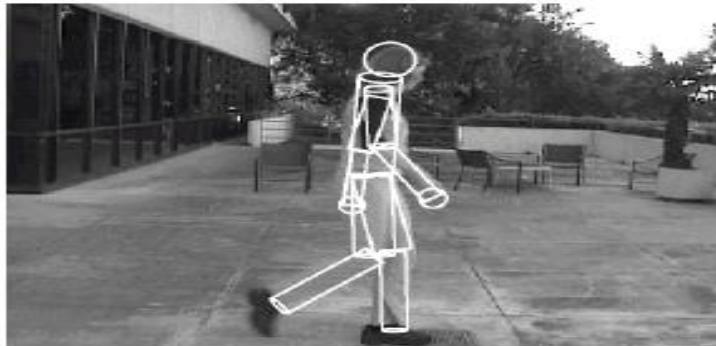
- Researchers in computer vision have been developing, in **parallel, mathematical techniques** for recovering the three-dimensional shape and appearance of objects in imagery.
- We now have reliable techniques for accurately computing a partial 3D model of an environment from thousands of partially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

12

## 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?



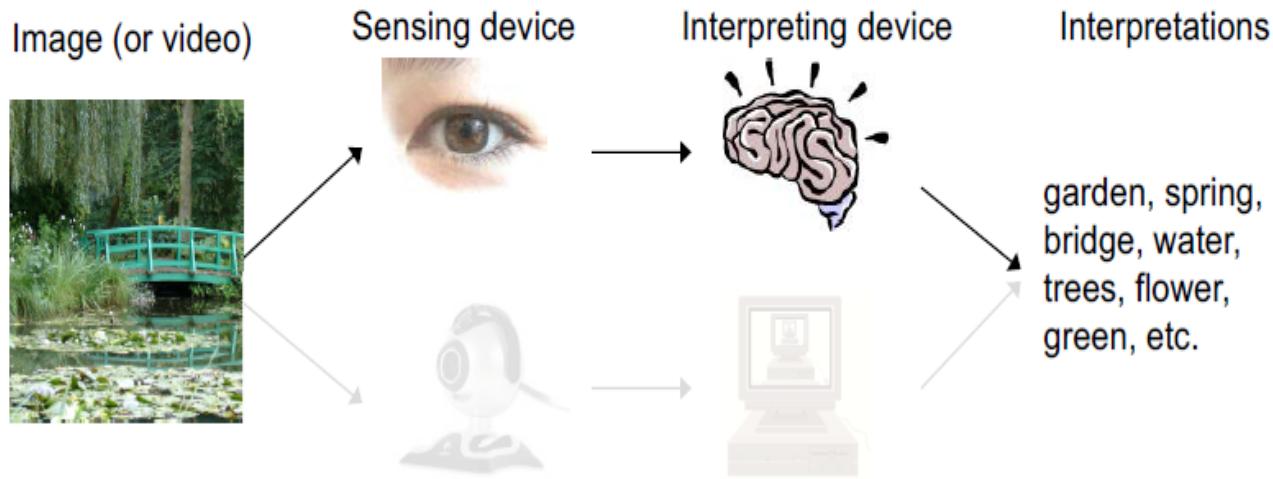
What is in this image?

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

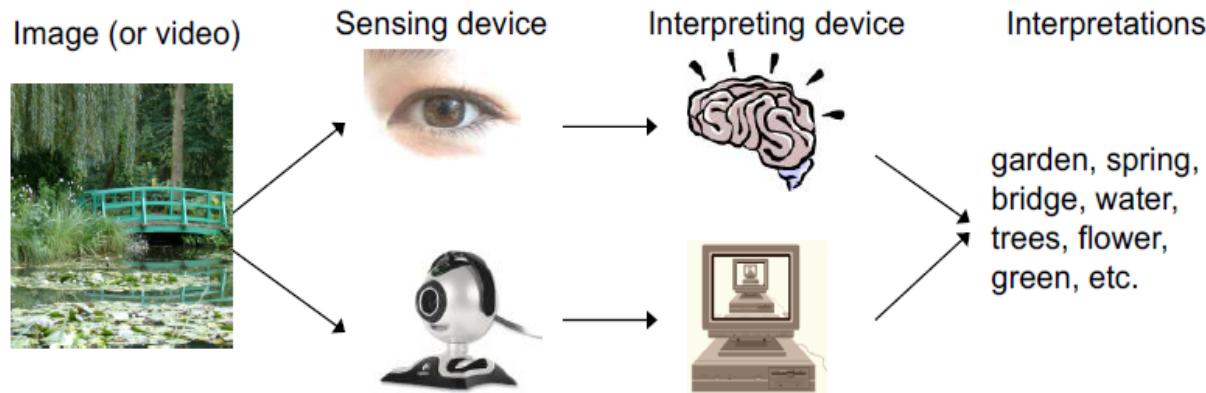
- Interpretations are ambiguous
- The forward problem (graphics) is well-posed
- The “inverse problem” (vision) is not

# What is the Computer Vision

# What is (human) 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”



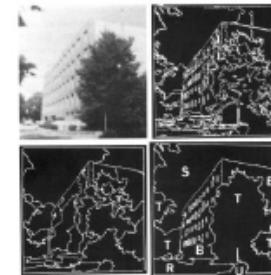
What we see

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

# Brief about Computer Vision

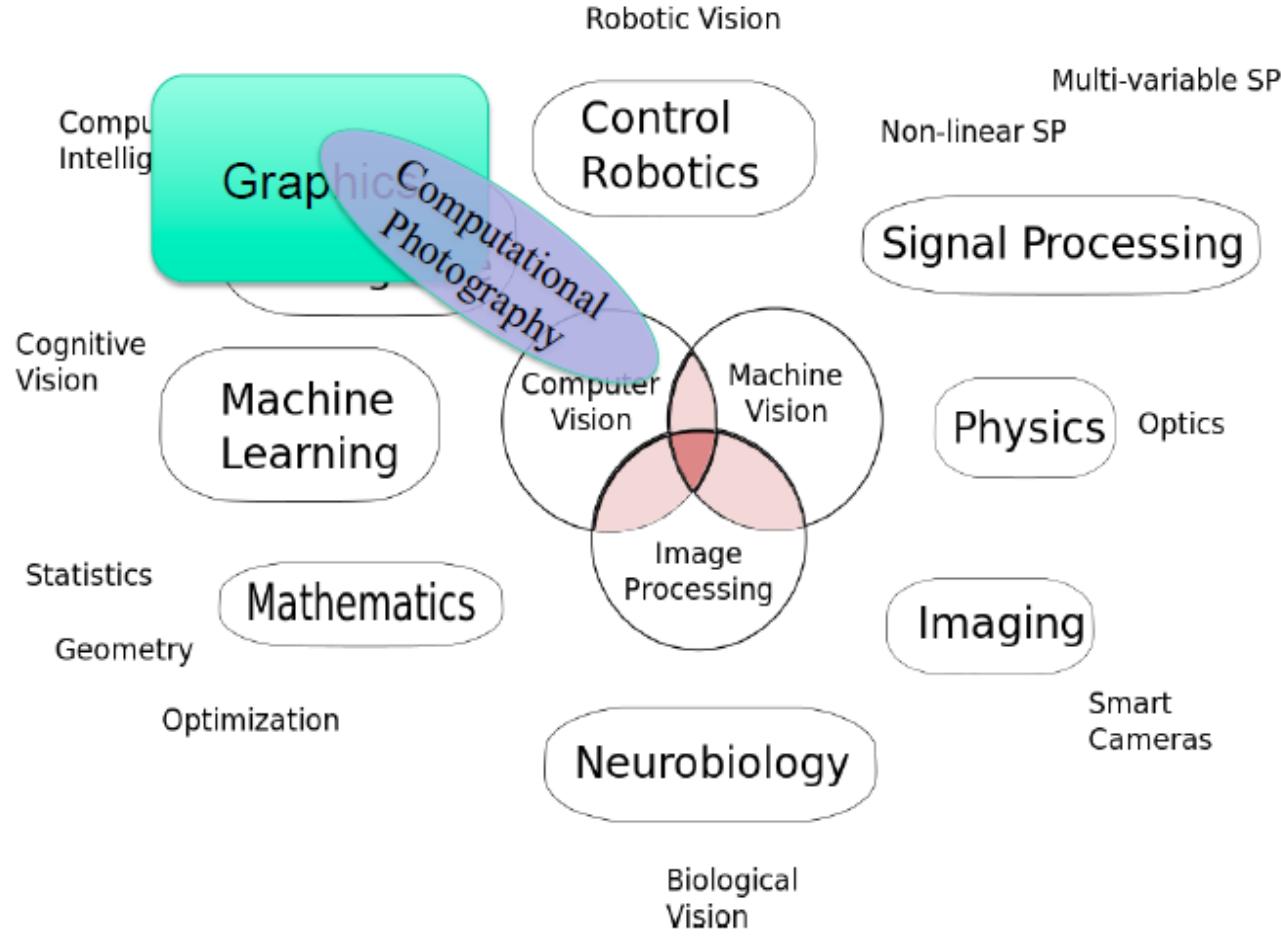
- 1960's: interpretation of artificial worlds
- 1970's: some progress on interpreting selected images
- 1980's: artificial neural networks (ANNs); shift toward geometry and increased mathematical model
- 1990's: face recognition; statistical analysis
- 2000's: broader recognition; large annotated datasets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



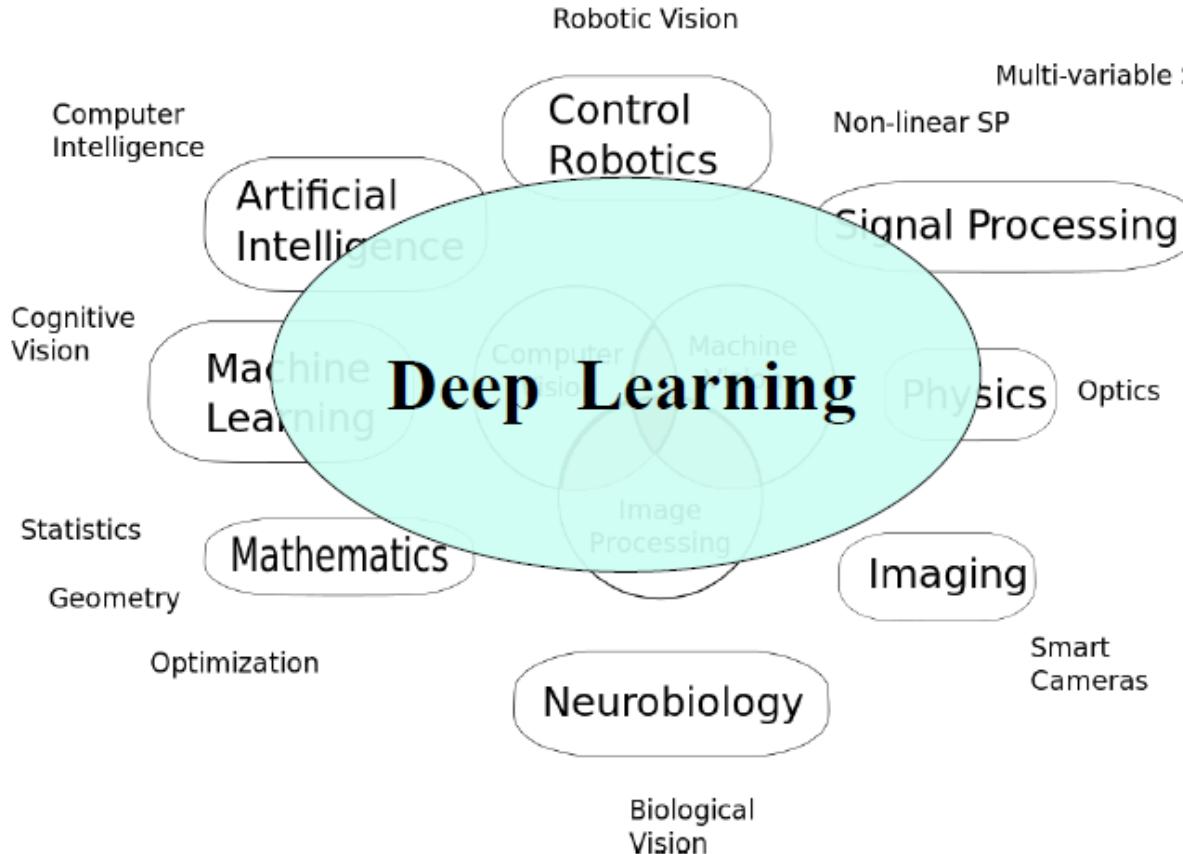
Ohta Kanade '78



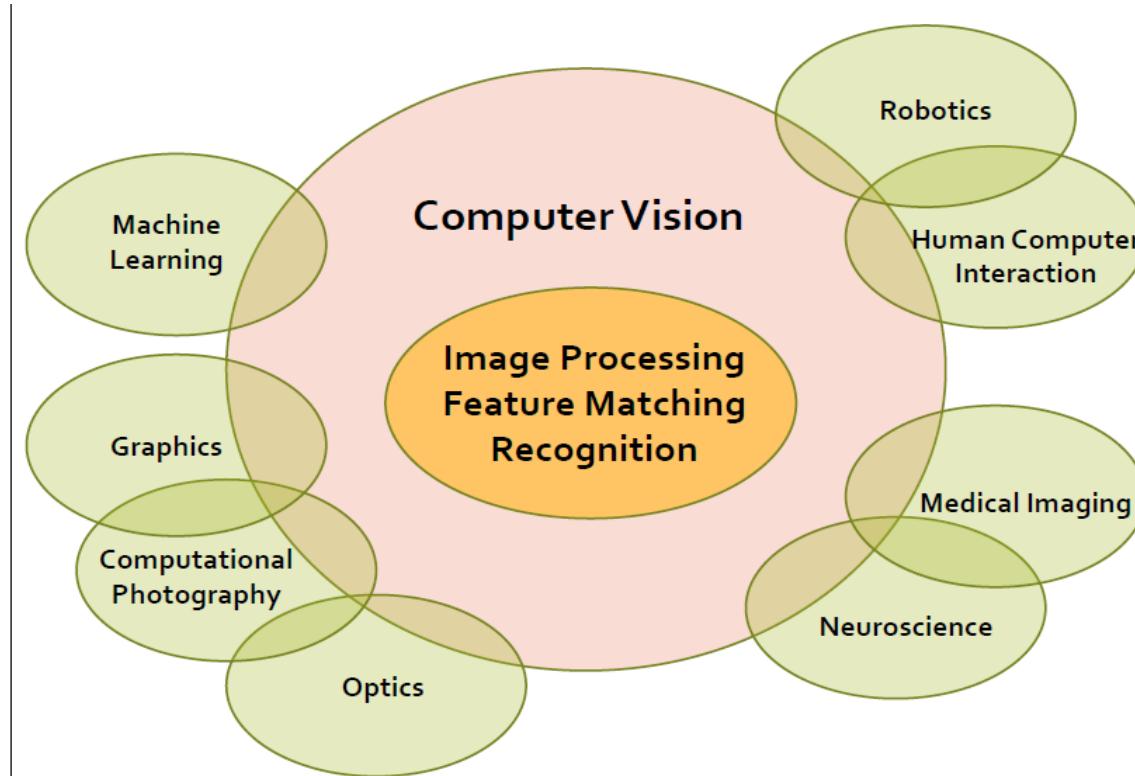
## Related Fields



# Related Fields



# Computer Vision Applications

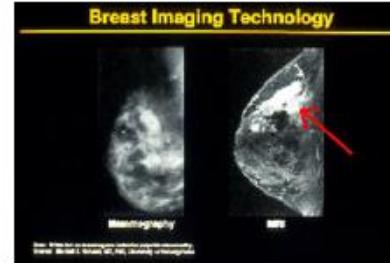


# Computer Vision Applications

23



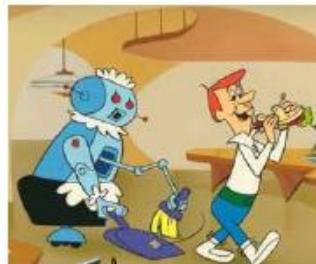
Safety



Health



Security



Comfort



Fun



Access

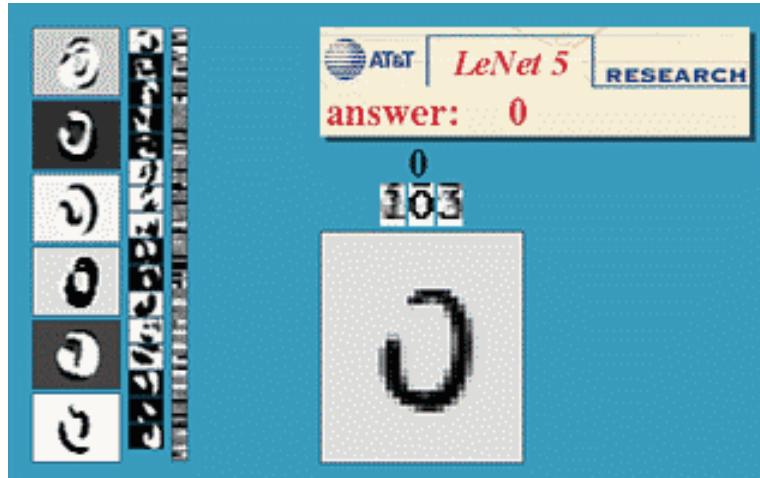
# Applications: touching your life

- 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\\_recognition](http://en.wikipedia.org/wiki/Automatic_number_plate_recognition)

# 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)



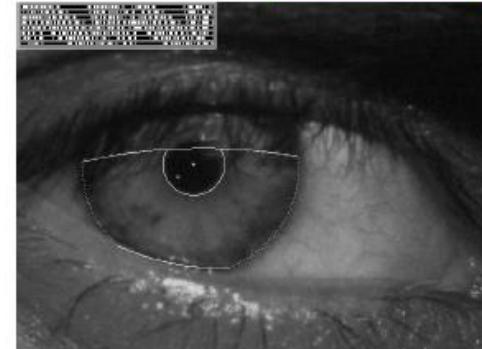
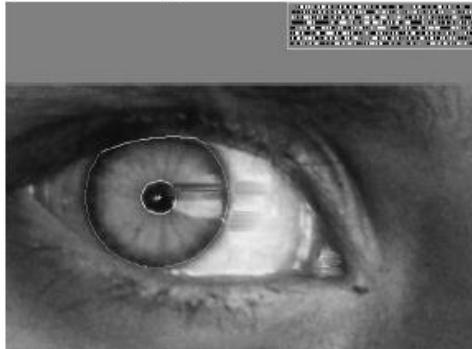
## Lane Hawk by Evolution Robotics

“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



The Space Needle is the Pacific Northwest's most recognizable landmark and is the symbol of the U.S. city of Seattle, Washington. Located on the grounds of Seattle Center, it was built for the 1962 World's Fair, during which time nearly 25,000 people a day used the elevator — 2.3 million visitors in all for the World Fair. It is now privately owned. The Space Needle is a tower 184 m (602 feet) high and 42 m (138 feet) wide at its widest point and weighs 9,551 tons. It is built to withstand winds of up to 203 km/h (125 mph) and earthquakes up to 9.1 magnitude. New 25 lighting rods on the roof to activate lightning strikes.

# 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

34

► manufacturer products      consumer products ◀◀

## Our Vision. Your Safety.



rear looking camera      forward looking camera      side looking camera

**EyeQ** Vision on a Chip



> read more

**Vision Applications**



Road, Vehicle, Pedestrian Protection and more

> read more

**AWS** Advance Warning System



> read more

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

> all news



Events

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

> read more

- Mobileye

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

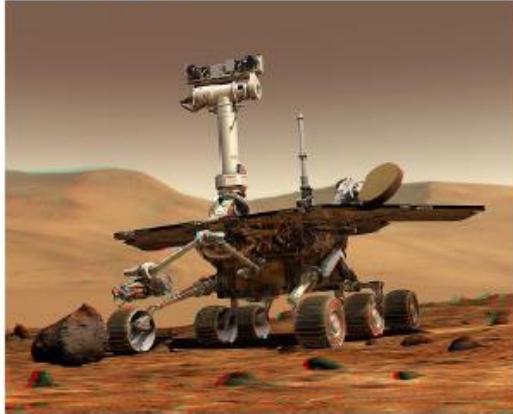
# Examples of state-of-the-art Google cars



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 Robots



NASA's Mars Spirit Rover

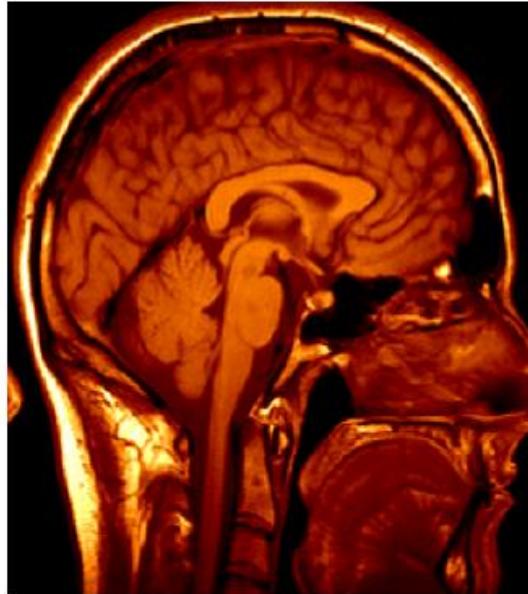
[http://en.wikipedia.org/wiki/Spirit\\_rover](http://en.wikipedia.org/wiki/Spirit_rover)



<http://www.robocup.org/>



# Examples of state-of-the-art Medical imaging



3D imaging  
MRI, CT

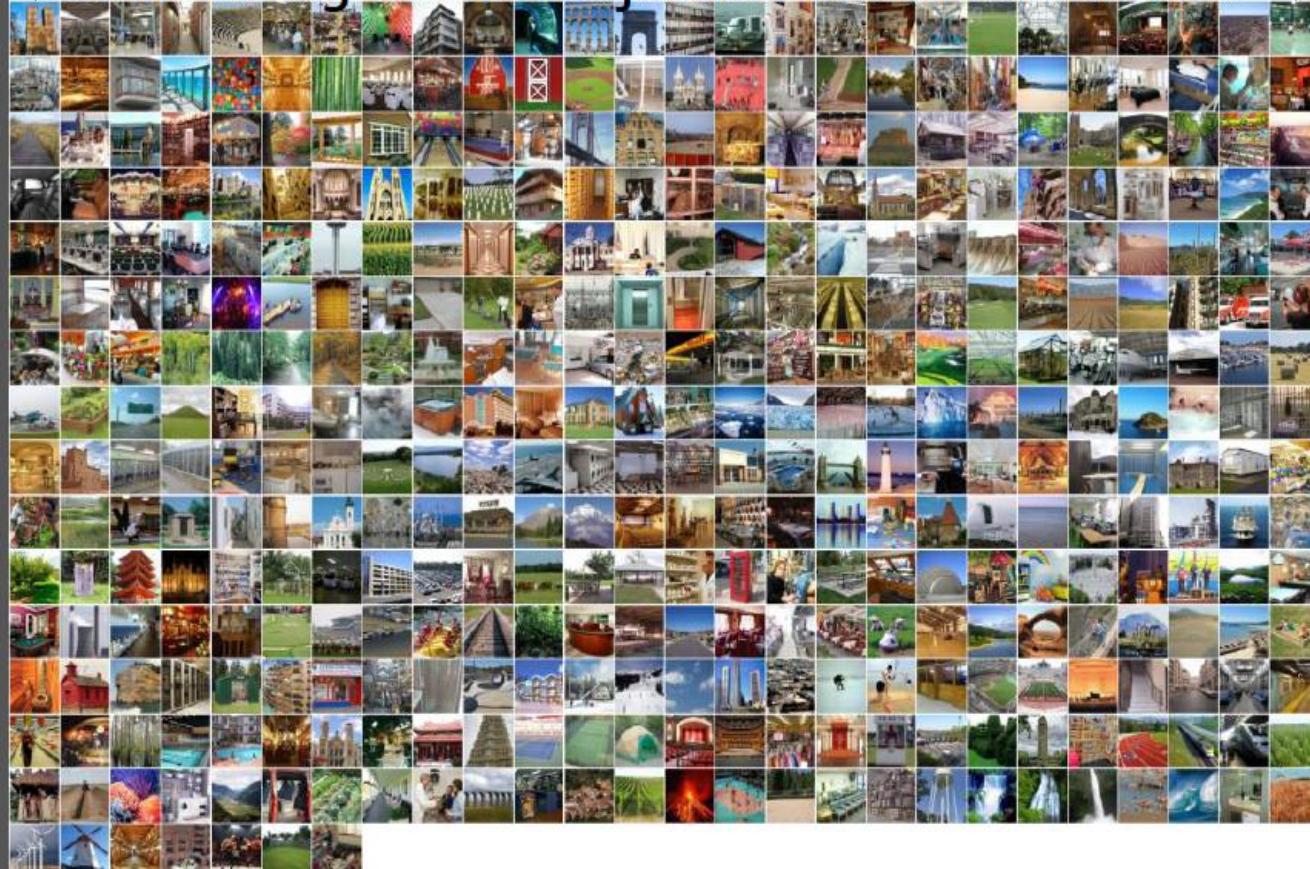


Image guided surgery  
Grimson et al., MIT



# 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](http://www.cs.unr.edu/CRCD/ComputerVision/cv_resources.html)

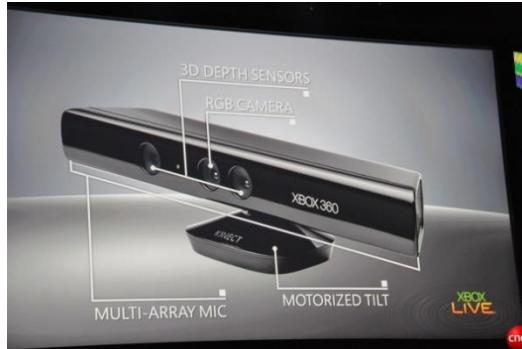
## How do we solve computer vision problems?

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.

# Interactive Games: Kinect

- Object Recognition: <http://www.youtube.com/watch?feature=iv&v=fQ59dXOo63o>
- Mario: <http://www.youtube.com/watch?v=8CTJL5IUjHg>
- 3D: <http://www.youtube.com/watch?v=7QrnwoO1-8A>
- Robot: <http://www.youtube.com/watch?v=w8BmgtMKFbY>



# 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 (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.



# Projects



- Hybrid images with Laplacian pyramids
- pB Lite: learning image boundaries
- Scene recognition with bag of words
- Face Detection
- Structure from Motion
- Your choice for final project

# Aim of our Research Group:

45

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.



# Thanks and Acknowledgement

46



# Thank you

