

# Computer Vision

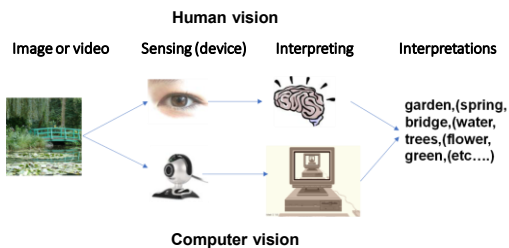
## Chapter 1: Introduction

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## Plan

- What is computer vision?
  - Concepts and definitions
  - Levels of vision (Low level vision, Middle level vision, High level vision)
- Related fields
- Applications areas

## What is computer vision?



From CS131 course "computer vision",  
 Prof. Fei-Fei Li, Stanford "Vision" Lab

## The goal of computer vision

- To bridge the gap between pixels and "meaning"



What we see

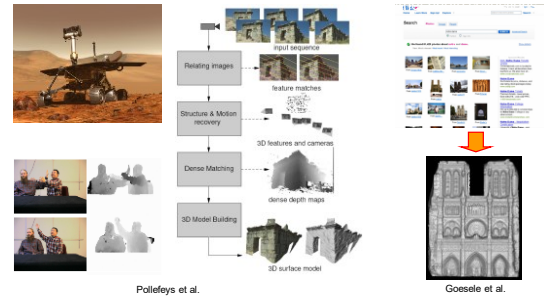
|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| 9 | 3 | 2 | 5 | 4 | 7 | 5 | 9 | 8 |
| 3 | 0 | 1 | 2 | 3 | 4 | 5 | 8 | 7 |
| 2 | 1 | 0 | 3 | 2 | 5 | 4 | 7 | 6 |
| 5 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| 4 | 3 | 2 | 1 | 0 | 3 | 2 | 5 | 4 |
| 7 | 4 | 5 | 2 | 3 | 0 | 1 | 2 | 3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

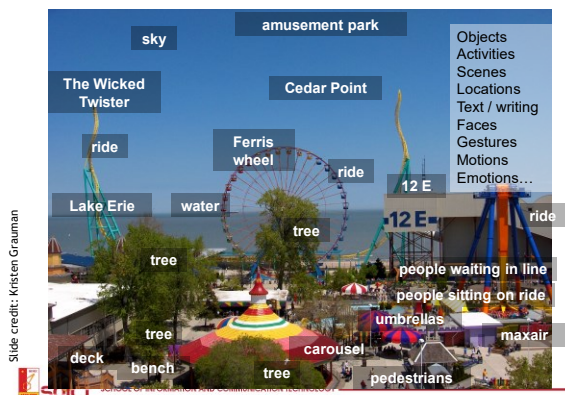
## What kind of information can we extract from an image?

- Metric 3D information
- Semantic information

## Vision as measurement device



## Vision as a source of semantic information



## What is computer vision?

- Computer vision
  - Is an **interdisciplinary scientific field** that deals with how computers can be made to gain **high-level understanding** from digital images or videos.
  - From the perspective of engineering, it seeks to automate tasks that the human visual system can do.
- Computer vision tasks include
  - methods for **acquiring, processing, analyzing and understanding** digital images,
  - and **extraction of high-dimensional data from the real world** in order to produce numerical or symbolic information, e.g., in the forms of decisions. (*Wikipedia*).

## What is computer vision?

- The two definitions of CV can be defined as a scientific field that extracts information out of digital images.
- Another way to define CV is through its applications.
  - Computer vision is building algorithms that can understand the content of images and use it for other application [3].



What kind of scene?  
Where are the cars?  
How far is the building?  
...



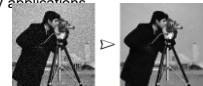
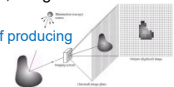
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## What is computer vision?

### Levels of vision

- **Low-level Vision:** Image Formation, Acquisition, Image Processing
  - **Image formation** studies the **forward process of producing images** and videos
  - **Image acquisition:**
    - A digital image is produced by several **image sensors**.
    - Depending on the type of sensor, the resulting **image data** is an ordinary 2D image, a 3D volume, or an image sequence.
  - **Image processing** focuses on 2D image data processing using **point operators** such as contrast enhancement, filtering (local operations), noise reduction, **image transforms**. Image processing is considered as pre-processing that is usually necessary to process the image data for CV applications.
    - Work with image as a matrix
    - Input: image → output: image



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## What is computer vision?

### Levels of vision

- **Middle-level Vision:** Feature, Image matching
  - Feature extraction: Image features at various levels of complexity are extracted from the image data. Examples of such features: Edges, ridges, lines, texture, shape ...
  - Image matching
  - Image segmentation



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## 3D urban modeling



[Bing maps](#), Google Streetview

Source: S. Seitz



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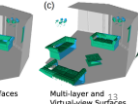
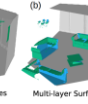
## What is computer vision?

### Levels of vision

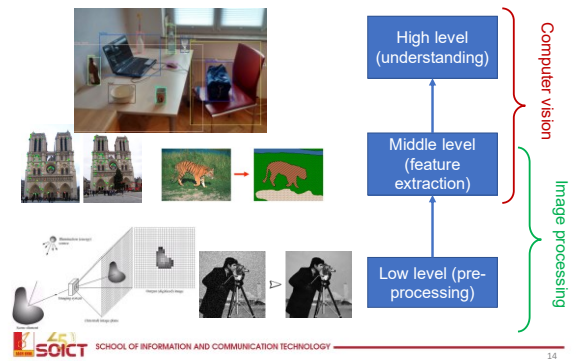
- **High-level Vision:** High-level vision is to infer the semantics, for example, object recognition and scene understanding.
- Several application topics:
  - Object recognition (classification), Identification
  - Detection
  - Motion analysis
  - Scene reconstruction; 3D reconstruction
  - Image-based rendering ....



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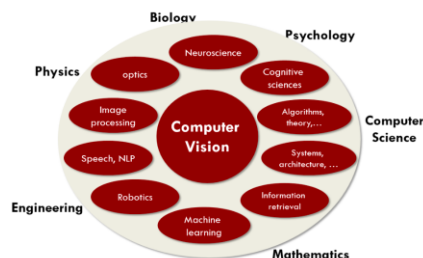
## Image processing vs. Computer vision



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## Related fields



Computer vision at the intersection of multiple scientific fields [3]

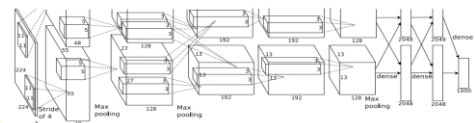


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## Related fields

- Machine Learning: "The field of study that gives computers the ability to learn without being explicitly programmed." – *Arthur Samuel*
- Artificial intelligence and computer vision share other topics such as pattern recognition and learning techniques.
- Computer vision - Deep learning: Artificial Neural Networks with many layers (CNN: Convolutional Neural Network )



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## Applications areas

### Robotics Application

- Localization-determine robot location automatically
- Navigation
- Obstacles avoidance
- Assembly peg – in – hole, welding, painting
- Manipulation e. g. PUMA robot manipulator
- Human Robot Interaction HRI: Intelligent robotics to interact with and serve people

## Applications areas

### Security Application

- Biometrics iris, fingerprint, face recognition
- Surveillance-detecting certain suspicious activities or behaviors



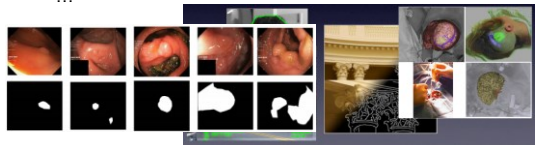
## Examples



## Applications areas

### Medicine Application

- Classification and detection e. g.
- 2D/3D segmentation
- 3D human organ reconstruction MRI or ultrasound
- Vision-guided robotics surgery



## Applications areas

### Industrial Automation Application

- Industrial inspection defect detection
- Barcode and package label reading
- Object sorting
- Document understanding e. g. OCR
- ...

### Transportation Application

- Autonomous vehicle
- Safety, e.g., driver vigilance monitoring
- ...

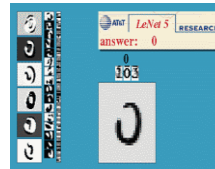


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## Examples

Optical character recognition (OCR)



Digit recognition, (AT&T labs)



License plate readers  
[http://en.wikipedia.org/wiki/Automatic\\_number\\_plate\\_recognition](http://en.wikipedia.org/wiki/Automatic_number_plate_recognition)

Source: from S. Seitz



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## Examples

- Autonomous vehicle



- **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.”



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