

HA NOI UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND COMMUNICATION TECHNOLOGY


Computer Vision

Chapter 1: Introduction

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General information

- Course name:
COMPUTER VISION
- Code: IT5409
- Credit: 3(3-1-0-6)
 - Lecturer: 45 hours
 - Capstone project: 15 hours
 - Experiments: 0 hours
- Evaluation: Mid-term (0.4)
Final term: written exam (0.6)




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Course Content

- **Chapter 1.** Introduction
- **Chapter 2.** Image formation, acquisition and digitization
- **Chapter 3.** Image Processing
- **Chapter 4.** Feature detection and matching
- **Chapter 5.** Segmentation
- **Chapter 6.** Motion object detection and tracking
- **Chapter 7.** Object recognition and deep learning




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Reference books

- [1]. Richard Szeliski (2011). Computer Vision: Algorithms and Applications. Springer.
<http://szeliski.org/Book/>
- [2]. David A. Forsyth, Jean Ponce (2011). Computer Vision: A modern Approach. Pearson
- [3]. Ranjay Krishna, Ed and Compiler "Computer Vision: Foundations and Application", Stanford University, First printing, December 2017.



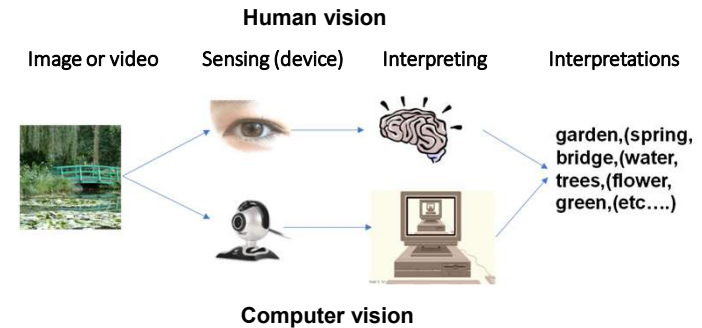
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Plan chapter 1

- 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

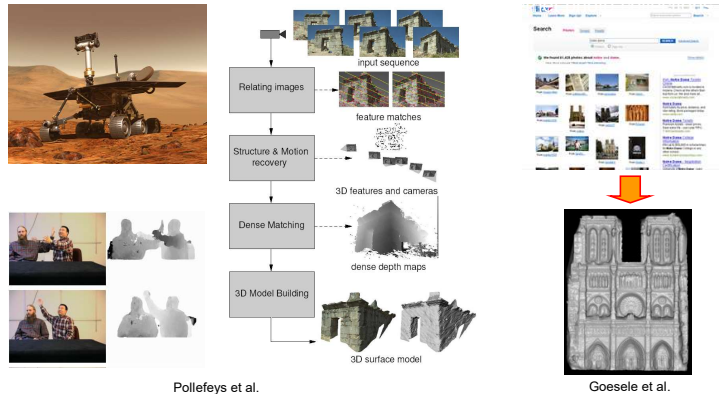
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2	1	0	3	2	5	4	7	6
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4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

What kind of information can we extract from an image?

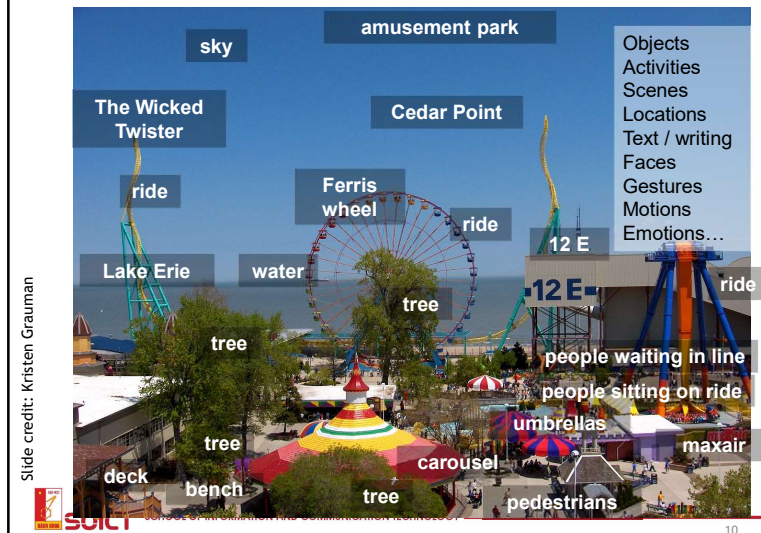
- Metric 3D information
- Semantic information

Vision as measurement device



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Vision as a source of semantic information



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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*).

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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?
...

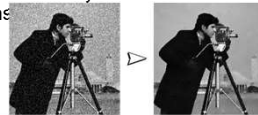
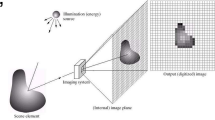
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What is computer vision?

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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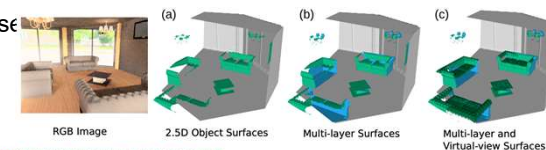
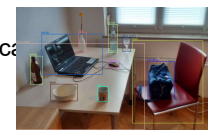
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What is computer vision?

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-base

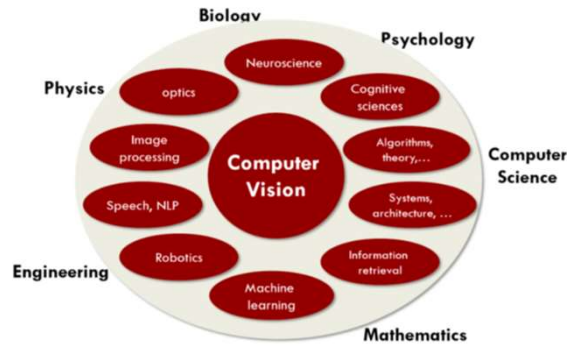


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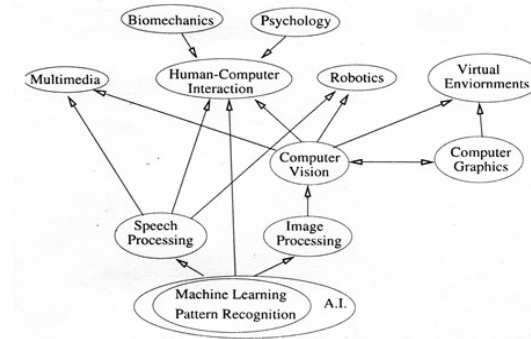
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Related fields



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

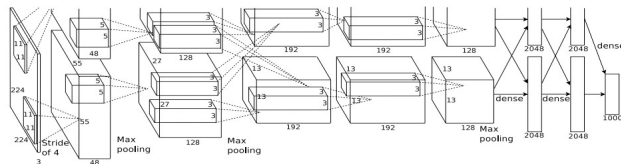
Related fields



Source: From EECS 432-Advanced Computer Vision, Northwestern University

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)



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

– ...



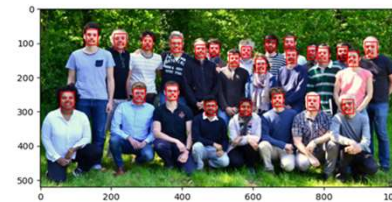
Fingerprint scanners



Face recognition systems

Source: from S. Seitz

Examples Face Detection



Source: from S. Seitz

Examples of Computer Vision

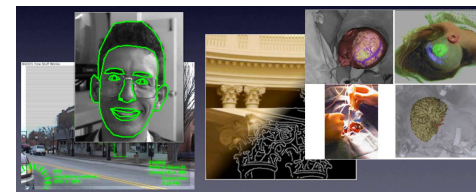


Slide from Vicente Ordonez

Applications areas

Medicine Application

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



Slide from Jason Lawrence

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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Facebook's suggestion



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Examples Toys and Robots

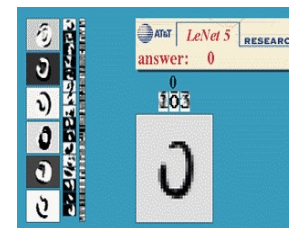


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Examples Optical character recognition (OCR)



Digit recognition, (AT&T labs)



License plate readers

http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Source: from S. Seitz



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