CSCE 867: Computer Vision

Spring 2025

Dr. Yan Tong

Today's Agenda

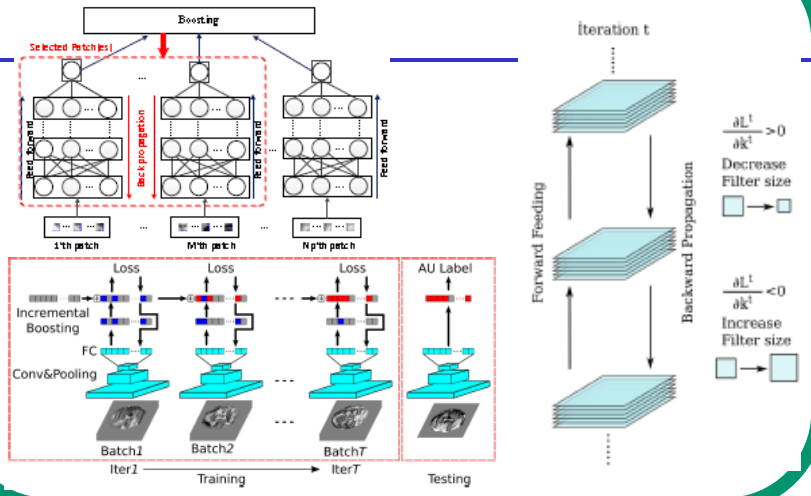
Welcome and self-introduction

Various administrative issues.

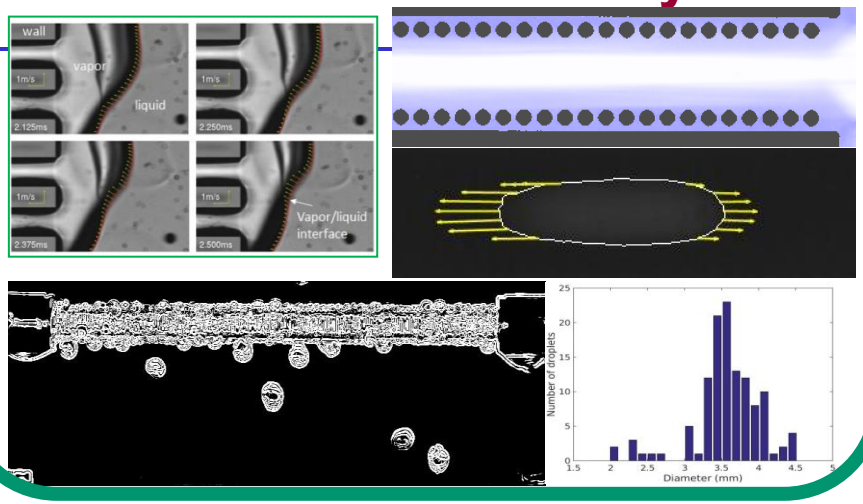
What is this course about?

Dr. Tong's Main Research Areas

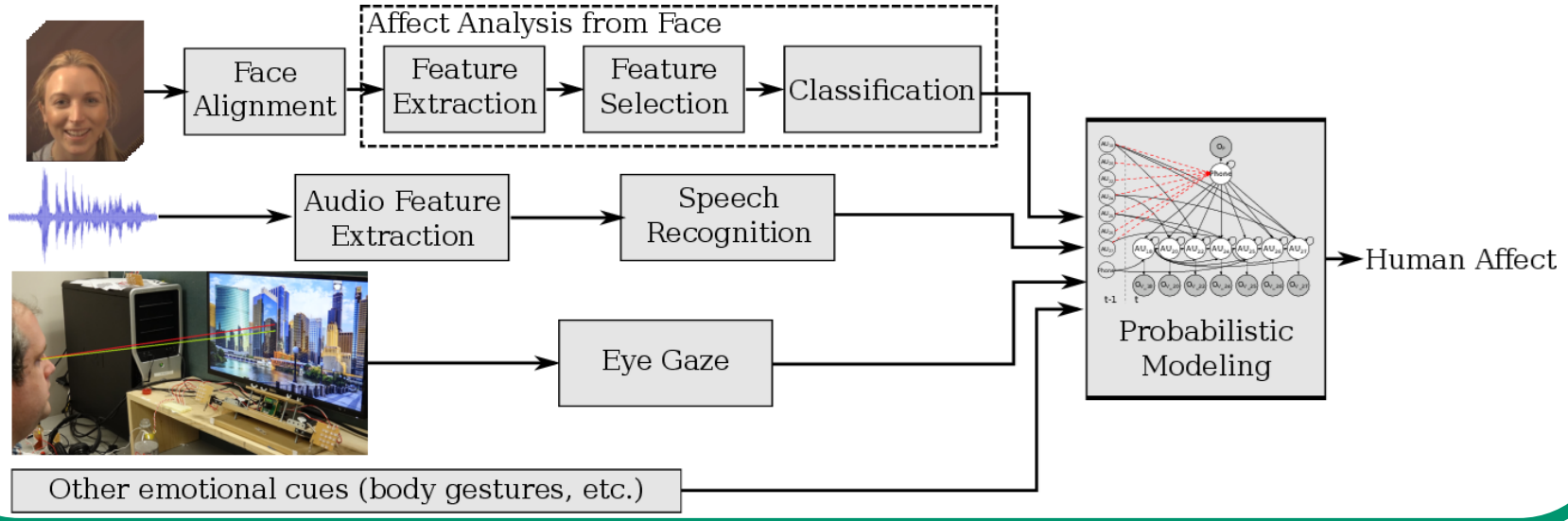
Fundamental Research in CV/ML



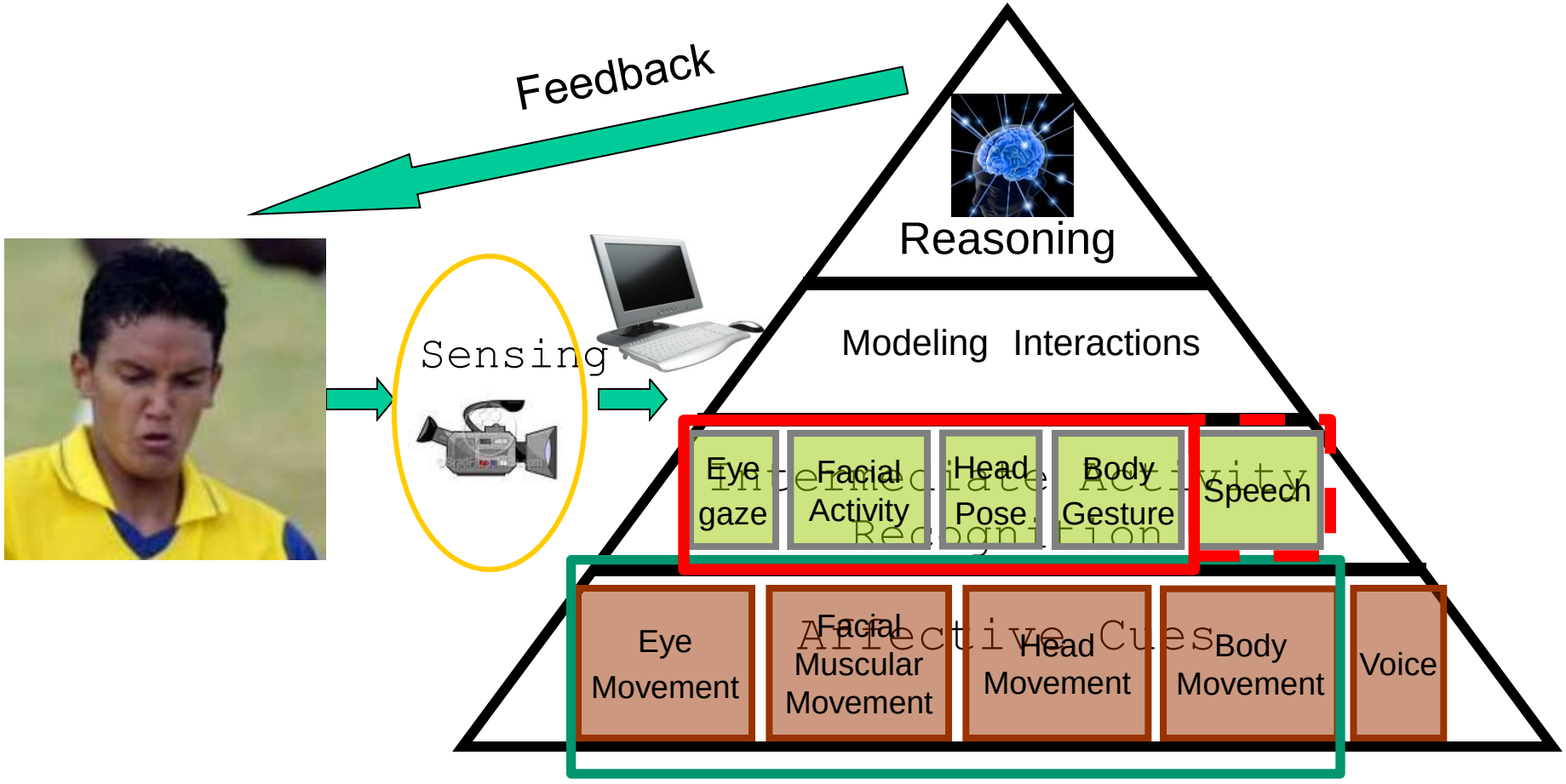
CV/ML Enabled Data Analysis



Multimodal Information Fusion



Dr. Tong's Research: Multimodal Affective Computing – An Area of Computer Vision



Now, Tell Me About Yourself!

- Name
- Major
- Why do you take Computer Vision?

Class Communication

Class homepage

http://www.cse.sc.edu/~tongy/csce867/csce867.html

Blackboard (blackboard.sc.edu)

- Discussion board
- Course announcements, lecture notes, homework assignments, projects, etc.
- Submission of assignments

Send me an email at tongy@cse.sc.edu if you have any questions regarding the course

Tentative Syllabus

Available in Blackboard and at class website

http://www.cse.sc.edu/~tongy/csce867/csce867syl.pdf

Goals and Learning Outcomes

This graduate level course will cover both classical and recent exciting progresses on the theory and practice of the computer vision. After taking the course,

- You will achieve the necessary knowledge to solve various practical computer-vision problems
- You will build a solid background for further computer-vision research.

Topics

The following is a list of tentative topics we plan to cover in this one-semester class (Changes may be made based on the available time):

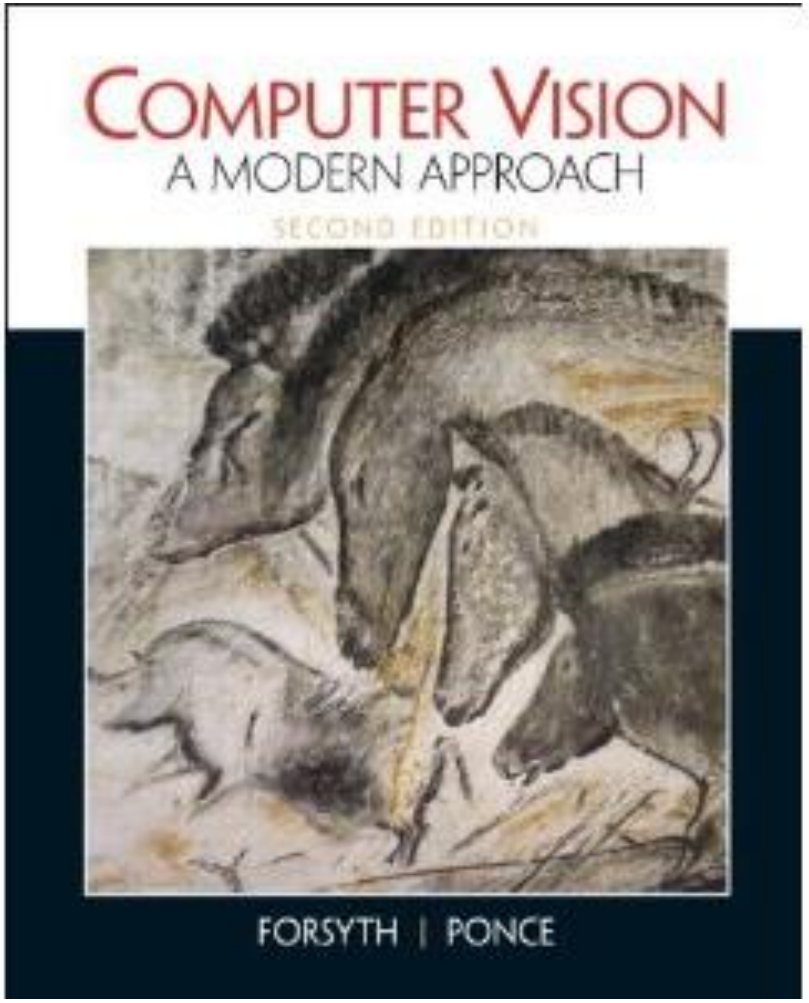
- **Image formation:**
  - Computational model of camera
  - Radiometry
  - Camera calibration
- **Early vision on one image:**
  - Linear filters
  - Edge detection
  - Features
- **Early vision on multiple images:**
  - Stereo vision
  - Motion estimation
- **Mid-level vision: segmentation and object tracking**
- **High-level vision**
- **Special topics on applications**

Recommended Textbook

***Computer Vision – A Modern Approach*, 2nd Edition, by Forsyth and Ponce, Prentice Hall, 2011**

We will not cover all the topics in this textbook

We will discuss some topics that are not in this textbook



Reference

- ***Computer Vision: Algorithms and Applications*, by Richard Szeliski, Springer, 2011**
- ***Introductory Techniques for 3-D Computer Vision*, by Emanuele Trucco and Alessandro Verri, 1998**

If you don't have image processing background

- ***Digital Image Processing,* Rafael C. Gonzalez and Richard E. Woods, 3rd Edition, Prentice Hall**

Grading

Grading System:

A	B+	B	C+	C	D+	D	F
100-90	89-86	85-80	79-76	75-70	69-66	65-60	59-0

Grading policy:

***Homework assignments (4)**	**(5% each)**
***Programming projects (2)**	**(10% each)**
One midterm exam	**(15%)**
One research-oriented course project	**(30% in total)**
***Quizzes (10)**	**(15% in total)**

*Late submission of homework assignments and projects may be accepted with late submission penalty applied

Late Submission Policy

- A due date is specified for each assignment or each deliverable of the project.
- All course deadlines are listed in Eastern Time Zone.
- Late submissions of **homework or programming projects** can be accepted if completing it within one week after the deadline with late submission penalty applied:
  - 10% loss for the first day late and an additional 5% loss for each following late day
  - Everyone is granted for a ONE-TIME waiver of late submission penalty – No penalty if you submit your assignment in three days after due date. For team deliverables, you cannot use the waiver if any member in the team has used the waiver before. Please notify me in advance, when you use this waiver.
- No late submission of final project presentation or written report is allowed
- No makeup exam is allowed except excusable absences with appropriate documentations

The Nature of This Course

This is a computer science course

- It will involve two programming projects
  - Choose the language you are most familiar with
  - Matlab/C++/Python is recommended
- It will involve a large amount of math
  - Calculus, linear algebra, geometry
  - Probability, random processes
  - Analog/digital signal processing
  - Optimization theory
  - Graph theory
- **Make sure you're prepared for this**

The Nature of This Course

This is a graduate-level course

- Research oriented – project is the emphasis
  - –30% in your final grade
- Understanding → creativity
  - –your own original work/opinion/result
- Basic knowledge → research frontier
  - –learn through reading recent papers

The Nature of This Course

This is a multi-disciplinary course

- Computer vision has applications in many fields, such as medicine, military, internet, library, etc.
- Computer-vision research involves tools from many fields, such as signal processing, physics, mathematics, psychology, geometry, optics, color science, graphics, optimization, artificial intelligence, machine learning, etc.
- It is a very challenging but important problem in computer science, and many computer-vision problems are open problems
- It is not a very well-established discipline such as physics and calculus, many topics are application-oriented
- Linear algebra, probability and statistics are very widely used in computer vision for building many vision models

Final Project Topics

Option 1: A complete research project

- Introduction (problem formulation/definition)
- literature review
- the proposed method and analysis
- experiment
- conclusion
- reference

Option 2: A survey research

- A well-defined problem or topic
- a complete list of previous (typical) work on this problem
- clearly and briefly describe it
- analyze each methods/groups and compare them
- give the conclusion and list of references

Final Project Requirement

Requirements and deliverables:

- Decide topic and write a one-page abstract (due 11:59pm, Sunday, Feb. 23)
- Discussion with the instructor
- Research work and final report writing
- Oral presentation

Teamwork (2-person team) is acceptable for Option 1 ONLY

- talk to the instructor first
- under a single topic, each member must have own specific subtopic/tasks
- a combined report, but each member needs to clearly show own contributions
- A combined presentation

Final Project Requirement

Written report due time: 11:59pm, Tuesday, May 6

Report format: the same as a complete conference paper

Academic integrity (avoiding plagiarism)

- don't copy other person's work
- describe using your own words
- complete citation and acknowledgement whenever you use any other work (either published or online)

Evaluation

- Abstract (be clear and concise) 20%
- written report (be clear, complete, correct, etc.,) 50%
- oral presentation 30%
- quality: publication-level project– extra credits (Option 1 only) up to 10%

Project Requirement

Notes:

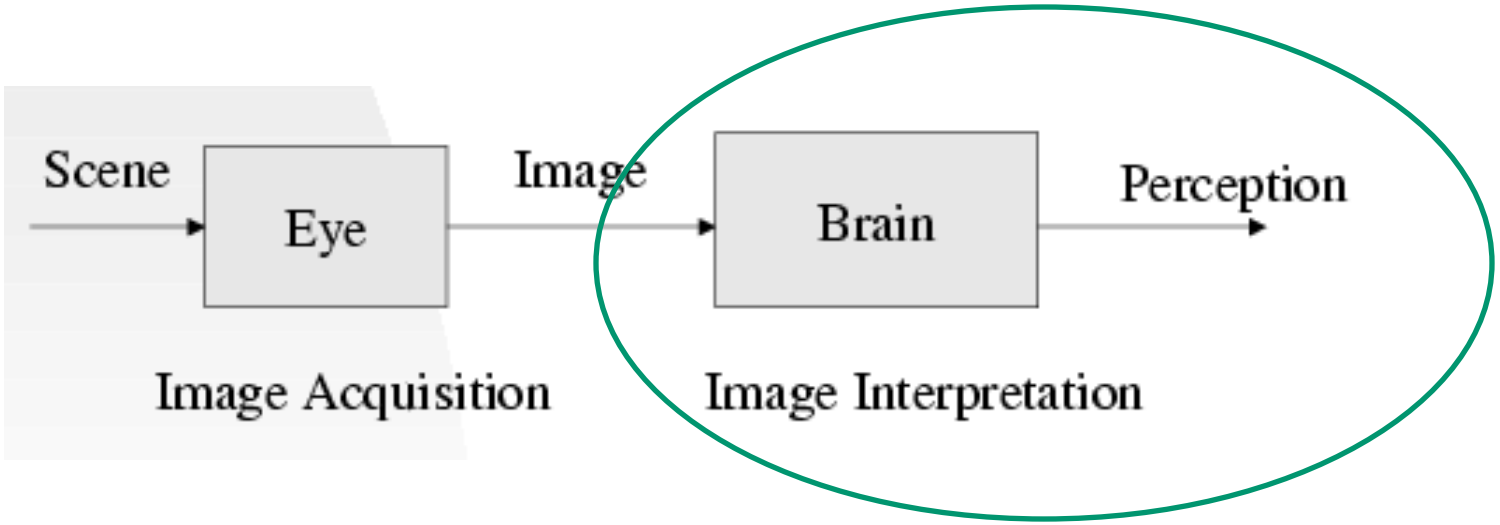
- you are encouraged to incorporate your own expertise in, but the project topic must be related to the content of this course
- discuss with the instructor on topic selection, progress, writing, and presentation
- Use the library and online resource

Major research journals and conferences on computer vision

- International Conference on Computer Vision (ICCV)
- IEEE International Conference on Computer Vision and Pattern Recognition (CVPR)
- IEEE Trans. Pattern Analysis and Machine Intelligence (PAMI)
- International Journal on Computer Vision (IJCV)
- You may find useful literature in them for your project

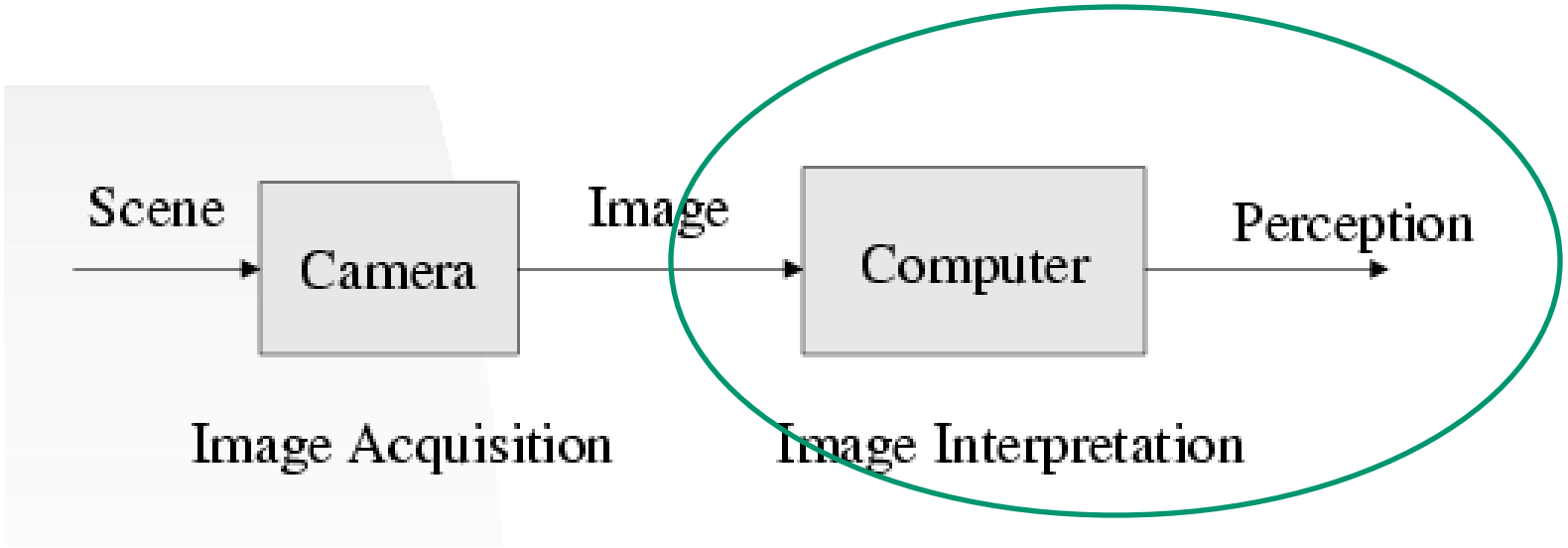
Vision

"Vision is the process of discovering from images what is present in the world and where it is" – David Marr



Computer Vision

Computer Vision is the study of analysis of pictures and videos (using computers) in order to achieve results similar to those as by human.



An Example

Problem: Given an image *I*, finding people in images

Question: Does *I* contain an image of a person?

“Yes” Cases

Phil Noble / AP


Mike Hewitt / Allsport


Patrick Gardin / AP


Andy Barron / Reno Gazette-Journal


Sydney Morning Herald

“No” Cases


Eric Miller / Reuters


Mark Garkfinkel / The Boston Herald

Jeff J. Mitchell / Reuters


Monroe County Sheriffs Department / Newsmakers


Uno Andersson / AP

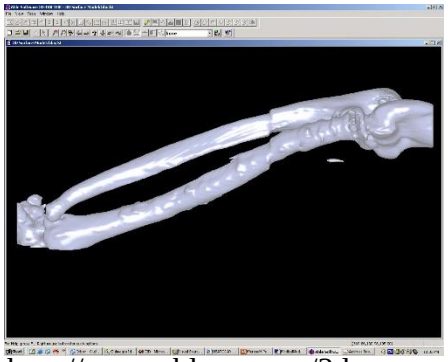

NASA via AFP

Why Computer-Vision

We are using computer vision techniques every day in our daily life.

Numerous applications

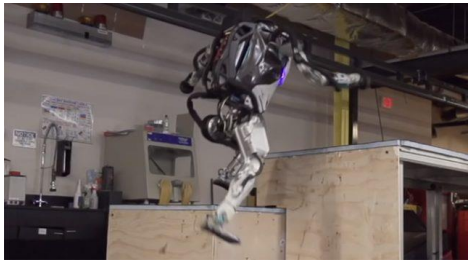
- 3D/4D Medical image
- Surveillance
- Image retrieval from database
  - –Google image
  - –Amazon go
- Self-driving
- Robotics
- and more …



http://www.ablesw.com/3d-doctor/surgmod.html

https://cars.usnews.com/cars-trucks/autonomous-vehicle-levels

https://www.castlewallsecurity.com/home-security-cameras/



https://www.extremetech.com/tag/boston-dynamics

Why Computer-Vision

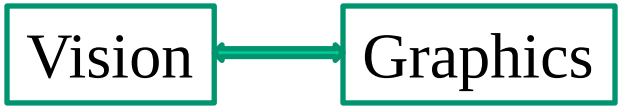
The total size of the worldwide computer vision industry was estimated at $10.6 billion in 2019 (Computer Vision Market Size & Share Report, 2020-2027 (grandviewresearch.com)), and will increase to $18.24 billion by 2025 (Machine Vision Market Size Worth $18.24 Billion By 2025 (grandviewresearch.com))

Vision vs Graphics

Vision: **from image to model/perception (analyzing image)**

Graphics: **from model/perception to image (constructing image)**

So they are inverse and correlated processes



Human vision always see the world with prior model (knowledge) in the mind

Models are usually important in vision

Problem is how to incorporate the model into the image understanding process

Related Areas

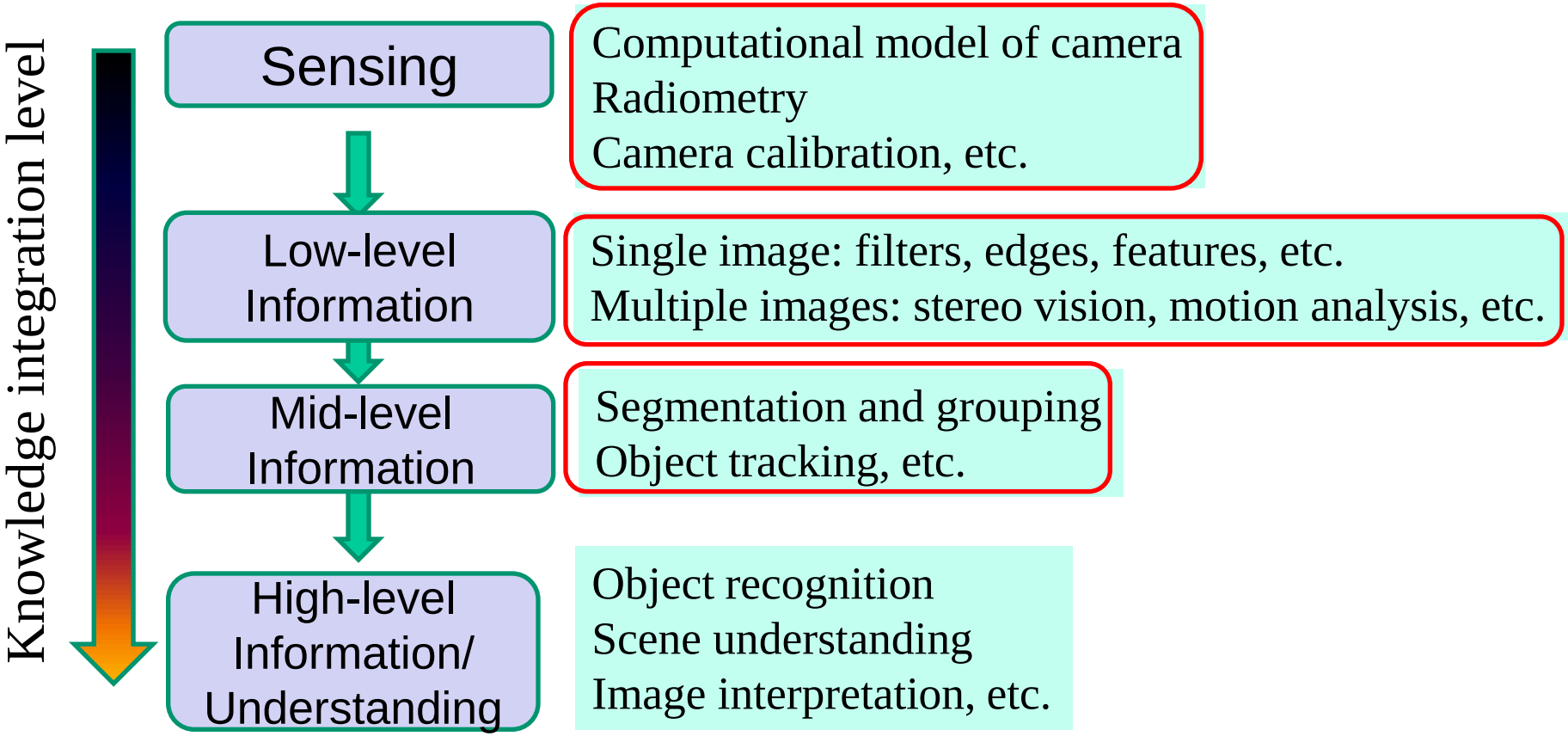
Computer vision overlaps with *image processing,* and *machine learning* significantly.

- *Image processing*: operations are usually performed from image to image including compression, restoration, and enhancement

- *Machine learning*: development of computer algorithms to automatically learn models from data (experience) and improve prediction/decision making

Image processing and *machine learning* are important tools used in computer vision.

Hierarchy of Computer Vision Problems



Some Problems in Computer Vision: Imaging Process

Imaging process

- Light reaches surfaces in 3D
- Surfaces reflect light
- Sensor element receives light energy

Factors

- Intensity of energy
- Surface roughness
- Surface material

Issues

Shadow and occlusions