Computer Vision (컴퓨터 비전, HY24011)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING,
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Course Information

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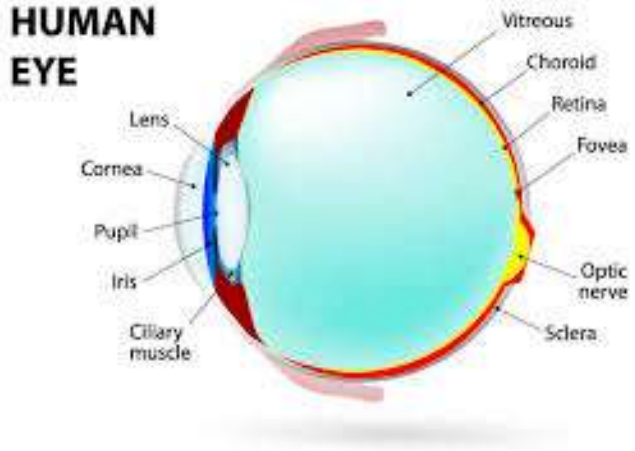
- Course Webpage:
  - https://learning.hanyang.ac.kr/courses/150710 (in LMS)
  - Course materials, assignments, and other announcements

What is Computer Vision?

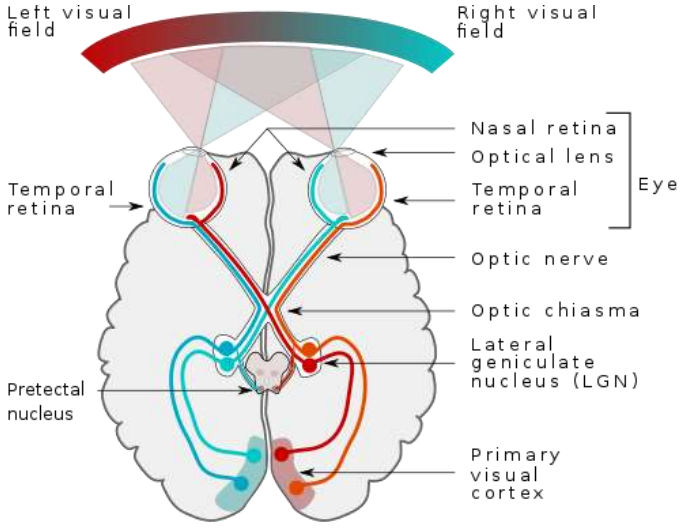
- Computer vision: a simulation of human visual processes
- How do humans do it?
  - Humans perceive the three-dimensional structure of the world with ease

Human Visual System

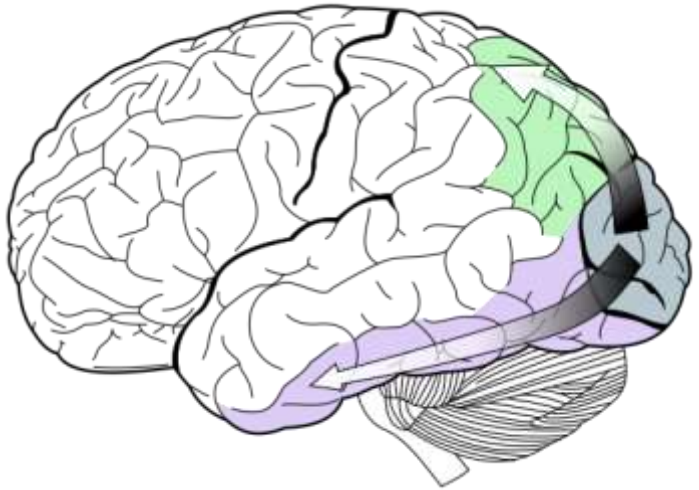
- Vision is most important and most complex sense
- Visual system includes eyes, visual cortex, and the connecting pathways
- The visual dorsal stream (green) is involved in recognizing actions(“where”), while ventral stream (purple) is involved in recognizing objects(“what”)



Eye Structure



Human Visual System



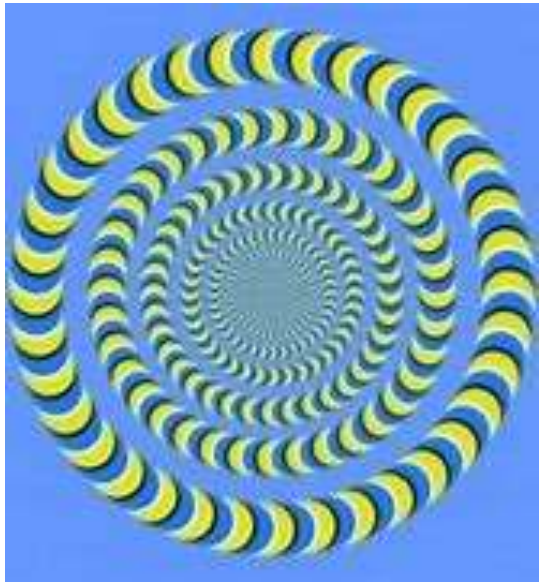
Visual Cortex

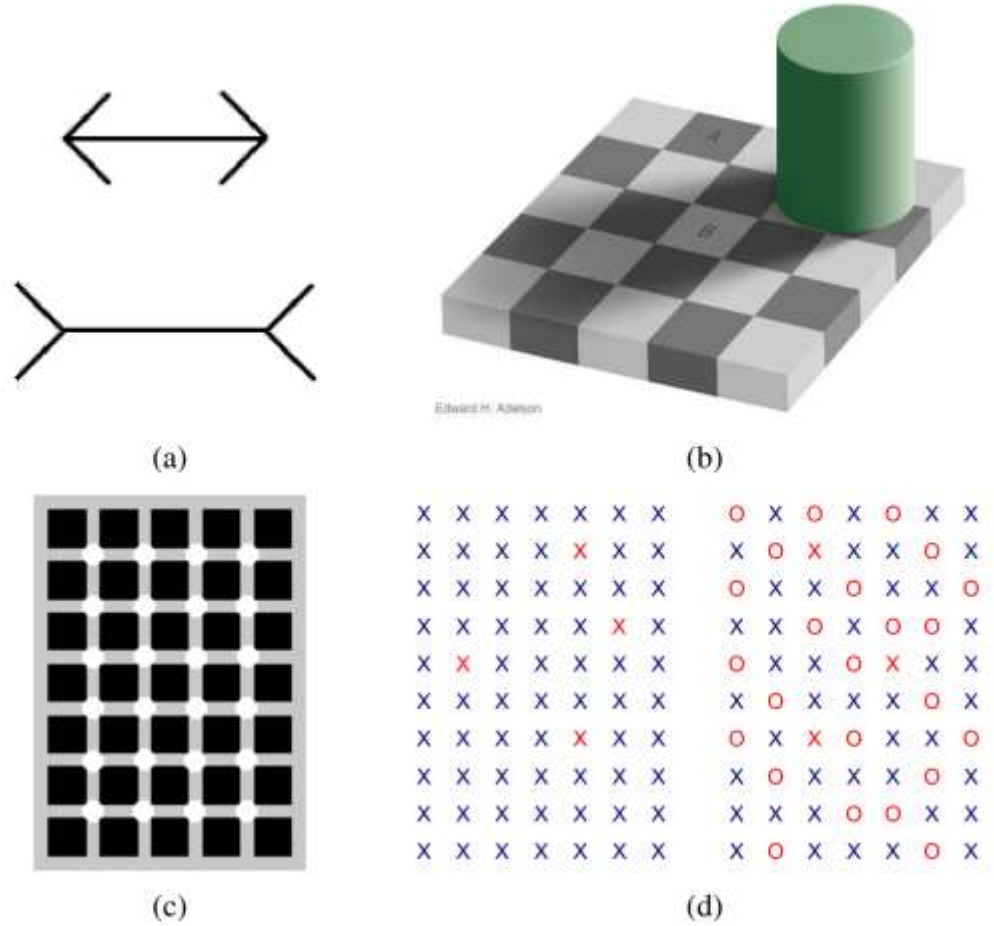
Human vision is good at

- Perform classification, detection, segmentation, tracking easily
- 3D reconstruction
- Fast and robust
- Fast and smooth transition
- Cooperate with other cognitive processes

Human vision is weak at

- Optical illusions
- Weak at precise measurements
- Limited field of view
- Fatigue, aging…





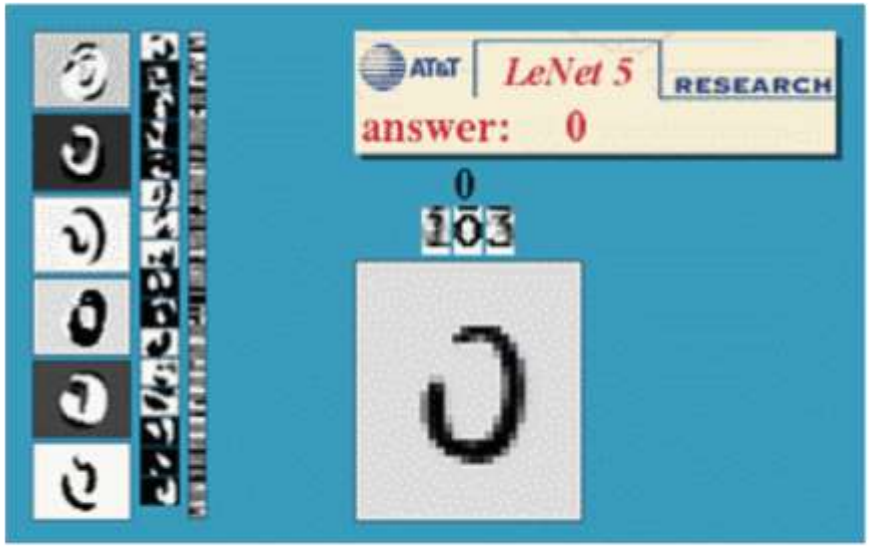
Common Optical Illusions

What is Computer Vision?

- A simulation of eye
  - Giving the computer “eyes” to see and identify as humans would
  - Teach computer to interpret and understand the world through images
- Mimicking the human visual perception with computational algorithms
  - Computer getting information out of images/videos
  - Automatically identifying objects in images or videos
- Inverse processing
  - Inverting image formation
  - Inverse graphics

Computer Vision Applications

- Optical Character Recognition (OCR)
- Machine inspection



(a) (b)

(a) OCR: recognition of handwritten postal codes
(b) Measuring tolerance of auto body parts

Computer Vision Applications

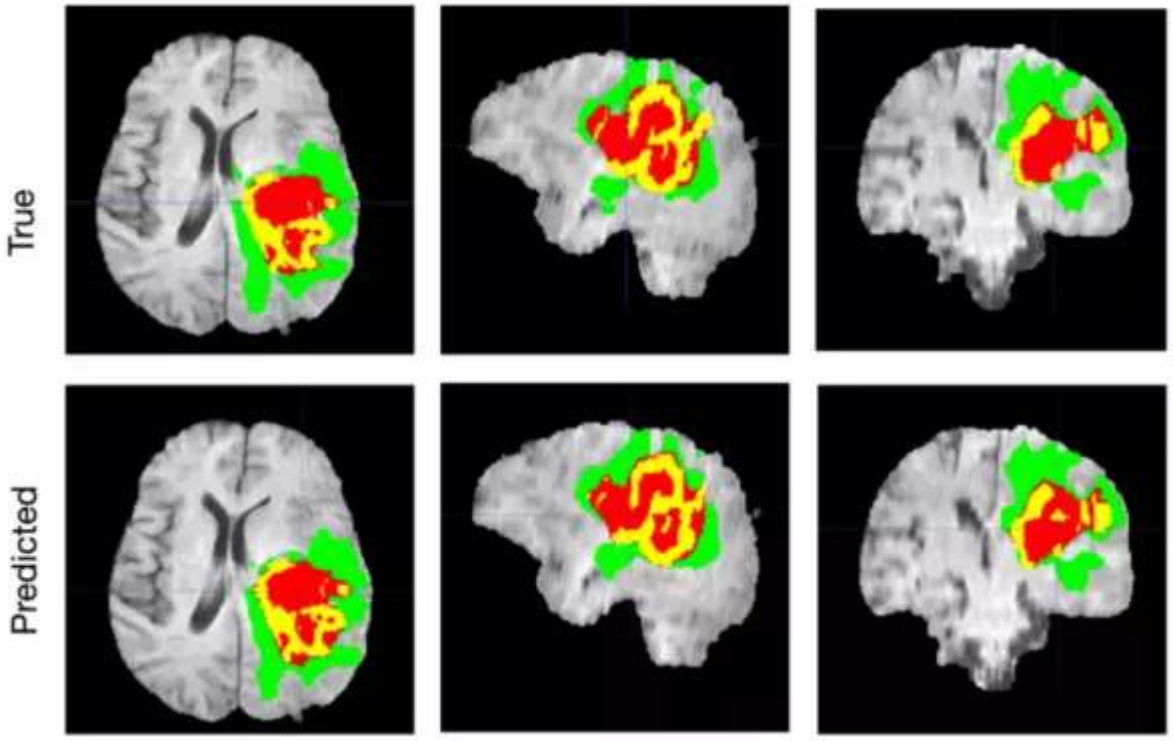
- Retail: object recognition for automated checkout lanes
- Warehouse logistics: autonomous package delivery, picking

AmazonGo

Autonomous parts picking by robot manipulators

Computer Vision Applications

- Computer vision in Medical Imaging
  - Cancer/Tumor Detection from CT and MRI images



Brain Tumor Segmentation

Computer Vision Applications

- Self-driving vehicles

Self-driving vehicle (2008)

MobileEye: vision system in high-end BMW,GM, Volvo models

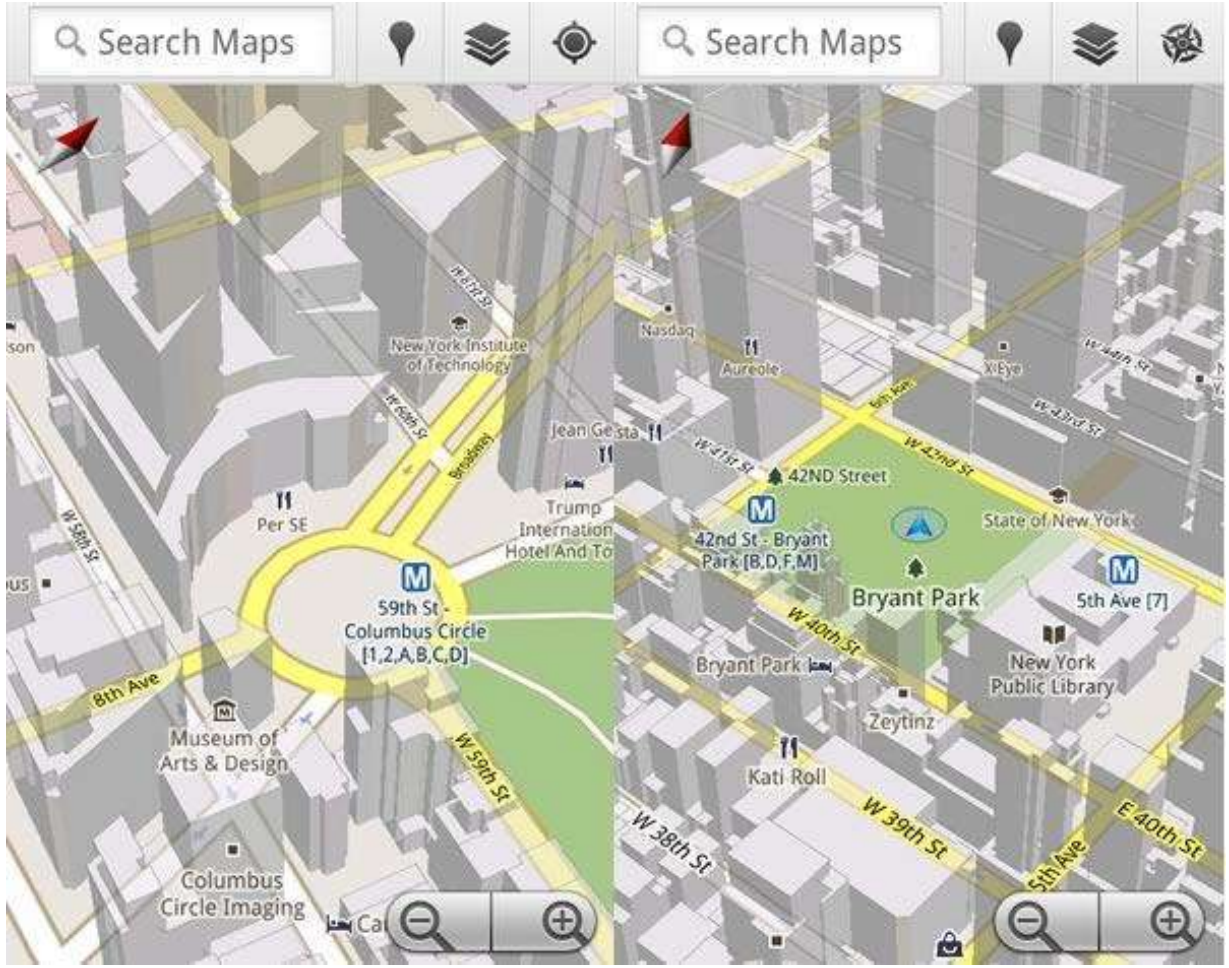
Computer Vision Applications

- 3D model building (photogrammetry)

Photogrammetry: fully automated construction from aerial and drone photographs

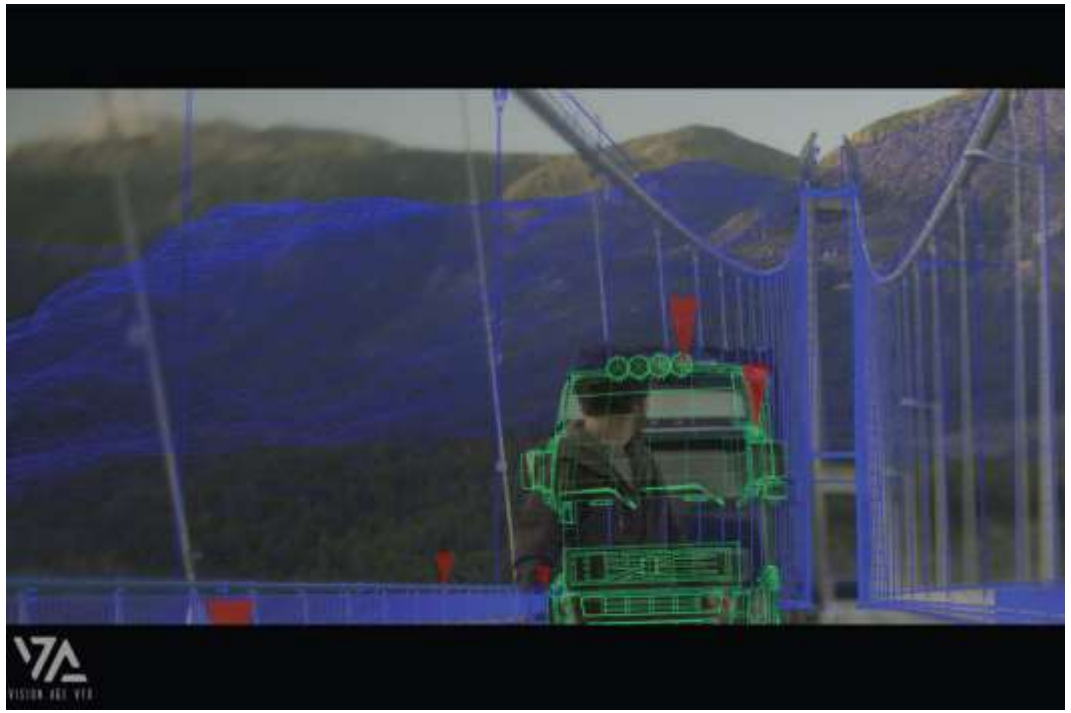
Computer Vision Applications

Google 3D Map (Google Earth)



Computer Vision Applications

- Match move: merging computer-generated imagery with live action footage
  - Tracking feature points to estimate camera movement (structure from motion)



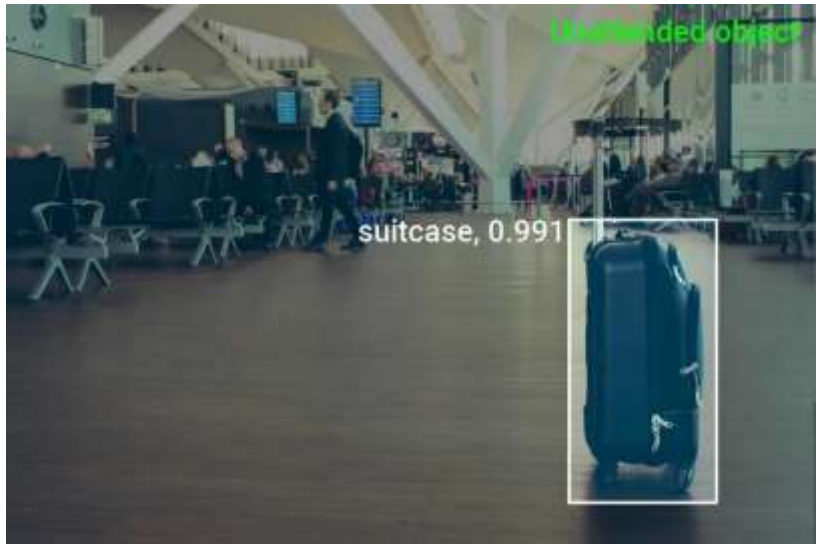
Computer Vision Applications

- Motion capture (mocap) or performance capture

Computer Vision Applications

- Surveillance

Customer detection in shopping malls



Abandoned object detection in airports

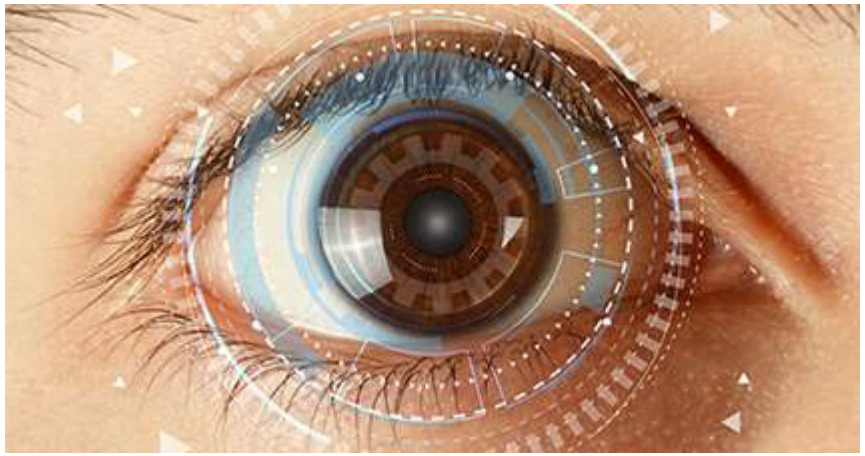
Customer tracking

(Images from viso.ai)

Computer Vision Applications

- Fingerprint recognition and biometrics

Palm recognition



Iris recognition

Face recognition

Computer Vision Applications

- Sports

The virtual first-down line(yellow) in televised football games

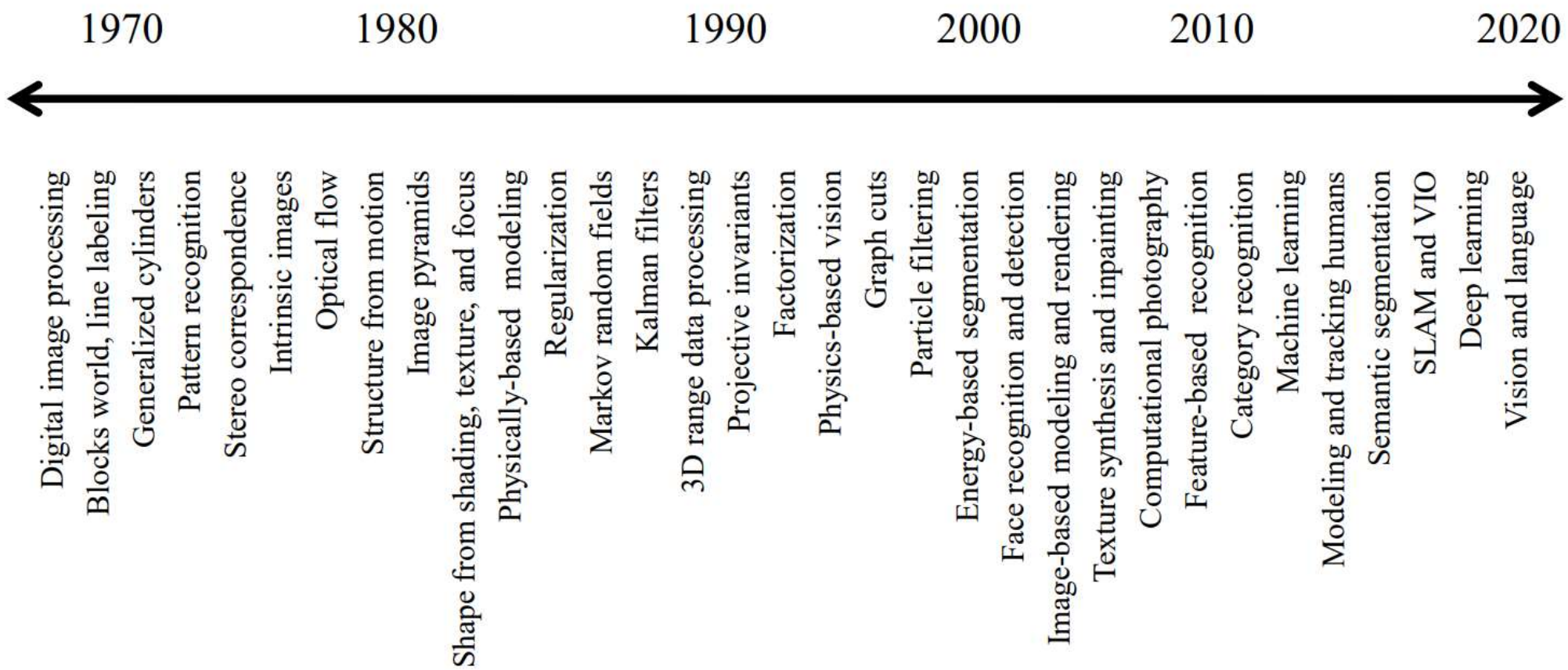
Computer Vision Applications

- Virtual and augmented reality (VR/AR)

Oculus Quest used in Beat Saber (VR)

Microsoft Hololens2 (AR)

Computer Vision: A Brief History



A rough timeline of most active topics in computer vision

Computer Vision Problems

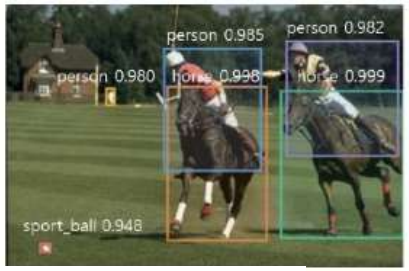
- Ultimate Goal
  - Mimicking the human perception in general situation
  - Almost impossible to achieve

- Realistic Goal
  - Do specific tasks with a high performance under the constrained environment
  - Divide computer vision problems into subproblems and

Computer Vision Problems

- Basic problems in computer vision
  - Classification
  - Detection
  - Segmentation
  - Tracking
  - Action Analysis
  - Etc…

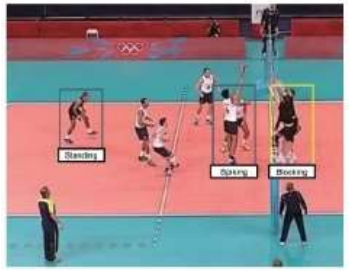
Classification



Detection

Segmentation

Tracking



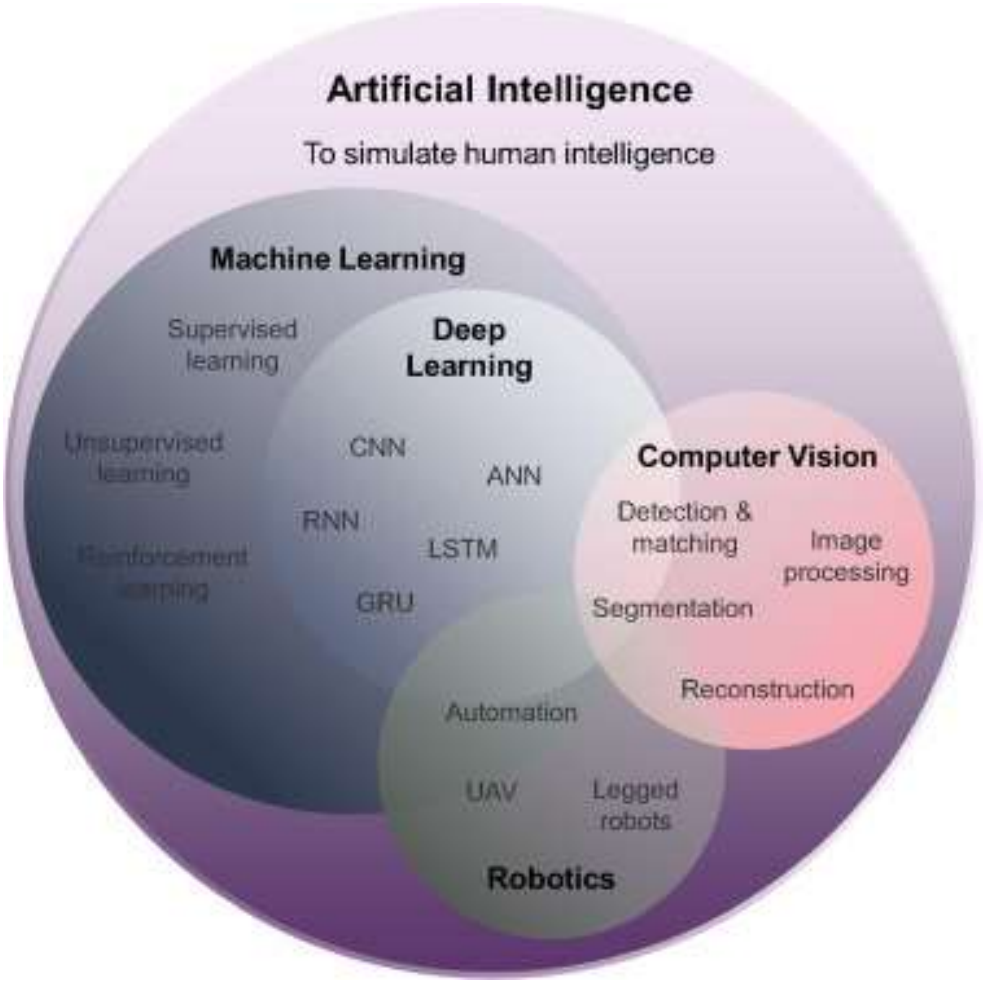
Motion Analysis

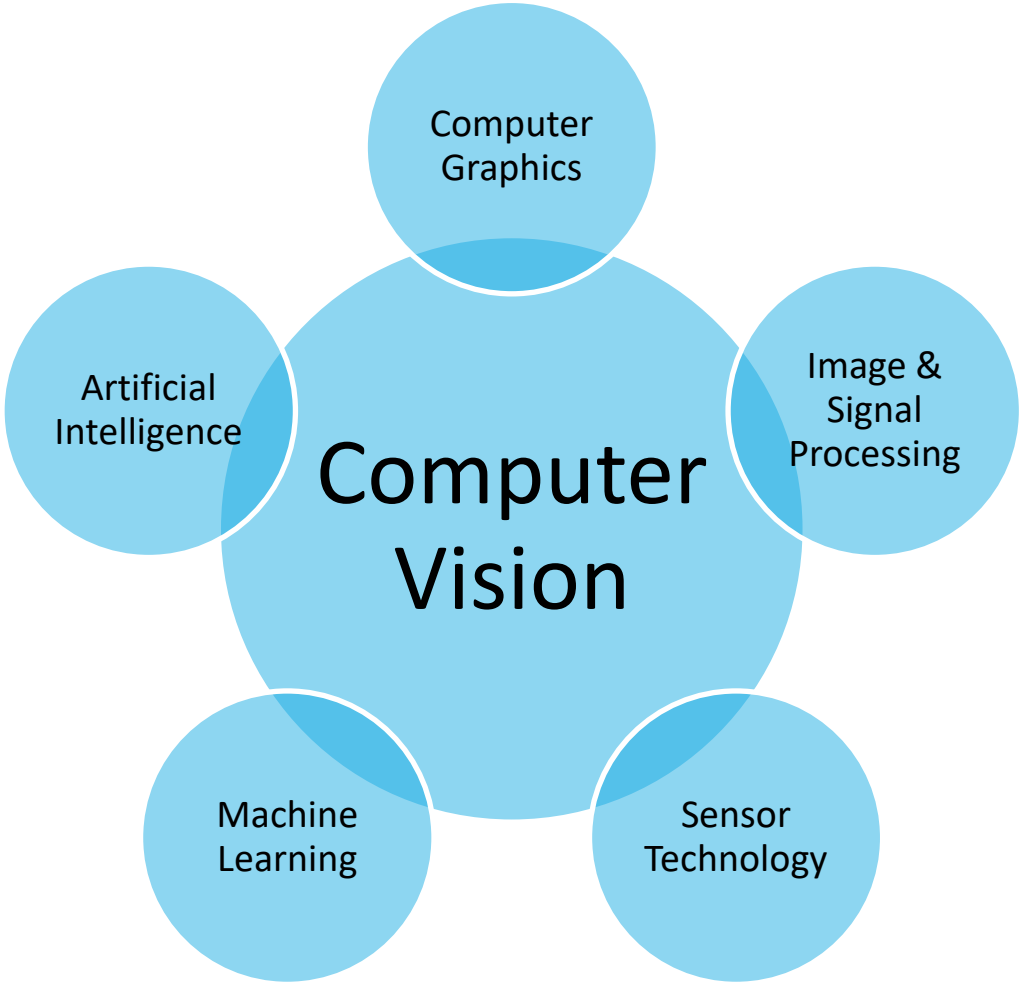
Computer Vision and Programming

- Classical computer vision and ML-based computer vision
  - ML-based vision emerged from around 2010s
  - Classical computer vision is ruled-based, whereas deep learning-based data-based

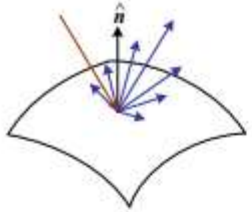
- CV Programming
  - C/C++, Java, Matlab, Python
  - C/C++
    - Huge optimized library (good for performance)
    - Difficult for beginners, lack of visualization, debugging, ML libraries
  - Python
    - Good for scientific computing – ML-friendly (ex. TensforFlow, PyTorch)
    - Slower run time (OpenCV is written in C/C++)

CV vs. other fields (ML, AI…)





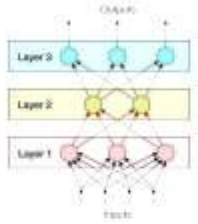
Topics Covered



2. Image formation

3. Image processing

4. Optimization

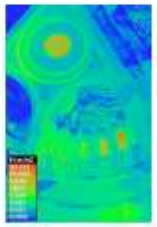


5. Deep learning

6. Recognition

7–8. Features & alignment

9. Motion estimation



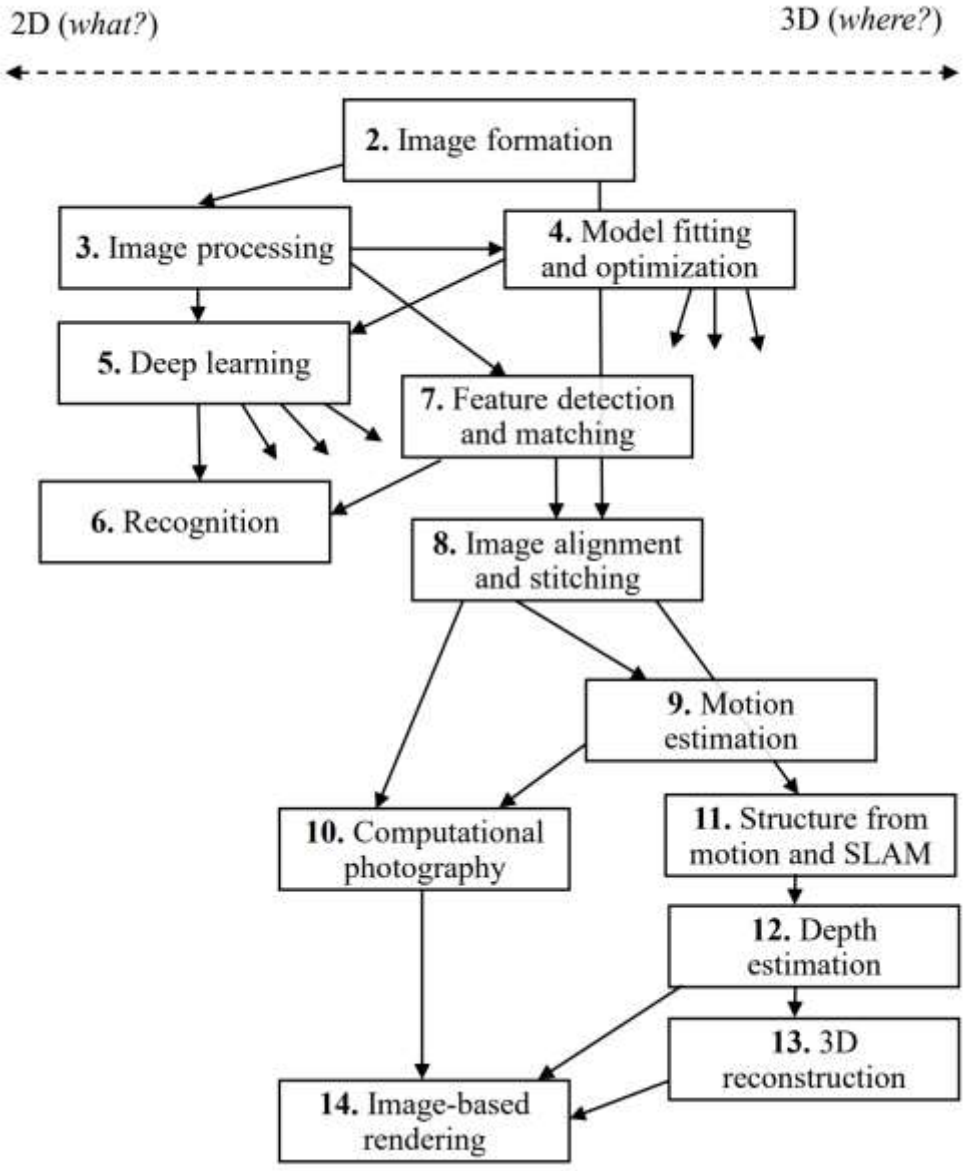
10. Computational Photography

11. Structure from motion

12. Depth estimation

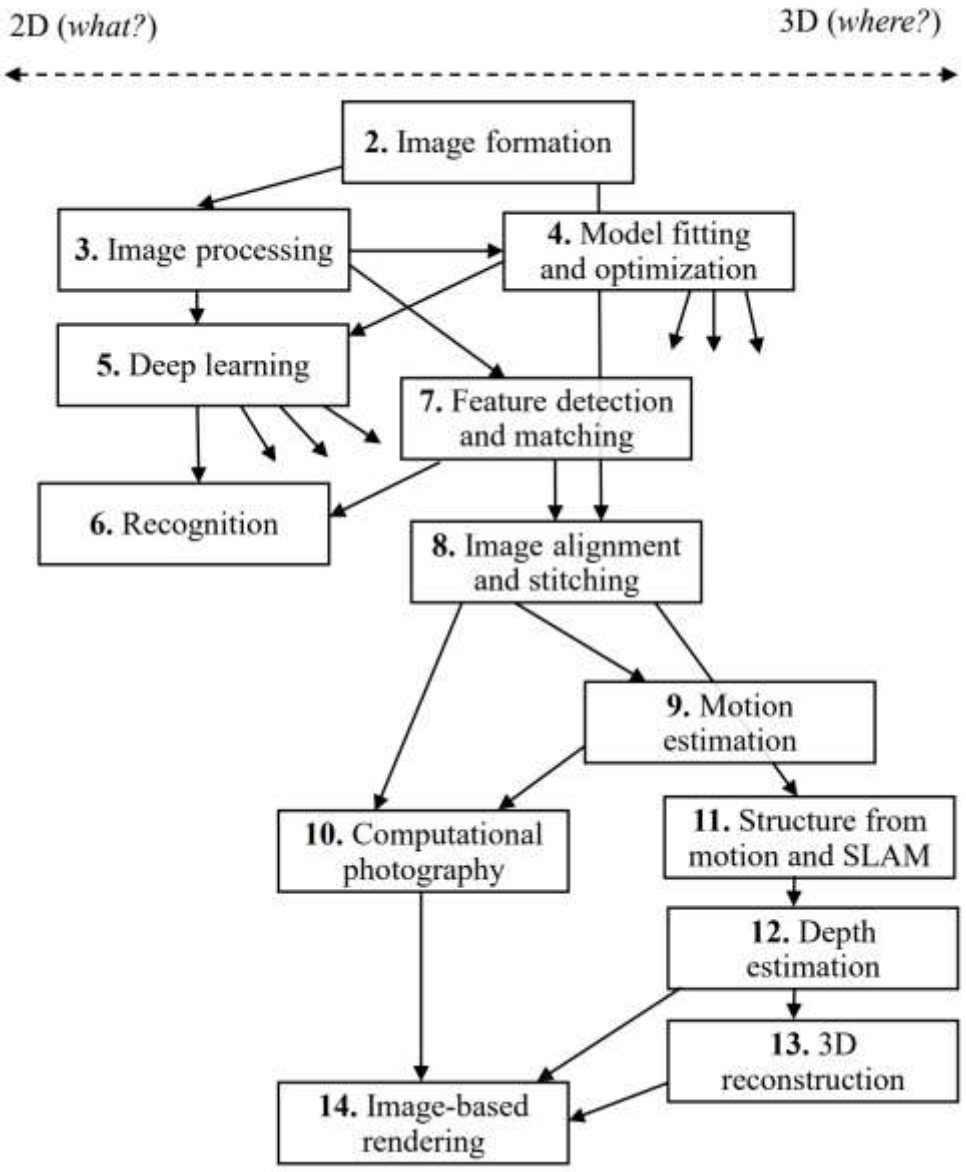
13. 3D reconstruction

14. Image-based Rendering



Topics Covered

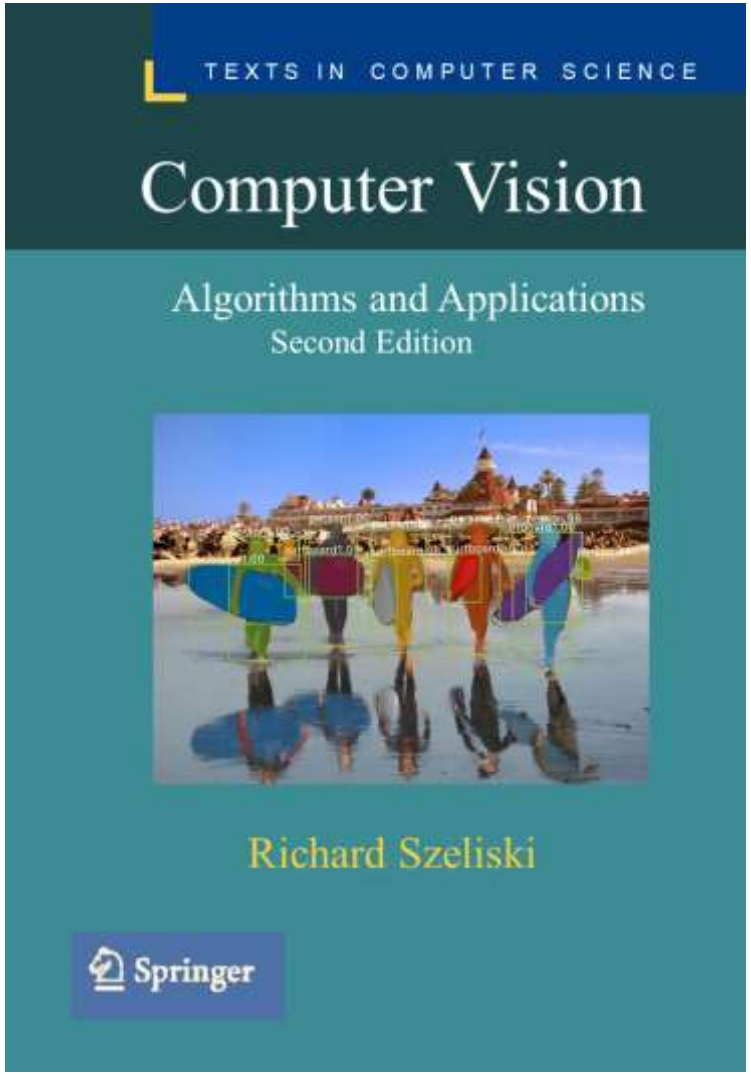
Week 1	Intro
Week 2	Image Formation
Week 3	Image Processing
Week 4	Edge Detection
Week 5	Feature Detection
Week 6	Segmentation
Week 7	Matching
Week 8	Midterm exam
Week 9	ML in CV
Week 10	Recognition
Week 11	Motion
Week 12	3D Vision - Stereo
Week 13	3D Reconstruction
Week 14	Computational Photography
Week 15	Other Topics in CV
Week 16	Final exam



References (in English)

- **Computer Vision: Algorithms and Applications**, 2nd Ed. By Richard Szeliski, Springer, 2020.
  - PDF can be downloaded from the author's webpage (https://szeliski.org/Book/)

- Other resources Computer Vision: A Modern Approach, 2nd Ed. By David Forsyth and Jean Ponce, 2011.
  - Image Processing, Analysis, and Machine Vision, 3rd Ed. By Sonka, M., Hlavac, V., and Boyle, R., Thomson, 2008.
  - Dive into deep learning by Zhang, A., Lipton, Z. C., Li, M., and Smola, A.J., 2019.



References (in Korean)

- **컴퓨터 비전**, 오일석 저, 한빛 아카데미, 2014.
  (Computer Vision by Oh, I.S., Hanbit Academy, 2014)

- 컴퓨터 비전과 딥러닝, 오일석 저, 한빛 아카데미, 2023.
  (Computer Vision and Deep Learning by Oh, I.S., Hanbit Academy, 2023)

- OpenCV로 배우는 컴퓨터 비전과 머신러닝, 황선규, 2019.
  (Computer Vision and Machine Learning with OpenCV 4, by Hwang, S., Gilbut, 2019)

More Course Info

- Classroom(s)
  - Lecture sessions: Tuesdays, 14:30 – 16:30, Y311-0506
  - Practice sessions: Thursdays, 11:00 – 13:00, Y311-0512

Bring your own laptop to practice sessions!!!

- Grades
  - Midterm Exam 30%
  - Final Exam 30%
  - Assignments 30%
  - Attendance 10%

Prerequisites

- Basic math knowledge
  - Linear algebra: be prepared for vector and matrix calculus!
  - Calculus: differentials, Taylor series,...
  - Probabilities: essential in understanding ML-related stuff

- Programming skills:
  - We will use Python with Numpy, matplotlib, (PyTorch)
  - Data structures
  - Algorithms

Assignments

- There will be two types of assignments

① Type 1: Review tasks
  - Handed out during/after practice sessions
  - Relatively simple, short exercises
  - Submit by the next practice session
  - No late submissions

② Type 2: Programming assignments (about 3)
  - Handed out with separate announcements
  - More complex, long programming assignments
  - Usually 2 weeks
  - Penalty for late submission, not accepted after 3 days

- Announcements and submissions will be handled via LMS
- **No collaboration! – Only as permitted to use code by the staff of the course**