



**THE UNIVERSITY OF TEXAS AT DALLAS**

# Introduction to Computer Vision

CS 6384 Computer Vision

Professor Yapeng Tian

Department of Computer Science

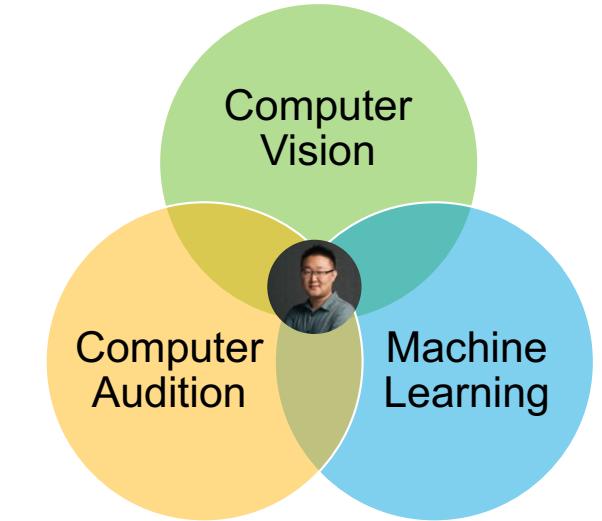
# Instructor

Yapeng Tian

Assistant Professor in UTD@CS (joined Fall 2022)

Research area:

- Computer Vision
- Computer Audition
- Machine Learning



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# Today

- What is computer vision?
- Why study computer vision?
- Why is computer vision difficult?
- Course overview

# Every Image Tells a Story

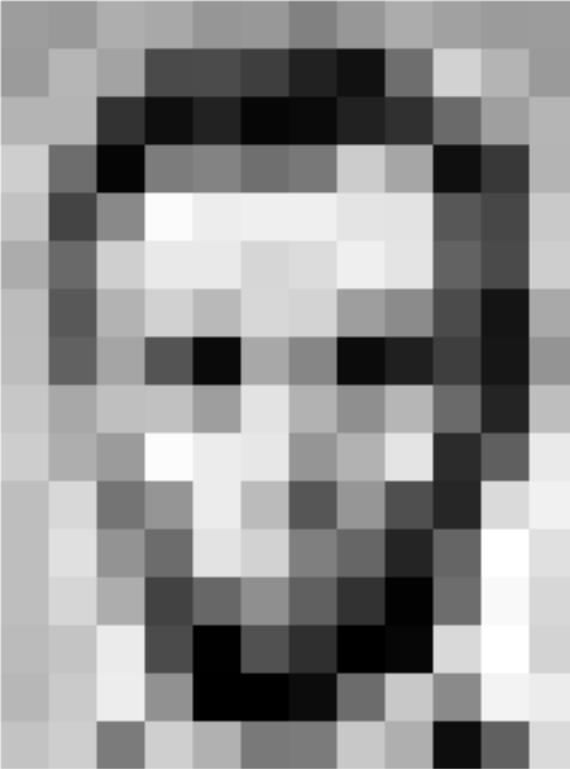


<https://unwritten-record.blogs.archives.gov/2019/04/11/a-picture-is-worth-a-thousand-words/>

- Primary goal of computer vision: perceive the “story” behind the picture by machines
- Compute properties of the world
  - 3D shape
  - Names of people or objects
  - What happened?

Slide Credit: Noah Snavely

# The Goal of Computer Vision



157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	84	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	299	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	105	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	209	138	243	236
196	206	123	207	177	121	123	200	175	13	96	218

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A gray image is represented by a 2D matrix in computer, and each pixel value is in [0, 255].

# The Goal of Computer Vision

- Compute the 3D shape of the world

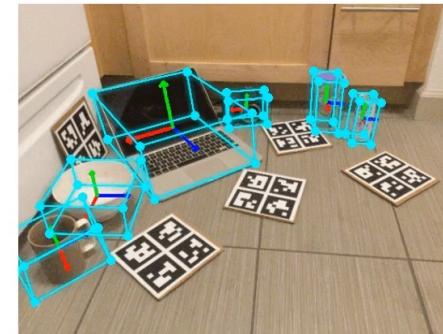


Kinect RGB-D camera

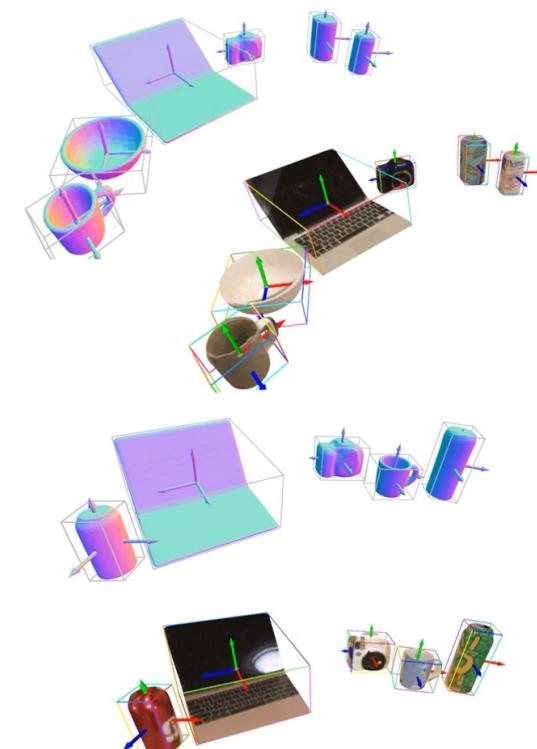
Input RGB-D



6D pose and size



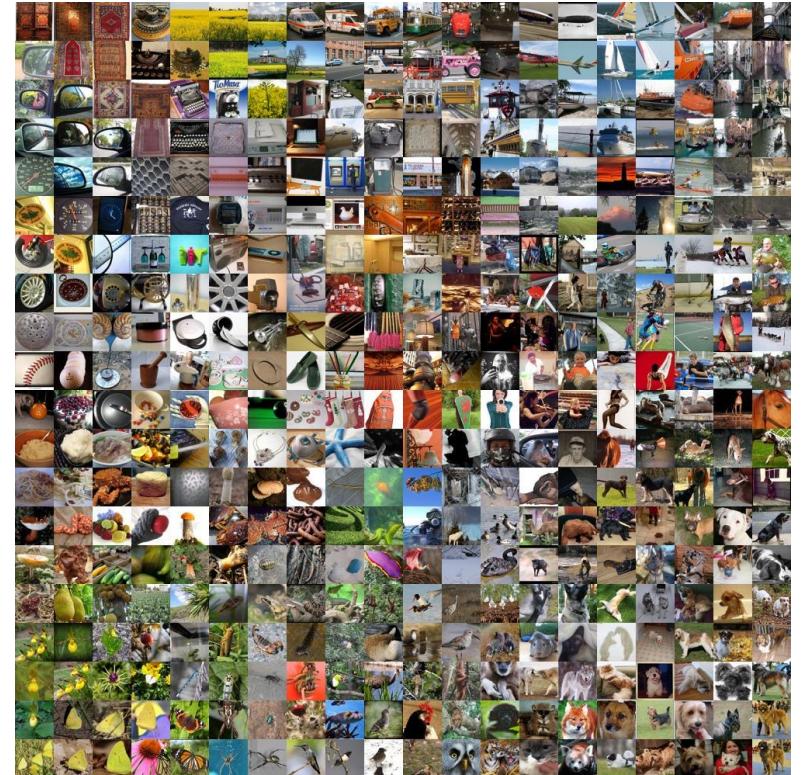
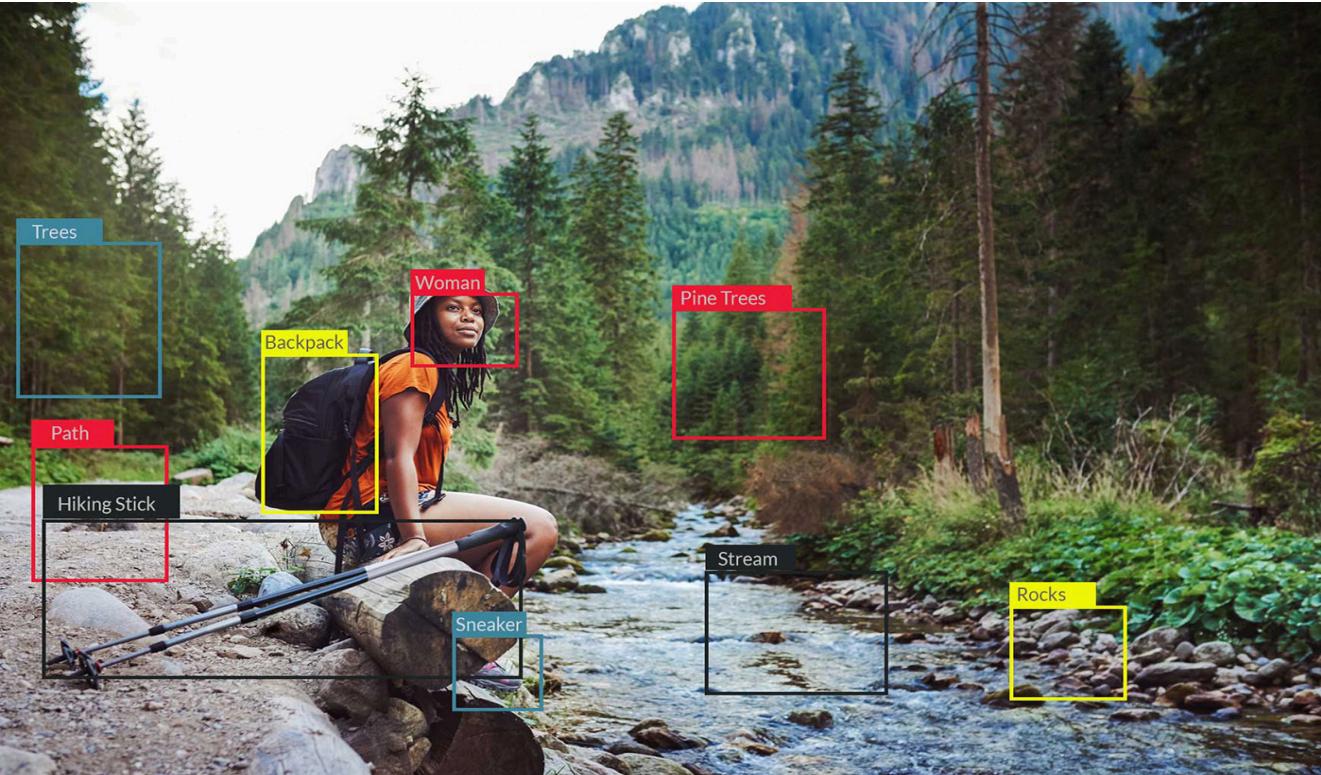
Per-frame 3D Prediction



<https://zubair-irshad.github.io/projects/ShAPO.html>

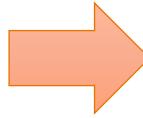
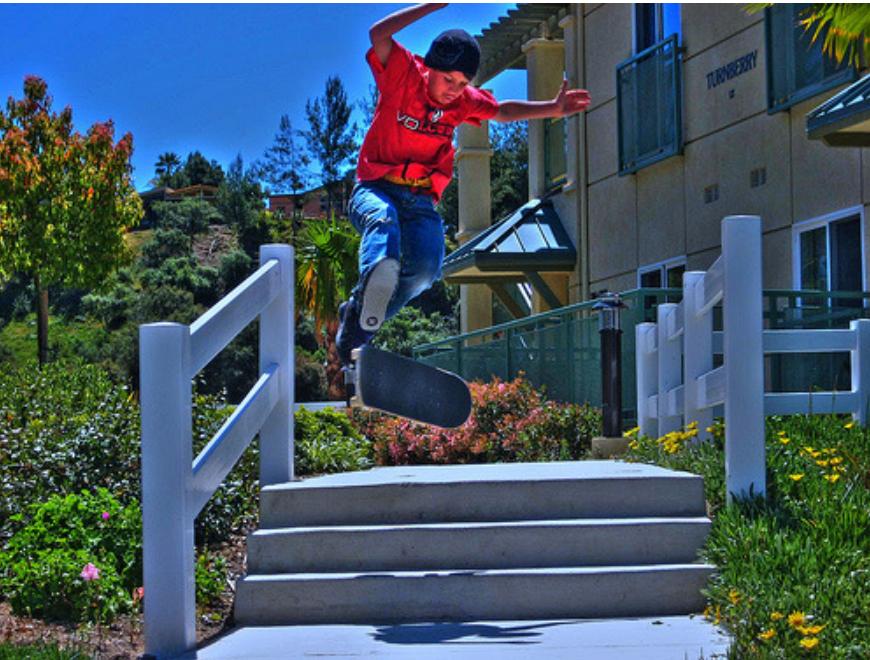
# The Goal of Computer Vision

- Recognize persons and objects



# The Goal of Computer Vision

- Describe visual content



**a man on a skateboard jumping over a railing.**

<https://huggingface.co/spaces/SRDdev/Image-Caption>

# The Goal of Computer Vision

- Enhance photo quality



Image super-resolution

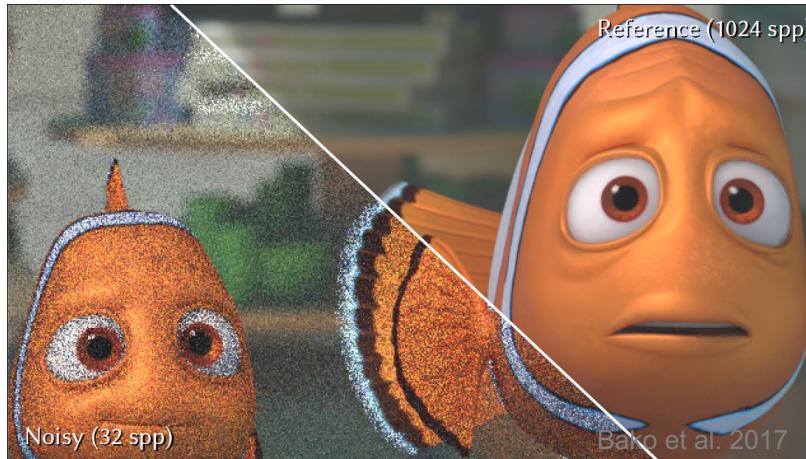


Image denoising



Low-light image enhancement



Image deblurring



Image deraining

# The Goal of Computer Vision

- Manipulate photos



Image inpainting [theinpaint.com]



Style transfer [Gatys et al. 2016]

# The Goal of Computer Vision



Which image was produced by humans?

# The Goal of Computer Vision

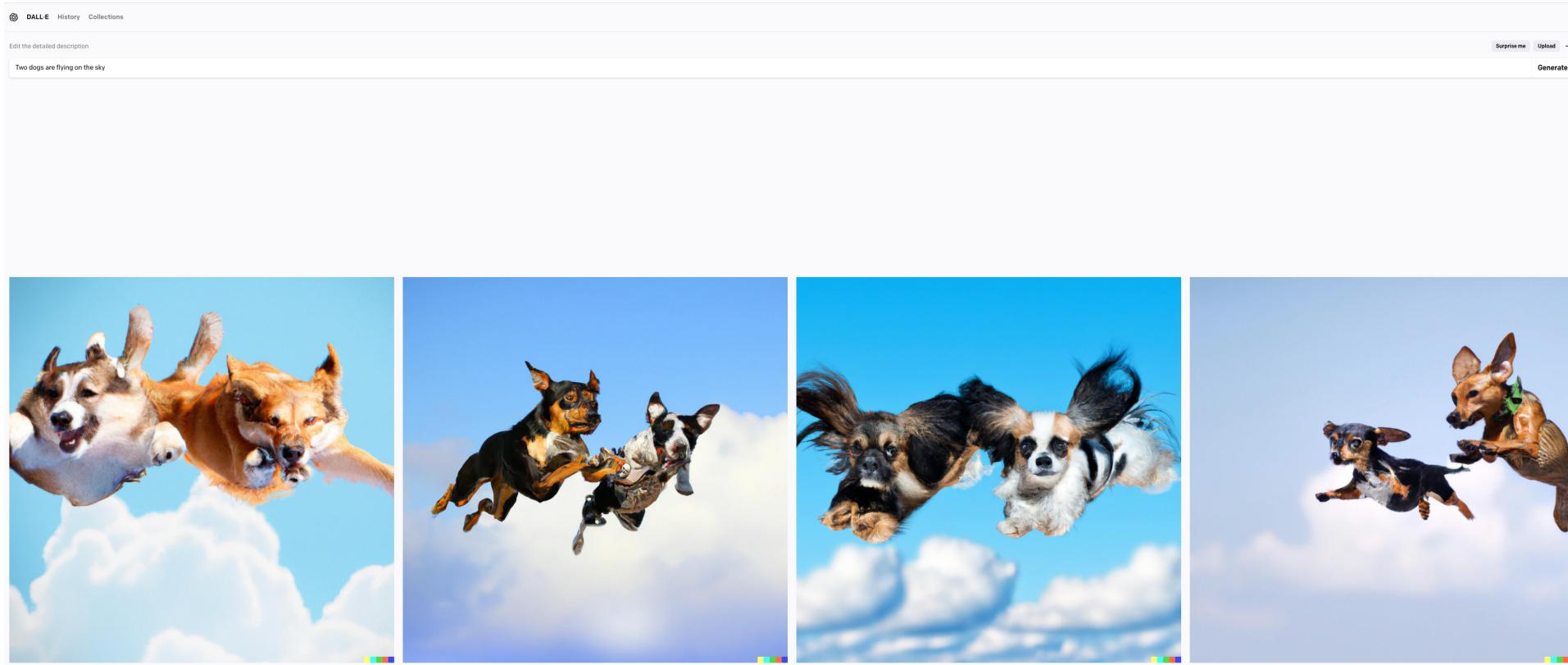
- Generate visual content by AI



DALL-E 2@OpenAI

# The Goal of Computer Vision

- Generate visual content by AI



# Why study computer vision?

- Billions of images/videos captured per day



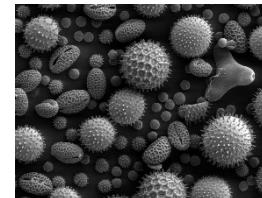
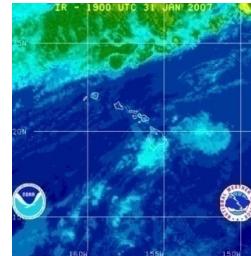
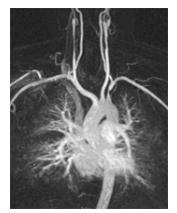
flickr



Google Photos



YouTube

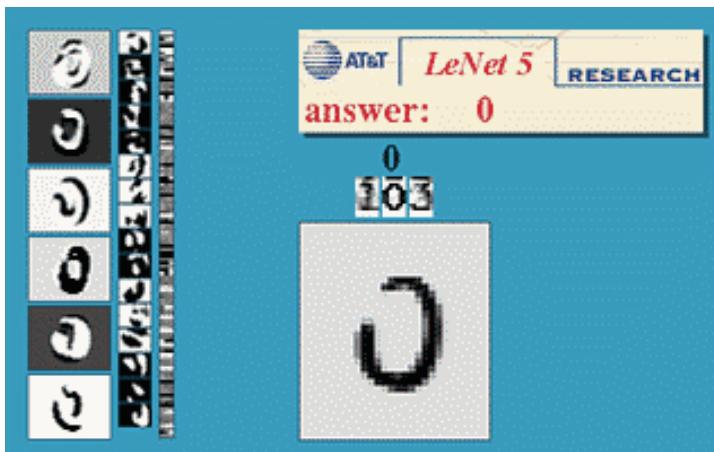


- Huge number of potential applications

Slide Credit: Noah Snavely

# Optical Character Recognition (OCR)

- recognize text from scanned images and documents



Digit recognition, Yann LeCun. (1990's)



Automatic check processing

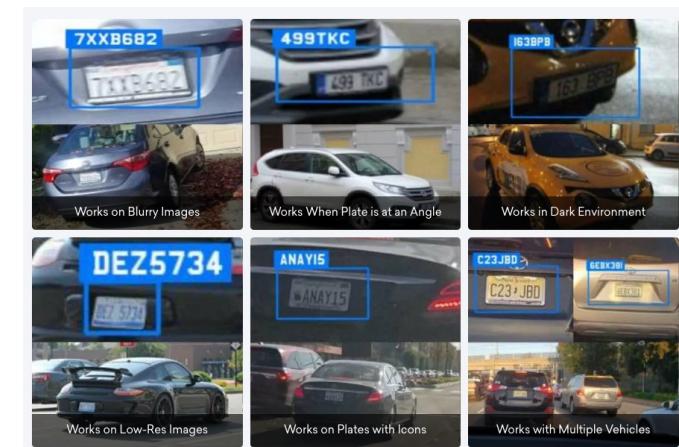


Plate recognition

# Biometric

Biometric techniques are methods used to identify individuals based on their physical or behavioral characteristics.



<https://modelcards.withgoogle.com/face-detection>



FaceID



A facial recognition system for law enforcement [Credit: Saul Loeb]

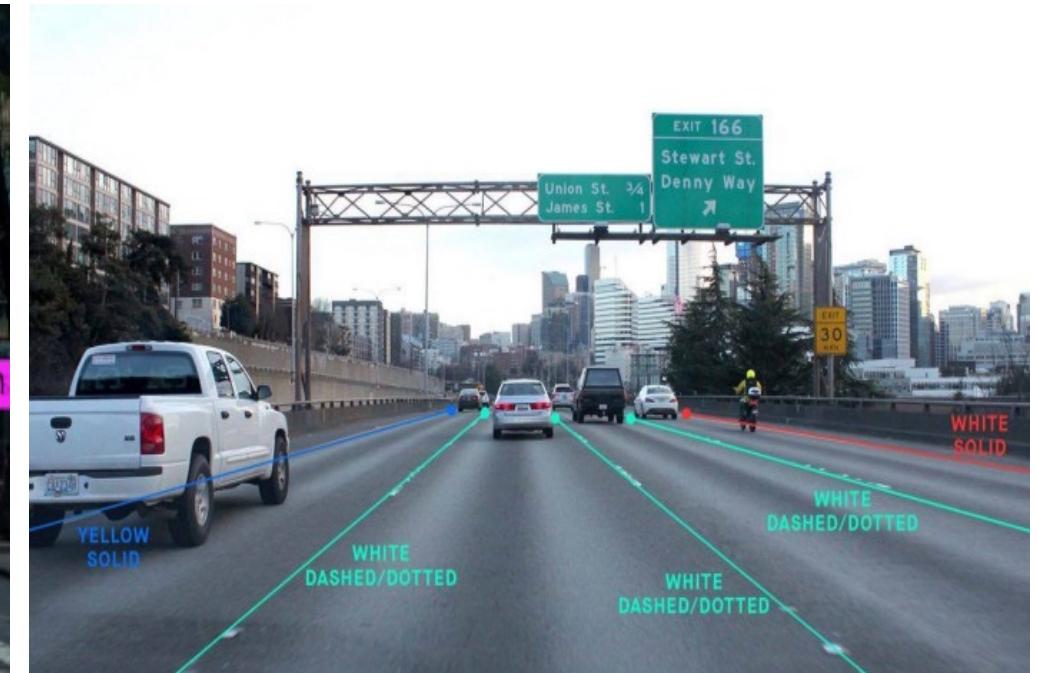
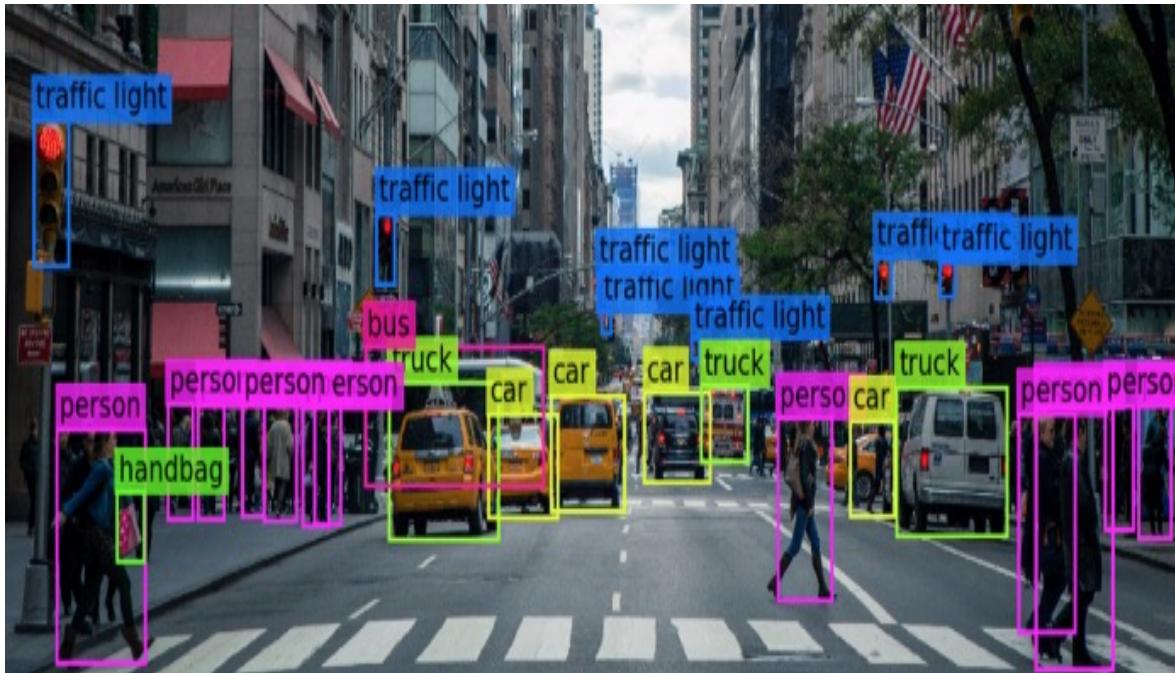


Access control

## Face Detection and Recognition

# Autonomous Driving

- Detect persons, cars, and lanes on roads and streets



Source: <https://medium.com/@safk8899/computer-vision-in-autonomous-vehicles-21dffaa873b23>

# Tesla Self-Driving Car



[https://vimeo.com/192179726?embedded=true&source=vimeo\\_logo&owner=128712855](https://vimeo.com/192179726?embedded=true&source=vimeo_logo&owner=128712855)

# Robotics

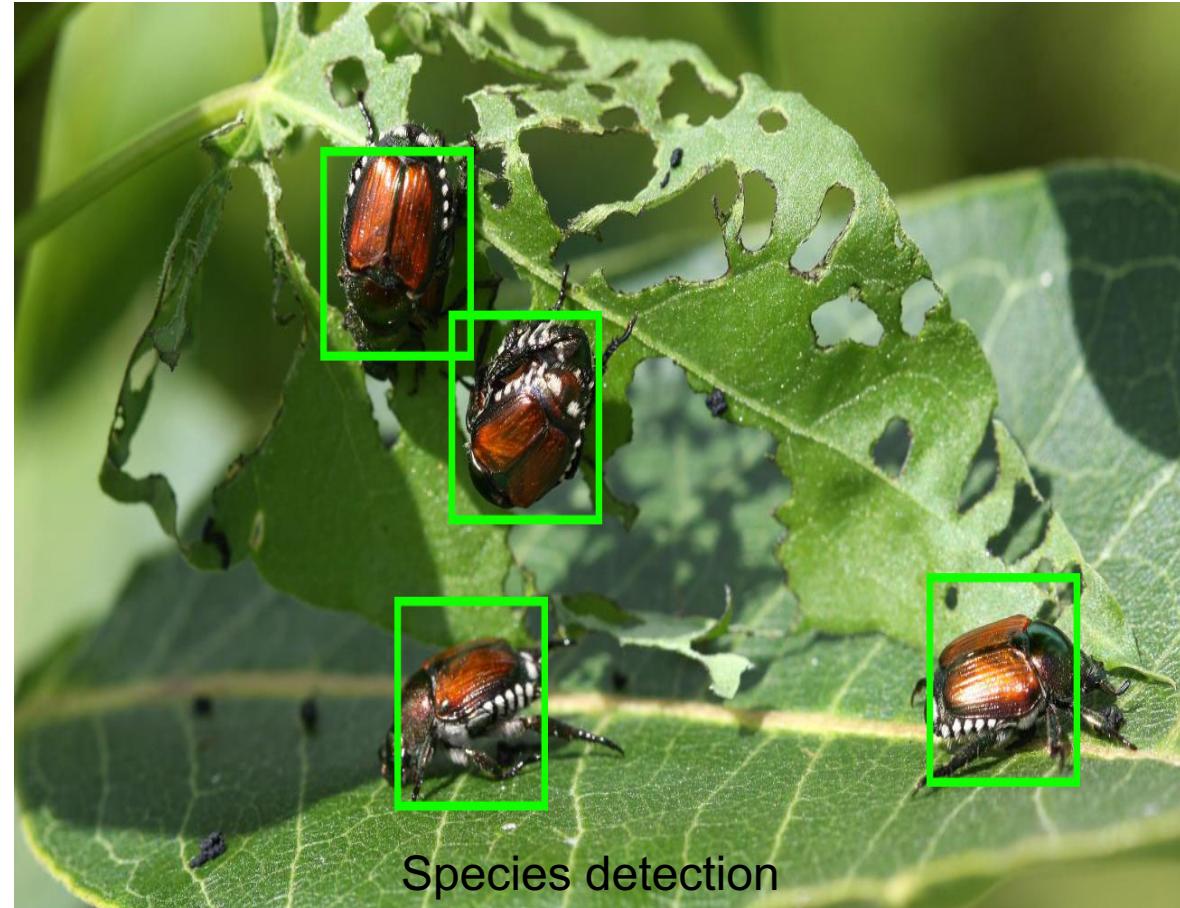
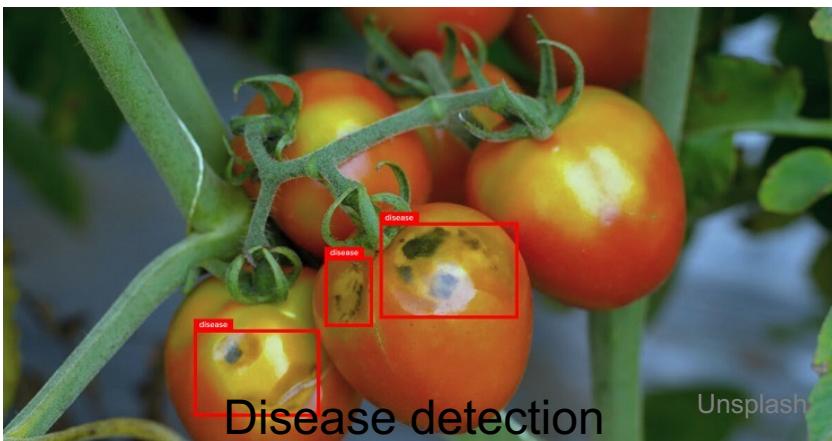


Automotive Manufacturing



Delivery Robots

# Agriculture



# Healthcare



<https://www.youtube.com/watch?v=nezqrfAP-g8>

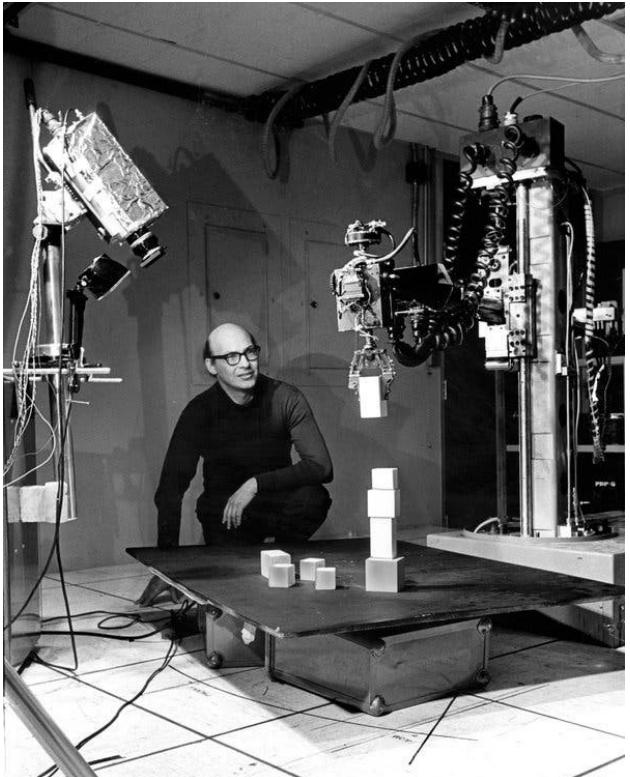
# Virtual/Augmented Reality



Meta's Codec Avatars

<https://www.youtube.com/watch?feature=oembed&v=w52CziLgnAc>

# The Origin of Computer Vision

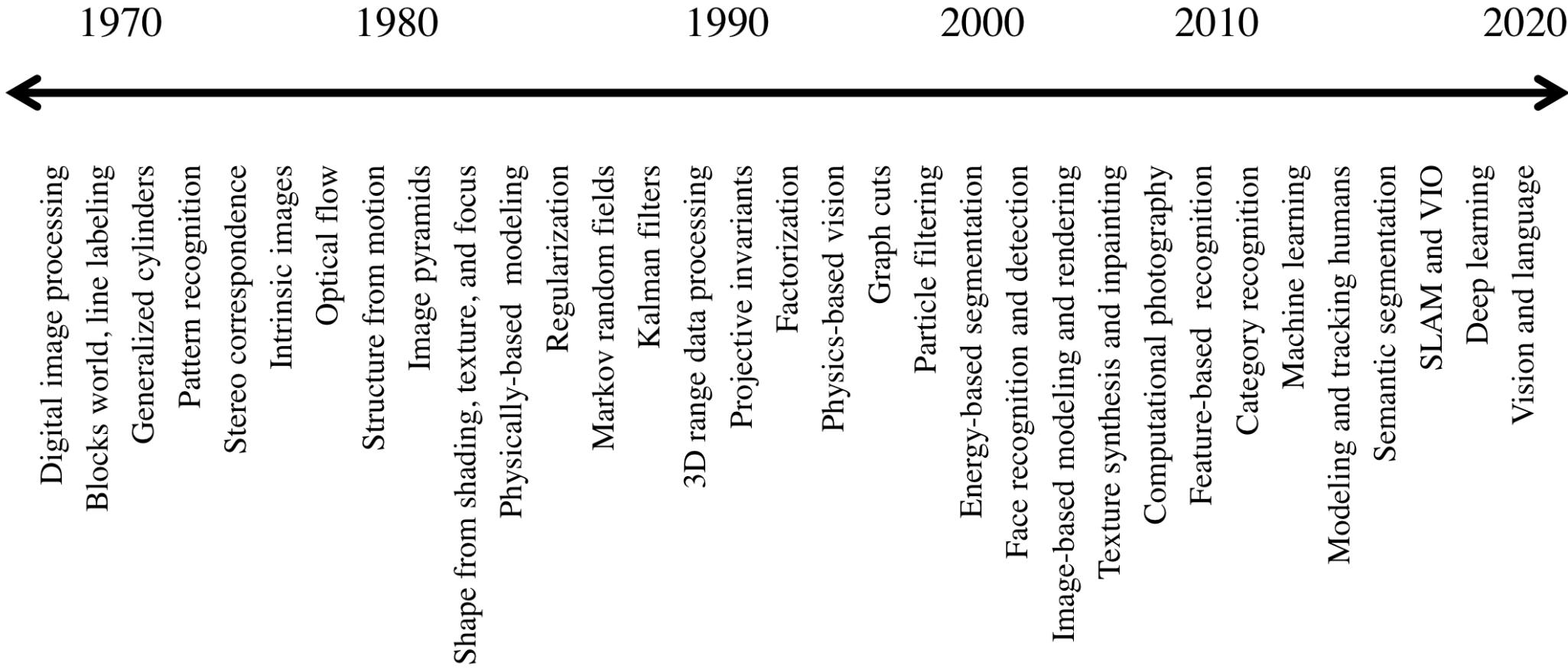


Marvin Minsky in a lab at M.I.T. in 1968.

- 1970s: Viewed as the visual perception component of an ambitious agenda to mimic human intelligence and to endow robots with intelligent behavior.
- At the time, it was believed by some of the early pioneers of AI and robotics that solving the “visual input” problem would be an easy step along the path.
- An undergraduate project assigned by Marvin Minsky in 1966: *“spend the summer linking a camera to a computer and getting the computer to describe what it saw.”*

Computer vision is far more complex than they thought!

# Timeline of Active Topics in Computer Vision



An active research area, rapidly changing, big progress made in recent 10 years!

# Why is computer vision difficult?



Slide Credit: Noah Snavely



Scale

# Why is computer vision difficult?



Intra-class variation



Motion (Source: S. Lazebnik)



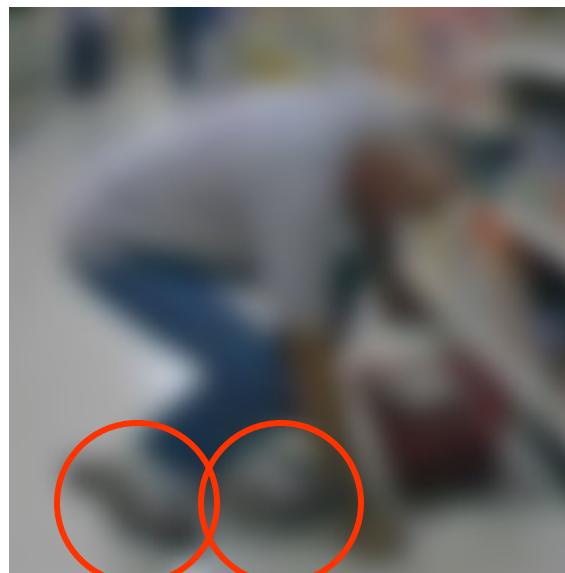
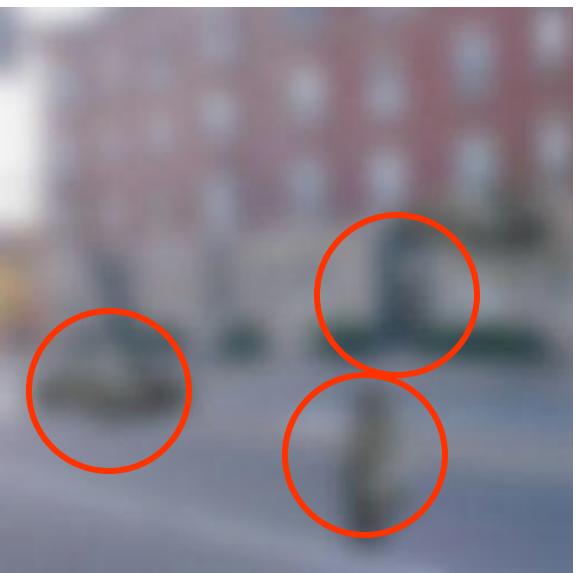
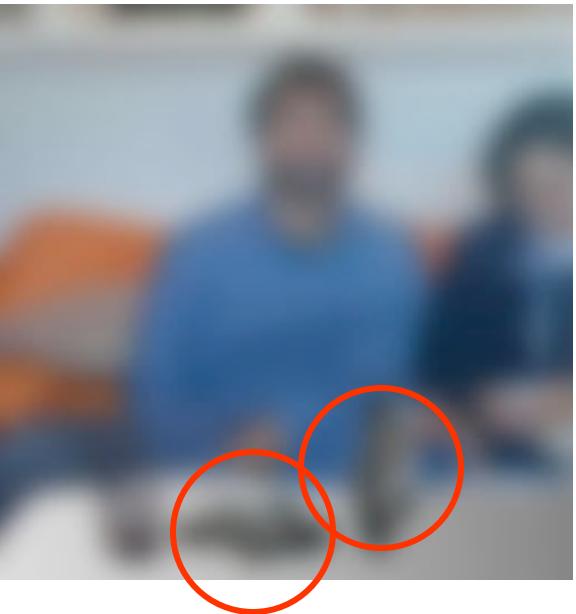
Background clutter



Occlusion

Slide Credit: Noah Snavely

# Challenges: local ambiguity



Slide Credit: Fei-Fei, Fergus & Torralba

# What will you learn?

Image Formulation and Processing

Feature Detection and Matching

Deep Learning in Computer Vision

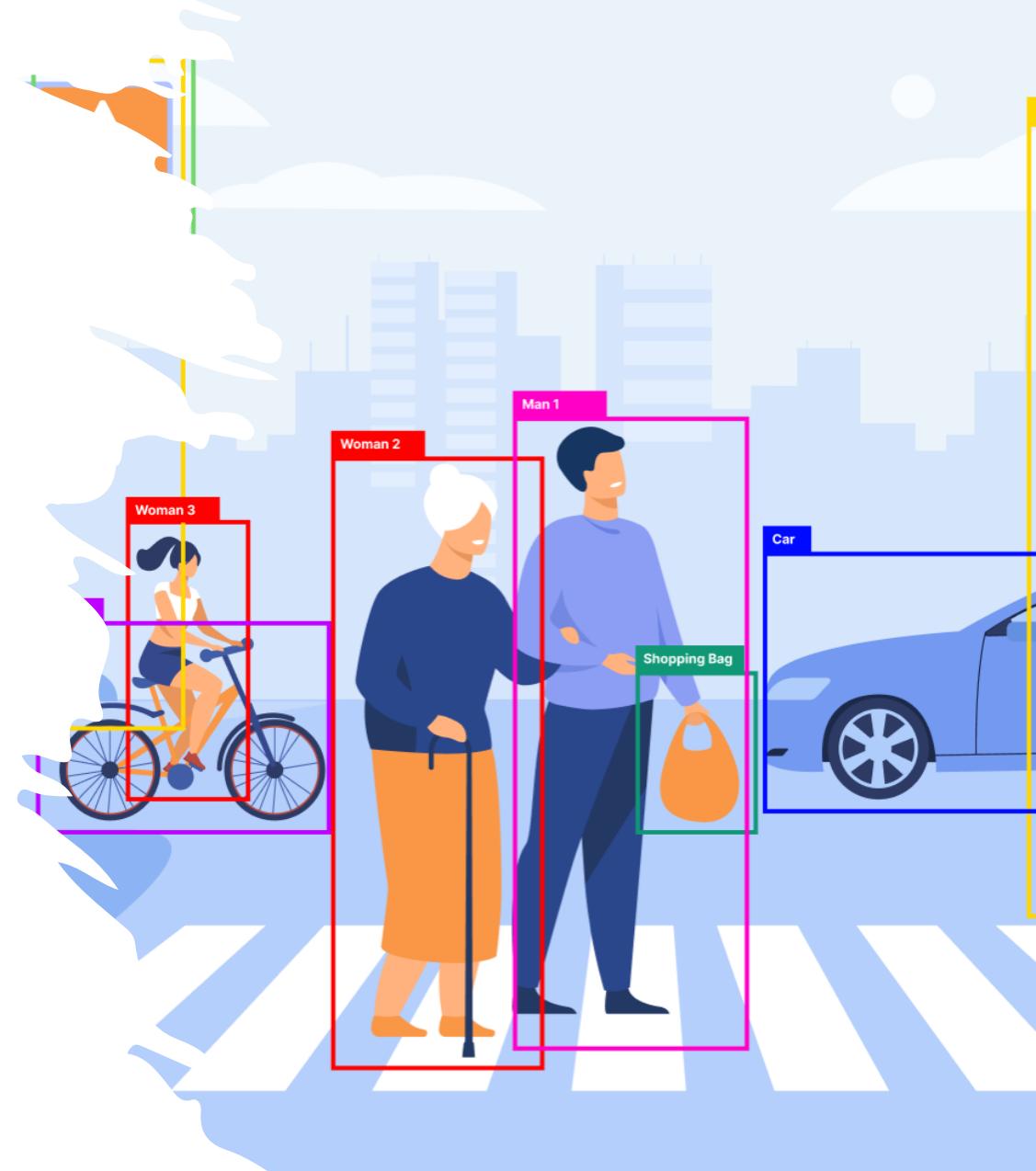
Visual Recognition

Visual Motion

3D Vision

Advanced Topics in Computer Vision

- NeRF, visual representation learning, vision and language, vision and audio



# Course Details

Richard Szeliski. Computer Vision: Algorithms and Applications. Second Edition, 2022.

Available online: <https://szeliski.org/Book/>

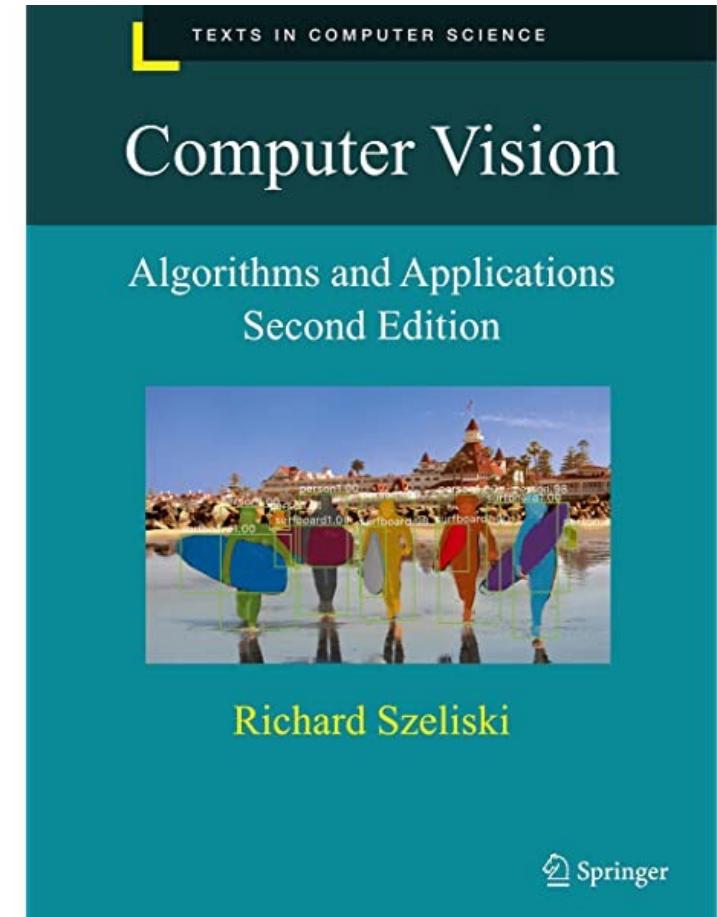
My office hour:

Tuesday 2pm - 4pm, ECSS 4.211

TA office hour: TBD

Course website: [www.yapengtian.com/t/6384S23](http://www.yapengtian.com/t/6384S23)

Course access and navigation: [eLearning](#)



# Grading Policy

## Homework (50%)

- 5 homework in total
- Submit all homework assignments on time. Collaboration is allowed but final work is done independently, and all collaborators should be acknowledged.
- Individual submission

## Team Project (40%):

- Develop and implement a method to solve a vision-related problem
- 2-3 students for a project
- Project proposal (5%)
- Project mid-term report (5%)
- Project presentation (10%)
- Project final report (20%)

## In-class Activity (10%)

- 10 quizzes

No final exam!

# Late Submission

- For the assignments (not including your final project report), students will be allowed a total of **five** late days per semester
- Each additional late day will incur a 20% penalty

# Questions?