Announcement

1/16/2025 Thursday

- CSCE 508
  - Image Processing

- Please pick up the packet in the front as you come in

About me …

- Hao Zheng
  - Assistant professor @ UL Lafayette since 08/2024
  - Born & grew up in China
  - Studied and worked in the US since 2016

- What are possible ways to call me?
  - Professor/Doctor Zheng ← If you can pronounce [dʒ’ɔŋ]
  - Hao ← Absolutely okay
  - Professor Hao / Professor ← If you aren’t comfortable with Hao…

Some more about me…

- I wish I do not, but I make mistakes.

- Especially when it is about details that are not very important.
  - Operation *at t* or *t+1?*

- Don’t feel afraid of speaking it out if something is not normal.
  - Statistics show that you will be right 99 out of 100 times when that happens……

COURSE LOGISTICS

Summary of the printed logistics.

Full version is available on Moodle

Very important… because there are lots of shortcuts to getting an A …

Welcome to CSCE 508

- Instructor
  - Hao Zheng
  - hao.zheng@louisiana.edu
  - Oliver Hall Rm 357
- Guaranteed office hours
  - 1:00-2:30pm on Mondays
  - 2:00-3:30pm on Fridays
- Extra office hours
  - By appointments

- Teaching assistant
  - Clement T. Okolo
  - clement.okolo1@louisiana.edu
  - Oliver Hall Rm 327
- Guaranteed office hours
  - 11:00am-1:00pm on Tuesday
  - 11:00am-1:00pm on Thursday
- Extra office hours
  - By appointments

Communication

- Anything that may influence your final letter grade: via email (@louisiana.edu)
- Less important ones: via Forum in Moodle
  - Let me know if you cannot see it.
- Questions to me: via email/Moodle
  - If it's a personal question, you can email me.
  - If it's likely relevant to others (e.g., question about a homework), please chat in the Moodle Forum.

Course overview

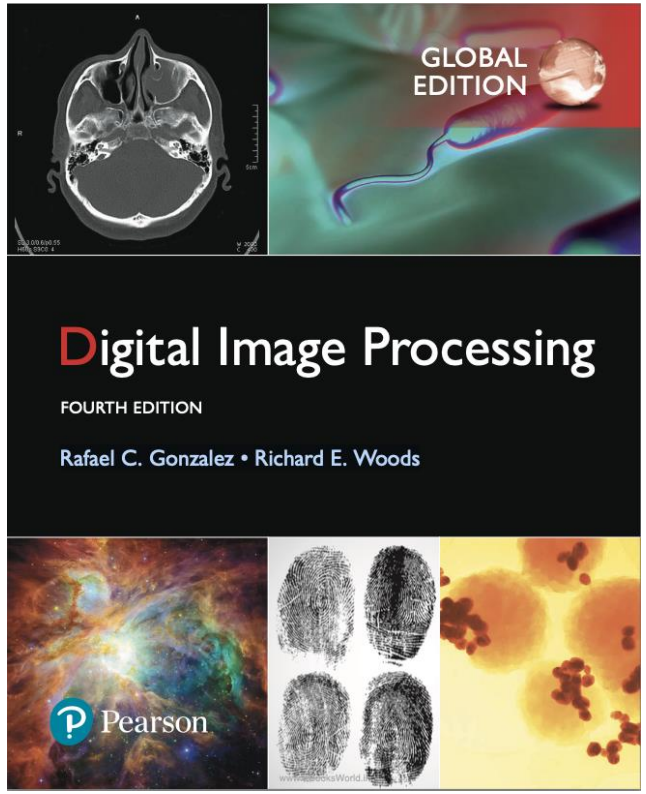
- Course Summary
  - Traditional and modern image processing techniques

- Course Objectives
  - Understand the basic digital image processing (DIP) techniques.
  - Implement classical DIP algorithms.
  - Understand modern ML-based image analysis techniques.
  - Apply ML techniques to solve real-world problems.

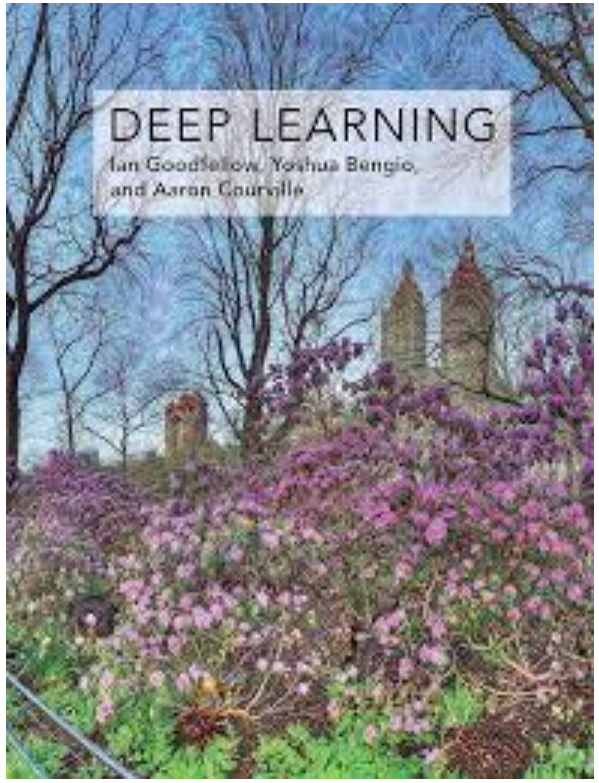
- Prerequisites
  - CMPS 430 (Computer Architecture) and CSCE 507 (Digital Signal Processing)
  - Linear algebra, Multivariate Calculus, and probability
  - Python

Textbook

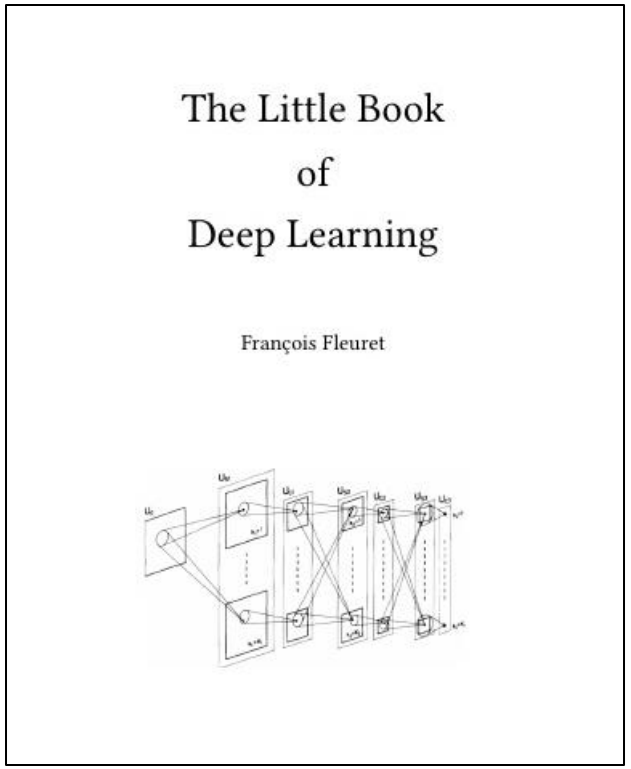
- *Digital Image Processing (Global Edition) (4th edition)* by Rafael C. Gonzalez and Richard E. Woods



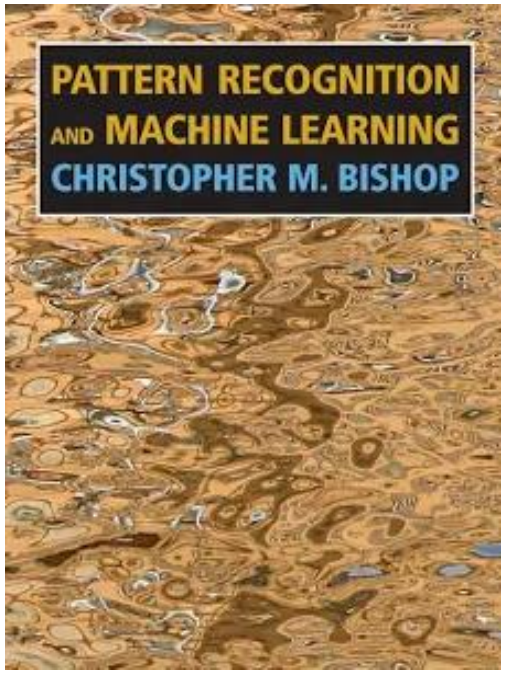
- *Deep Learning* by Ian Goodfellow, Aaron Courville, and Yoshua Bengio

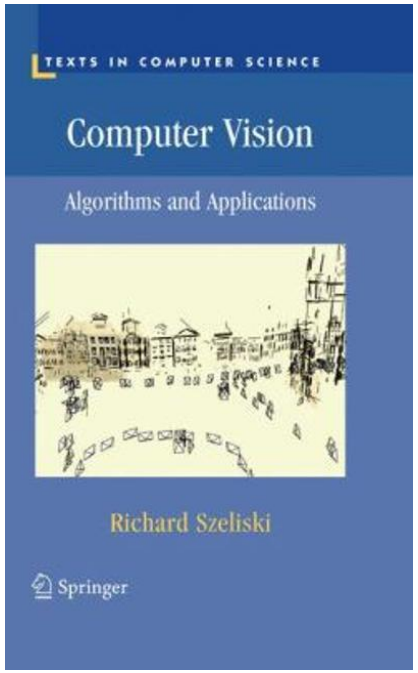


- *The Little Book of Deep Learning* by François Fleuret



Supplementary Materials





- Linear Algebra (YouTube)
- Multivariate Calculus (YouTube)
- Deep Learning for Computer Vision (YouTube)

Evaluation

- **Assignments (x4) (30%)**
- **Participation & Quiz (5%)**
- **Midterm Exam (x1) (15%)**
- **Course Project (x1) (30%)**
- **Final Exam (x1) (20%)**

Grade Scale	
A	>= 90 %
B	89 – 80 %
C	79 – 70 %
D	69 – 60 %
F	< 60 %

★ Make-up exam is only possible (for final) if you give a notice before the exam via e-mail both to me and department head Prof. Margala (and other officials, too, for administrations) with a valid official document (like Med. Doctor report).

Tentative schedule

Month	Week	Contents	Assignments	Final Project
Jan	Week 1 – 2	Introduction		
	Week 3	Image filtering	HW1	
Feb	Week 4 – 6	Image Reg. & Seg	HW2	Team sign up
	Week 6 – 9	Machine Learning	HW3	Proposal due
Mar	Week 10 – 11	Neural Network		Check in 1 (literature & data)
Apr	Week 12	Applications	HW4	Check in 2 (method & exp)
	Week 13 – 14	Project Presentation		
May	Week16	Wrap up & Final		Report

Assignments submission

- Written Problems
  - To process assignments efficiently, I ask you to do the following:
    - Everything is preferred to be **typed** (especially formulae)
      - I will give 0 if I cannot recognize the hand-written answers.
      - Latex source files will be released (including commands/macros useful for writing your answers)
    - Figures/tables/complicated formulae can be hand-drawn.
- Programming Problems
  - All in Python on Colab
  - You need save a copy of the file in your own Google drive, so that you can save your edits.
  - Afterwards, you can download the ipynb file and submit it to Moodle.

Final Project

- Project
  - Topics
    - Select from my designed project
    - Propose your own and get my approval
  - Team members: 1~3 students

- Evaluation
  - Draft Proposal (15%)
  - Revised Proposal (10%)
  - Draft paper (15%)
  - Final paper (40%)
  - Final presentation (20%)

Deadlines

- Written assignments
  - Due at the beginning of the class on the due date.
  - Give back to you in ~10 days
- Programming assignments & Final project milestones
  - Due at 5 PM on the due date.
- Late policy
  - University-excused absences are acceptable upon request prior to the deadline
  - Personal extensions may be given upon request prior to the deadline
    - Up to 1 extension will be given to each student
  - The late penalty increases by 10% per day
  - No more submission will be accepted after 1 week
  - If you finished it but just forgot to submit it, please email it to me ASAP

In-class exercises (ICE)/small quizzes

- In each lecture, there will be 1-2 things that you must know by the end.
  - i.e., lecture objectives

- I will ask 2-4 questions in each ICE and use your answers to measure your understanding.
  - You will spend less than 10 minutes to answer those questions.

- If you do not have any recorded 0's in ICE grades, you benefit from the **gray area policy: pushed up to next grade if less than 1 point away from it.**

- You are explicitly disallowed to participate in ICE remotely. It is easy to detect remote participation, and penalties will be given.

But I understand things happen.

- Up to 1 absence will be excused with an email notice.
  - In-class exercise (ICE) will be excused too.
  - You just need to email me and explain why you need an excuse.

- After then, a proper documentation/notice will be required.
  - E.g., from a doctor; from the university; from your prospective employer

Honor code

- Collaboration policy
  - You are allowed to discuss with other students.
  - But solutions of **ANY students** cannot be sent out.
    - You can explain to your classmates by showing your solutions/codes.
    - You cannot send them to others.
- Online resources
  - Copy & paste is allowed for any internet resources, but you have to
    - Cite the source by giving its full URL, and
    - Explicitly denote what is copied.
  - Directly generating solutions with ChatGPT is prohibited

	Resources	Solutions
Consulting	allowed	cite
Copying	cite	NOT allowed

Any question before we move on…?

Final key messages

Ask me (email/Moodle Forum) if you have any question.

I promise I will never judge you for asking questions.

It does hurt to ask in many cases in real life, but I guarantee that it won’t hurt to ask in my course.

Lecture 01

Introduction to…

“Image Processing”

= What will we learn and why?

(No need to take notes)

What Do You See?

What Do You See?

What Do You See?

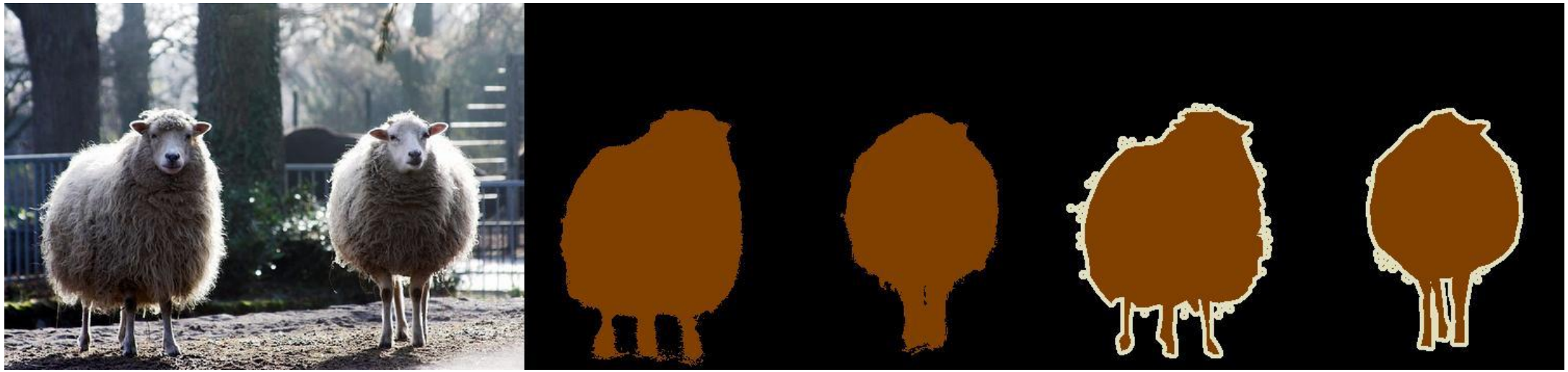


Image understanding: “What does it mean, to see?”

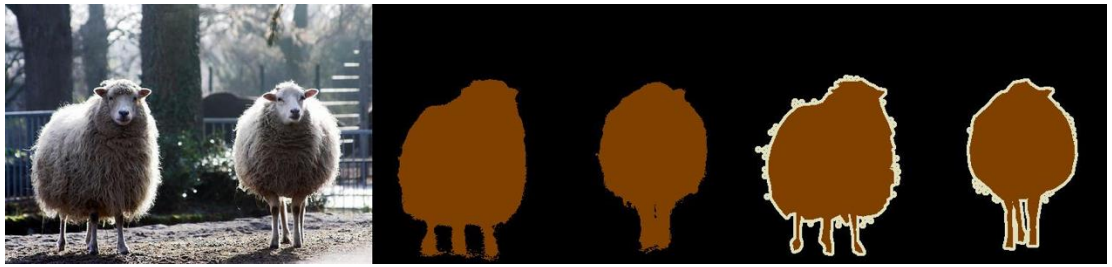
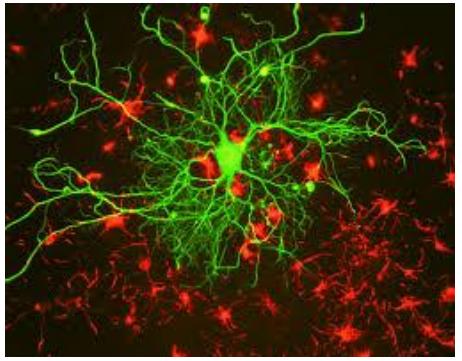


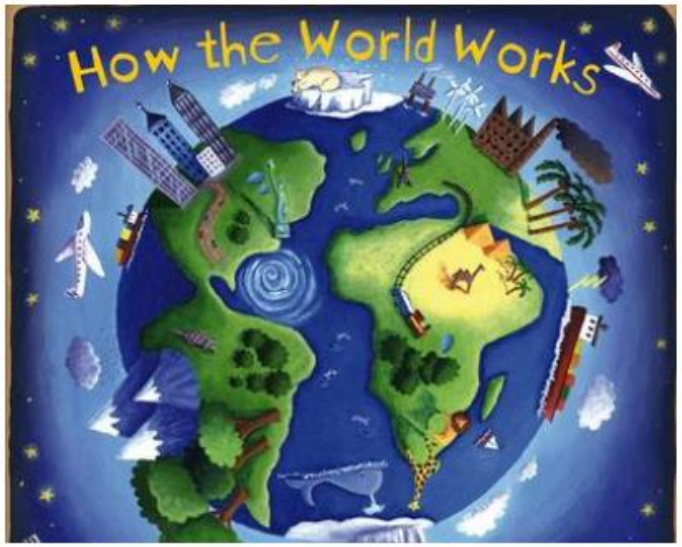
Image: 2D+moment capture
(Projection of real world)

- What is where (inside image)
  - Object: person, bike
  - Location: street
  - Attributes: # of bike, clothes’ colors
- How/Why/… (outside image)
  - Emotion, memory
  - Underlying physics
  - Future forecasting

Image formation



Human vision vs. Computer vision



Visual world:
3D+Time

Human Vision

Image formation

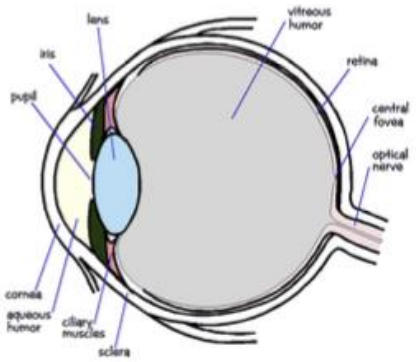


Image understanding

Computer Vision

AI Algorithms
(Focus of the course)

Topics

- What is image
  - Formation, representation
- Conventional techniques
  - Image descriptors, filtering, transformation
- Modern techniques
  - Artificial neural network
  - Deep learning
- Applications
  - Detection, classification, segmentation

Image Representation

- What is an image?
  - Image representation

An array of brightness values, represented as a 2D matrix of integers

Image Representation

- What is an image?
  - Color representation

An array of color values

Each color value is a vector

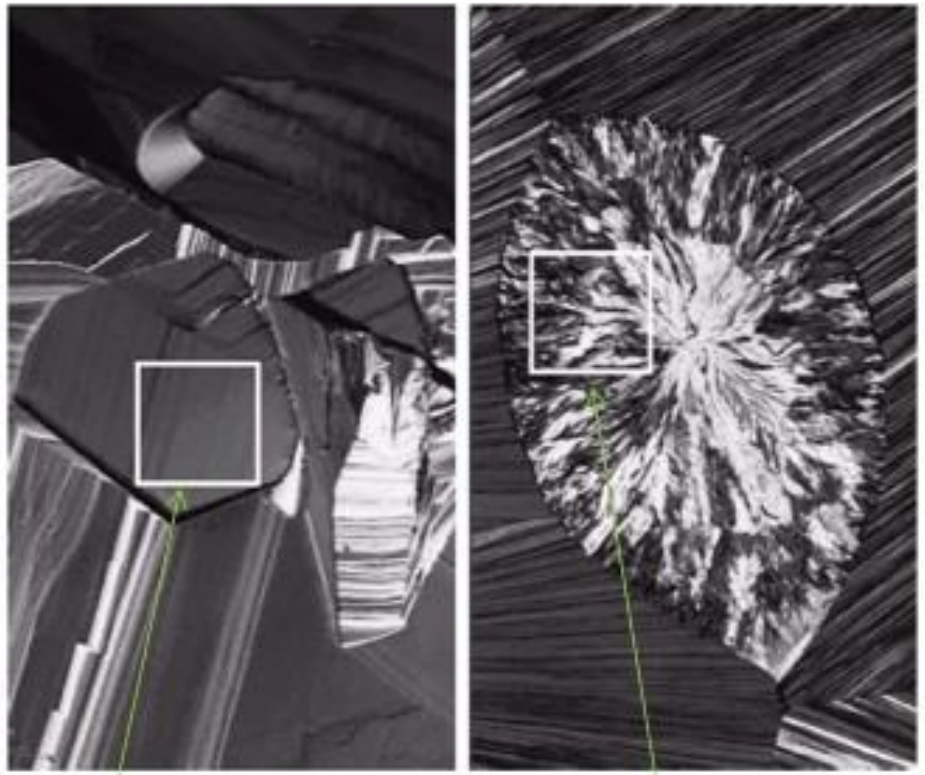
Encodes the luminance and chrominance information

Image Appearance

Color + Texture

Texture

Texture



Standard deviation of pixel values = 11.79

Standard deviation of pixel values = 74.63

#gray levels

$$\sigma^2(z) = \sum_{i=0}^{L-1} (z_i - m)^2 \, p(z_i)$$

Average of pixel values

Normalized gray-level histogram

Corner Detection

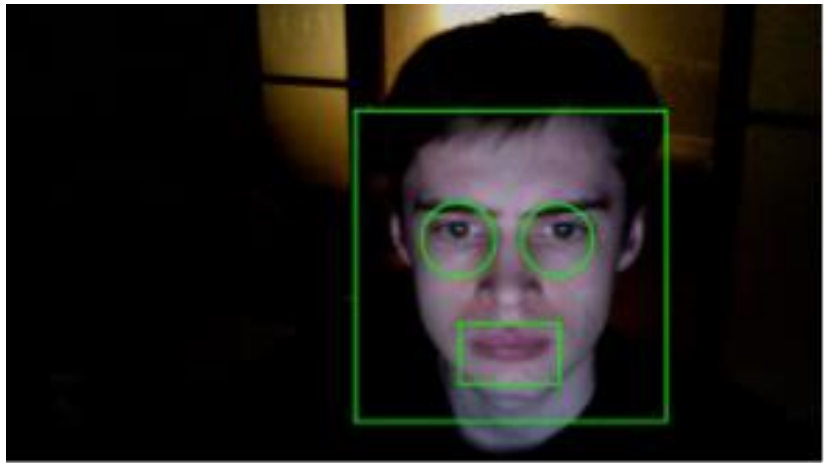
463 corners found

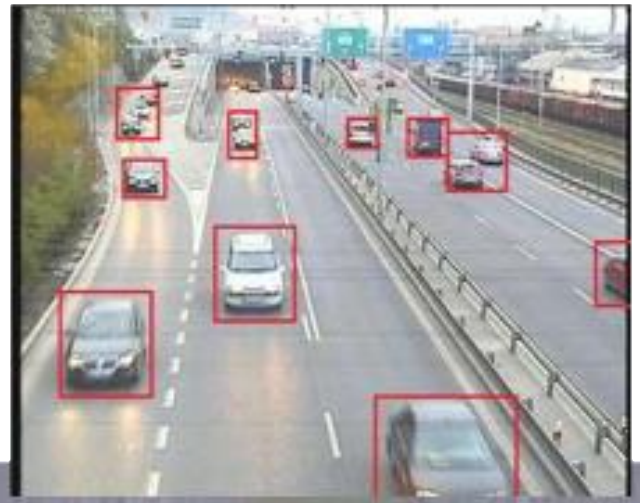
How do we find the corners?

A pixel is a corner if there are significant intensity jumps in two directions

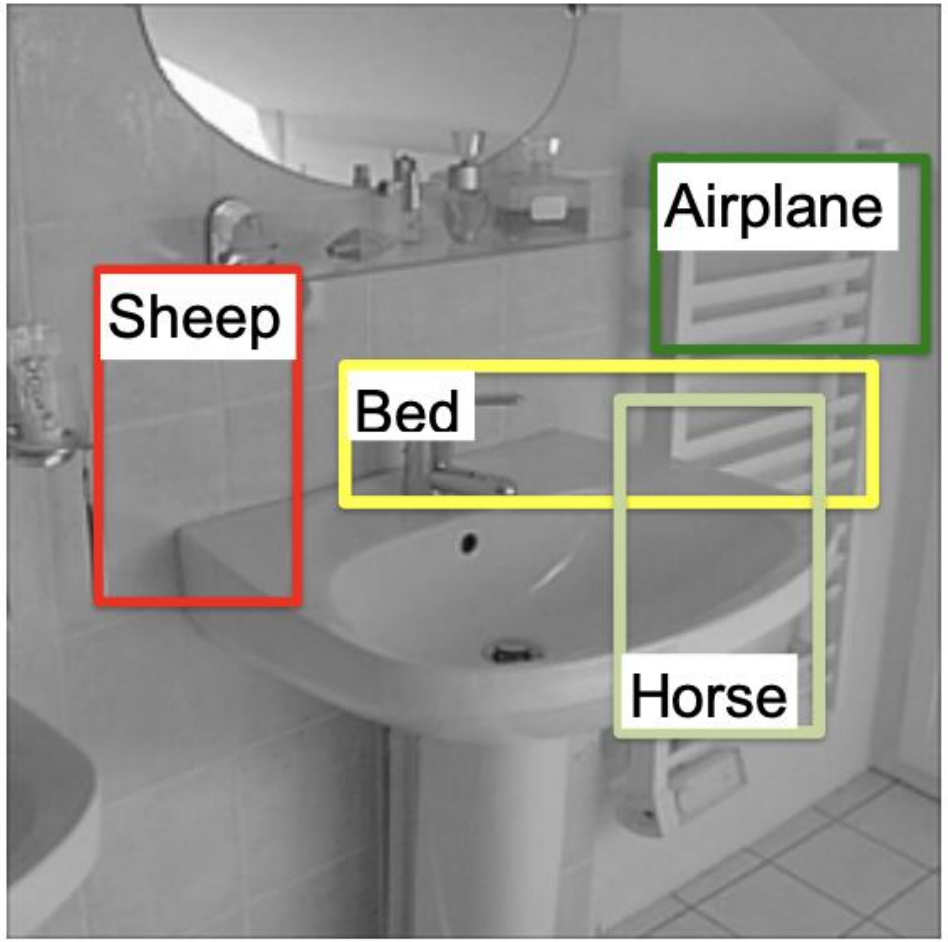
Determined from the gradient of the intensities

Object Detection





However, even 10 years ago



Object detection result
from the best method then

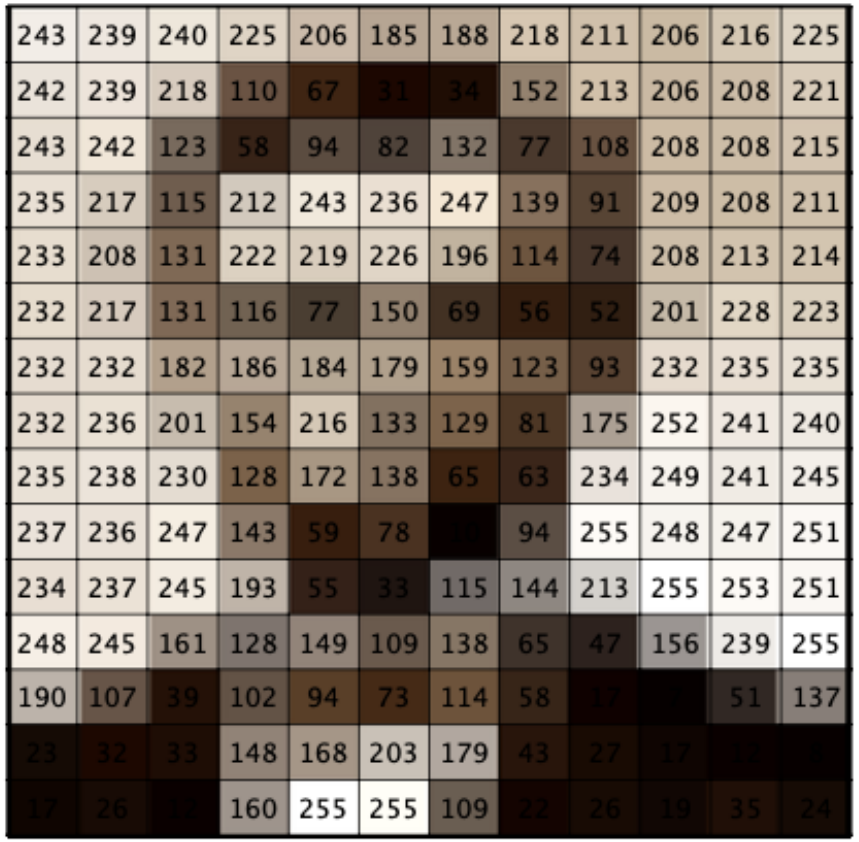
Challenge 1: need much extra knowledge

243	239	240	225	206	185	188	218	211	206	216	225
242	239	218	110	67	31	34	152	213	206	208	221
243	242	123	58	94	82	132	77	108	208	208	215
235	217	115	212	243	236	247	139	91	209	208	211
233	208	131	222	219	226	196	114	74	208	213	214
232	217	131	116	77	150	69	56	52	201	228	223
232	232	182	186	184	179	159	123	93	232	235	235
232	236	201	154	216	133	129	81	175	252	241	240
235	238	230	128	172	138	65	63	234	249	241	245
237	236	247	143	59	78	10	94	255	248	247	251
234	237	245	193	55	33	115	144	213	255	253	251
248	245	161	128	149	109	138	65	47	156	239	255
190	107	39	102	94	73	114	58	17	7	51	137
23	32	33	148	168	203	179	43	27	17	12	8
17	26	12	160	255	255	109	22	26	19	35	24

What computers see

→ ???

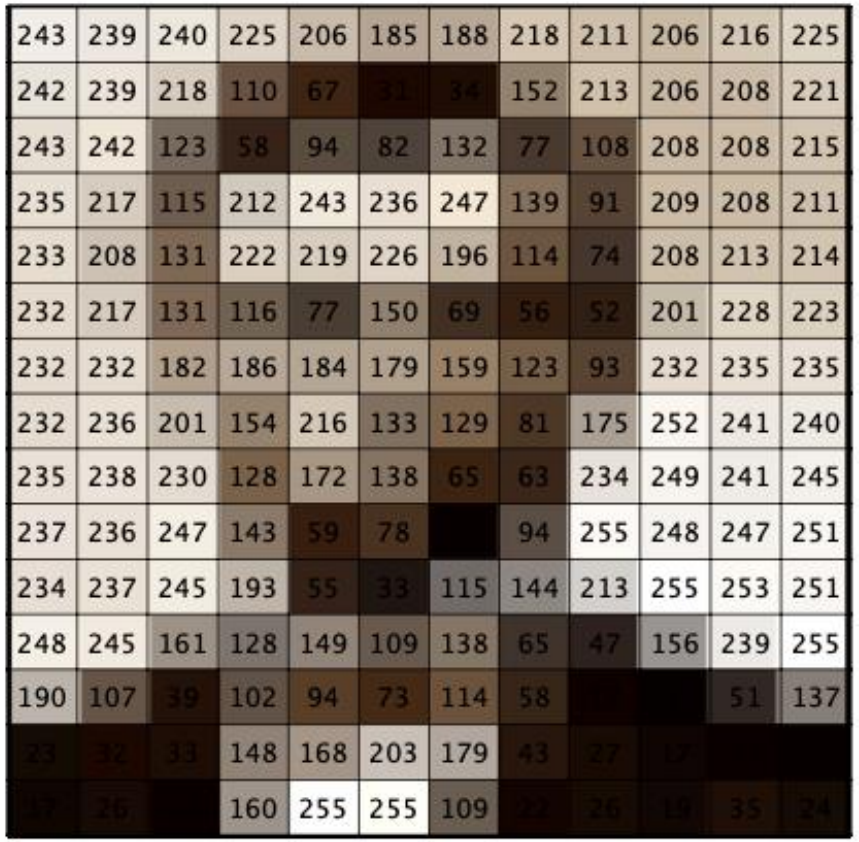
Challenge 1: need much extra knowledge



What human see

→ ???

Challenge 1: need much extra knowledge



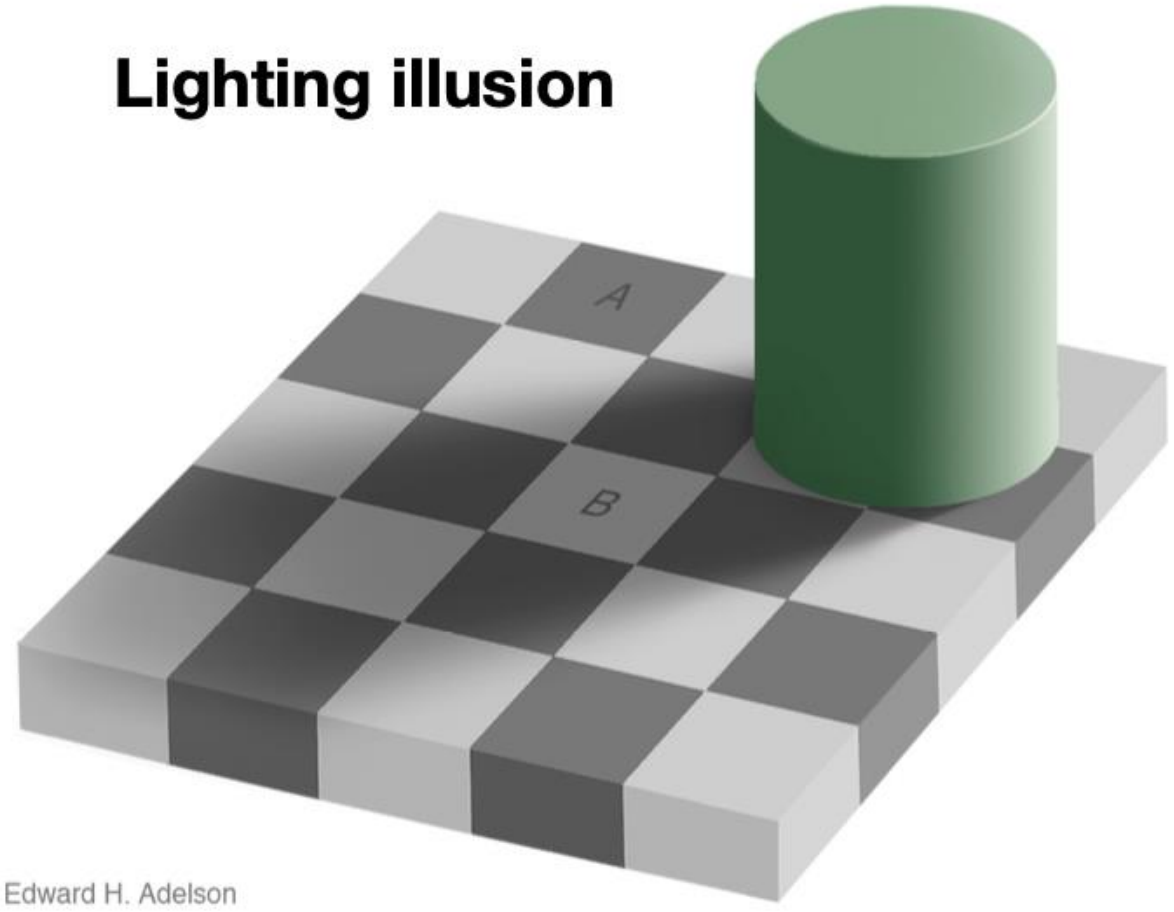
What human see

+ **Extra knowledge**

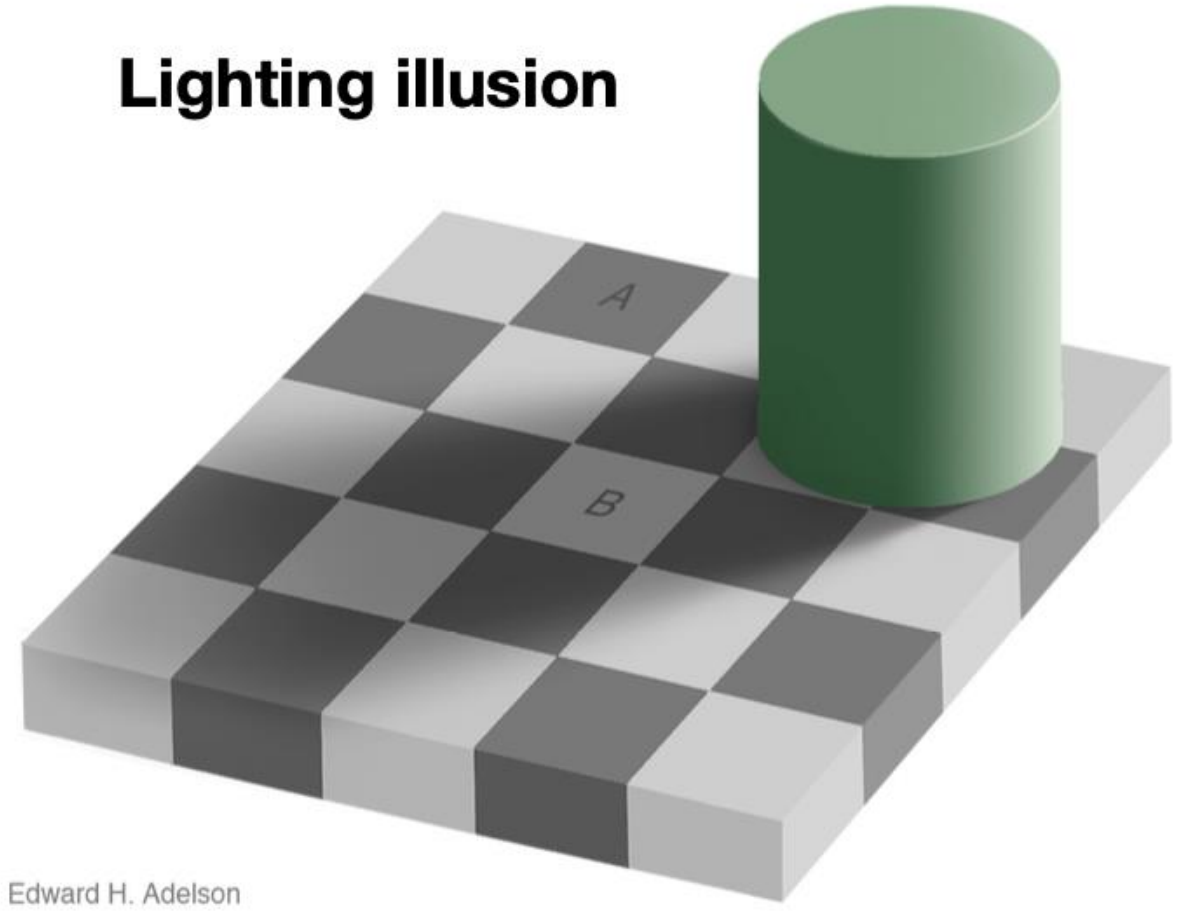
(e.g., History)

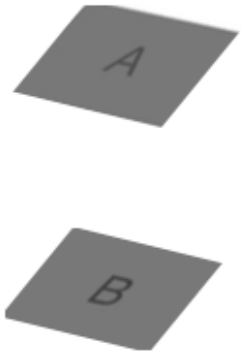
→ President Lincoln

Challenge 2: extra knowledge may backfire

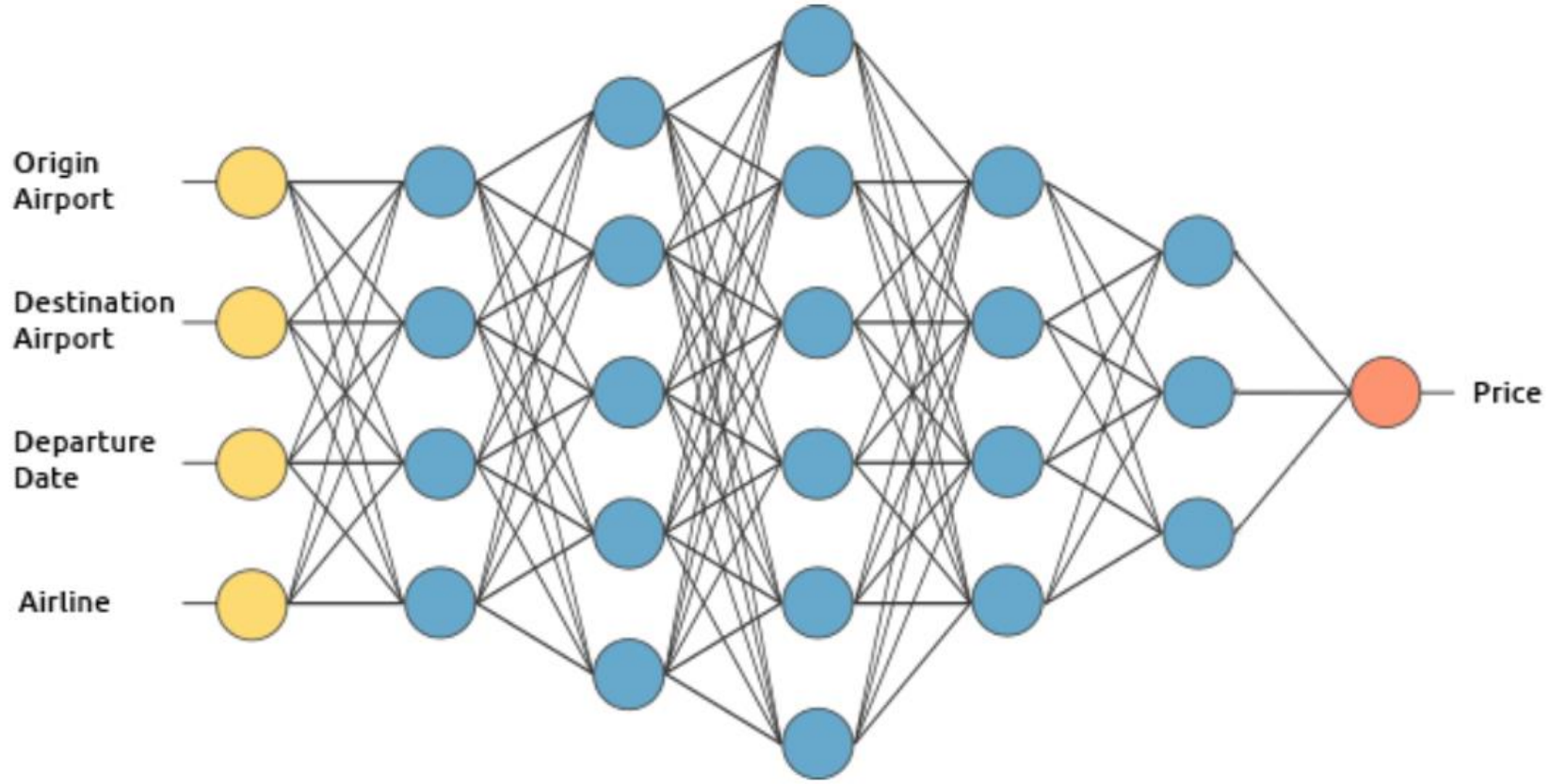


Challenge 2: extra knowledge may backfire





Nowadays: with the deep learning technology




27.9 FPS

Why you should study Image Processing

Service of the common good

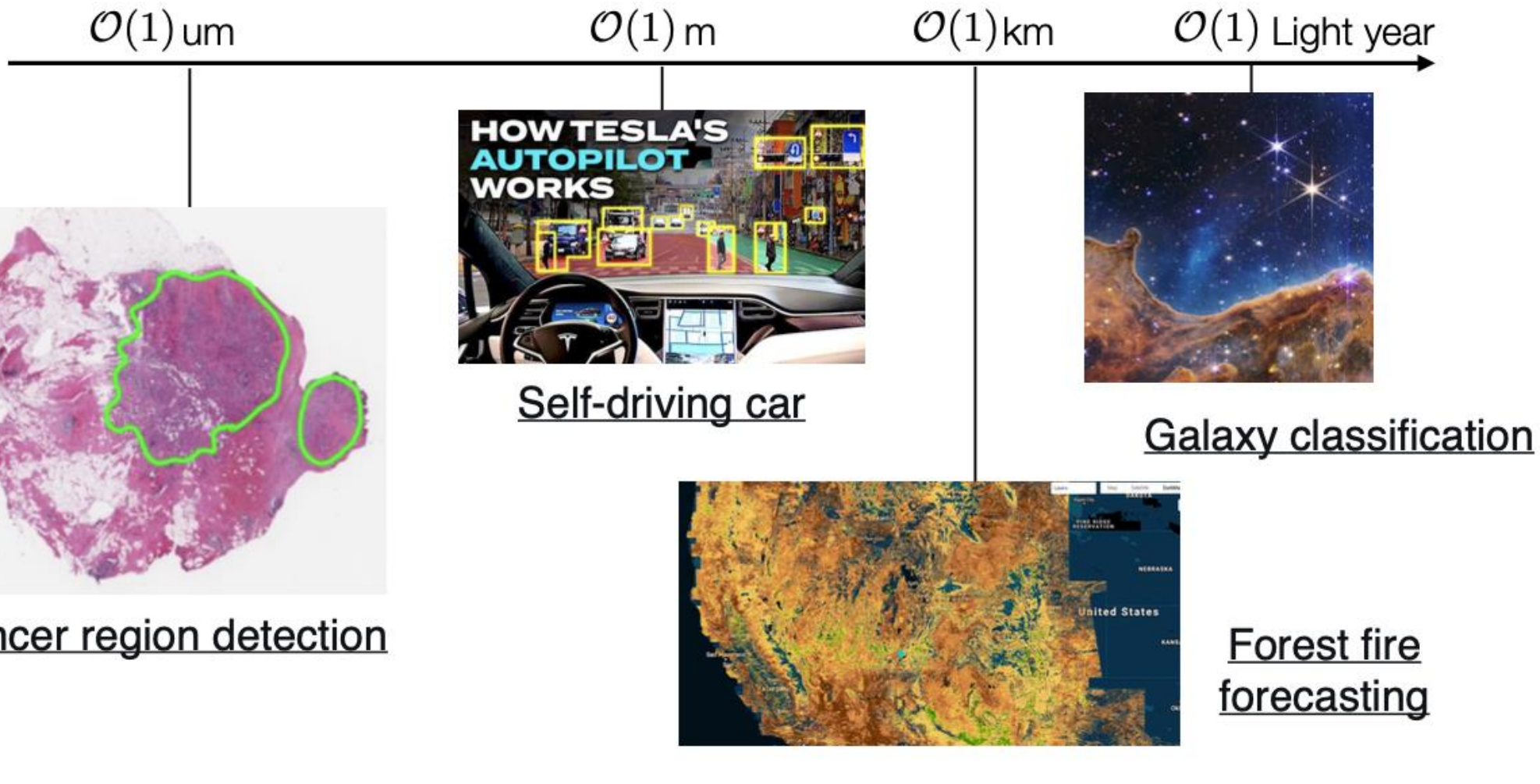
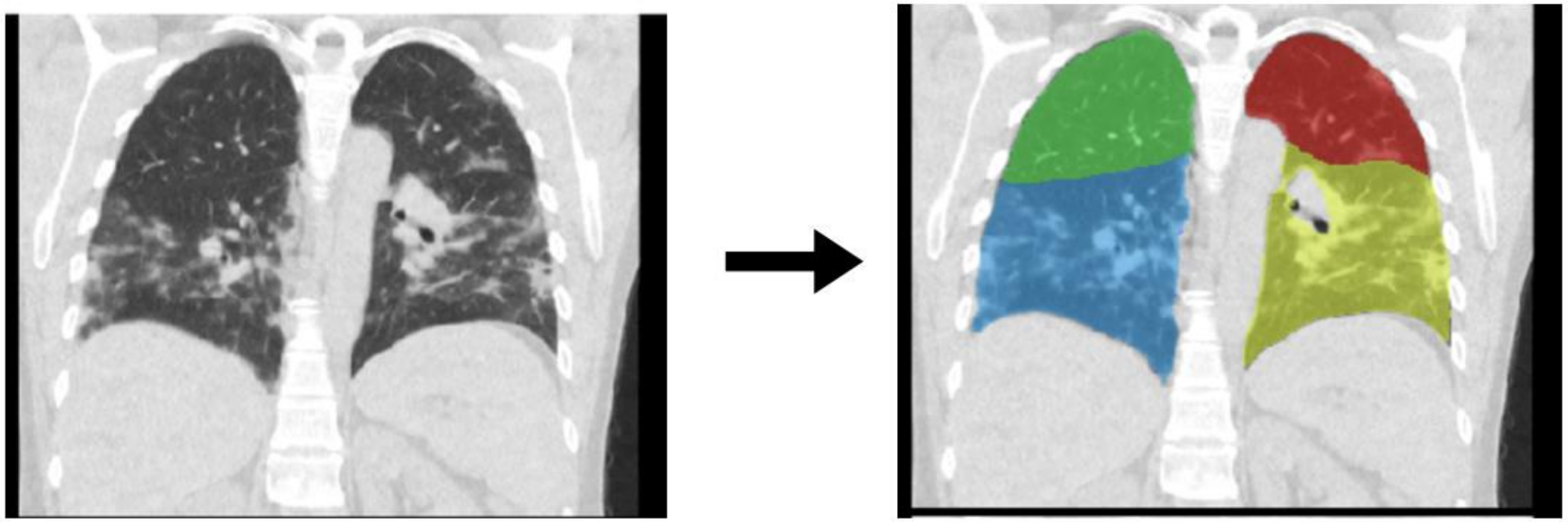


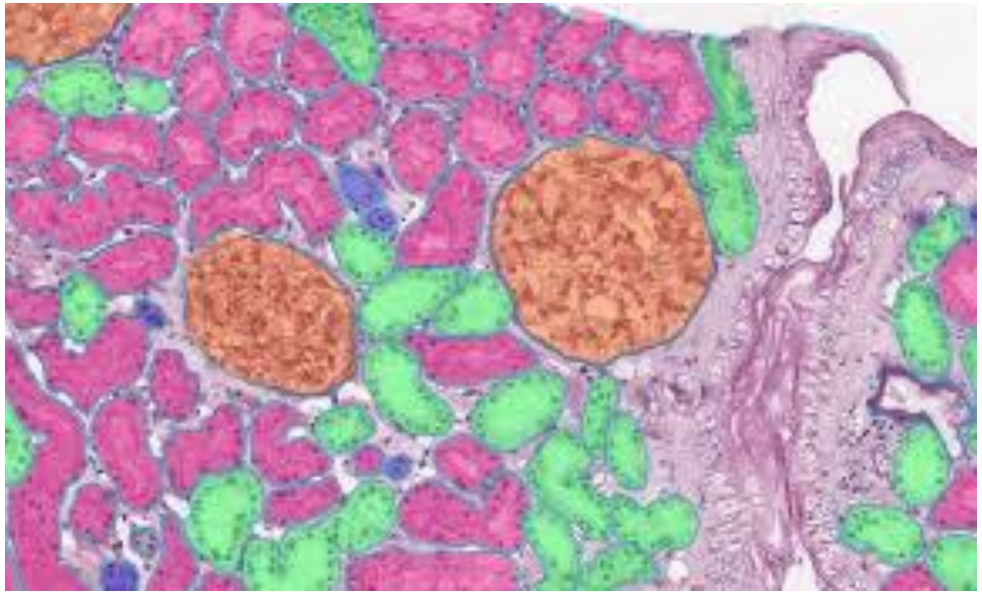
Image processing for healthcare

Semantic segmentation for medical images

Lung lobe segmentation from CT scans

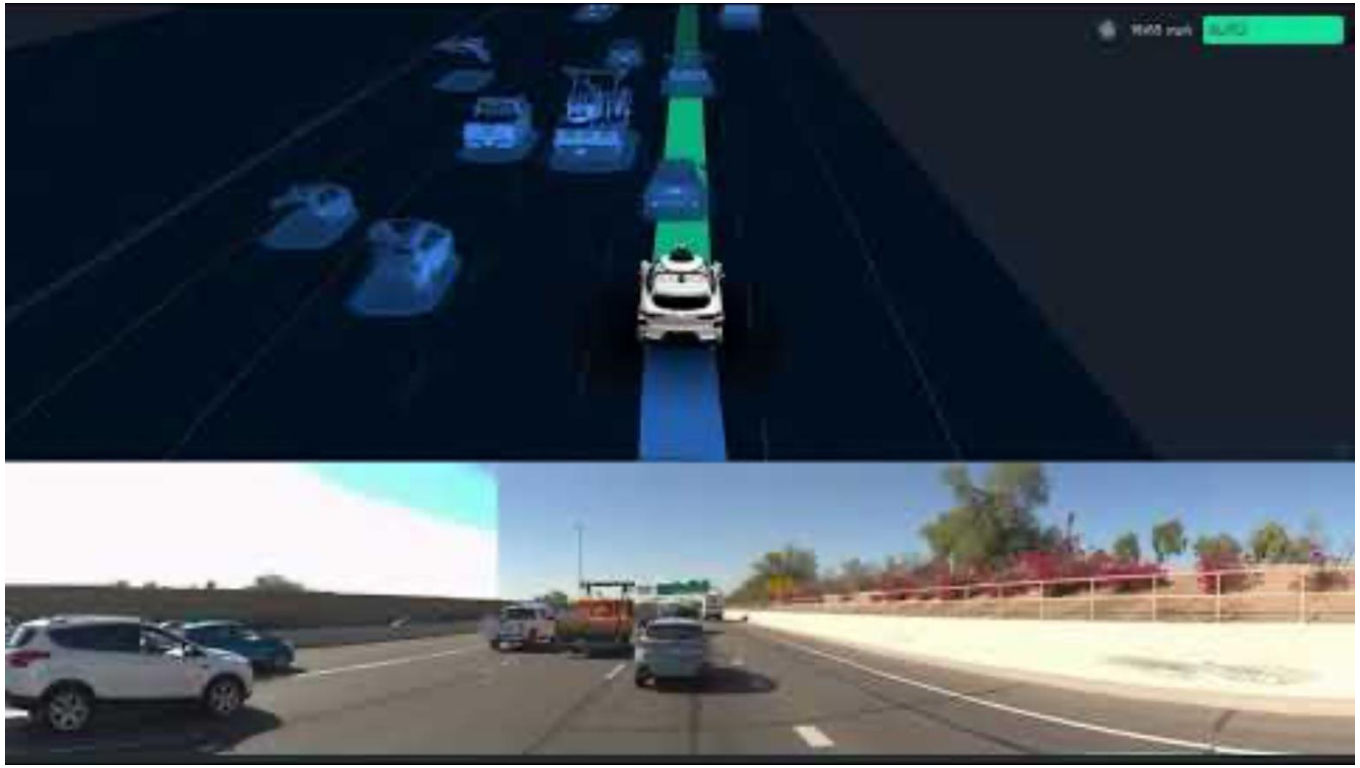


Computational pathology

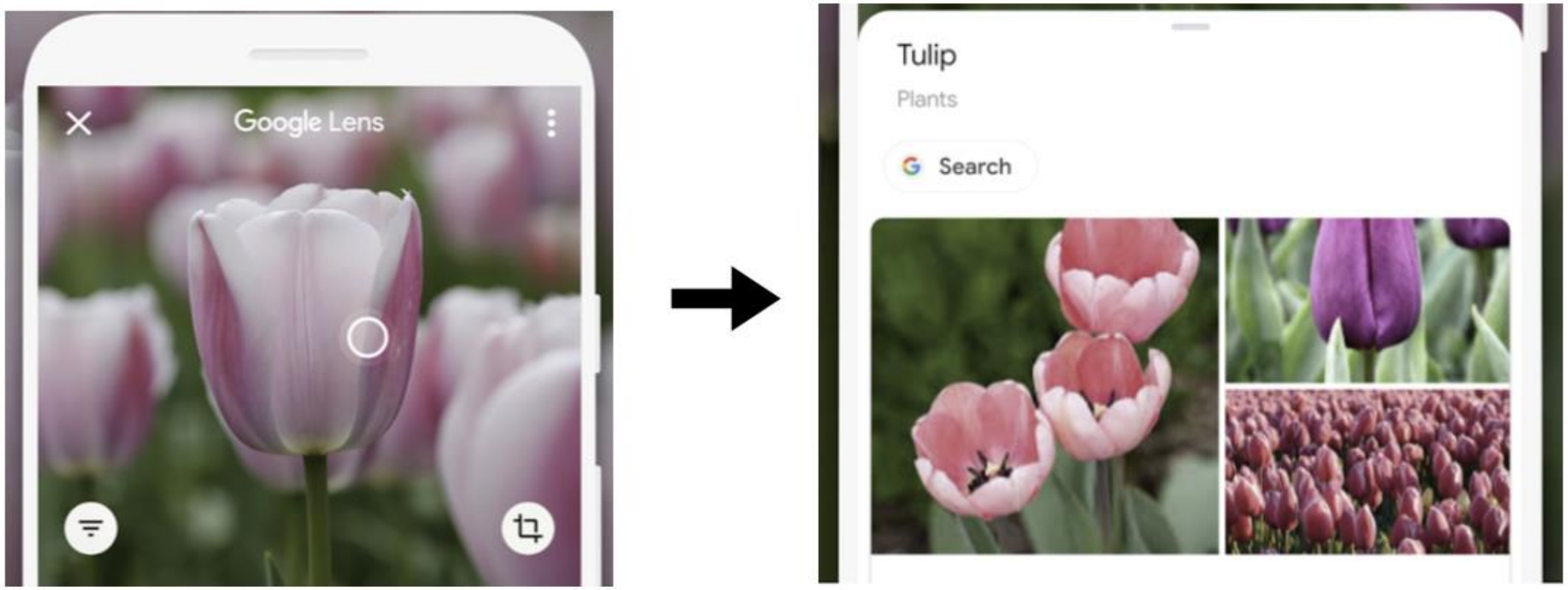


Autonomous driving

- Waymo robotaxi

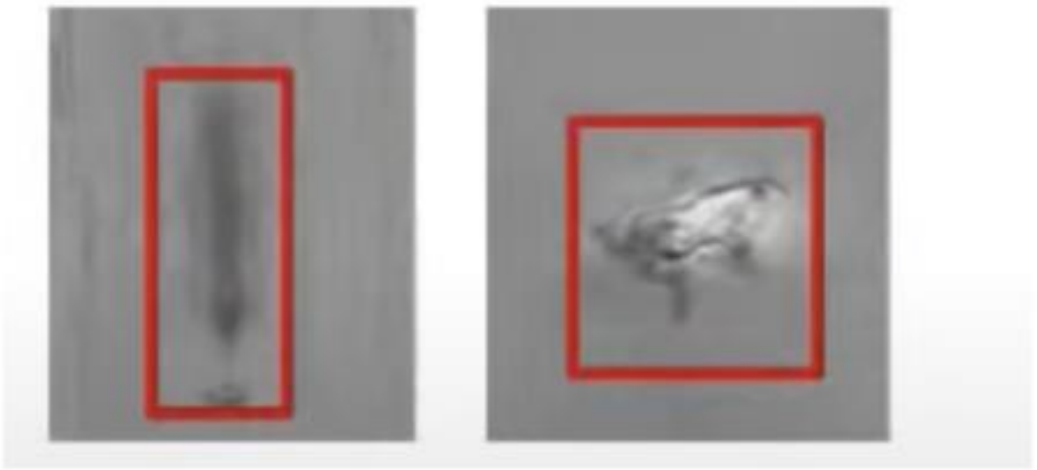


Google lens: image classification



Defect Detection for Manufacturing

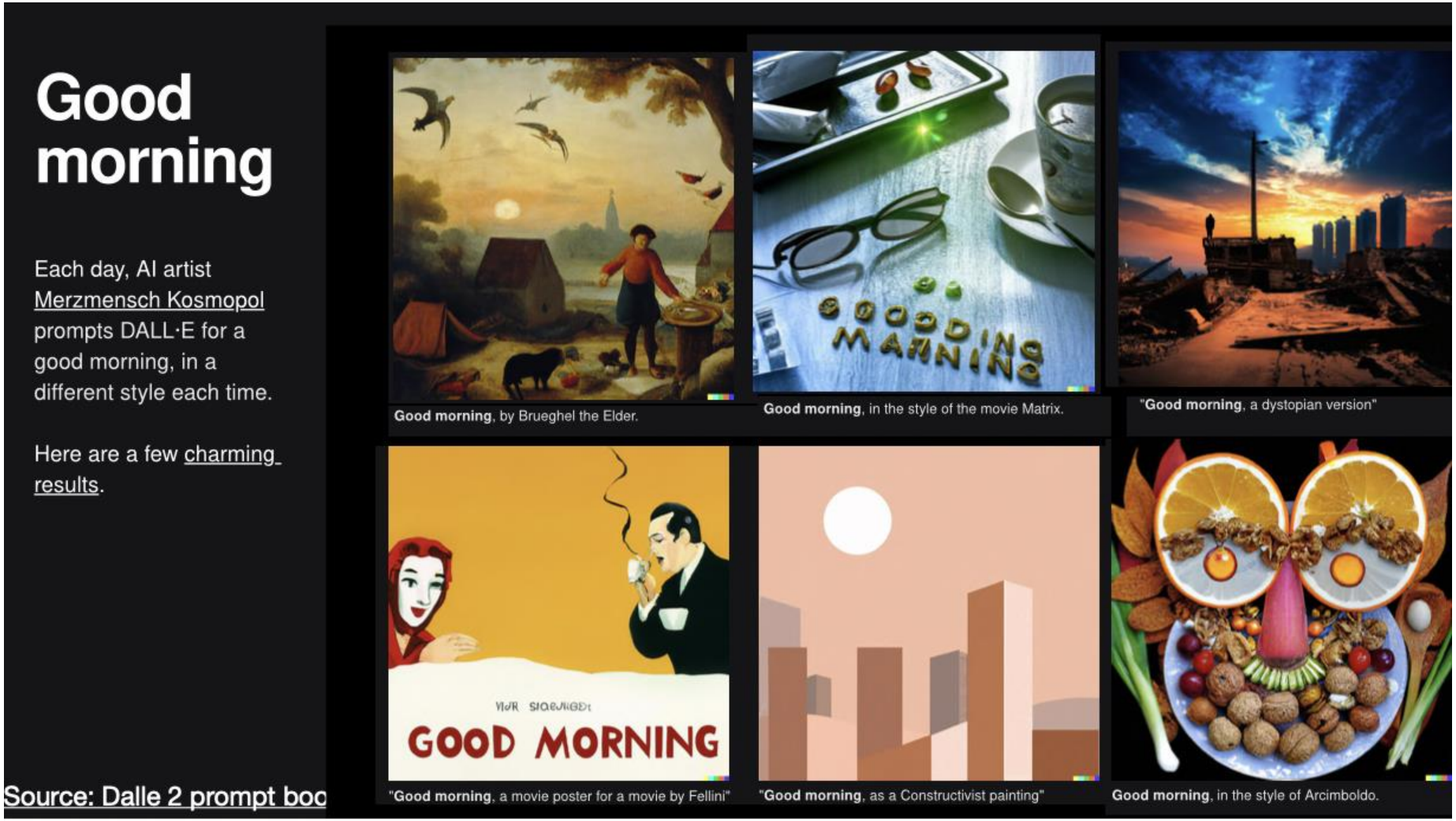
Input: Steel sheets images



Output: Defect regions

Generative AI

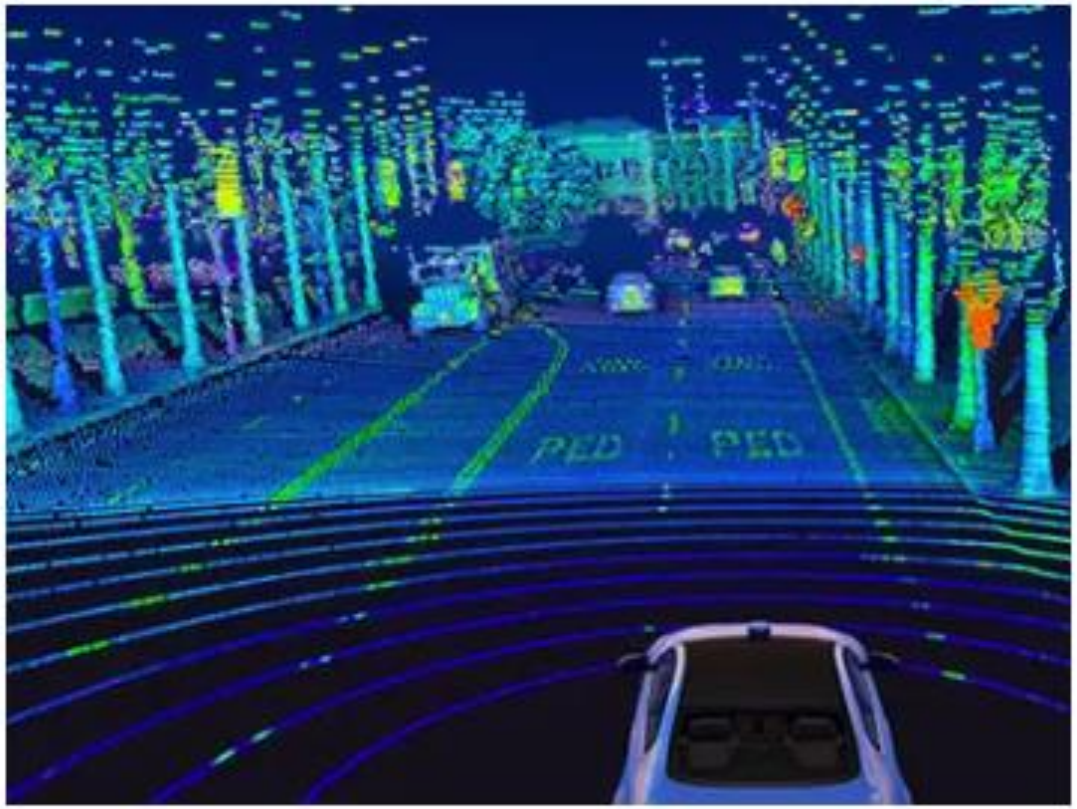
- DALL·E



Video = Image + Time

Video = Image + Time

3D data = higher spatial dimensions



What a self-driving car sees

AR: Microsoft's HoloLens

Ending announcements

- Please read syllabus at least once this week
  - To maximize your chance of getting an A

- If you have any thoughts on the tentative schedule, write it down and turn it in before you leave today