CMSC 472/672

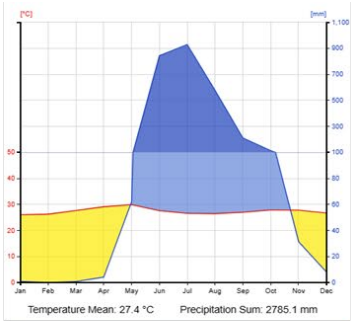
Lecture 1

Computer Vision

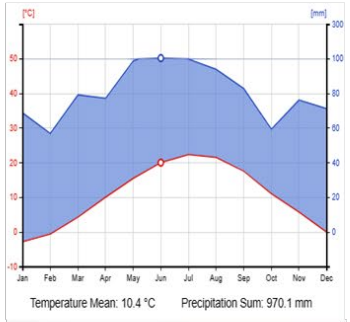
Some slides from Jayasuriya, Turaga, Szeliski

Tejas Gokhale ~ Tejas: Tay + Juss
Gokhale: Go + Clay

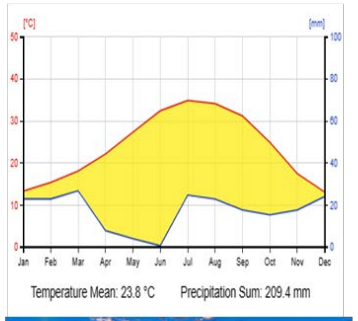
Assistant Professor
Computer Science
University of Maryland, Baltimore County



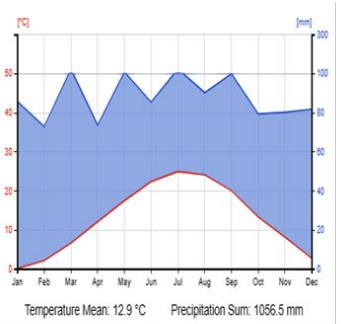
2011—2015
B.E. (Honours)
BITS Pilani
(Goa)



2016-2018:
M.S.
Carnegie Mellon
University



2018—2023:
Ph.D.
Arizona State
University



2023—present
Assistant Professor
University of Maryland
Baltimore County

https://www.tejasgokhale.com/

Course Staff

Instructor: Tejas Gokhale
Assistant Professor, CSEE

Wednesday 2:30 – 3:30 PM

ITE 342-B

gokhale@umbc.edu

Office Hours

TA: ???
...

TBD

Class Website

- This is your primary source for class material (slides, notes, readings, references, etc.)
- Assignments & Grades will be released on Blackboard

https://courses.cs.umbc.edu/graduate/672/

Quick Round of Introductions

1. Name
2. Major (e.g. CS, CE, EE, etc.)
3. Level (e.g. BS, MS, Ph.D. etc.)
4. Why are you taking this class?

What is this course about ?

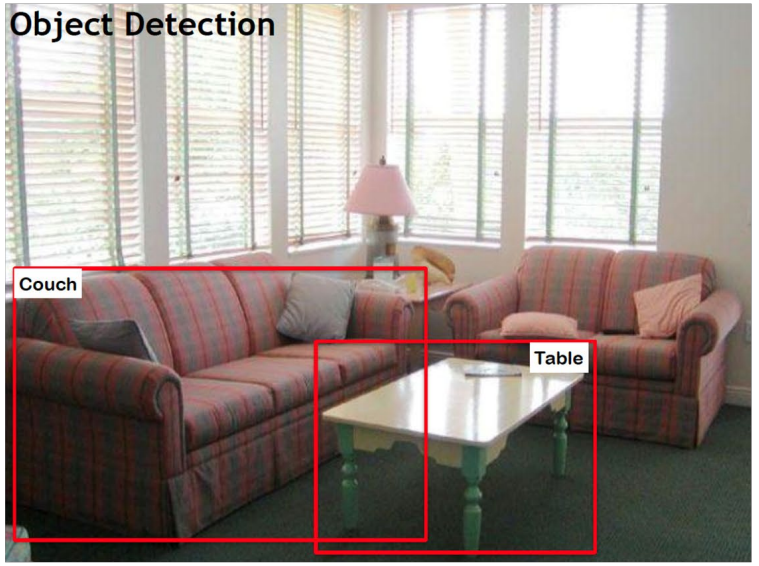
"Understanding Images"

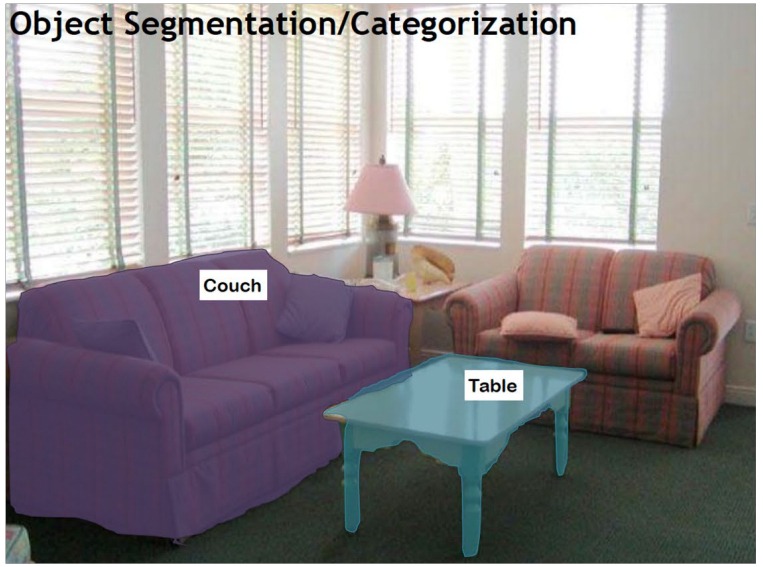
What is this course about ?

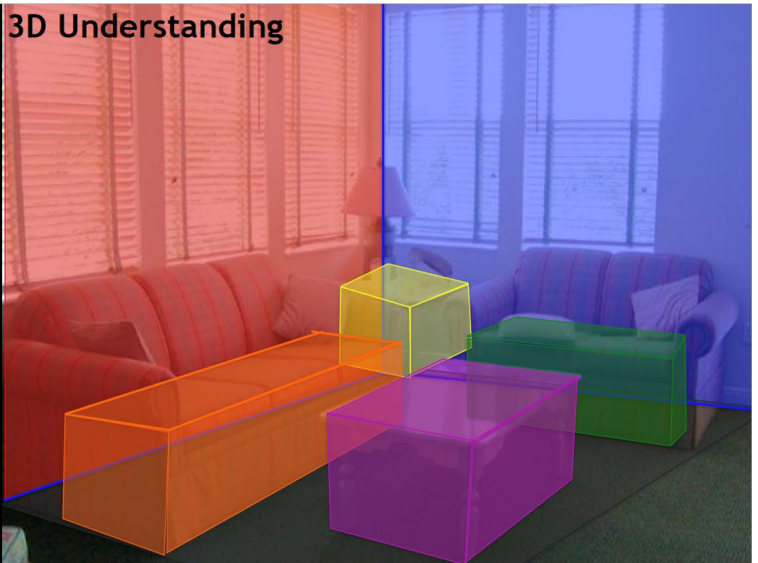
“Understanding Images”

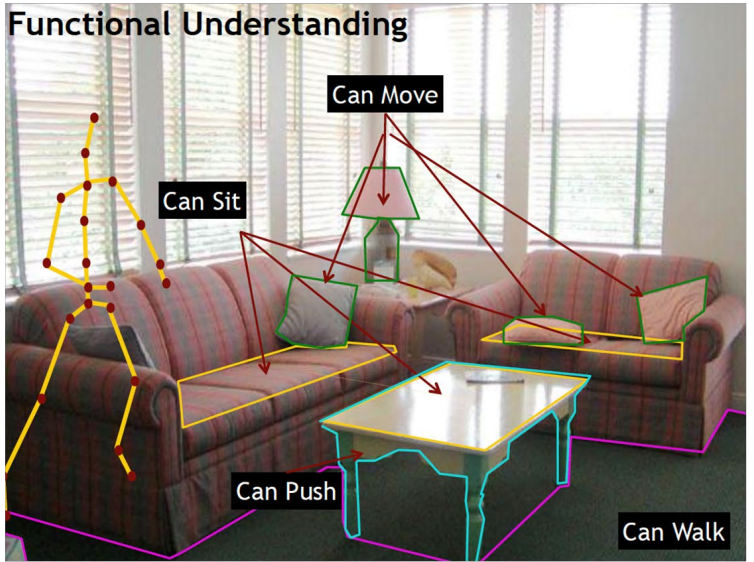
This course

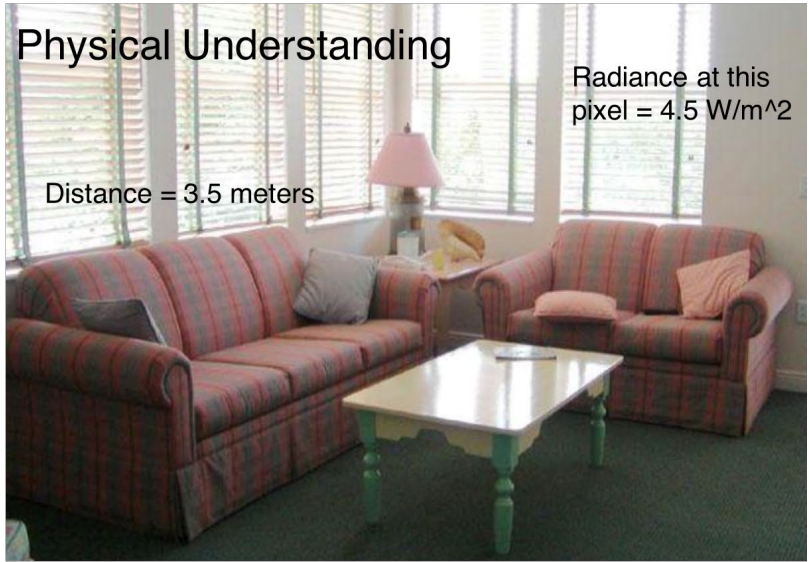
Computer Vision: Understanding Images











Why is CV difficult?

What I see

Why is CV difficult?

What I see

What a computer sees

```
08 02 22 97 38 15 00 40 00 75 04 05 07 78 52 12 50 77 91 08
49 49 99 40 17 81 18 57 60 87 17 40 98 43 69 48 04 56 62 00
81 49 31 73 55 79 14 29 93 71 40 67 53 88 30 03 49 13 36 65
52 70 95 23 04 60 11 42 69 24 68 56 01 32 56 71 37 02 36 91
22 31 16 71 51 67 63 89 41 92 36 54 22 40 40 28 66 33 13 80
24 47 32 60 99 03 45 02 44 75 33 53 78 36 84 20 35 17 12 50
32 98 81 28 64 23 67 10 26 38 40 67 59 54 70 66 18 38 64 70
67 26 20 68 02 62 12 20 95 63 94 39 63 08 40 91 66 49 94 21
24 55 58 05 66 73 99 26 97 17 78 78 96 83 14 88 34 89 63 72
21 36 23 09 75 00 76 44 20 45 35 14 00 61 33 97 34 31 33 95
78 17 53 28 22 75 31 67 15 94 03 80 04 62 16 14 09 53 56 92
16 39 05 42 96 35 31 47 55 58 88 24 00 17 54 24 36 29 85 57
86 56 00 48 35 71 89 07 05 44 44 37 44 60 21 58 51 54 17 58
19 80 81 68 05 94 47 69 28 73 92 13 86 52 17 77 04 89 55 40
04 52 08 83 97 35 99 16 07 97 57 32 16 26 26 79 33 27 98 66
88 36 68 87 57 62 20 72 03 46 33 67 46 55 12 32 63 93 53 69
04 42 16 73 38 25 39 11 24 94 72 18 08 46 29 32 40 62 76 36
20 69 36 41 72 30 23 88 34 62 99 69 82 67 59 85 74 04 36 16
20 73 35 29 78 31 90 01 74 31 49 71 48 86 81 16 23 57 05 54
01 70 54 71 83 51 54 69 16 92 33 48 61 43 52 01 89 19 67 48
```

Humans are good at it …

Are Humans good at it ?

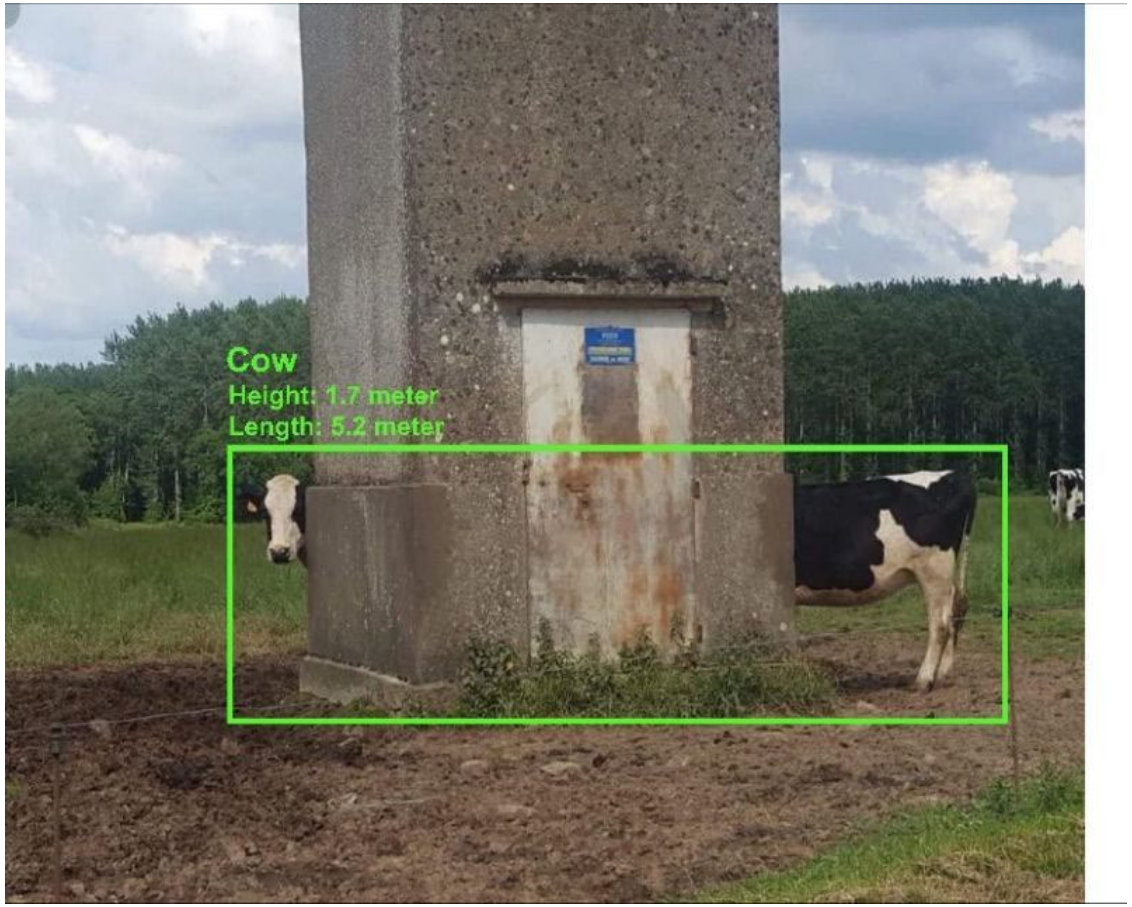
Challenges: object intra-class variation

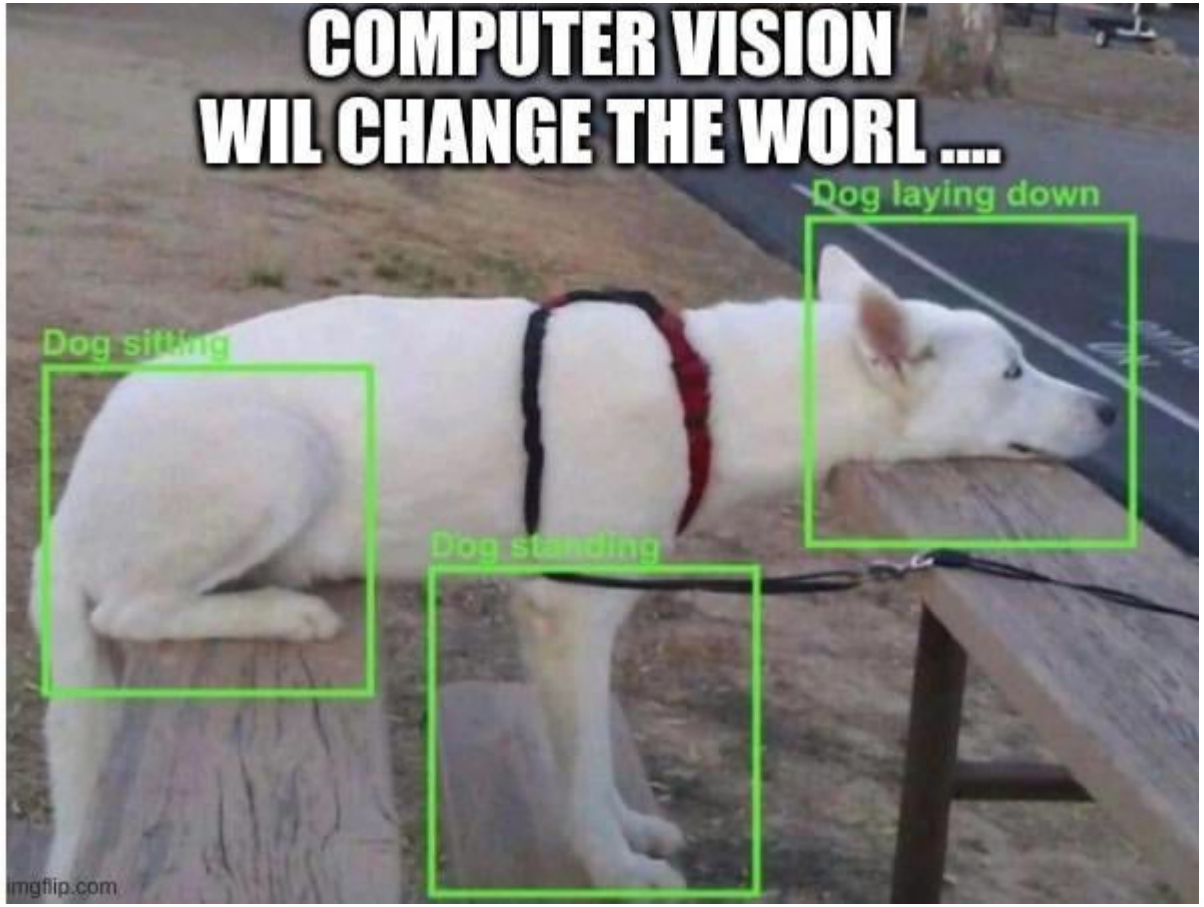
slide credit: Fei-Fei, Fergus & Torralba

Challenges: Motion

Challenges: background clutter

Challenges: “Commonsense”





Robustness Challenge: T-Shirt Lady at CVPR

What is computer science?

Typical answers: programming, coding, algorithms ...

An attempt to develop a theory of computation

to represent, understand, and interact with the world

in the form of computations.

What is computer vision?

An attempt to develop a theory

to represent, understand, and interact

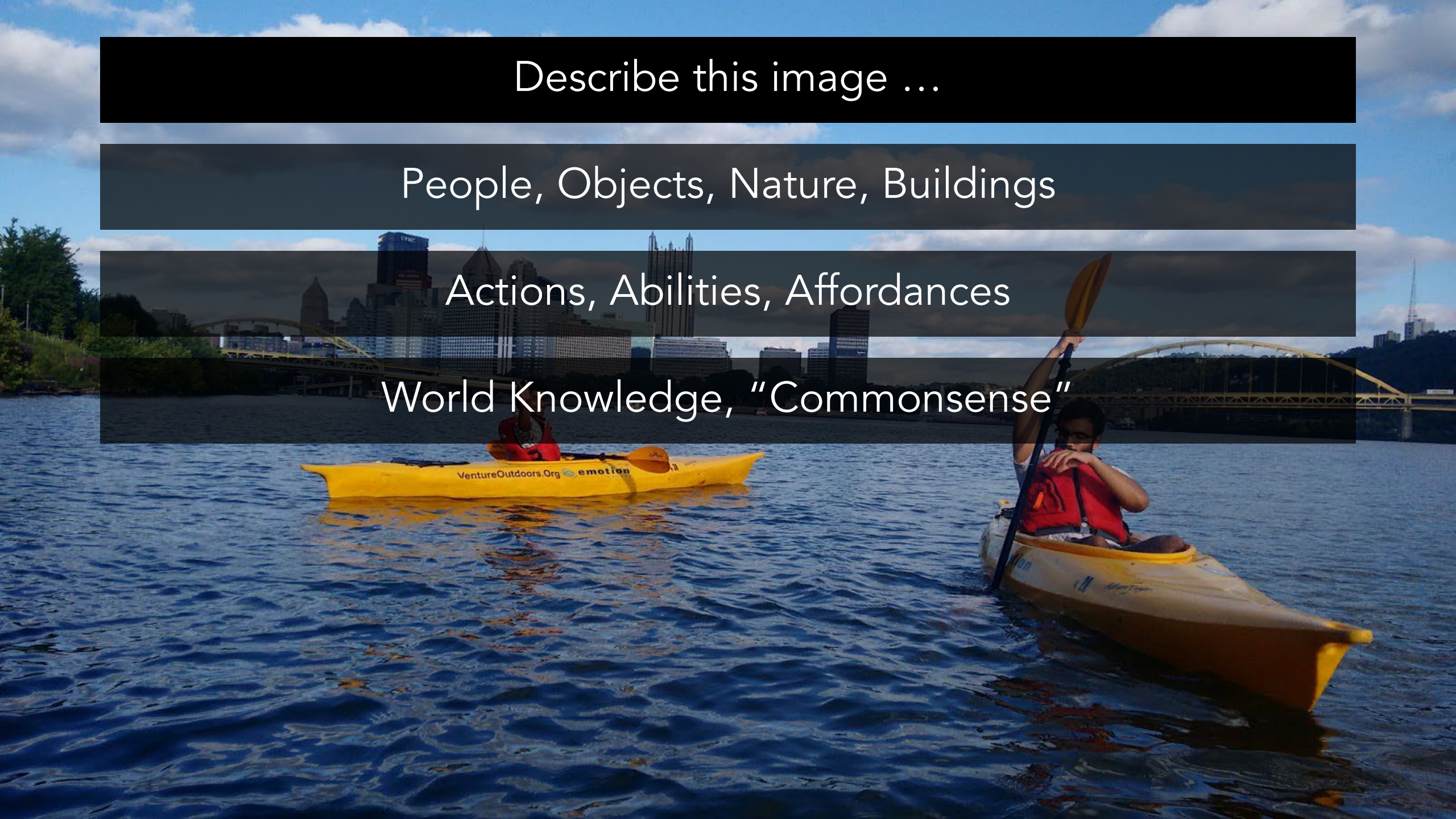
with the visual world

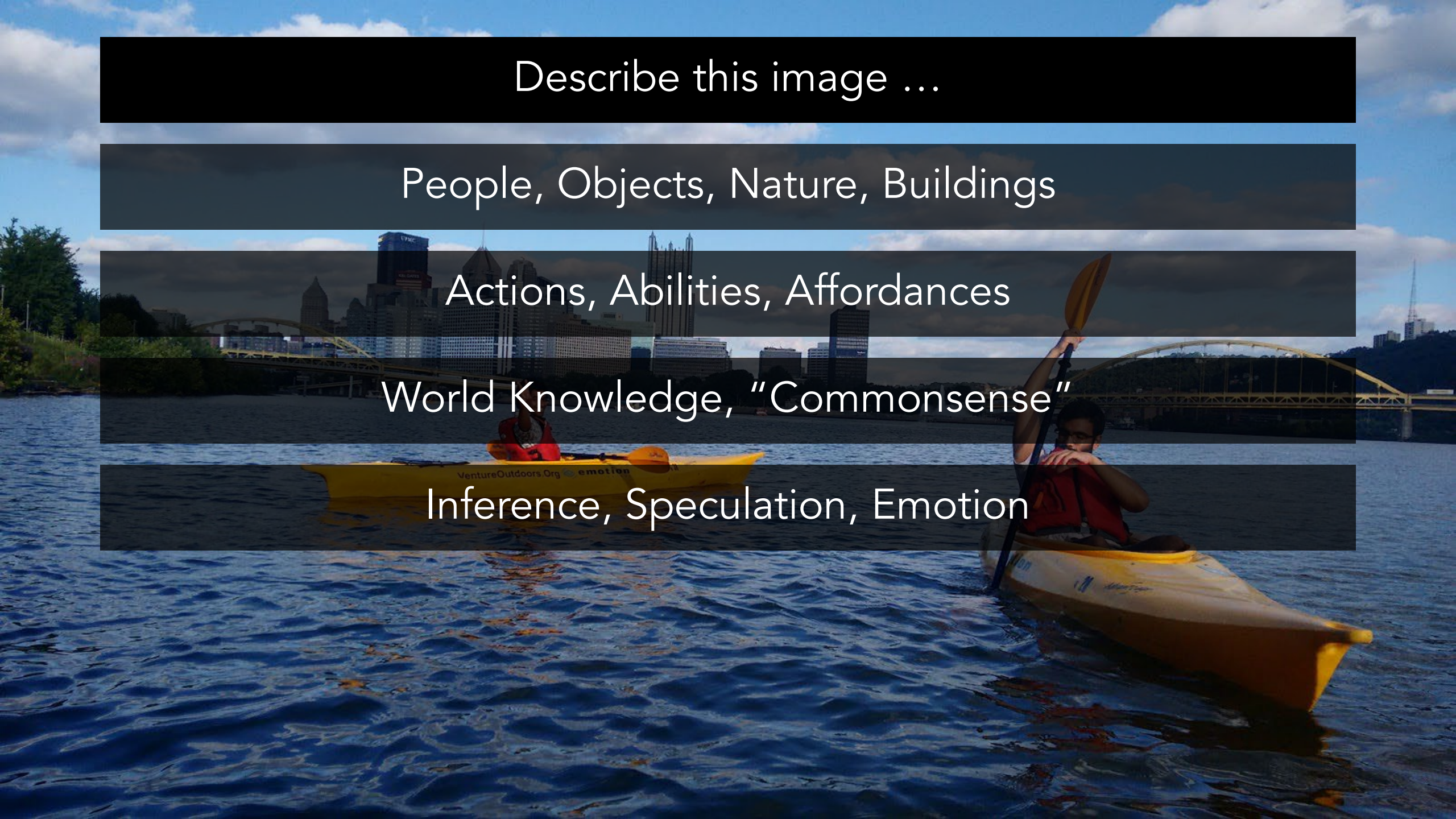
in the form of computations

Describe this image …


Describe this image …
People, Objects, Nature, Buildings
VentureOutdoors.Org
emotion

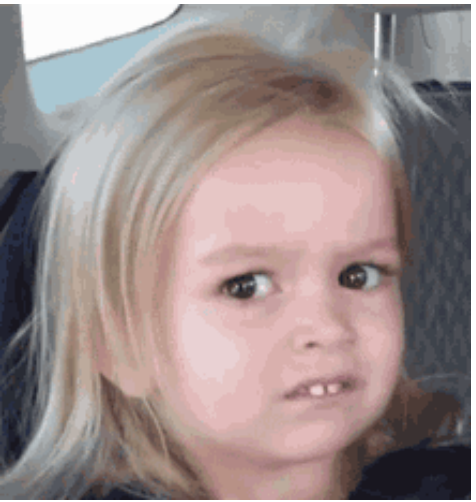

Describe this image …
People, Objects, Nature, Buildings
Actions, Abilities, Affordances
VentureOutdoors.Org
emotion


Describe this image …
People, Objects, Nature, Buildings
Actions, Abilities, Affordances
World Knowledge, “Commonsense”
VentureOutdoors.Org
emotion

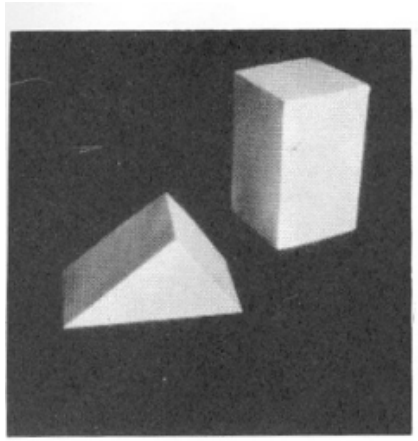

Describe this image …
People, Objects, Nature, Buildings
Actions, Abilities, Affordances
World Knowledge, “Commonsense”
Inference, Speculation, Emotion

Visuals convey *meaning*

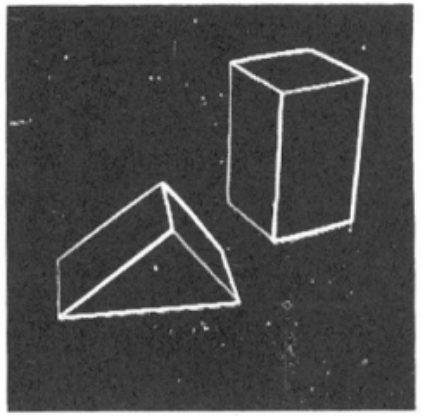
Visuals convey *emotions*



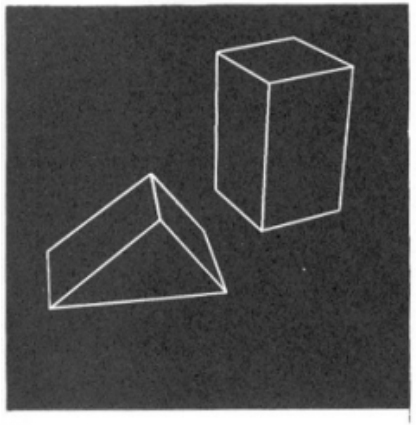
Some history ...



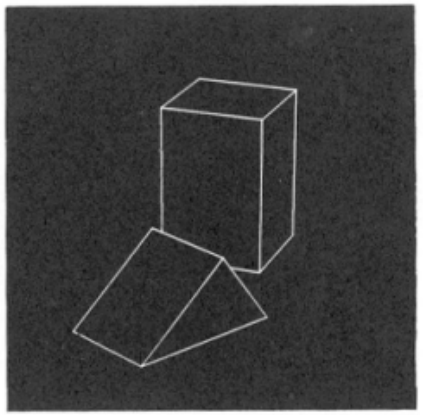
(a) Original picture.



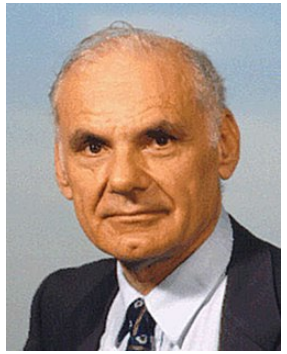
(b) Differentiated picture.



(c) Line drawing.



(d) Rotated view.



L. G. Roberts (later also created ARPANET – precursor to the internet)
Machine Perception of Three Dimensional Solids
Ph.D. Dissertation
MIT Dept of Electrical Engineering
1963

Computer Vision

is older than

MIT's Computer Science Program (1970s)

Some history ...

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

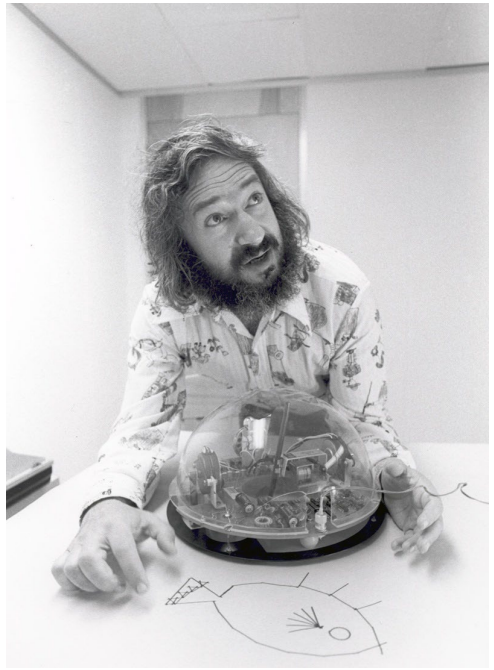
PROJECT MAC

Artificial Intelligence Group July 7, 1966
Vision Memo. No. 100.

THE SUMMER VISION PROJECT

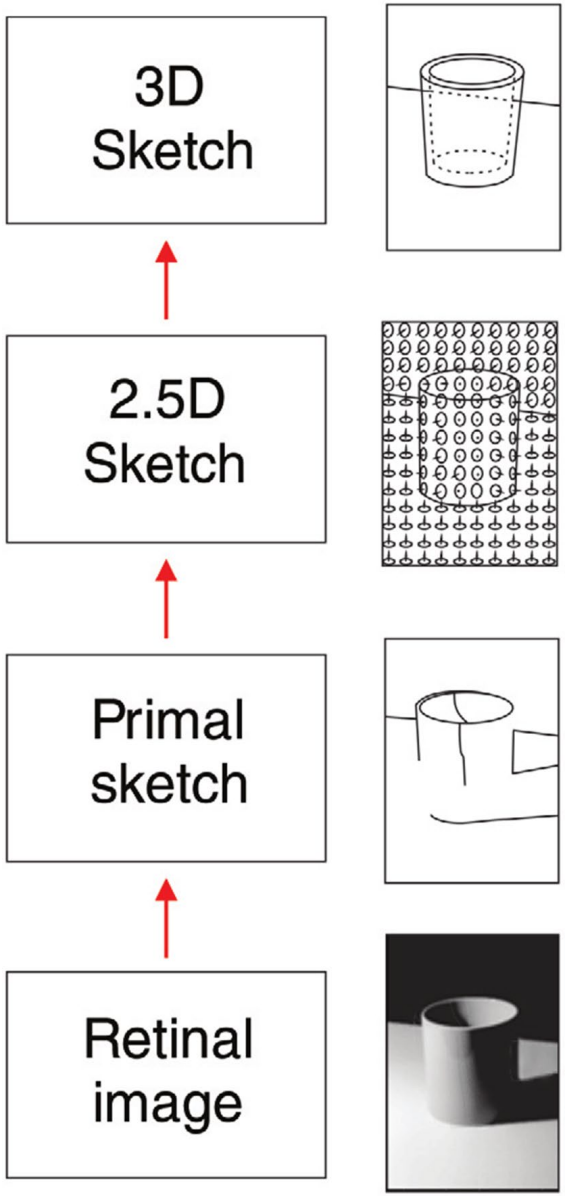
Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".



Marr's Vision (1982)

- British neuroscientist David Marr was very influential with his computational theory of vision
- Marr believed that visual understanding could be progressively grown from primitive lines/edges to 2.5D information and textures to finally 3D shapes
- It is still an open question of whether the brain *actually* works in this way, but many engineers and scientists found inspiration in making artificial vision systems based on Marr's model of vision.



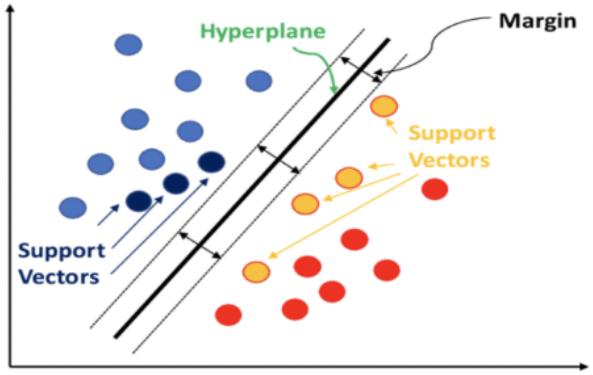
slide credit: Suren Jayasuriya

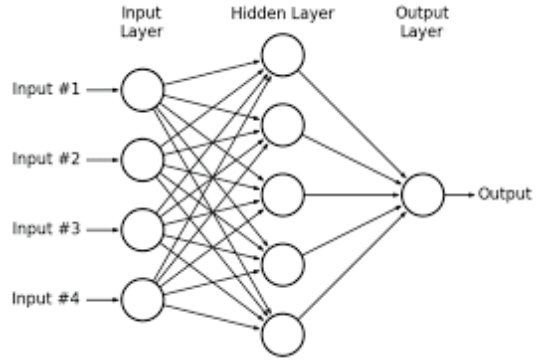
Counterpoint: Machine Learning & Statistical Methods

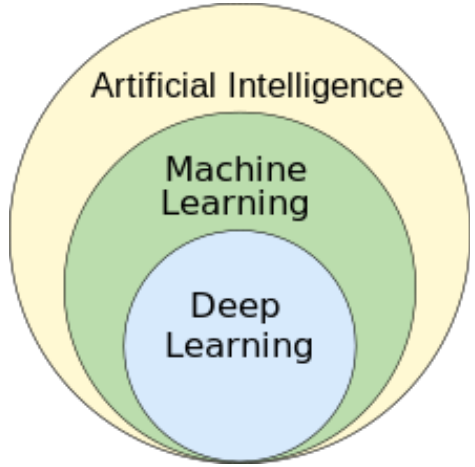
- To counter the computational theories of Marr, statistics and data-driven methods were being invented in the 1980s

- Such methods ***had*** limited application due to lack of available data and compute power (more on this later)

- Deep learning (by 2012 onward) has become a backbone of most computer vision systems

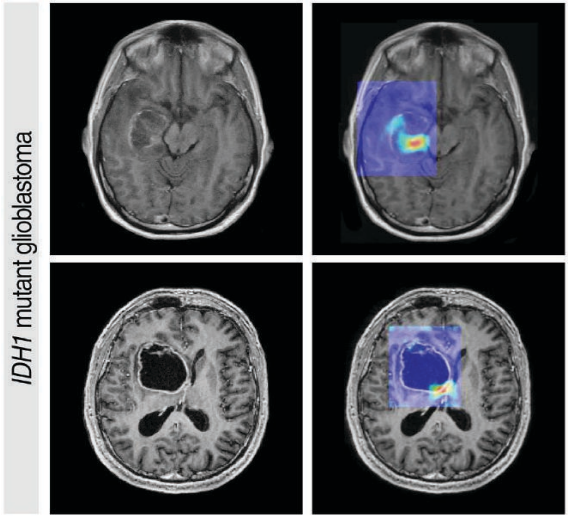




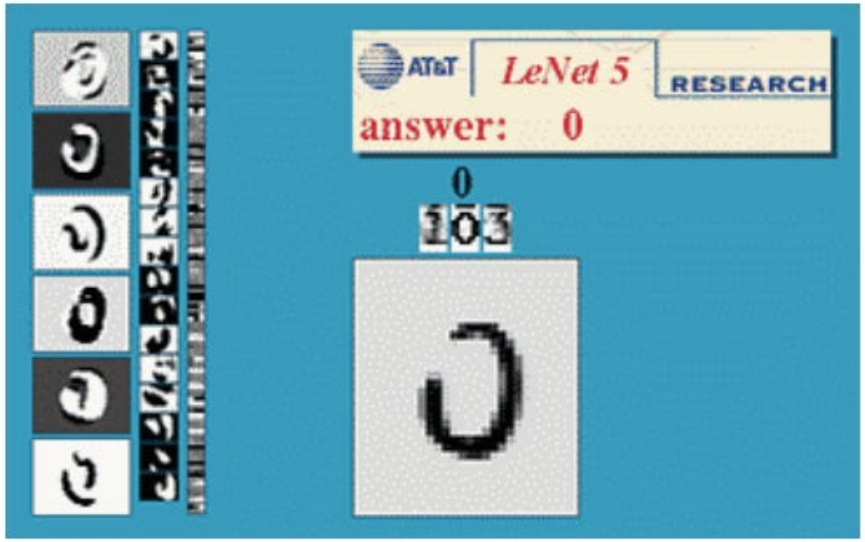


slide credit: Suren Jayasuriya

Fast Forward to Today



Optical character recognition (OCR)



Digit recognition
yann.lecun.com

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

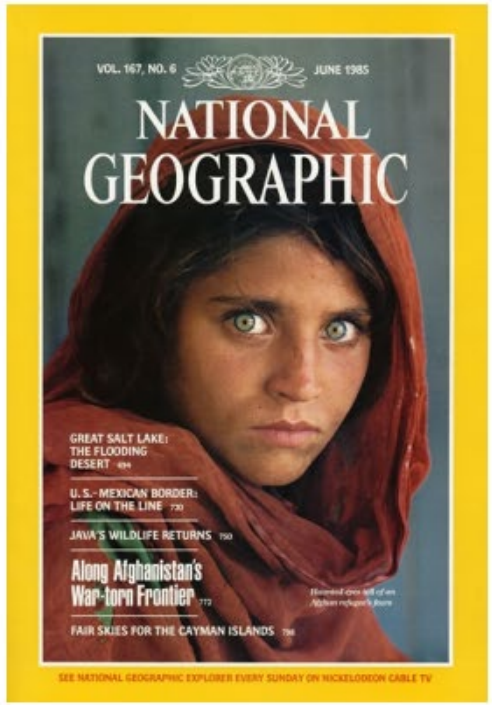
Automatic check processing

Sudoku grabber

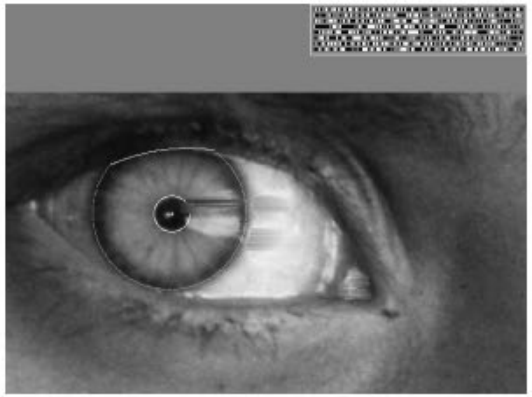
http://sudokugrab.blogspot.com/

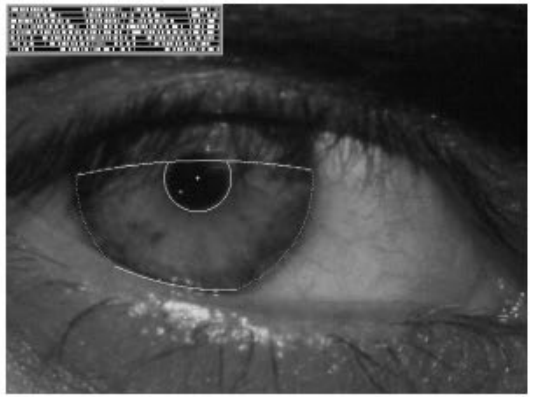
Source: S. Seitz, N. Snavely

Biometrics



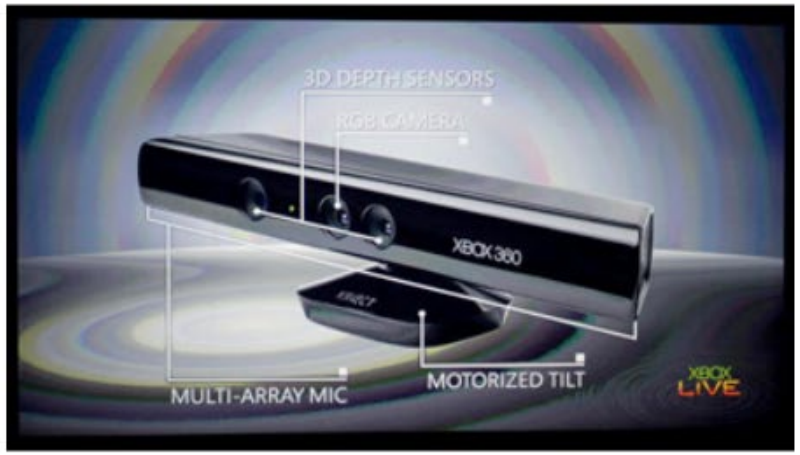
[How the Afghan Girl was Identified by Her Iris Patterns]

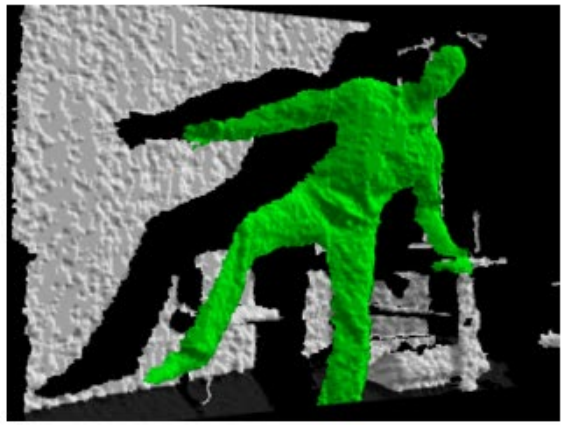


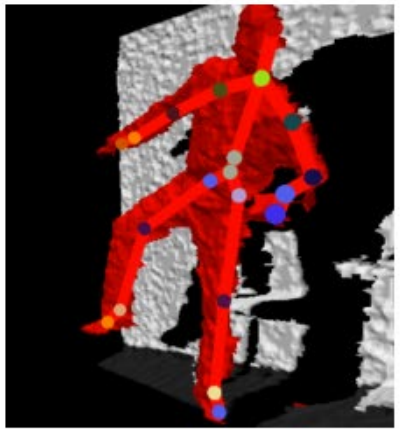


Source: S. Seitz

Vision-based interaction: Xbox Kinect







http://blogs.howstuffworks.com/2010/11/05/how-microsoft-kinect-works-an-amazing-use-of-infrared-light/

http://electronics.howstuffworks.com/microsoft-kinect.htm

http://www.xbox.com/en-US/Live/EngineeringBlog/122910-HowYouBecometheController

http://www.ismashphone.com/2010/12/kinect-hacks-more-interesting-than-the-devices-original-intention.html

Earth viewers (3D modeling)

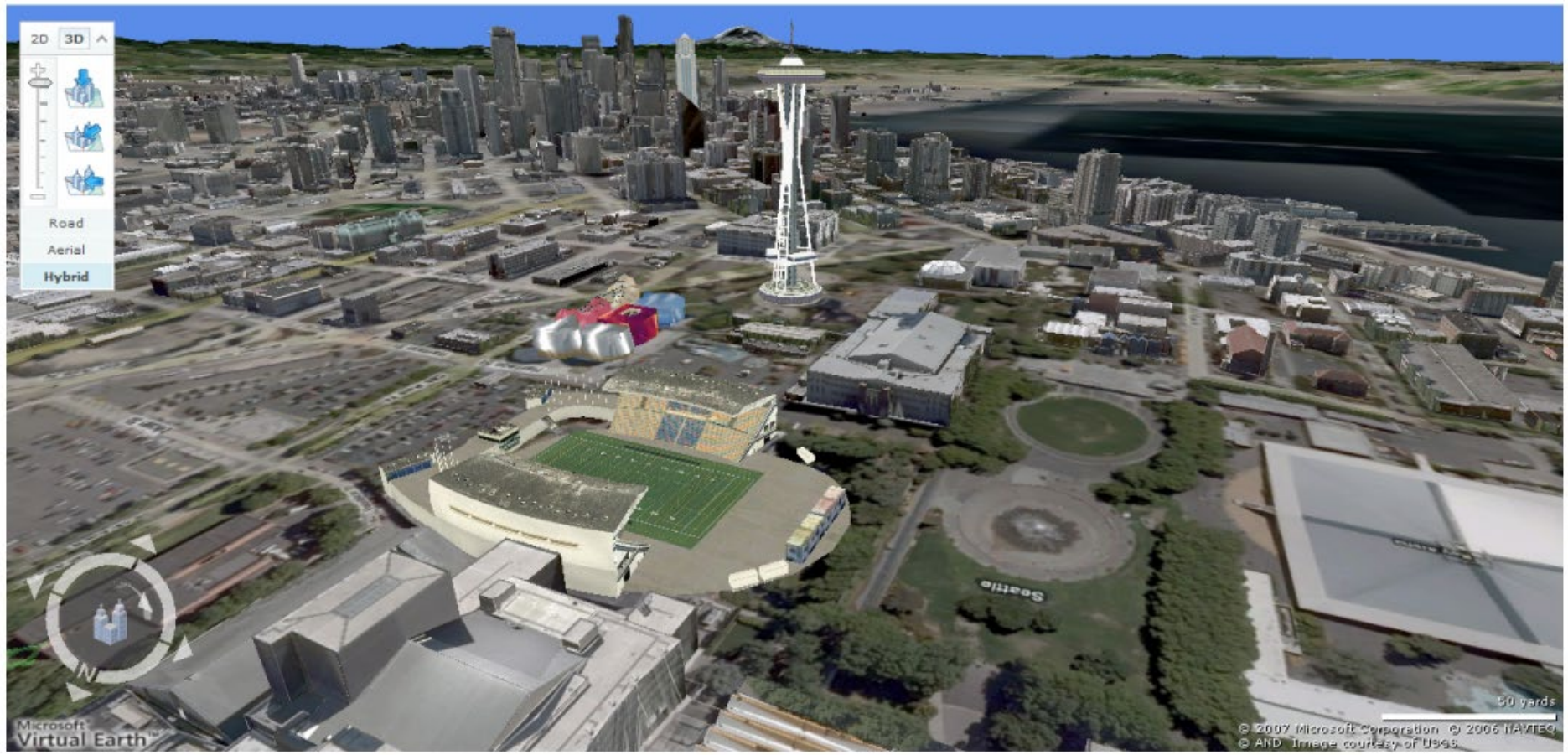
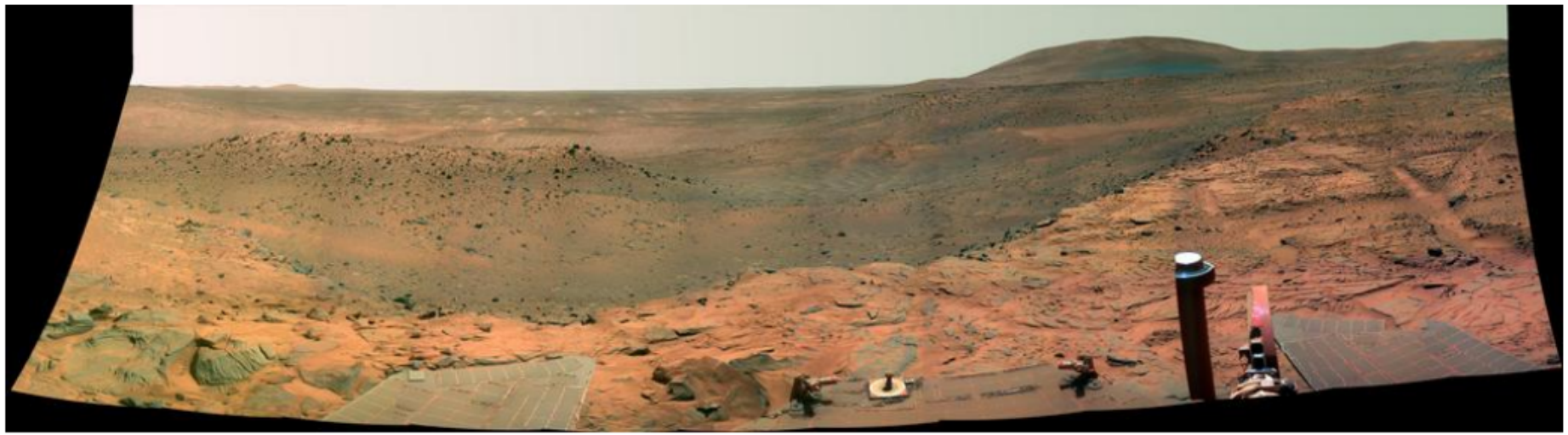


Image from Microsoft's Virtual Earth

(see also: Google Earth)

Source: Steve Seitz and Neel Joshi

Vision for robotics, space exploration



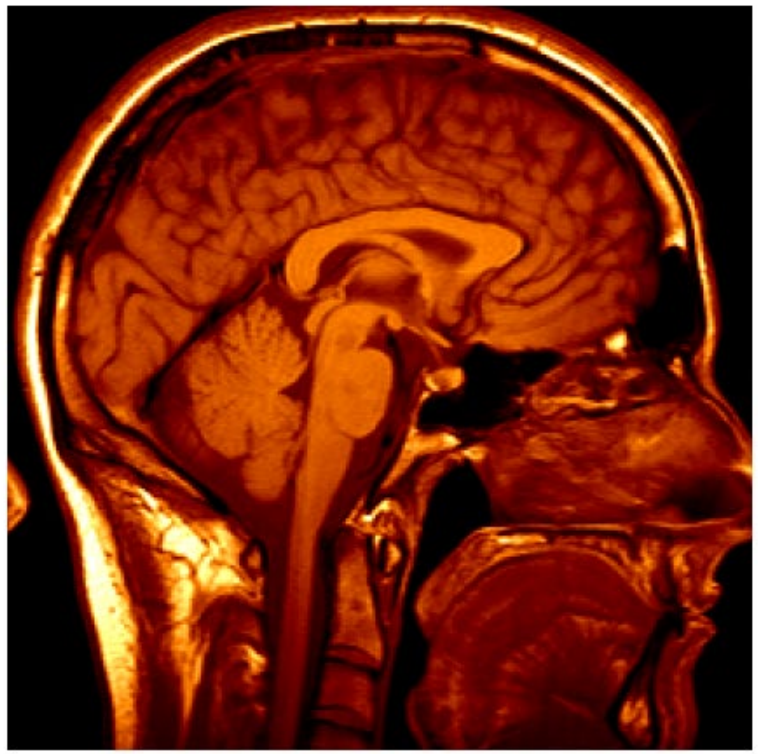
NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read "Computer Vision on Mars" by Matthies et al.

Source: S. Seitz

Medical imaging



3D imaging

MRI, CT

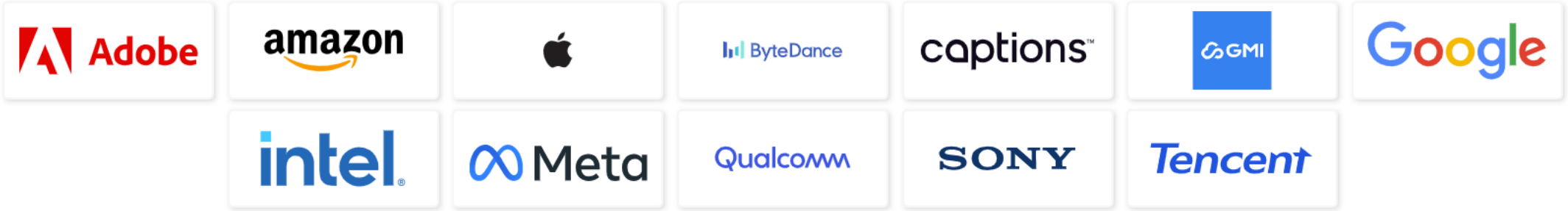
Image guided surgery

Grimson et al., MIT

Source: Steve Seitz and Neel Joshi

LOTS (!!!) of Industry

PLATINUM



GOLD

SILVER

What this course is NOT about ...

☒ A "review" of the state-of-the-art:

- we will talk about some recent work, but the main goal is to learn fundamentals

☒ Just another ML course but with a focus on image-based applications

- only one part of the course has ML / NN

☒ Broad introduction to "AI": CMSC 471/671: Artificial Intelligence

☒ "Hands-on" coding

- We expect you to be proficient in Python programming
- The TA will organize a PyTorch tutorial (during regular class hours)
- Homework and Projects: implementation.
- Lectures: mathematical concepts

What this course is about ...

First principles of computer vision

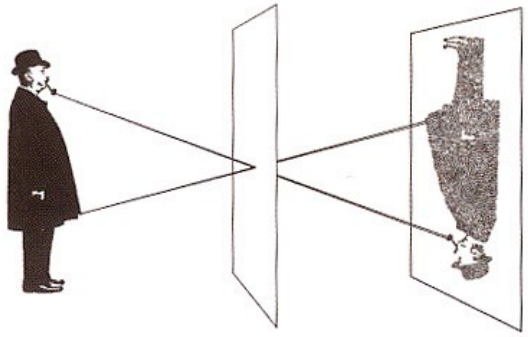
- Image Acquisition
- Image Processing and Features
- Geometry and Reconstruction
- Image Semantics (Recognition) – some ML here
- Temporality (Video Understanding)
- Image Synthesis (Generation)

In short, this course expects:

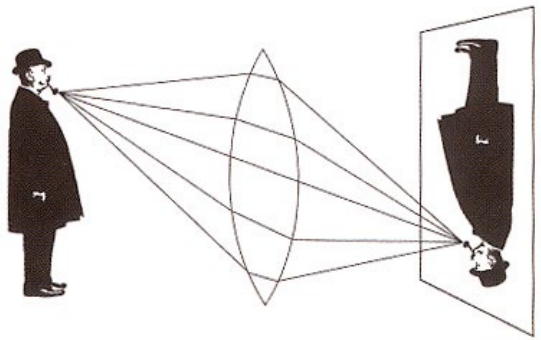
- mathematical rigor
- interest in fundamentals
- programming proficiency

Class Topics
(1) Image Acquisition

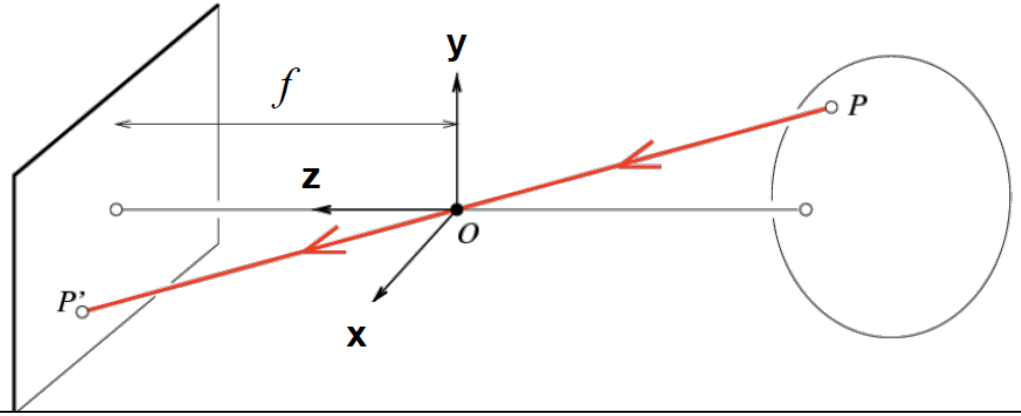
Photograph made with small pinhole



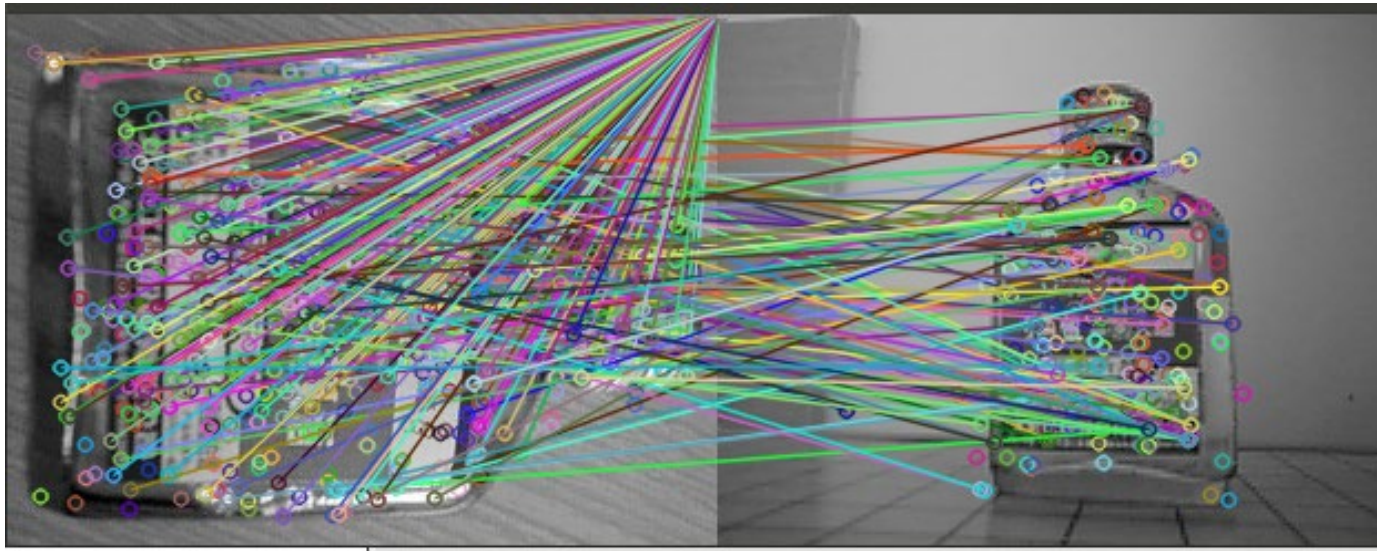
Photograph made with lens

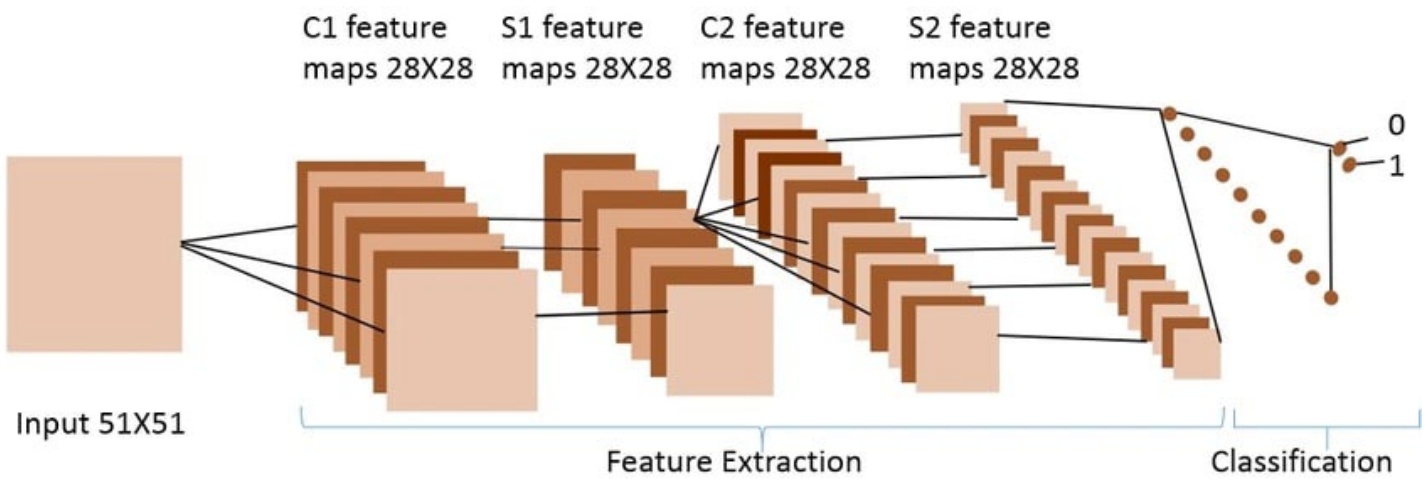


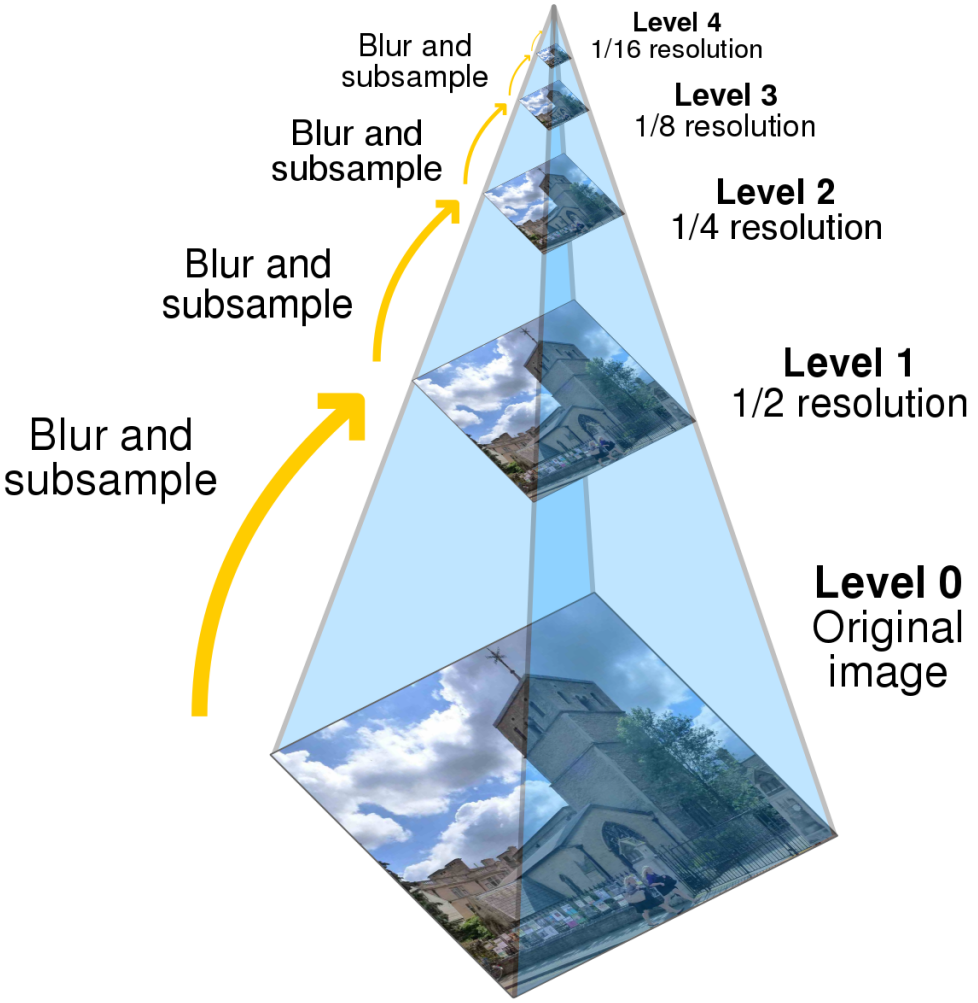
Modeling projection



Class Topics
(2) Image Processing & Features



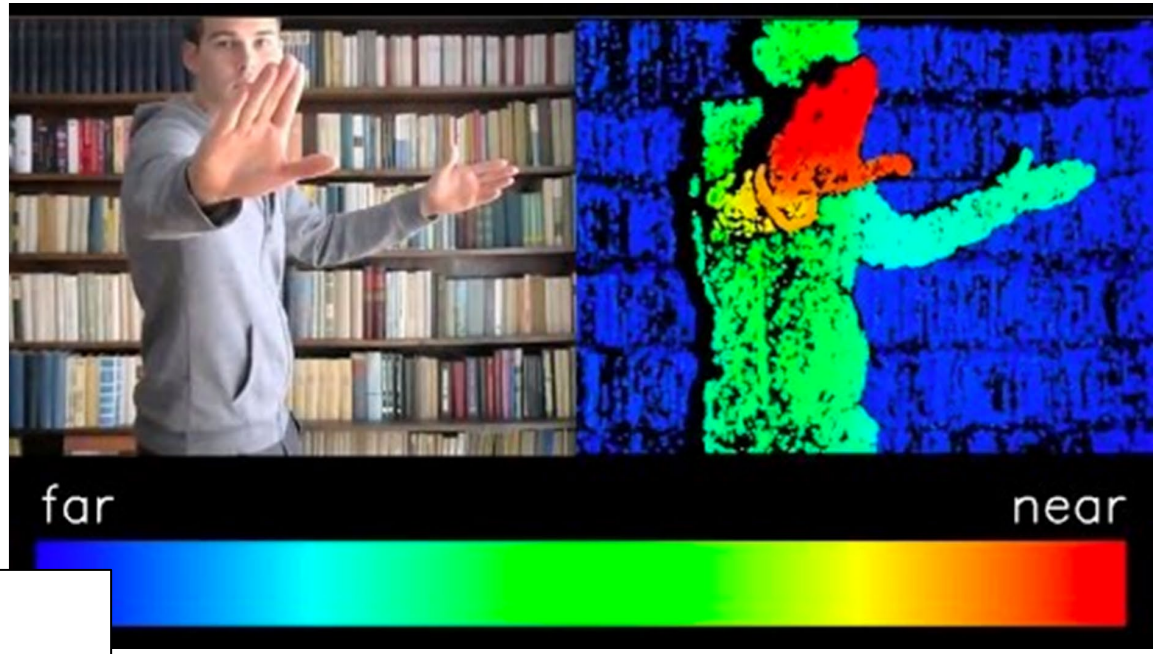


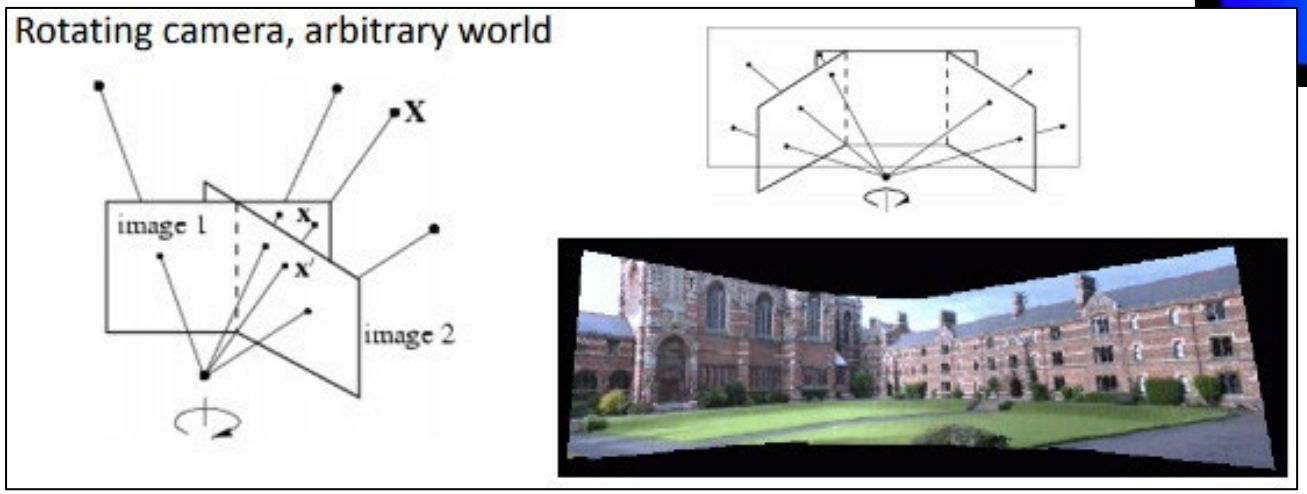


Class Topics
(3) Geometry (3D)

Topics:

- Epipolar Geometry and Stereo
- 3D geometry estimation
- Structure-from-motion

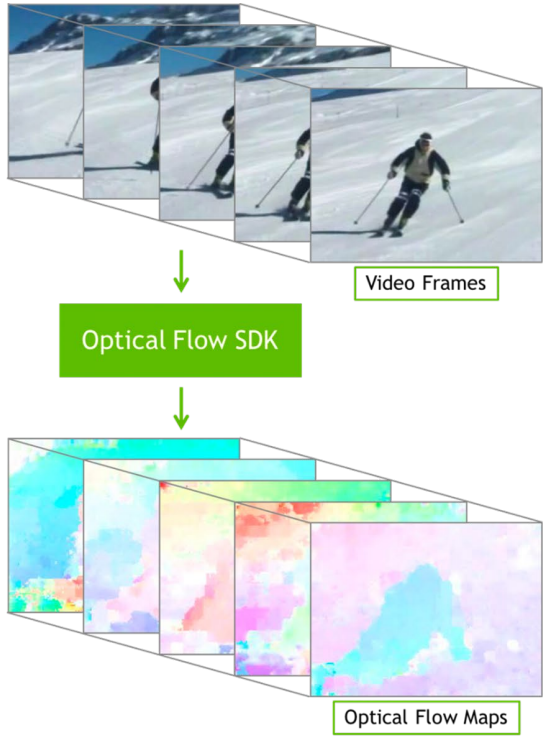


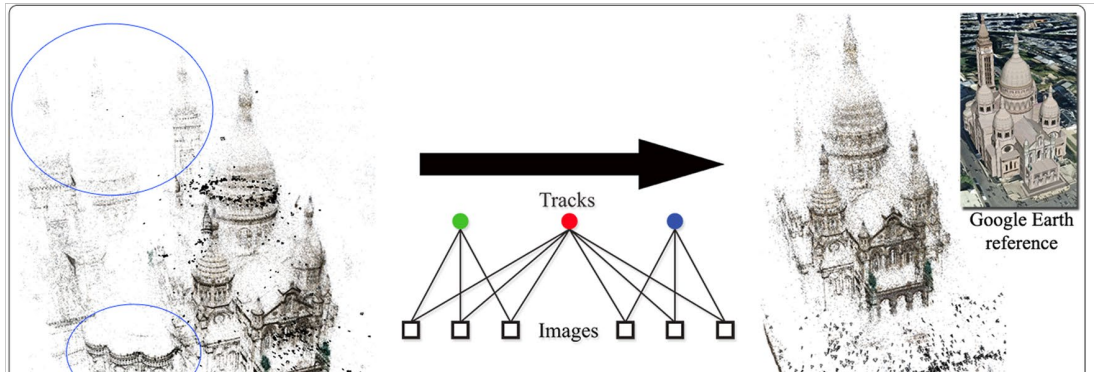


Class Topics
(4) Video (Temporal)

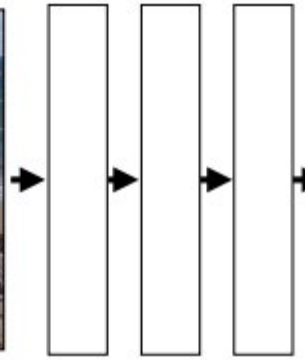
Topics:

- Motion/optical flow
- Video segmentation, tracking
- Simultaneous localization and mapping (SLAM)

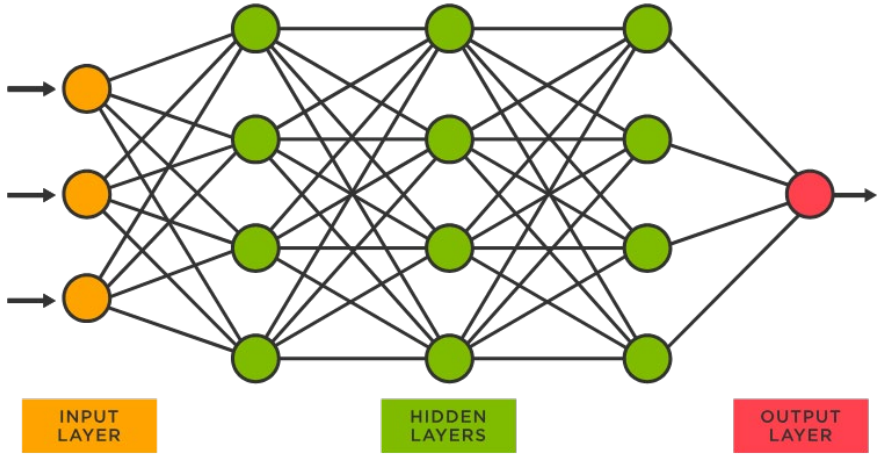




Class Topics
(5) Machine Learning for Vision



“Beach”



Advanced Topics: Vision + Language

Generating Text from Images

Caption Generator

A bird flying over water

Answering Questions about Images

What is the mustache made of?

AI System

bananas

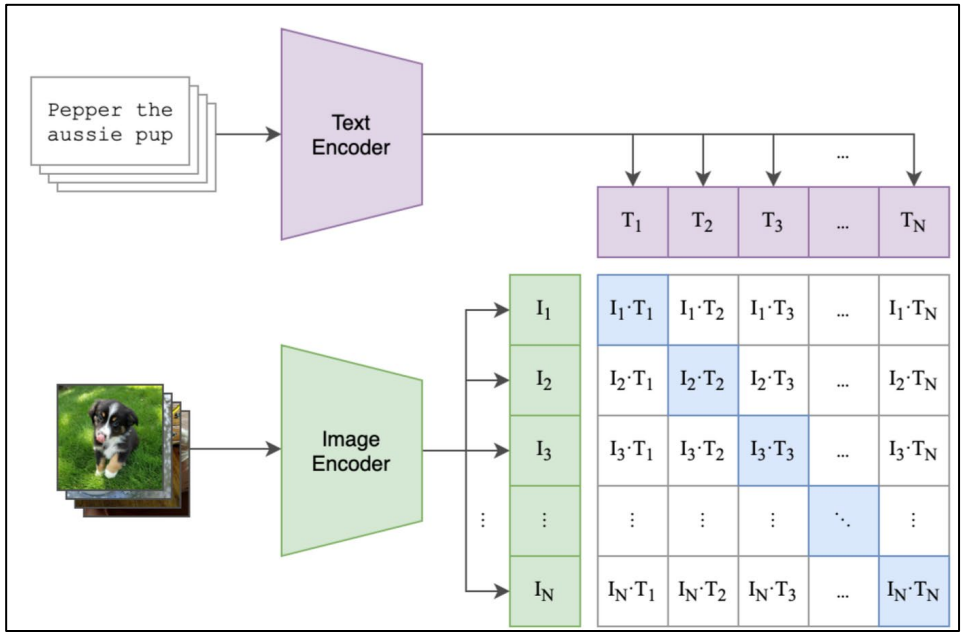
Generating Images from Text

"a corgi playing a flame throwing trumpet"

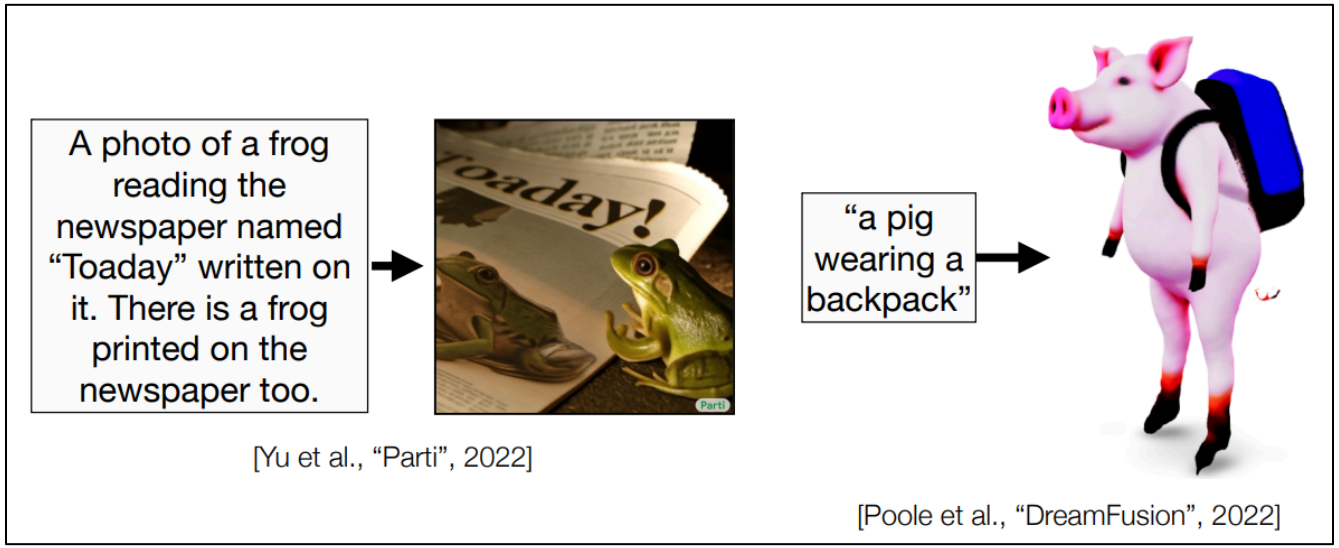
text encoder

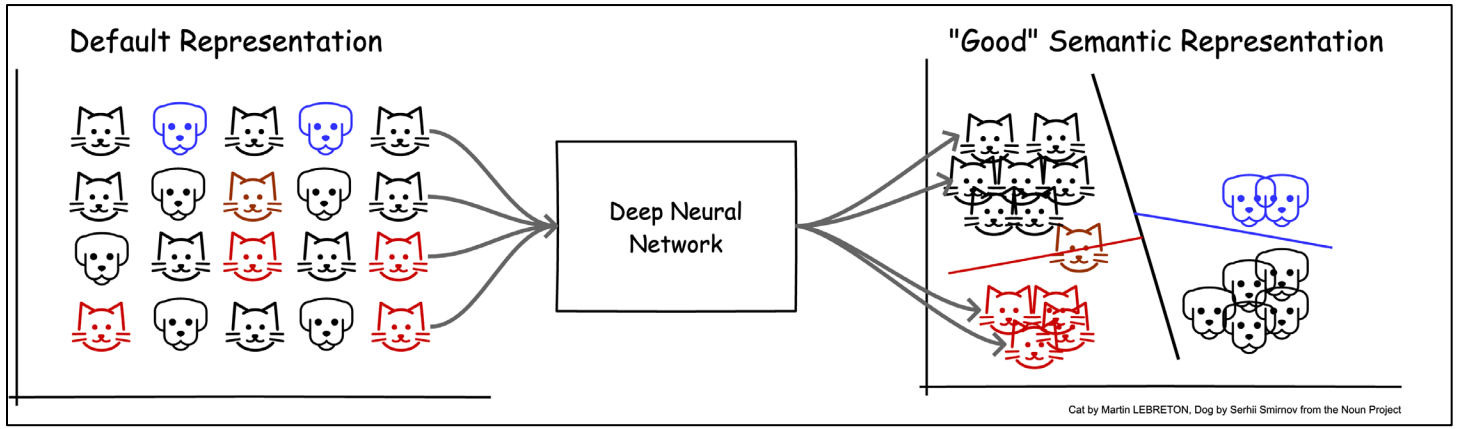
Advanced Topics

Representation Learning

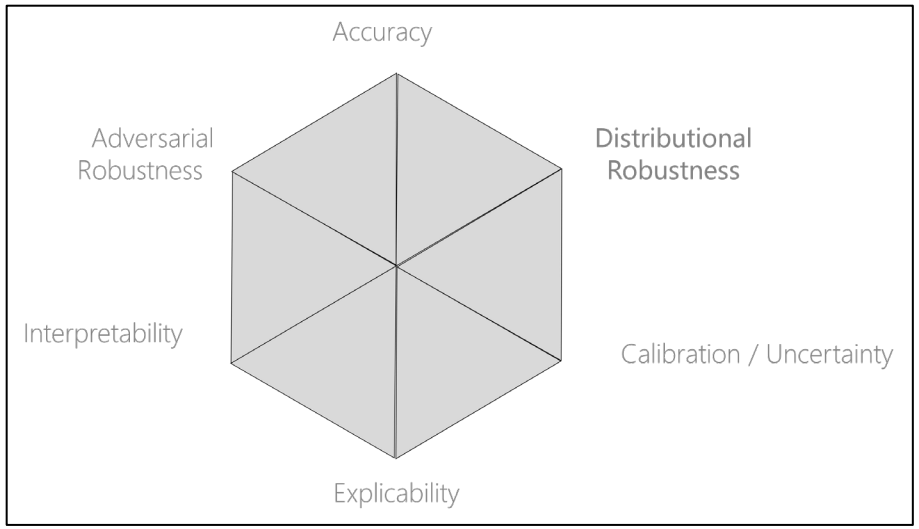


Generative Models





Robustness & Reliability



What we will learn to do

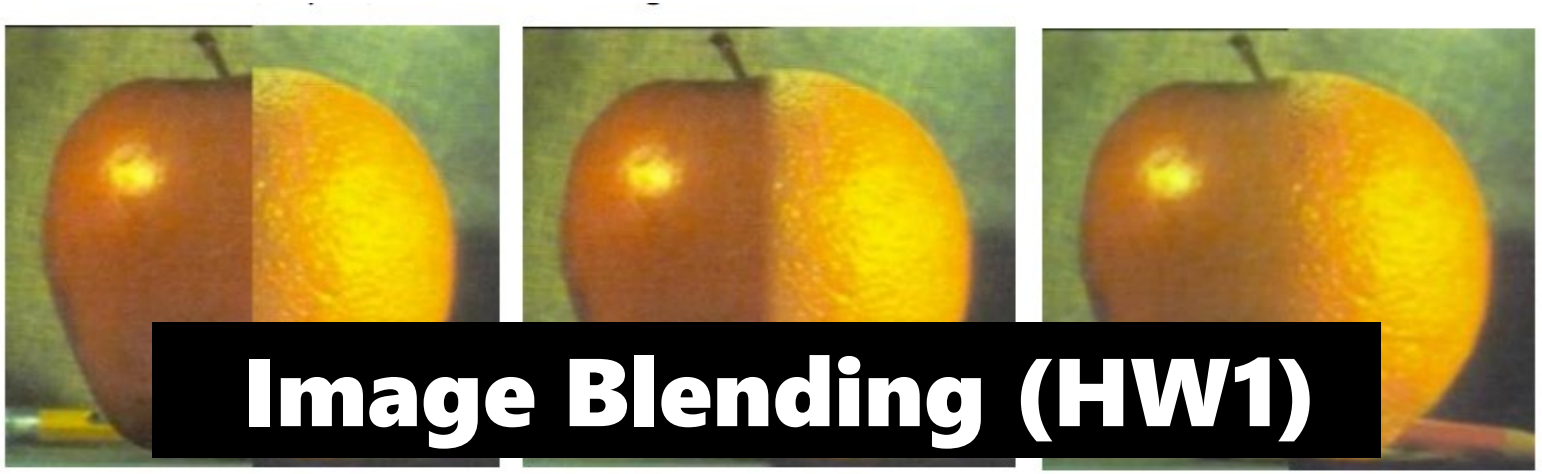


Image Blending (HW1)

Image Stitching / Panorama (HW2)

What we will learn to do

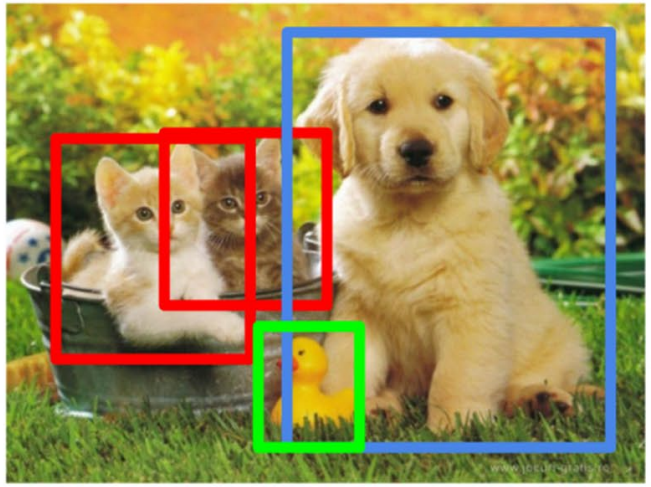
Classification

CAT

Classification + Localization

CAT

Object Detection



CAT, DOG, DUCK

Instance Segmentation

CAT, DOG, DUCK

Single object

Multiple objects

Course Logistics

Class Website

https://redirect.cs.umbc.edu/courses/graduate/672/

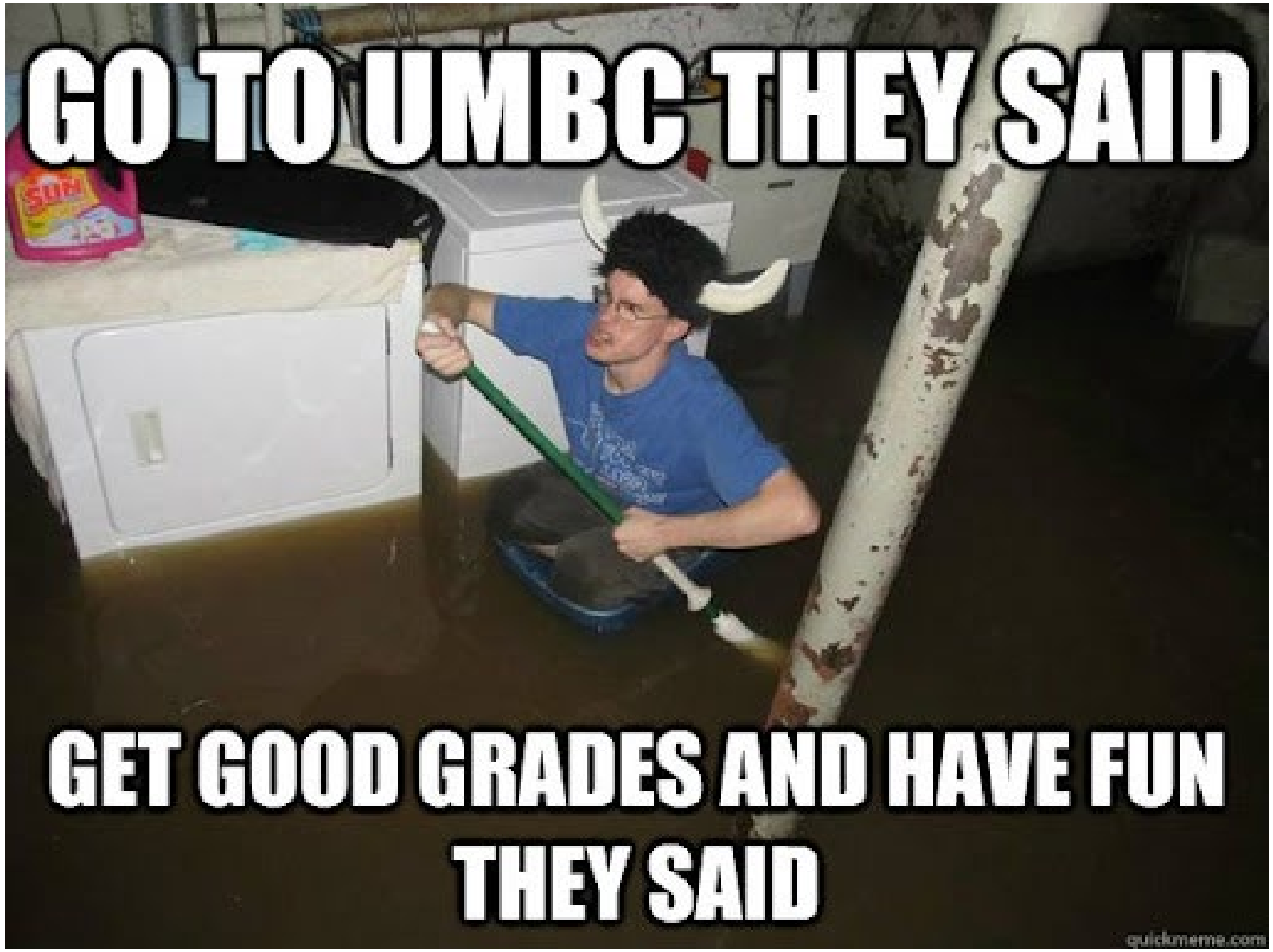
CMSC 472/672: Computer Vision

UMBC. Fall 2025

Instructor: Tejas Gokhale (OH: Wednesday 2:30 PM - 3:30 PM or by appointment; ITE 214);
Teaching Assistant: TBD ;
Time: Monday and Wednesday 4:00pm - 5:15pm
Location: ITE 229

Course Description | Schedule | Grading | Syllabus

Grading


GO TO UMBC THEY SAID
GET GOOD GRADES AND HAVE FUN
THEY SAID
quickmeme.com

Evaluation Components

Homework	3-5 assignments including conceptual questions, exercises, and Python implementation and system design.	30%
Project	Course project in groups of 3-4 (smaller or individual groups only for PhD students with the professor's consent).	35%

- 5% for project proposal
- 5% for status update video
- 4% for individual reflection
- 10% for final presentation
- 8% for final report
- 3% for summarizing other projects

There is no Final Exam

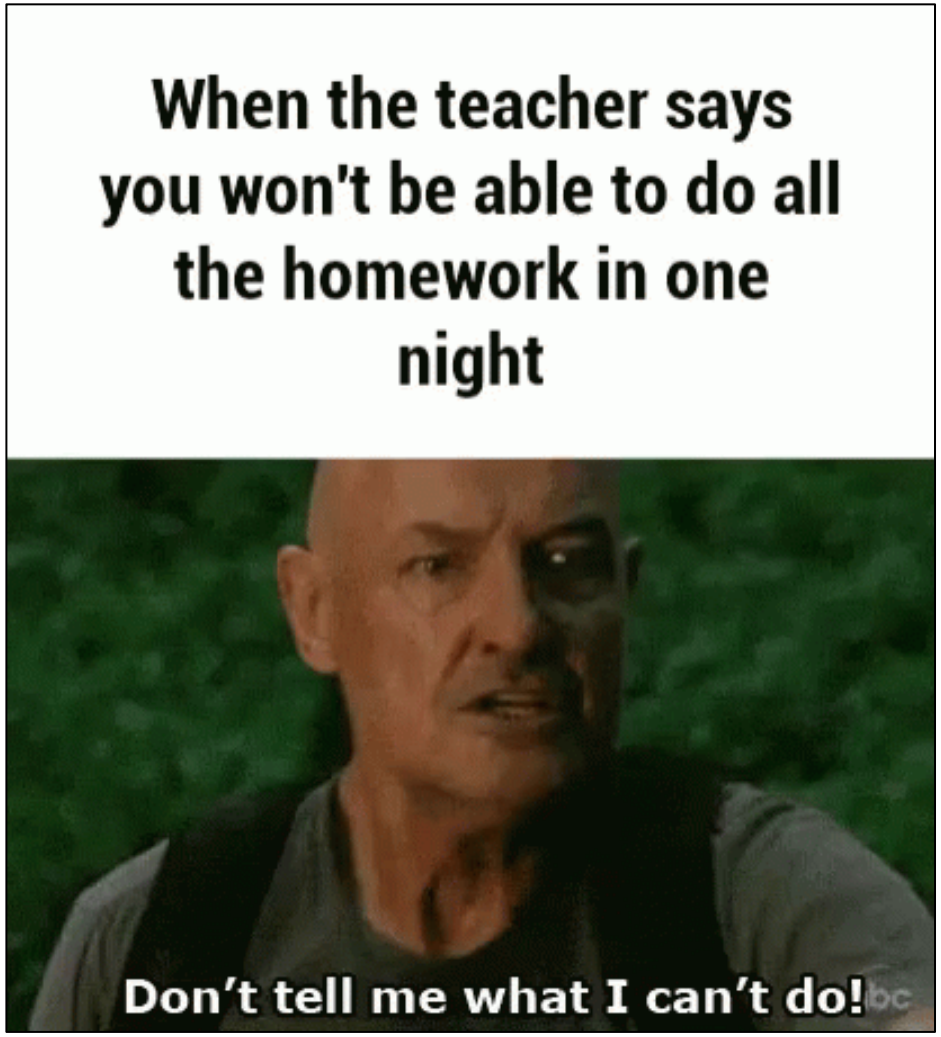
Quizzes	short quizzes during class	10%
Scribing	Take notes and typeset them for one lecture in the semester	5%
Midterm Exam	October 20th or 22nd (TBD) during class (4PM – 5PM)	20%

There will be opportunities for extra credit (max 10% of total grade)

Open-ended questions, writing assignments, creative assignments etc.

Homework

- Two major types of tasks:
  - Conceptual Questions (pen & paper)
  - Programming mini-projects in Python/Pytorch
- Conceptual:
  - Will be proofs / derivations
  - Points for steps (your thought process)
  - Show all of your work when answering
- Programming:
  - Most will be open-ended (exploratory). No right or wrong answers! Do your best!
  - Some tasks will result in bad results (by design). Evaluation will be based on your analysis and conclusions drawn from successful as well as failure cases.



Quizzes (in class)

- Multiple-choice / True-False / "draw a diagram" / short answer questions about previous lecture(s)
- Take notes during class (in your favorite format)
  - The very act of writing stuff down while you hear something new *really really* helps with information retention
- We will consider your "top k" grades out of "q" quizzes, with $\mathrm{q} - \mathrm{k} \geq 2$
  - E.g. $\mathrm{q} = 7$; $\mathrm{k} = 5$
  - There will be no make-up quizzes if you miss a class

Scribing

- Scribing ==
  - Taking high-quality detailed notes during a lecture
  - Typesetting them using Overleaf/LaTeX
  - *CVPR template is available on the Class Website*

- All students are required to scribe at least **once**
  - You can sign-up for your preferred lectures *(signup sheet: QR code)*

- ***Due Dates:***
  - *Notes for Monday lectures are due before class next Monday*
  - *Notes for Wednesday lectures are due before class next Wednesday*

Extra Credit

- HW will have some optional problems (but for extra credit!)
  - Open ended questions or tasks where your creativity is required
  - We may showcase best outcomes of these in class
- Extra credit is capped at 10%
  - 5 extra points and 91 in the rest of the class ➔ your final grade = 96
  - 18 extra points and 91 in the rest of the class ➔ your final grade = 101

Project

- **Intention:** an opportunity for
  - Doing original research in computer vision
  - Learning how to write coherent research reports based on your results
- **Expectation:** a simple original idea that
  - you can ***describe clearly***
  - relate the idea to existing work,
  - ***implement and test*** the idea on some real-world problem(s)
- How?
  - Write code, run it on some data, make some figures/tables to present results
  - read relevant background papers, collect some references
  - write a report describing your model, algorithm, and results.

Project


EVERY GROUP PROJECT
DOES 99%
OF THE WORK
HAS NO
IDEA WHAT'S
GOING ON THE
WHOLE TIME
HE'S NOT
DISAPPEAR
AT THE VERY
UP AGAIN TIL
THE VERY END

Project

- 5% for project proposal
- 5% for status update video
- 4% for individual reflection
- 10% for final presentation
- 8% for final report
- 3% for summarizing other projects

Regular, steady, well-planned work towards the final goal is the best way to complete your project

Project

Each student will be graded separately

Project Topic

Pick from our list or choose your own *

** needs approval from Tejas*

Group Size: 3 to 4 students

Declare group by March 1
*PhD / MS thesis students: can work alone**

** needs approval from Tejas*

Deliverables

- 5% for project proposal
- 5% for status update video
- 4% for individual reflection
- 10% for final presentation
- 8% for final report
- 3% for summarizing other projects

Deadlines (tentative)

Oct 3
Nov 7
Nov 7
Dec 3 or Dec 8
Dec 12
Dec 12

Deadlines & Late Days

- Late Days: each student will get 10 late days (for projects and HW only)
  - Each late day extends the deadline by 24 hours
  - Using a late day does not influence the grade.
  - Late submissions turned in *after all 10 late days have been exhausted* ***will receive 0 points***
- Projects: *if a group uses 1 late day ➔ 1 late day deducted from all group members!*
- *Quizzes: we will drop 2 (or more) lowest scores.* ***No make up quizzes.***
- Late days are provided to help you deal with illness or injury, emergencies, paper deadlines, conference travel, interviews, computer problems, or other personal reasons.

Do not use the late days as an excuse for procrastination ☺

Attending Classes

- Attendance is mandatory
  - Exceptions: health reasons and personal emergencies.
  - Impossible to do a good job at homework, quizzes, and midterm (70% of your grade) without your attendance and attention in class.
- Perks:
  - Classes have (relatively easy) quizzes.
  - Meet your future project team! Make new friends

You don't wanna miss these memes

Academic Integrity

I take academic integrity very seriously. You should too.
If you're unsure about something, ask us.
You are at a top-tier (R1) research university.
Use this privilege to learn. A good grade will follow.
Don't throw this opportunity away by cheating.

- Presentations, Survey Papers, Quizzes, Exams must be done independently.
- Do not plagiarize. Consequences will not be pleasant.
- Do not use "AI" assistants for any part of any assignment. Consequences will not be pleasant.
- Familiarize yourself with UMBC policy on plagiarism and other forms of cheating: https://academicconduct.umbc.edu/resources-for-students/
- Read the syllabus for consequences of academic integrity violations.

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3.4 Use of AI Assistants

This is a class that teaches you how to design AI systems. Using AI systems to do class work is therefore an obvious form of cheating. The use of AI systems or AI assistants (including but not limited to language models such as ChatGPT) for completing *any* part of assignments in this class is considered cheating. There are no exceptions to this rule.

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Use this privilege to learn. A good grade will follow.
Don't throw this opportunity away by cheating.

3.6 Good Practices

If the integrity of your work in this course is challenged, you are responsible for demonstrating proof that the work submitted is your own. A good starting point is to enable versioning/tracking in Google Docs, Word, Pages, or other software so that your writing activities/progress during the semester can be logged if necessary. Keeping copies of research notes, scribbles, and related material may be helpful, too.

3.7 Viva or Oral Defense of Flagged Submissions

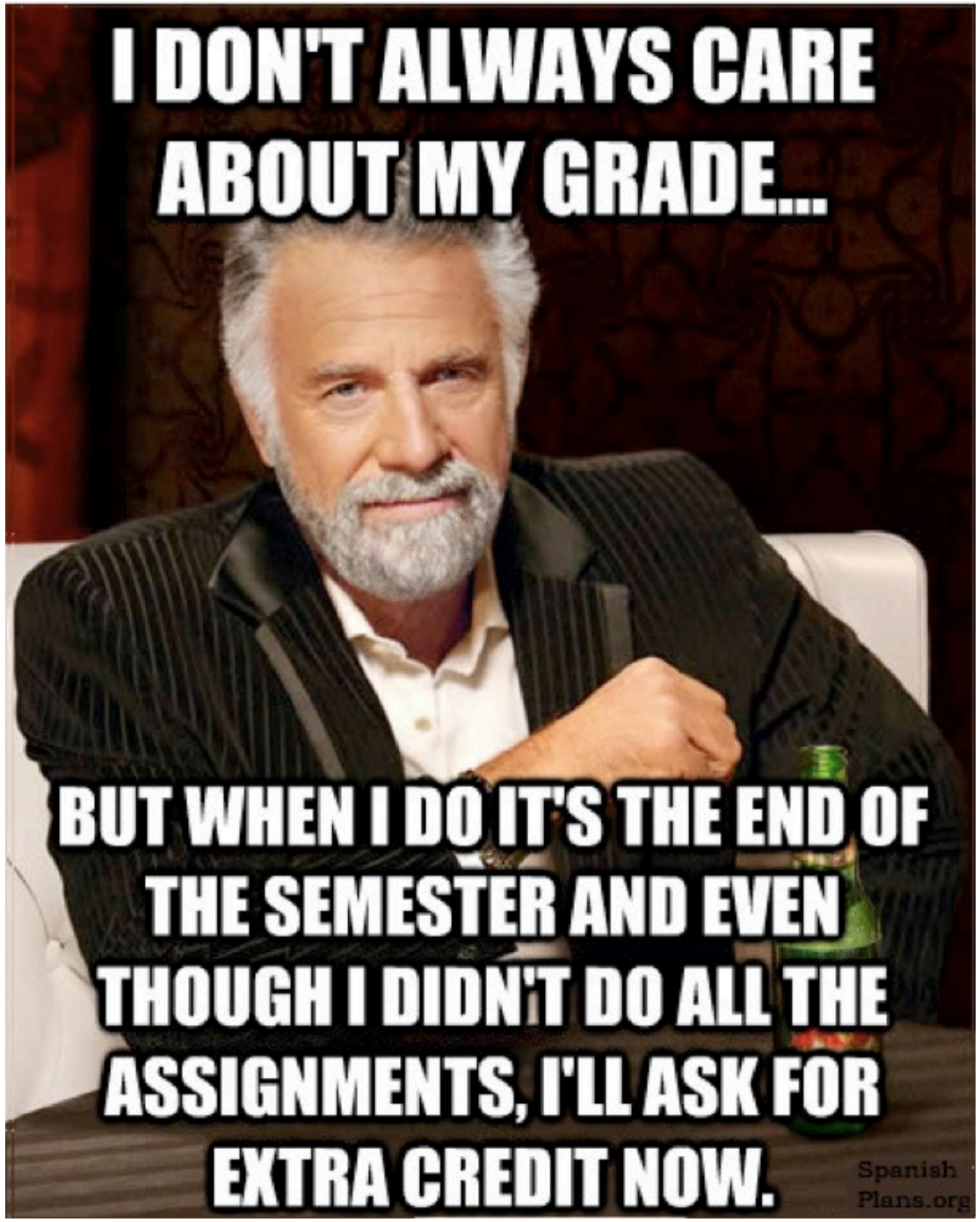
To ensure academic and professional integrity, I reserve the right to hold a one-on-one oral viva (defense) of submissions deemed questionable, to determine your knowledge and mastery of the topic/resources versus the material submitted. Failing that viva will result in an 'F' on the assignment and an Academic Integrity violation report filed with the Graduate School.

Academic Integrity

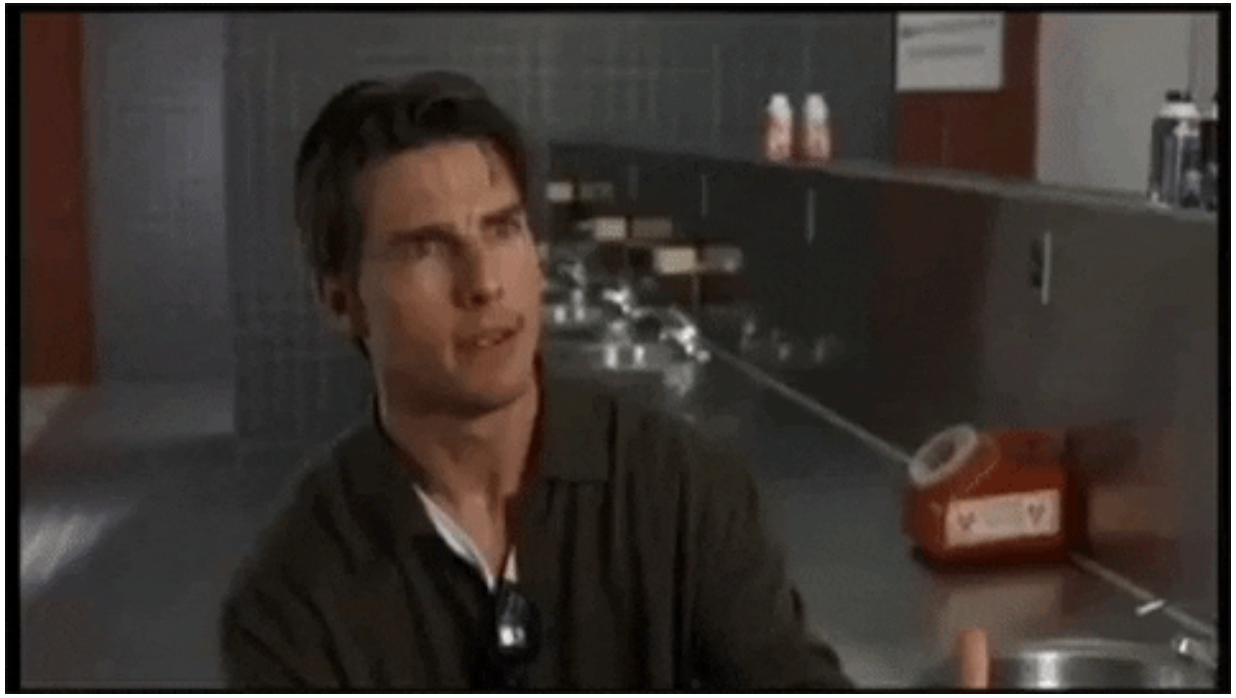
I take academic integrity very seriously. You should too.
If you're unsure about something, ask us.
You are at a top-tier (R1) research university.
Use this privilege to learn. A good grade will follow.
Don't throw this opportunity away by cheating.

3.8 Penalties

Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. The **absolute minimum penalty** for a first offense of academic dishonesty in this course is a grade of zero on the assignment and a one-letter-grade reduction in the final class grade. However, depending on the nature of the offense, the penalty may be more severe, including but not limited to an `F` for the course, suspension, or expulsion. The minimum penalty for a second offense of academic dishonesty is an `F` for the course without possibility of dropping, but may be more severe.



Seek Help Early!

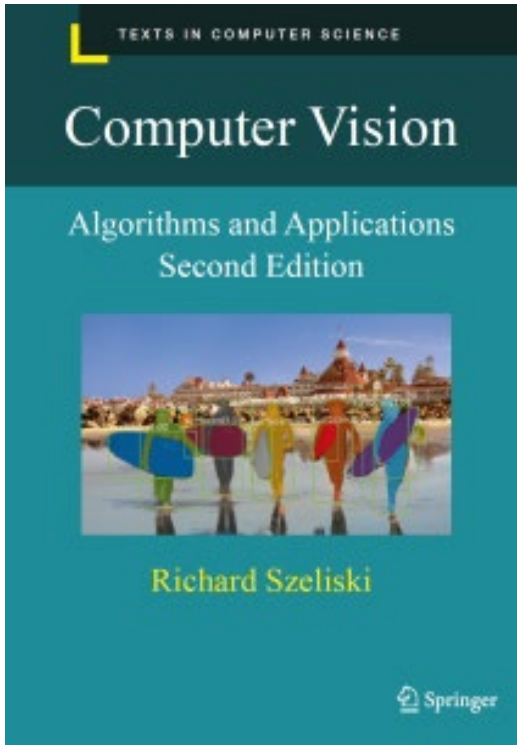


Help us help you.

Recommended Background

- Linear algebra + calculus + geometry + prob/stats (required)
  - 472/672 should not be your first introduction to these topics
  - Without these tools, you are likely to struggle with the course.
- Python programming with numerical libraries like `numpy`
  - TA will give a tutorial on computer vision with PyTorch
- Useful resources to brush up on these topics
  - deeplearningbook.org/contents/linear_algebra.html
  - https://www.deeplearningbook.org/slides/02_linear_algebra.pdf
  - deeplearningbook.org/contents/prob.html
  - https://www.deeplearningbook.org/slides/03_prob.pdf

Readings

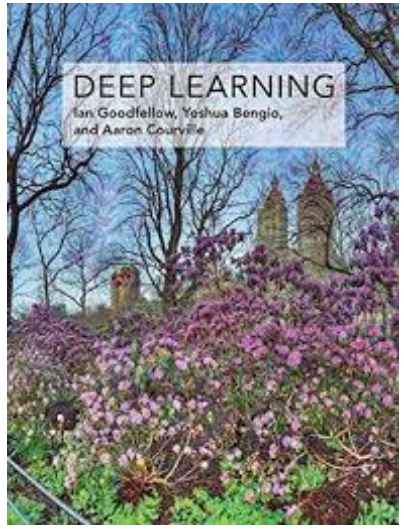


https://szeliski.org/Book/

Free download

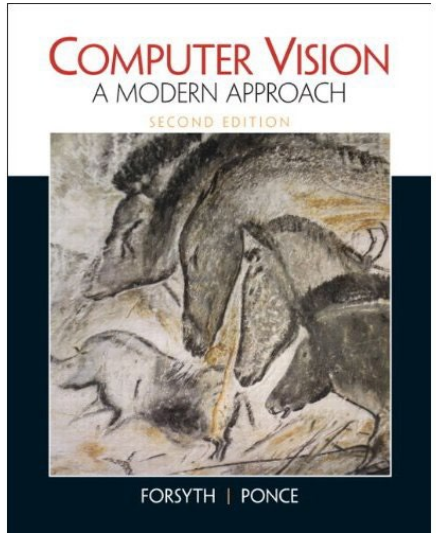
Topic-specific reading will be provided (pdf)

Other useful resources:



www.deeplearningbook.org/

Free download



GPU Computing

- Homeworks do not require GPUs
- Projects (depending on the topic you choose) might need GPUs
- GPUs are very expensive.

  PLEASE DON'T UPGRADE YOUR COMPUTER JUST FOR THIS CLASS !!!

- Google Colab is your friend
  - Collab Pro is free for students!

New Google Colab features for higher education

Jul 18, 2025 · 2 min read

Read AI-generated summary

Share

Students and professors can get Colab Pro free of charge for a year, plus check out new features like an interactive slideshow mode.

472 (undergrad) vs 672 (grad)

- We are confident that 472 students are at least as capable than their 672 classmates
- ***No difference in class materials, exams, quizzes, majority of homework***
- Homework: additional parts for 672
- Grad projects will be evaluated at a higher standard

472 (undergrad) vs 672 (grad)

Main difference: projects (scope and novelty)

- Projects will be graded in terms of "relative growth"
  - ***You may have previous research experience***
  - ***You may be taking this class to get research experience***
- Grad projects:
  - Original & unique research hypothesis with a potential for publication
- Undergrads projects can be:
  - Original & unique research hypothesis with a potential for publication
  - Working on an idea that we provide (i.e. you get to skip "ideation")
  - Innovative applications or combination of existing work

FAQ: I'm waitlisted – what can I do?

1. I'm sorry this is happening to you. Thanks for your patience.
   I (like you) am also bound by UMBC's waitlist policy.

09/03/2025	Waitlist Deadline	Last day to add yourself to a waitlist for a course
09/04/2025	Waitlists Deactivated	Waitlists are deactivated and purged
09/10/2025	Schedule Adjustment Deadline	Last day to make changes to your schedule Last day to change grade method Last day to drop a course without a W grade Last day to add internships, independent studies, or

2. On 09/08 if you're still interested, see me after class. No promises, but I'll try.

FAQ: Access to Practice Quizzes and Midterm?

- This is a graduate-level class – we will test your concepts (and not your ability to do fast arithmetic / memorization)
  - Make sure you understand the concepts
  - Read the slides and references mentioned in class
- Enjoy the class. Be rigorous. Don't be afraid to fail.
- Don't study just for the grade – study because you enjoy the topic!
- There are no study guides, question bank, practice tests – this is not high school !
- Welcome to the real world!

FAQ: How do I succeed in this class?

- Use pen-and-paper. Draw! Draw! Draw!
- Computer vision is a very popular *and open-source* topic
  - Feel free to read or watch lectures from other professors
- Focus on grasping fundamentals!
  - HW will become easy once you know the concepts behind the problems and projects.
- Ask for help
  - TA Office Hours
  - Tejas Office Hours

FAQ: Can I join your research lab?

- The Cognitive Vision Group (CVG) broadly works on "conceptual characterization of visual scenes" with some goals including:
  - interpretation of visual data in presence of incomplete information,
  - recognizing and adapting to novelty and variations,
  - leveraging external knowledge and reasoning modules to generalize to new contexts, domains, environments, and tasks,
  - acquiring visual knowledge and communicating it to other machines and humans.

- Joining (See FAQ/note on my website)
  - Take this class and talk to me during office hours about your interests
  - https://www.tejasgokhale.com/docs/cvg_starter_pack.pdf

Other Questions?

Scribing / Project Team Signup Sheet

Class Website

Timeline of Buzzwords in Vision

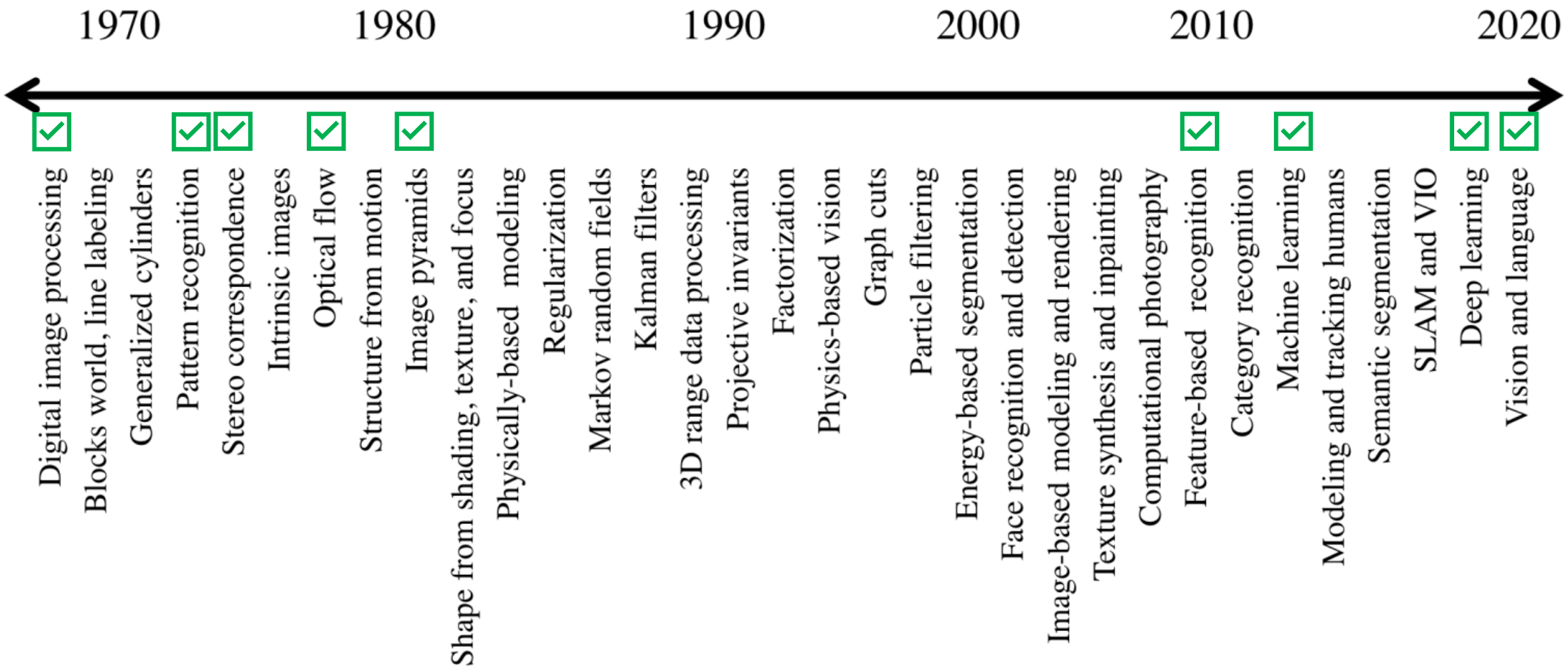
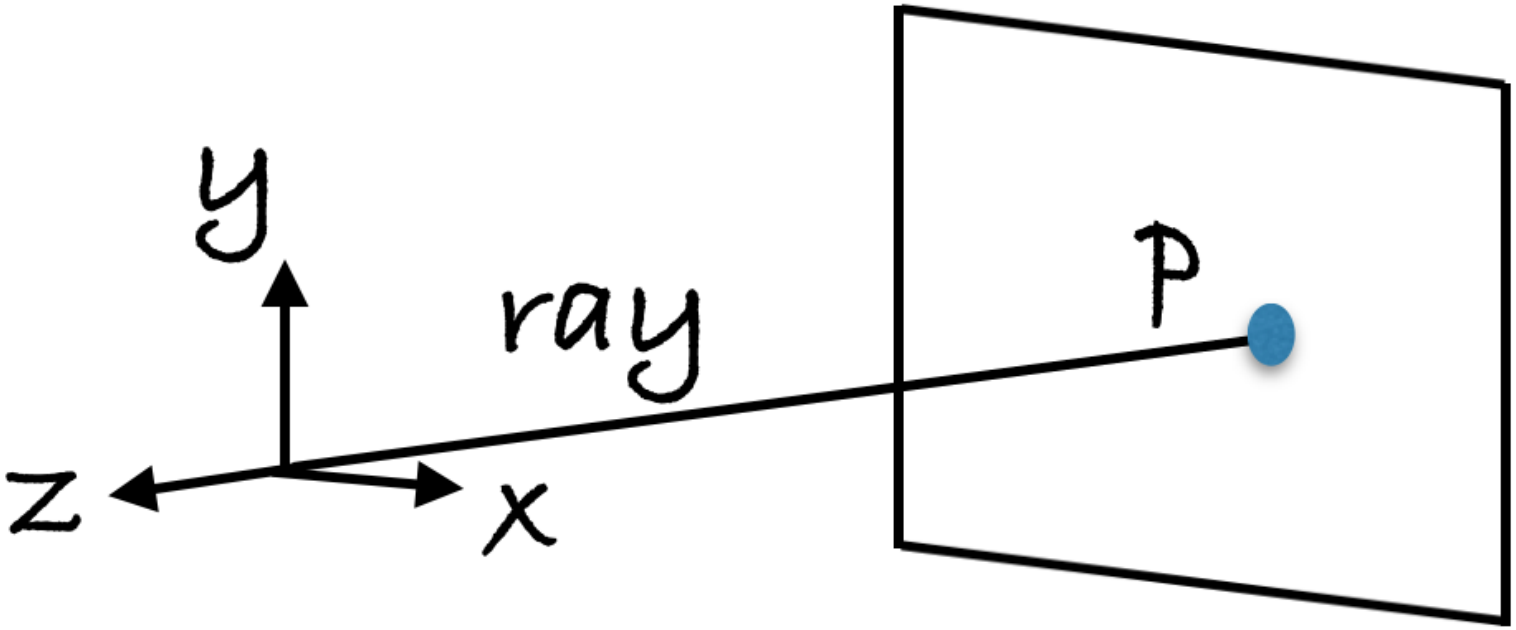


Image Formation



Let’s say we have a sensor…

digital sensor
(CCD or CMOS)

… and an object we like to photograph

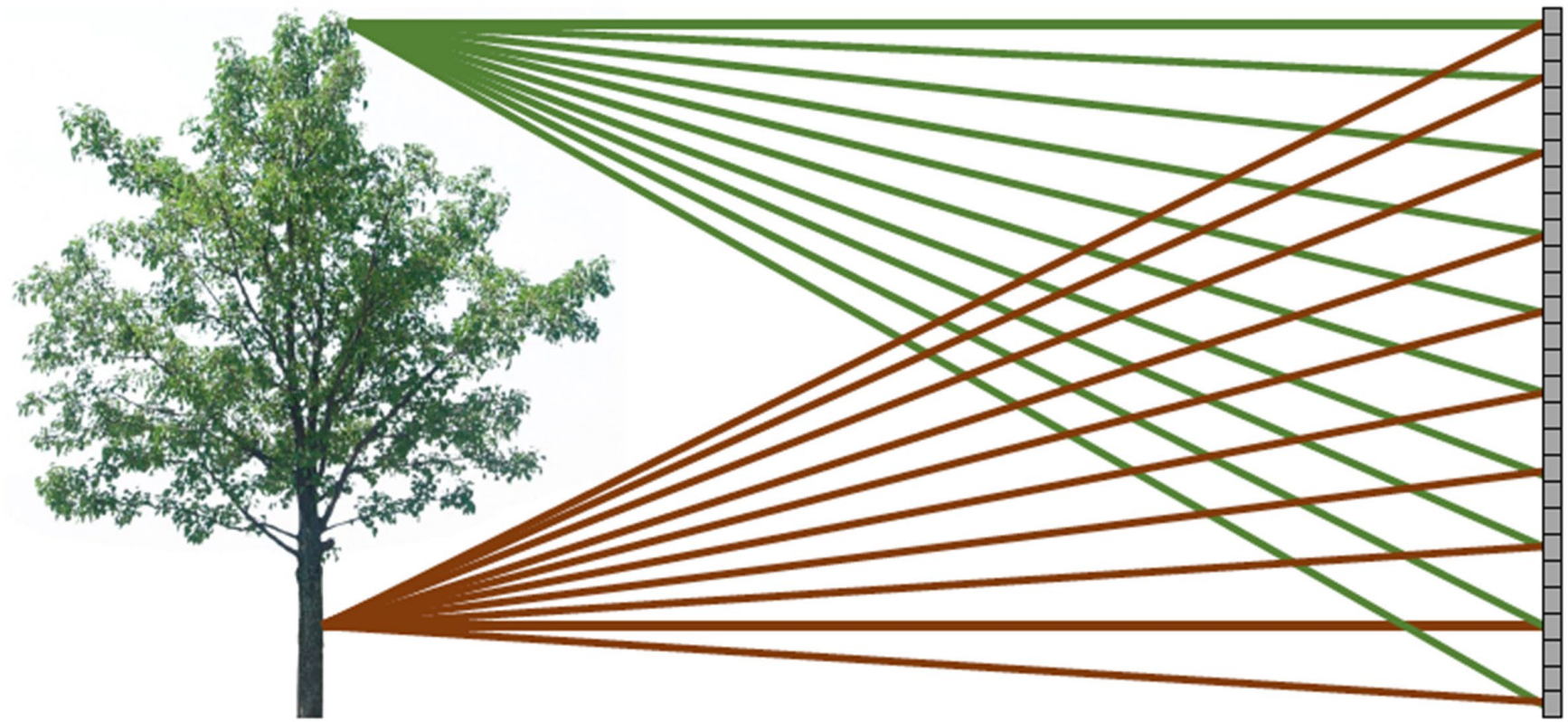
real-world object

digital sensor (CCD or CMOS)

What would an image taken like this look like?

Bare-sensor imaging

real-world object



digital sensor (CCD or CMOS)

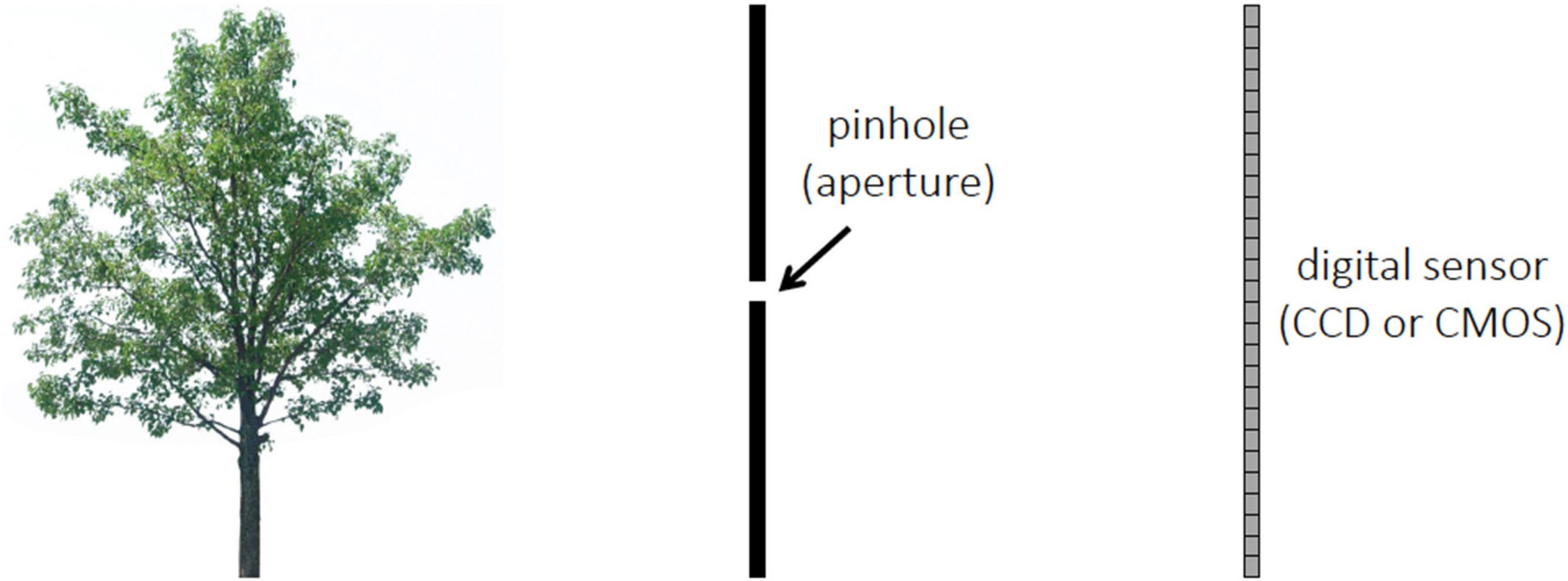
All scene points contribute to all sensor pixels

What does the image on the sensor look like?

Bare-sensor imaging

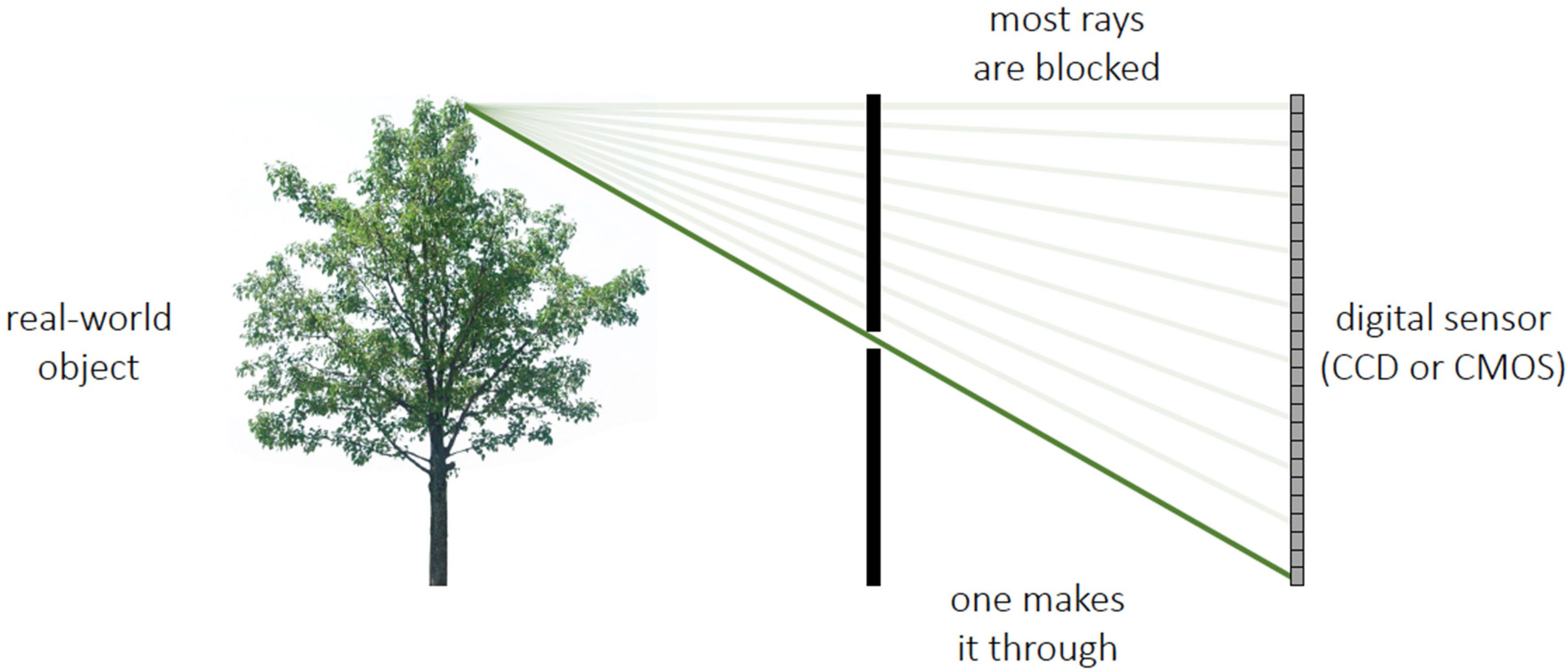
All scene points contribute to all sensor pixels

Let’s add something to this scene

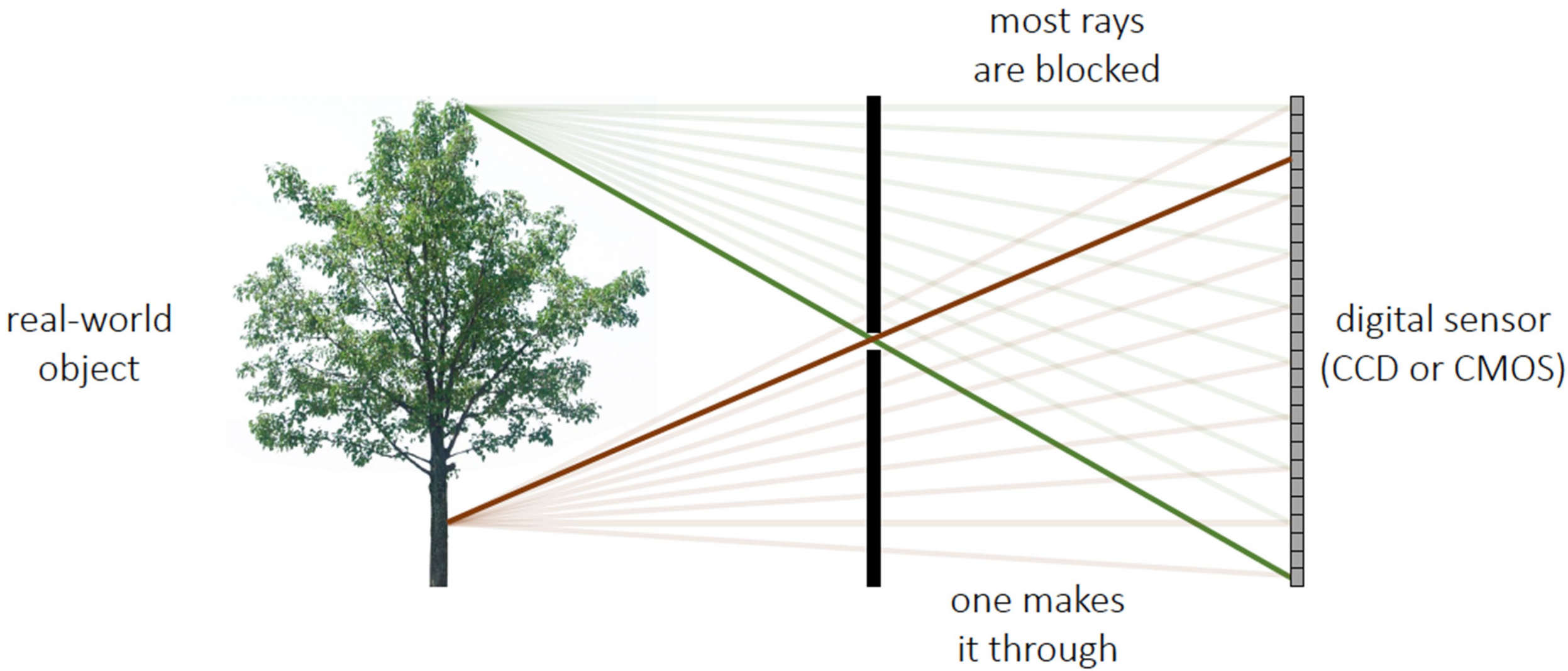


What would an image taken like this look like?

Pinhole imaging

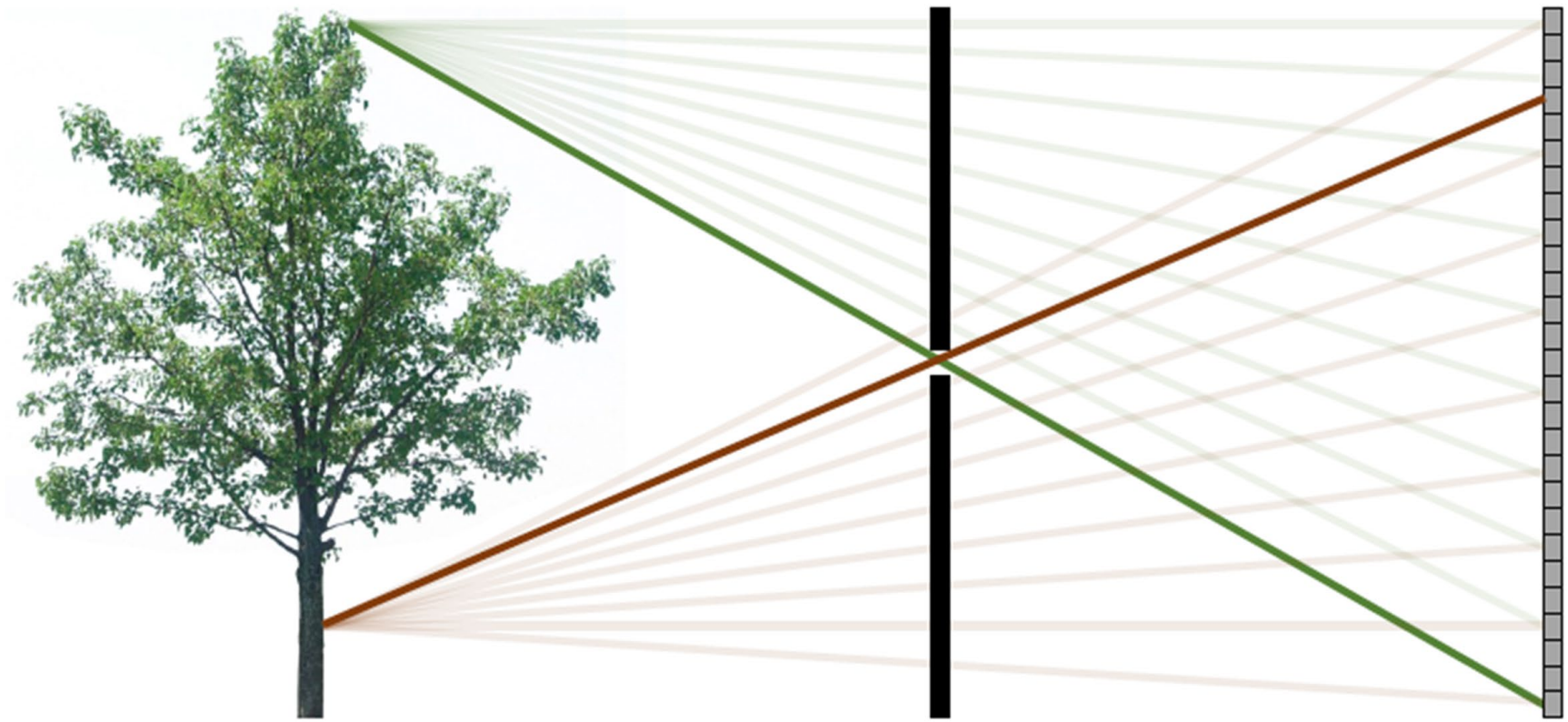


Pinhole imaging



Pinhole imaging

real-world object



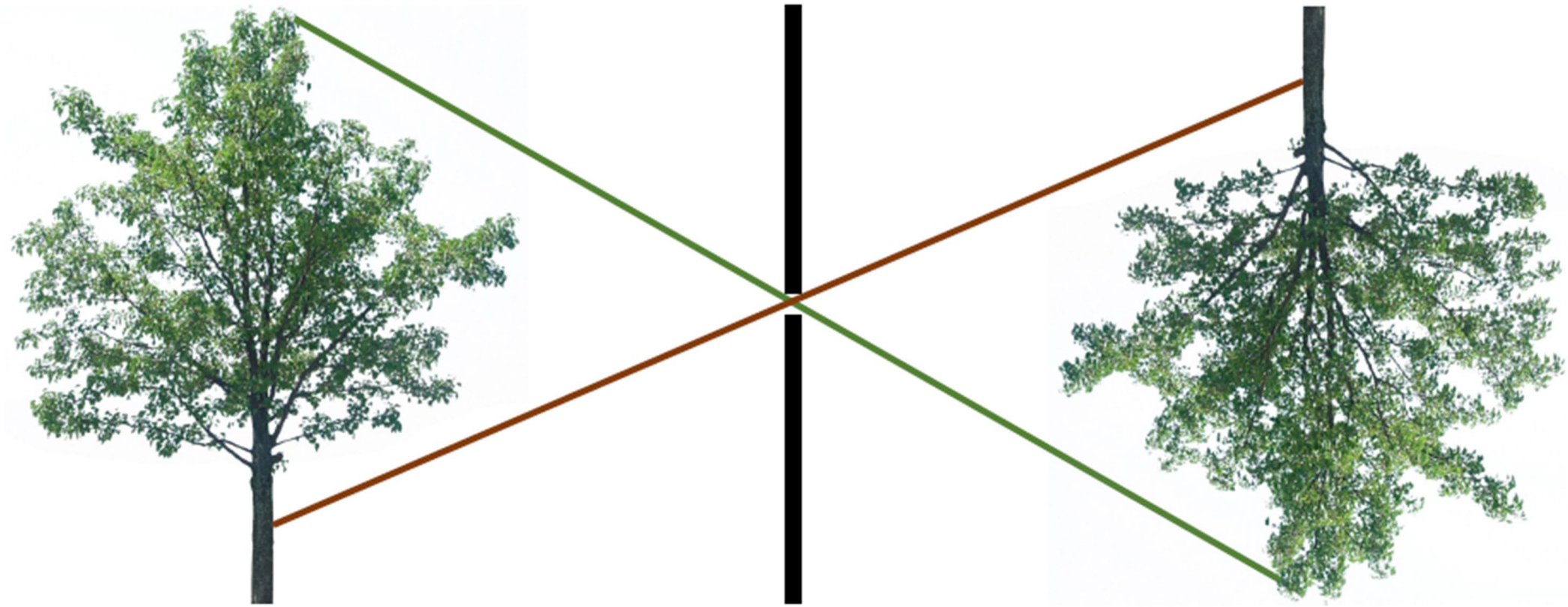
digital sensor (CCD or CMOS)

Each scene point contributes to only one sensor pixel

What does the image on the sensor look like?

Pinhole imaging

real-world object



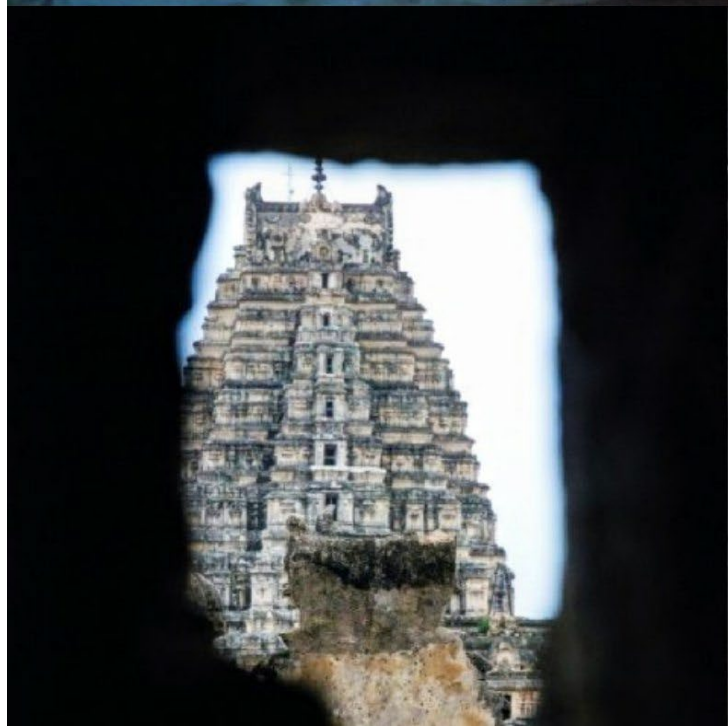
copy of real-world object (inverted and scaled)

“Camera Obscura”

- Camera obscura = “dark chamber” in Latin
- Theorized to be the reason for distortions in prehistorical neolithic paintings ...
- Mozi (China, ~ 400 BC)
- Aristotle (Greece, ~ 350 BC)

Ancient Architecture or Accidental Pinhole Camera?

- Shiva Temple in Hampi (India)
- inverted image can be seen
- Built in ~600 AD



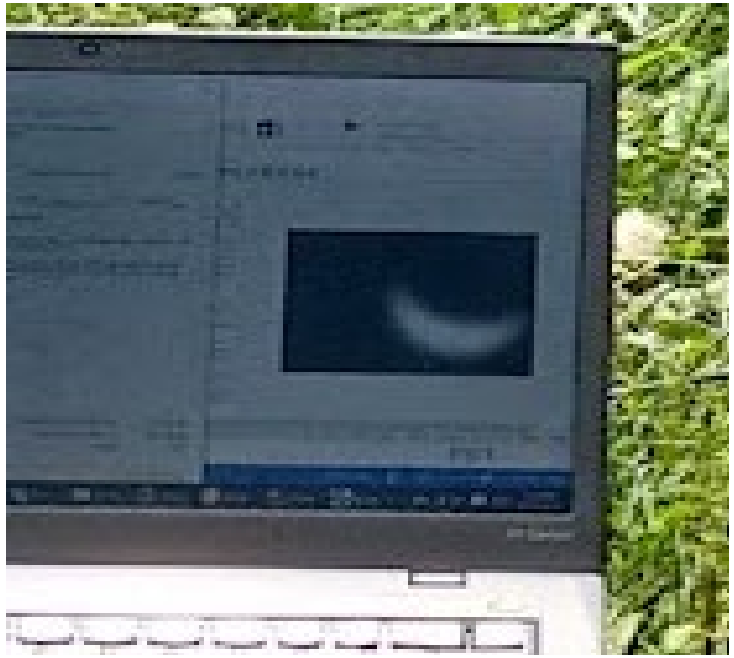
Make your own pinhole camera while the sun shines (Ancient Computer Vision Proverb)

Paper with a hole in it … some creative friends … an auspicious day …

Where are they now? Faculty at UMBC, Faculty at UC Riverside; Fellow at Allen Institute; Research Scientist at Adobe …

“Make your own pinhole camera while the sun shines”
(Ancient Computer Vision Proverb)

“Great American Eclipse” of August 21, 2017



“Make your own pinhole camera while the sun shines” (Ancient Computer Vision Proverb)

“Great North American Eclipse” of April 8, 2024 at UMBC

“Make your own pinhole camera while the sun shines” (Ancient Computer Vision Proverb)

Images produced by natural pinholes [edit]

(Images of the eclipse created by natural pinholes formed by tree leaves)

North Cascade mountains (British Columbia and Washington).

East Wenatchee, Washington

Moon, Pennsylvania

Pinhole camera terms

real-world object

barrier (diaphragm)

pinhole (aperture)

camera center (center of projection)

image plane

digital sensor (CCD or CMOS)