Introduction

Computer Vision
Fall 2019
Columbia University

Cameras everywhere

Also scary times

The New York Times

Facial Recognition Is Accurate, if You're a White Guy

By Steve Lohr

Feb. 9, 2018

Facial recognition technology is improving by leaps and bounds. Some commercial software can now tell the gender of a person in a photograph.

When the person in the photo is a white man, the software is right 99 percent of the time.

But the darker the skin, the more errors arise — up to nearly 35 percent for images of darker skinned women, according to a new study that breaks fresh ground by measuring how the technology works on people of different races and gender.

What is vision?

“What does it mean, to see? The plain man's answer (and Aristotle's, too) would be, to know what is where by looking.”

— David Marr, 1982

1945 - 1980 (35 years old)

What is vision?

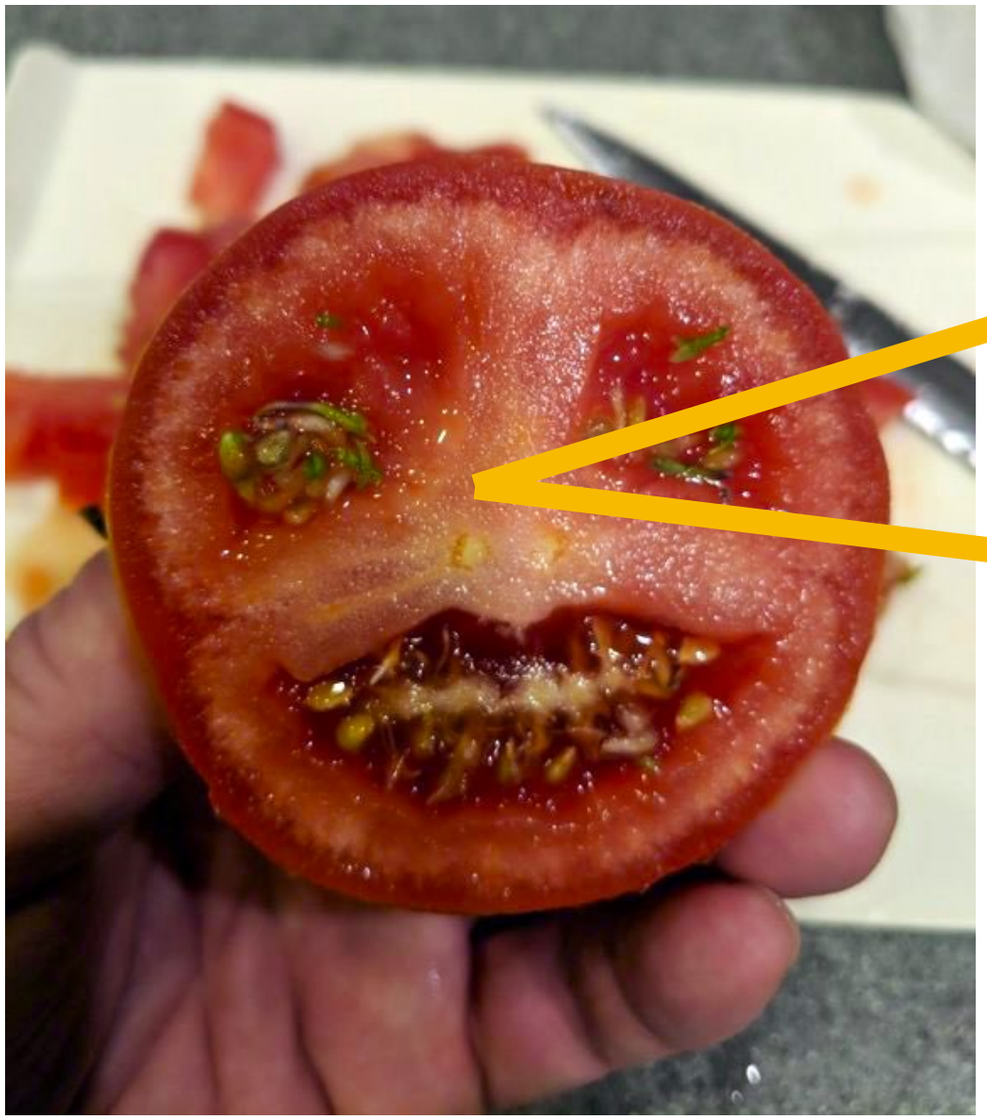
"To know what is where by looking"
— David Marr, *Vision (1982)*

What is vision?

Measurement: 173 redness, 101 greenness, 68 blueness

"To know what is where by looking"
— David Marr, *Vision (1982)*

What is vision?

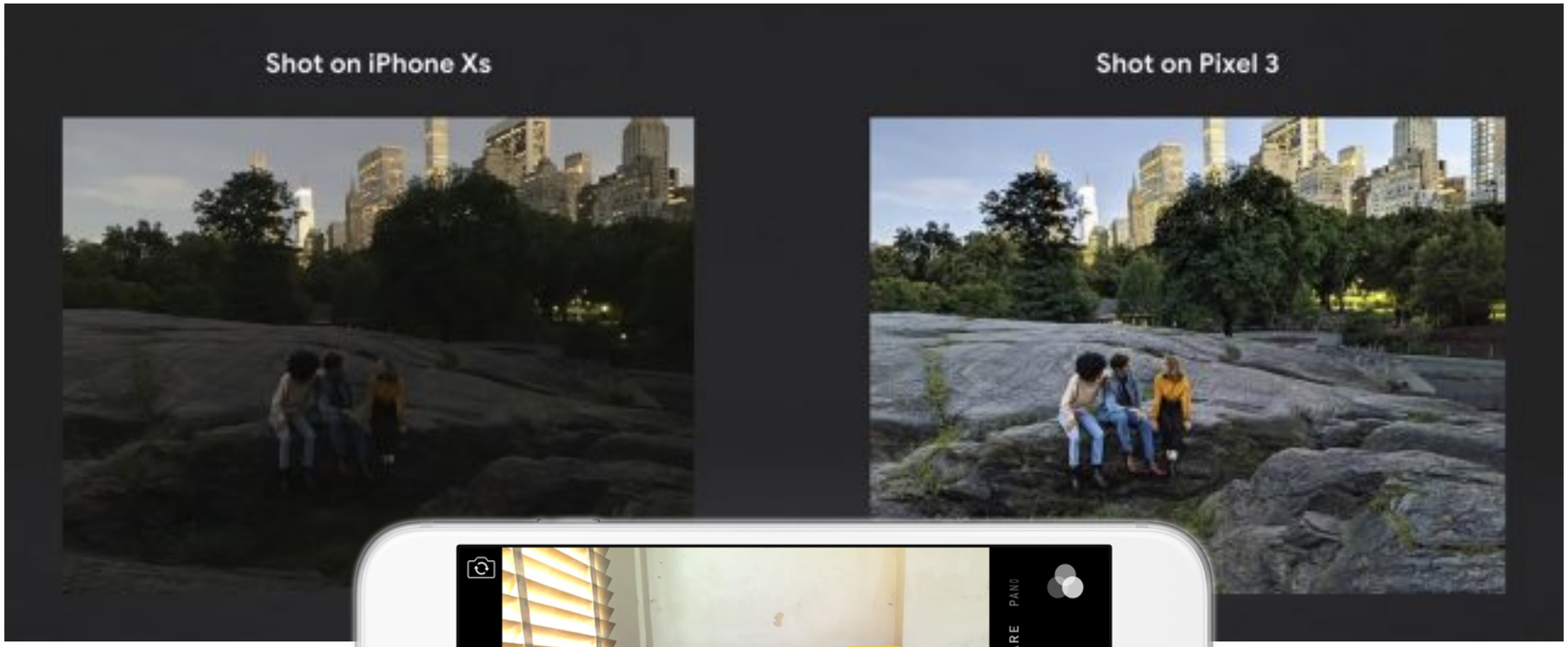


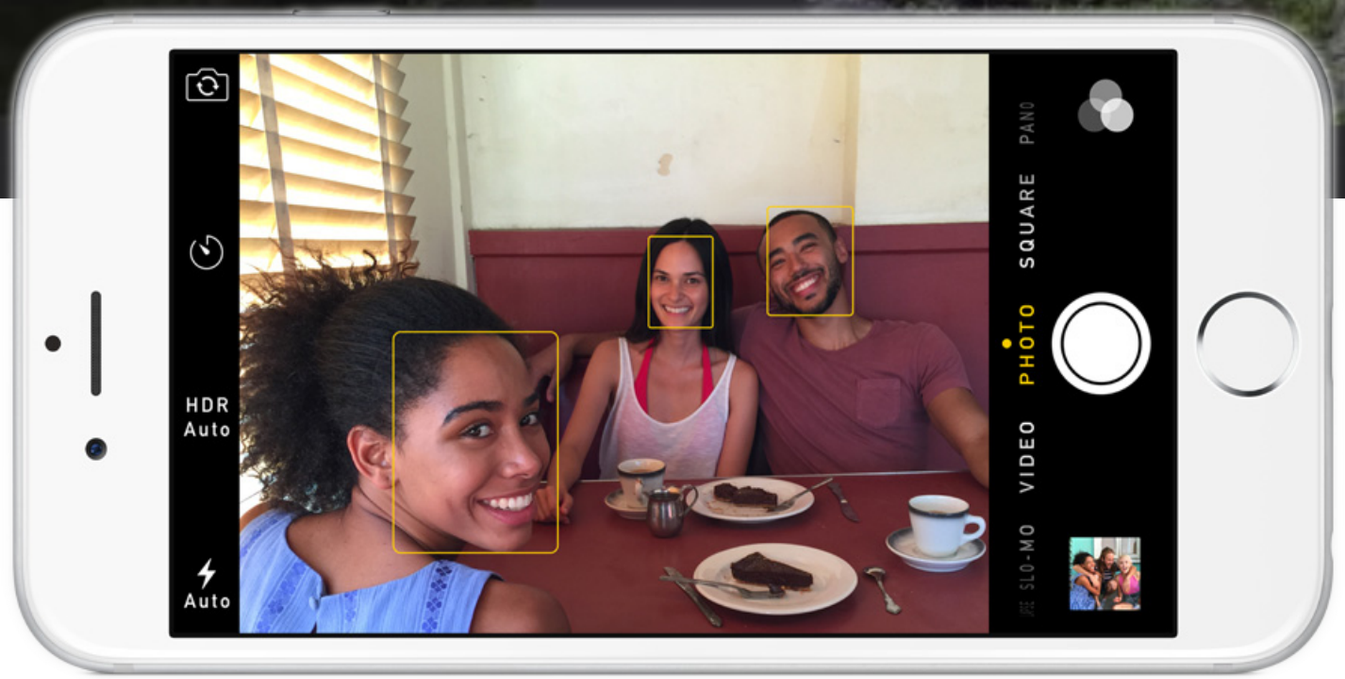
Measurement: 173 redness, 101 greenness, 68 blueness

Perception: Sliced Tomato

"To know what is where by looking"
— David Marr, *Vision (1982)*

Computational Photography





Biometrics

1984

- "the most recognized photograph" in the history of the *National Geographic* magazine

- No one knew her identity…

Sharbat Gula

1984 2002

Optical Character Recognition

Security and Tracking

“The work was painstaking and mind-numbing: One agent watched the same segment of video 400 times. The goal was to construct a timeline of images, following possible suspects as they moved along the sidewalks. It took a couple of days” Washington Post

Health

Gaming

Shopping

Special Effects

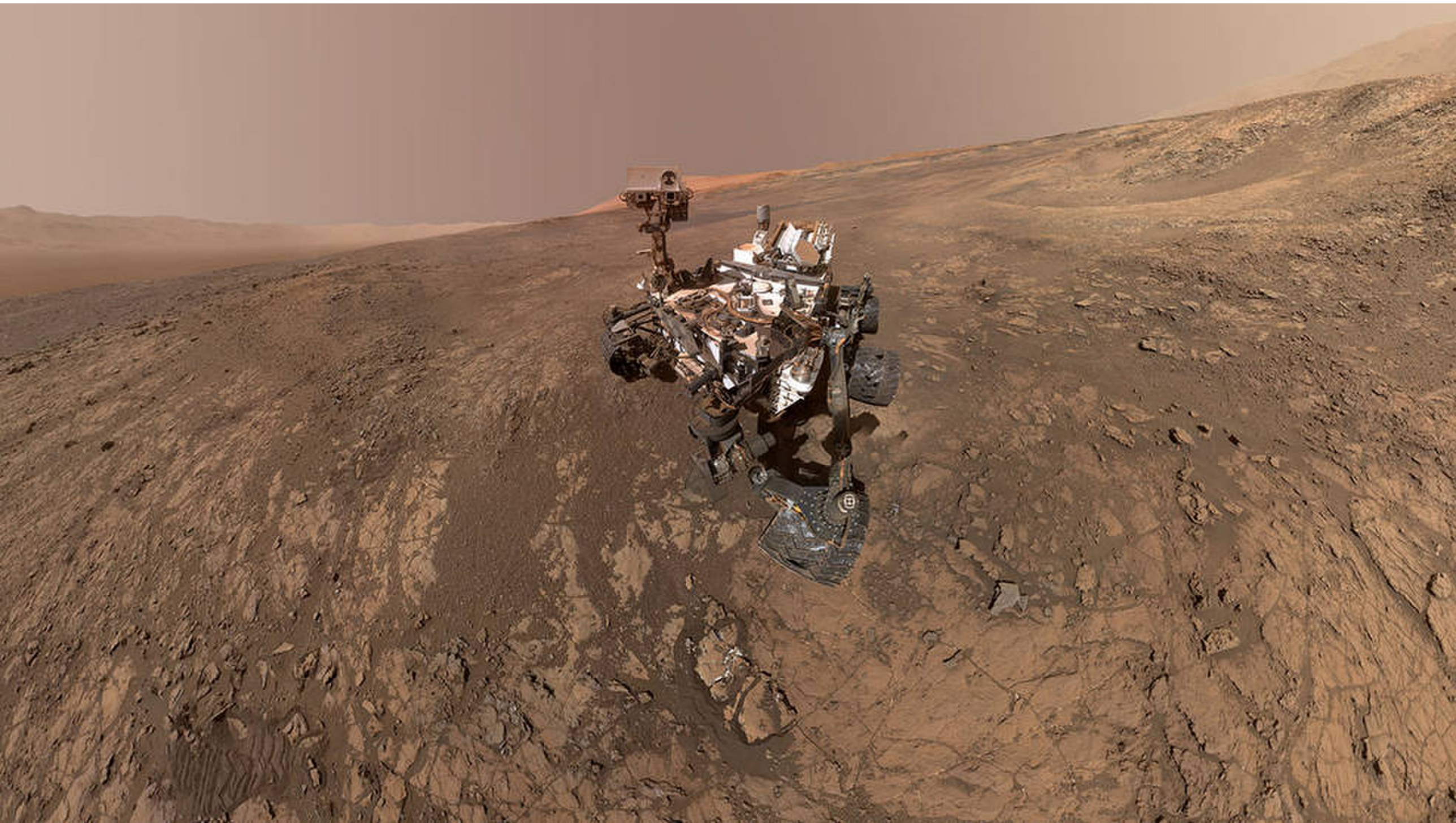
Insight

Walmart in Wichita, Kansas

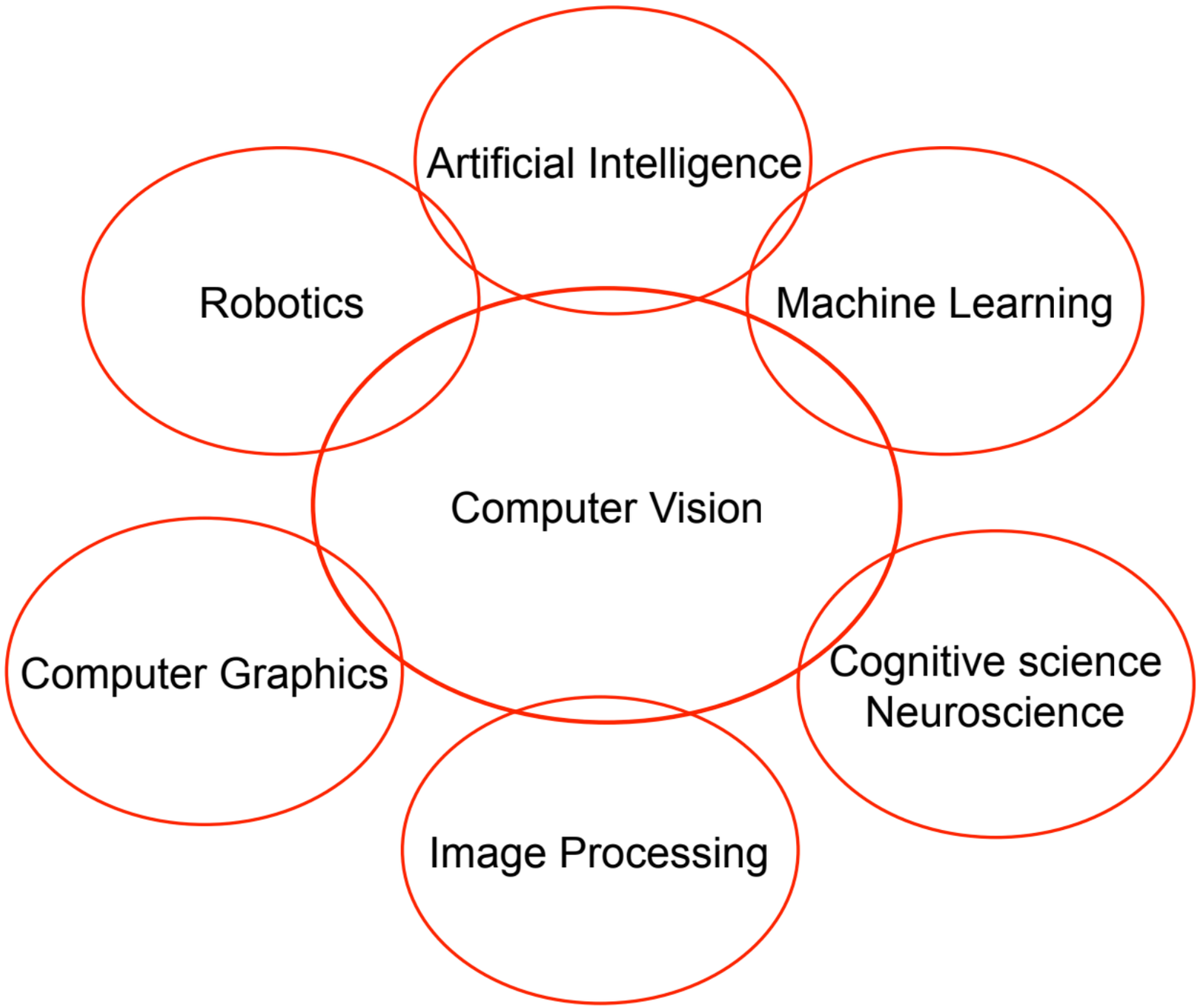
Self-driving Cars

Augmented Reality

Space Exploration

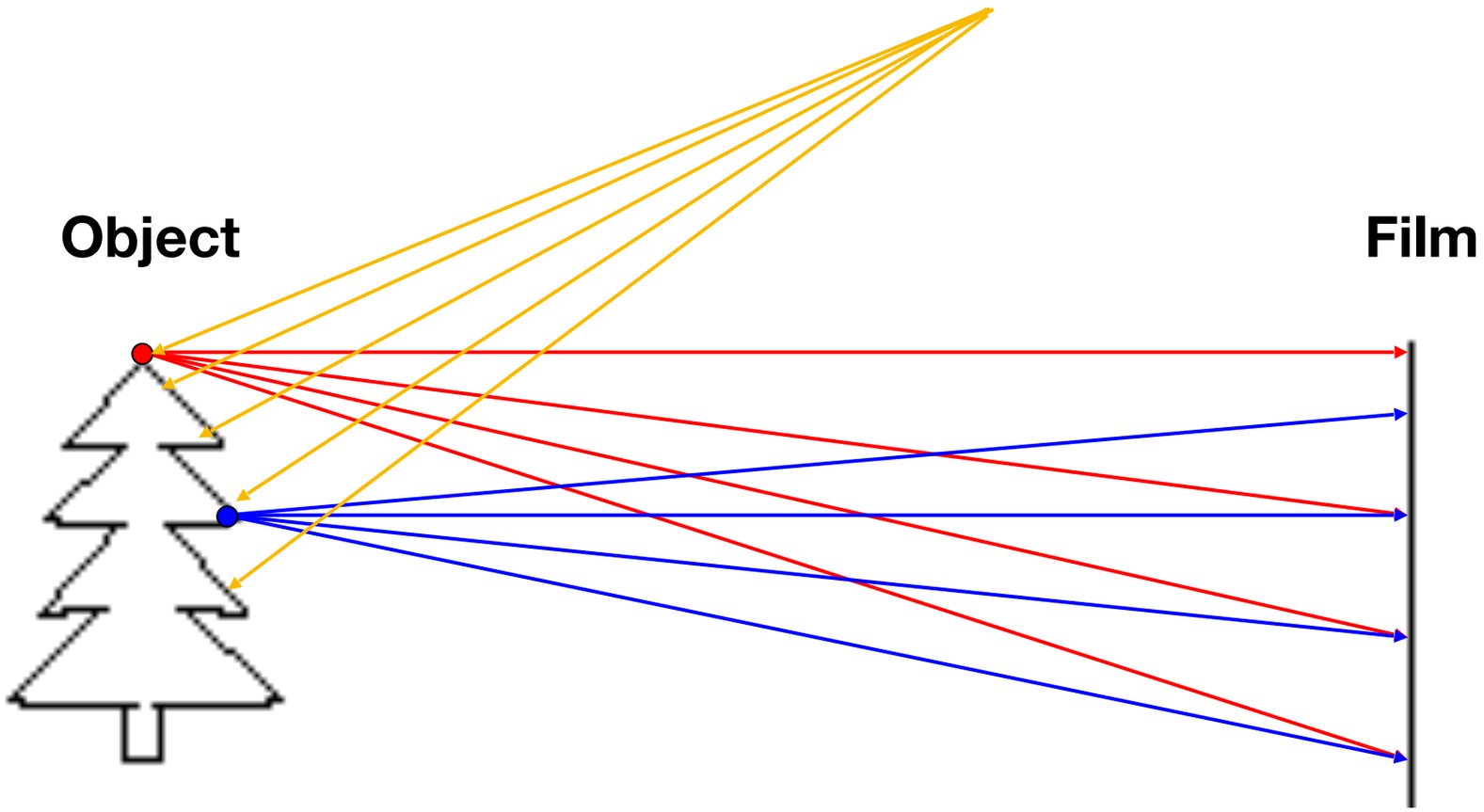


What is vision?



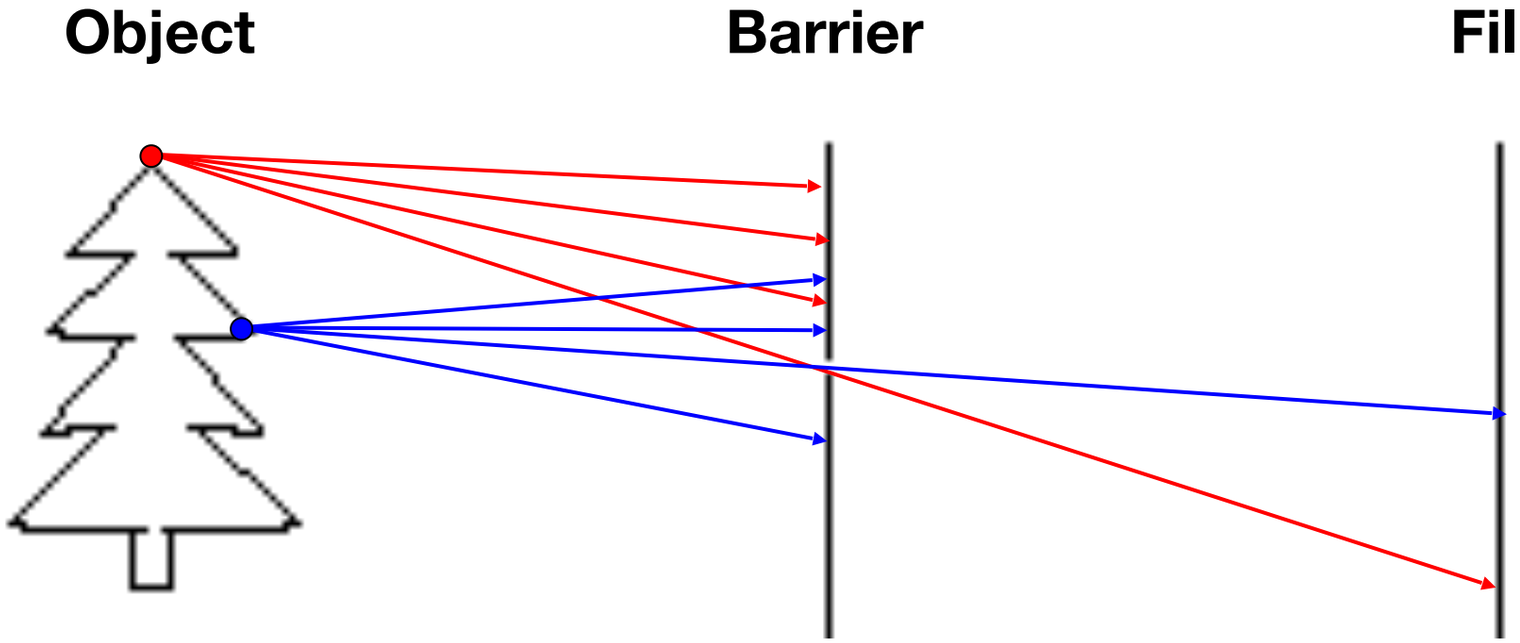
Slide credit: Kristen Grauman

Image Formation



Slide credit: Steve Seitz

Image Formation



Add a barrier to block off most of the rays

Slide credit: Steve Seitz

Representing Digital Images

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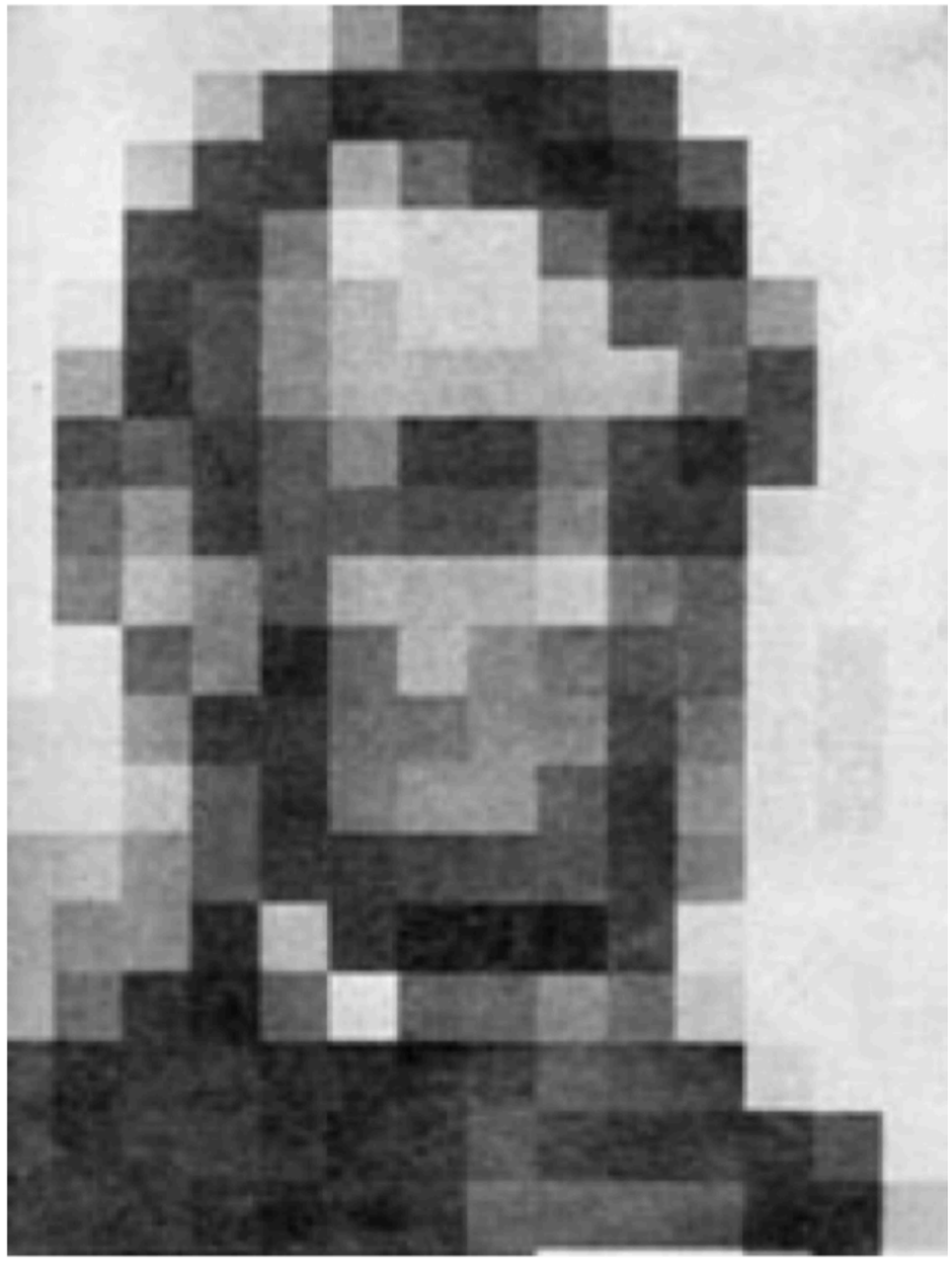
43	7	0	123	4	13	454	23	5	87
67	5	76	4	3	56	67	87	65	45
97	0	6	3	6	25	7	3	587	8
78	5	54	7	876	71	54	76	9	75
45	81	67	78	78	5	4	75	86	8
5	4	3	35	8	256	6	4	3	36
7	6	64	3	4	7	77	76	4	54
64	35	46	46	64	56	7	56	4	7
75	464	576	75	75	75	57	64	75	75

Slide credit: Deva Ramanan

Representing Digital Images



Slide credit: Deva Ramanan

Representing Color Images

Color images, RGB color space

R

G

B

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".

Illumination

“Neither Autopilot nor the driver noticed the white side of the tractor trailer against a brightly lit sky, so the brake was not applied.” — Tesla Company Blog

Slide credit: S. Ullman

Occlusion

René Magritte, 1957

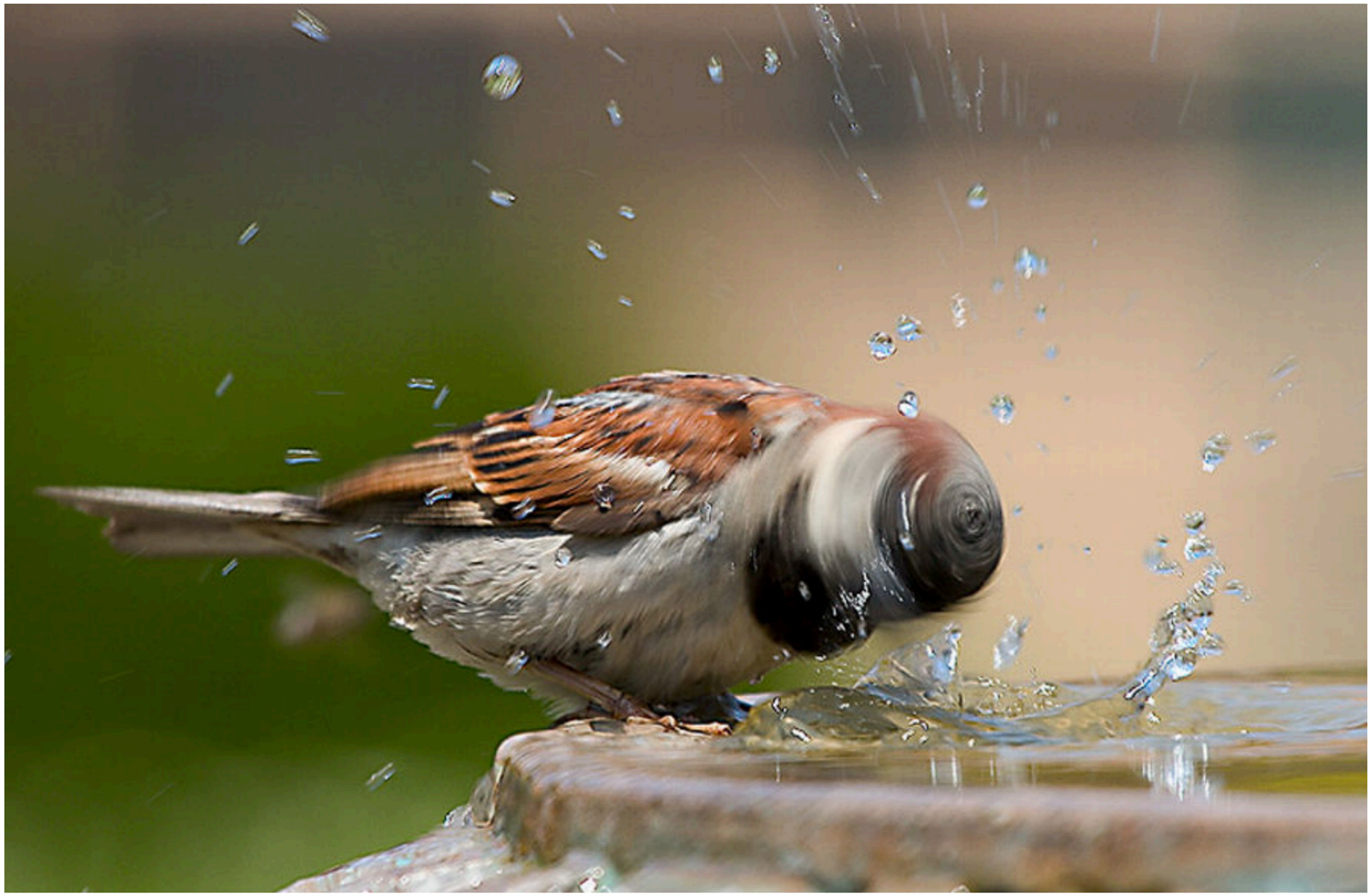
Class Variation

Slide credit: Antonio Torralba

Clutter and Camouflage

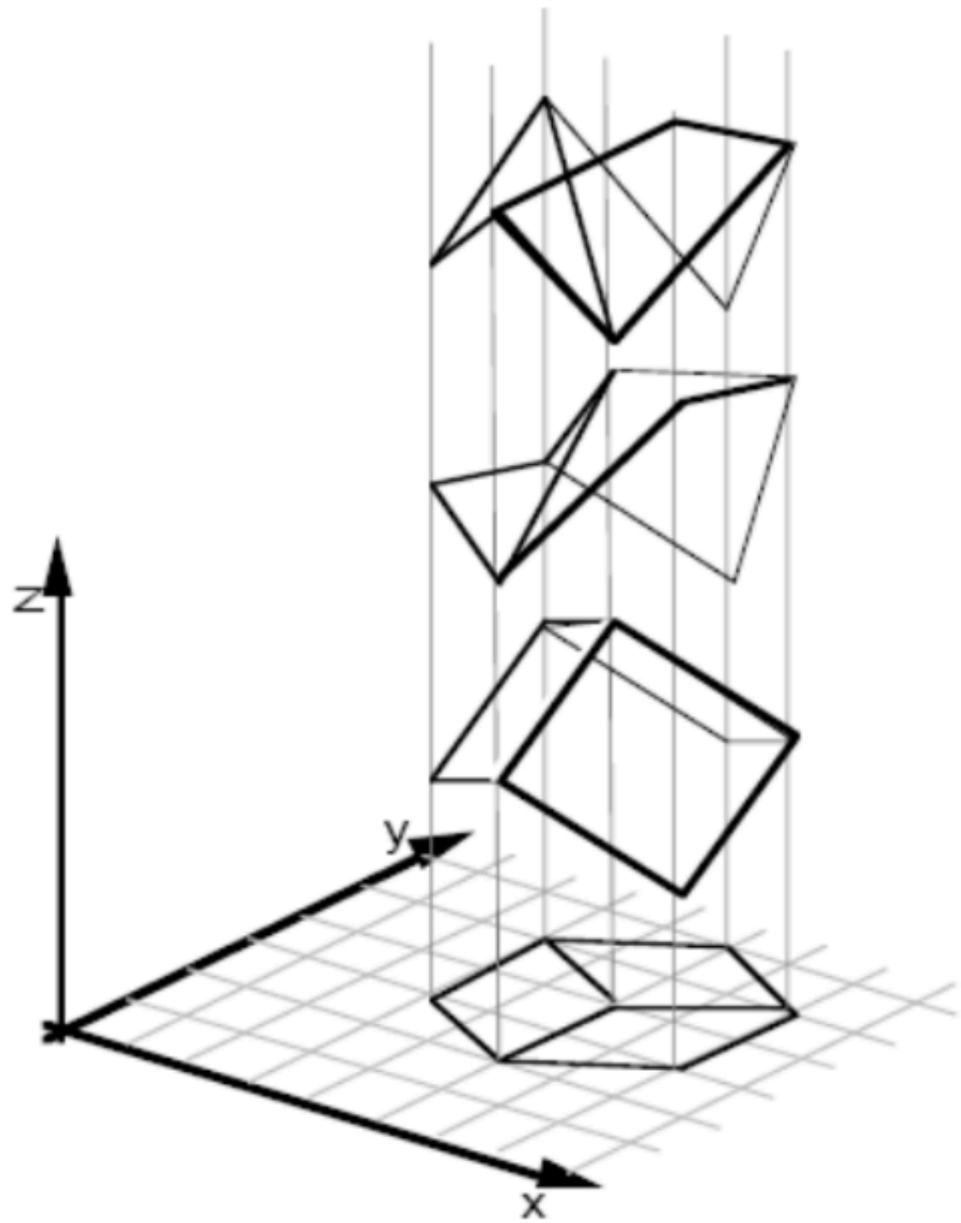
Color

Motion



Slide credit: S. Lazebnik

Ill-posed Problem

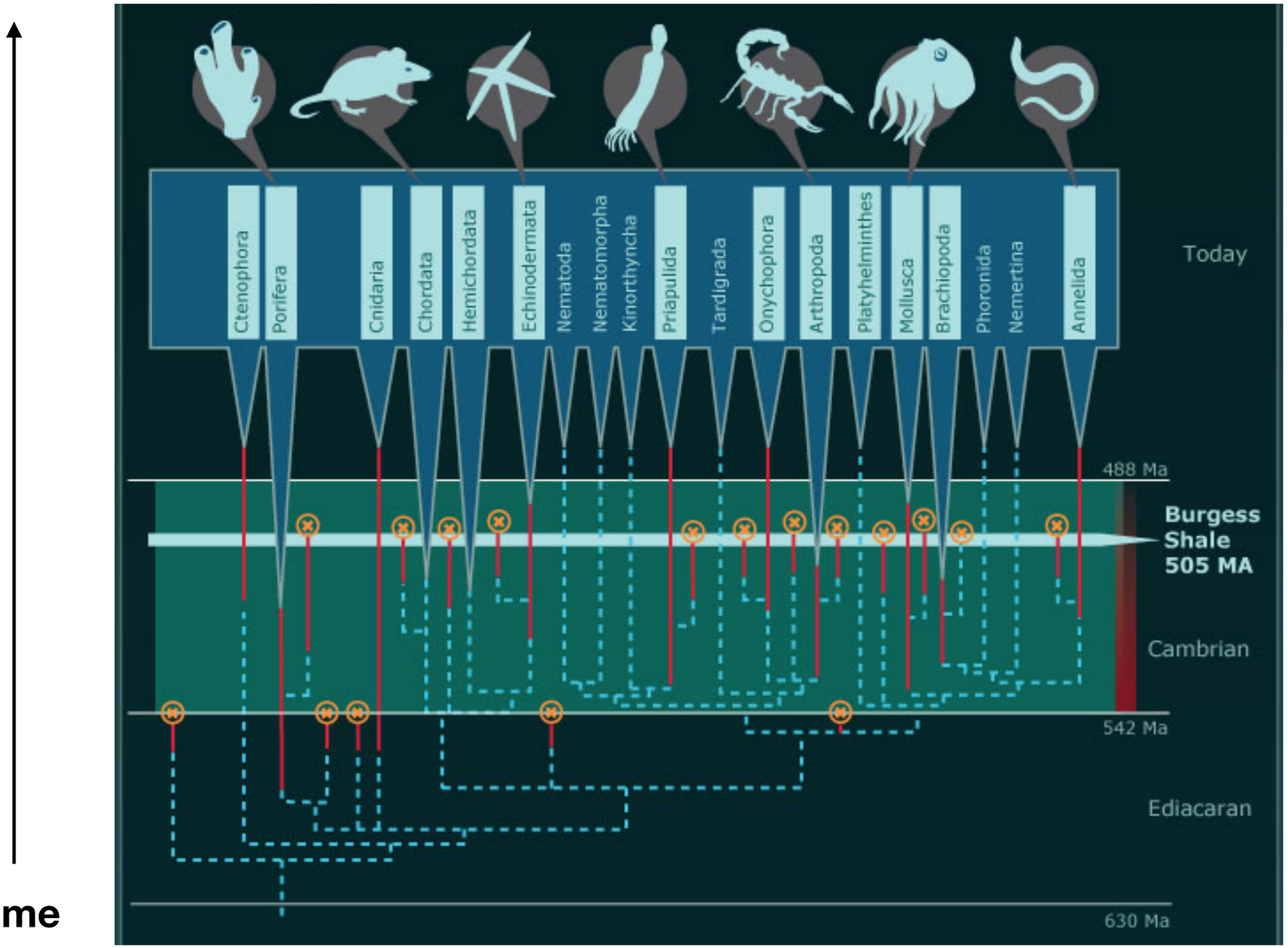


[Sinha and Adelson 1993]

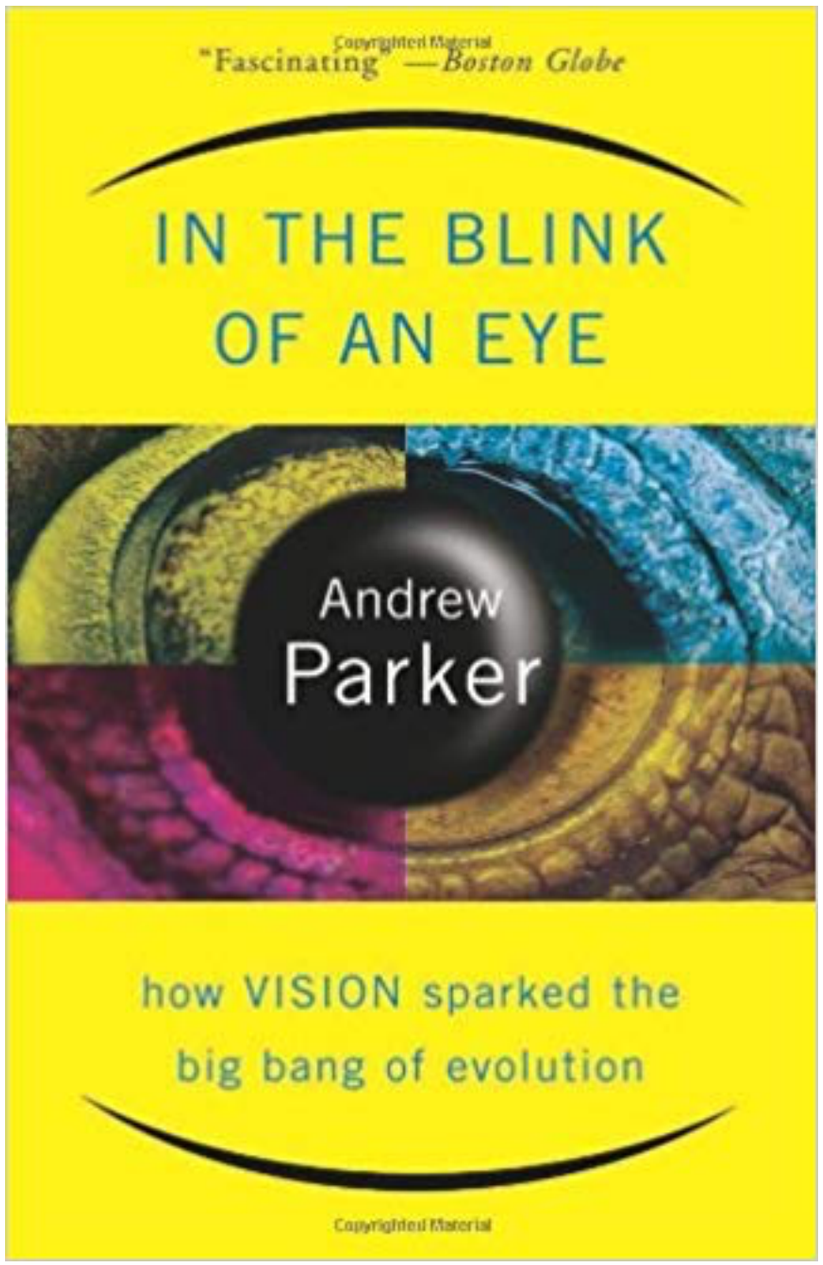
Ill-posed Problem

Ill-posed Problem

Cambrian Explosion

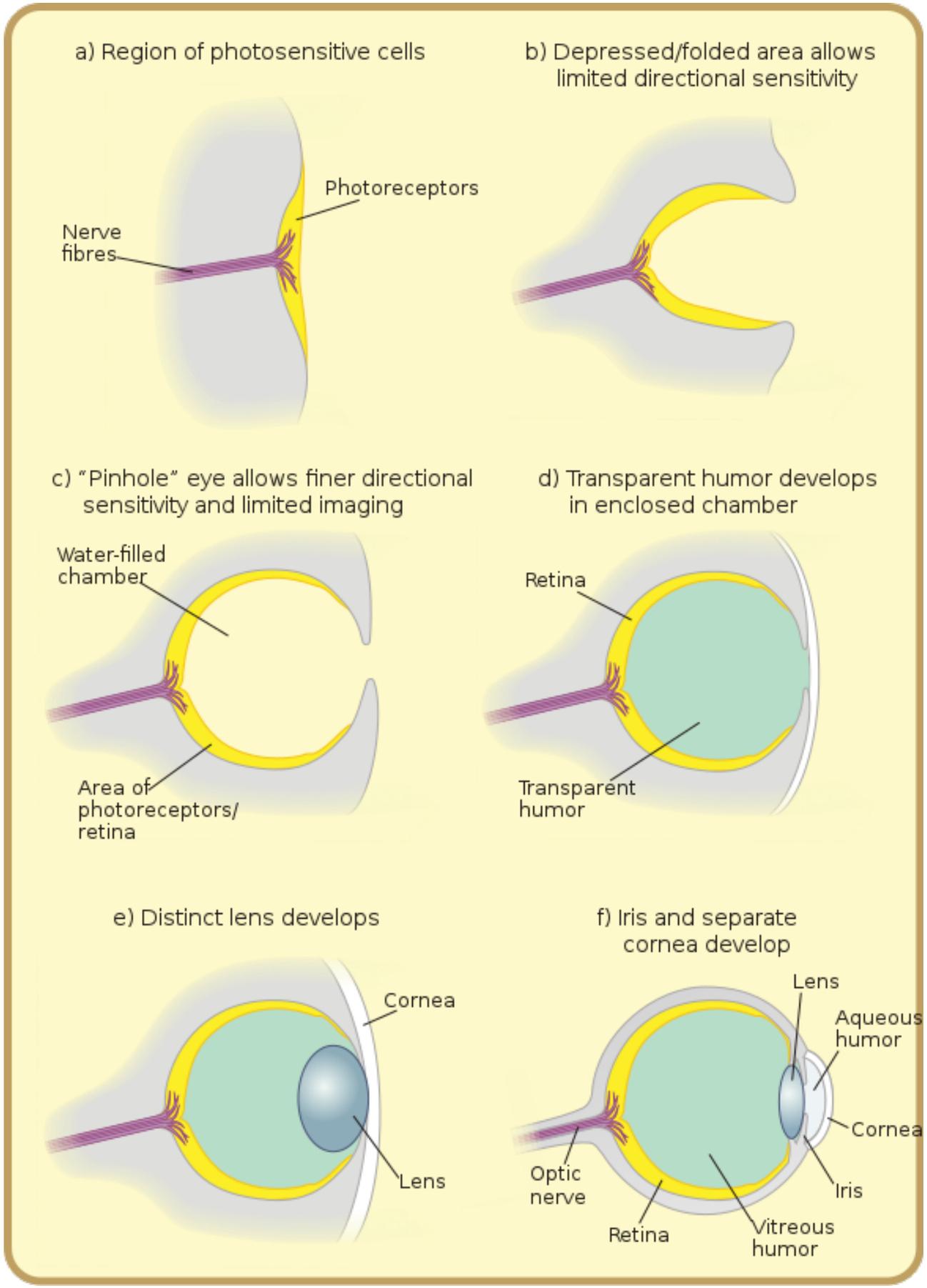


Cambrian Explosion



"The Cambrian Explosion is triggered by the sudden evolution of vision," which set off an evolutionary arms race where animals either evolved or died.
— Andrew Parker

Slide credit: Fei-Fei Li



Evolution of Biological Eye

A quick experiment
Animals or Not?

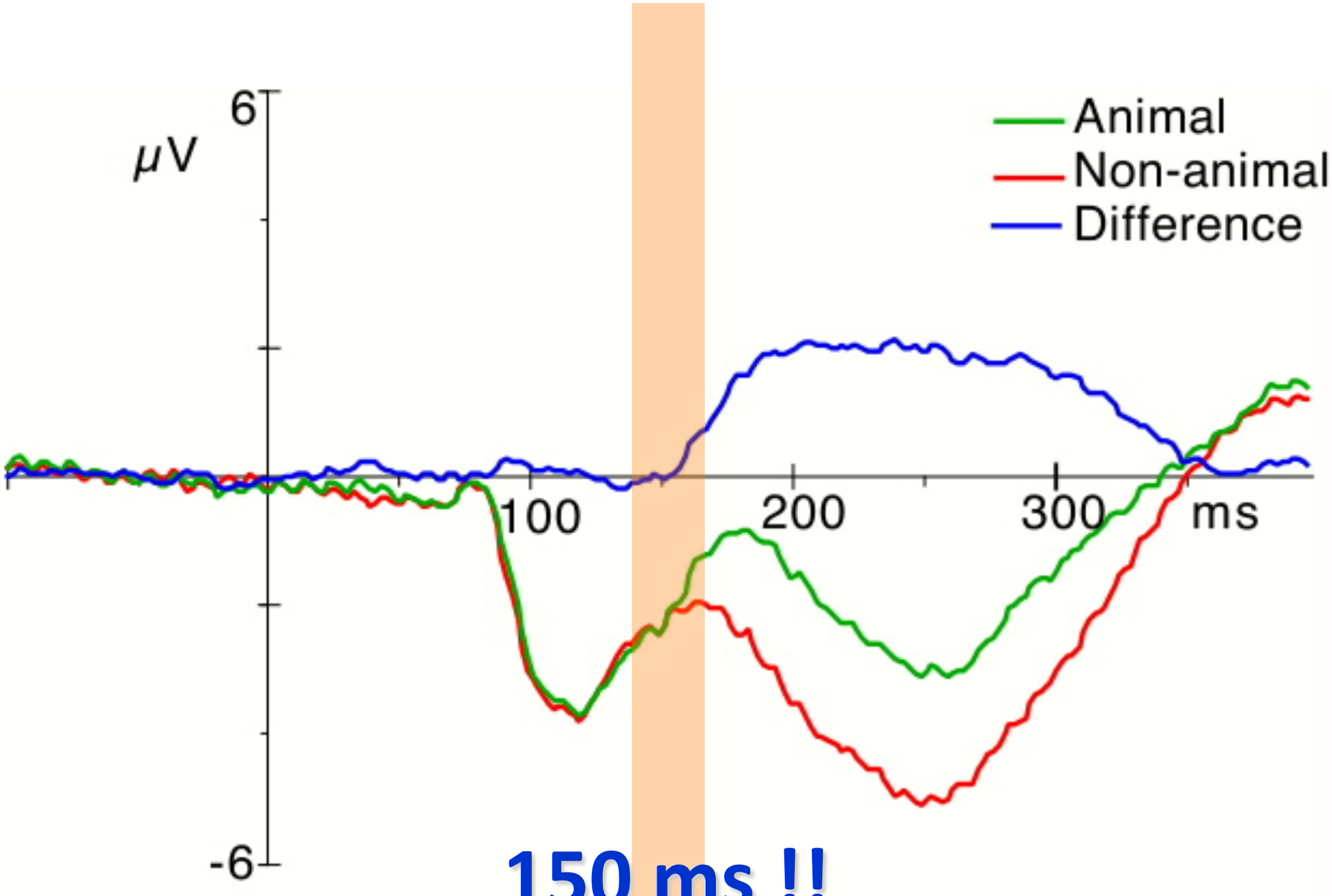
Slide credit: Jia Deng


3aokg Al5ail
photographer ©


10638

Slide credit: Jia Deng

Thorpe, et al. *Nature,* 1996

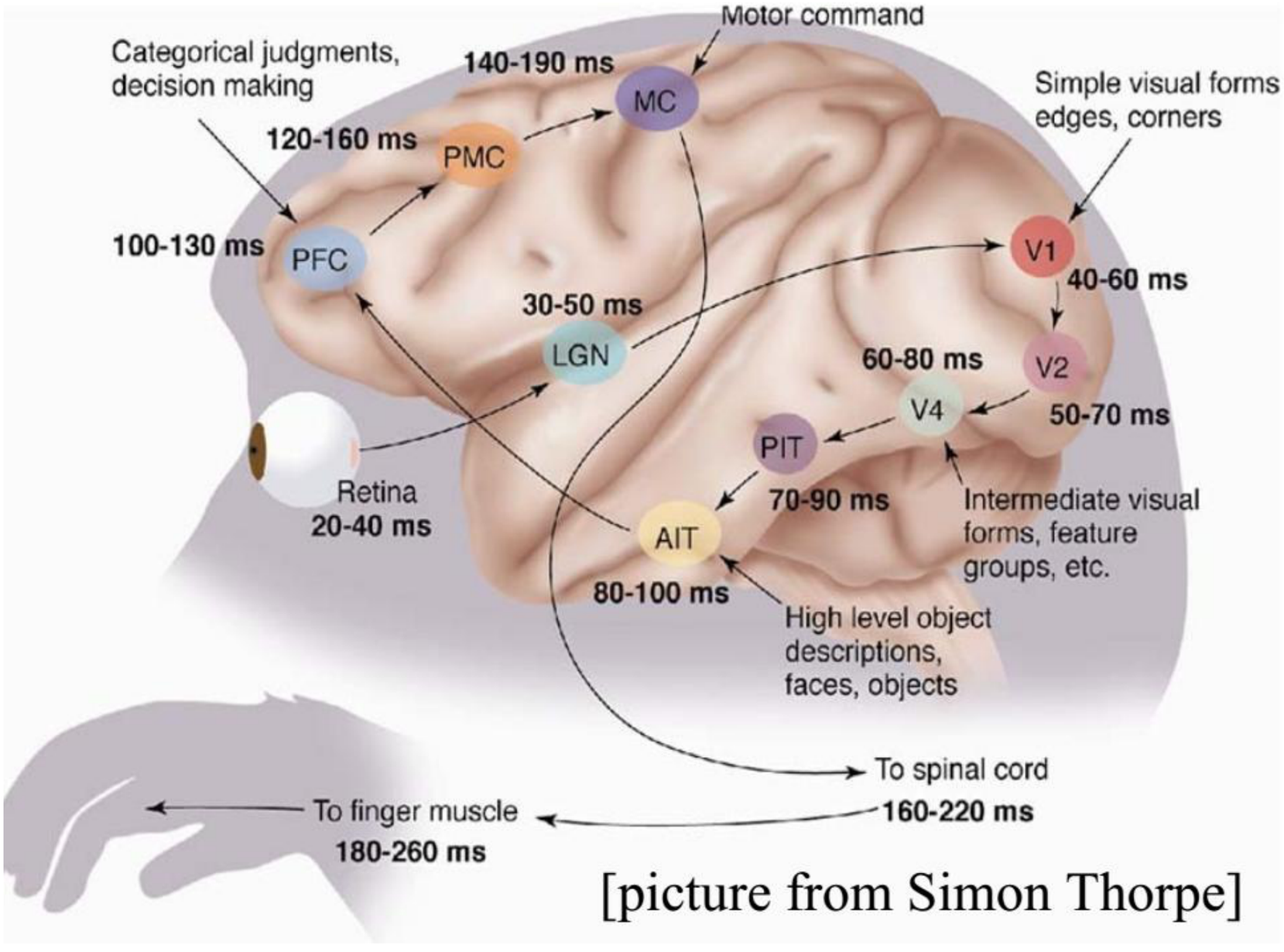


150 ms !!

Thorpe, et al. *Nature,* 1996

Why not build a brain?

About 1/3rd of the brain is devoted to visual processing



[picture from Simon Thorpe]

Marr Levels

1. **Computational**
   What problems should we solve? The API

2. **Algorithmic**
   How the problem should be the solved. The software.
   Bayesian or frequentist? Learning? Symbolic?

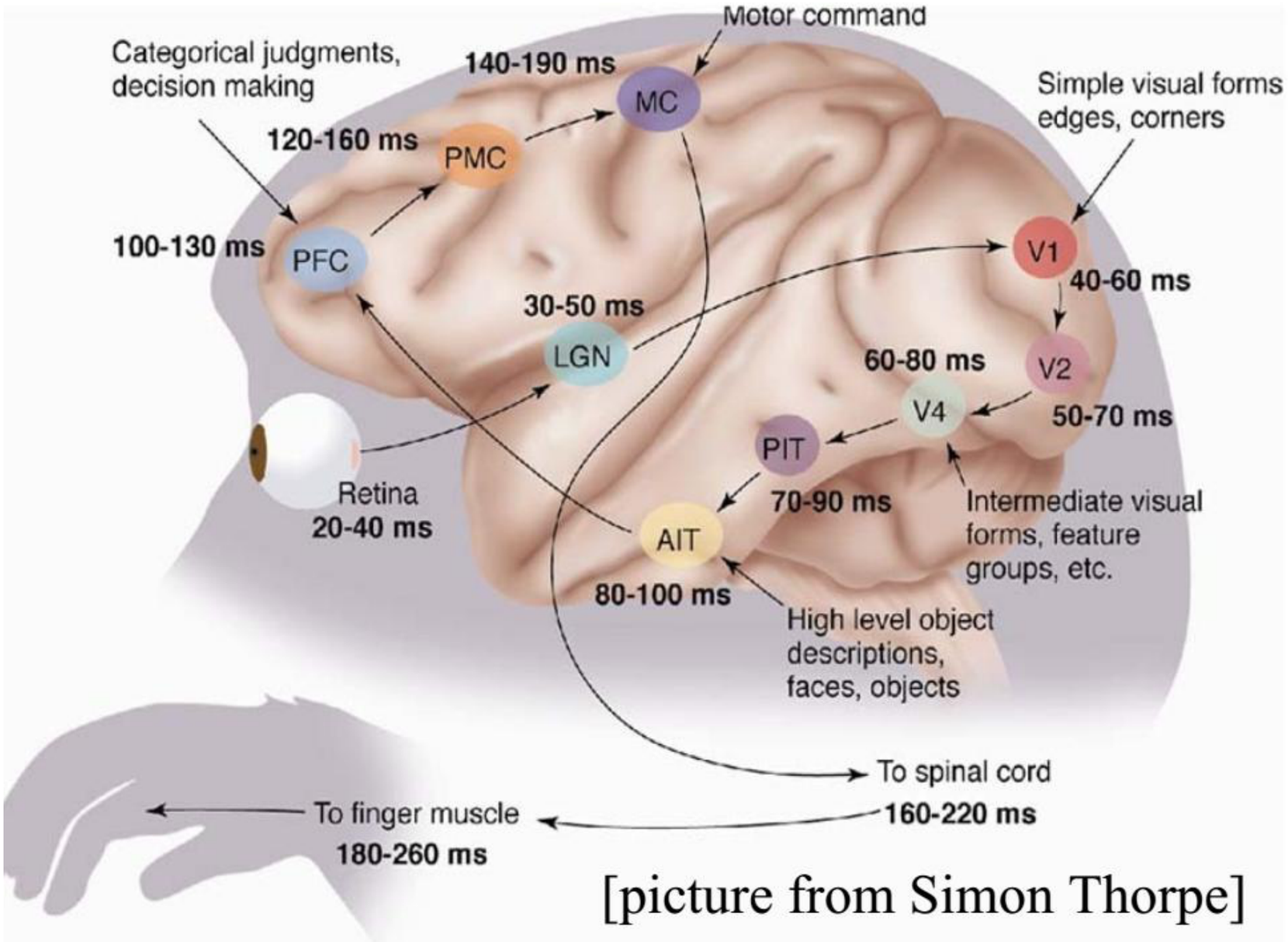
3. **Implementation**
   The physical mechanism. Silicon or wetware?

Do we have the hardware?

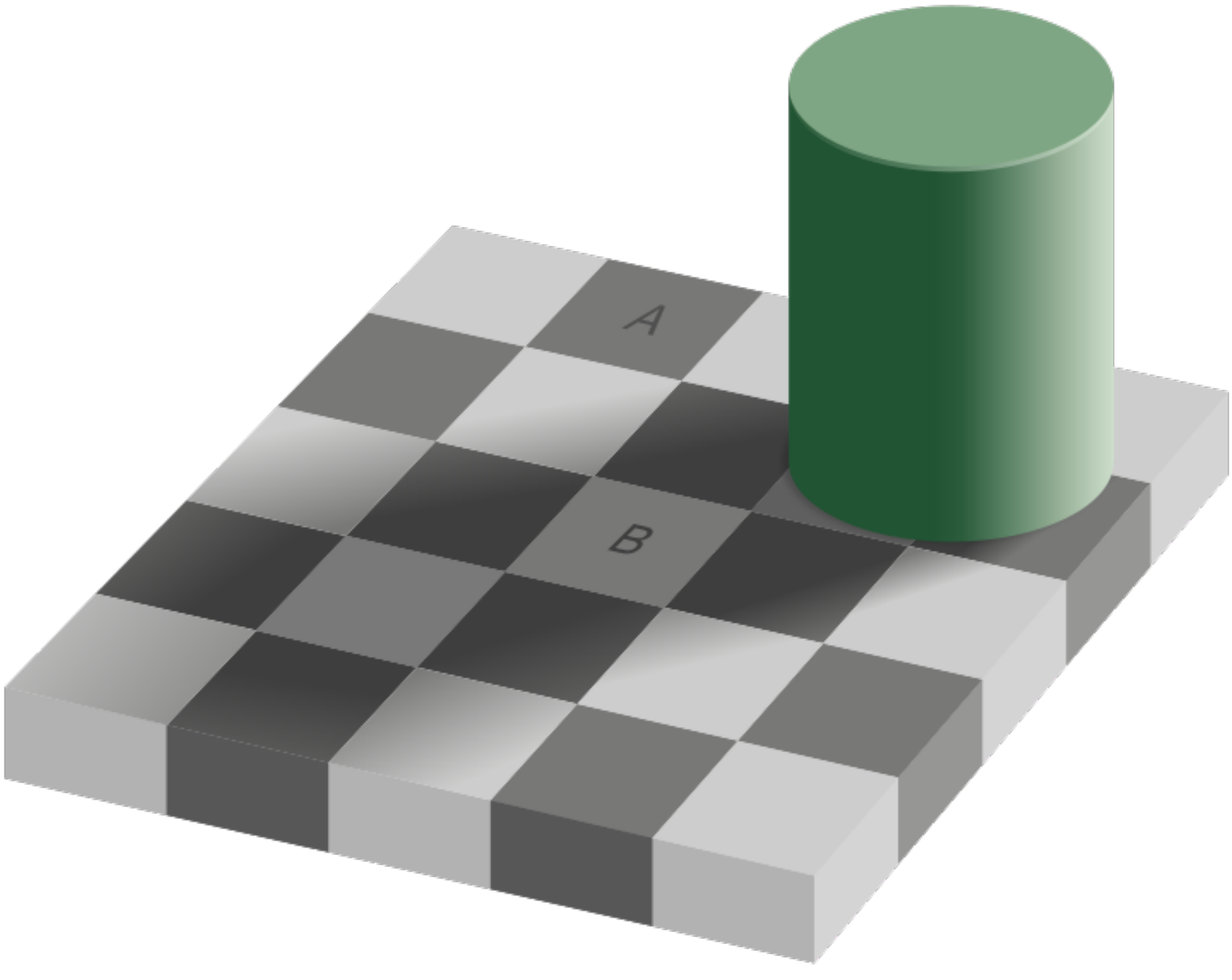
10^{11} parallel neurons

10^{8} serial transistors

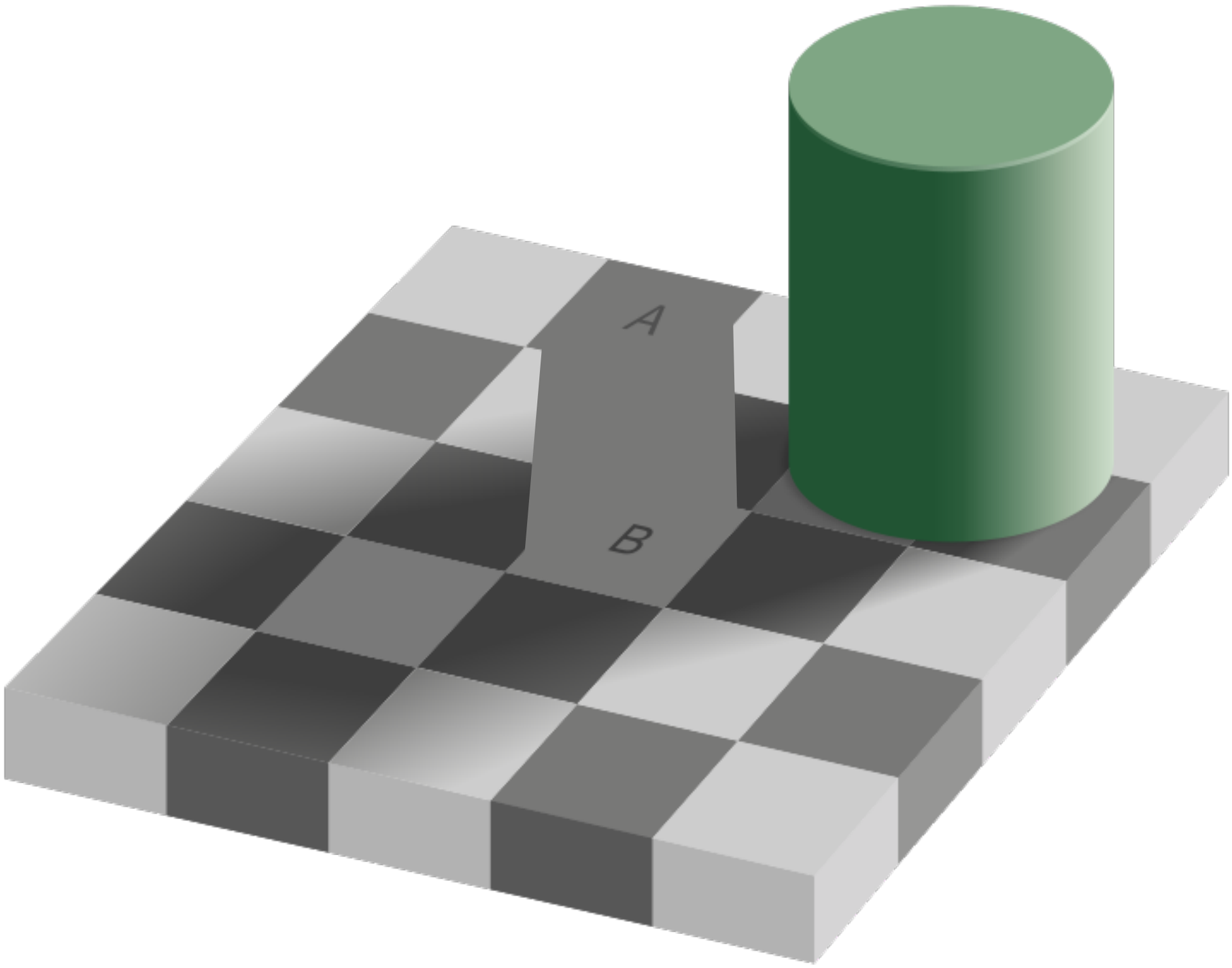
We don’t know the software



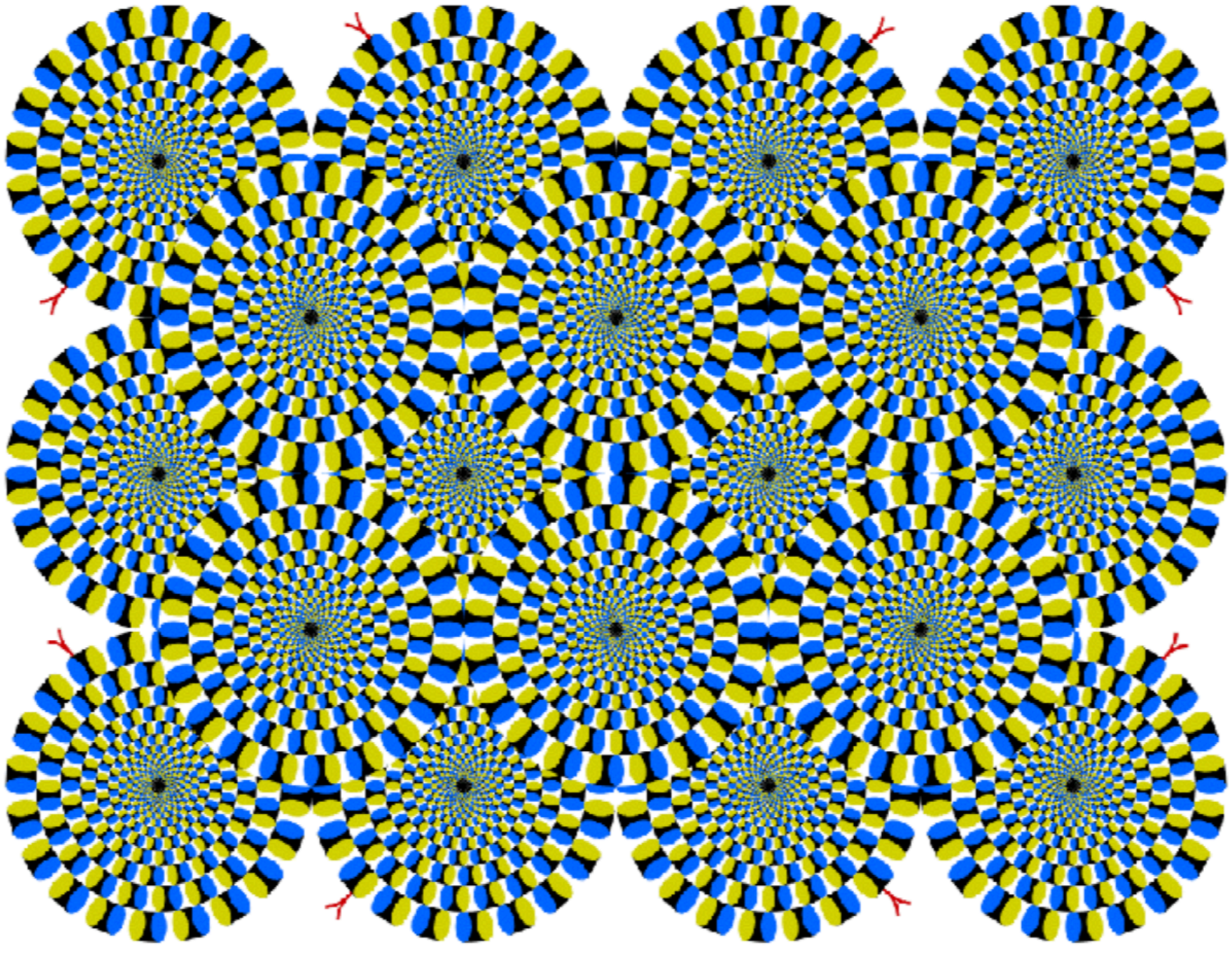
[picture from Simon Thorpe]


A
B

Adelson Illusion



Illusionary Motion

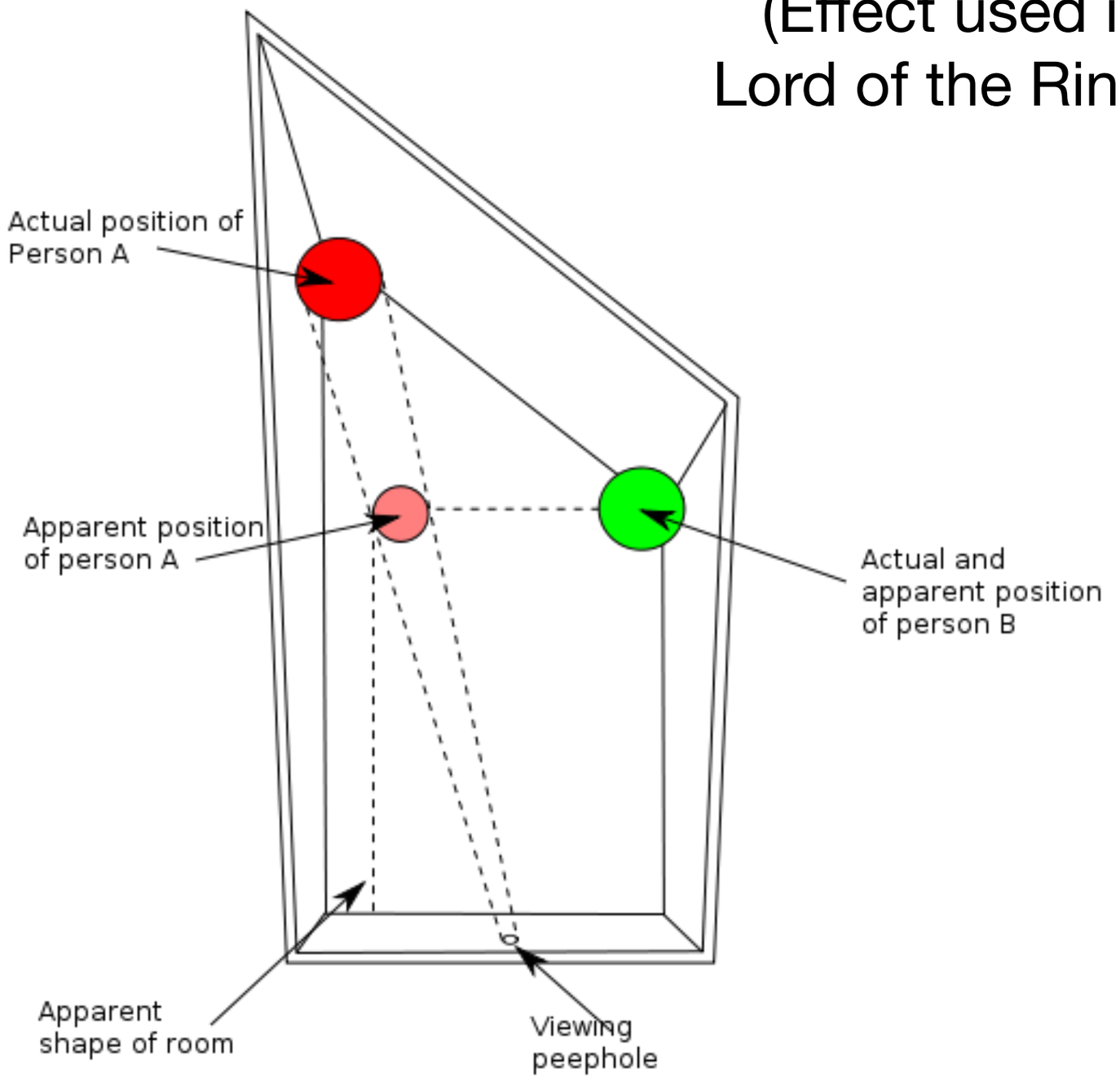


Scale Ambiguity

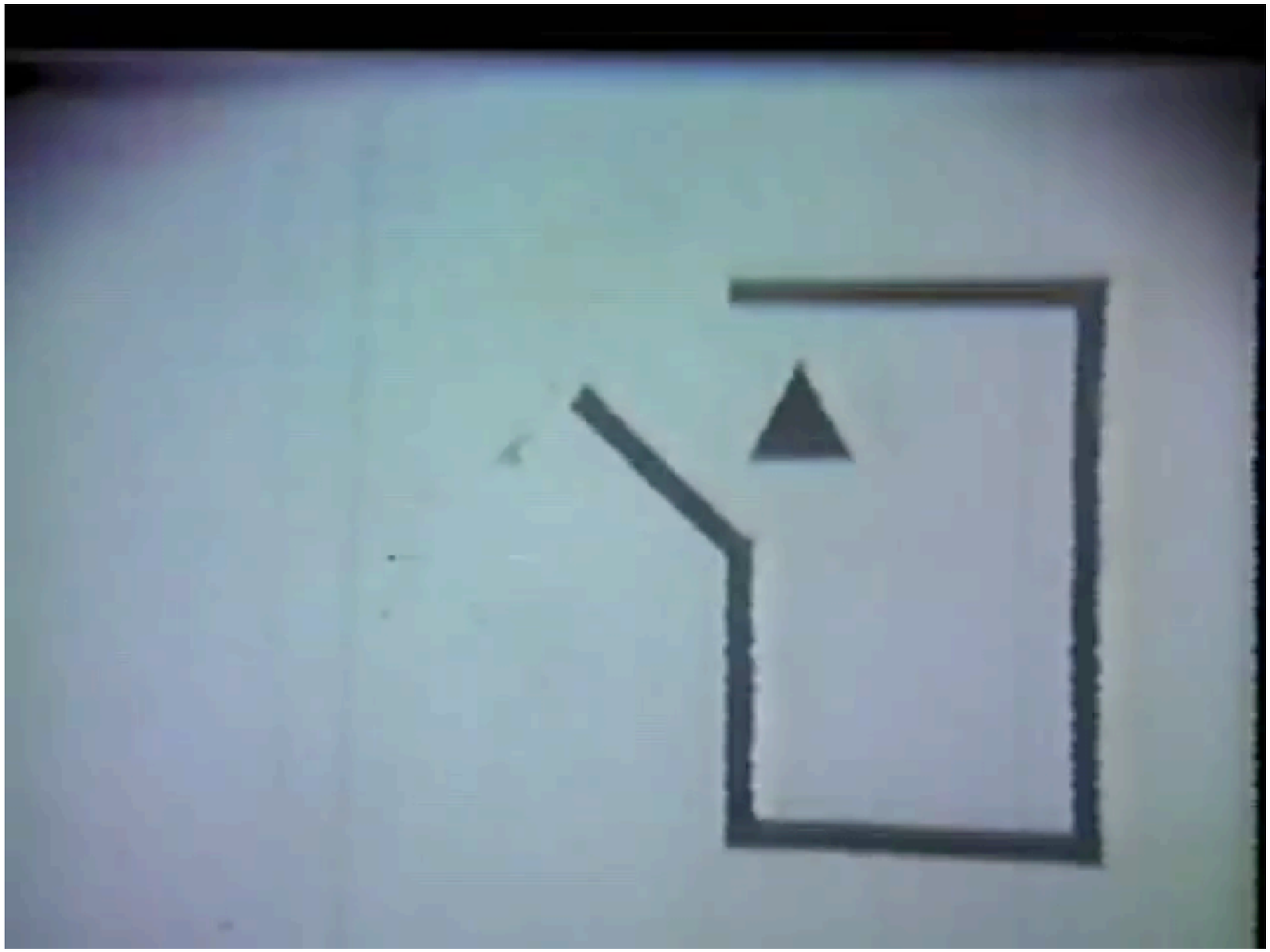
The Ames Room

The Ames Room

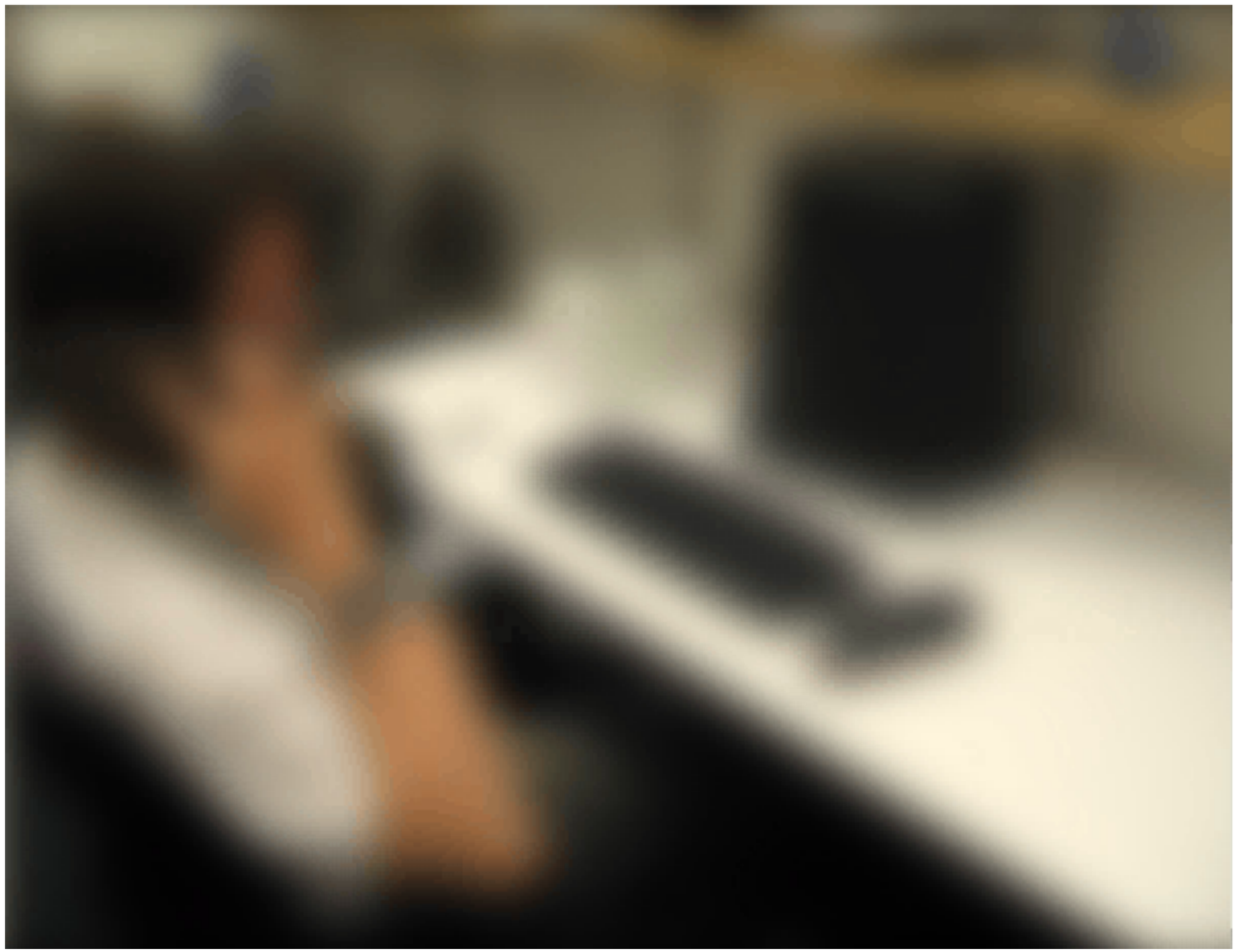
(Effect used in
Lord of the Rings)



Heider-Simmel Illusion



What objects are here?

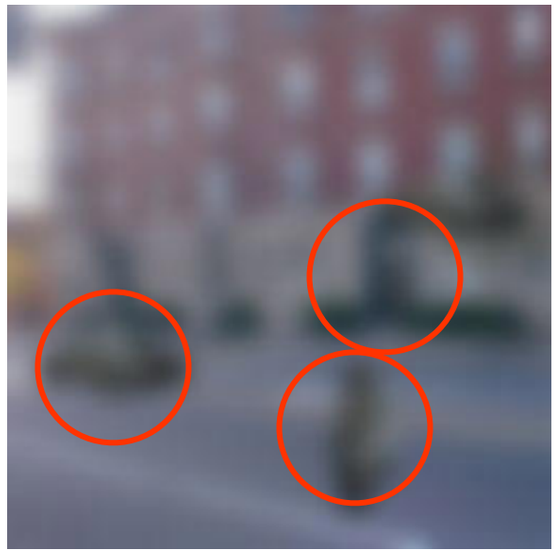


Slide credit: Rob Fergus and Antonio Torralba

Context

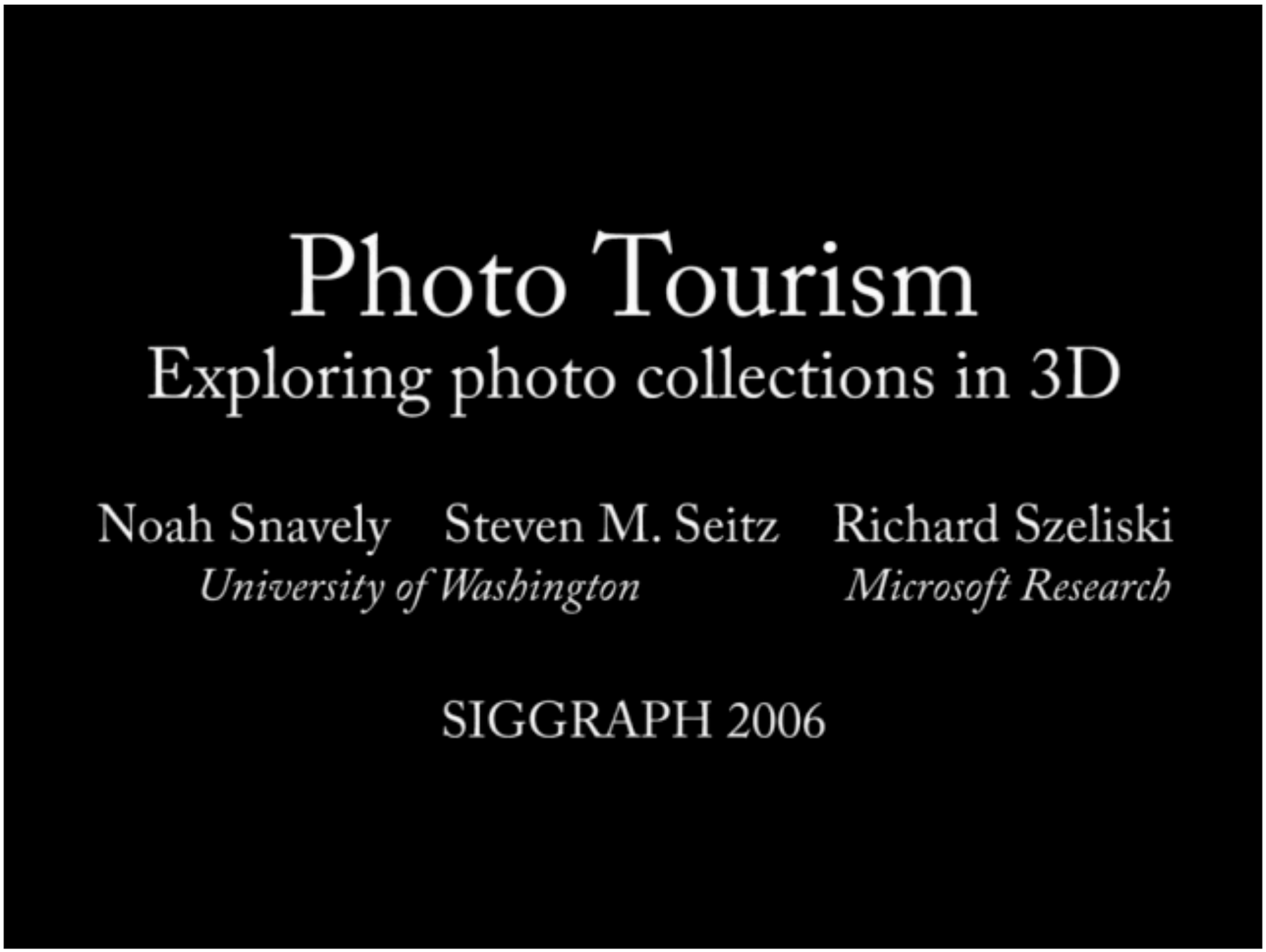
Slide credit: Rob Fergus and Antonio Torralba

Context



Slide credit: Fei-Fei Li, Rob Fergus and Antonio Torralba

Tool 1:
Physics and Geometry

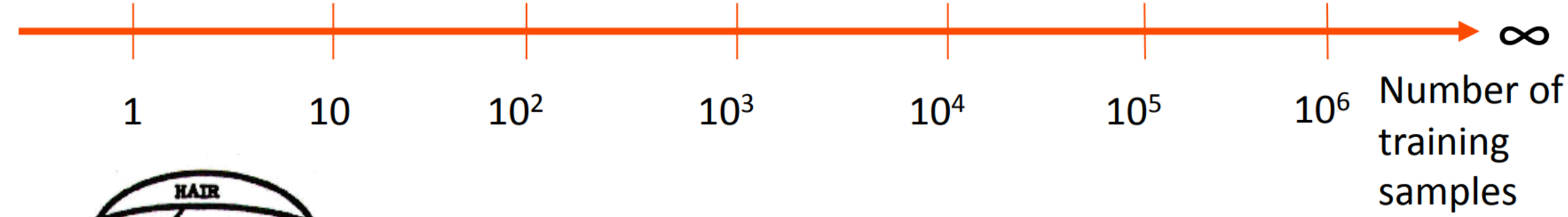


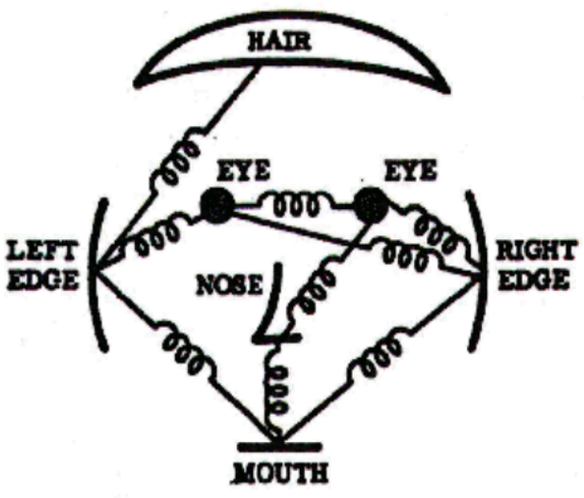
Tool 2:
Data and Learning

Two Extremes of Vision

Extrapolation problem
Generalization
Diagnostic features

Interpolation problem
Correspondence
Finding the differences





Slide credit: Aude Oliva

Evolution of Vision Datasets

Created here in 1996

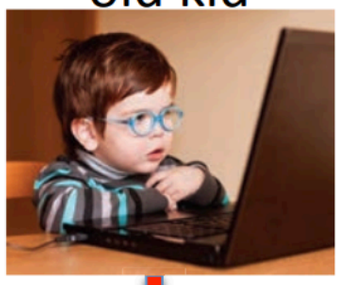
COIL-20

Caltech 101

MNIST (1998)

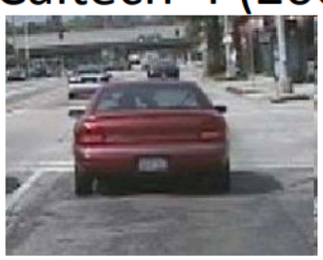
IMAGENET (2009)

2 year old kid



10^3 10^4 10^5 10^6 10^7 10^8 10^9 # images

Caltech-4 (2003)



PASCAL (2005)

Slide credit: Aude Oliva

Course Information

Computer Vision
Fall 2019
Columbia University

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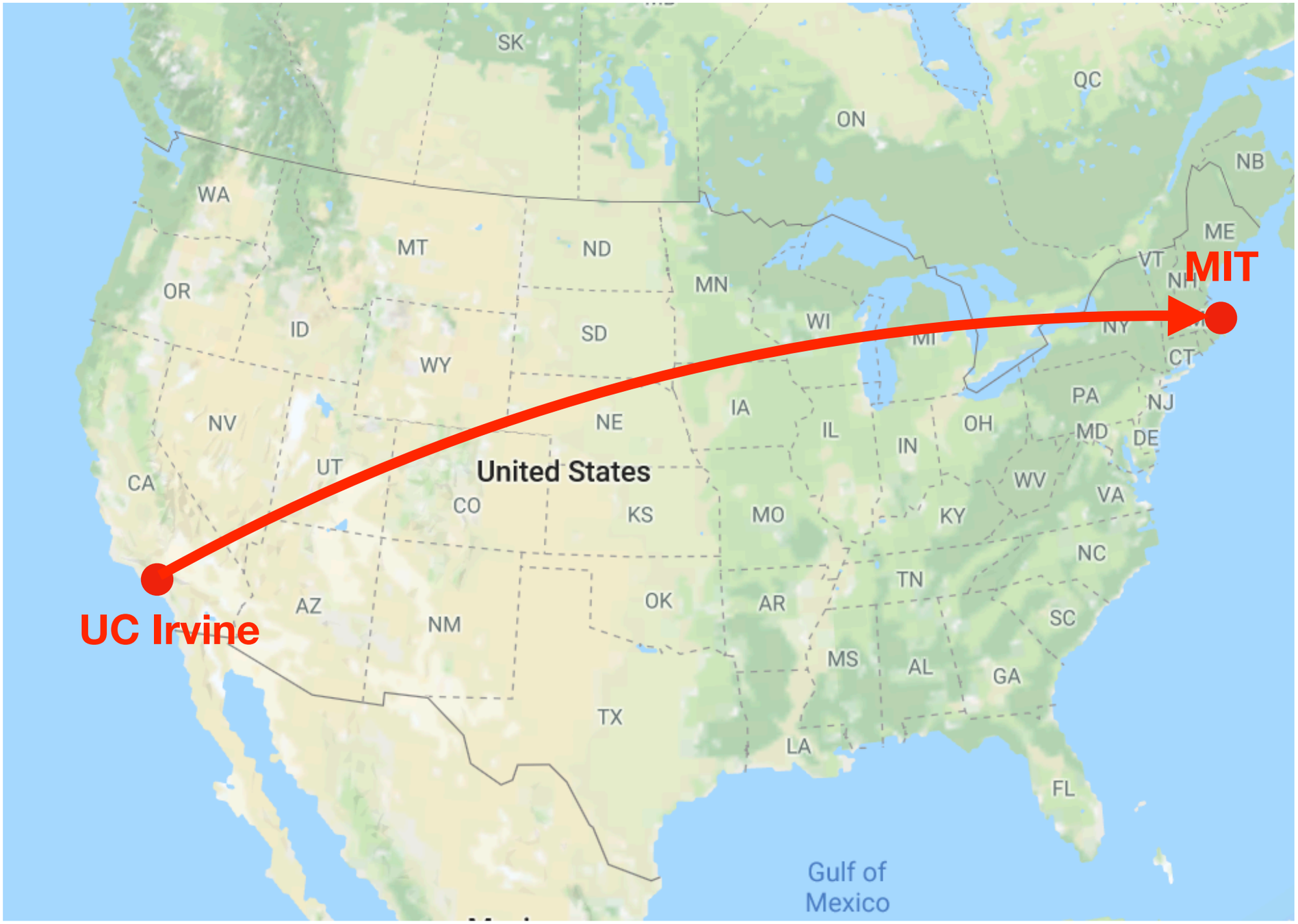
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About Me


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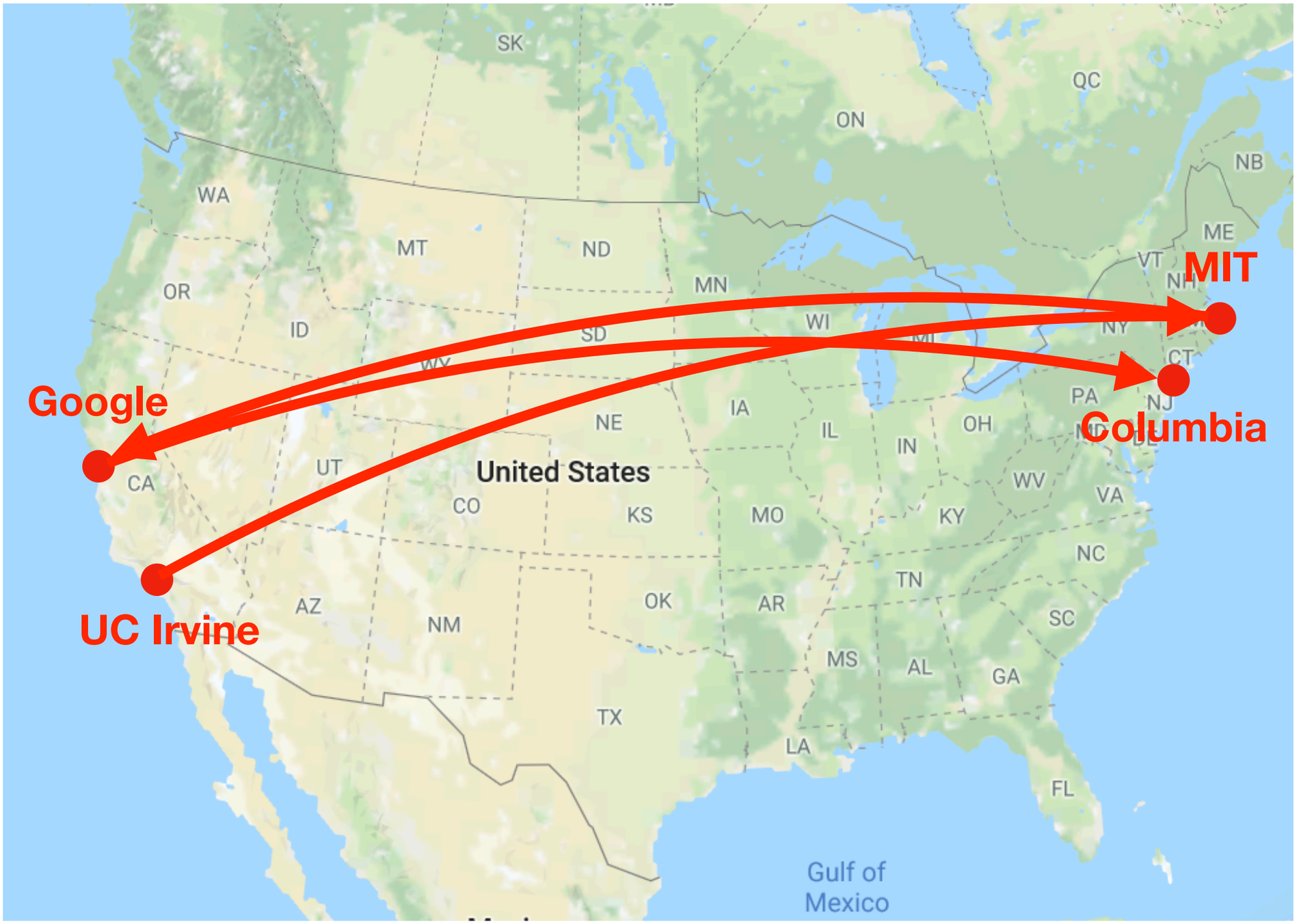
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What about you?

- Major?
- Year?
- Research area?

Staff and Office Hours

- **Carl Vondrick**
  Office Hours: Tuesday's 5:30pm
- TAs:
  - **Yicun Liu (head TA)**
  - **Qin Hayou**
  - **Basile Van Hoorick**
  - We are hiring 4 more

FAQ: Can you add me?

- No.
- Overflow room is overflowing.
- If you don’t plan to take class, please drop today.

FAQ: Do I need to know C?

- No. The problem sets will use **Python**.

- Familiarity with linear algebra and calculus will be helpful but not required.

FAQ: How to contact you?

- No emails — please use **Piazza**
- You can send private messages on Piazza
- Our goal is 24 hour response time during week.

Grading

- 70% Problem Sets
- 30% Quiz

Problem Sets

- 8 problem sets, each worth 100 points.

- Turn in via **CourseWorks** before deadline. No exceptions. One minute late is late. The late penalty applied is by number of days late, rounded up:
  - 1 day late = lose 10 points
  - 2 days late = lose 20 points
  - 3 days late = lose 30 points
  - 4 days late = lose 40 points
  - 5 days late = lose 50 points
  - 6 days late = lose all points

My Favorite Excuses

- “My code took long time to run”: make it run faster, or start sooner.

- ”My PDF was accidentally corrupted”: word processing is pre-requisite for CS degree.

- If you have serious reason, ask your advising dean to contact us.

Collaboration Policy

- Solutions available during TA office hours.

- You can have high-level discussion in groups of 3. But, you must write up assignments individually.

- Include names of collaborators on PDF.

Problem Set 0

- Due this **Thursday, September 5th**. No exceptions and no late days allowed.

- Use as self-assessment. If problem set is hard, the rest of course may be challenging.

Final Quiz

- **December 5th** during class

- Covers material from lecture and homework.

- If you come to class and do best on homework, you will do fine.

Academic Honesty

- Academic dishonesty results in:
  - Automatically fail whole course.
  - We refer your case to the Dean’s office.

Readings (Optional)

http://szeliski.org/Book/