MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

Visual Computing Group

CYENS CENTRE OF EXCELLENCE

University of Cyprus – MSc Artificial Intelligence

MAI644 – COMPUTER VISION

Lecture 1: Introduction to Computer Vision

Melinos Averkiou

CYENS Centre of Excellence

University of Cyprus - Department of Computer Science

m.averkiou@cyens.org.cy

Co-financed by the European Union
Connecting Europe Facility

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Today's Agenda

- Who we are
- Introduction to Computer Vision
  - What is Computer Vision
  - How hard is Computer Vision
  - Why is Computer Vision so hard
  - How to organize Computer Vision
  - Why study Computer Vision
  - Applications
- What we do

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Who we are

Visual Computing Group at CYENS Centre of Excellence

Melinos Averkiou
MRG Leader

Yiangos Georgiou
Research Associate (DTP)

Marios Loizou
Research Associate

Yeshwanth Kumar Adimoolam
Research Associate (DTP)

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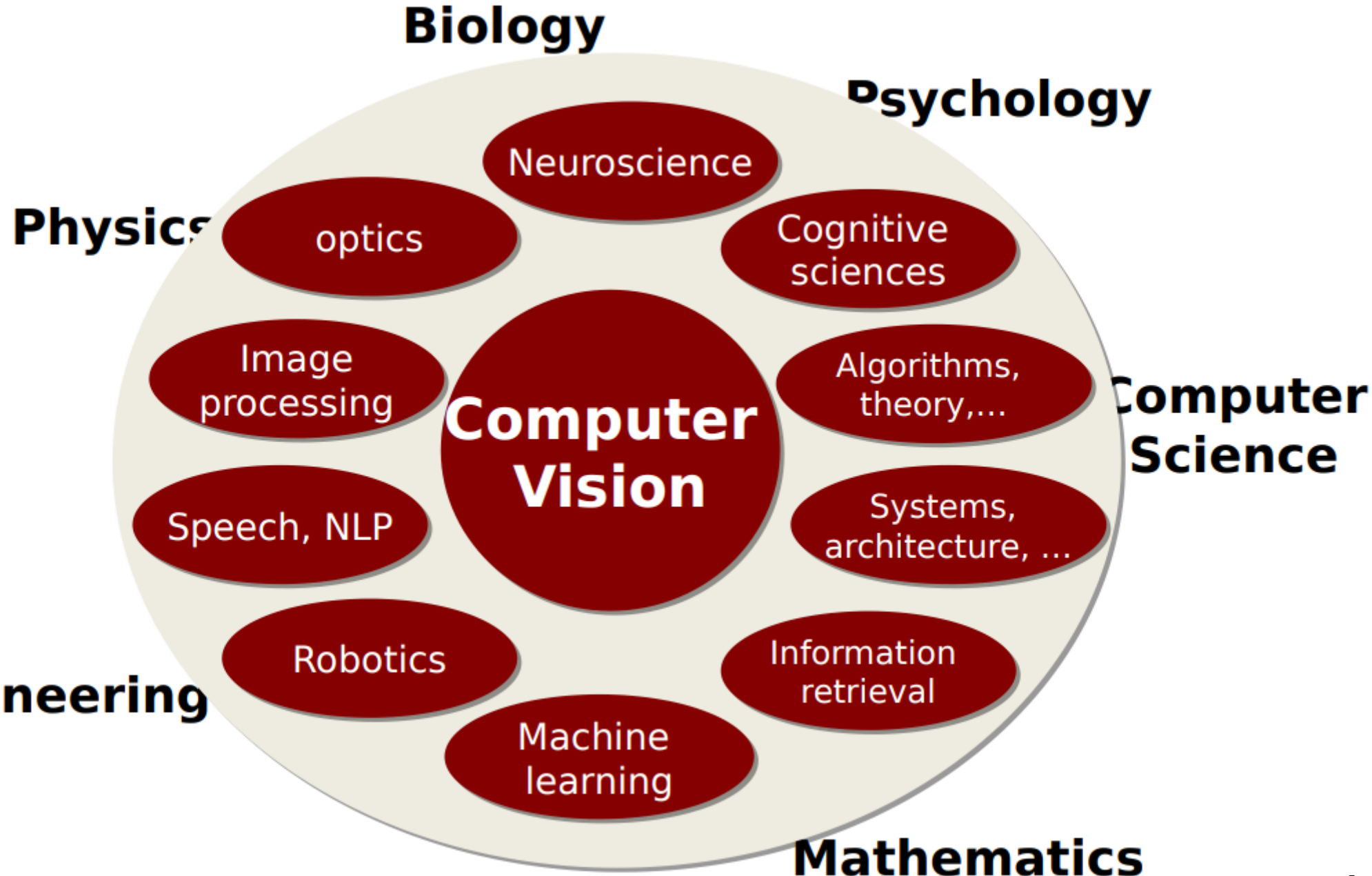

[Niebles]

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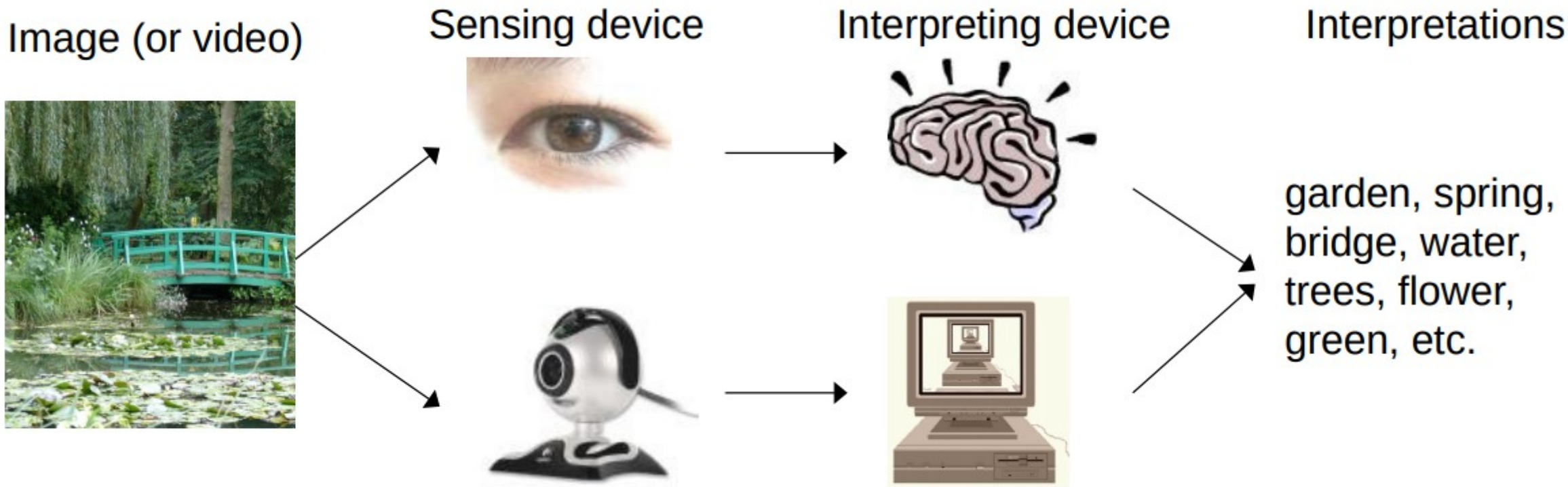
What is (Computer) Vision ?



[Niebles, Fergus]

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What is (Computer) Vision?

- *Vision* is about discovering from images
  - **what** is present in the scene, and
  - **where** it is

- In *Computer Vision* a ***camera*** (or several ***cameras***) is linked to a computer
- The computer interprets ***images*** of a scene to obtain information
- Useful for tasks such as navigation, manipulation and recognition

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What is Computer Vision?

Computer Vision's **goal** is to obtain a high-level **understanding** of the world using images as input

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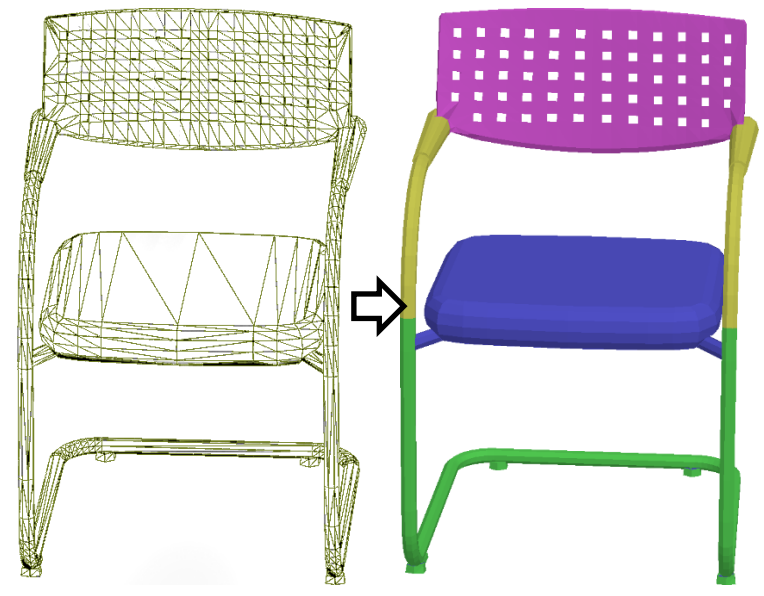
Understand = Obtain **Semantics** & **Geometry**

3D Object layout
Input: RGBD Image

Building facade segmentation
Input: RGB Image



Object semantic segmentation
Input: 3D Mesh

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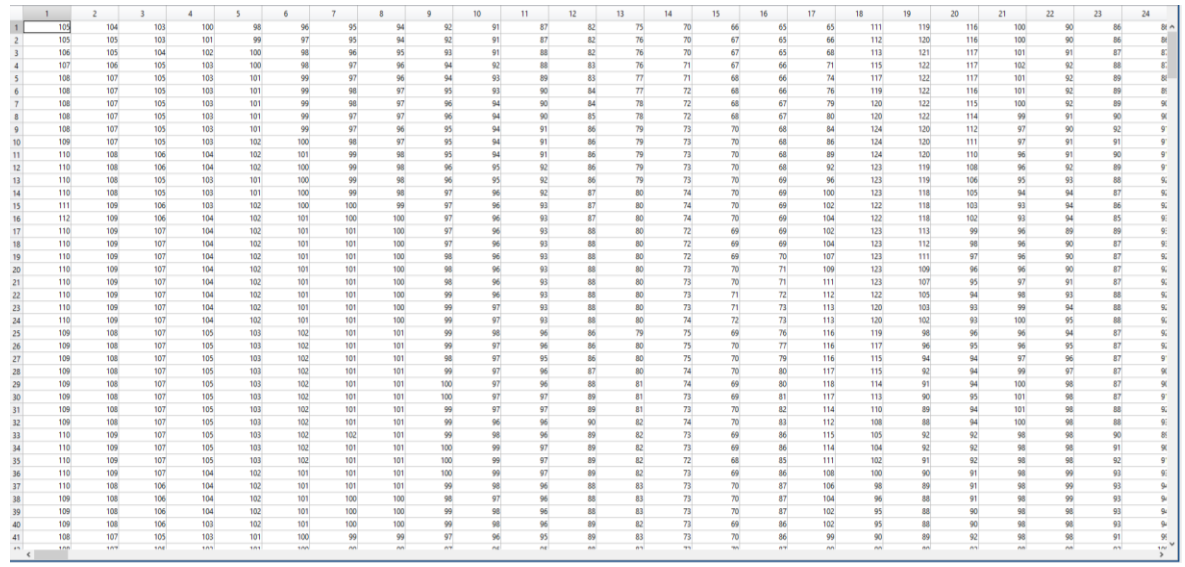
Understanding the world is hard for machines

What we see



What the machine sees

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How hard is Computer Vision ?

- The Summer Vision Project – MIT AI Memo 100, 1966
  - ‘Solve vision in a summer project’ - almost an urban legend
    - Basic foreground/background segmentation,
    - Analyse scenes with simple non-overlapping objects,
    - Extend the system to more complex objects.

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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".

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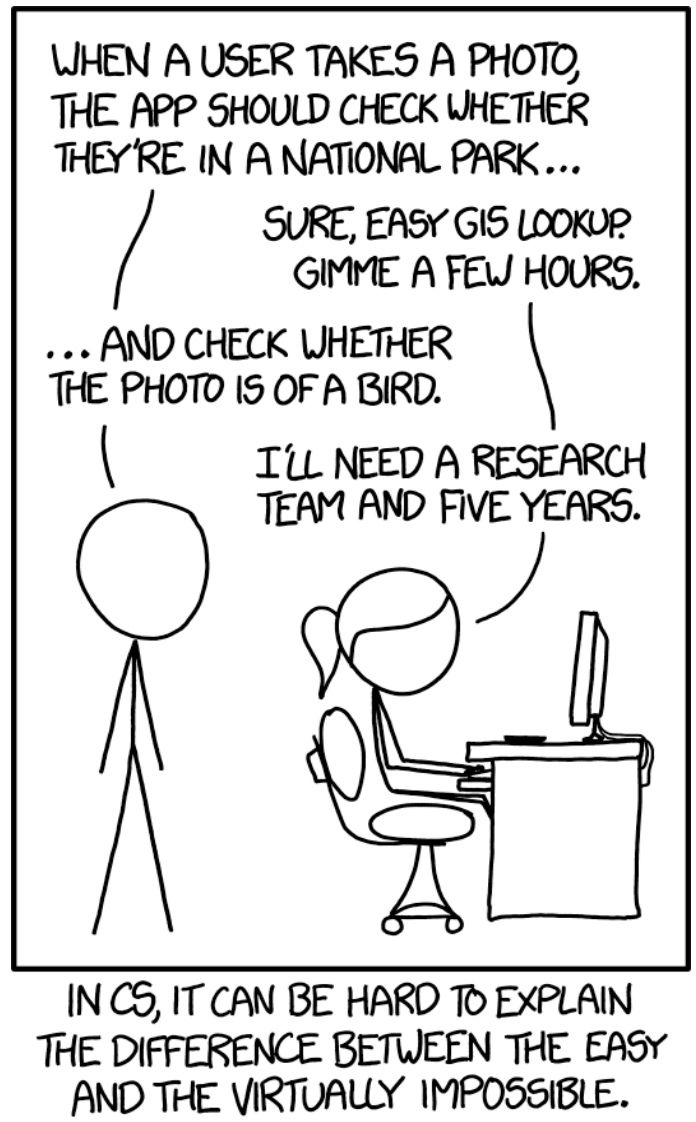
How hard is Computer Vision ?



XKCD

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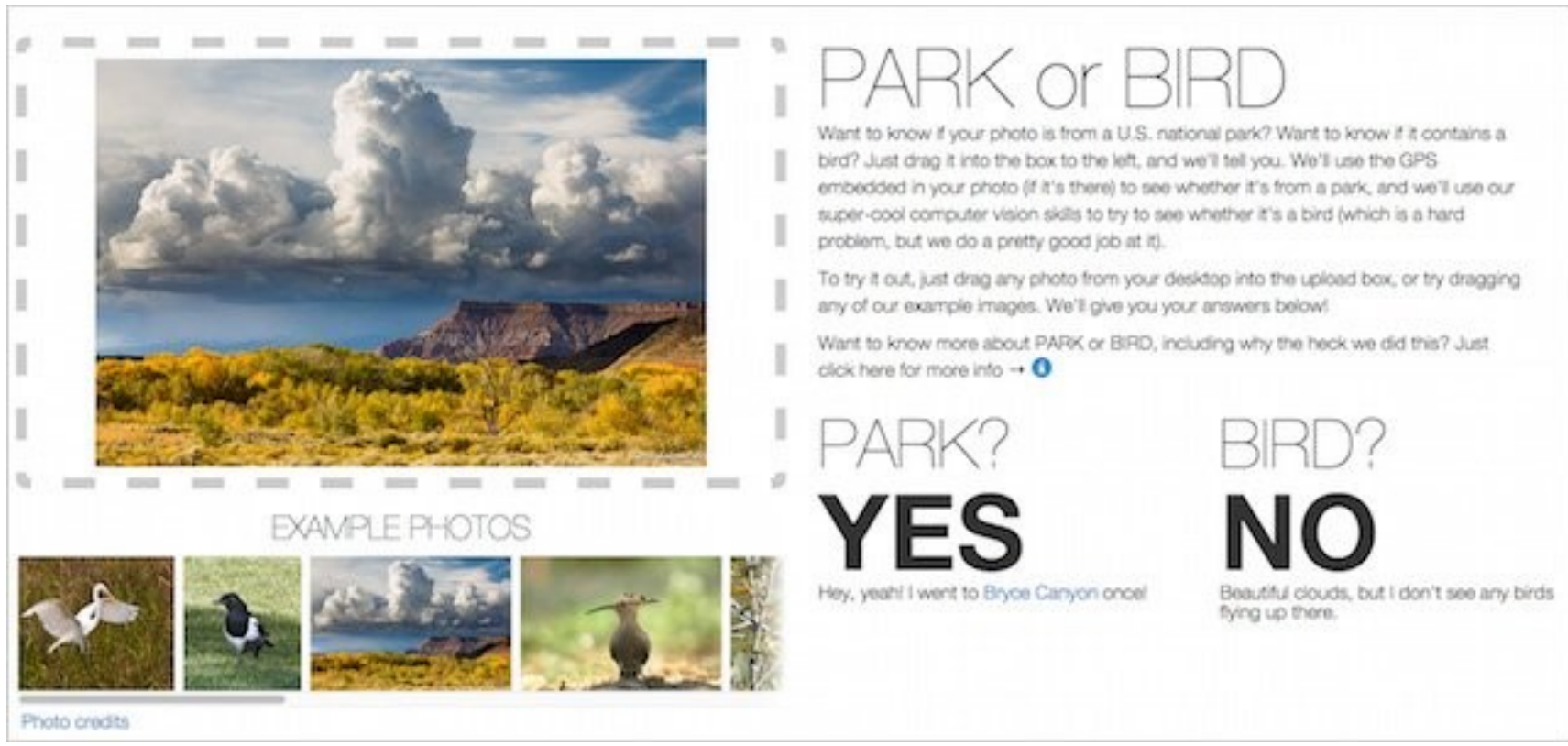
How hard is Computer Vision ?



[Flickr 'solved' it]

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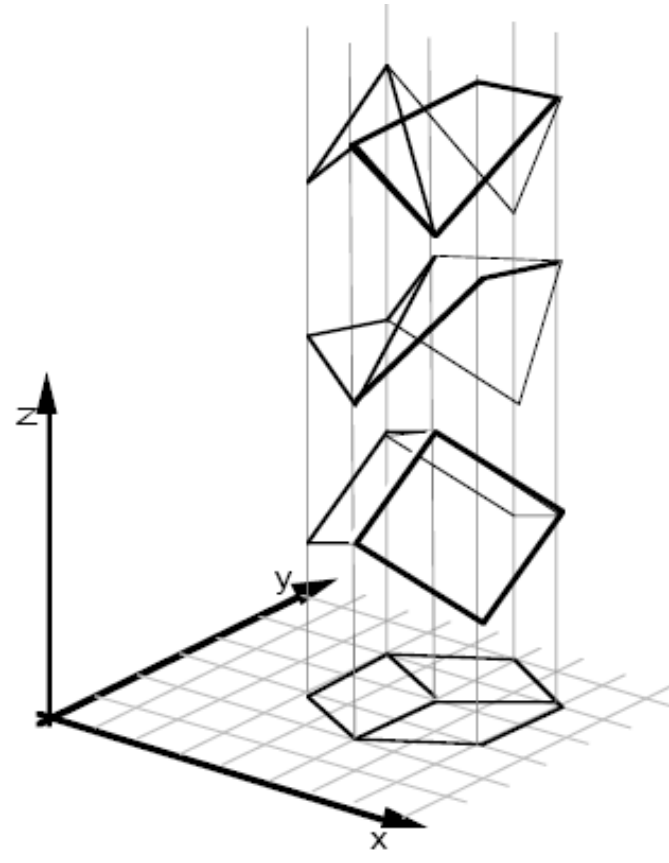
Why is Computer Vision so hard?

Because it is an ill-posed problem



[Sinha and Adelson 1993]

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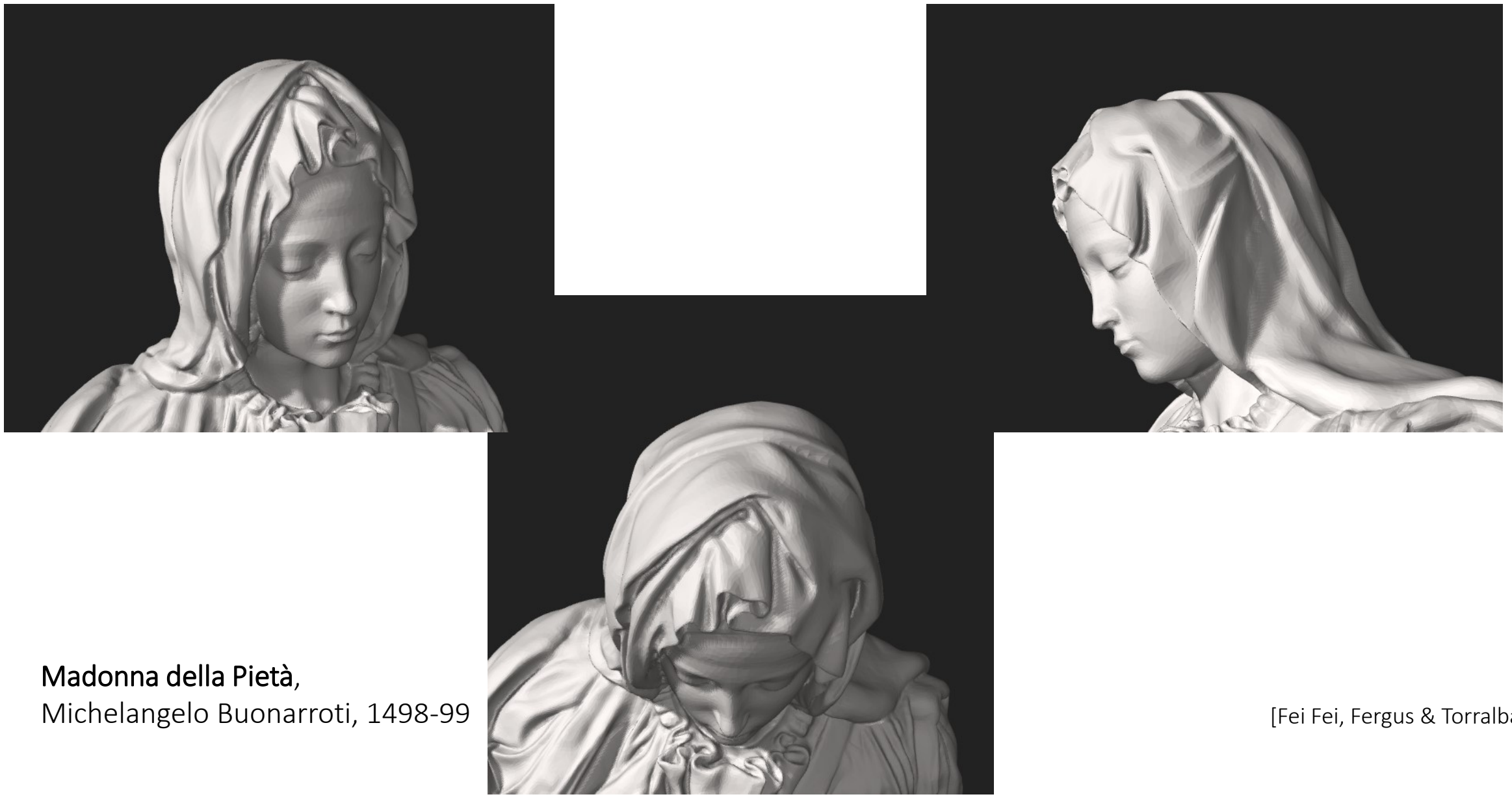
Challenge 1: viewpoint variation



Madonna della Pietà,
Michelangelo Buonarroti, 1498-99

[Fei Fei, Fergus & Torralba]

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Challenge 2: illumination

[S. Ullman]

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Challenge 3: occlusion

The Blank Signature, Rene Magritte, 1965

[Fei Fei, Fergus & Torralba]

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Challenge 4: scale

[Fei Fei, Fergus & Torralba]

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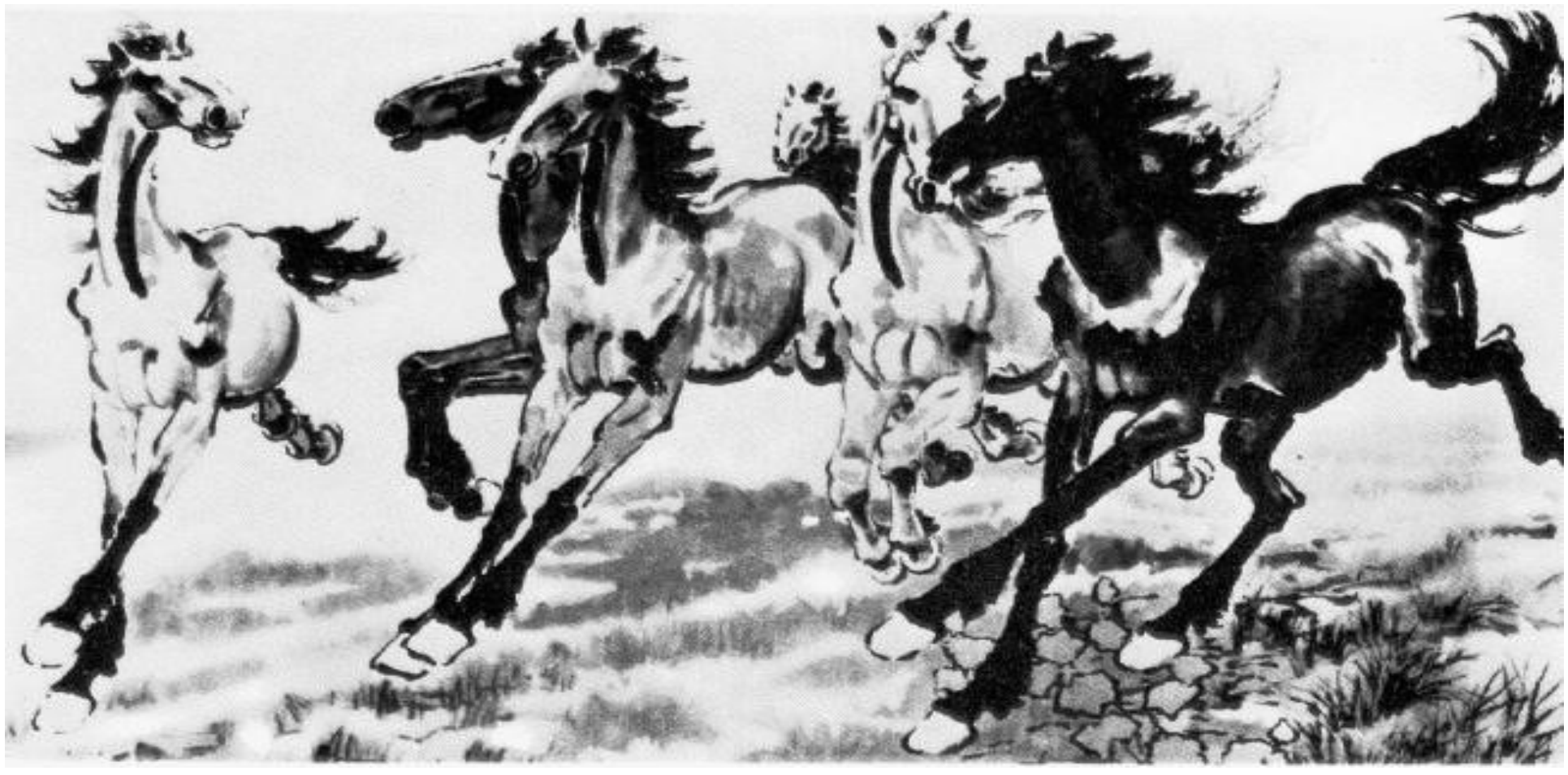
Challenge 5: deformation



Six Galloping Horses,
Xu Beihong, 1942

[Fei Fei, Fergus & Torralba]

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Challenge 6: background clutter

The Maiden,
Gustav Klimt, 1913

[Fei Fei, Fergus & Torralba]

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Challenge 7: object intra-class variation






[Fei Fei, Fergus & Torralba]

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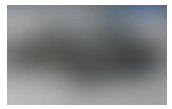
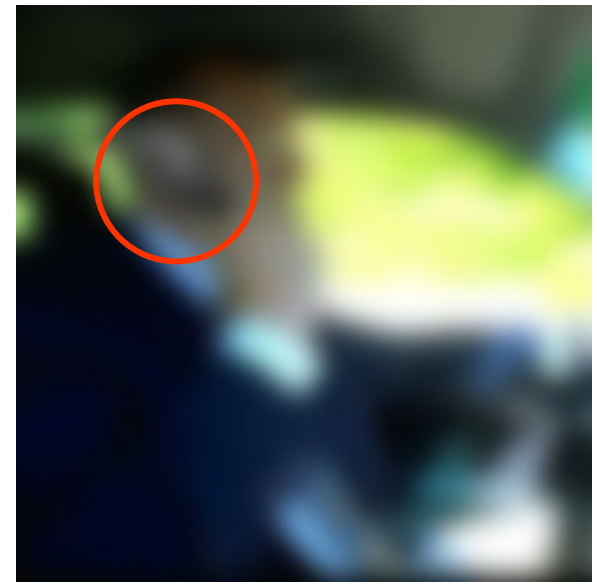
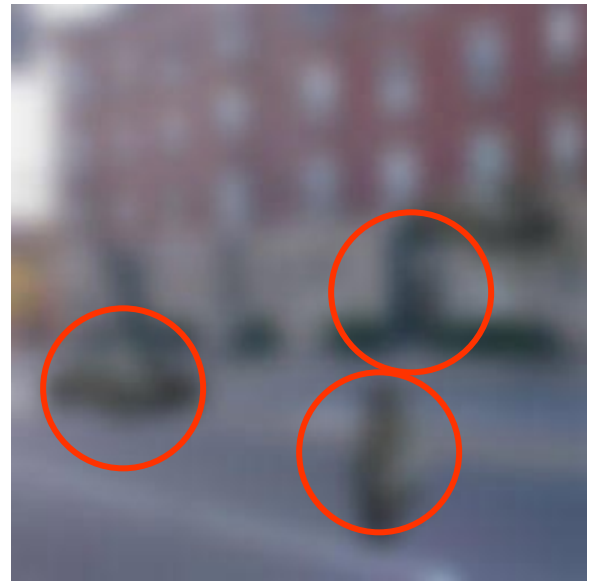
Challenge 8: local ambiguity







[Fei Fei, Fergus & Torralba]

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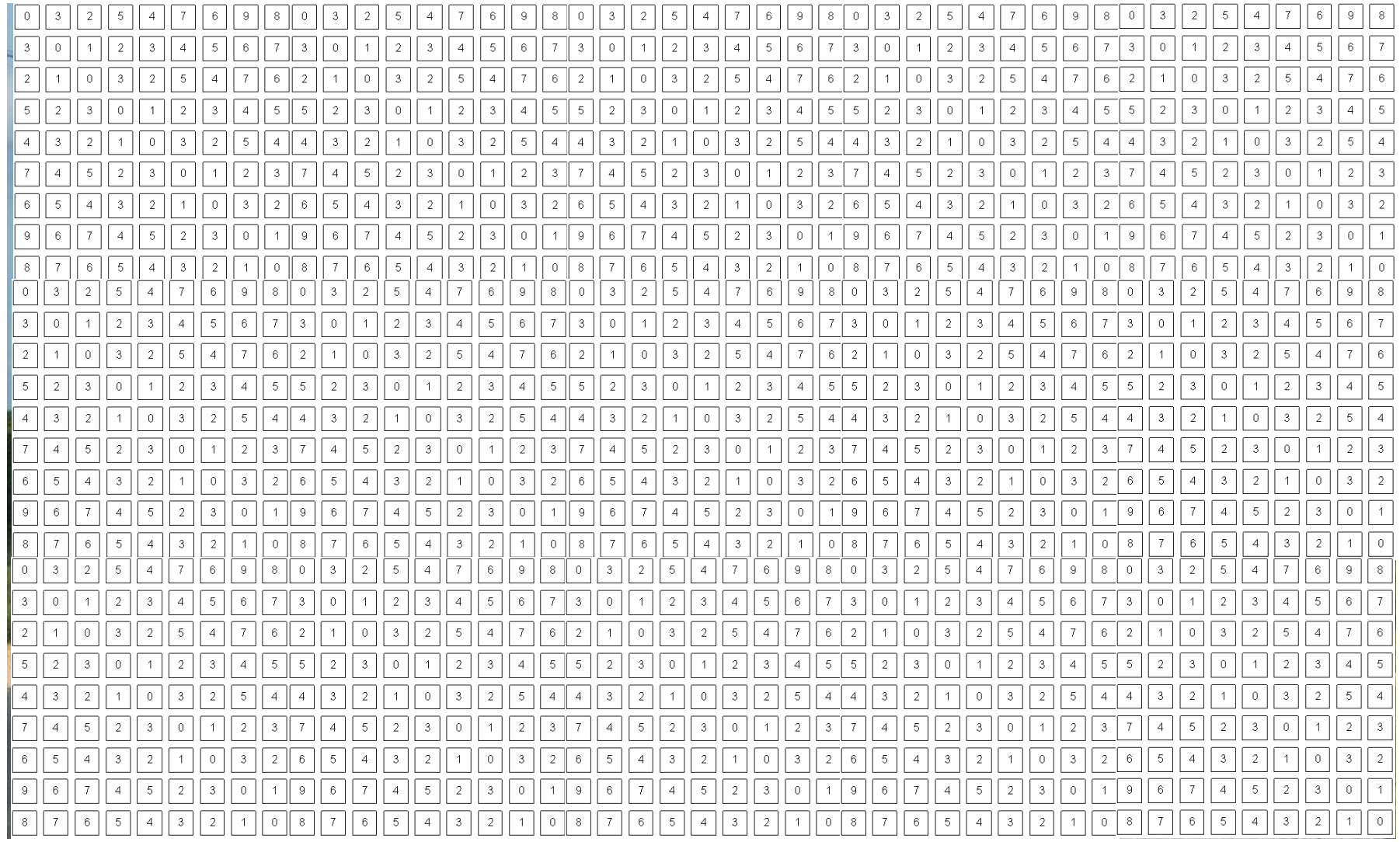
How to organize Computer Vision ?



[Shapiro]

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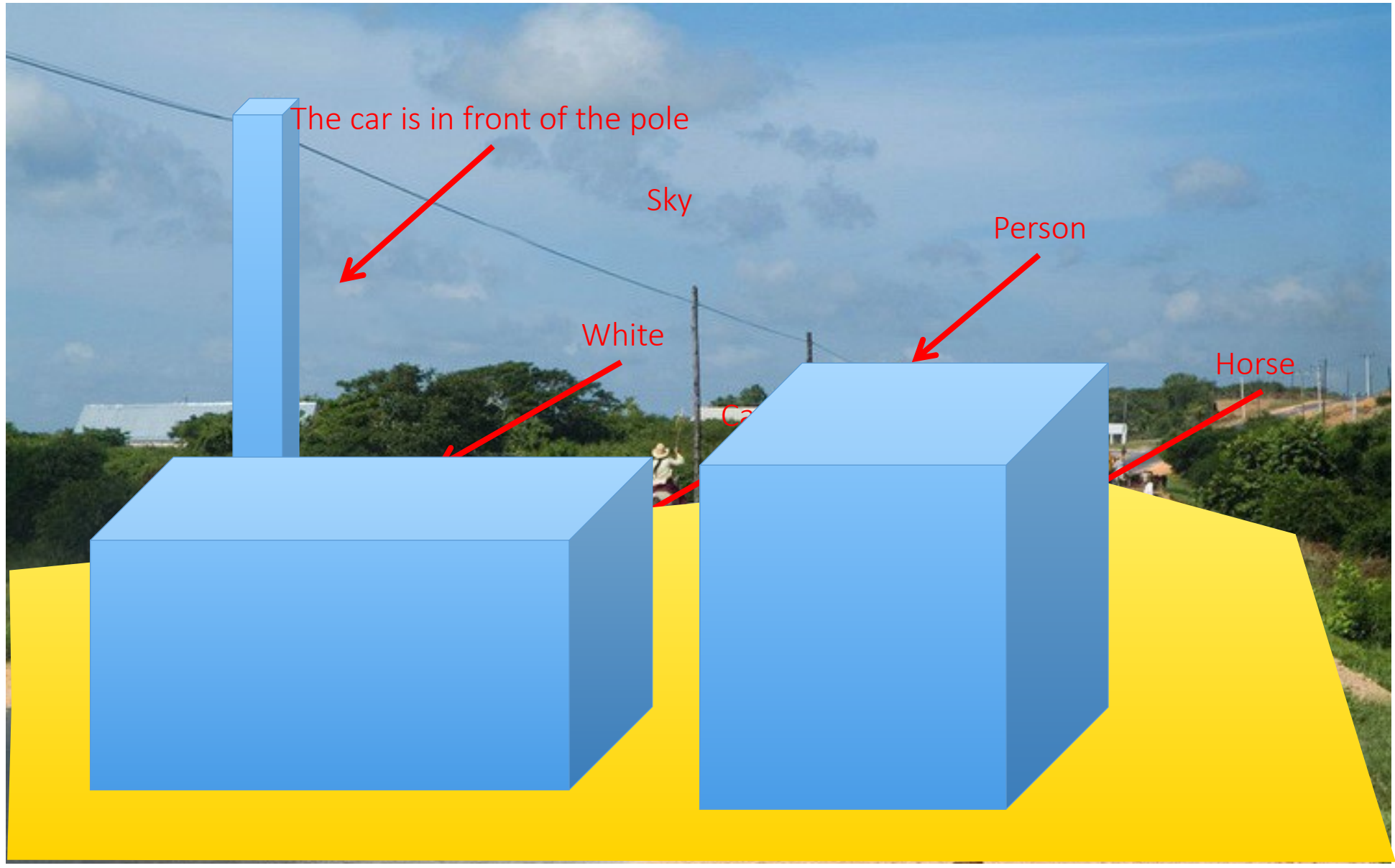

[Shapiro]

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How to organize Computer Vision ?

- Low Level Vision
  - Measurements
  - Enhancements
  - Region segmentation
  - Features
- Mid Level Vision
  - Reconstruction
  - Depth
  - Motion Estimation
- High Level Vision
  - Category detection
  - Activity recognition
  - Deep understanding

[Shapiro]

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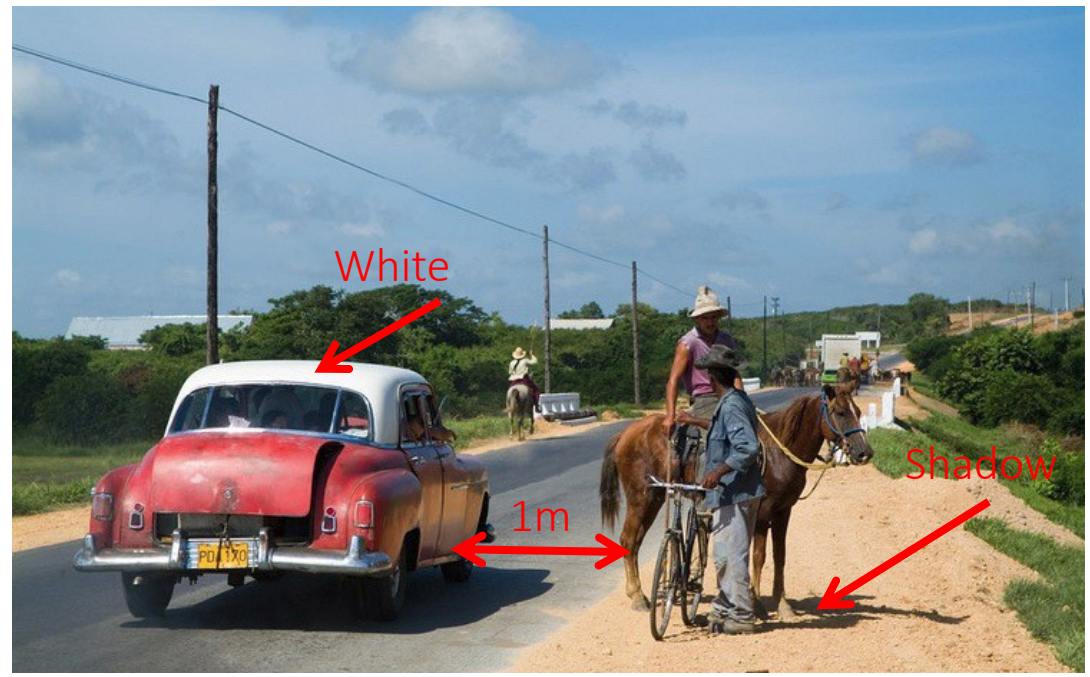

[Shapiro]

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Low-Level: Exposure

[Redmon]

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Low-Level: Edges

[Redmon]

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Low-Level: Segmentation (color)

[Redmon]

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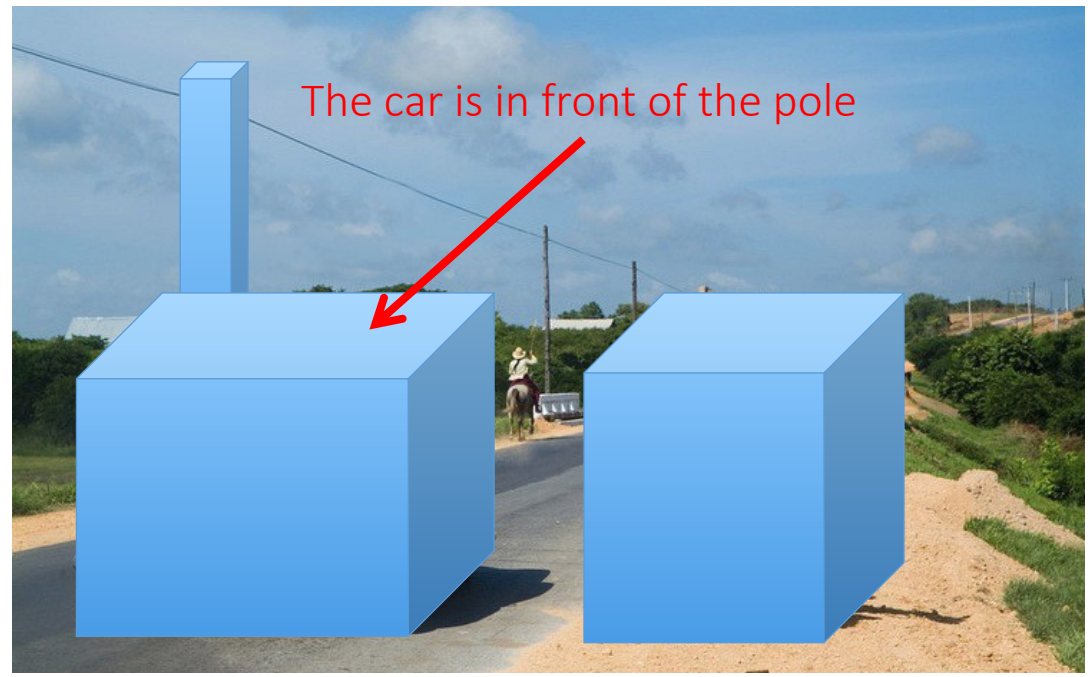

[Shapiro]

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Mid-Level: Panorama Stitching

[Redmon]

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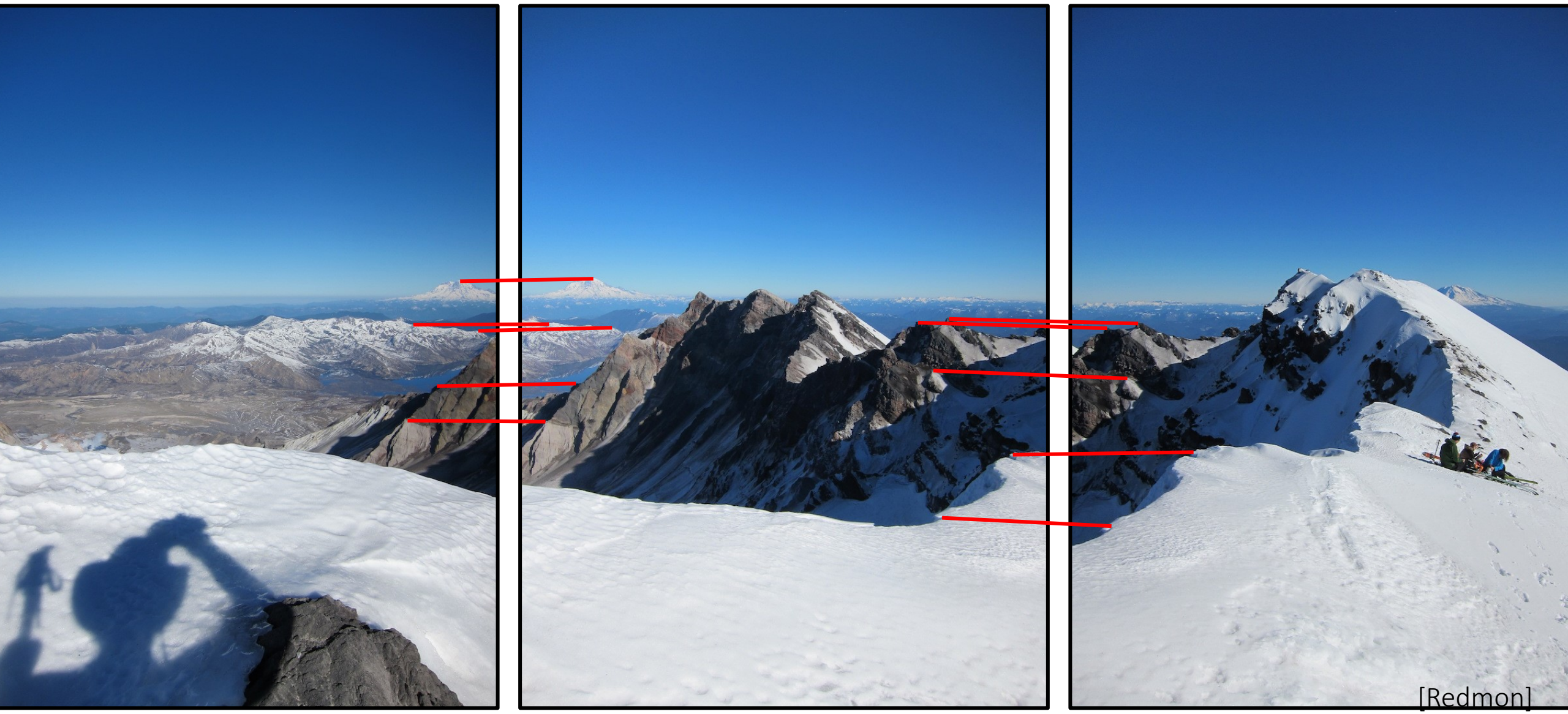
Mid-Level: Panorama Stitching



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Mid-Level: Multi-View Stereo

[Redmon]

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Mid-Level: Multi-View Stereo

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Mid-Level: Multi-View Stereo

[Building Rome in a Day, Agarwal et al., ICCV 2009]

The Colosseum, 2,106 images, 819,242 points

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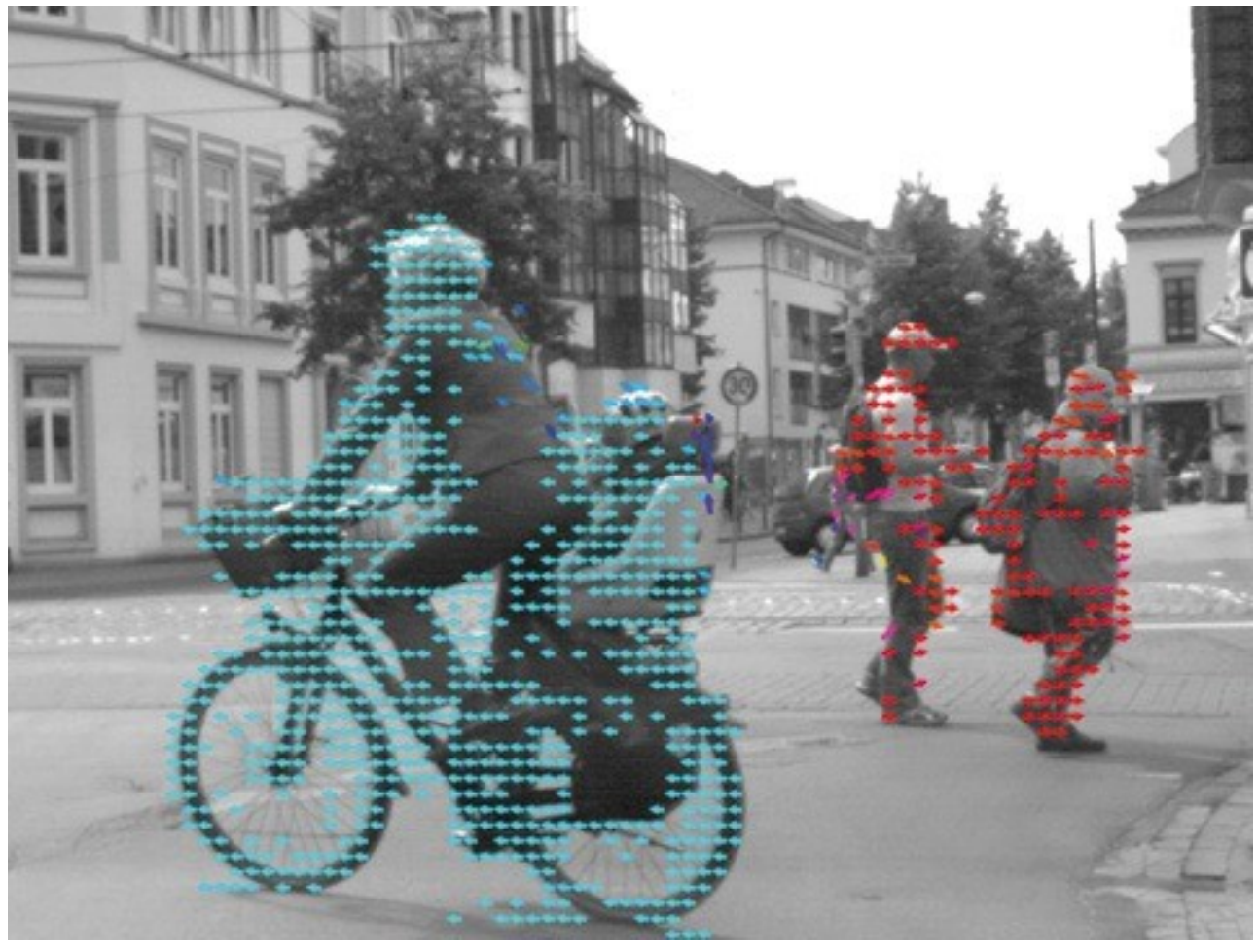
Mid-Level: Optical Flow



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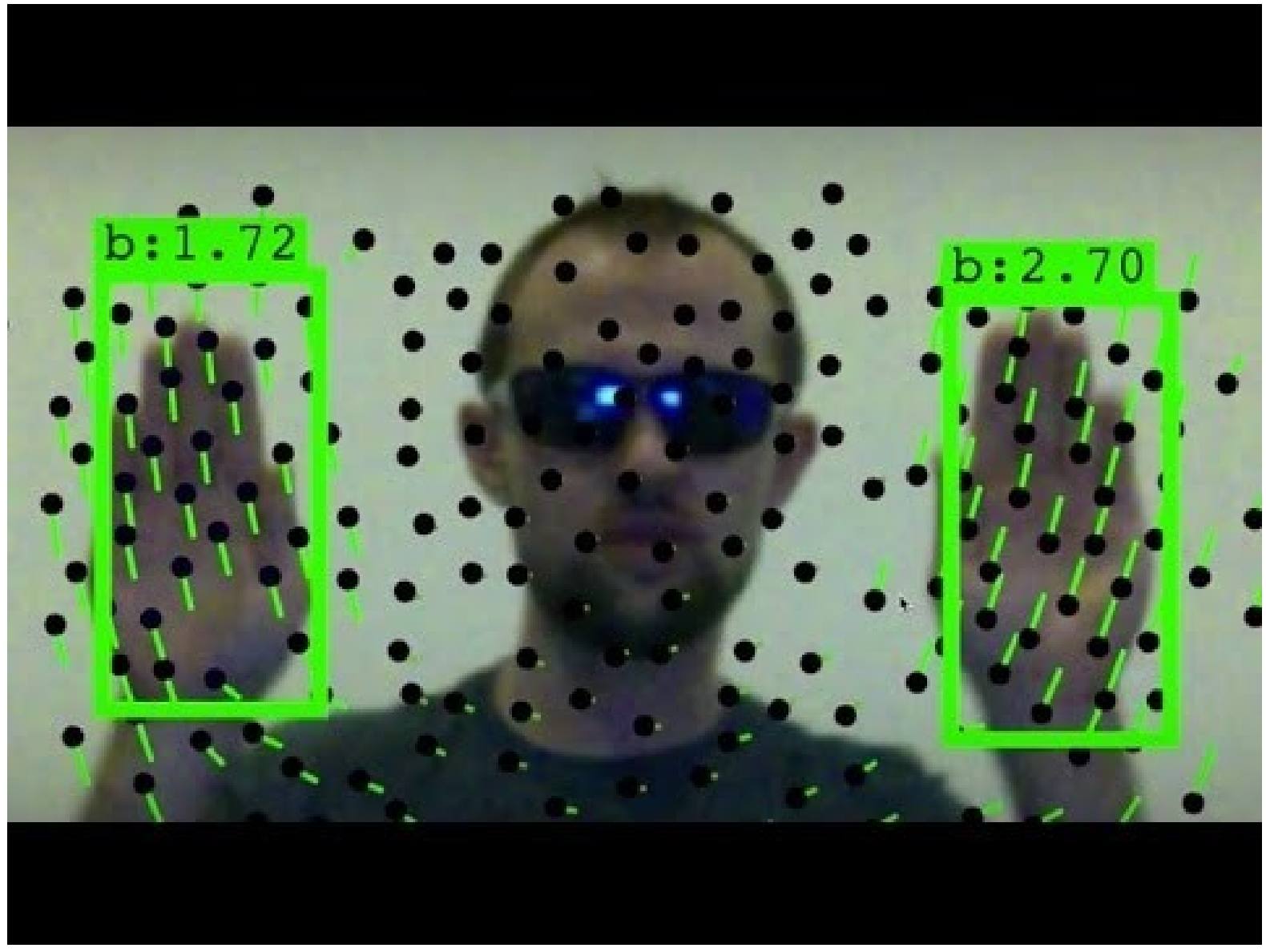

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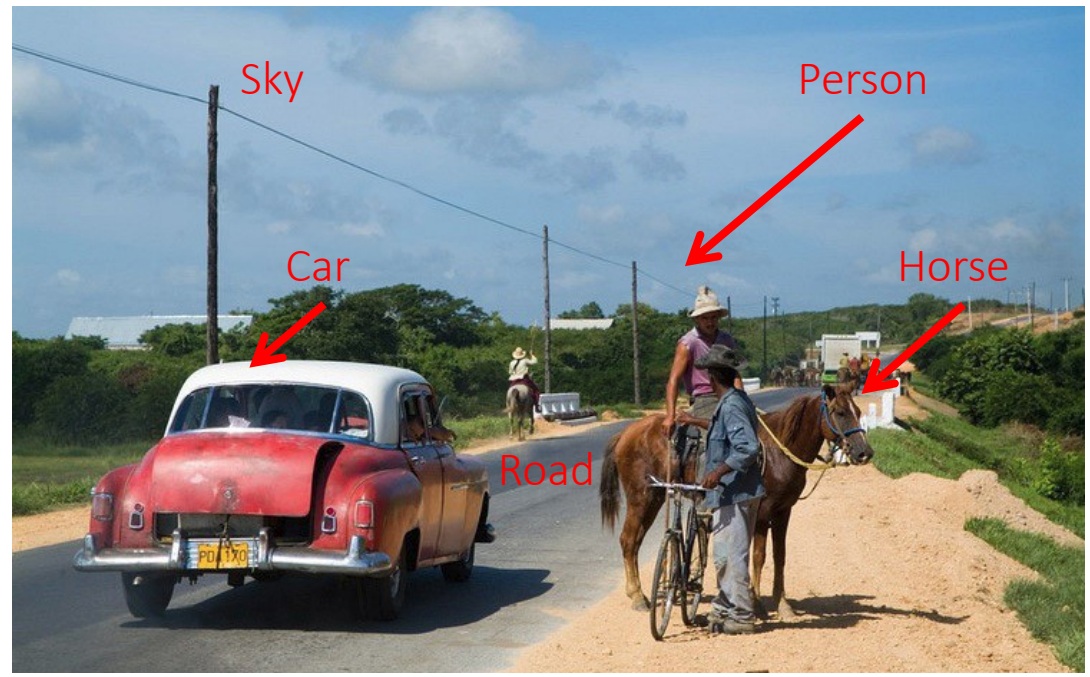

[Shapiro]

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High-Level: Classification

- What is in the image?

[Redmon]

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High-Level: Tagging

- What are ALL the things in the image?

[Redmon]

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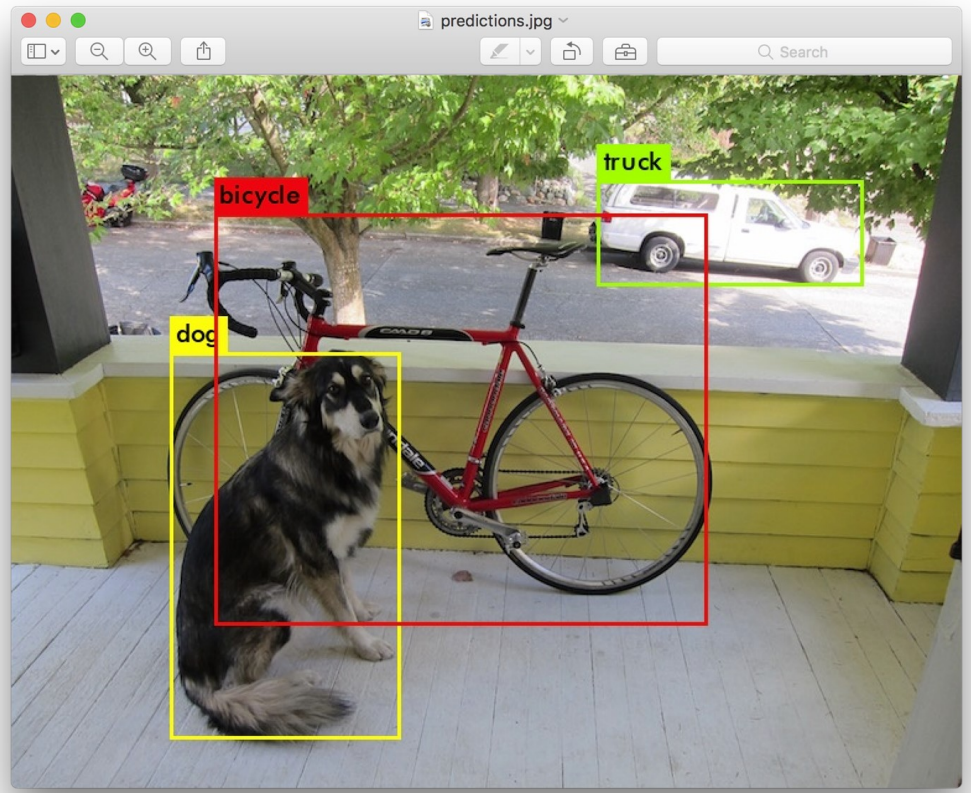
High-Level: Detection

- What are ALL the things in the image?
- Where are they?



[Redmon]

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High-Level: Semantic Segmentation

[Redmon]

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High-Level: Instance Segmentation

http://www.youtube.com/watch?v=OOT3UIXZztE [Redmon]

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Why study Computer Vision?

- *Match* (or *beat*) human vision

→ central to Artificial Intelligence, countless applications

- Understand human vision → neuroscience
- Do research with huge impact
- Get a job in the industry
- Timing is perfect: AI revolution – big data, faster hardware, deep learning

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Do research with huge impact

Google Scholar

Top publications

Categories

	Publication
1.	Nature
2.	The New England Journal of Medicine
3.	Science
4.	The Lancet
5.	IEEE/CVF Conference on Computer Vision and Pattern Recognition
6.	Advanced Materials
7.	Nature Communications
8.	Cell
9.	Chemical Reviews
10.	Chemical Society reviews
11.	Journal of the American Chemical Society
12.	Angewandte Chemie
13.	Proceedings of the National Academy of Sciences
14.	JAMA
15.	Nucleic Acids Research

2021

Google Scholar

Top publications

Categories

English

	Publication	h5-index	h5-median
1.	Nature	414	607
2.	The New England Journal of Medicine	410	704
3.	Science	391	564
4.	IEEE/CVF Conference on Computer Vision and Pattern Recognition	356	583
5.	The Lancet	345	600
6.	Advanced Materials	294	406
7.	Cell	288	459
8.	Nature Communications	287	389
9.	Chemical Reviews	270	434
10.	International Conference on Learning Representations	253	470
11.	JAMA	253	446
12.	Neural Information Processing Systems	245	422
13.	Proceedings of the National Academy of Sciences	245	337
14.	Journal of the American Chemical Society	245	330
15.	Angewandte Chemie	235	314

2022

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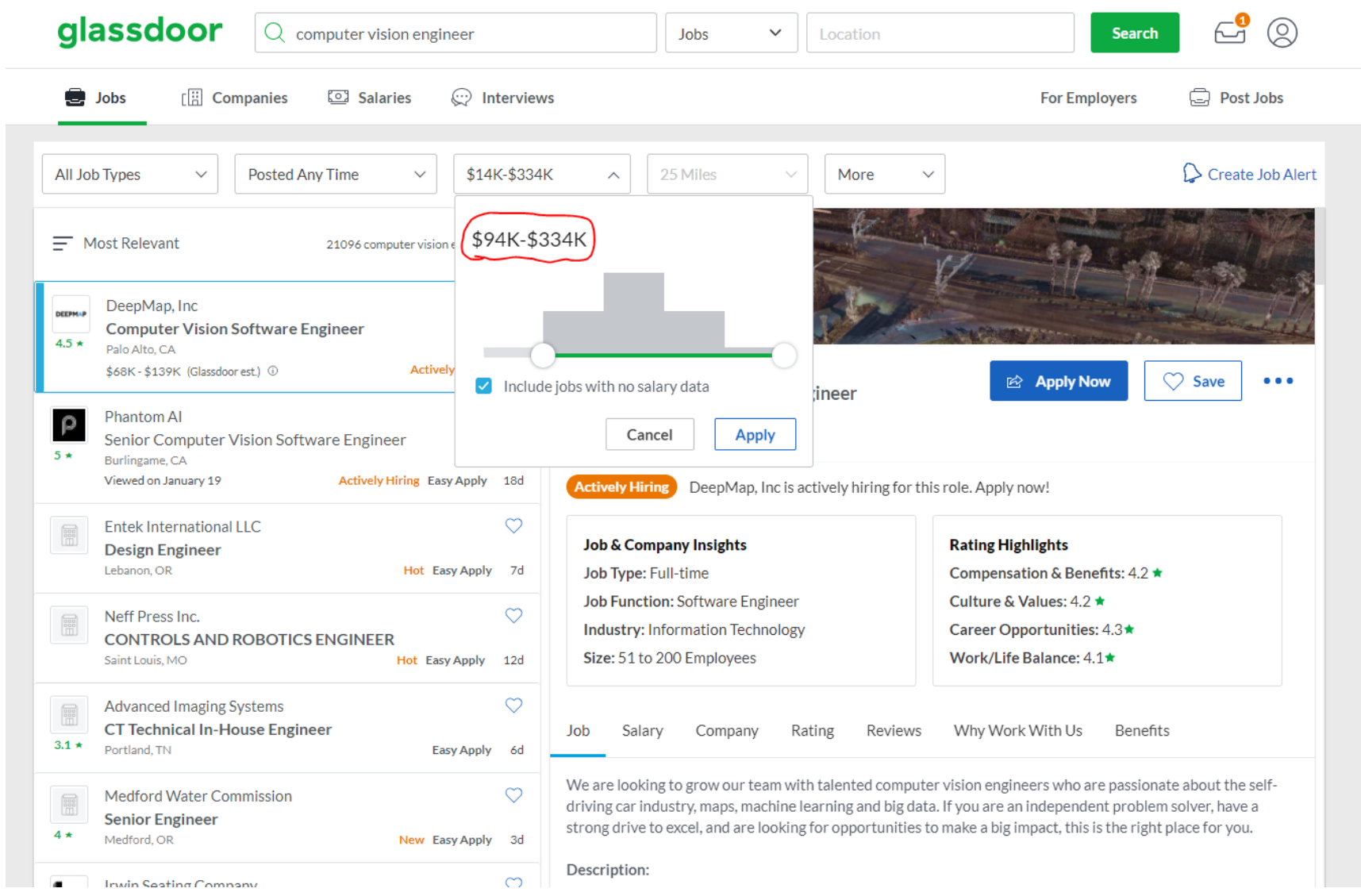
Get a job in the industry



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Today's Agenda

- Course Overview
- Introduction to Computer Vision
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  - How hard is Computer Vision
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- What we do

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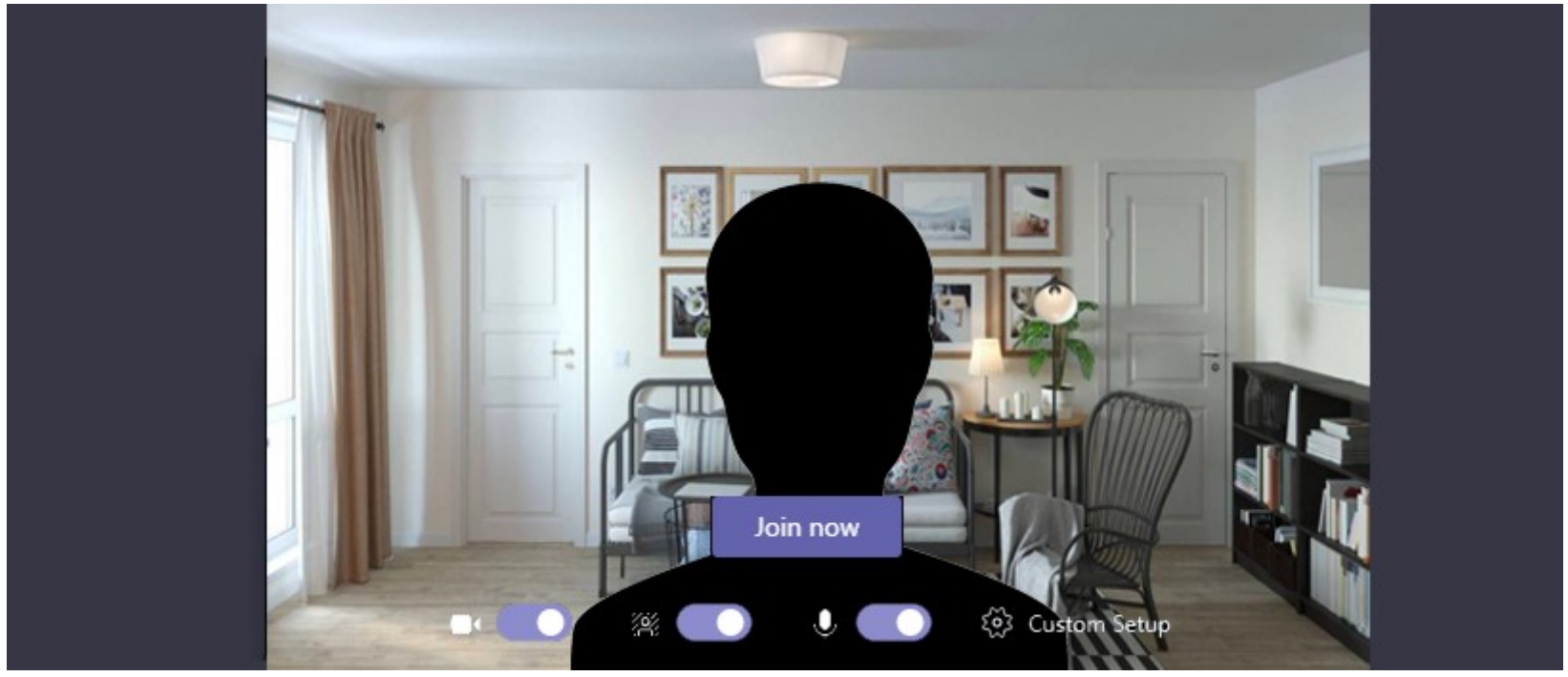
Segmentation and Matting



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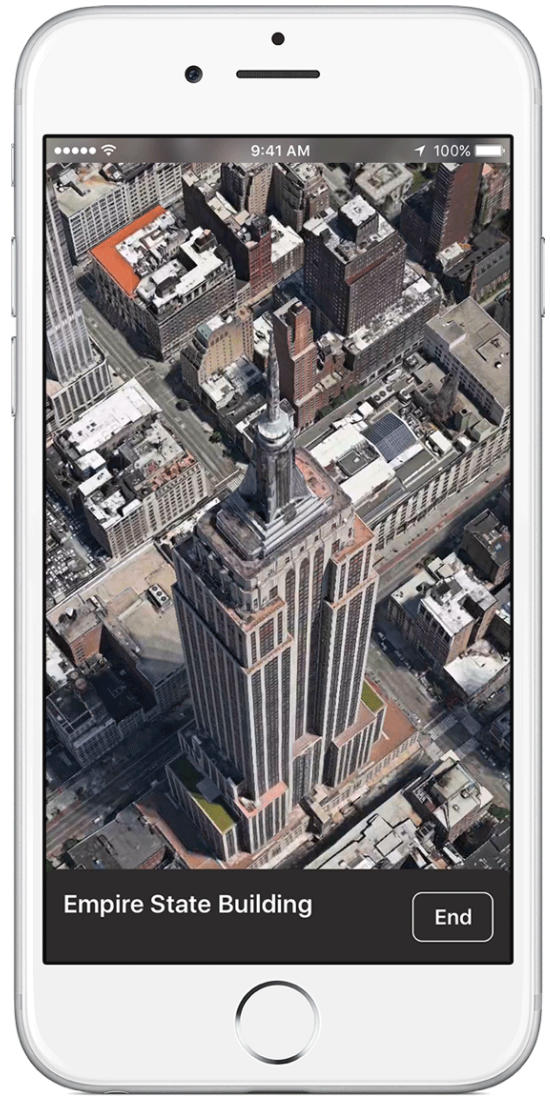
3D Maps



Apple Maps

[Seitz, Szeliski]

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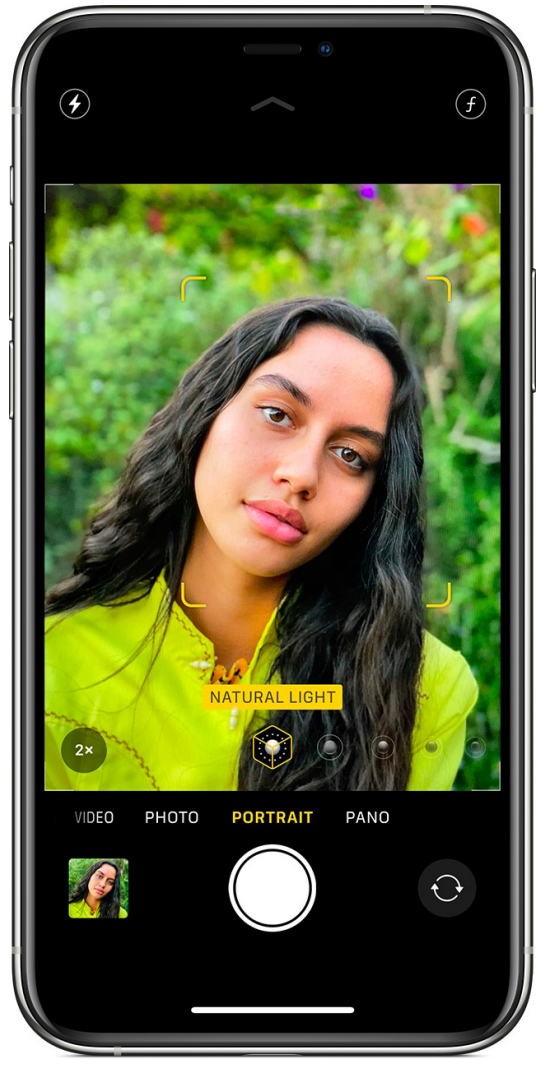
Computational photography



Portrait mode

simulating wider aperture

[Seitz, Szeliski]

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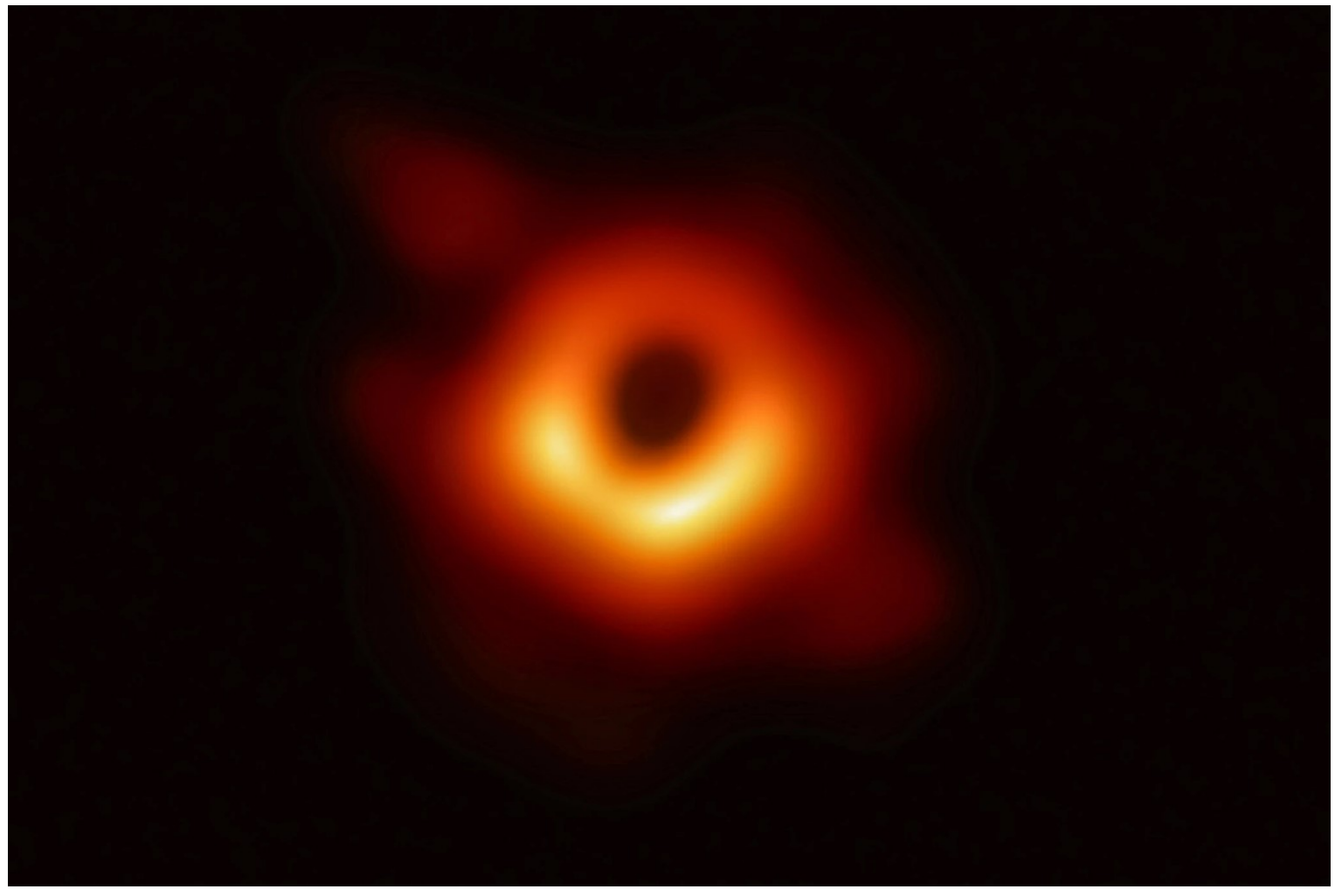
Even wider aperture…



How scientists captured the first image of a black hole, 2019

[Seitz, Szeliski]

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3D photos

[3D Photos on Facebook](#)

Estimate depth from photo to create animation

[Seitz, Szeliski]

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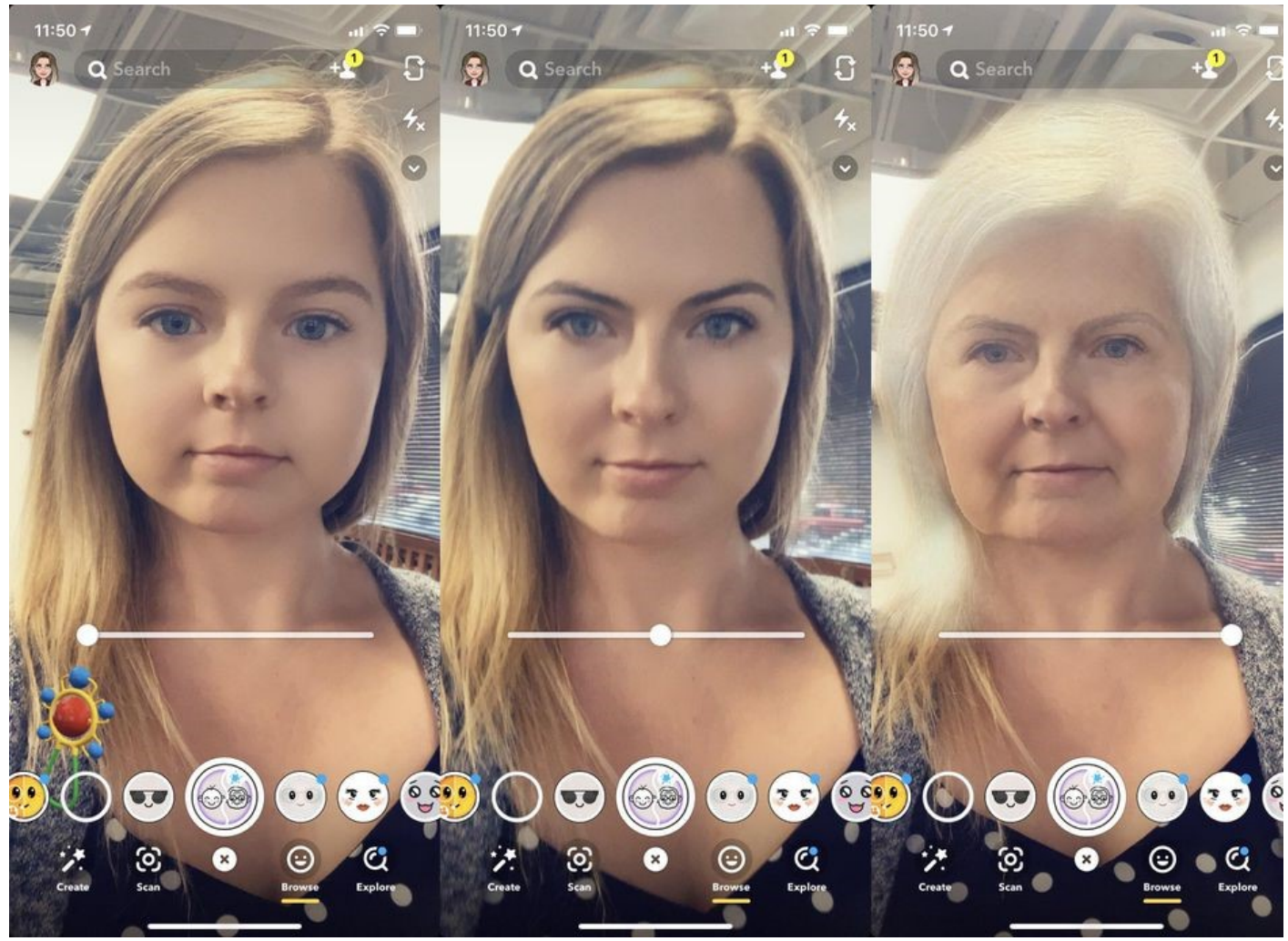
Age Simulation



From CNET

Snapchat Time Machine

[Seitz, Szeliski]

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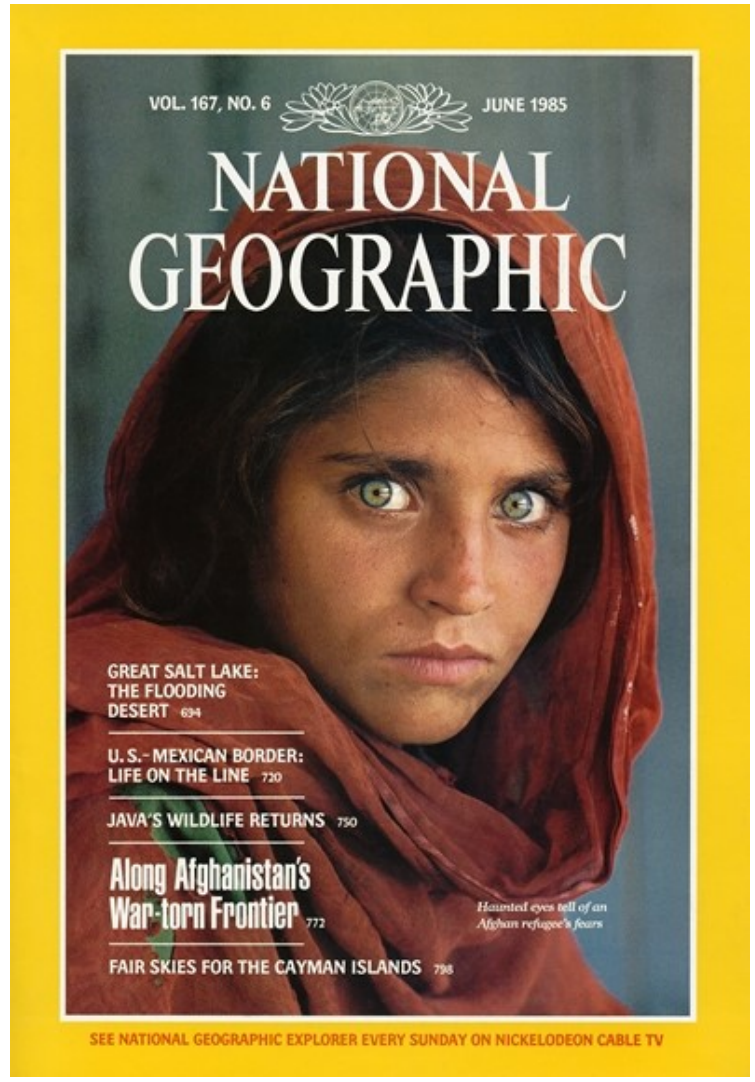
Face recognition



Who is she?

[Seitz, Szeliski]

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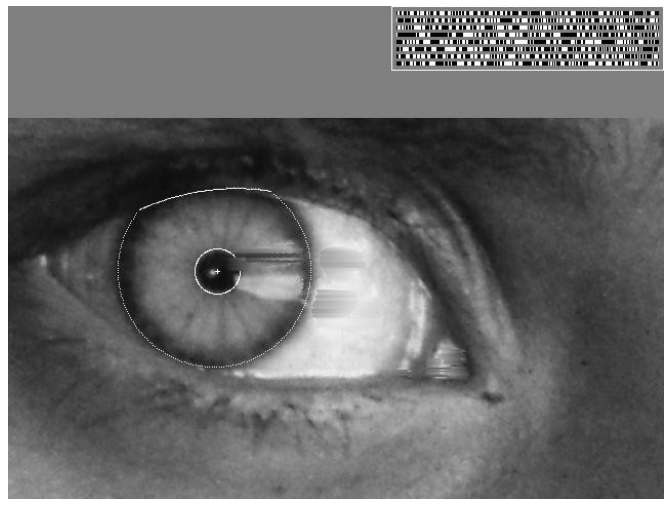
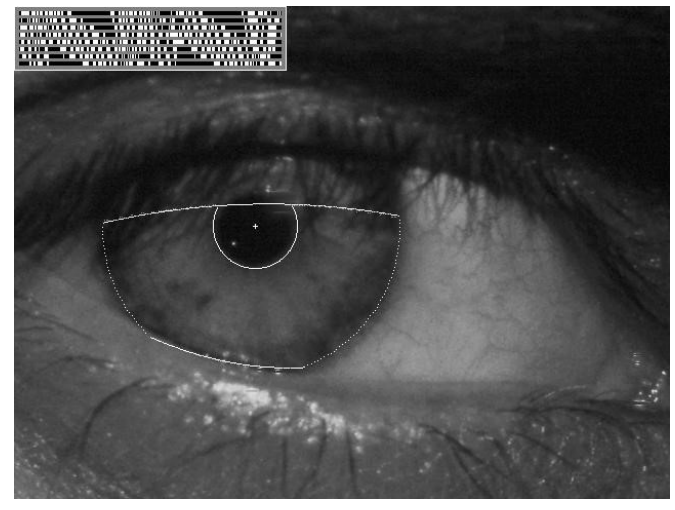
Vision-based biometrics

"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story





[Seitz, Szeliski]

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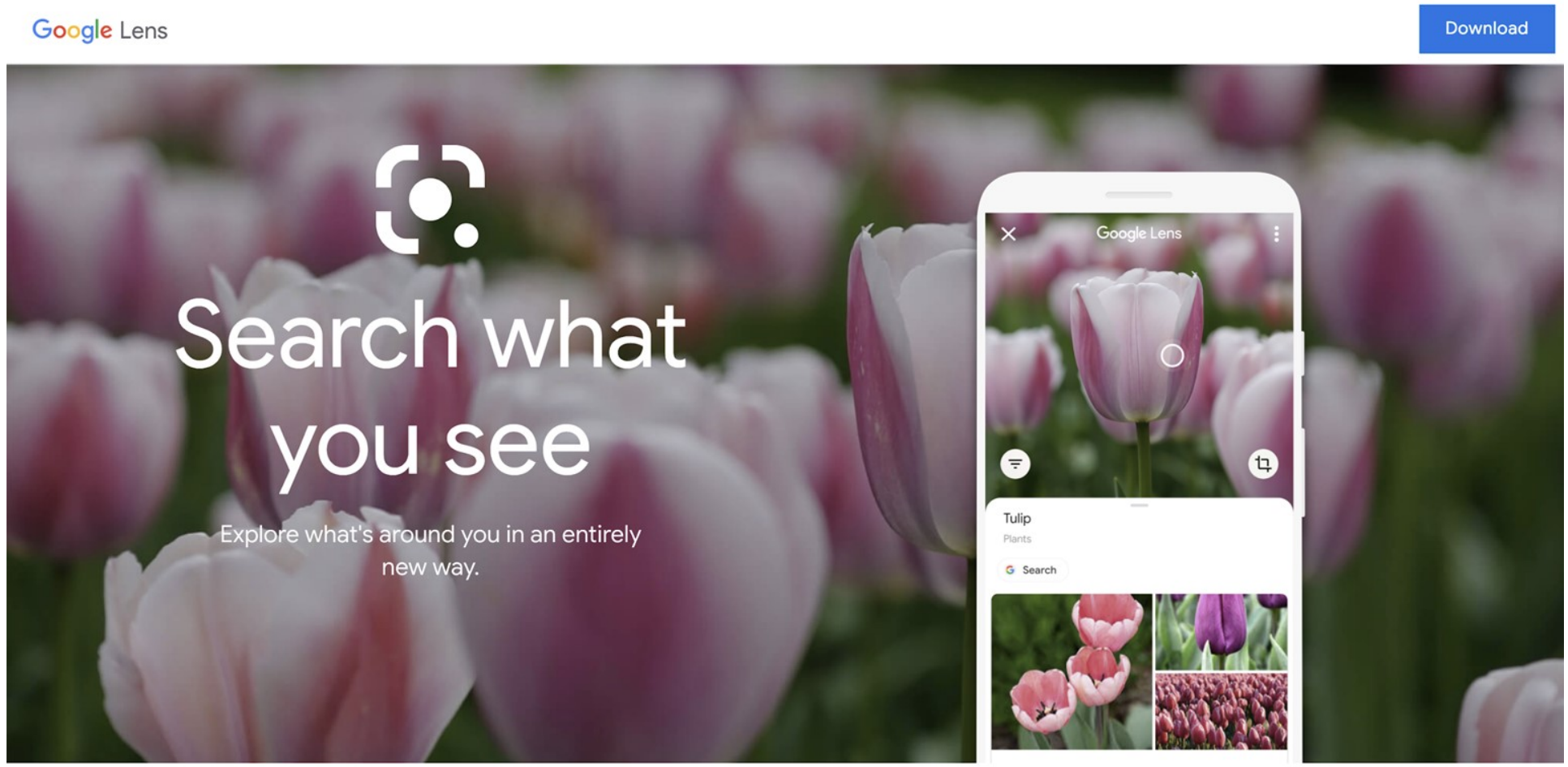
Object recognition



[Seitz, Szeliski]

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Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

[Seitz, Szeliski]

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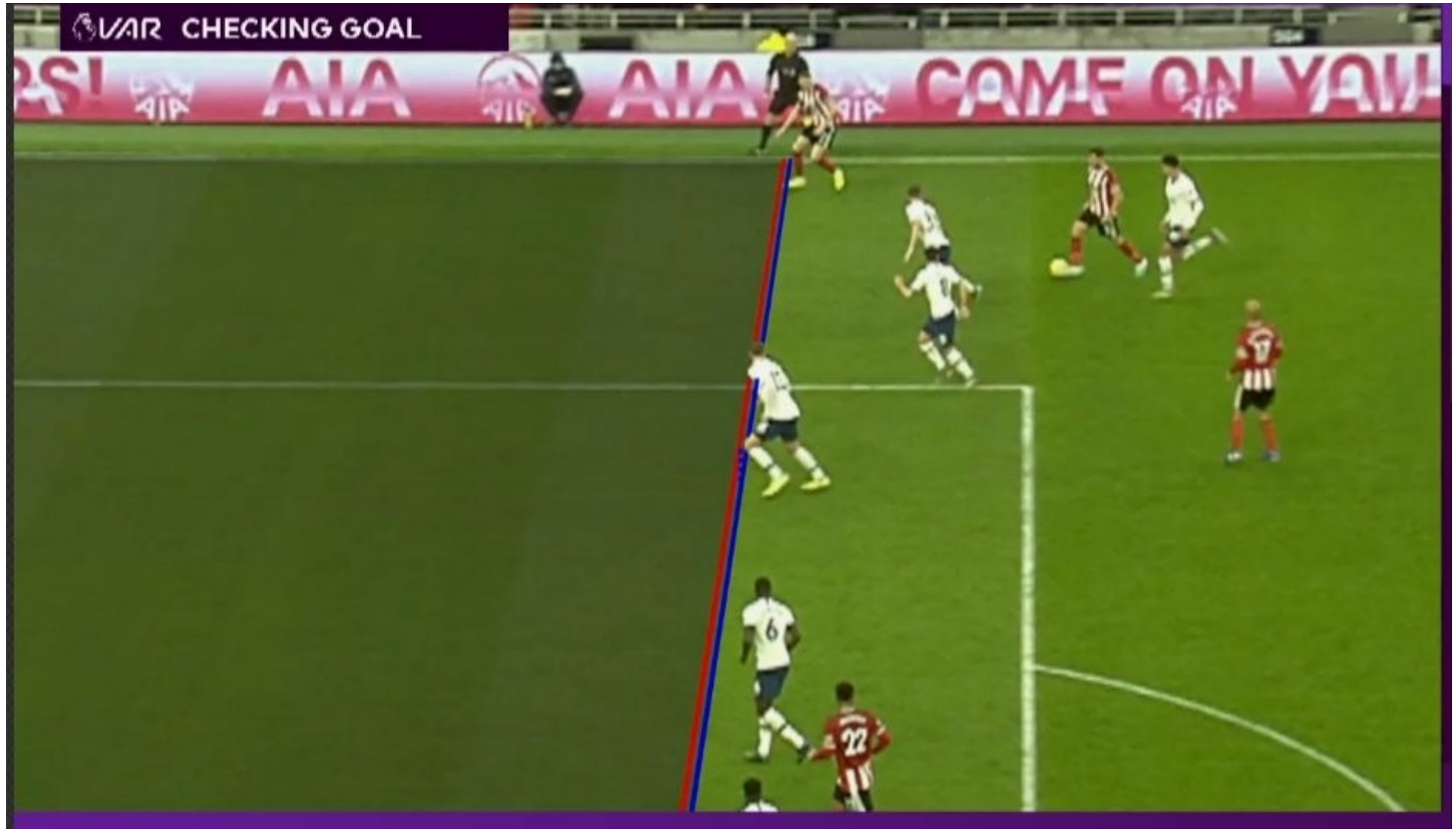
Sports - VAR



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Games

Microsoft’s XBox Kinect

[Seitz, Szeliski]

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Virtual Reality - Metaverse

Oculus Quest, Beat Saber

[Seitz, Szeliski]

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Augmented Reality - Metaverse

Microsoft Hololens 2

[Seitz, Szeliski]

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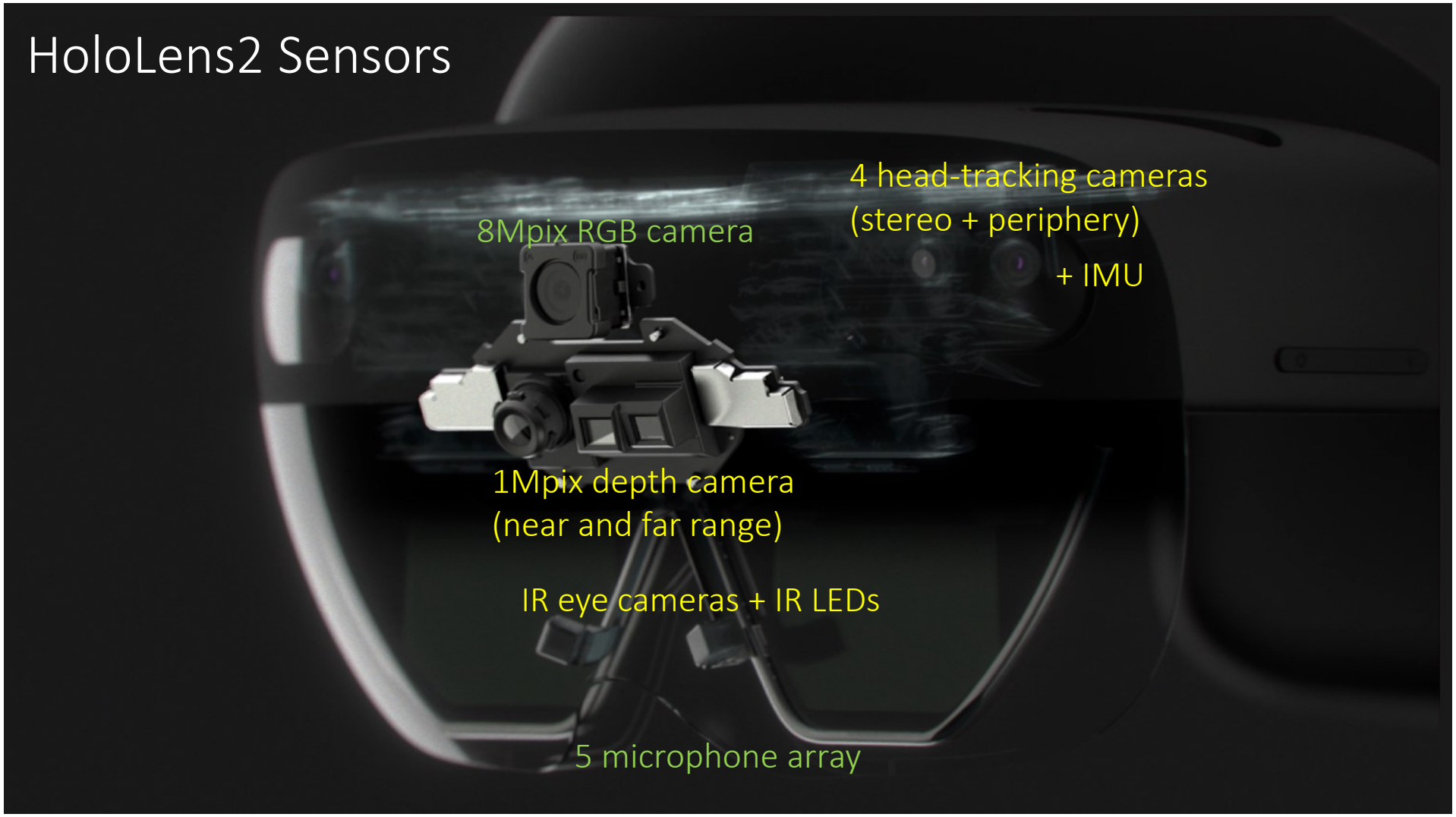
Augmented Reality - Metaverse



[Seitz, Szeliski]

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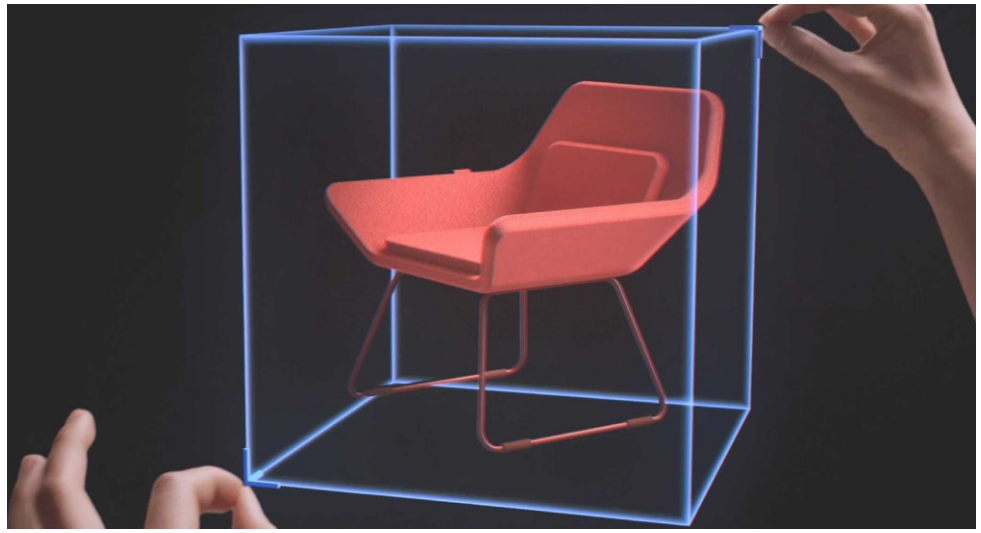
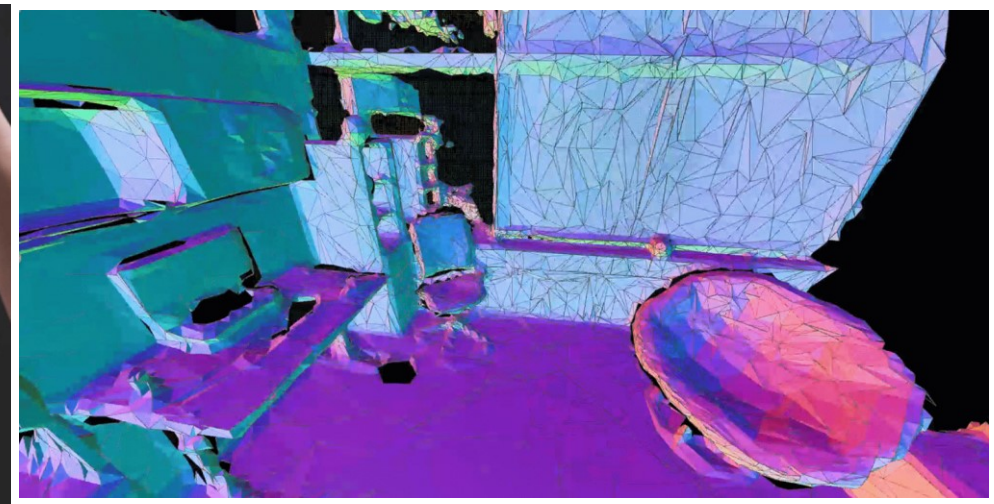
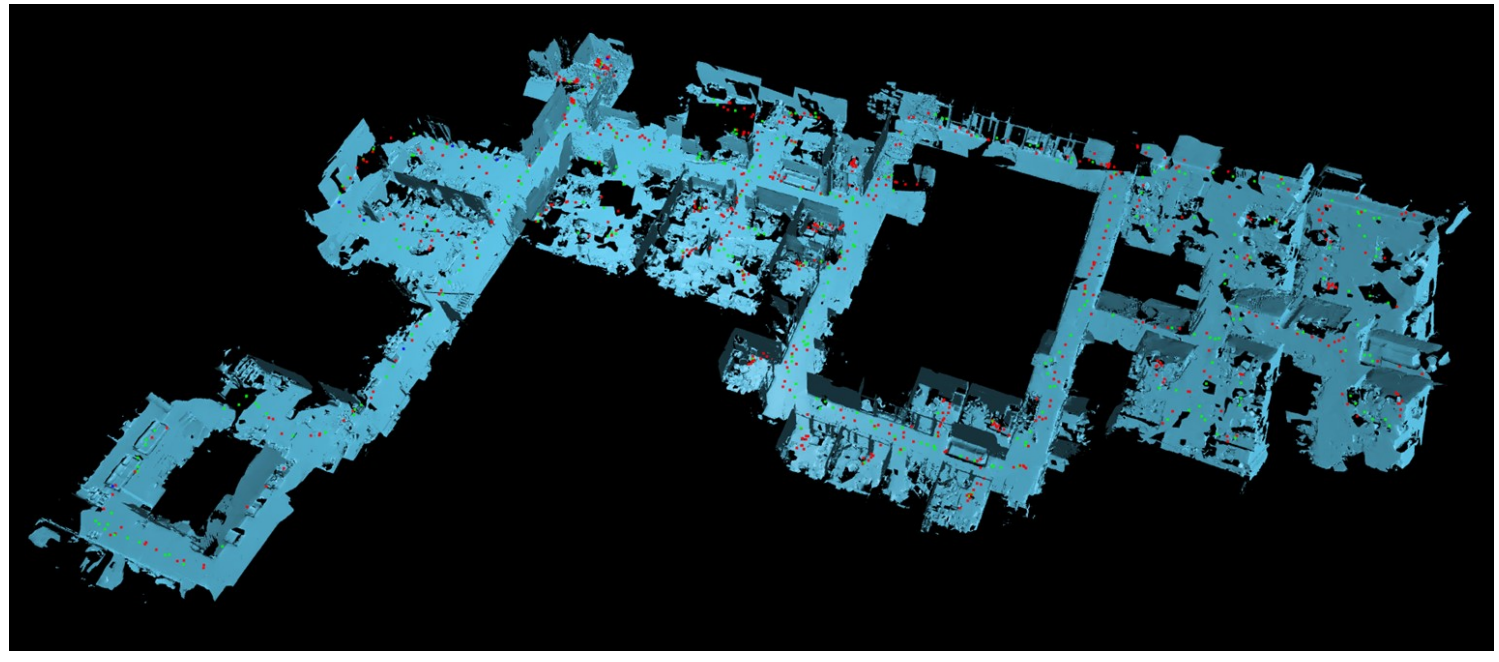
Augmented Reality







[Seitz, Szeliski]

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Phone-based AR

http://www.youtube.com/watch?v=0Pj-jzy6ESE

[Seitz, Szeliski]

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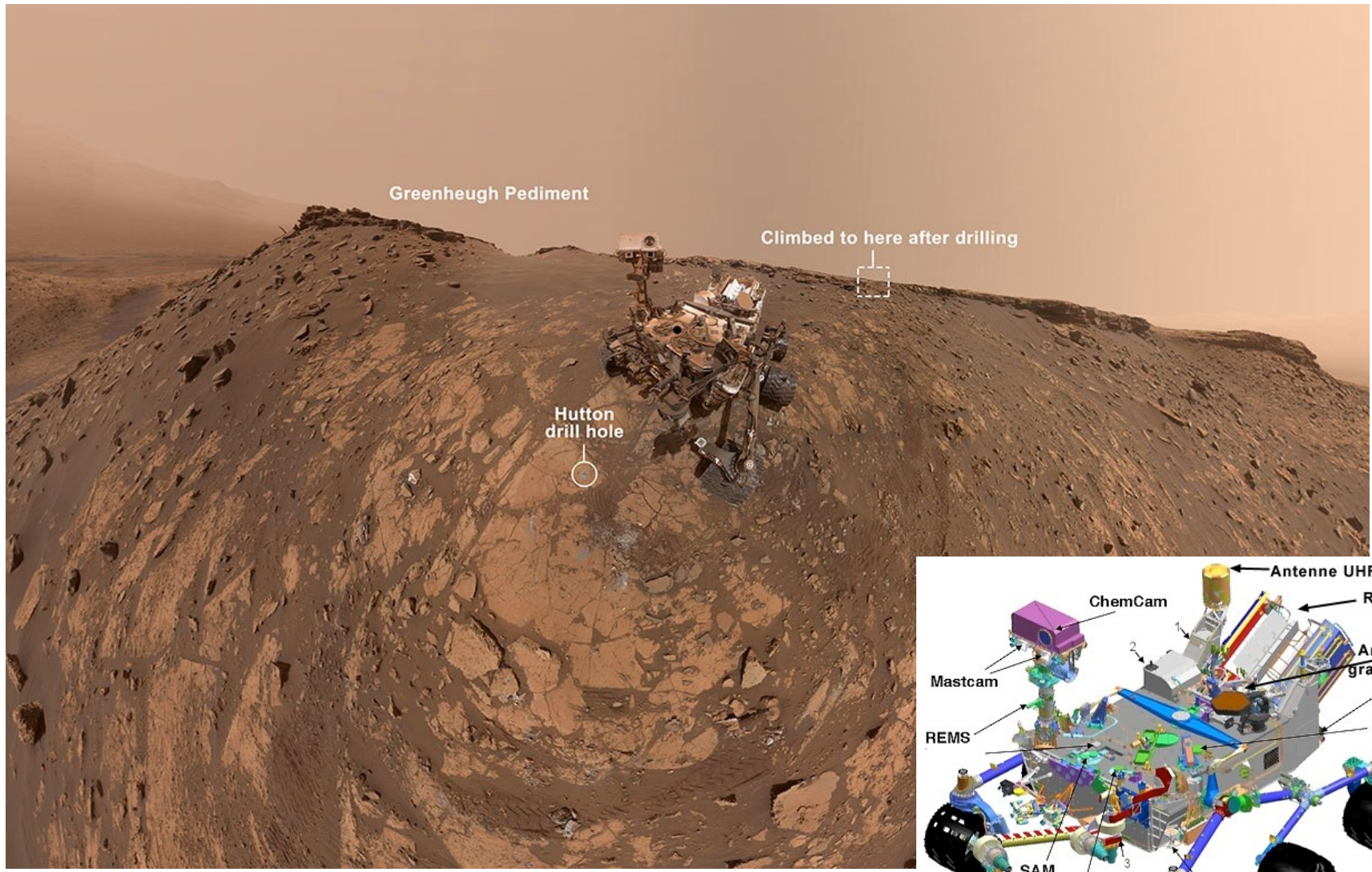
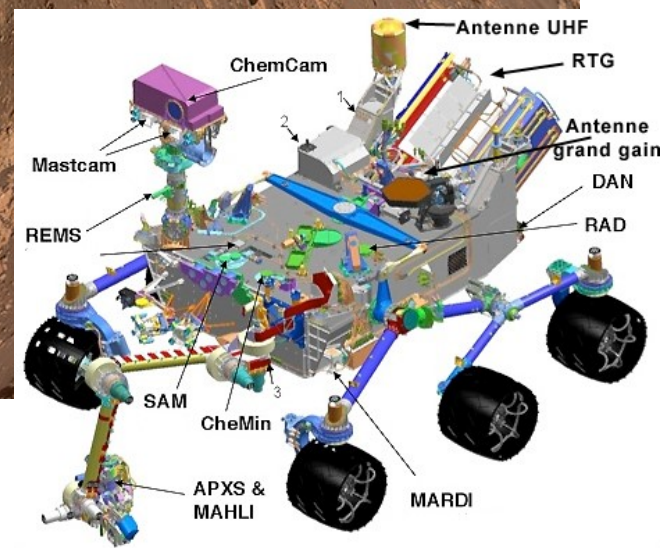
Robotics





NASA's Mars Curiosity Rover (self portrait)
https://en.wikipedia.org/wiki/Curiosity_(rover)

[Seitz, Szeliski]

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Smart cars

Mobileye

- Vision systems currently in high-end BMW, GM, Volvo models

[Seitz, Szeliski]

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Self-driving cars

https://waymo.com/tech/

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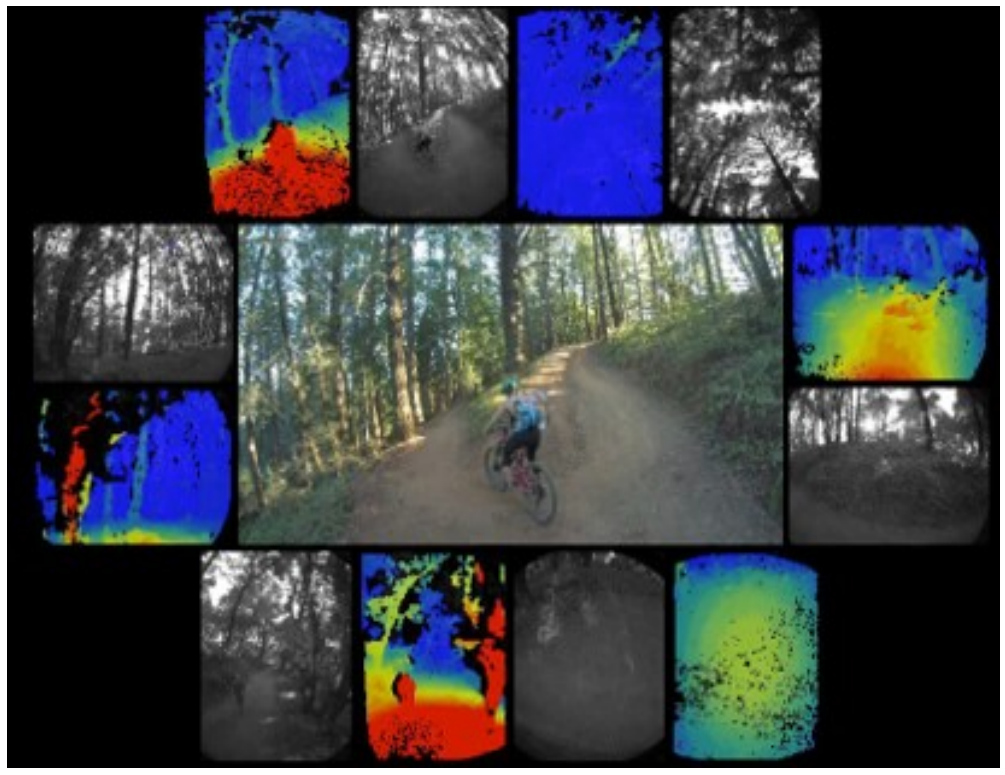
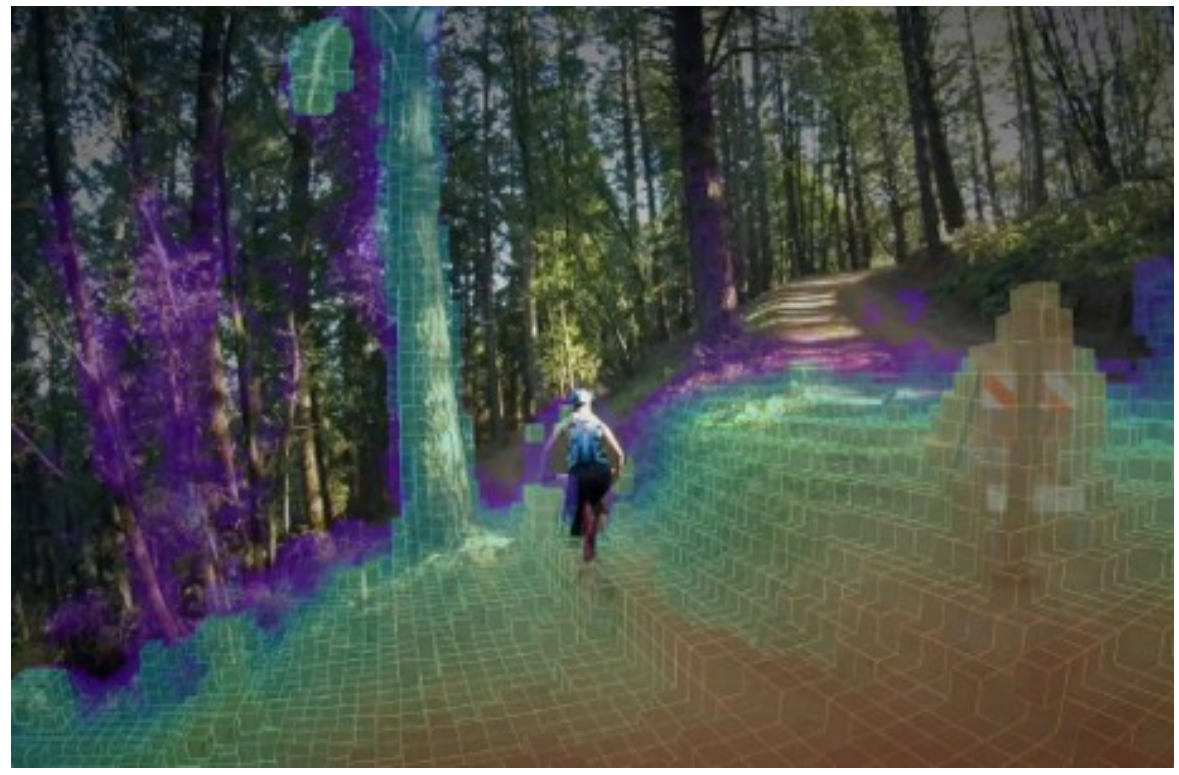
Drones





https://www.skydio.com/

[Seitz, Szeliski]

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Research: Yolo

http://www.youtube.com/watch?v=MPU2HistivI

[Seitz, Szeliski]

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Research: StyleGan

http://www.youtube.com/watch?v=BIZg_PPuj_0

[Seitz, Szeliski]

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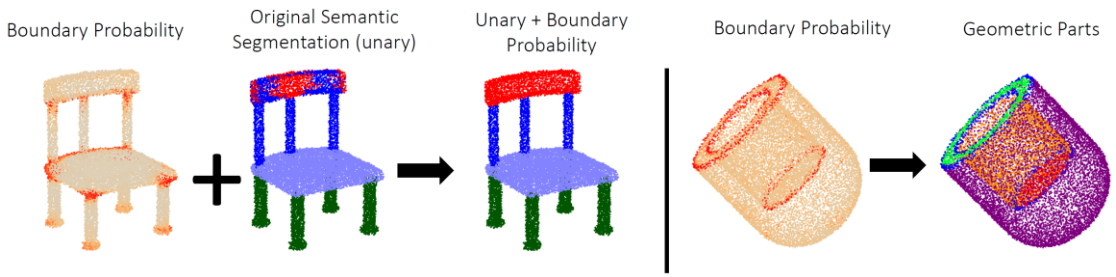
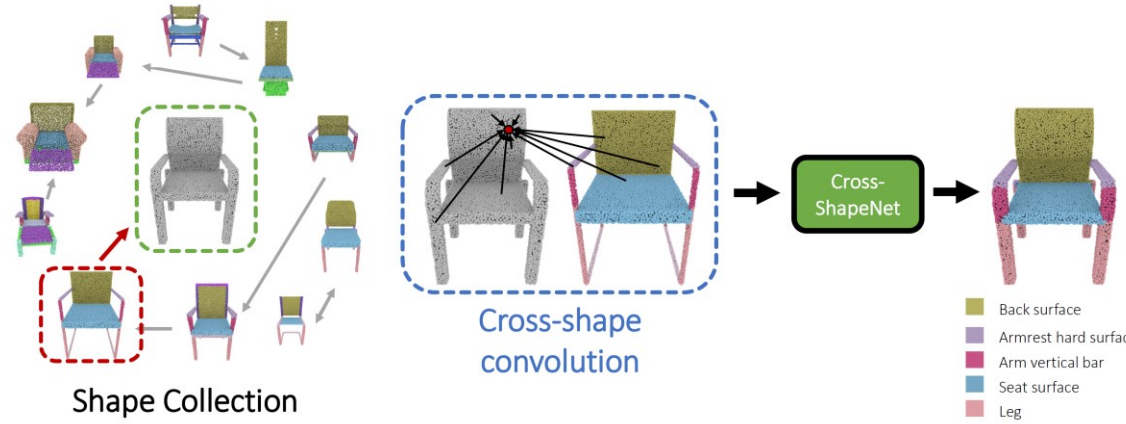
3D Shape Understanding

3D Building Semantic Understanding

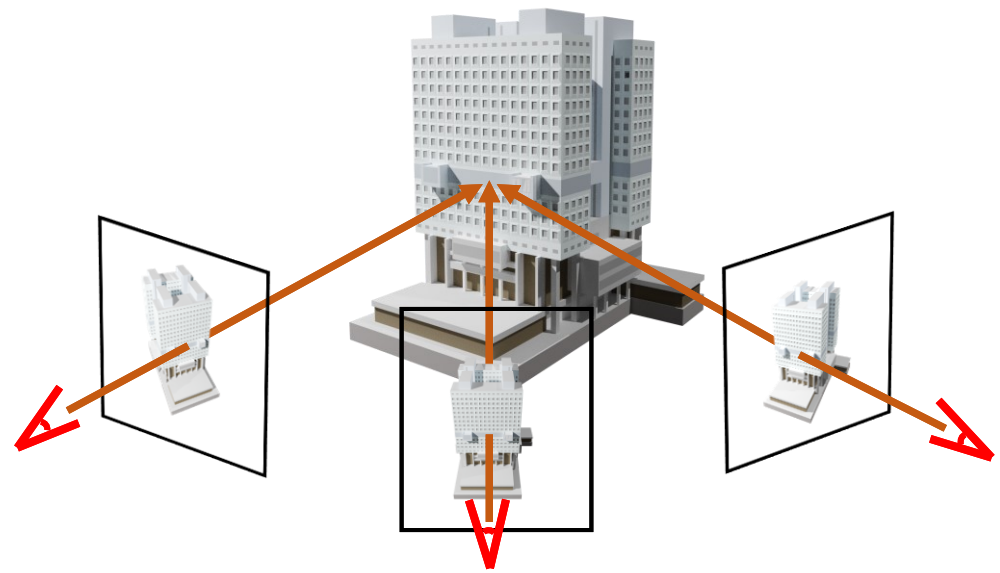
Geometric/Semantic Decomposition



Cross-shape semantic segmentation



Neural 3D Reconstruction



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Texture Generation for 3D Data

Single-View Guided Façade Synthesis

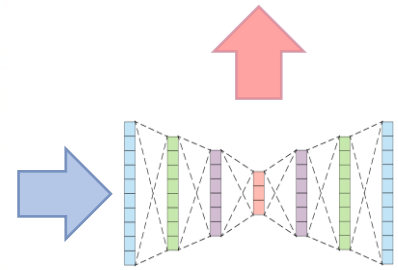
Reference Façade Images | 3D Scene Renderings

Interactive Texturing

Projective Urban Texturing

Street Level Panoramic Images

Textured 3D Geometry



PUT

Textured Atlas

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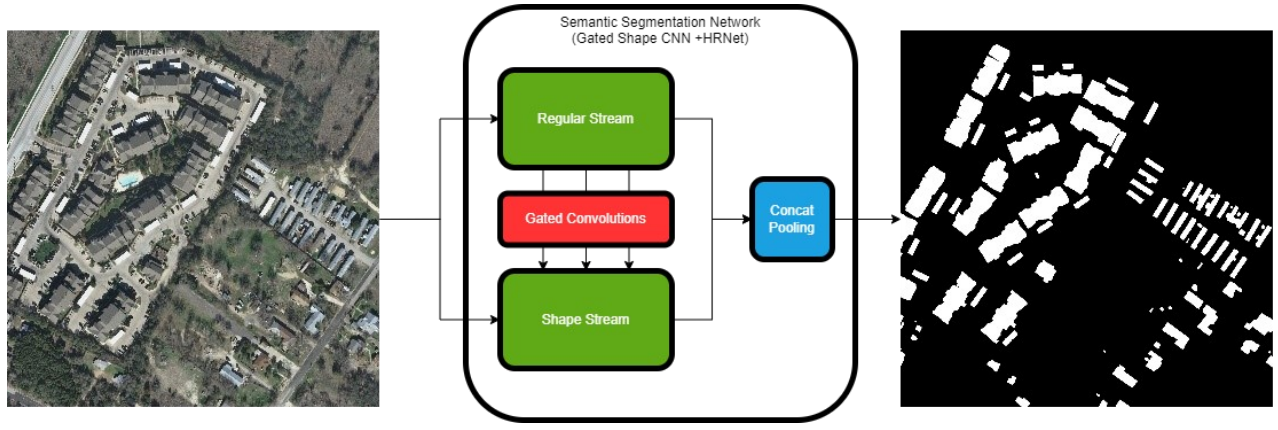
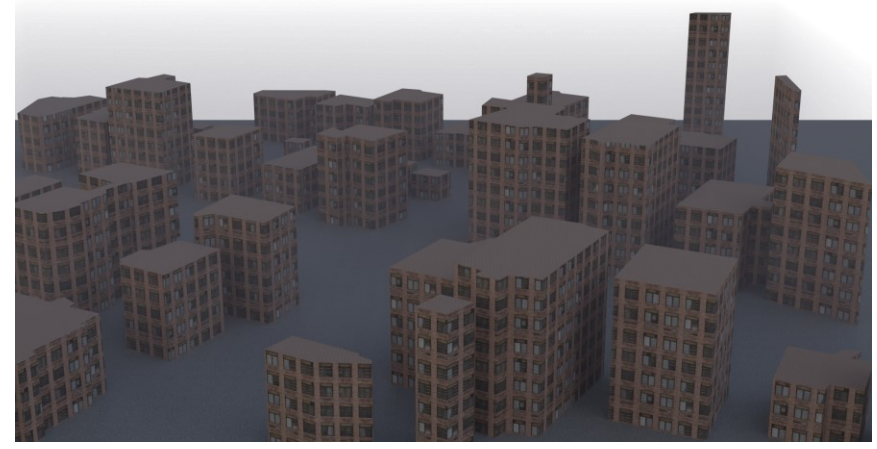
Urban Semantic Understanding from Remote Sensing Data Sources

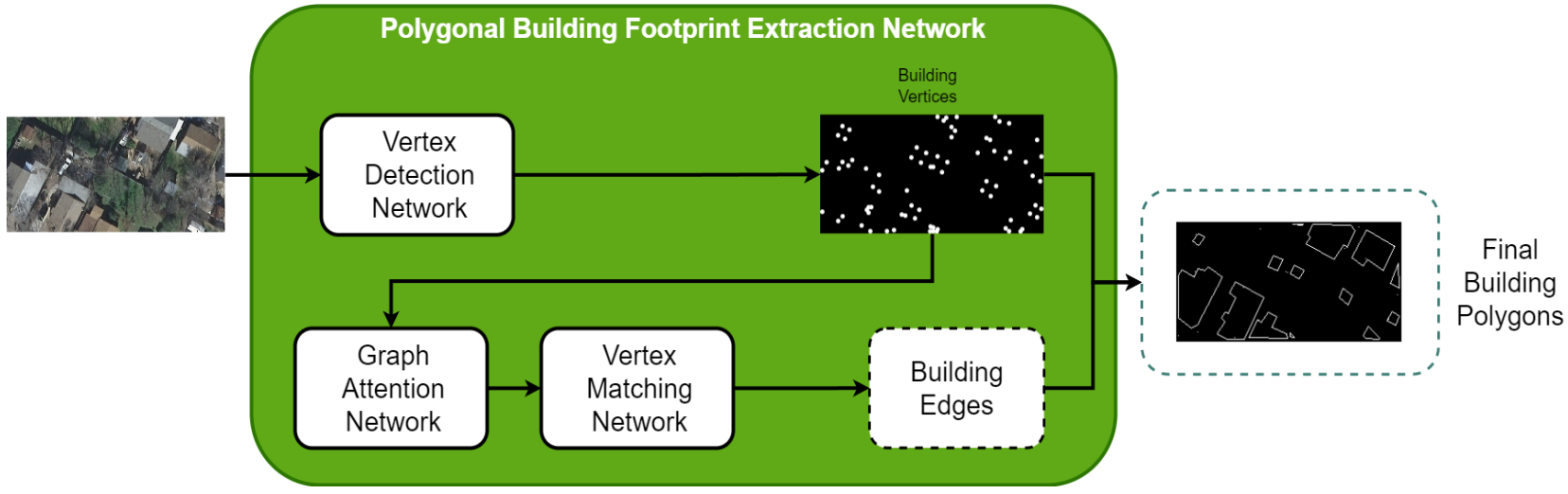
Semantic Segmentation of Buildings



Urban 3D Reconstruction



Building Footprint Extraction



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Master programmes in Artificial Intelligence 4 Careers in Europe

Visual Computing Group

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