CSCI 5561 Computer Vision

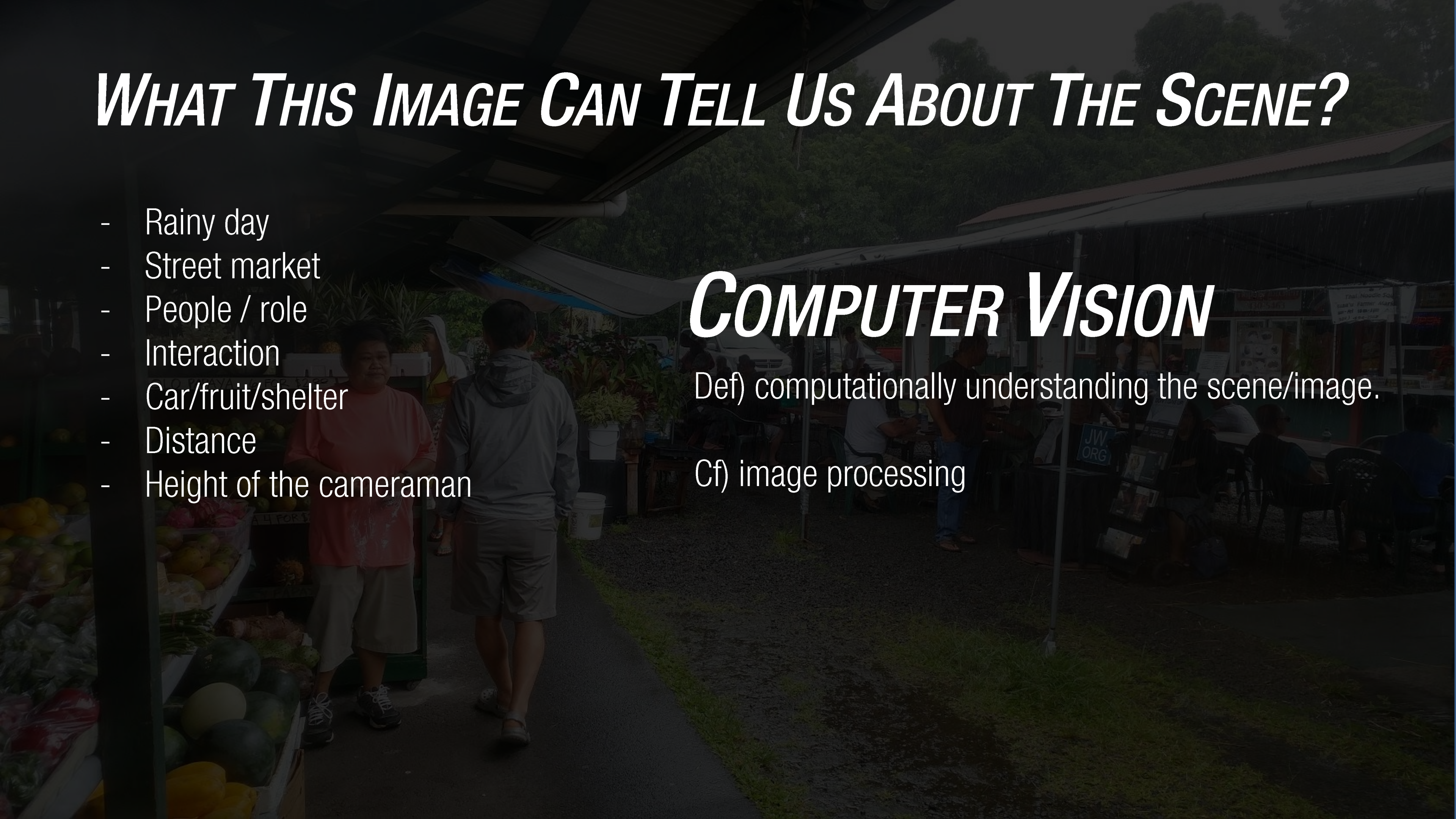
Hyun Soo Park

3D Motion Reconstruction
(Trajectory Stream Association)

What This Image Can Tell Us About The Scene?

What This Image Can Tell Us About The Scene?

- Rainy day
- Street market
- People / role
- Interaction
- Car/fruit/shelter
- Distance
- Height of the cameraman



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Computer Vision

Def) computationally understanding the scene/image.

Cf) image processing

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Computer Vision

Def) computationally understanding the scene/image.

Cf) image processing

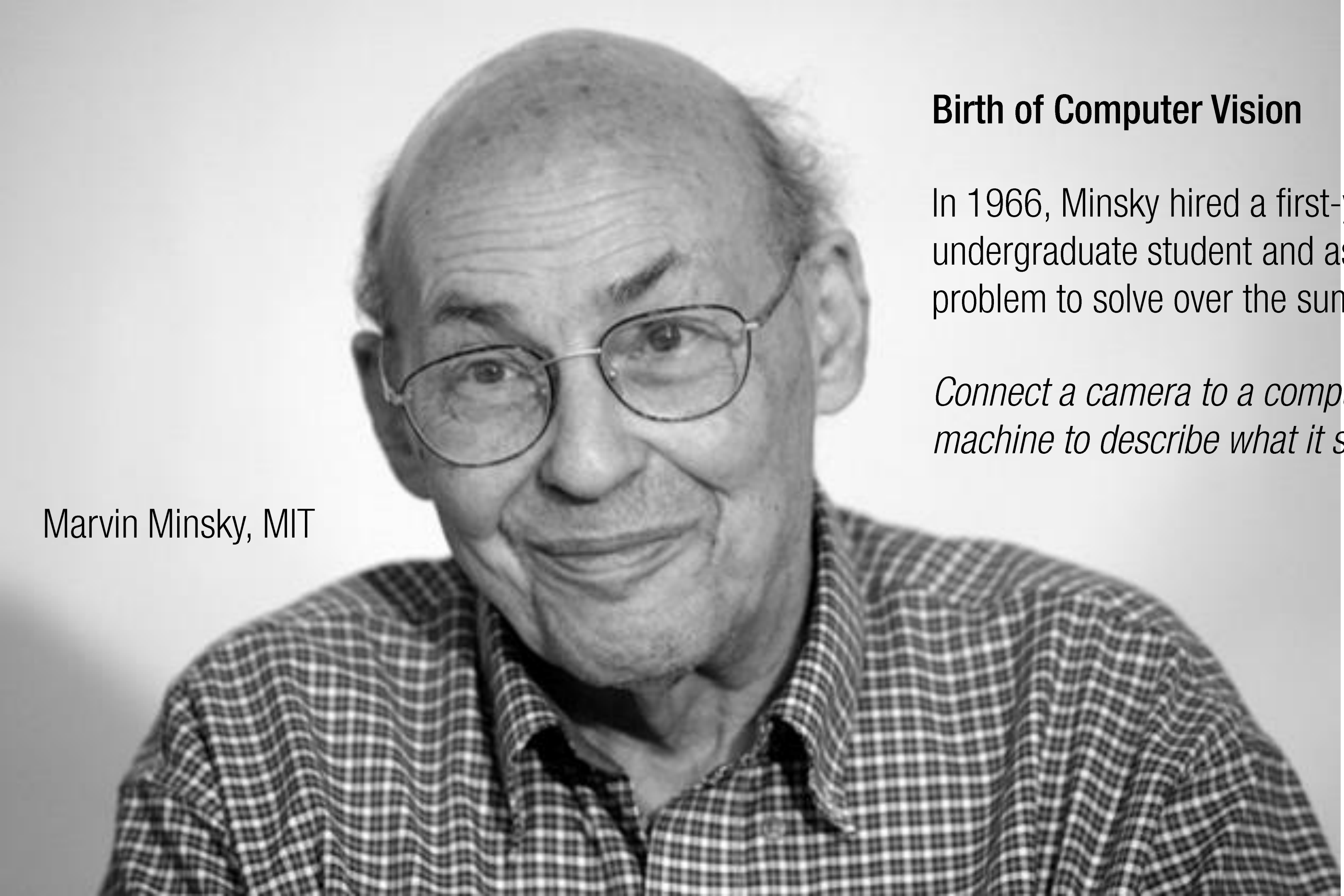
Extremely difficult

# of pixels: 8.2M

Birth of Computer Vision

In 1966, Minsky hired a first-year undergraduate student and assigned him a problem to solve over the summer:

Connect a camera to a computer and get the machine to describe what it sees.



Marvin Minsky, MIT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

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

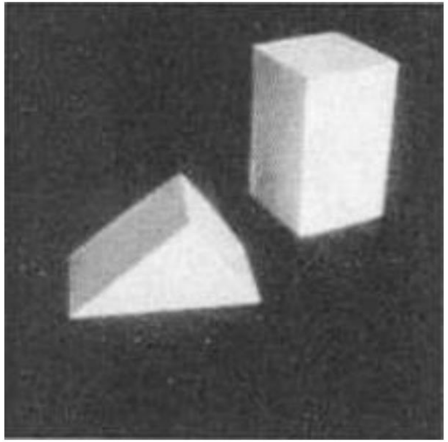
THE SUMMER VISION PROJECT

Seymour Papert

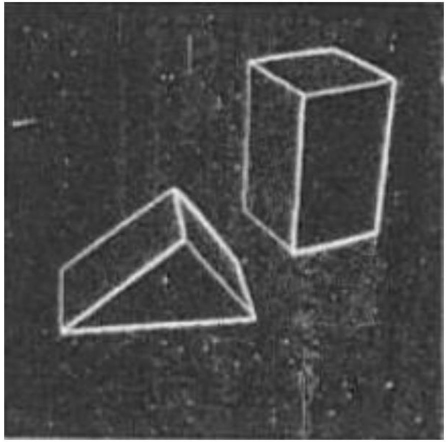
The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the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

1960's: interpretation of synthetic worlds

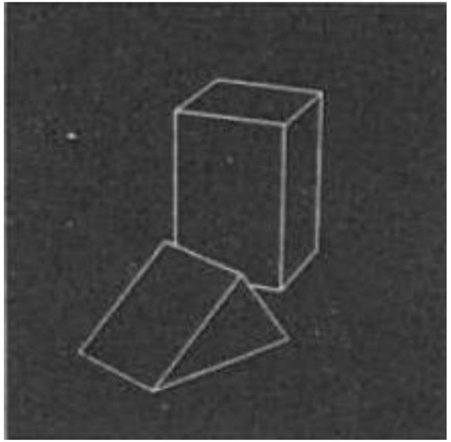
Larry Roberts
"Father of Computer Vision"



Input image



2x2 gradient operator

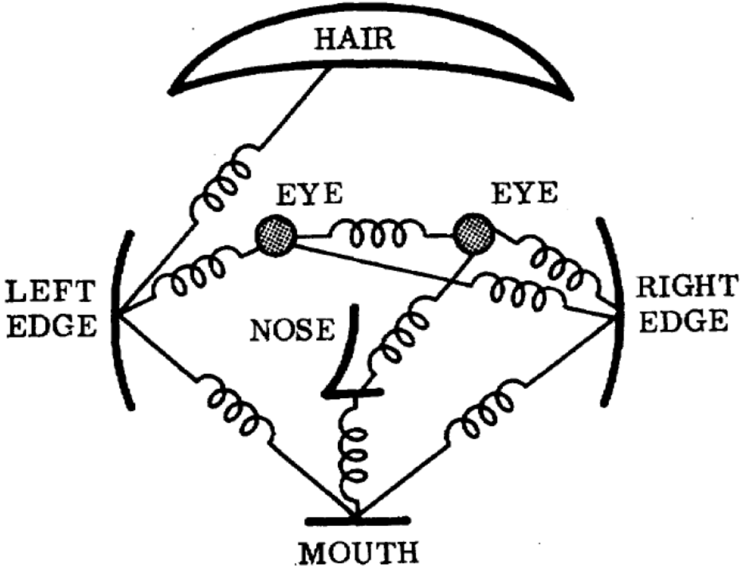


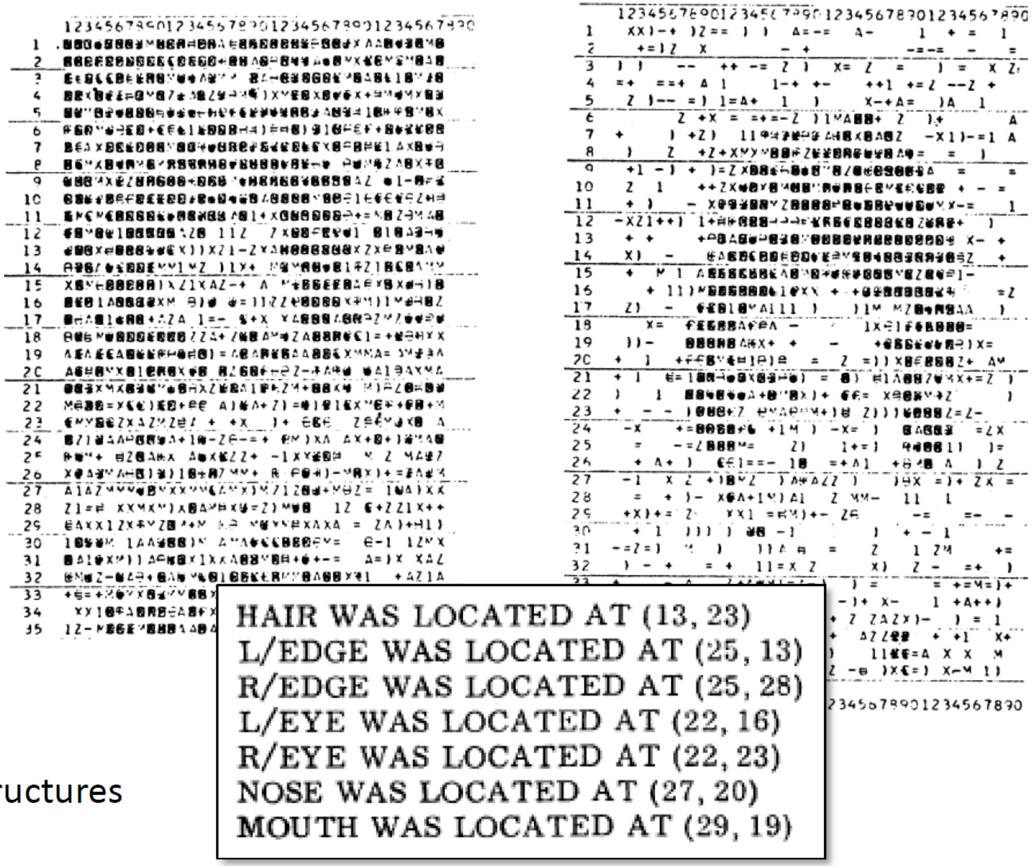
computed 3D model
rendered from new viewpoint

Larry Roberts PhD Thesis, MIT, 1963,
Machine Perception of Three-Dimensional Solids

Slide credit: Steve Seitz

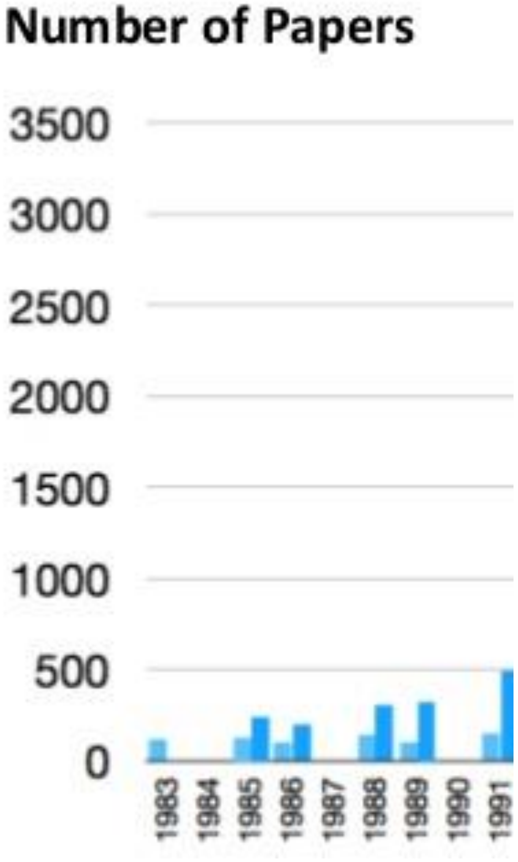
1970’s: some progress on interpreting selected images





The representation and matching of pictorial structures
Fischler and Elschlager, 1973

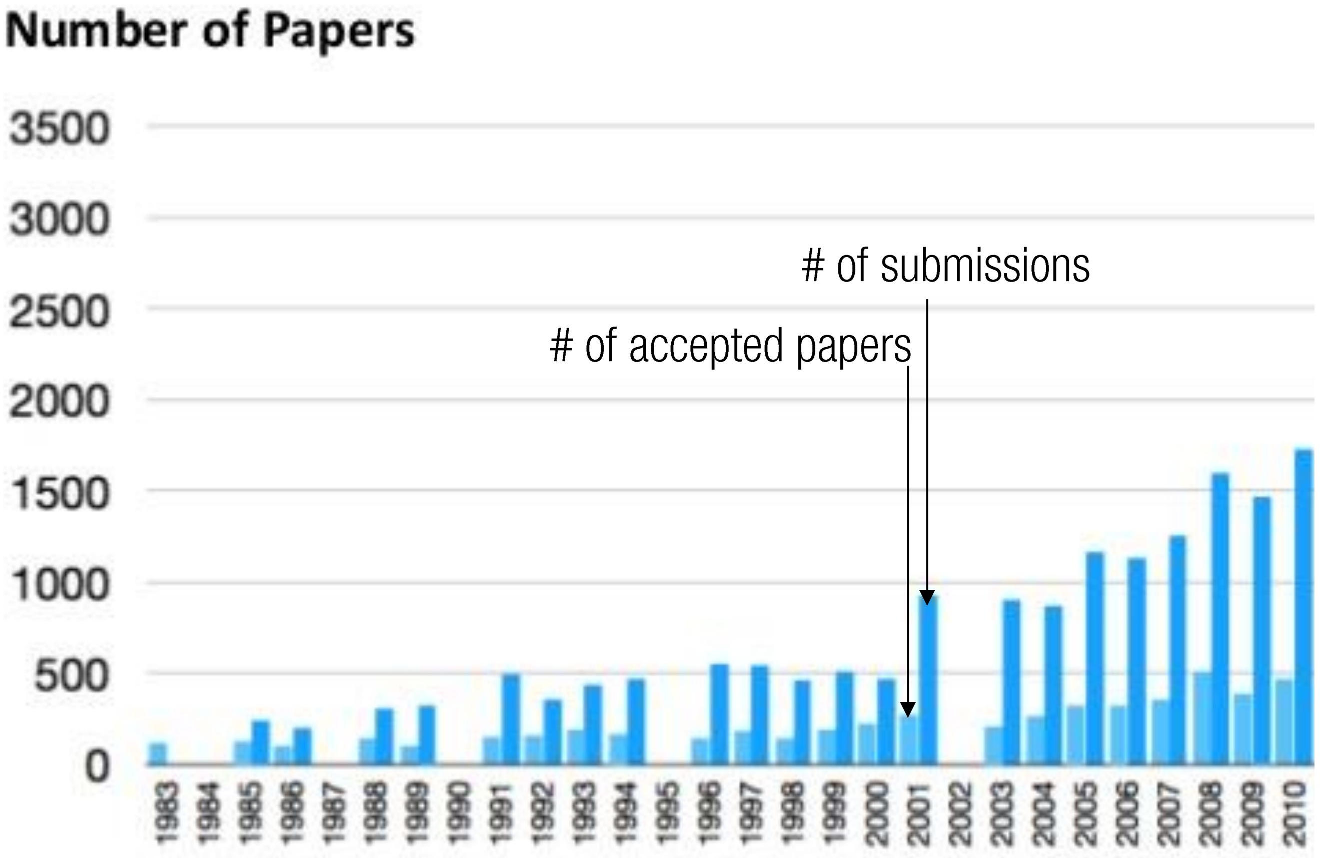
Conference on Computer Vision and Pattern Recognition



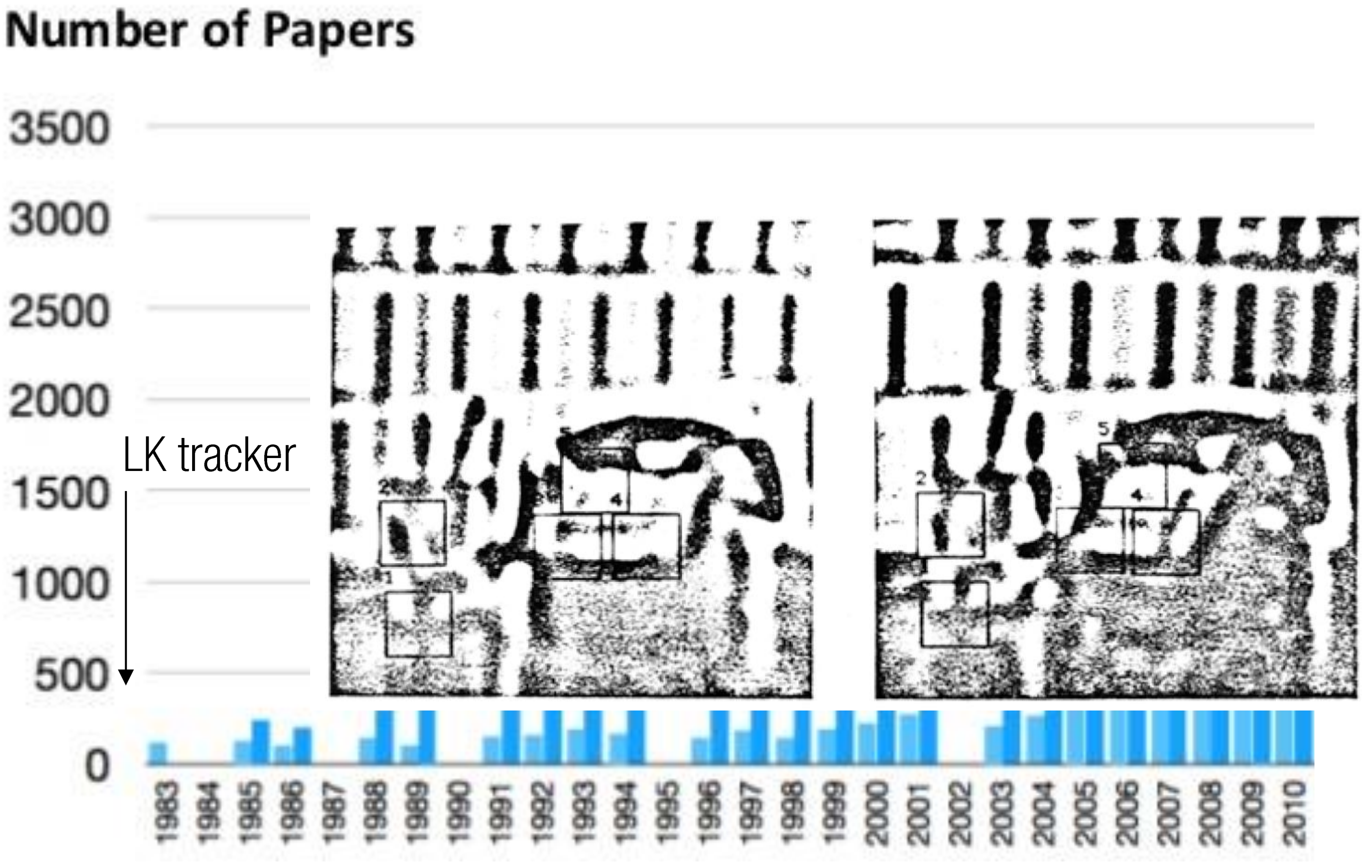
Takeo Kanade, CMU

Dana Ballard, U of Rochester

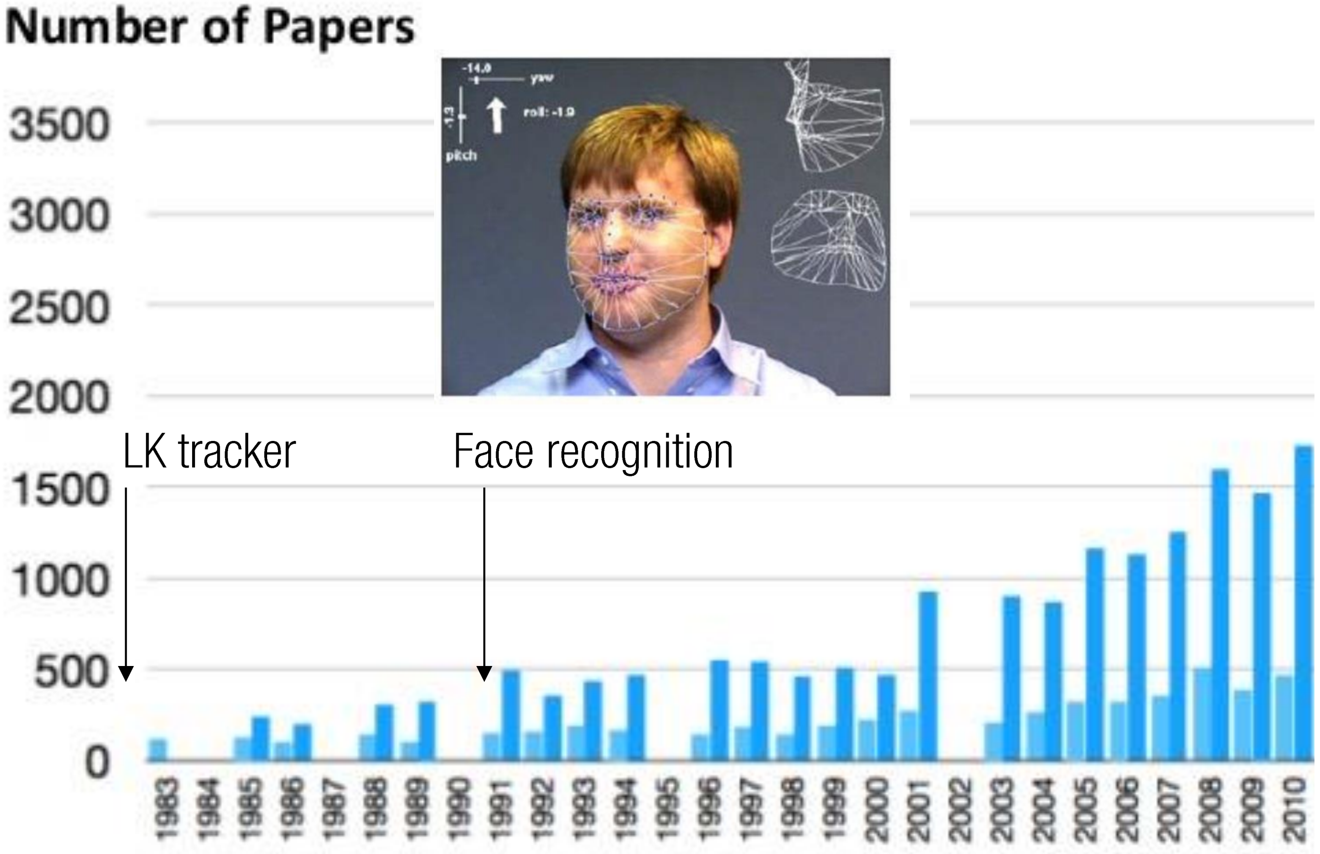
Conference on Computer Vision and Pattern Recognition



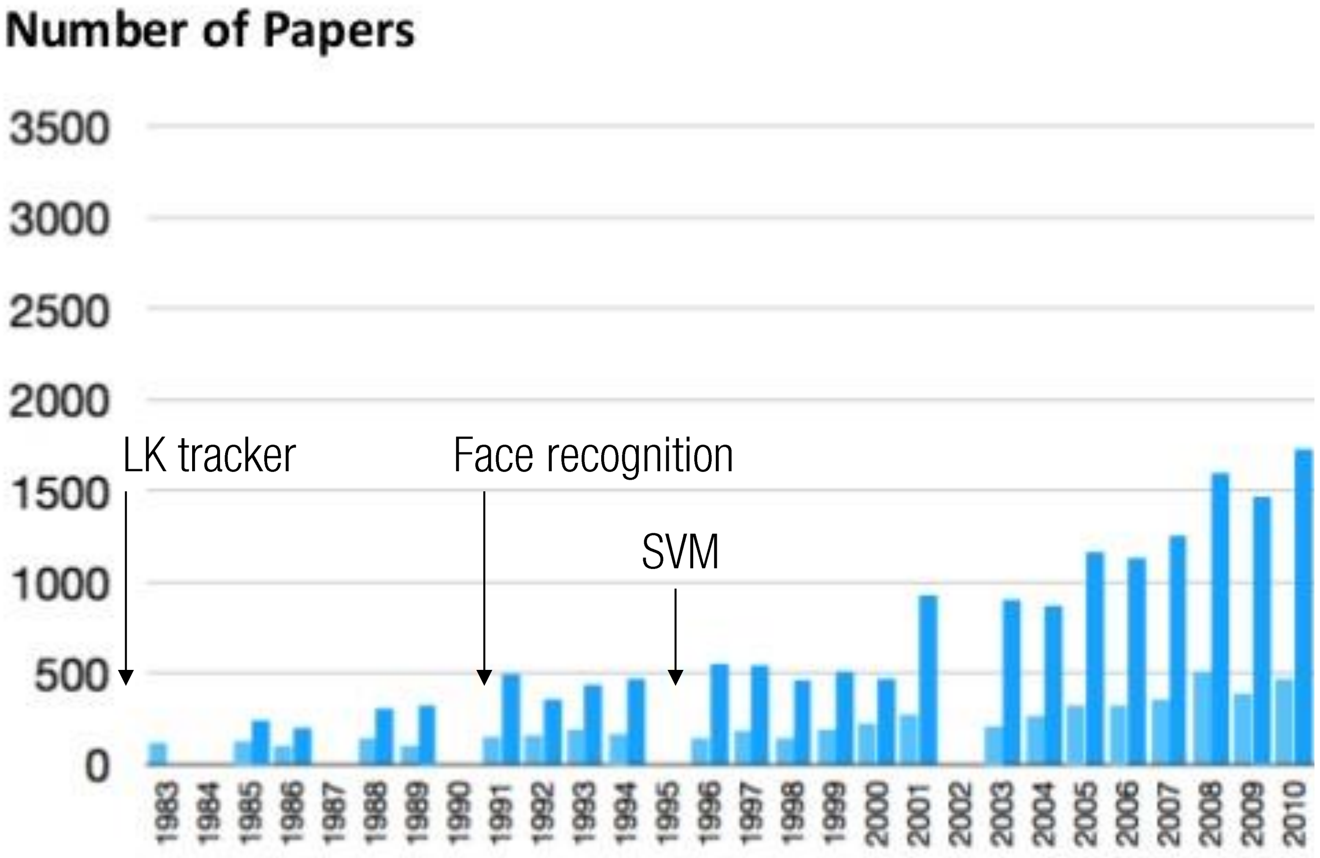
Conference on Computer Vision and Pattern Recognition



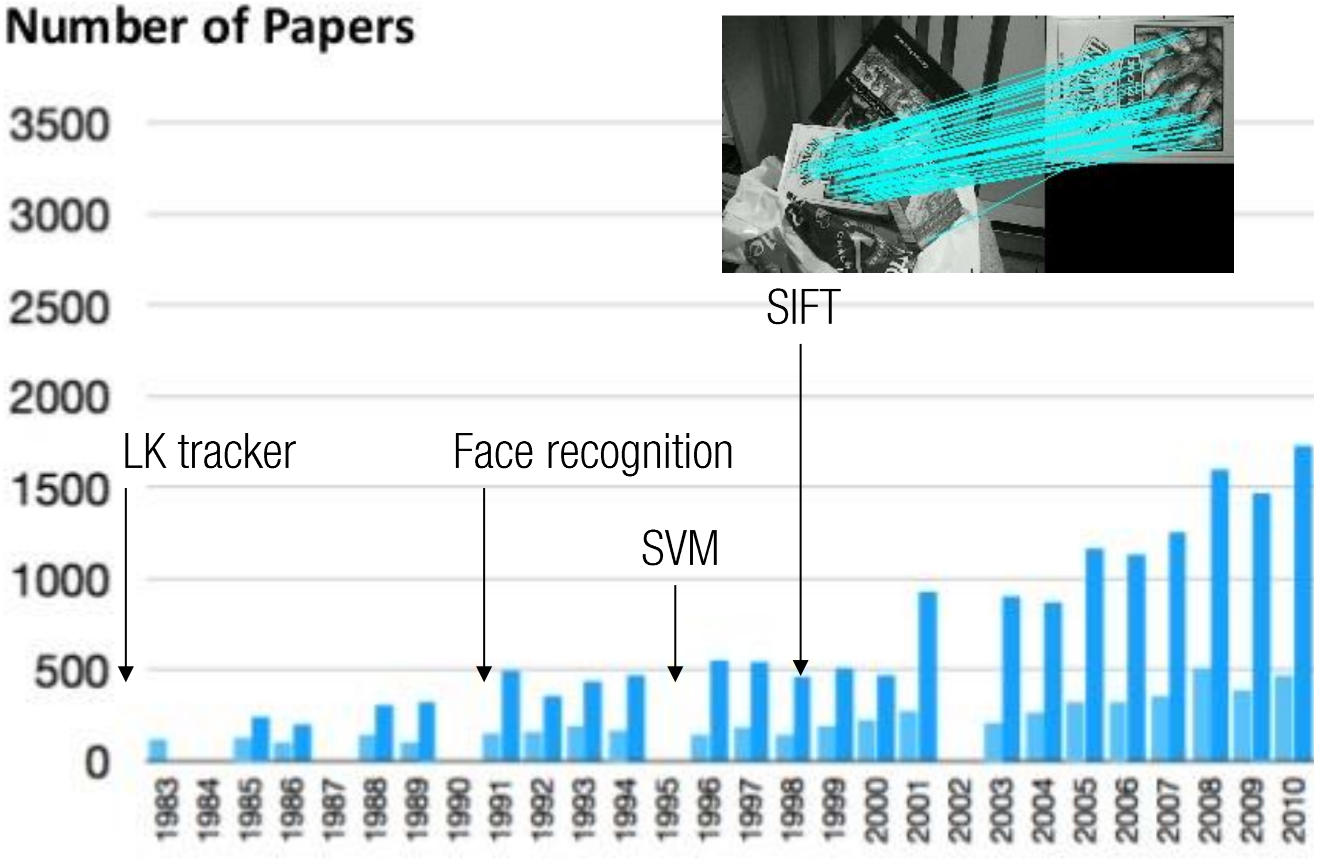
Conference on Computer Vision and Pattern Recognition



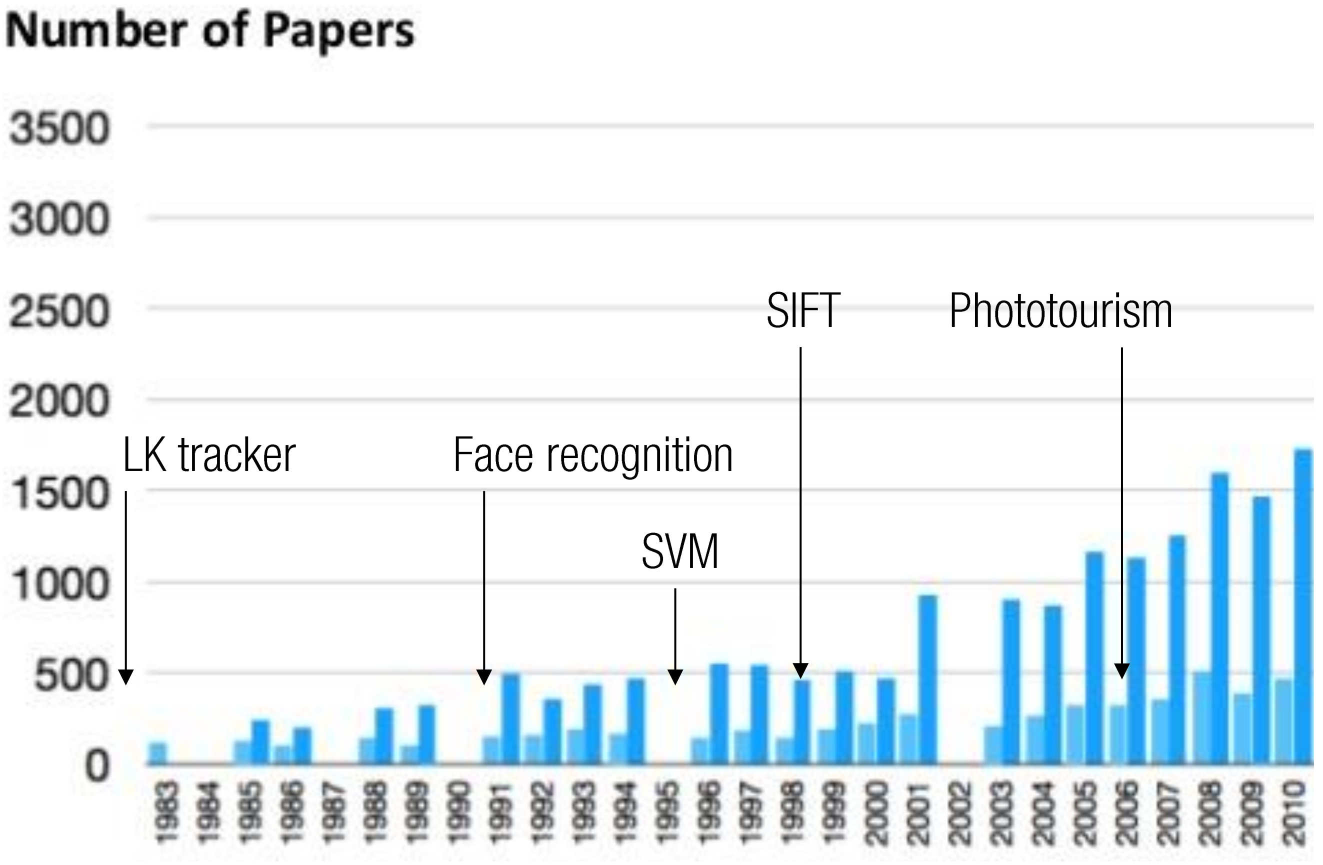
Conference on Computer Vision and Pattern Recognition



Conference on Computer Vision and Pattern Recognition



Conference on Computer Vision and Pattern Recognition



Conf

Num

350

300

250

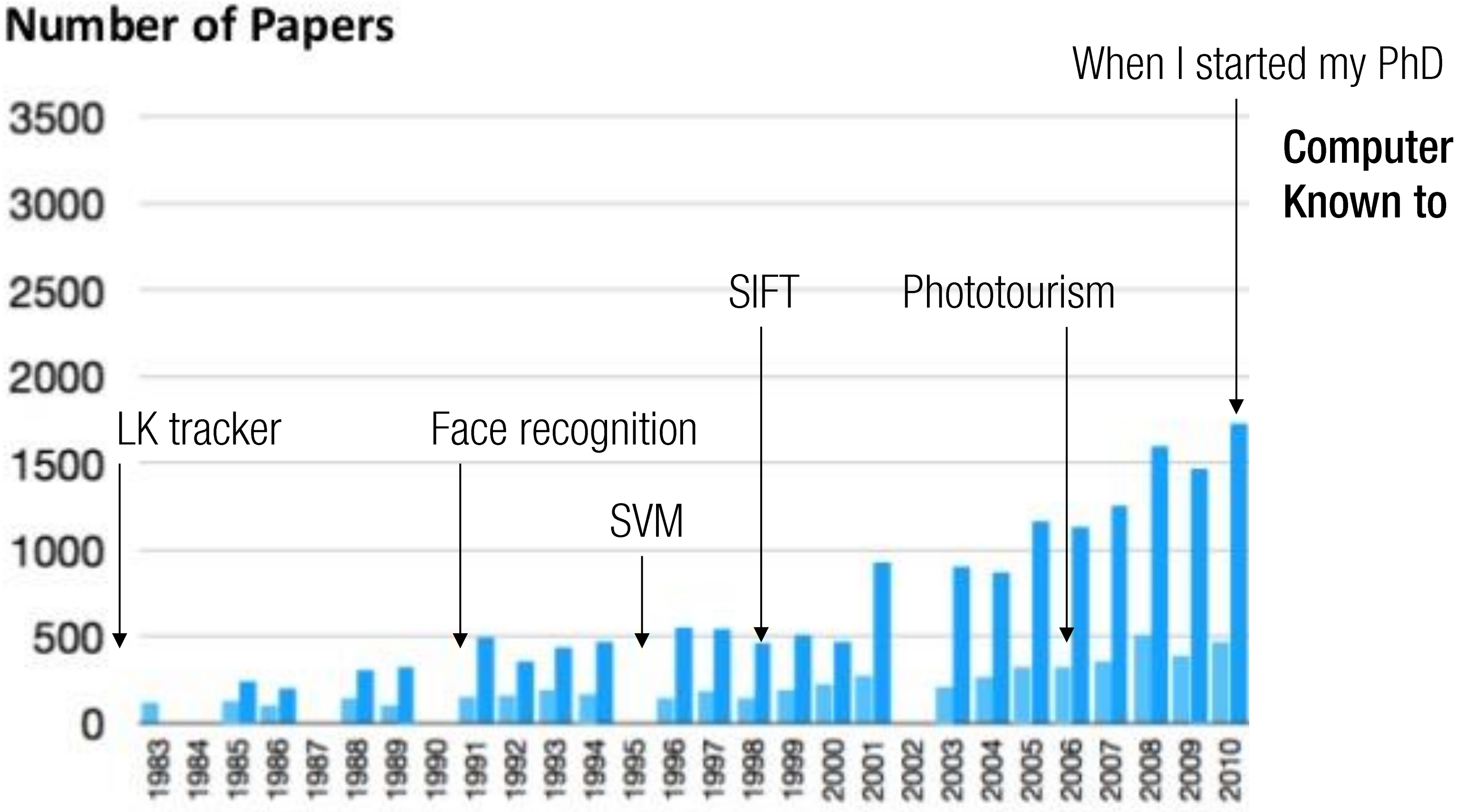
200

150

100

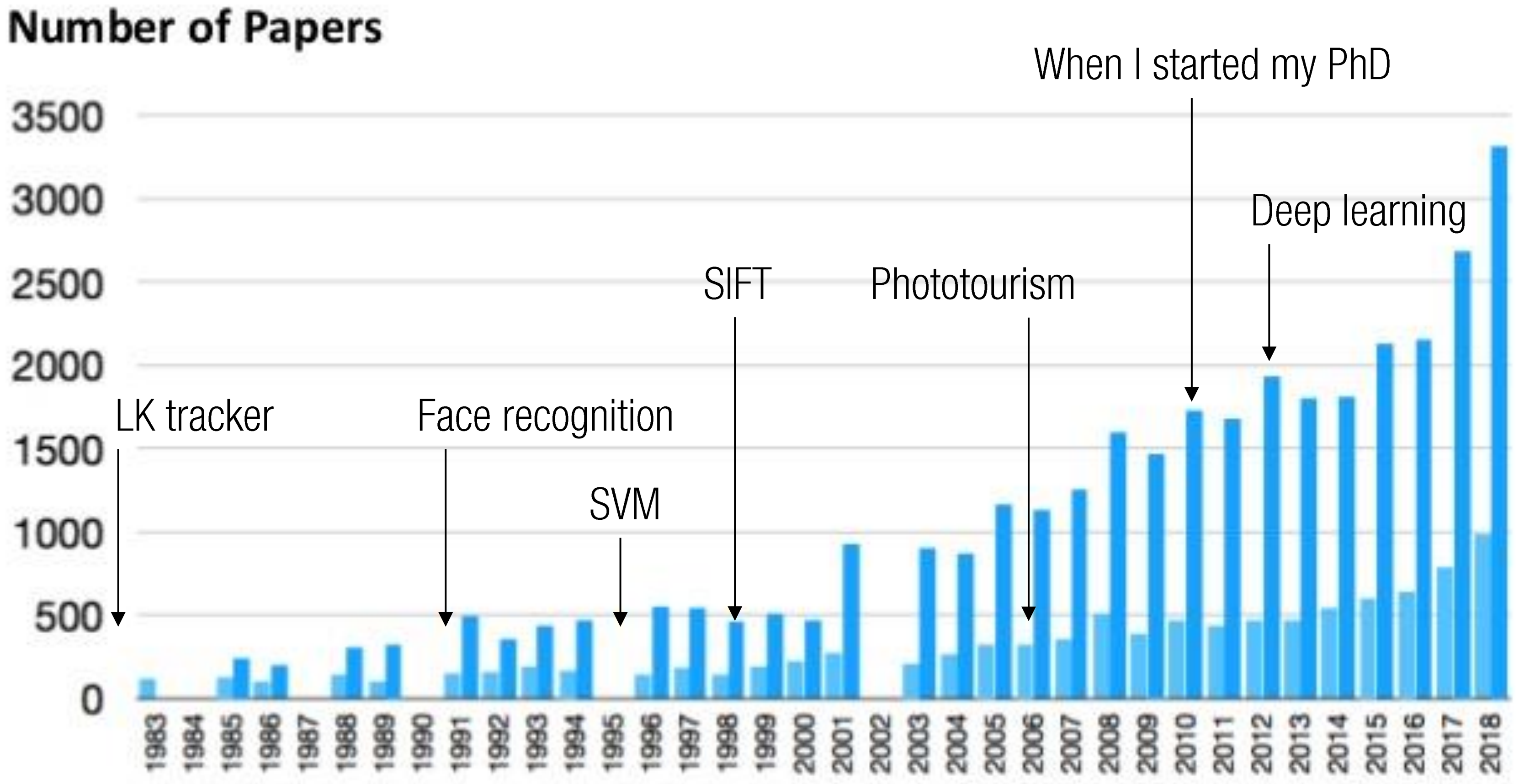
50

Conference on Computer Vision and Pattern Recognition

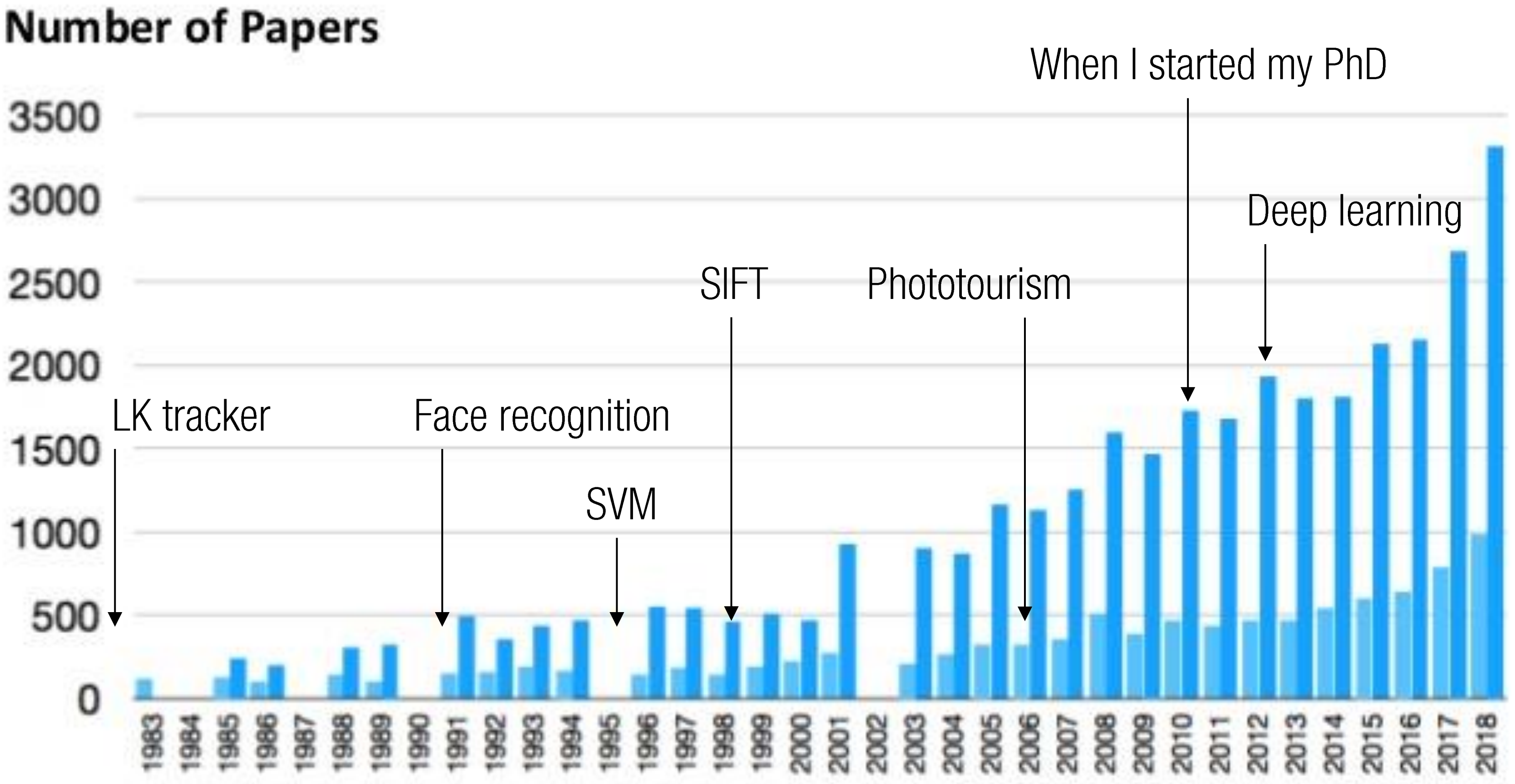


Computer vision
Known to be NOT working

Conference on Computer Vision and Pattern Recognition



Conference on Computer Vision and Pattern Recognition

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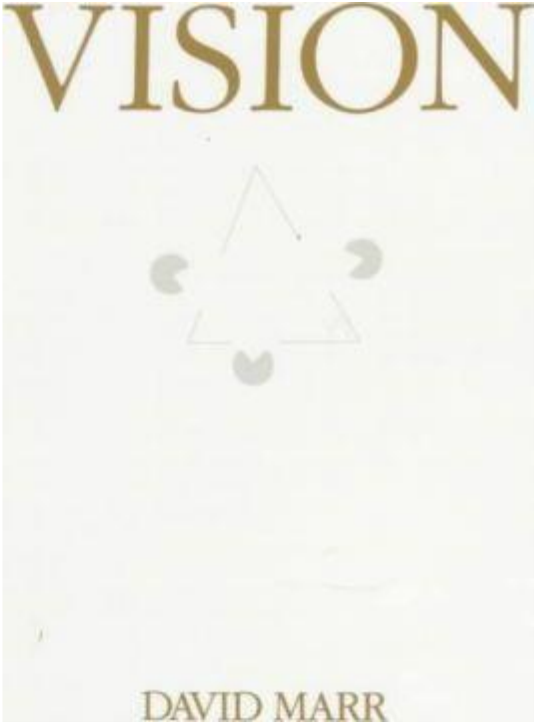
How to Make a Computer to Understand an Image?

MARR'S VISION

David Marr (1945-1980)



1982

Three Levels of Visual Perception

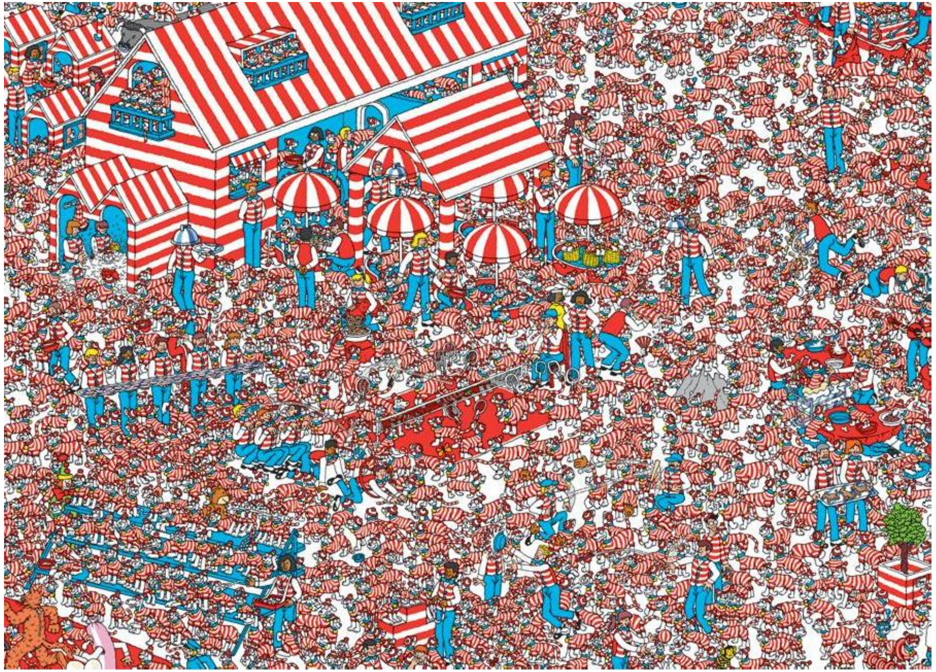
David Marr (1945-1980)

THREE LEVELS OF VISUAL PERCEPTION

David Marr (1945-1980)

1. Computational

e.g., what is the goal of the computation?



How to computationally find Waldo?

THREE LEVELS OF VISUAL PERCEPTION

David Marr (1945-1980)

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e.g., what is the goal of the computation?

How to formulate the objective:

$$\underset{p}{\text{minimize}} \sum_{\mathbf{x}} \Big(J\big(w(\mathbf{x}; p)\big) - T(\mathbf{x}) \Big)^2$$

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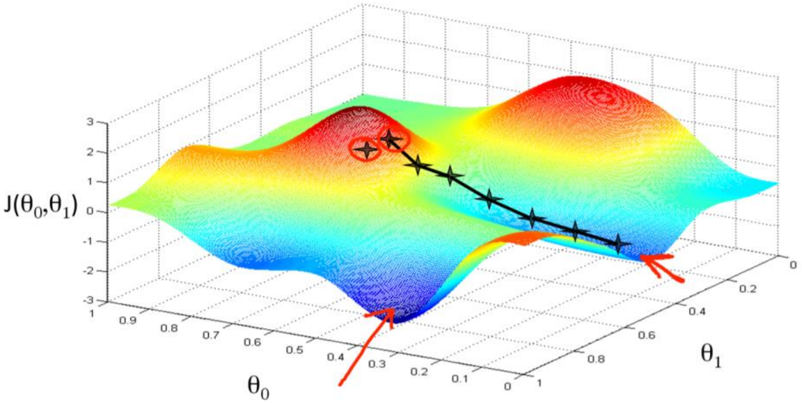
How to achieve the objective:

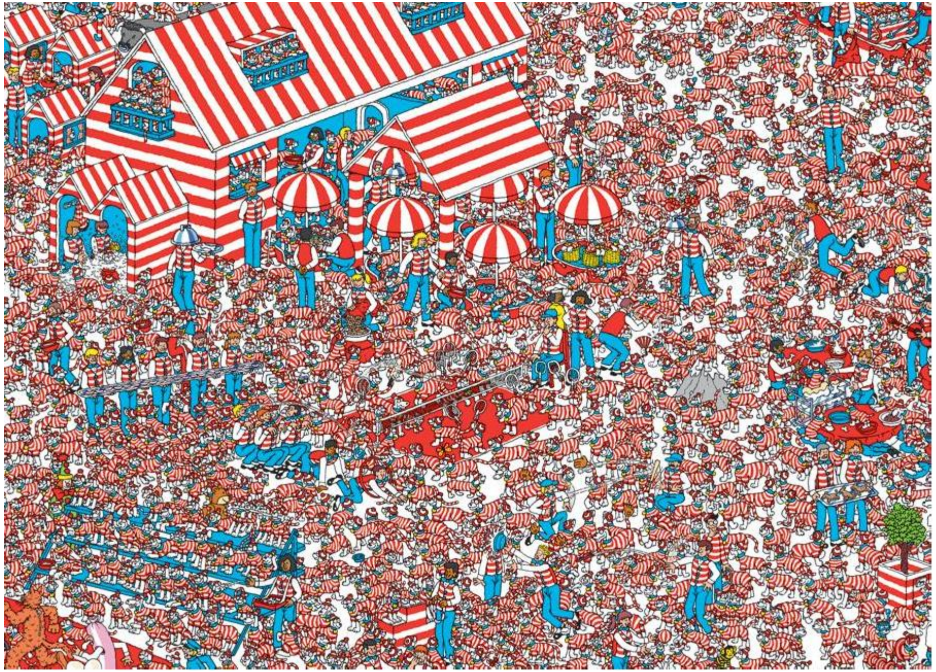


THREE LEVELS OF VISUAL PERCEPTION

David Marr (1945-1980)

2. Algorithmic

e.g., what representation can implement the computation?



How to represent the image?

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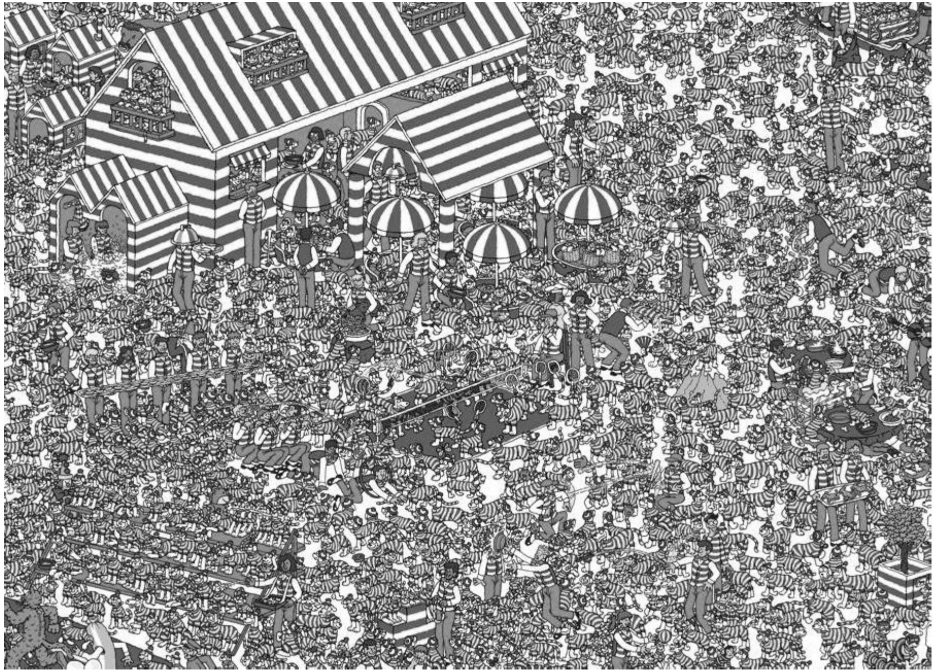

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78	99	108	106	117	117	149	205	206	169	109	118	147	150	155	217	222	233
78	98	106	104	116	115	148	205	206	169	109	118	147	150	155	217	222	233
78	103	113	111	121	120	151	207	208	170	108	117	146	149	154	217	223	233
74	145	176	170	164	158	183	226	229	178	93	103	134	136	143	224	233	239
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223	222	213	197
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114	112	125	145
222	222	226	233
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246	246	248	251
246	246	247	249
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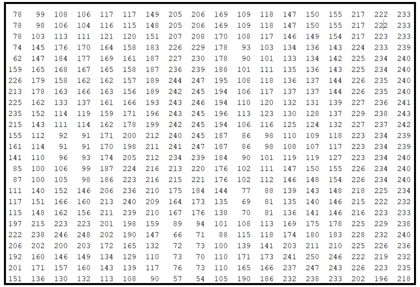

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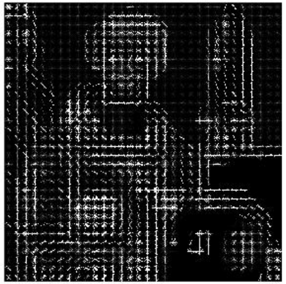
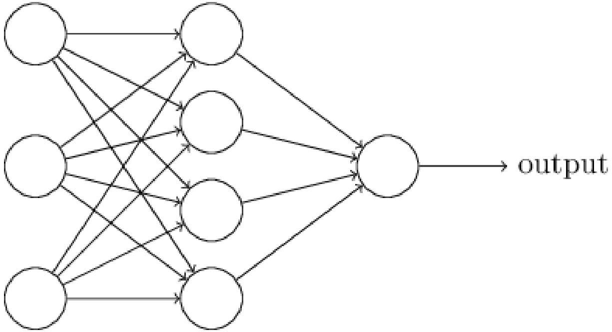


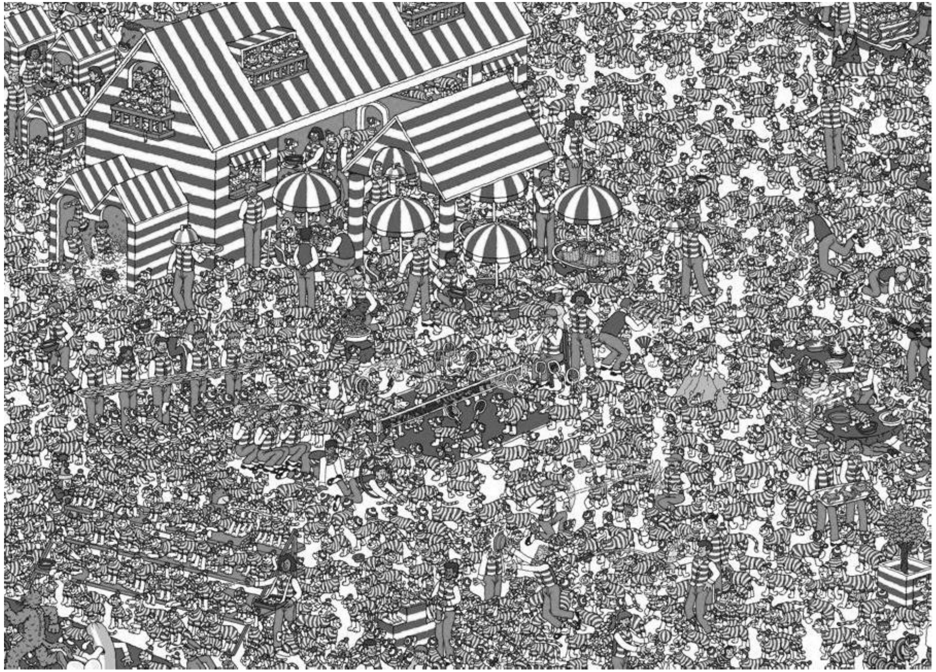


THREE LEVELS OF VISUAL PERCEPTION

David Marr (1945-1980)

3. Implementational

e.g., how hardware can carry out such computation?



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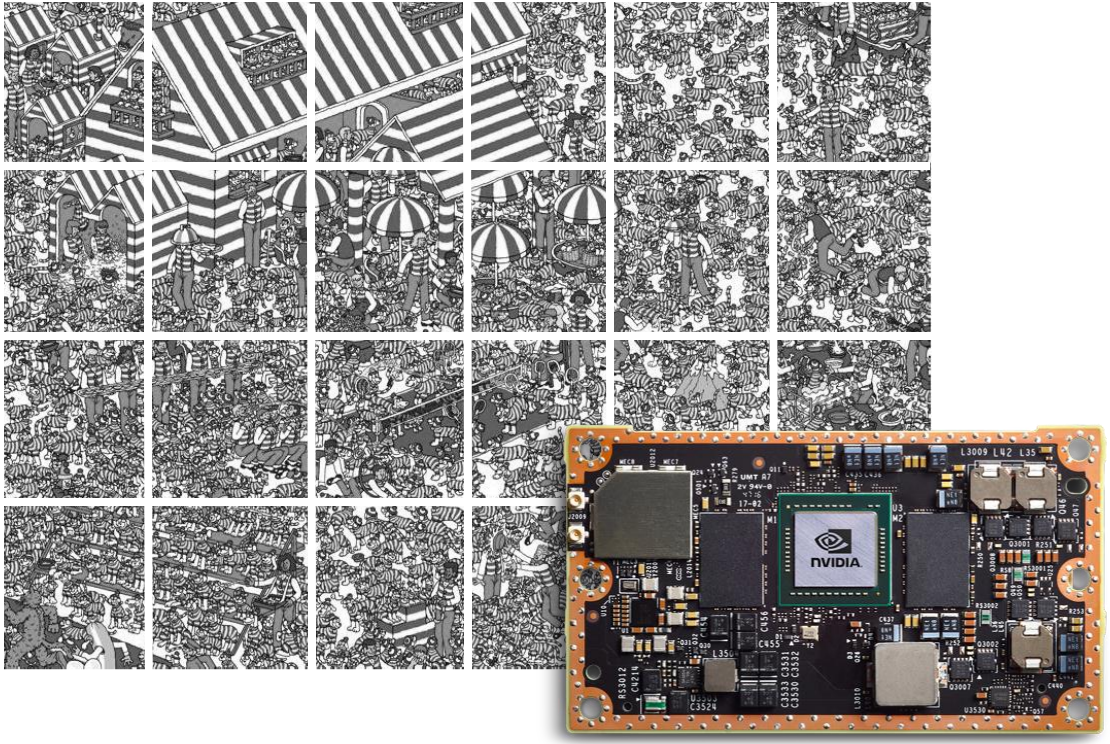

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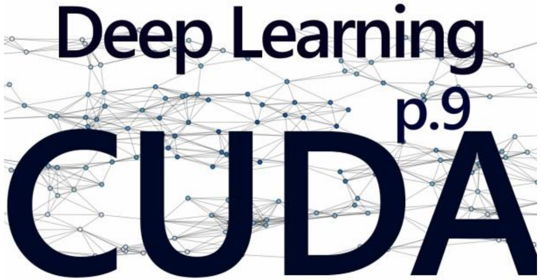

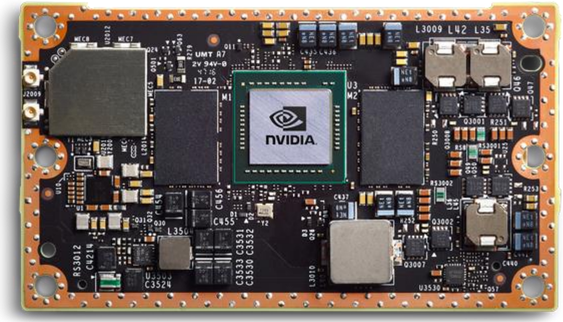

Three Levels of Visual Perception

David Marr (1945-1980)

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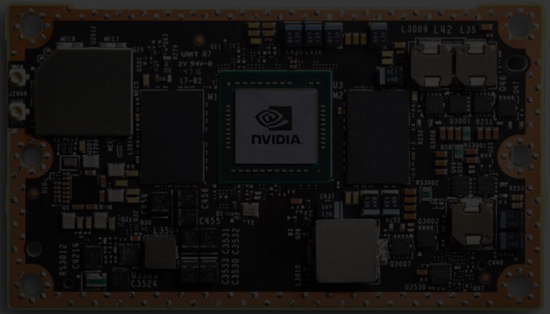
Beyond the Scope of This Course.



What Will Be Covered?

Basics and 4 Rs of Computer Vision

BASICS

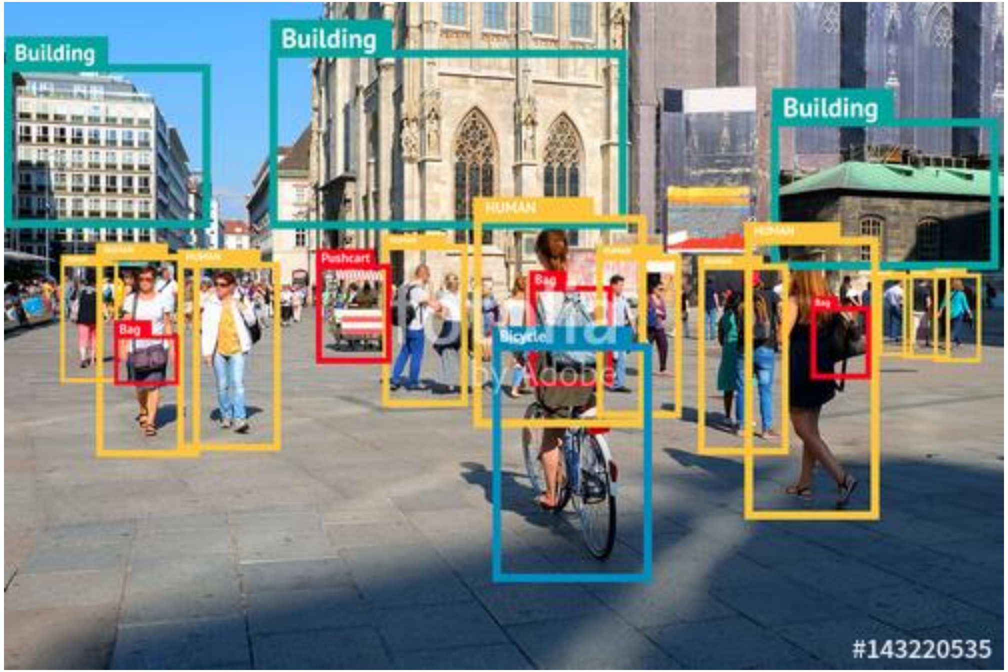
Image formation
Image convolution/filtering
Feature representation

4 Rs: Registration

Optical flow
Image alignment
Tracking

4 Rs: Recognition

Bag of feature
Template matching
Object proposal
Convolutional neural network



4 Rs: Reorganization

Graph cuts
Superpixel
Semantic segmentation

4 Rs: Reconstruction

- Camera geometry
- Epipolar geometry
- Stereo

What Will Not Be Covered?

What Will Not Be Covered?

- Basic Machine Learning knowledge
- MATLAB / Python programming
- Linear algebra / Calculus

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- Basic Machine Learning knowledge
- MATLAB / Python programming
- Linear algebra / Calculus

Tips:

1. Drop this course if you are not fluent on these materials---you will be embrassed if you ask these even during office hours.
2. Drop this course if you are not confident on mathematical programming, e.g., translating math concept to code.
3. Drop this course if you are not confortable on debugging and the usage of debugging tools.
4. Study by yourself and read relevant materials (e.g., book, wikipedia, coursera).

EVALUATION

- 5 programming assignments (15% each)
  - Late submission: 20% off from each extra late day
- 1 final written exam (10%): Dec 10th in-class
- Project (two students) (15%)
  - Written project proposal 5% (3 pages): Nov 1 midnight
  - Poster presentation 5%: Dec 12th in-class
  - Written final report 5% (6 pages): Dec 18th midnight

No make-up assignment and exam

Office Hour

- Hyun Soo Park: MW 2-3pm @ Shepherd 261
- Zhixuan Yu: TTh 1-2pm @ Shpherd 234

COURSE WEBSITE

https://www-users.cs.umn.edu/~hspark/csci5561_F2019/csci5561.html

Fall 2019 CSCI 5561
Computer Vision

Tue/Thr 4:00pm-05:15pm @ Keller Hall 3-125

Information

Syllabus

Instructor: Hyun Soo Park (hspark at umn.edu)
Office hour: Mon/Wed 2:00pm-3:00pm (Shepherd Laboratory 261)

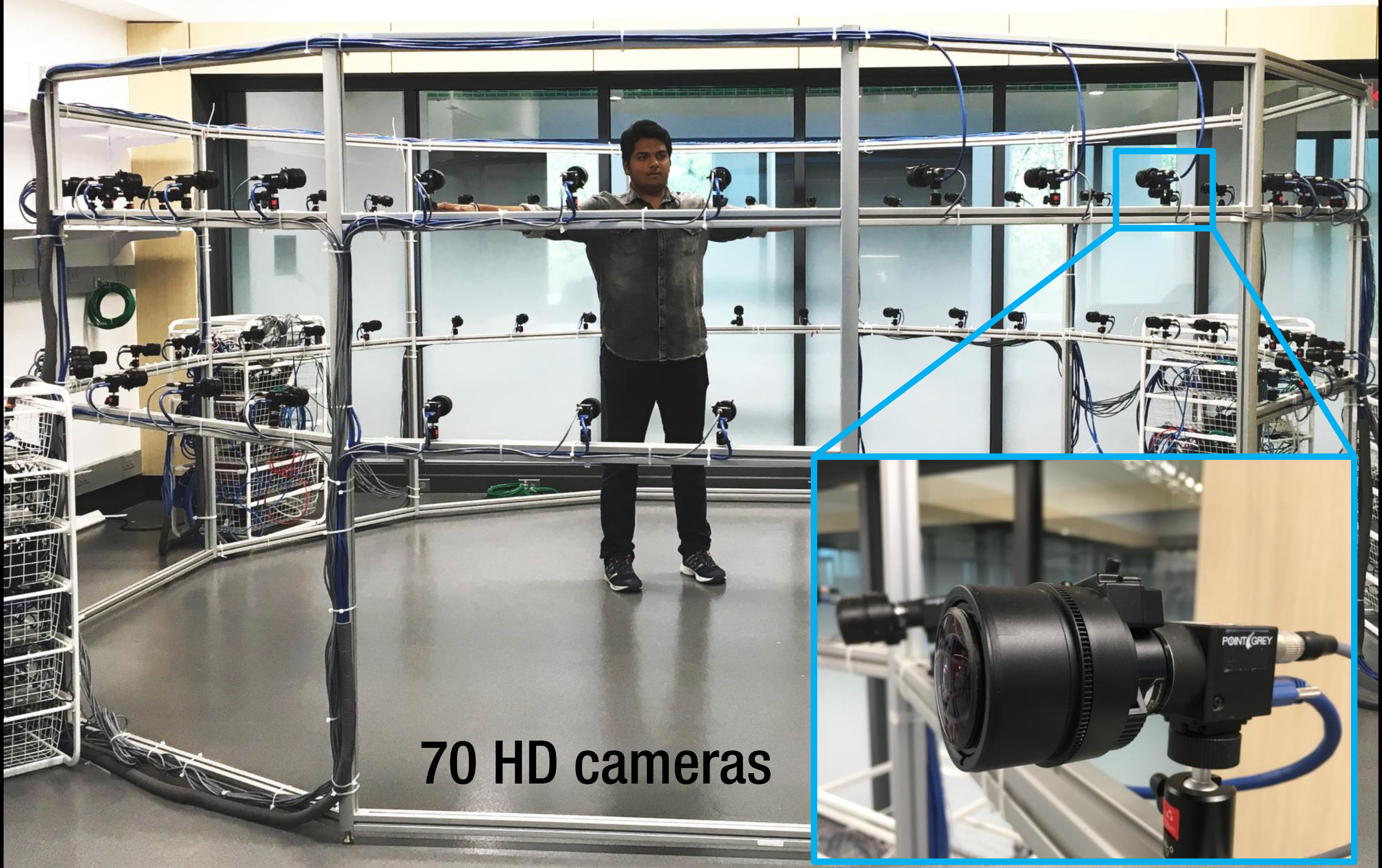
TA: Zhixuan Yu (yu000064 at umn.edu)
Office hour: Tue/Thr 1:00pm-2:00pm (Shepherd Laboratory 234)

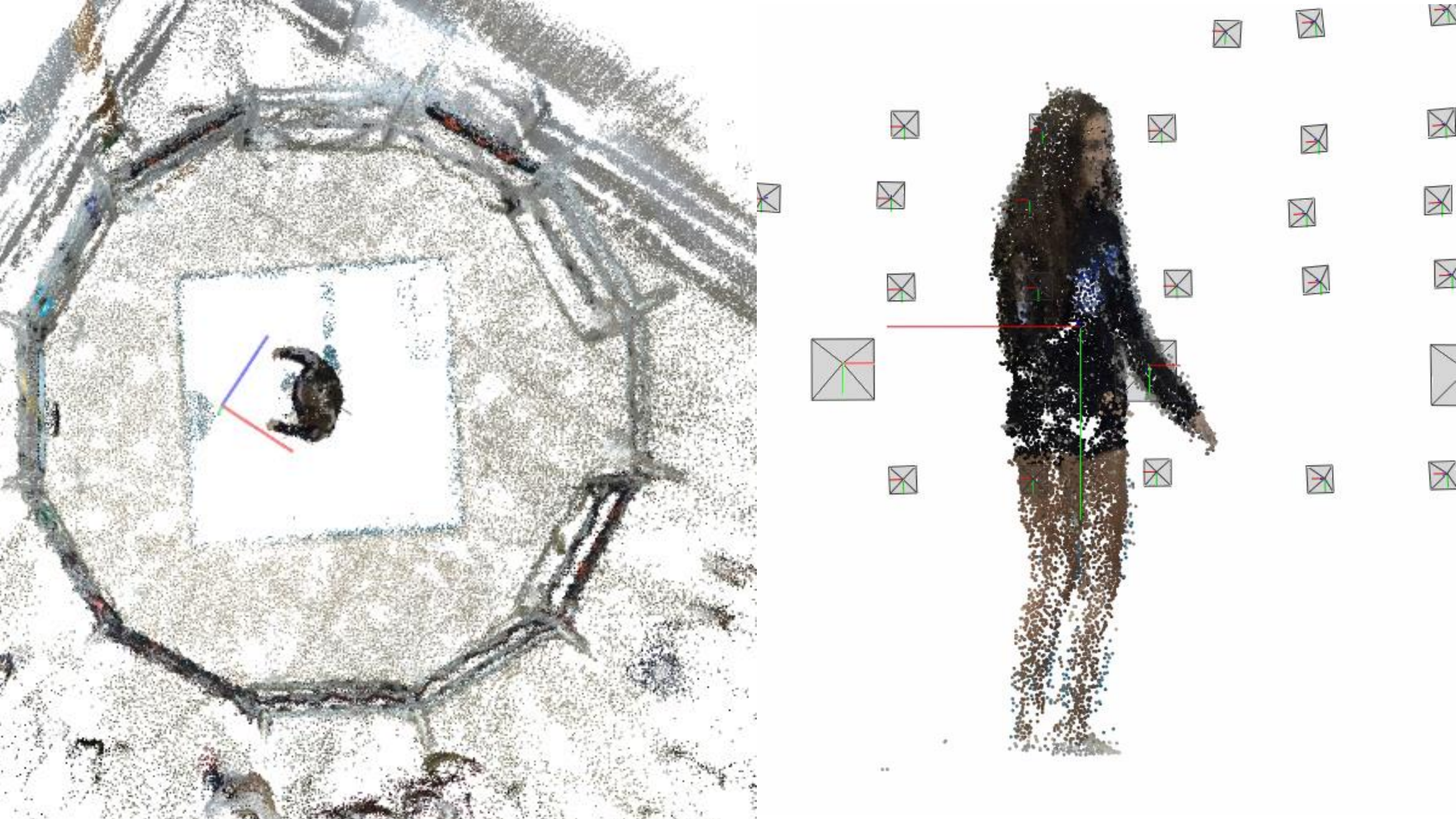
Textbook: Not required but the following books will be frequently referred:
+ "Computer Vision: Algorithms and Applications", Richard Szeliski
+ "Computer Vision: A Modern Approach", David A. Forsyth and Jean Ponce

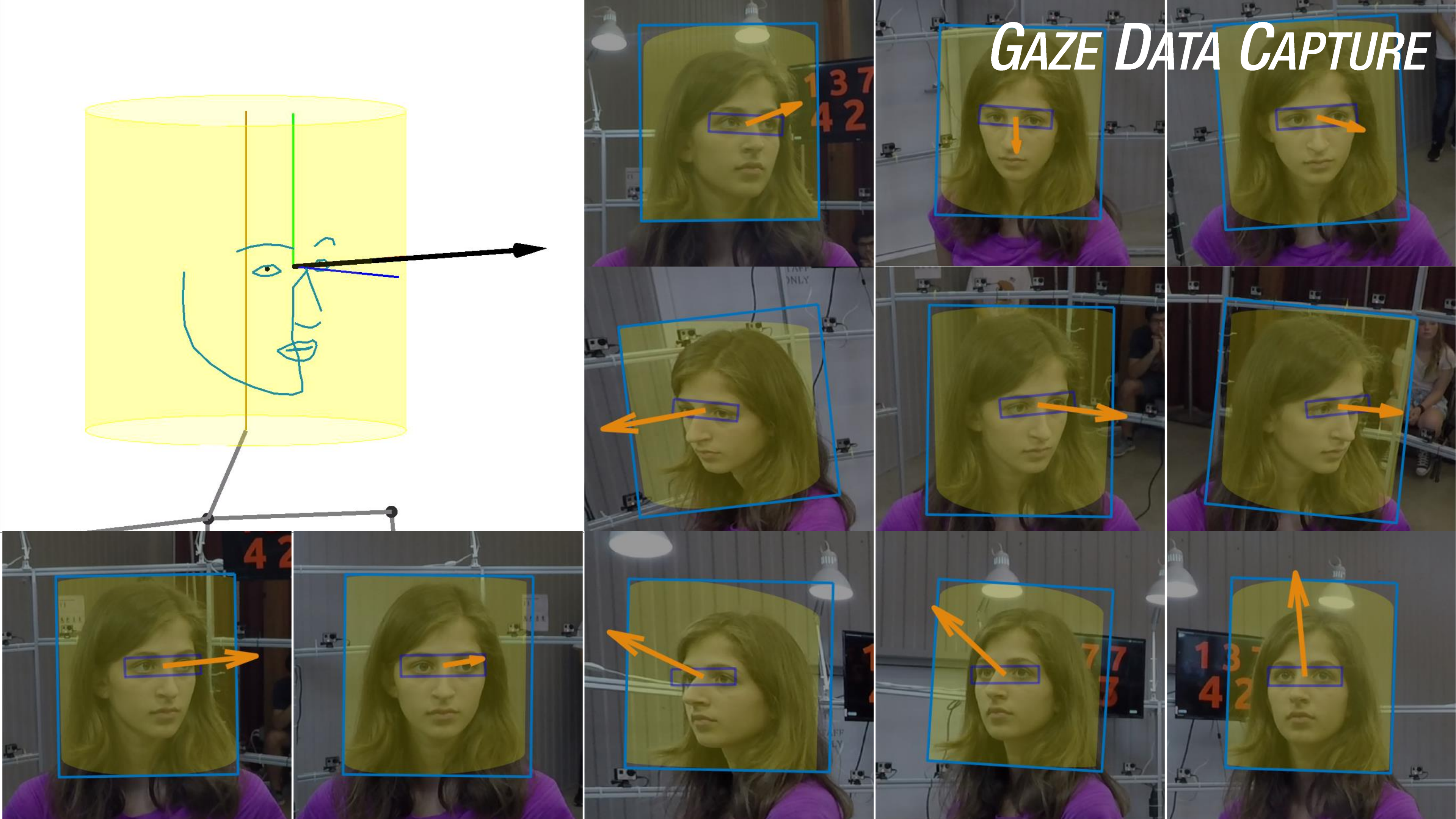
The course materials are inspired by the slides of Jianbo Shi (UPenn), Kris Kitani (CMU), James Hays (GATECH), Kristen Grauman (UT Austin), Steve Seitz (UW), and Robert Collins (PSU).

- Syllabus
- Schedule
- Lecture slide

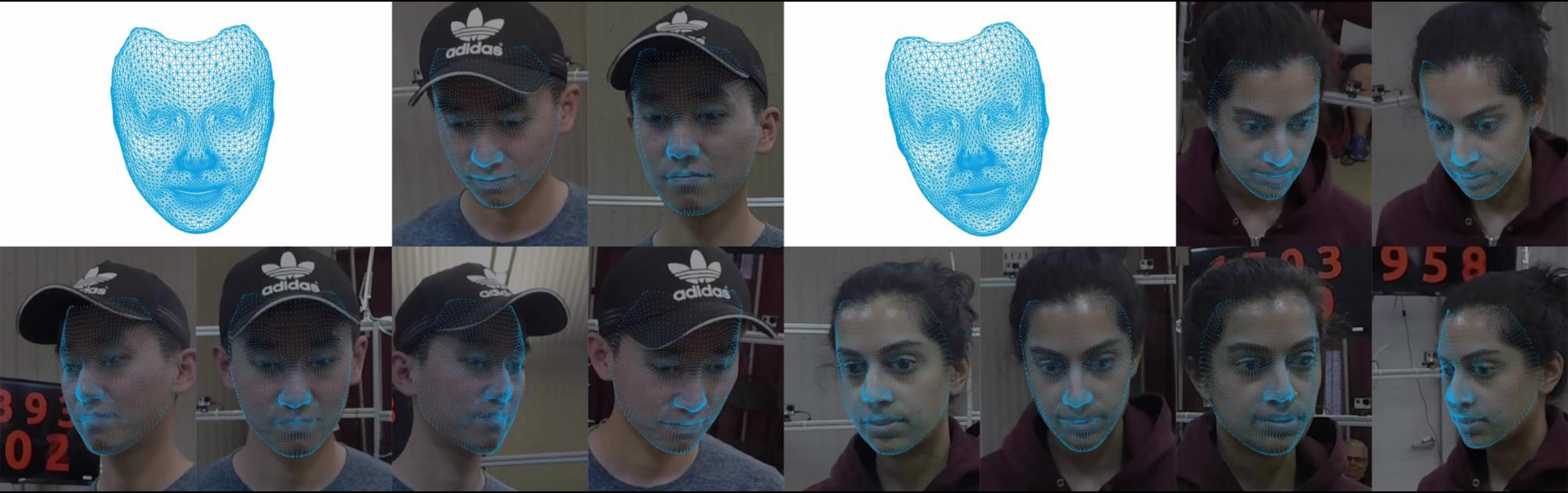
Who am I?


70 HD cameras
POINT GREY



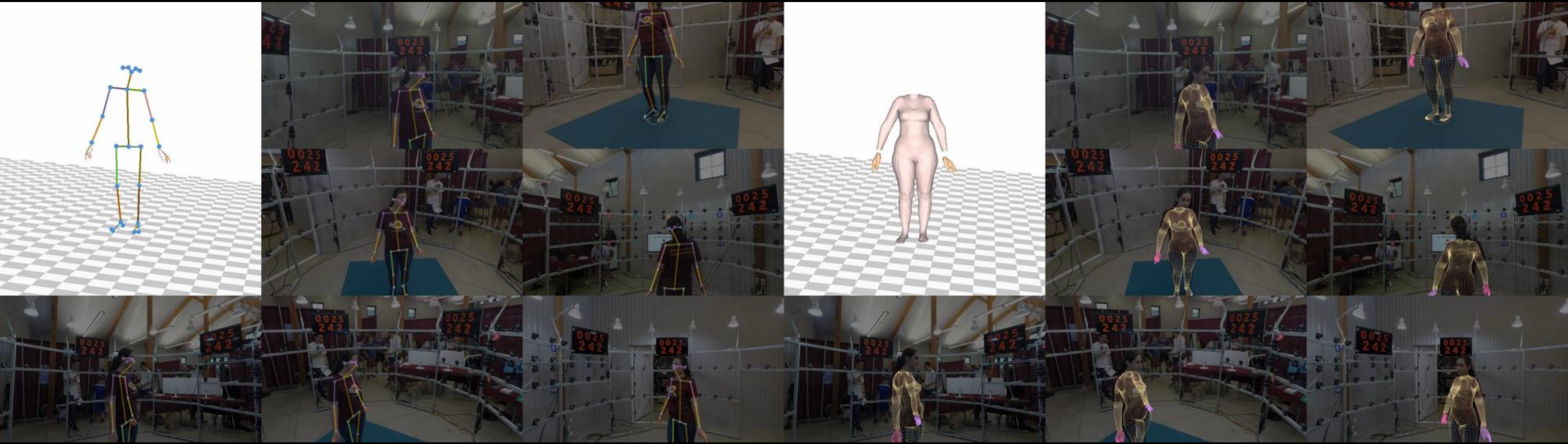

GAZE DATA CAPTURE

Face Data Capture



Body Data Capture

Body Data Capture

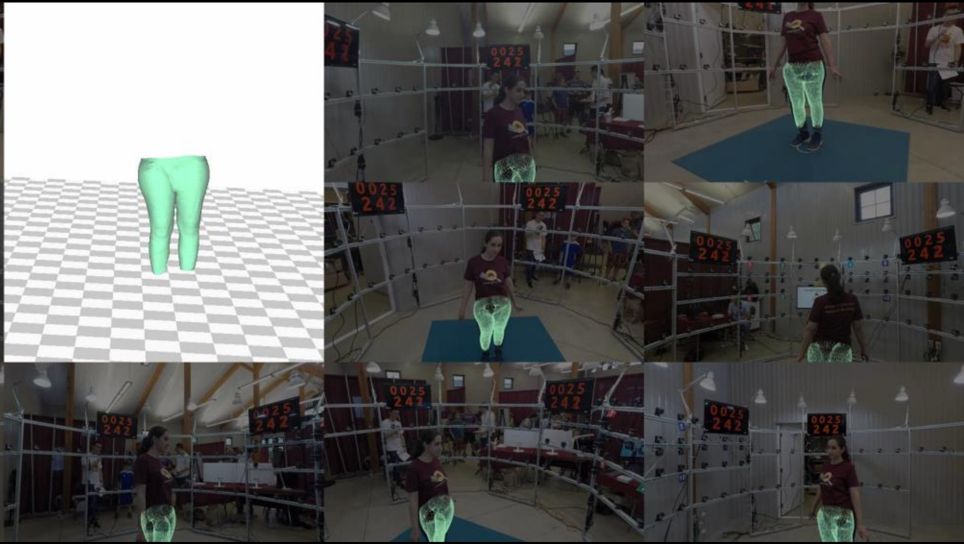


Skeleton

Body skin

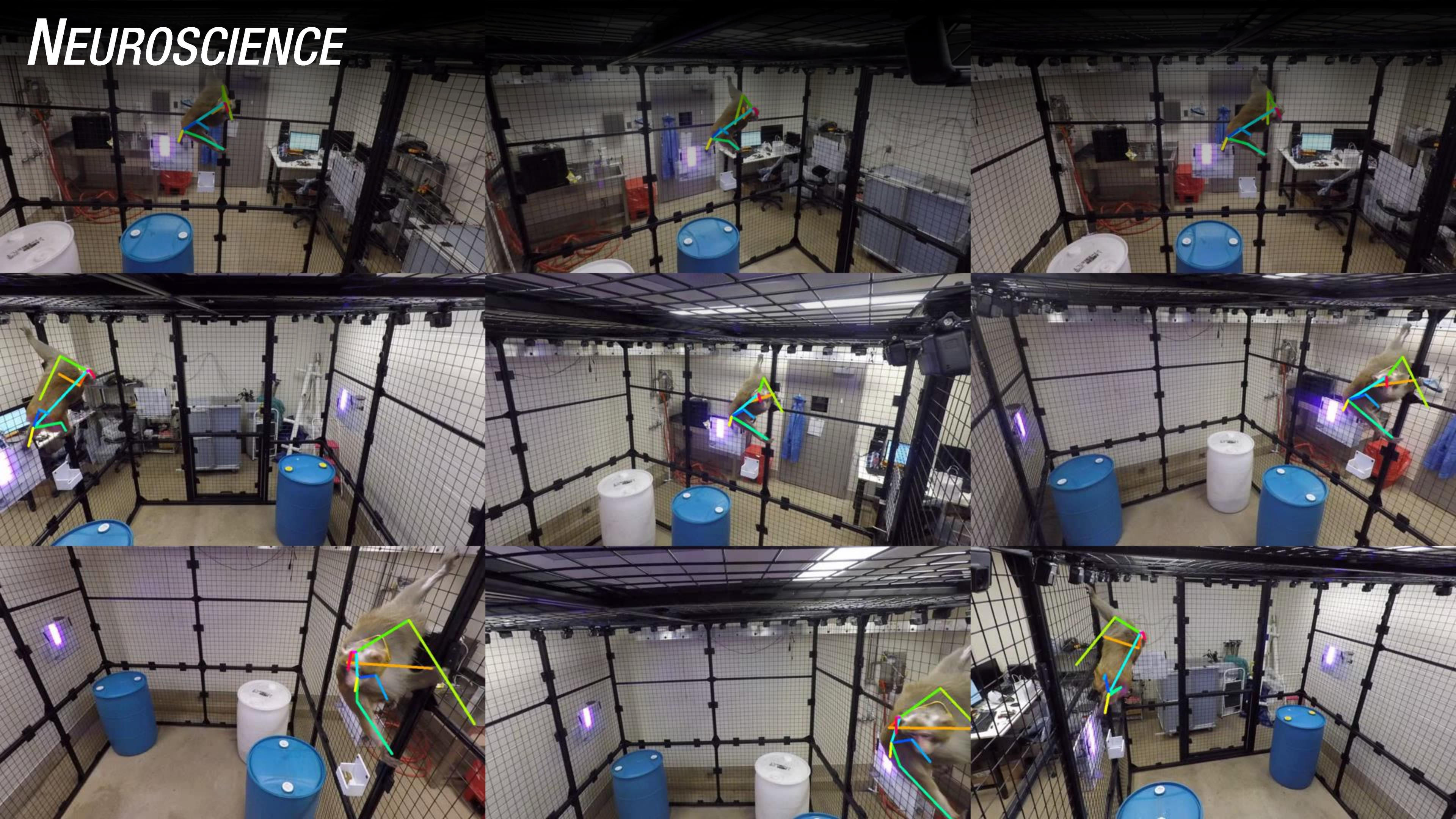
Cloth Data Capture

Top

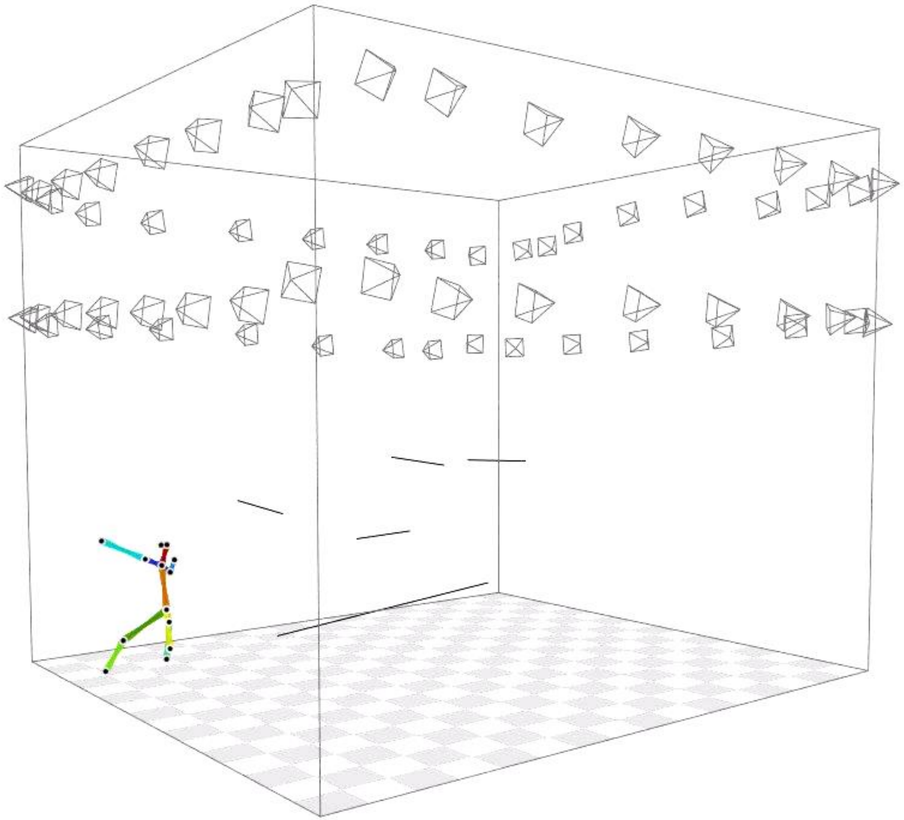


Pants

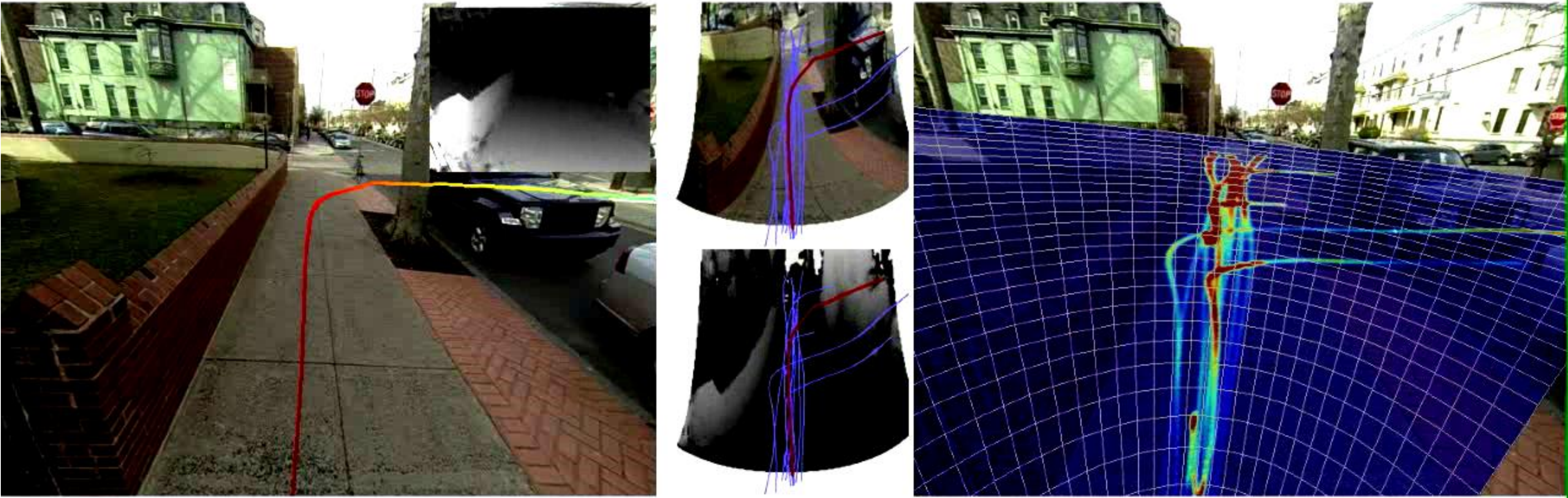
NEUROSCIENCE



NEUROSCIENCE



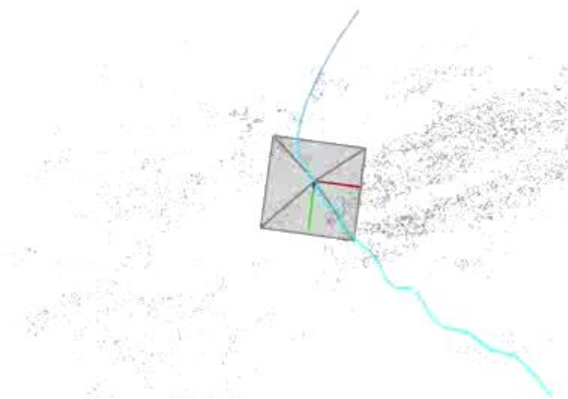
3D reconstruction of monkey movement



Ground truth EgoRetinal map Predicted trajectories

SENSORIMOTOR SKILL LEARNING

https://www.youtube.com/watch?v=aVJ45wIUE88



3D reconstruction