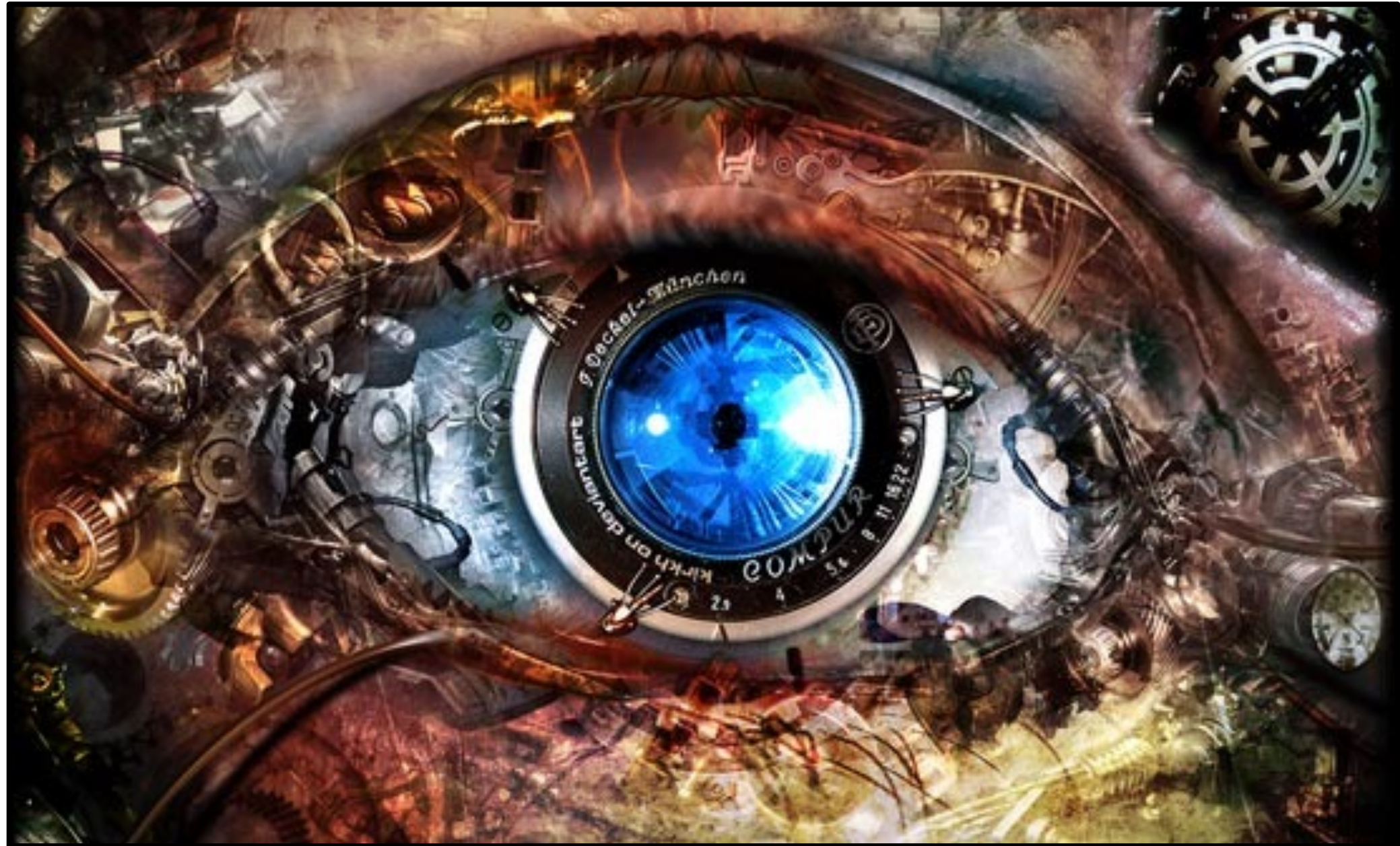


# Introduction



16-385 Computer Vision  
Fall 2022, Lecture 1

# Overview of today's lecture

- Teaching staff introductions
- What is computer vision?
- Course fast-forward and logistics

# Teaching staff introductions



# Hi!



**Matthew O'Toole**  
**(Instructor)**



**Benjamin Attal**



**Emily Kim**

What is  
computer vision?





Photo by Svetlana Lazebnik

**What a person sees**









Photo by Svetlana Lazebnik

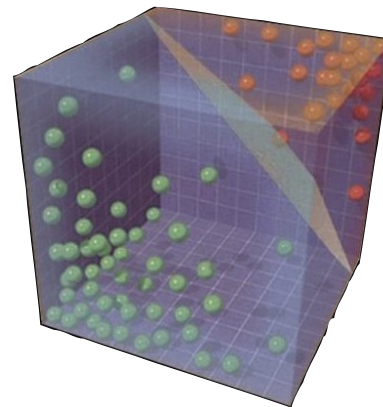
**Why are we able to interpret this image?**



The goal of computer vision is  
to give computers  
**(super) human-level perception**

# typical perception pipeline

**representation**



'fancy math'



**output**

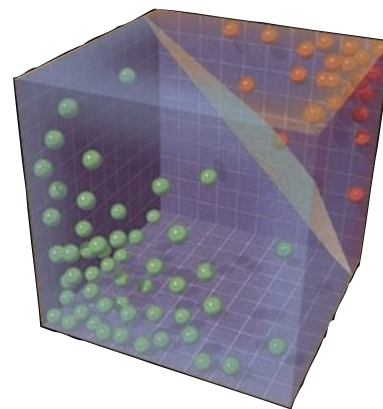


# typical perception pipeline

**representation**



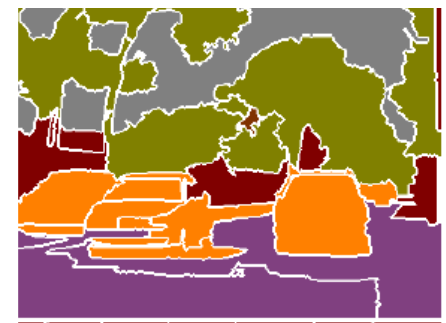
what should we look at?  
(image features)



'fancy math'



**output**



what can we understand?  
(semantic segmentation)

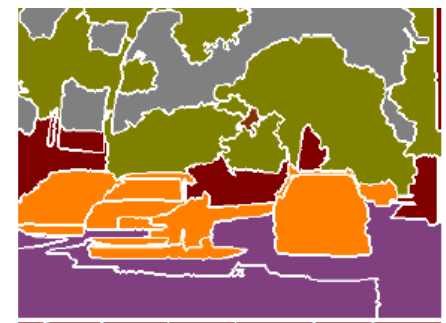
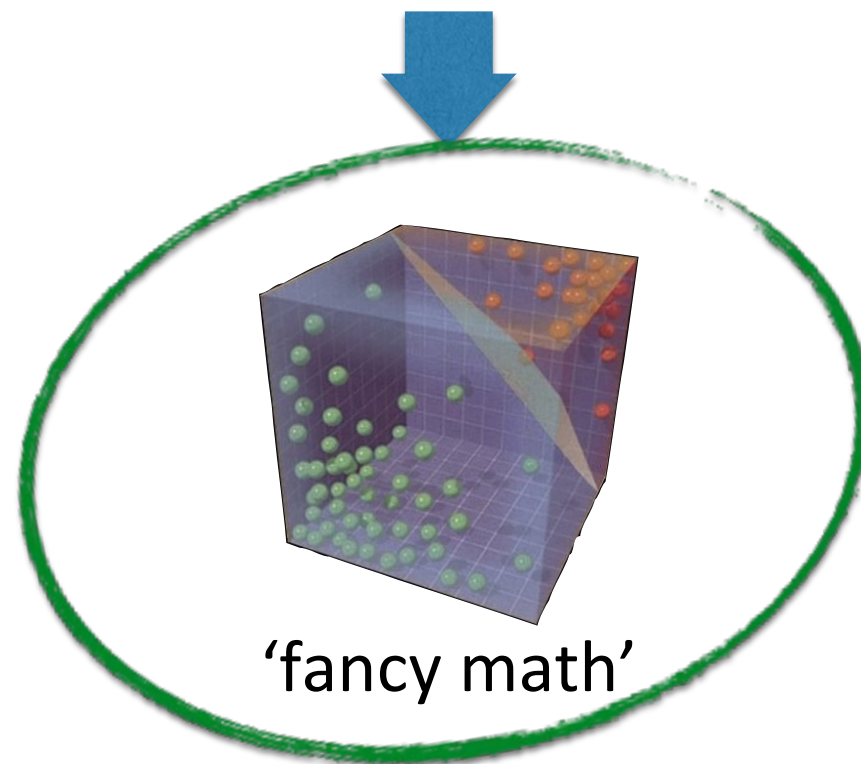
# typical perception pipeline

**representation**



what should we look at?  
(image features)

easy to get lost in  
the techniques

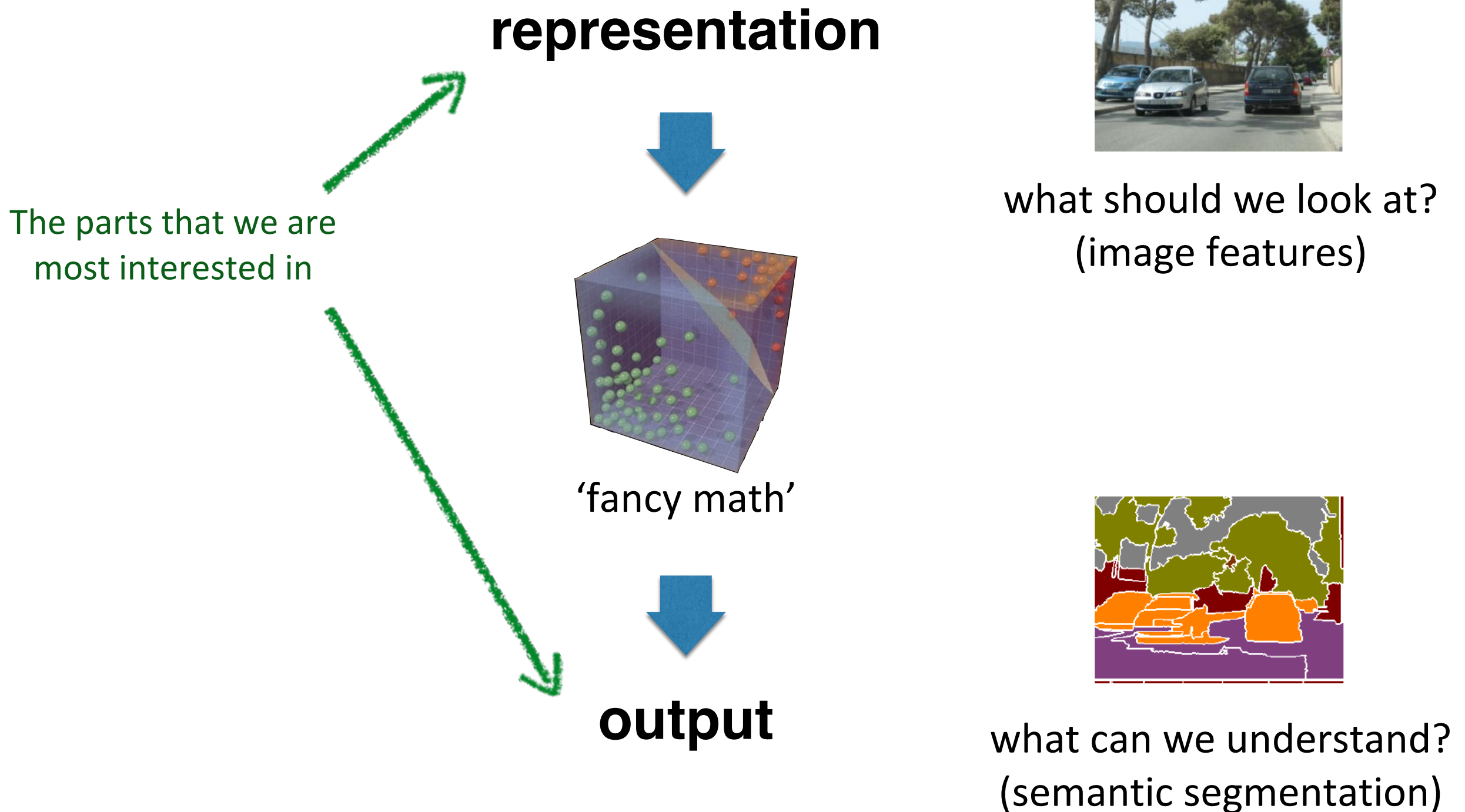


what can we understand?  
(semantic segmentation)

**output**



# typical perception pipeline



Important note:

**In general, computer vision does not work**



Important note:

**In general, computer vision does not work**  
(except in certain situations/conditions)

# Applications of computer vision



# Machine Vision



Automated visual inspection

# Object Recognition



Toshiba Tech IS-910T

2013



DataLogic LaneHawk LH4000

2012



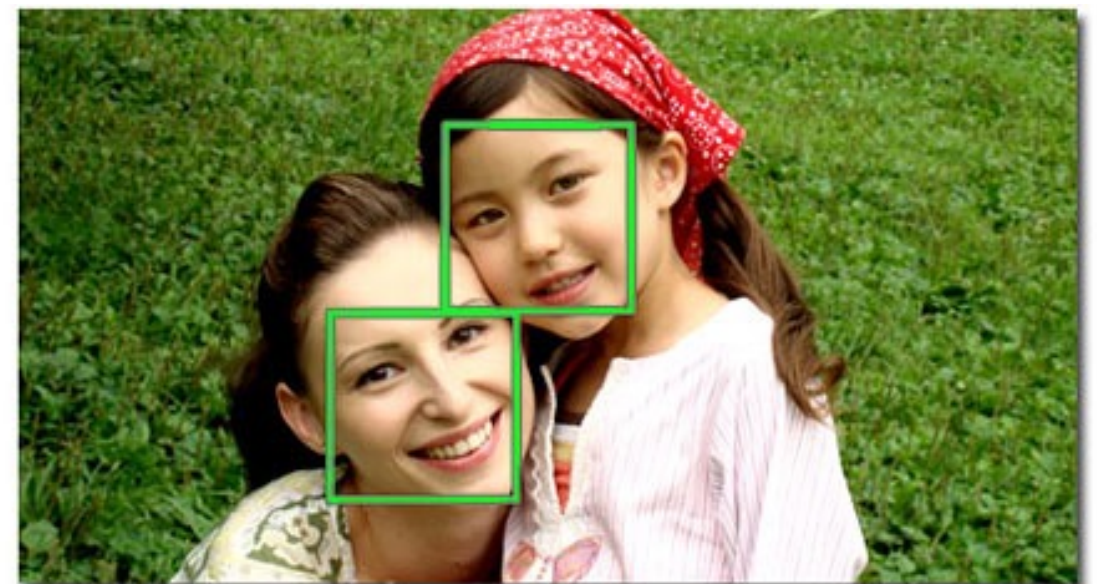
# Face detection



Sony Cyber-shot



Age recognition



Smile recognition



# Face ID



# Face ID





# Identifying plants



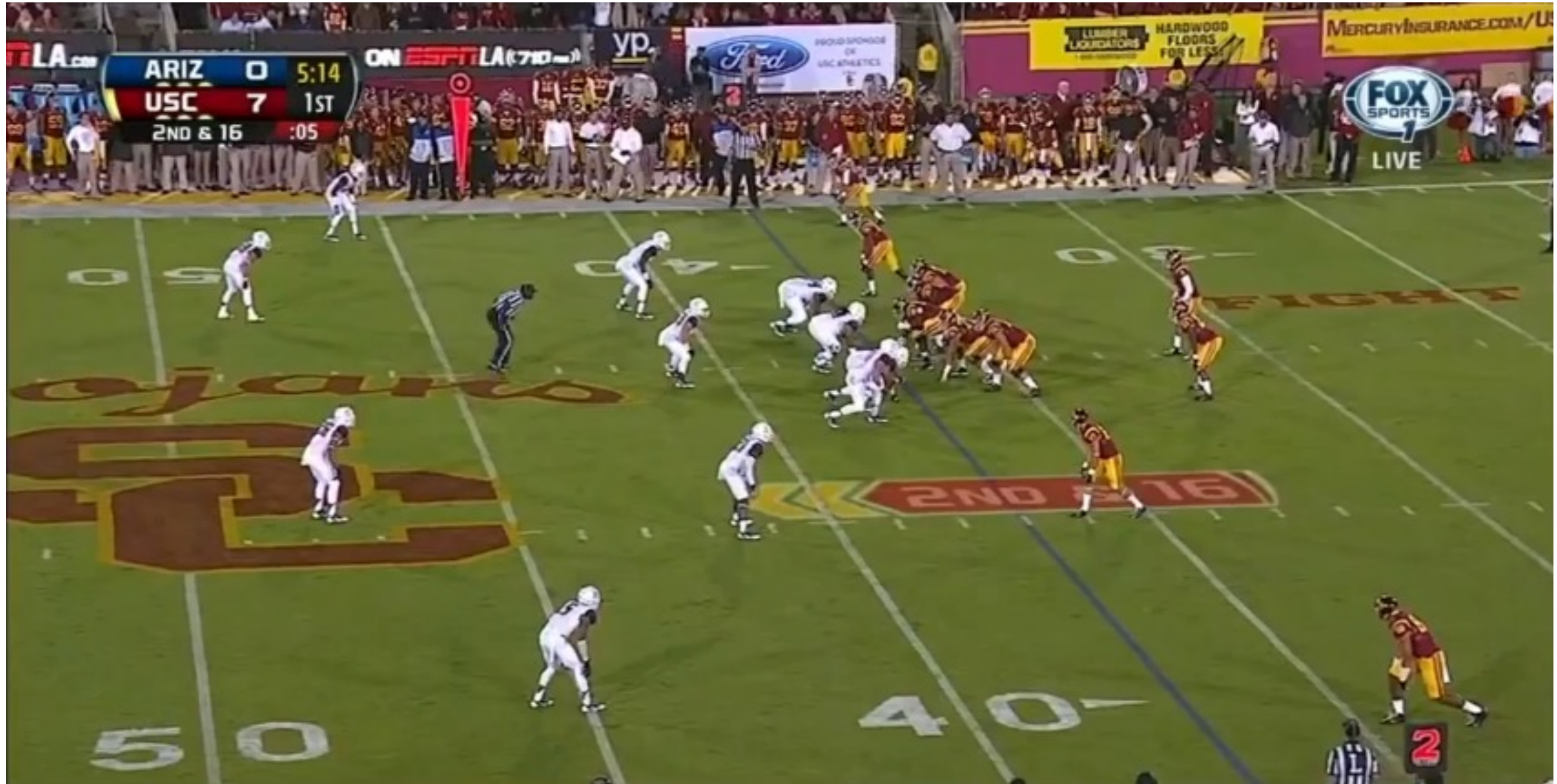


# Google translate





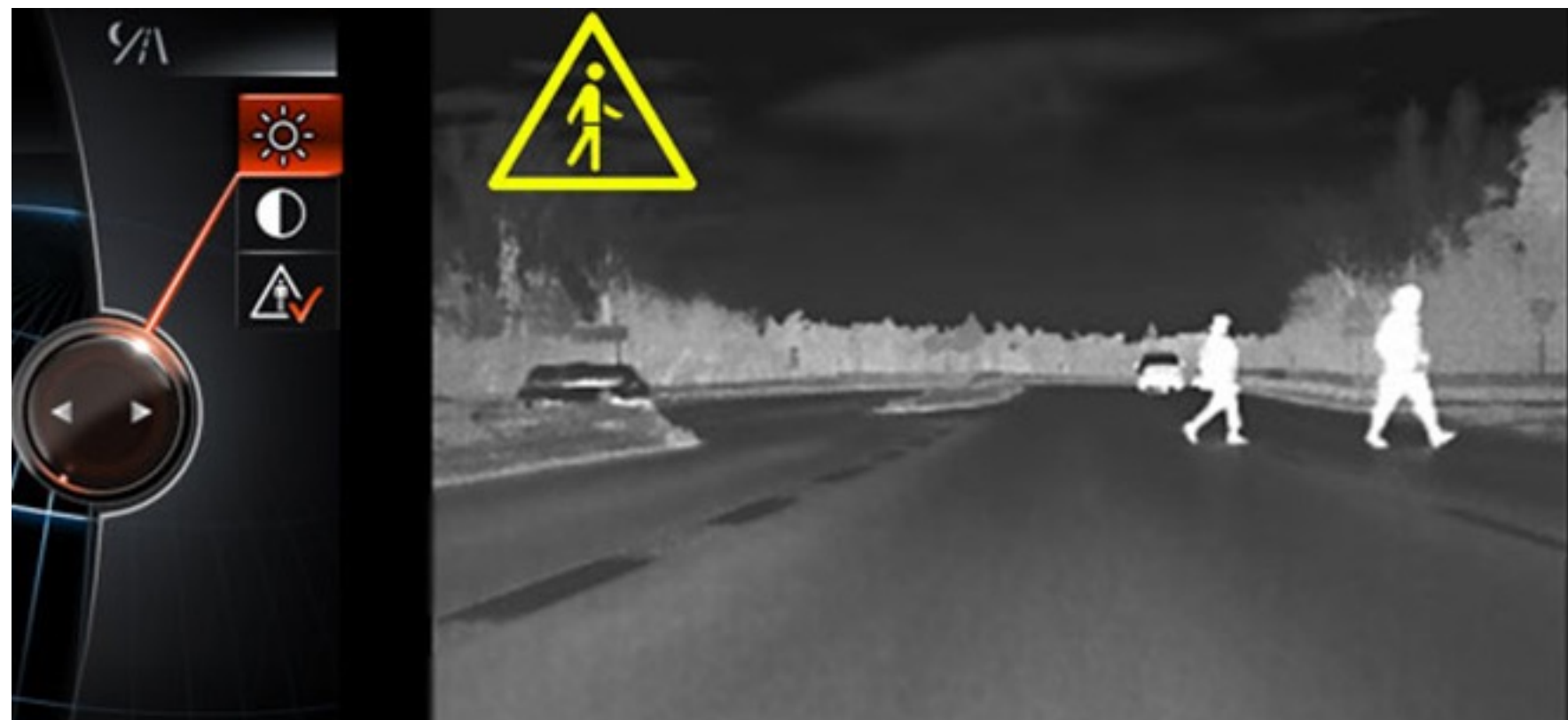
# First-down line





BMW 5 series

BMW night vision





# Vision in Cars





# Image stitching

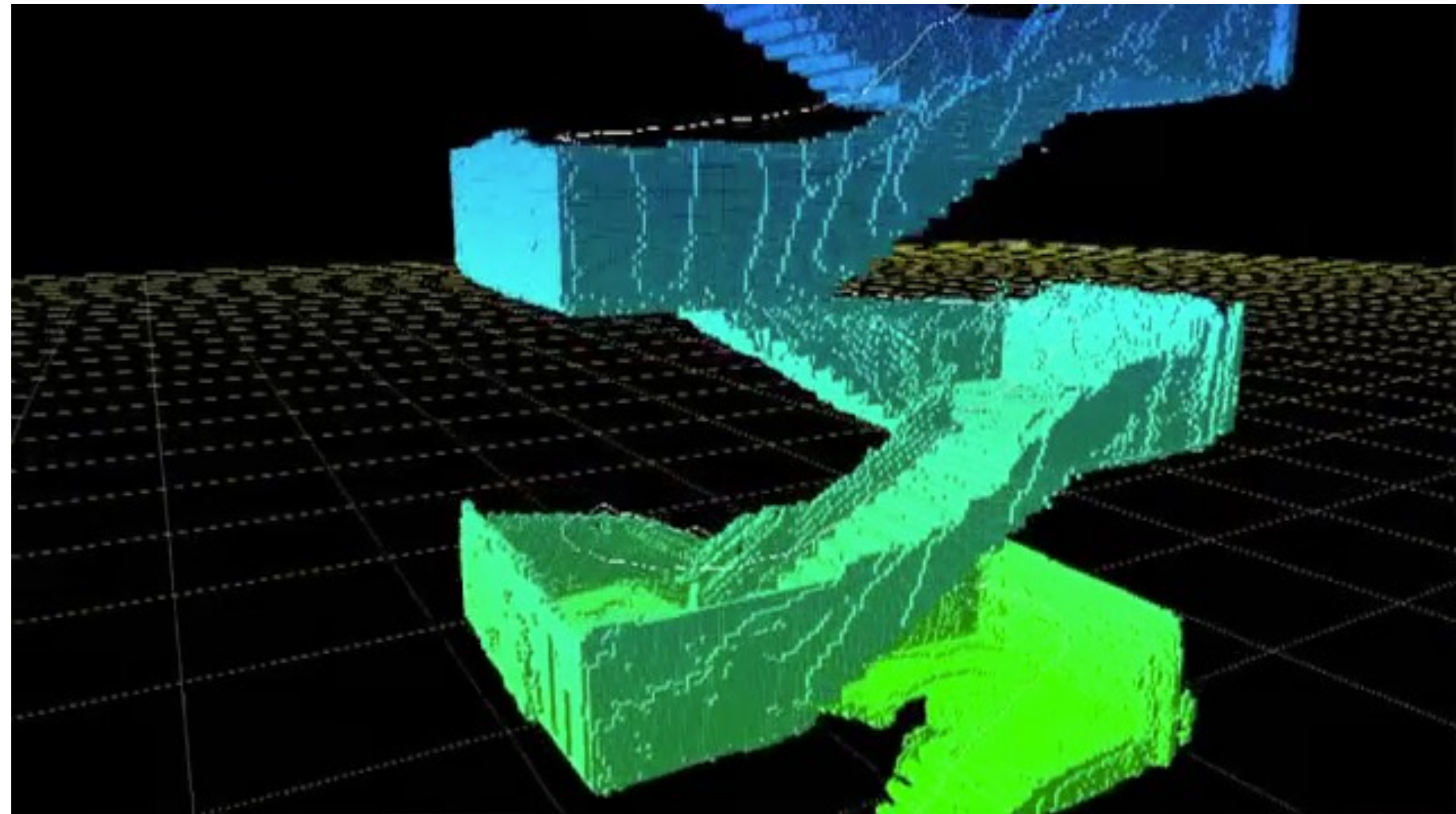


# Photosynth





# Tango

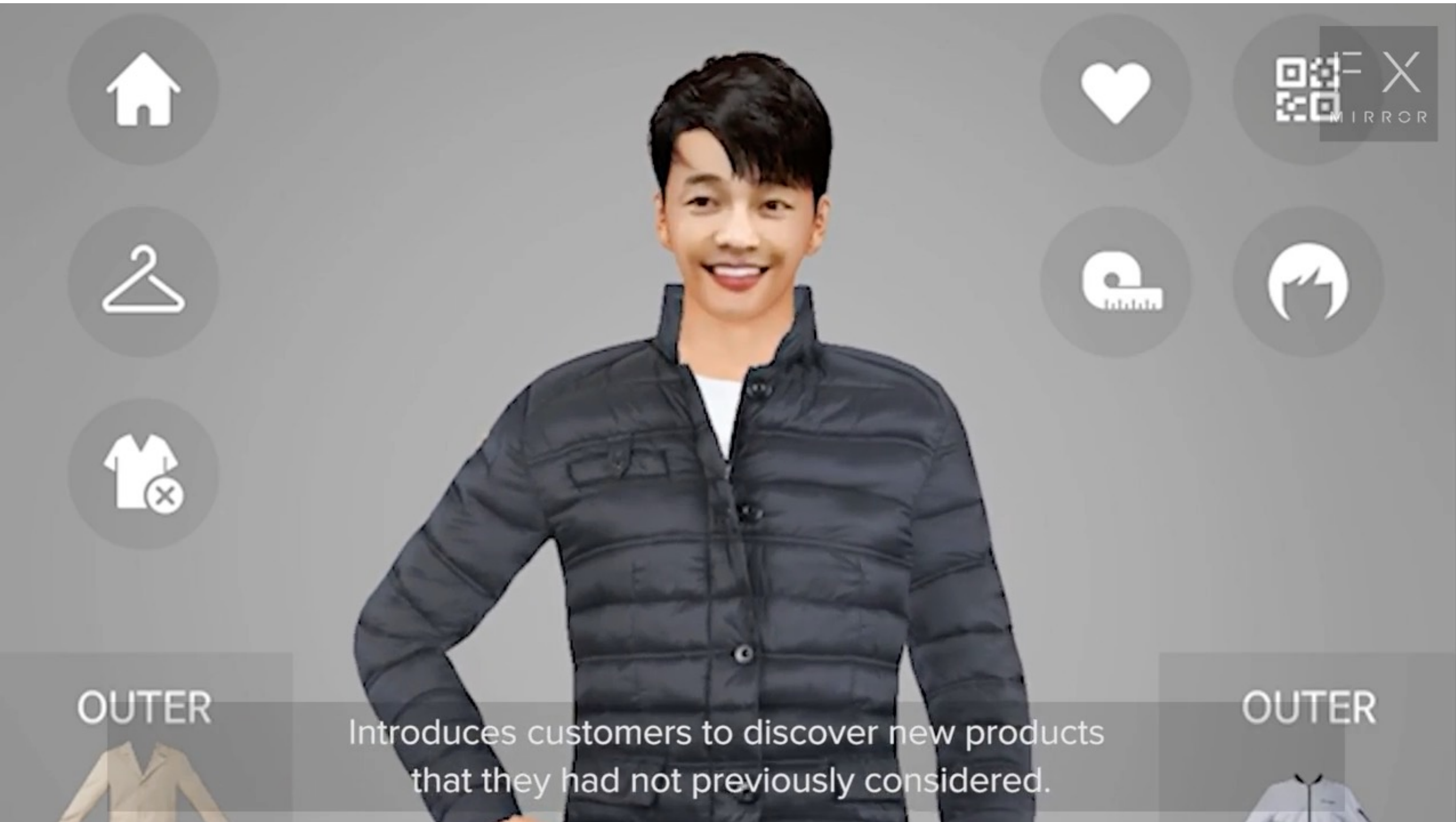


# Computer Vision for VR





# Virtual Fitting



OUTER

Introduces customers to discover new products that they had not previously considered.

OUTER

# Style Transfer

Artwork © Jakub Javora



**Synthesized Result**

Source: [Jamriška et al. 2019]



**Input Video**



**Input Keyframe #1**



# Reenactment Pipeline



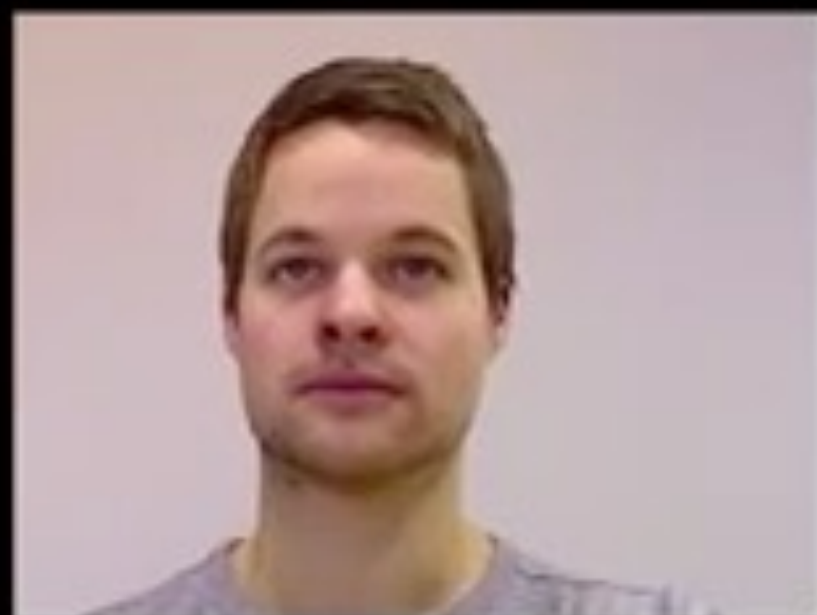
Input Source



Tracking Source



Expr. Transfer



Input Target



Tracking Target



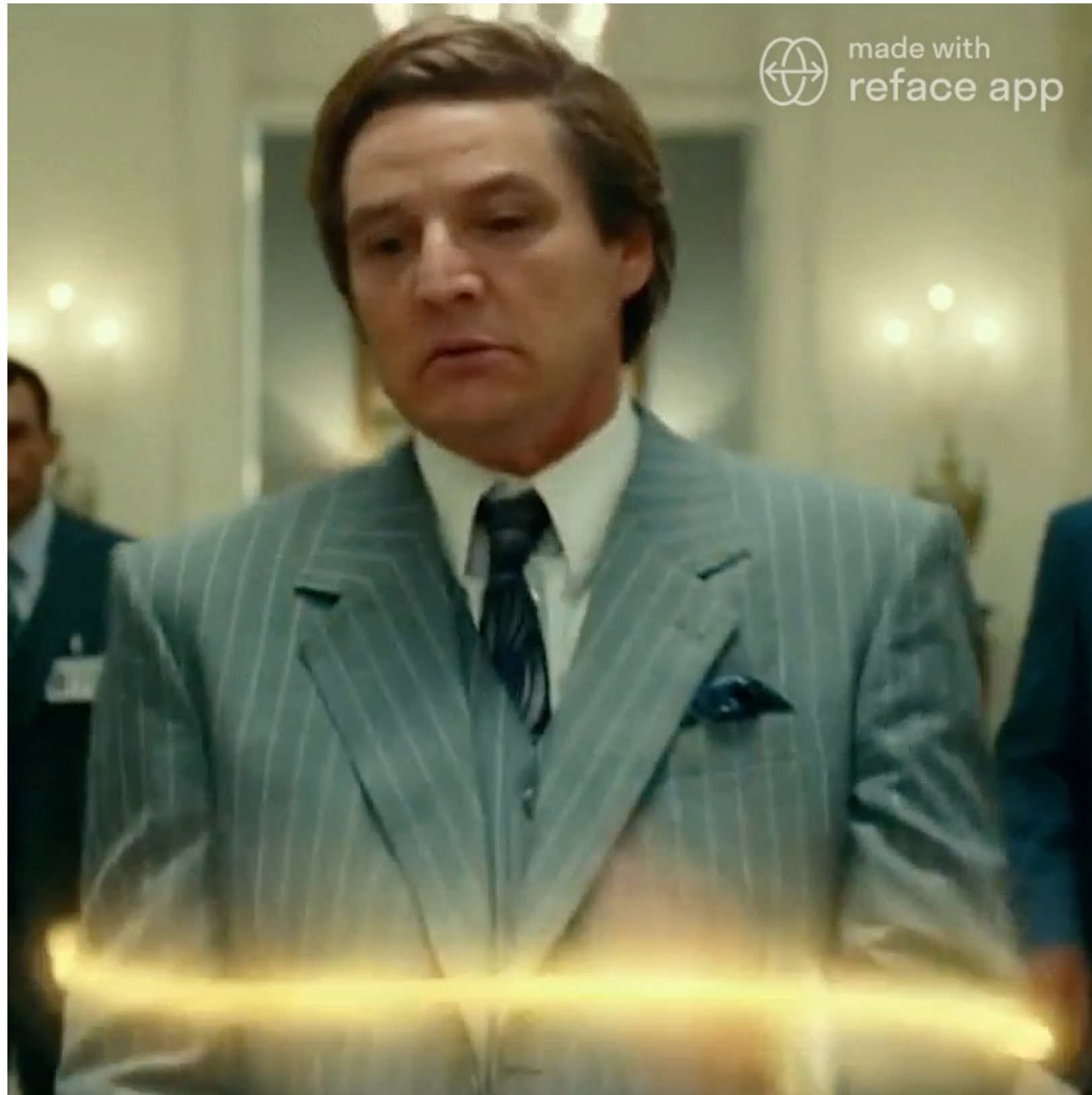


# Deep Fake

VFXCHRISUME



# Deep Fake



It's a good time to do  
computer vision





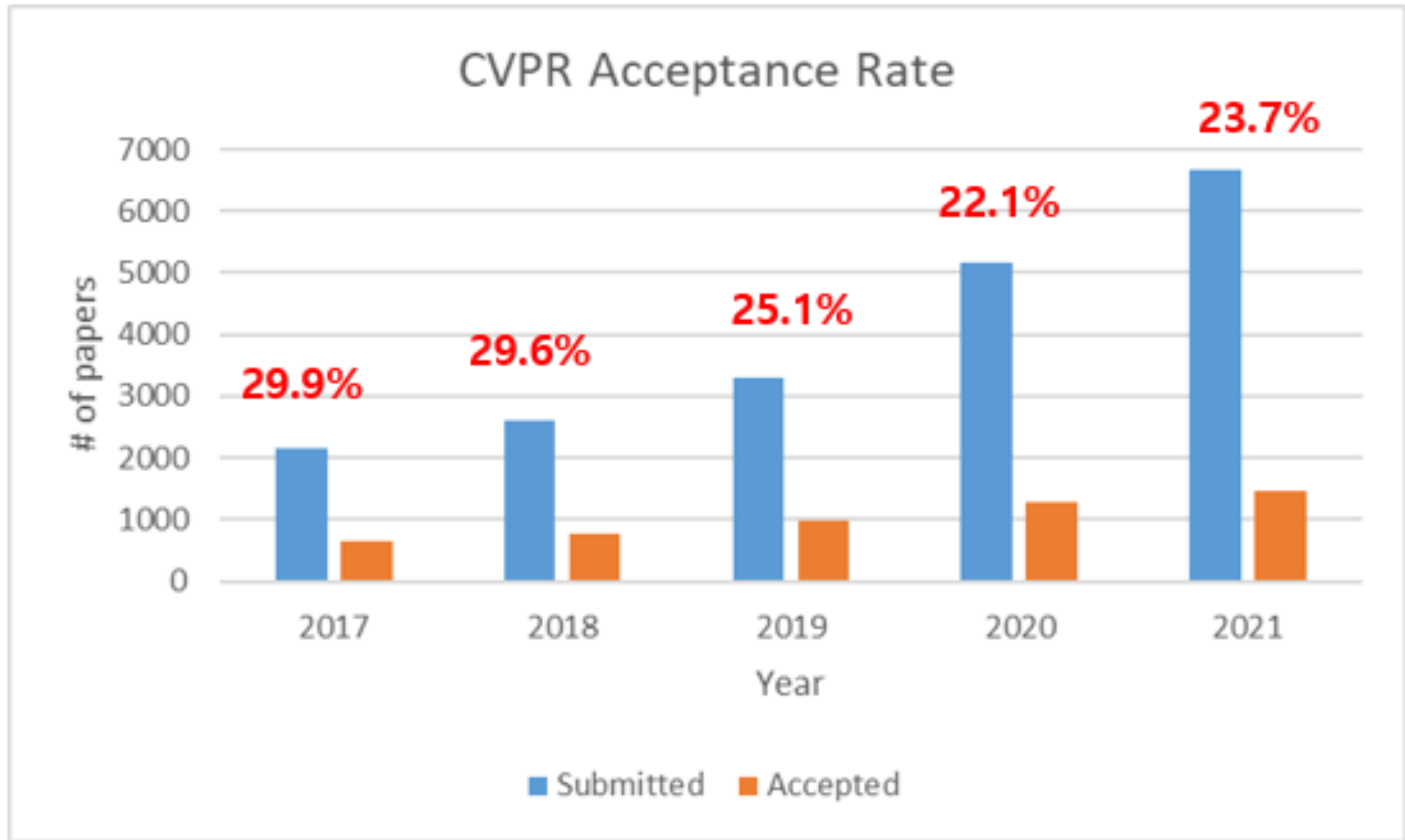


Industry aggressively hiring CV graduates, or even students!

(strong dominant industrial presence at conferences for recruitment)



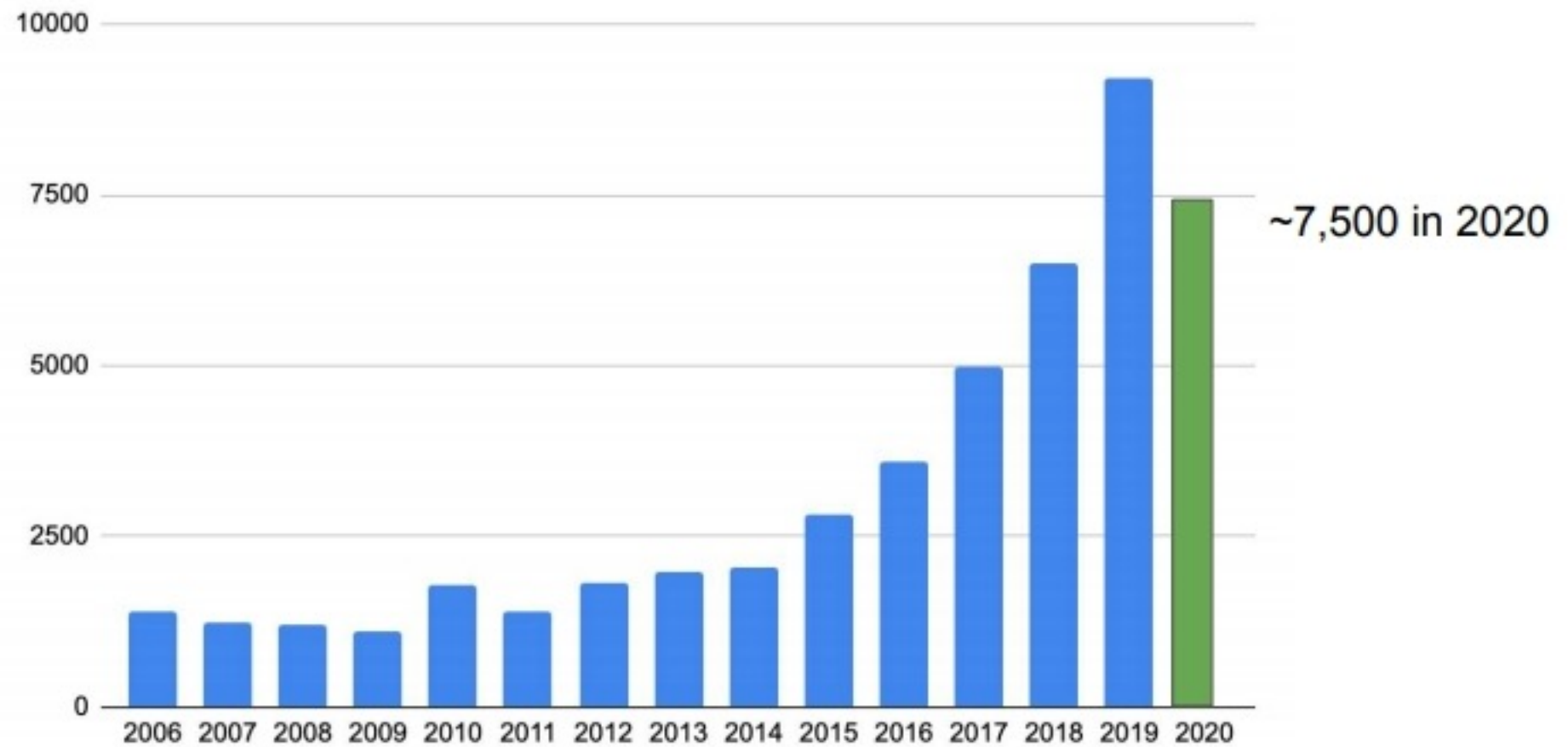
# Stats for CVPR (Computer Vision and Pattern Recognition)





# Stats for CVPR (Computer Vision and Pattern Recognition)

## Attendees per year



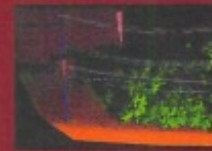
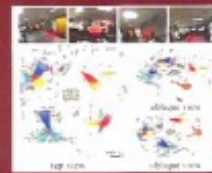
# Computer vision at CMU

Dedicated courses for each subject we cover in this class:

- Physics-based Methods in Vision
- Geometry-based Methods in Computer Vision
- Computational Photography
- Visual Learning and Recognition
- Statistical Techniques in Robotics
- Sensors and sensing

... plus an entire department's worth of ML courses.

# Master in Computer Vision at CMU



## Master of Science - Computer Vision

# MSCV

August 2016 - December 2017 (16-month program)

Computer vision is the study of acquiring and interpreting visual imagery. As computer vision shifts from research to development, there is a critical need for developers with expertise in this field.

### GOALS

- Offer a comprehensive set of courses
- Facilitate hands-on research and development projects
- Expose students to current and emerging state-of-the-art Computer Vision applications
- Prepare students for careers in Computer Vision

### COURSES

Introduction to Computer Vision  
Introduction to Machine Learning  
Mathematical Fundamentals for Robotics  
Visual Learning and Recognition  
Geometry-based Methods in Computer Vision

#### Electives (choose 2)

Human Communication and Multimodal Machine Learning  
The Visual World as seen by Neurons and Machines  
Comprehensive Sensing and Sparse Optimization  
Large Scale Learning using Images and Text  
Big Data approaches in Computer Vision  
Human Motion Modeling and Analysis  
Statistical Techniques in Robotics  
Physics-based Methods in Vision  
Probabilistic Graphical Models  
Statistical Machine Learning  
Convex Optimization  
Vision Sensors

#### Project and Seminar Courses

MSCV Seminar MSCV Project I MSCV Project II

### ADMISSION AND APPLICATION

Requirements: Undergraduate (B.S. or equivalent) in engineering, computer science or applied mathematics

#### Application Materials

- Résumé • General GRE
- TOEFL / IELTS (Foreign Students only)
- Statement of Purpose (1 to 2 pages)
- Letters of Recommendation (3 Required)
- Undergraduate/Graduate (as applicable) Transcripts

Only online applications will be accepted.

Early application deadline: December 3, 2015

Final application deadline: December 15, 2015

FOR INDUSTRY SPONSORSHIPS PLEASE CONTACT  
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[www.ri.cmu.edu/MSCV](http://www.ri.cmu.edu/MSCV)

MSCV Faculty



Srinivasa  
Narasimhan  
MSCV Program Director



Martial  
Hebert  
MSCV Spiritual Guru



J. Andrew (Drew)  
Bagnell



Fernando  
De la Torre Frade



Abhinav  
Gupta



Kris M.  
Kitani



Simon  
Lucey



Deva  
Kannan Ramanan



Yaser Ajmal  
Sheikh



# Course logistics

# Website



<http://16385.courses.cs.cmu.edu/>

(includes links to Canvas and Piazza)

# Assignments Canvas

<https://canvas.cmu.edu/courses/31588>

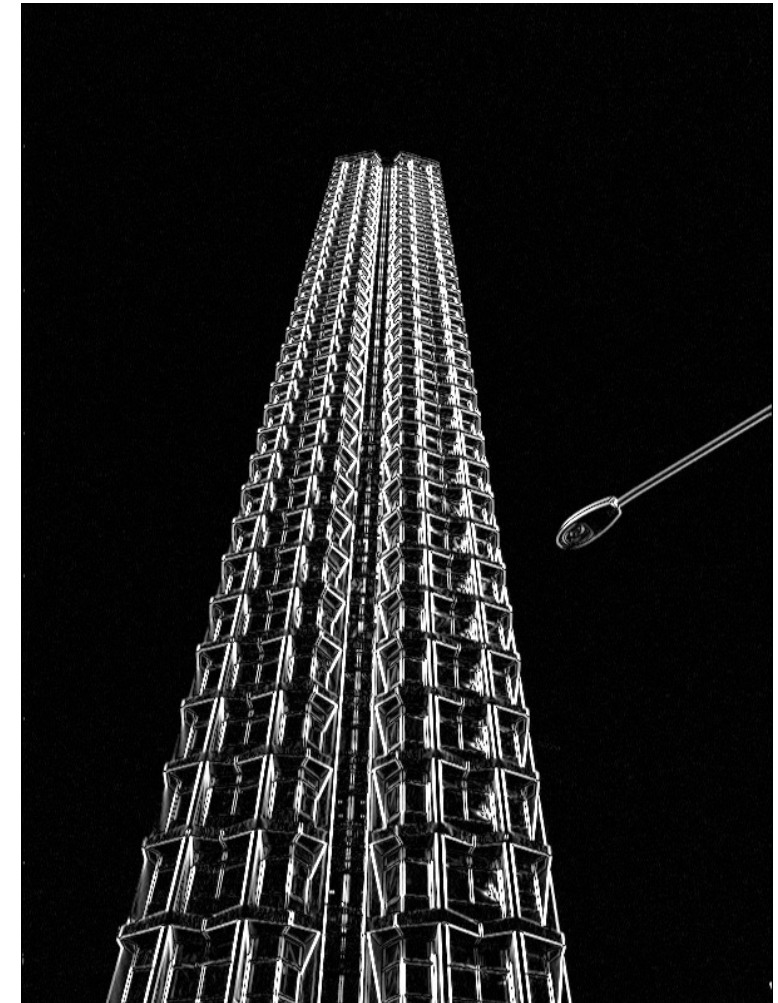
# Discussion & Notes piazza

<https://piazza.com/cmu/fall2022/16385>

# Topics to be covered

Image processing:

- Basics of filtering.
- Image pyramids.
- Gradients and lines.
- Hough transforms.

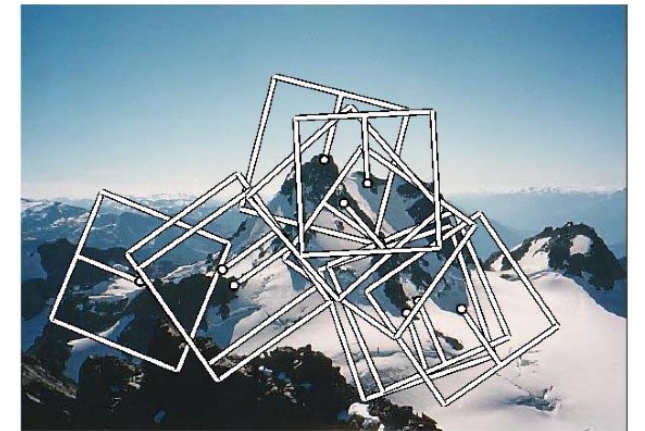
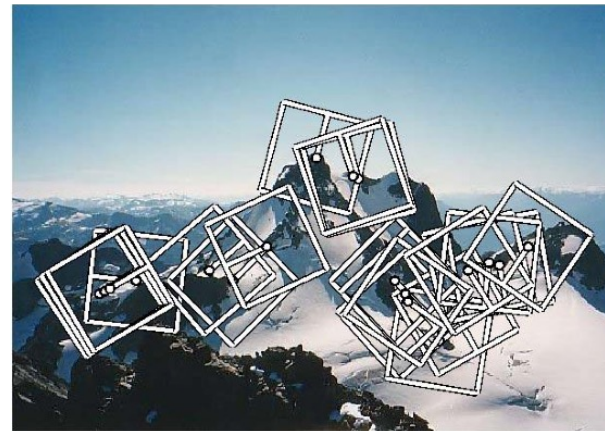




# Topics to be covered

Feature detection and correspondences:

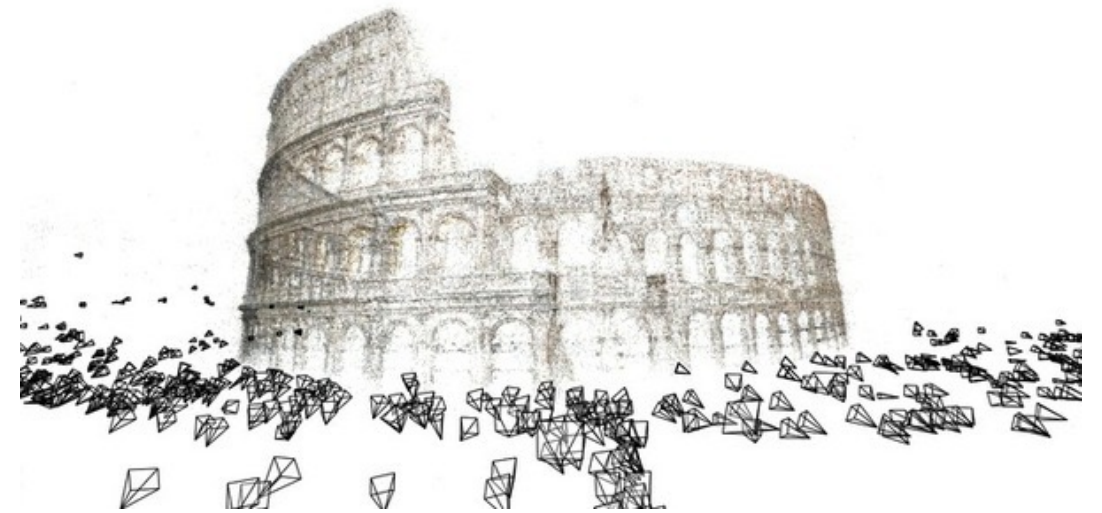
- Corner detection.
- SIFT et al.
- Feature descriptors.
- RANSAC.



# Topics to be covered

Transformations and geometry:

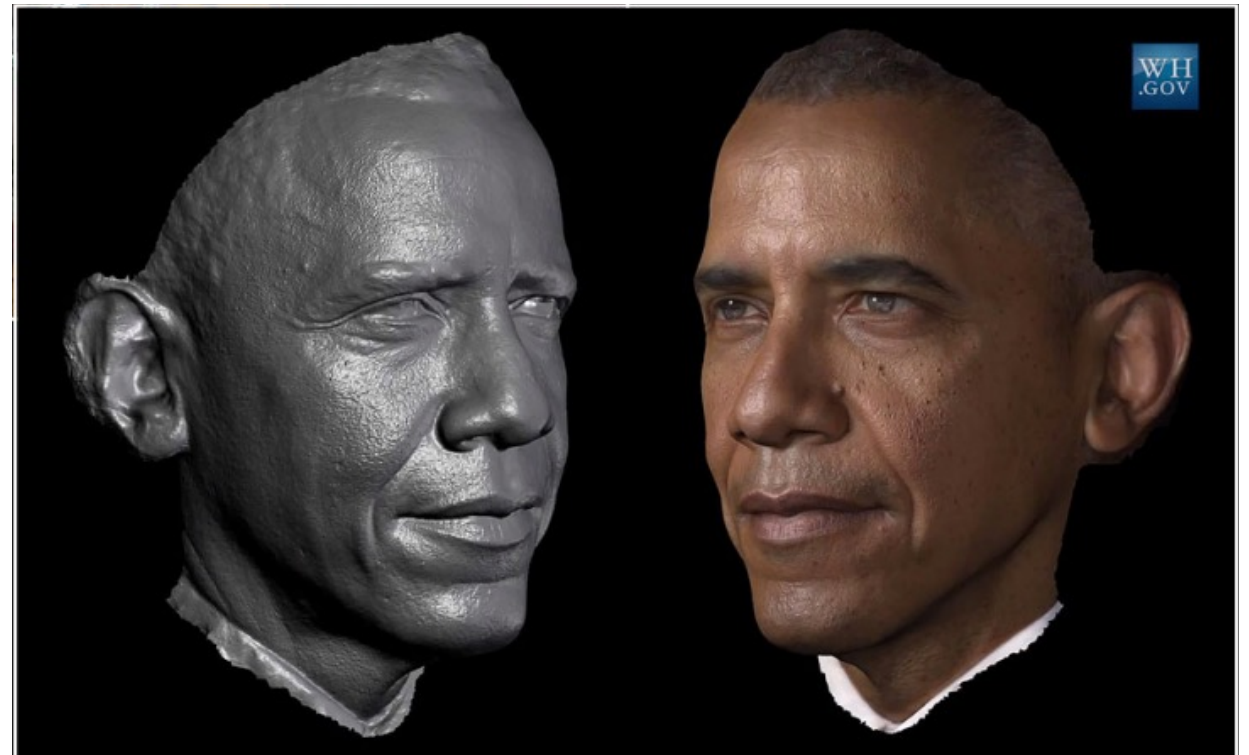
- Homographies and image alignment.
- Camera models.
- Fundamental matrix.
- Epipolar geometry and stereo.
- Structure from motion.



# Topics to be covered

Physics-based vision:

- Reflectance and image formation.
- Radiometry.
- Shape from shading.
- Photometric stereo.
- Color.

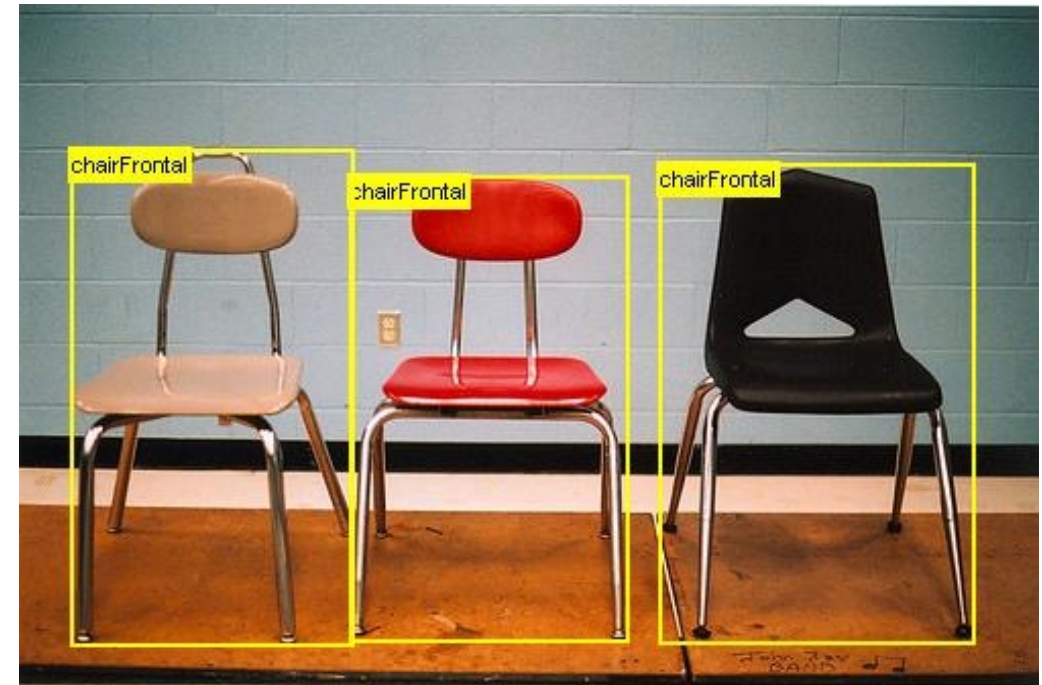




# Topics to be covered

Objects, faces, and learning:

- Basics of probability.
- K-means, KNN, PCA, SVM.
- Bag of words.
- Viola-Jones face detection.
- Perceptron, backpropagation.
- Convolutional neural networks.



# Topics to be covered

Dealing with motion:

- Optical flow (LK, HS).
- Image registration.
- Kalman Filtering.
- Tracking (KLT, Mean-Shift).



# Grading

- Six two-week programming assignments: 70%
- Eleven weekly take-home quizzes: 27%
- Class, Website, and Piazza participation: 3%

## **Participation:**

- Be active! Ask questions.
- Post on Piazza and course website.



# Programming Assignments

- a lot of programming in Python
- hours and hours of programming
- days and days of debugging
- generous grading policy
- take advantage of extra credit

Assignment 1 Hough Transform  
Assignment 2 Homography  
Assignment 3 Stereo  
Assignment 4 Bag of Words  
Assignment 5 Convolutional Neural Nets  
Assignment 6 Image Alignment

# Programming Assignments

- a lot of programming in Python
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Assignment 1 Hough Transform
Assignment 2 Homography
Assignment 3 Stereo
Assignment 4 Bag of Words
Assignment 5 Convolutional Neural Nets
Assignment 6 Image Alignment

**Seriously.. a lot of programming, so start early!**

# Leniency

Late days for programming assignments:

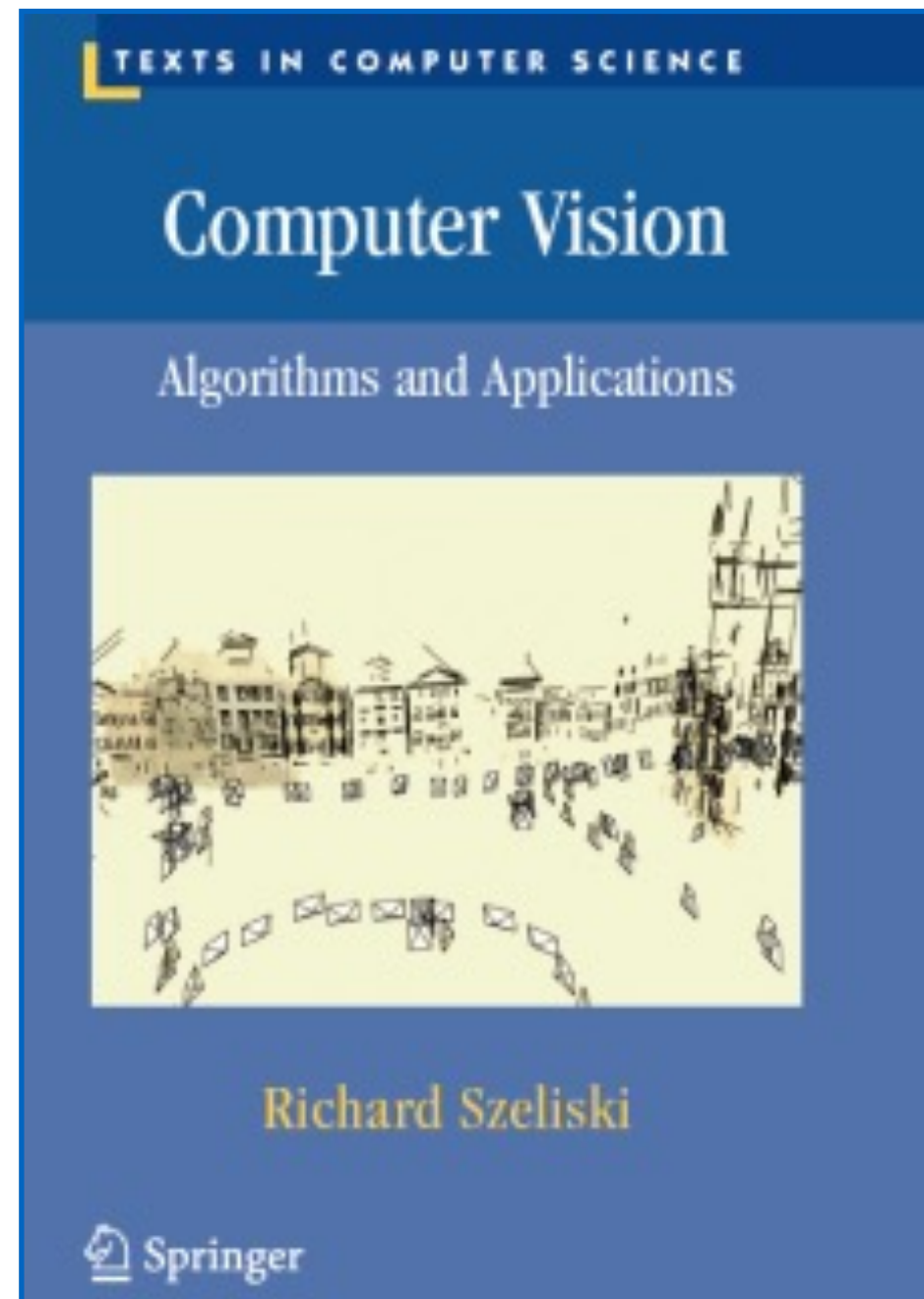
- 10% reduction of points per late day
- 6 free late days total
- use them wisely... save for later (harder) assignments!

Option to skip take-home quizzes:

- you only need to submit 8 out of 11 quizzes
- late quizzes will not be graded



# Book



PDF online

<http://szeliski.org/Book/>

# Prerequisites

We assume familiarity with calculus, linear algebra, basic probability, and programming.

Formal prerequisites:

- "Mathematical Foundations of Electrical Engineering" (18-202) and "Principles of Imperative Computation" (15-122)

OR

- "Matrix Algebra with Applications" (21-240) and "Matrices and Linear Transformations" (21-241) and "Calculus in Three Dimensions" (21-259) and "Principles of Imperative Computation" (15-122)

If you are missing a prerequisite but still want to enroll, let me know and we'll discuss it.

# Contact information

- Feel free to email us about administrative questions.
  - please use [16385] in email title!
- Lecture questions should be asked on course website (or in lecture), and assignment/quiz/logistic questions should be asked on Piazza.
  - we won't answer technical questions through email.
  - you can post anonymously if you prefer.
- Office hours will be determined by poll.
  - feel free to email me about additional office hours.

I will announce office hours at the end of this week.