

Introduction



16-385 Computer Vision
Spring 2021, 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)



Chaoyang Wang



Arpita Routray

What is
computer vision?



Photo by Svetlana Lazebnik

What a person sees



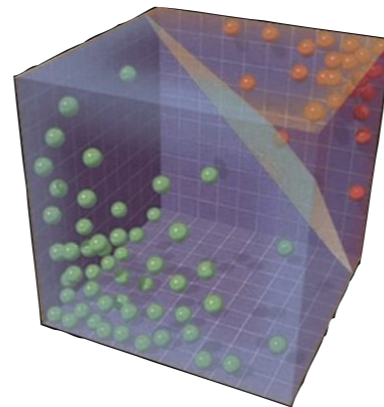
Photo by Svetlana Lazebnik

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



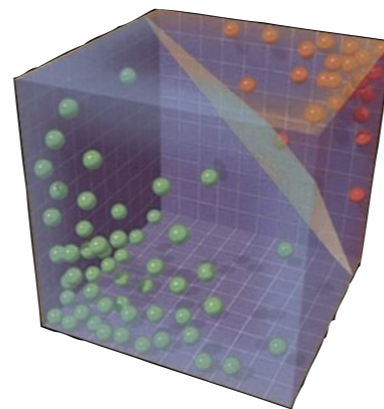
'fancy math'



output

typical perception pipeline

representation



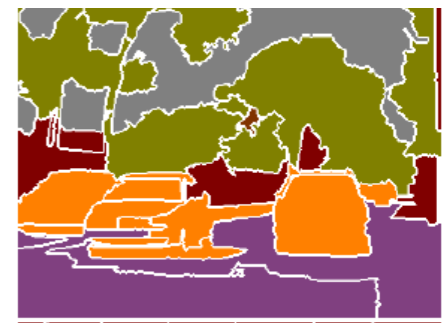
'fancy math'



output



what should we look at?
(image features)



what can we understand?
(semantic segmentation)

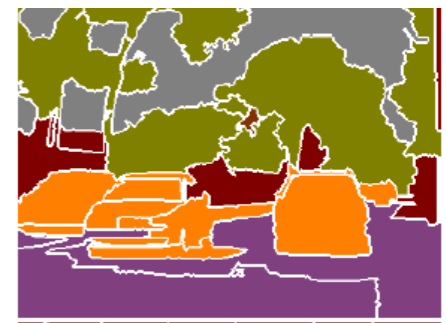
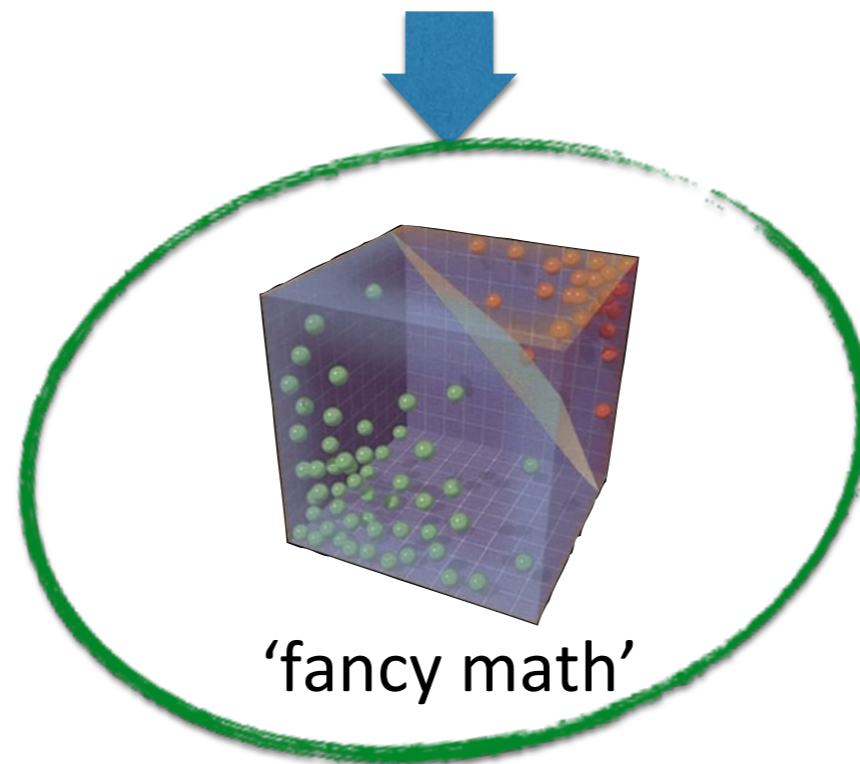
typical perception pipeline

representation



what should we look at?
(image features)

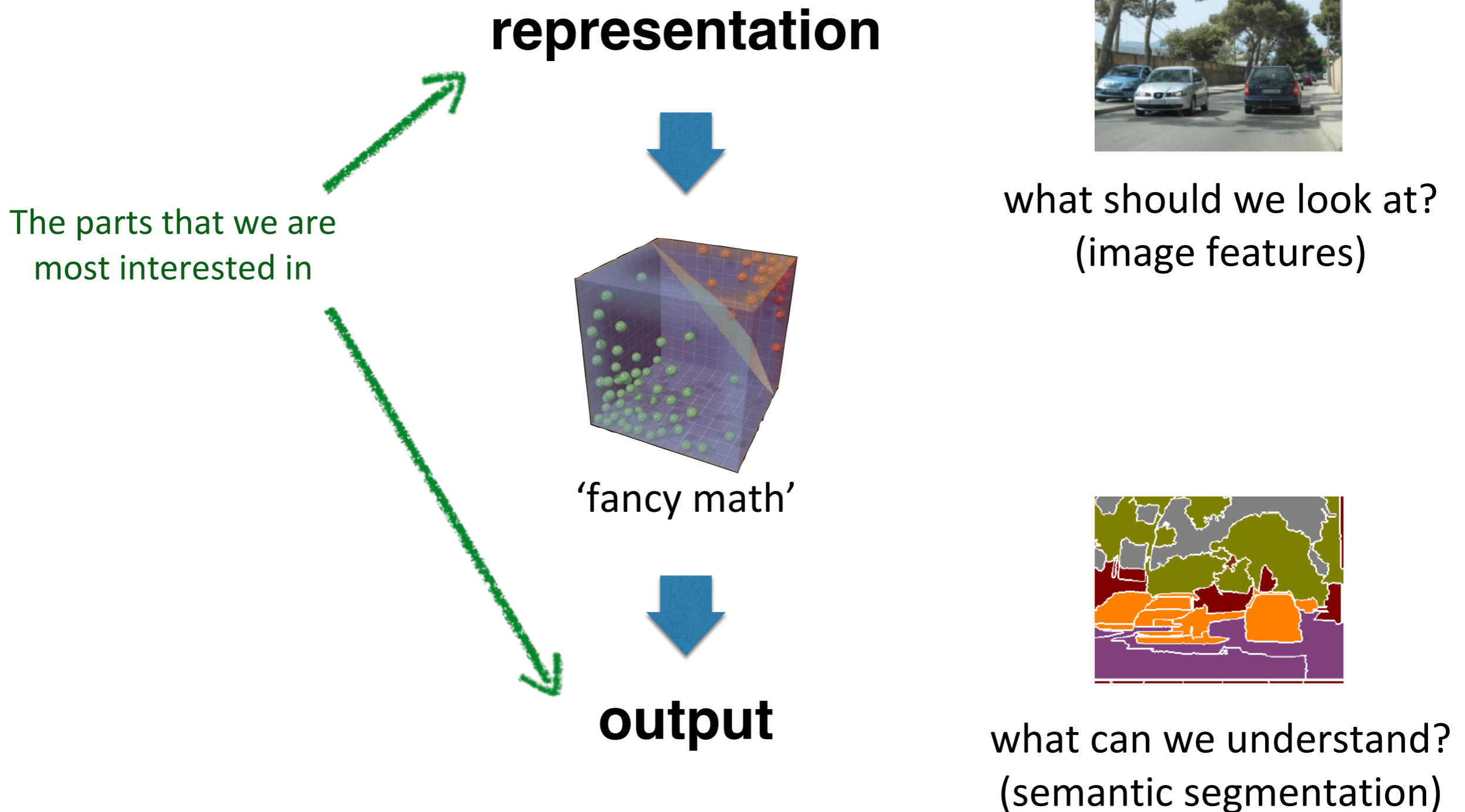
easy to get lost in
the techniques



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

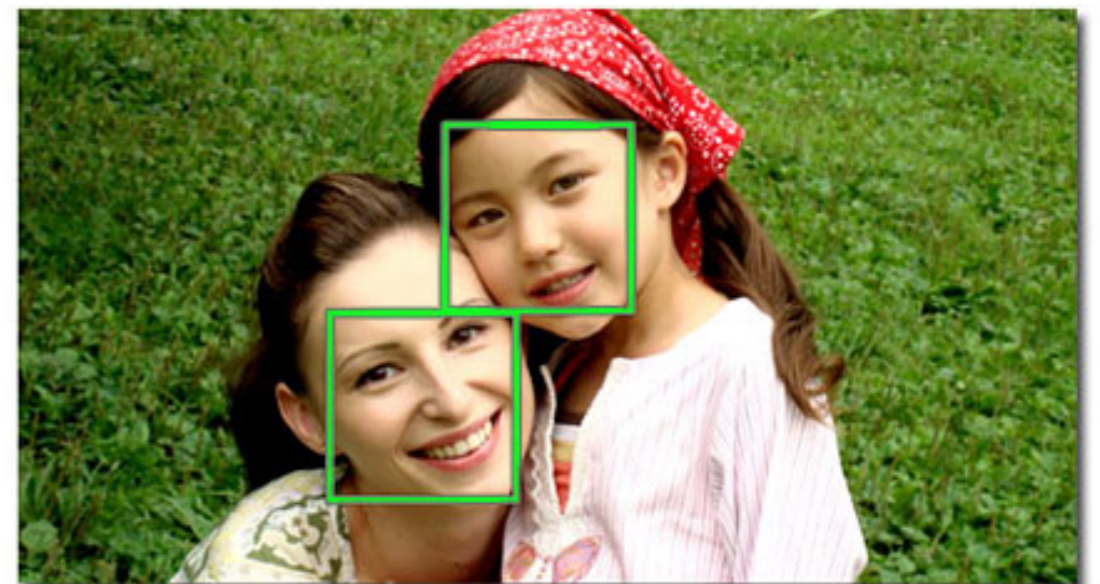
Face detection



Sony Cyber-shot



Age recognition




Smile recognition

Face makeovers

TAAZ
THE BRAINS BEHIND THE BEAUTY

 NEW iPhone
Hair Try On App

 License TAAZ technology
for web, mobile, in-store

HOME

START MAKEOVER

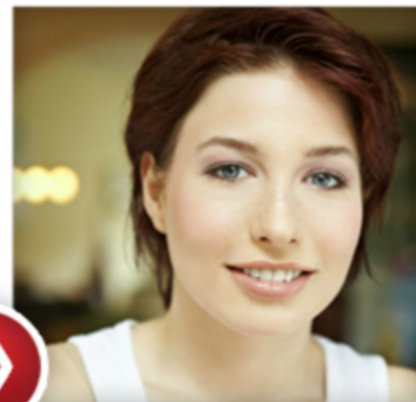
BROWSE LOOKS

TRENDS

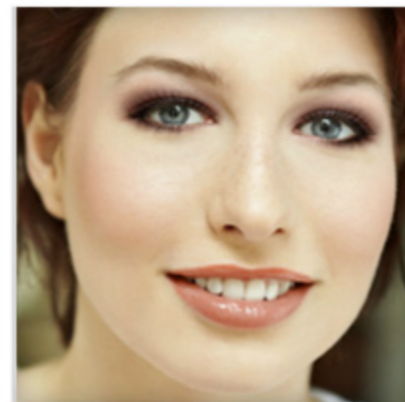
ADVICE

ABOUT

Creating
your own
new look
is easy



1. Upload your photo

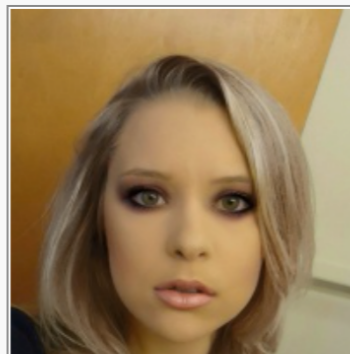


2. Apply some makeup



3. Choose a hairstyle

try
it
now!



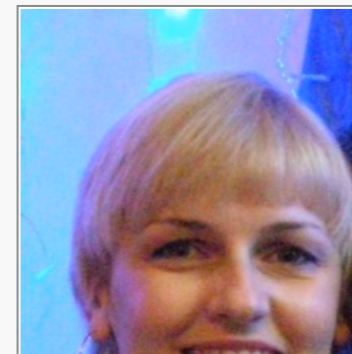
TODAY'S FEATURED MAKEOVER

rtyjukilop.l,kmujny

By: **audreyrose26**

14  3 

Create your own perfect look.
Try on hairstyles, colors & makeup
in the TAAZ Virtual Makeover.



TODAY'S FEATURED ADVICE QUESTION

which look is better?

Asked by: **KKsu**

1  1 

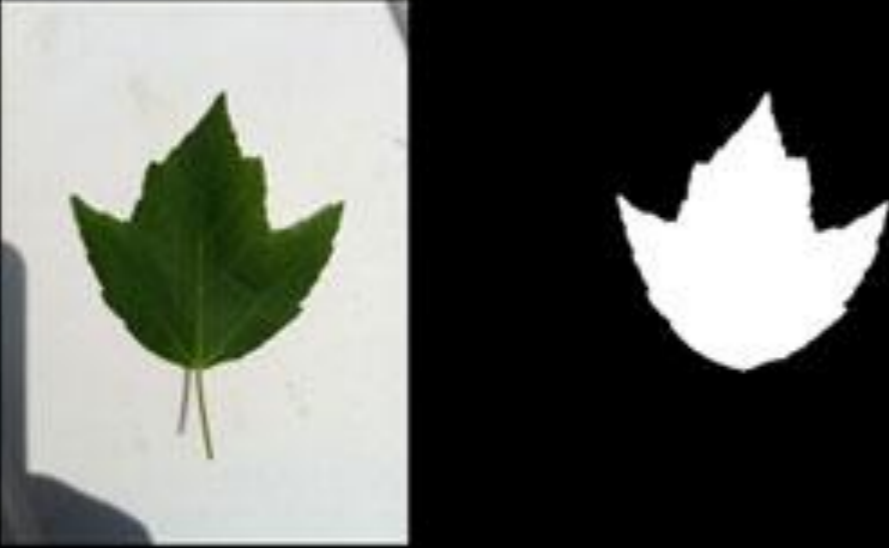
Ask your burning beauty question.
Our community and experts are here
to help!






leafsnap

Verizon 12:38 PM

Back Results Map ⓘ



Snap It! Results

-  **Red Maple**
Acer rubrum
-  **Striped Maple**
Acer pensylvanicum
-  **Sycamore Maple**
Acer pseudoplatanus

12:20 PM 100%

🌿 First Last Scientific ⓘ

	<i>Ilex opaca</i>	Q A B C D E F G H J K L M N O P Q R S T U V W Y
	American Hornbeam <i>Carpinus caroliniana</i>	
	American Linden <i>Tilia americana</i>	
	American Sycamore <i>Platanus occidentalis</i>	
	Amur Corktree <i>Phellodendron amurense</i>	

Home Browse Collection Options Snap It!



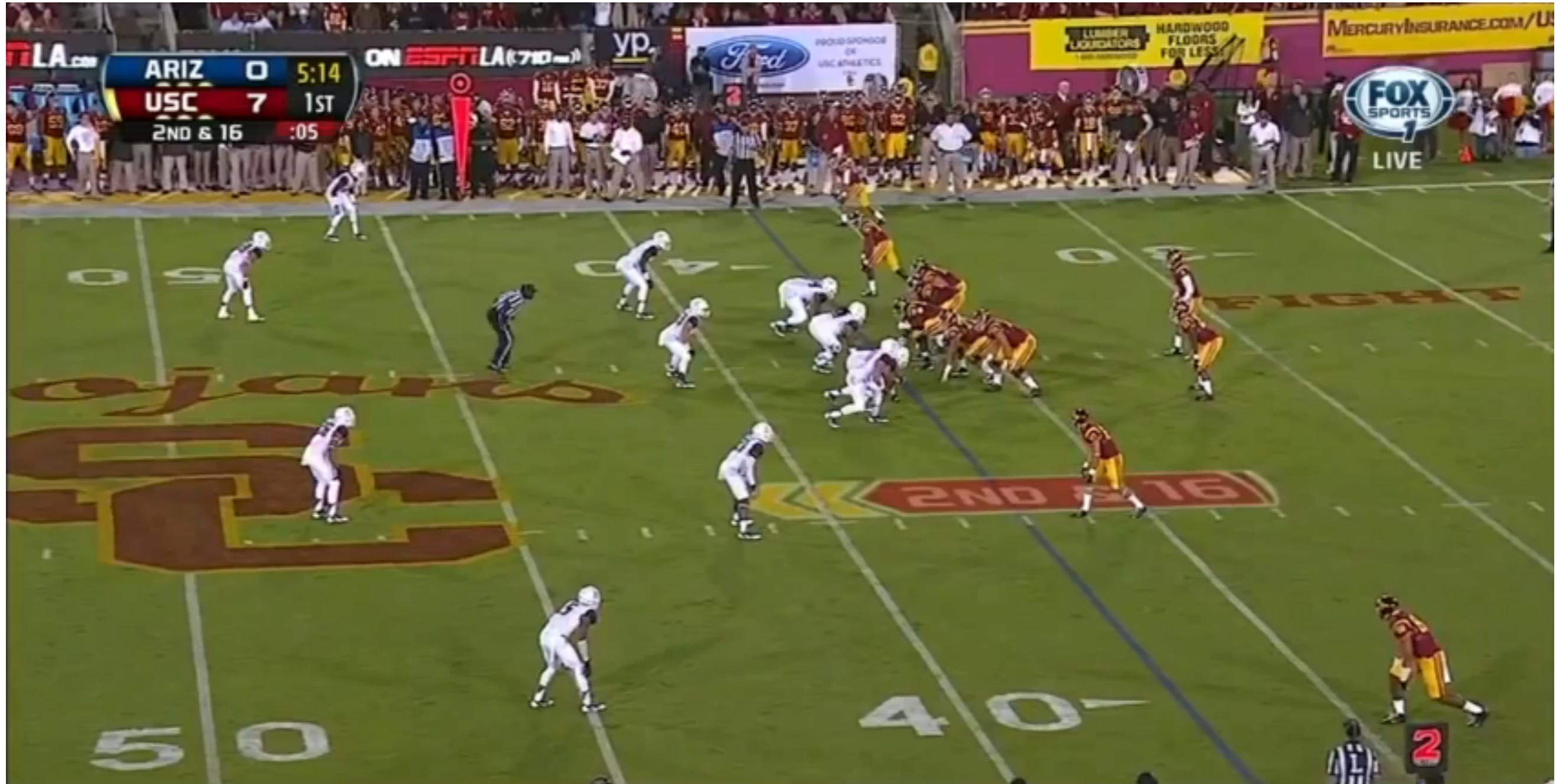
Word Lens



Word Lens

www.QuestVisual.com

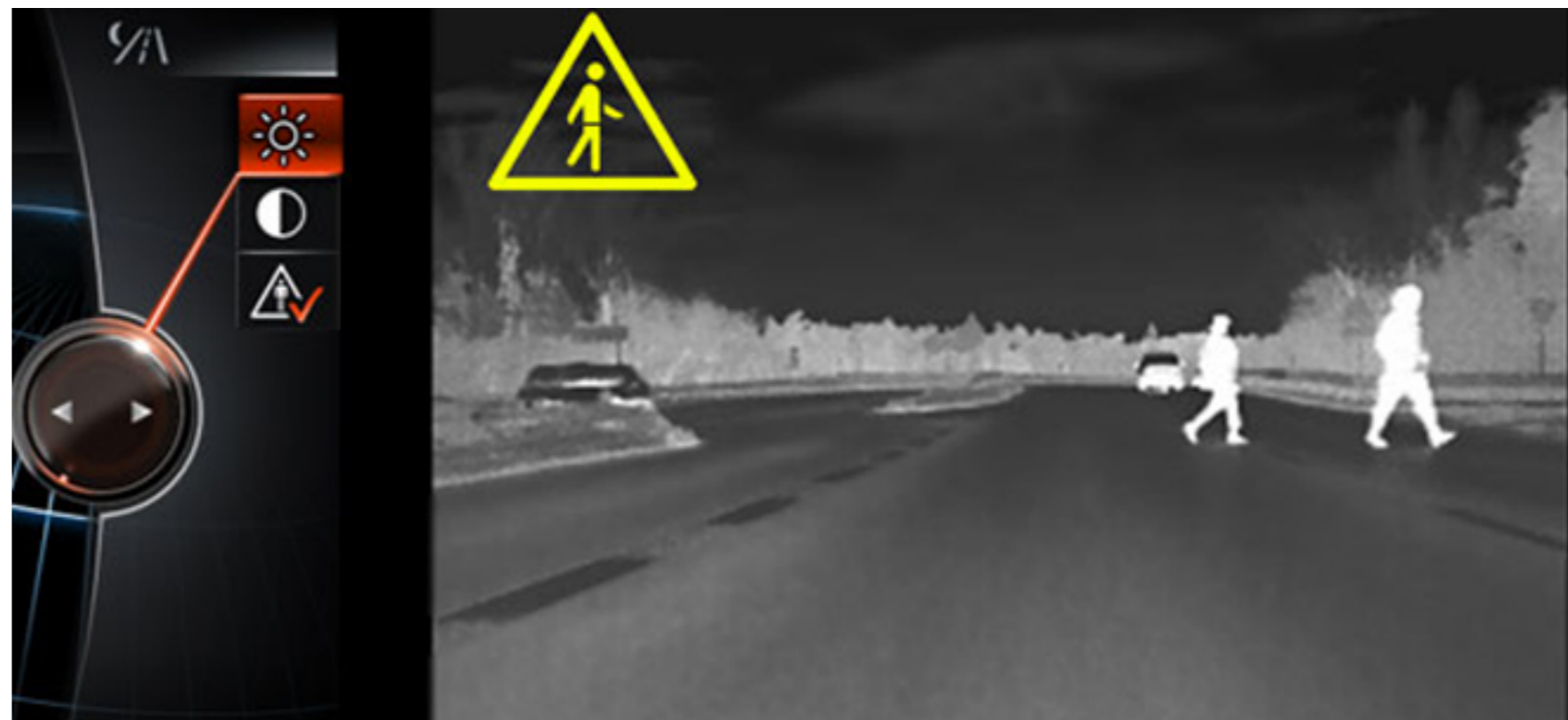
First-down line





BMW 5 series

BMW night vision





“Around view” camera

Infiniti EX





The system converts image data taken by 4 super-wide angle cameras, to display a virtual image of the vehicle from above.

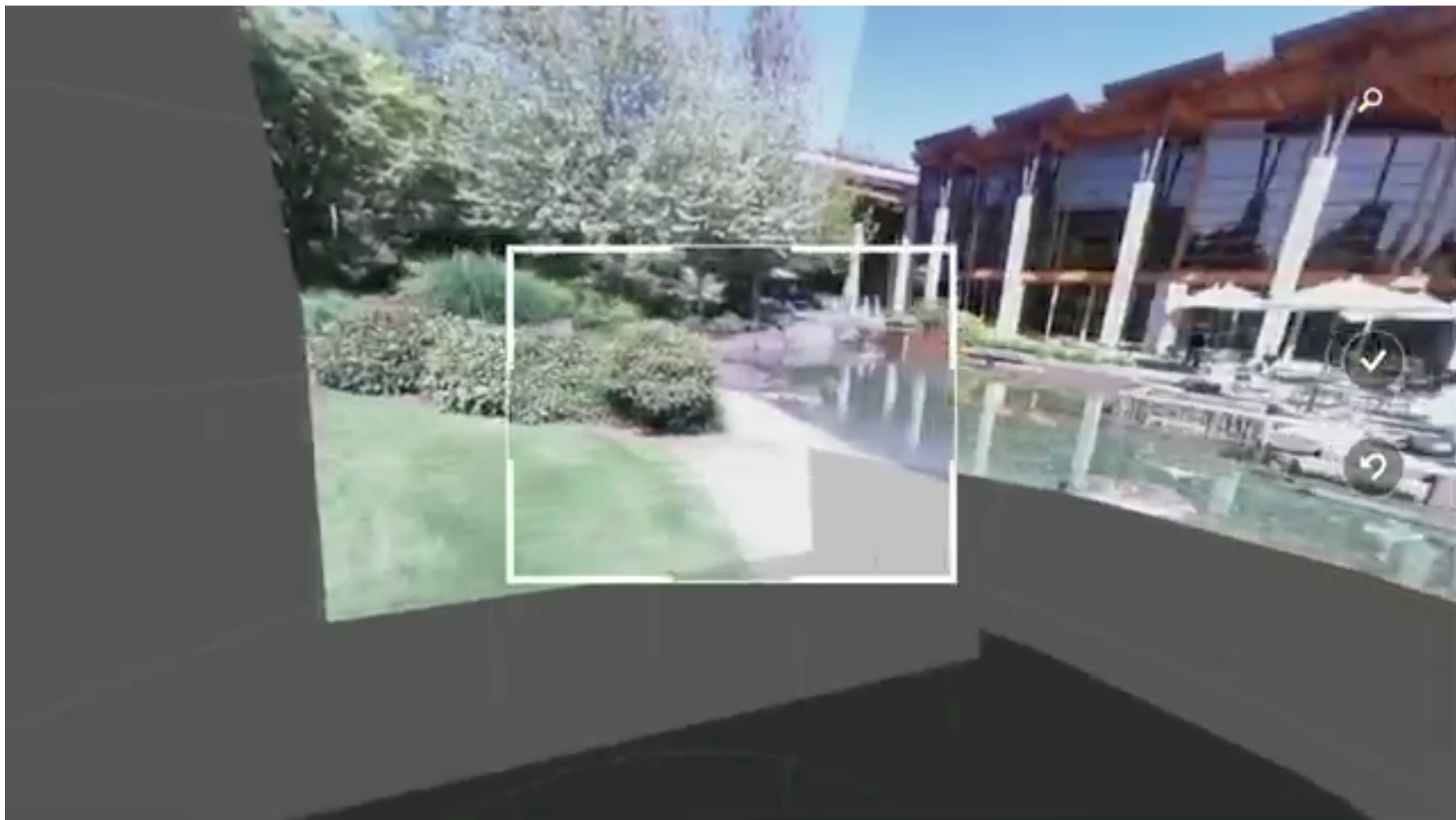
Vision in Cars



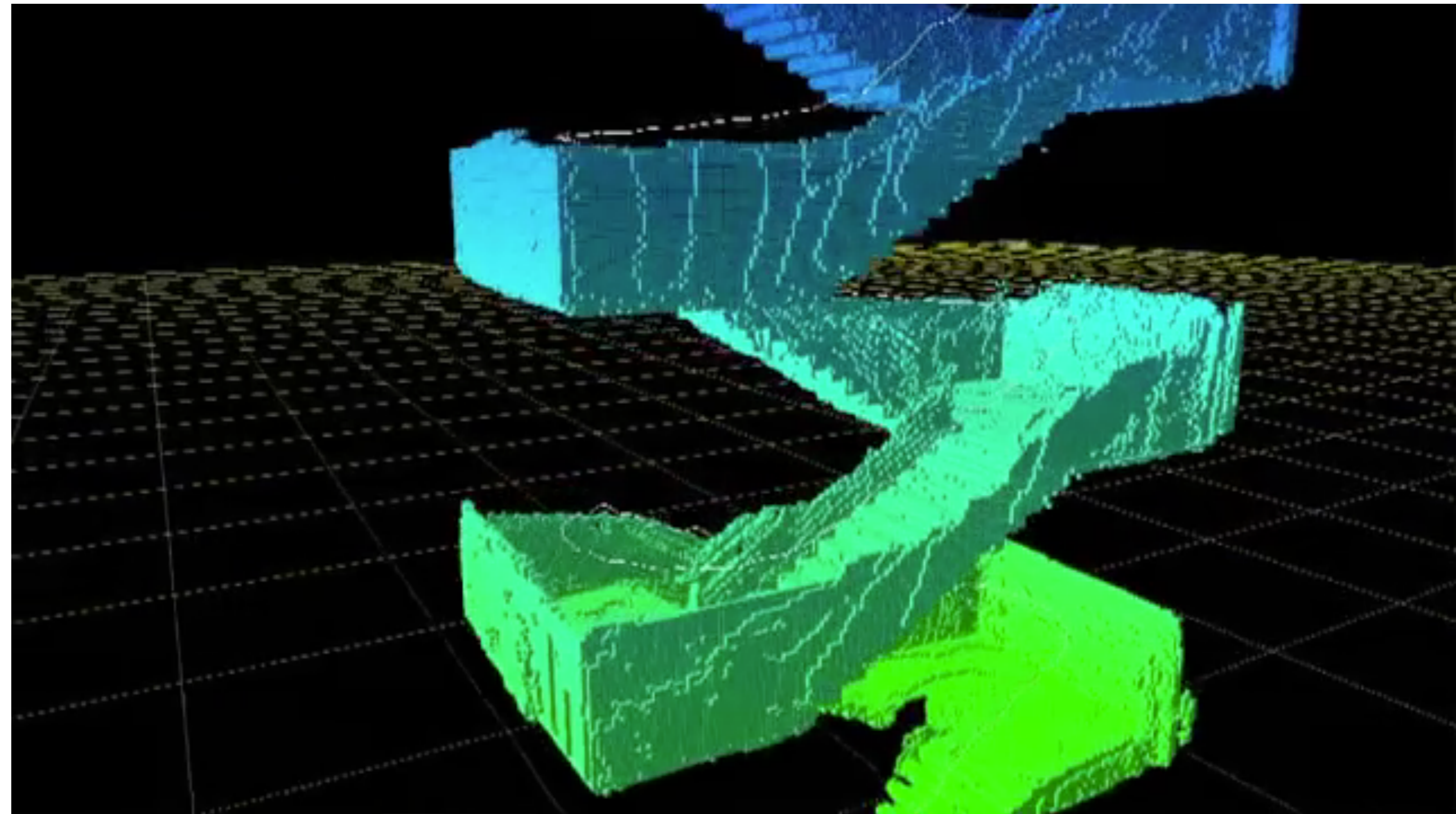
Image stitching



Photosynth



Tango



Virtual Fitting



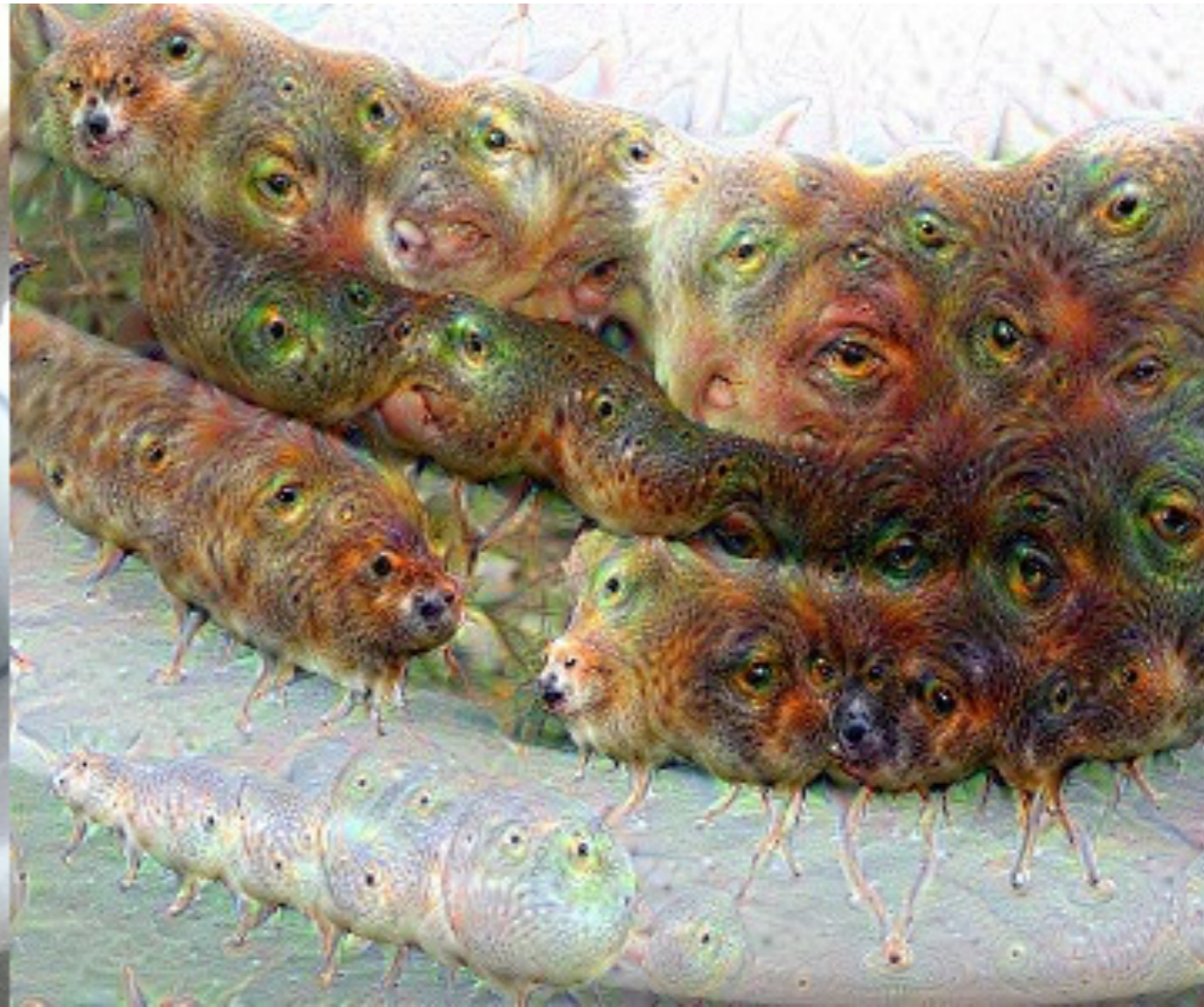
Computer Vision for VR



Deep Face



Deep Dream





Facebook video style transfer 2016

Face2Face: Real-time Face Capture and Reenactment of RGB Videos

*Justus Thies¹, Michael Zollhöfer²,
Marc Stamminger¹, Christian Theobalt²,
Matthias Nießner³*

¹University of Erlangen-Nuremberg

²Max-Planck-Institute for Informatics

³Stanford University

CVPR 2016 (Oral)

It's a good time to do
computer vision

Industry aggressively hiring CV faculty from universities

The image displays a grid of university portraits and company logos, illustrating the trend of industry hiring CV faculty from universities. The universities and companies shown are:

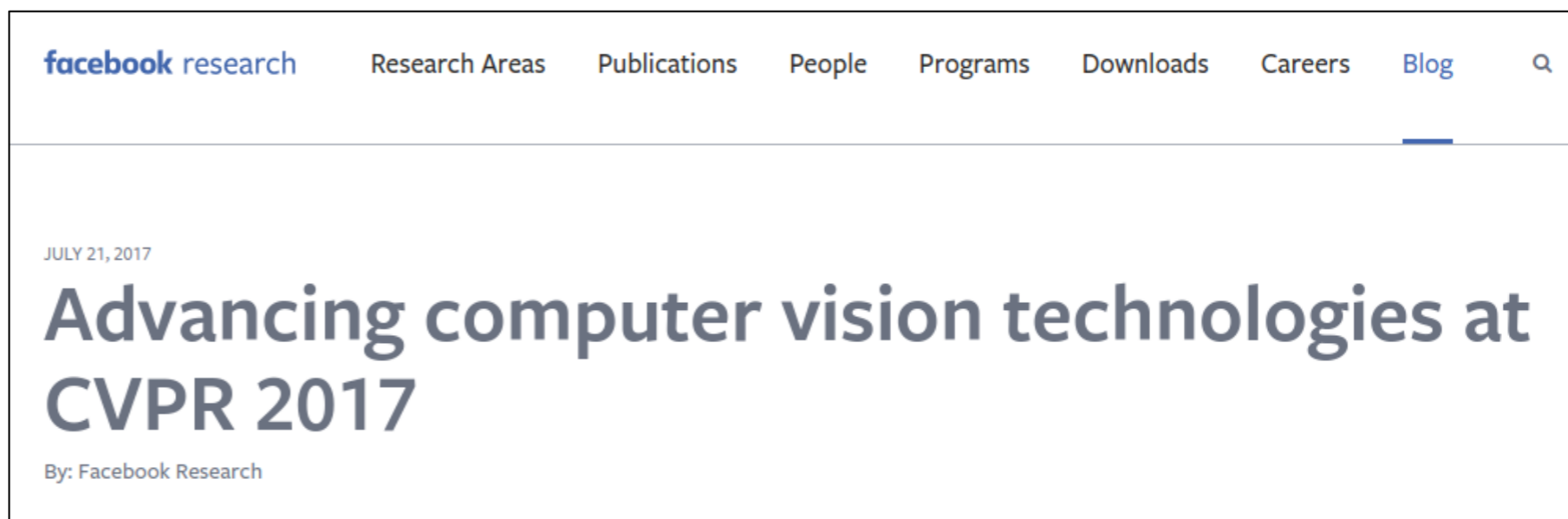
- Universities:** UW, Berkeley, CMU, Toronto, UCSD, Columbia, UCLA, USC, NYU, CMU, CMU, Stanford, Stanford, Stanford, NYU, NYU, GTech, GTech, UT Austin, Toronto, CalTech, UW, SFU, CMU, CMU, CMU, GTech, CMU, CMU, MIT, Toronto, UW.
- Companies:** UBER, NVIDIA, amazon.com, Zillow, Oculus VR, ARGO AI, Apple, IBM, Google, Dropbox.

The layout consists of several rows of portraits and logos. The top row features portraits from UW, Berkeley, CMU, and Toronto, followed by the UBER logo. The second row includes portraits from UCLA and USC, the Dropbox logo, and portraits from UCSD and Columbia. The third row shows a portrait from NYU, the Facebook logo, two portraits from CMU, and the NVIDIA logo. The fourth row contains portraits from Stanford, CMU, and Stanford, along with the amazon.com logo. The fifth row features portraits from NYU, GTech, GTech, and UT Austin, and a portrait from Toronto. The sixth row includes portraits from CalTech and UW, and the Stanford, NYU, and Google logos. The seventh row shows logos for Zillow, Oculus VR, and ARGO AI. The eighth row features portraits from SFU, CMU, CMU, CMU, GTech, Apple, IBM, and MIT. The final row contains portraits from CMU, MIT, Toronto, and UW, and the Google logo.



Industry aggressively hiring CV graduates, or even students!

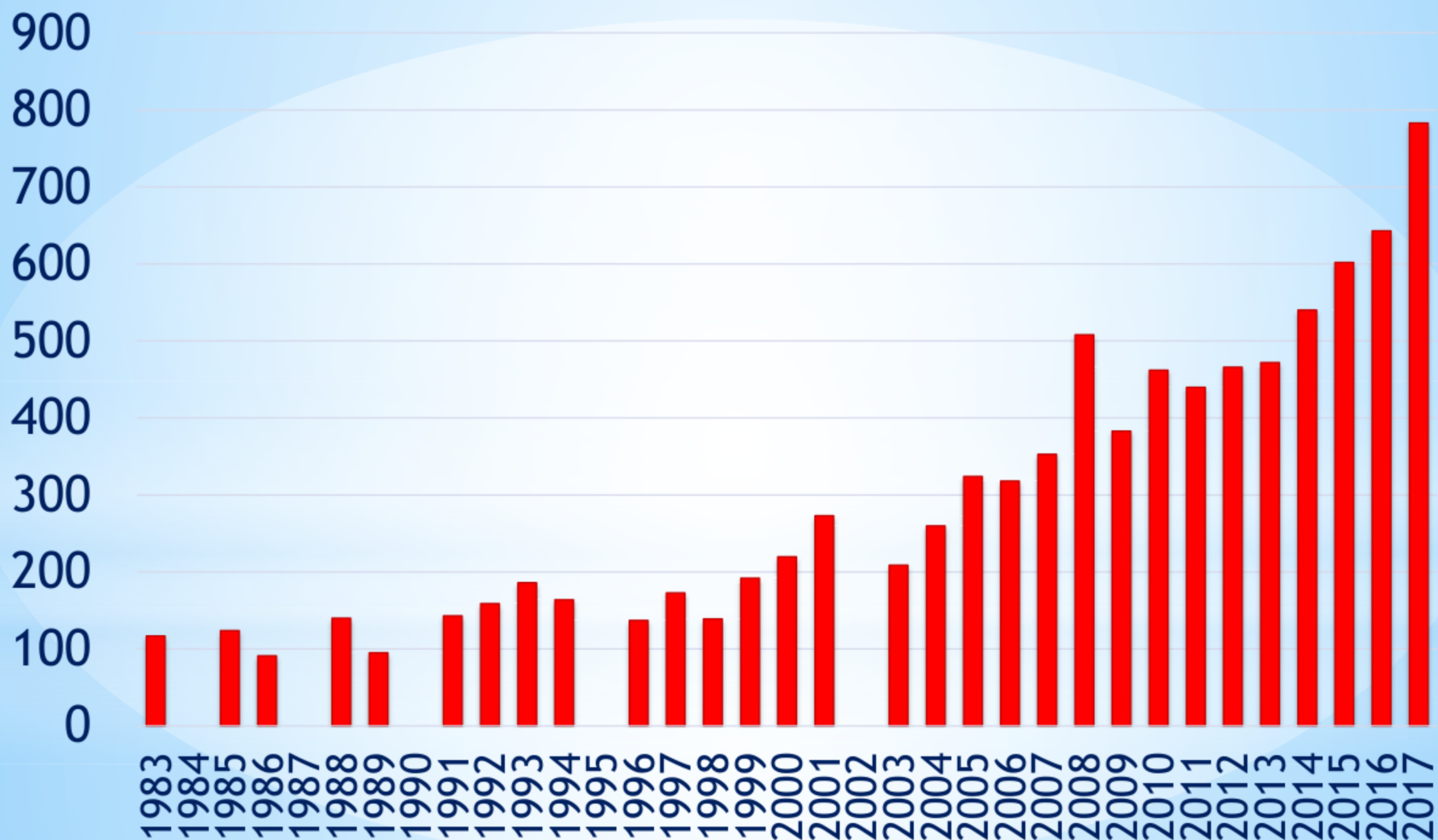
(strong dominant industrial presence at conferences for recruitment)



CVPR GROWTH

Number of **papers** at CVPR

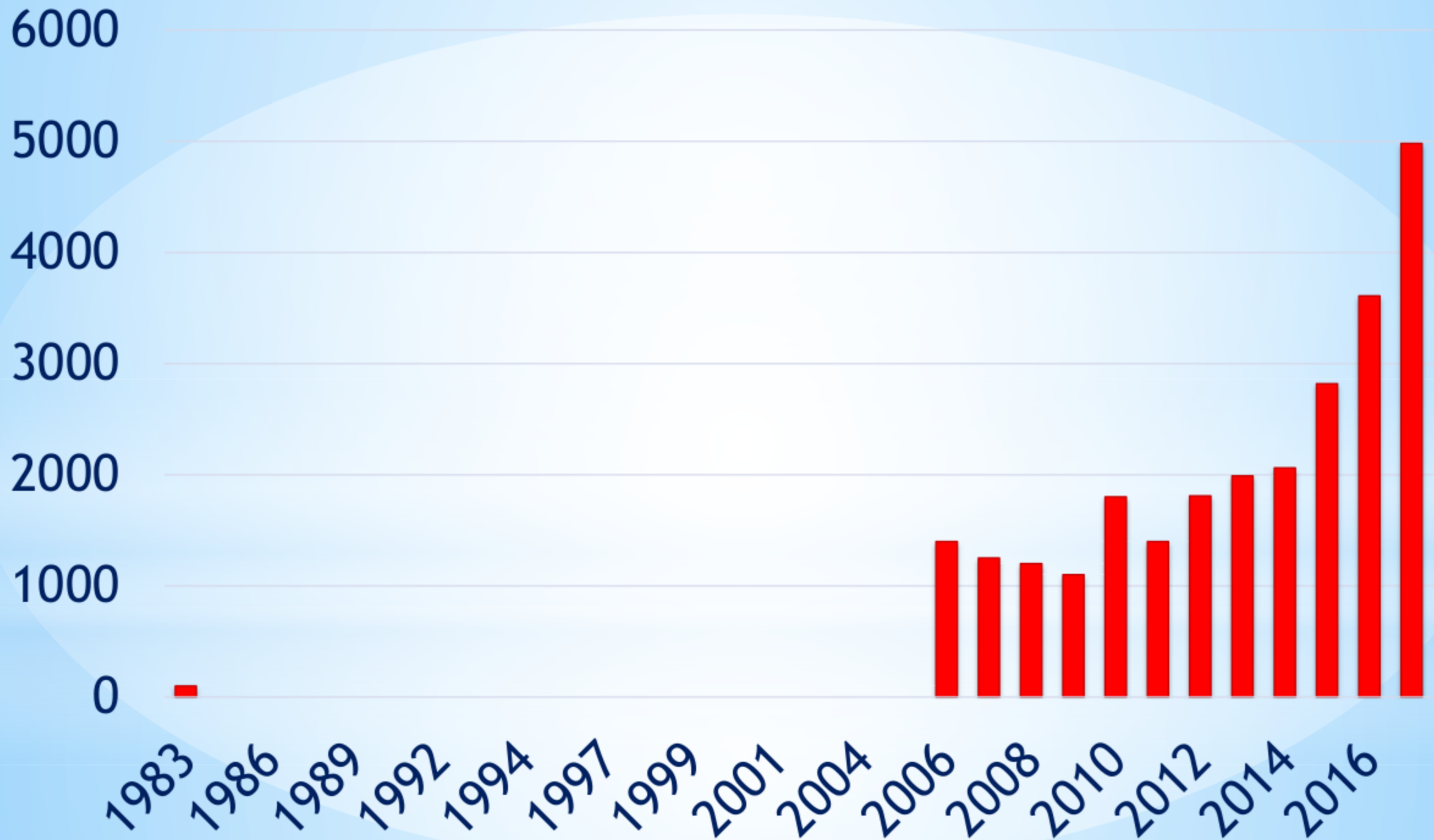
*Original slide
courtesy of
CVPR 2016*



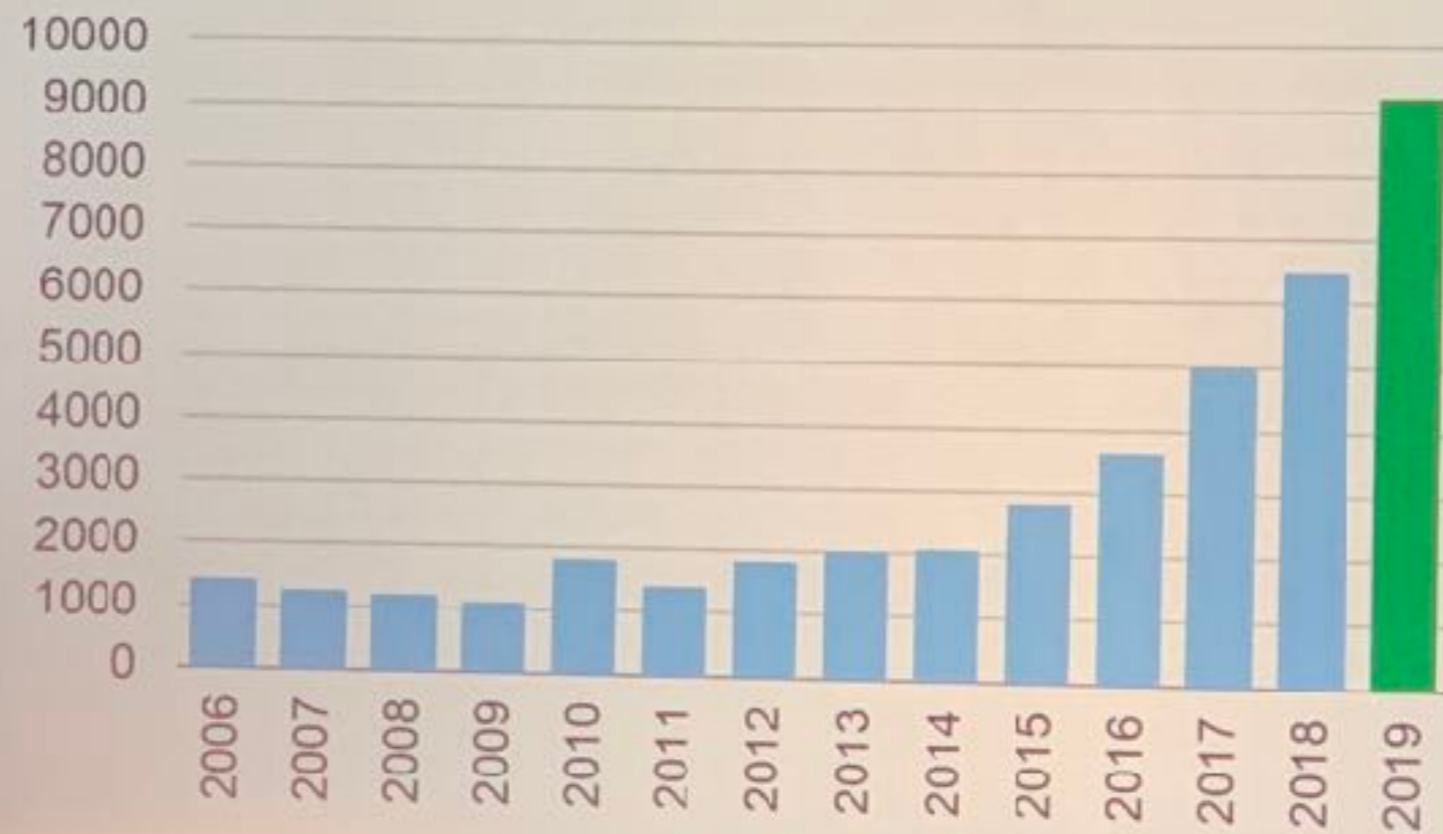
CVPR GROWTH

Number of **attendees** at CVPR

*Original slide
courtesy of
CVPR 2016*



CVPR Attendance Trend



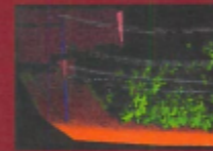
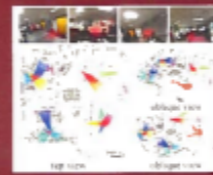
Computer vision at CMU

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



Carnegie Mellon
THE ROBOTICS INSTITUTE



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
JULIE GOLDSTEIN (JGOLDS@CS.CMU.EDU), 412-268-4017

Carnegie Mellon University
5000 Forbes Avenue, Pittsburgh, PA 15232
ms-cv@ri.cmu.edu

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/22432>

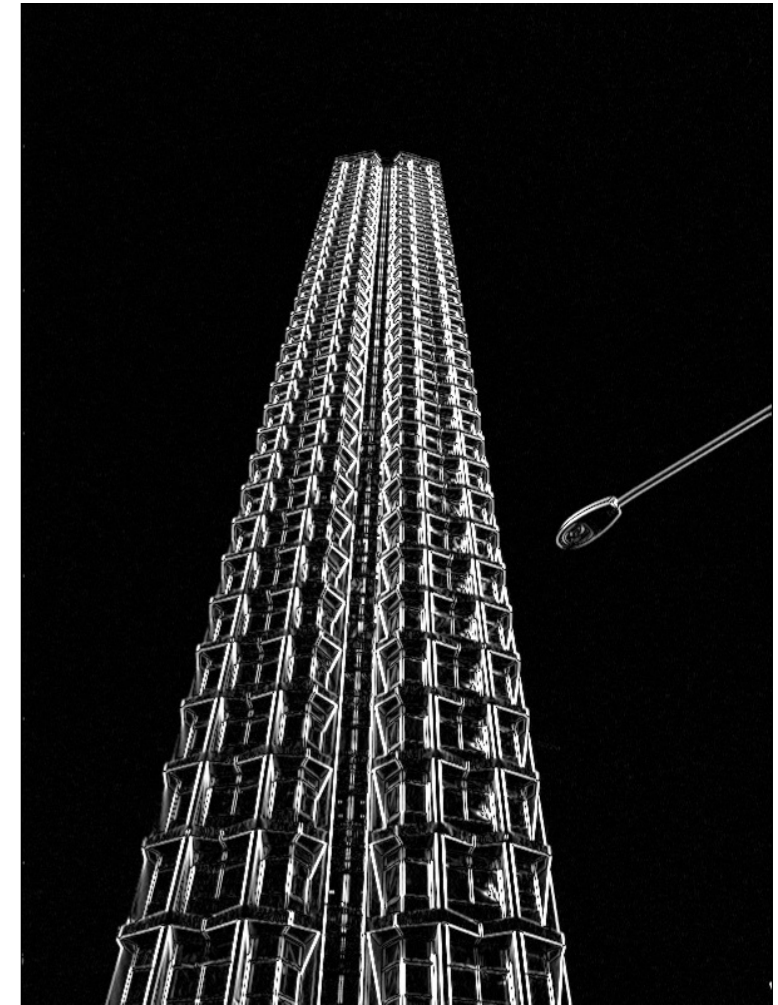
Discussion & Notes piazza

<https://piazza.com/class/kkkab1jgrqg4ww>

Topics to be covered

Image processing:

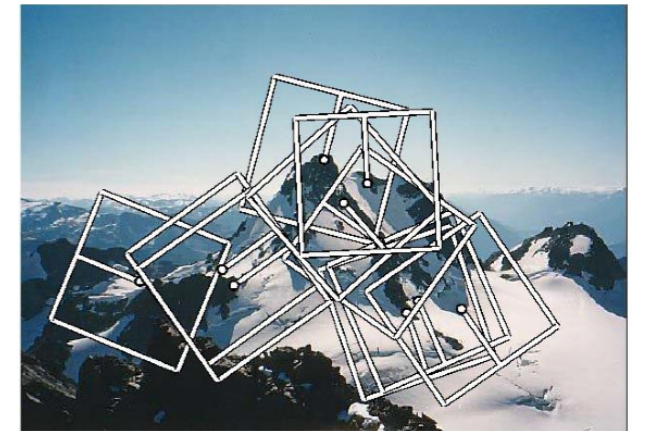
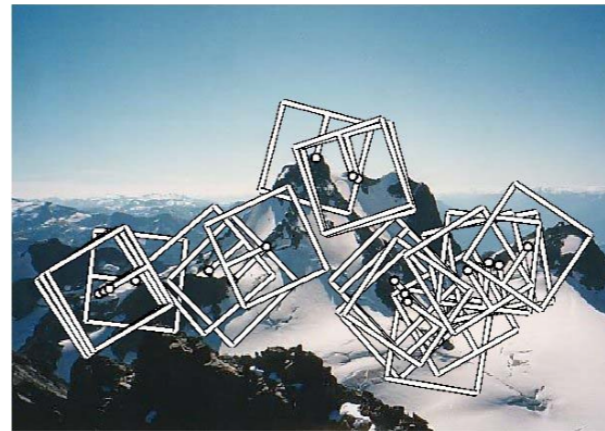
- Basics of filtering.
- Image pyramids.
- Gradients and lines.
- Hough transforms.



Topics to be covered

Feature detection and correspondences:

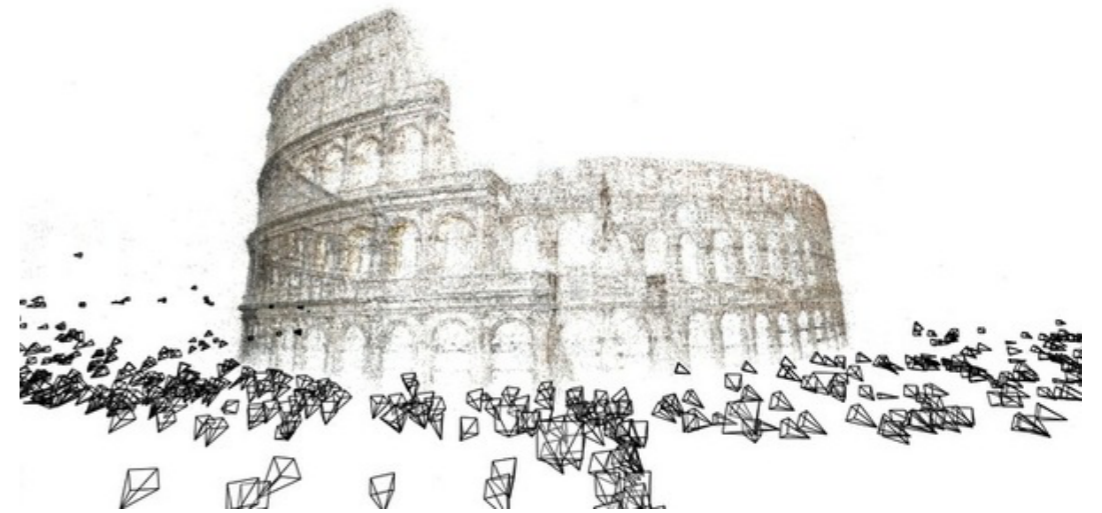
- Corner detection.
- SIFT et al.
- Feature descriptors.
- RANSAC.



Topics to be covered

Transformations and geometry:

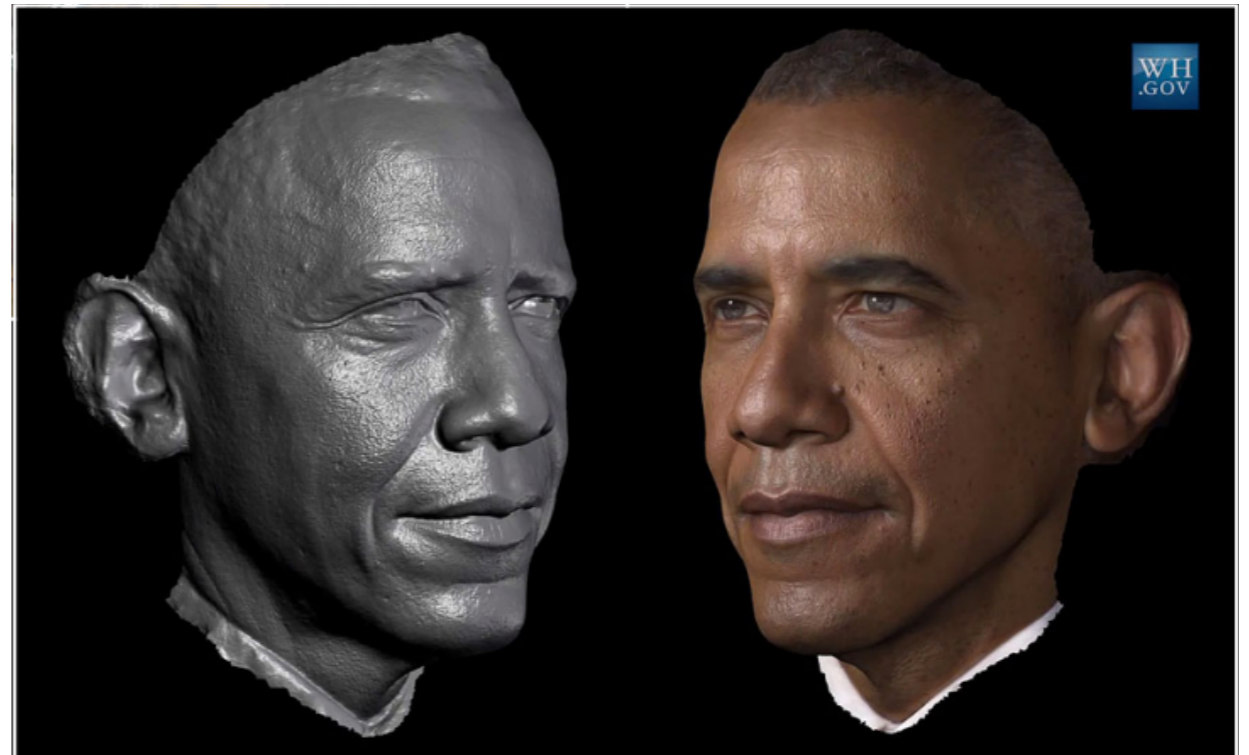
- Homographies and image alignment.
- Camera models.
- Fundamental matrix.
- Epipolar geometry and stereo.
- Structure from motion.



Topics to be covered

Physics-based vision:

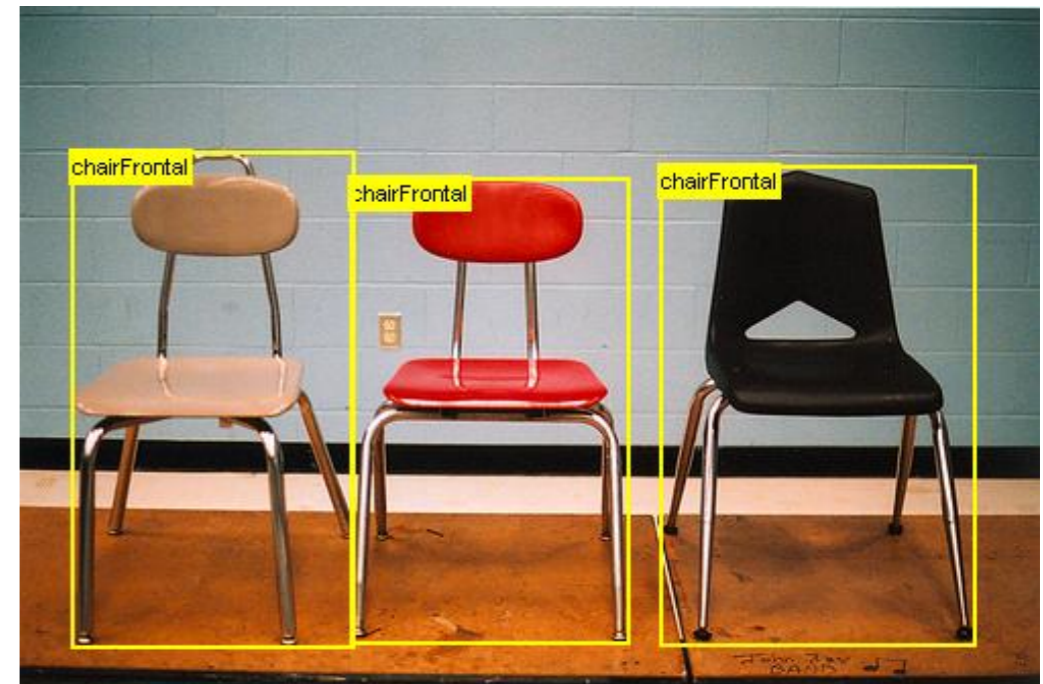
- Reflectance and image formation.
- Radiometry.
- Shape from shading.
- Photometric stereo.
- Color.



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:

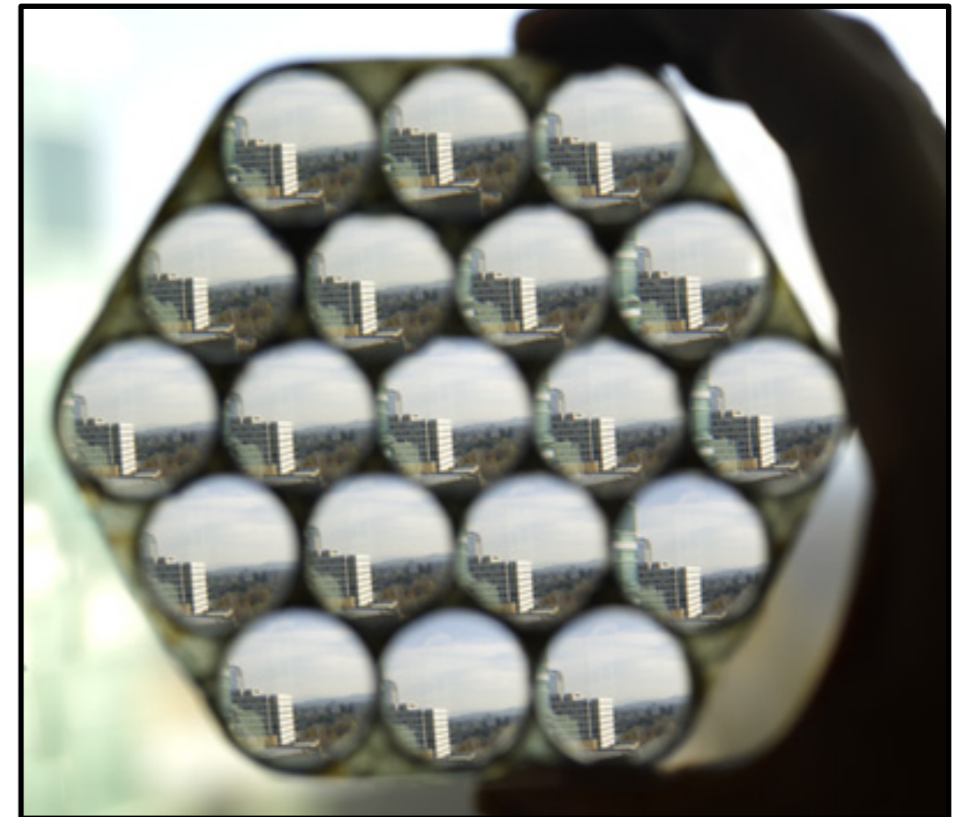
- Optical flow (LK, HS).
- Image registration.
- Kalman Filtering.
- Tracking (KLT, Mean-Shift).



Topics to be covered

Special topics:

- Computational photography.
- ???



Grading

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

Participation:

- Be online for lectures and participate in chat (if possible).
- Post on Piazza and course website.
- Ask (and answer) questions.

Programming Assignments

- a lot of programming in Python.
- hours and hours of programming.
- days and days of debugging.
- generous grading policy (like grad school)
- take advantage of extra credit

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

Programming Assignments

- a lot of programming in Python.
- hours and hours of programming.
- days and days of debugging.
- generous grading policy (like grad school)
- take advantage of extra credit

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

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

Leniency

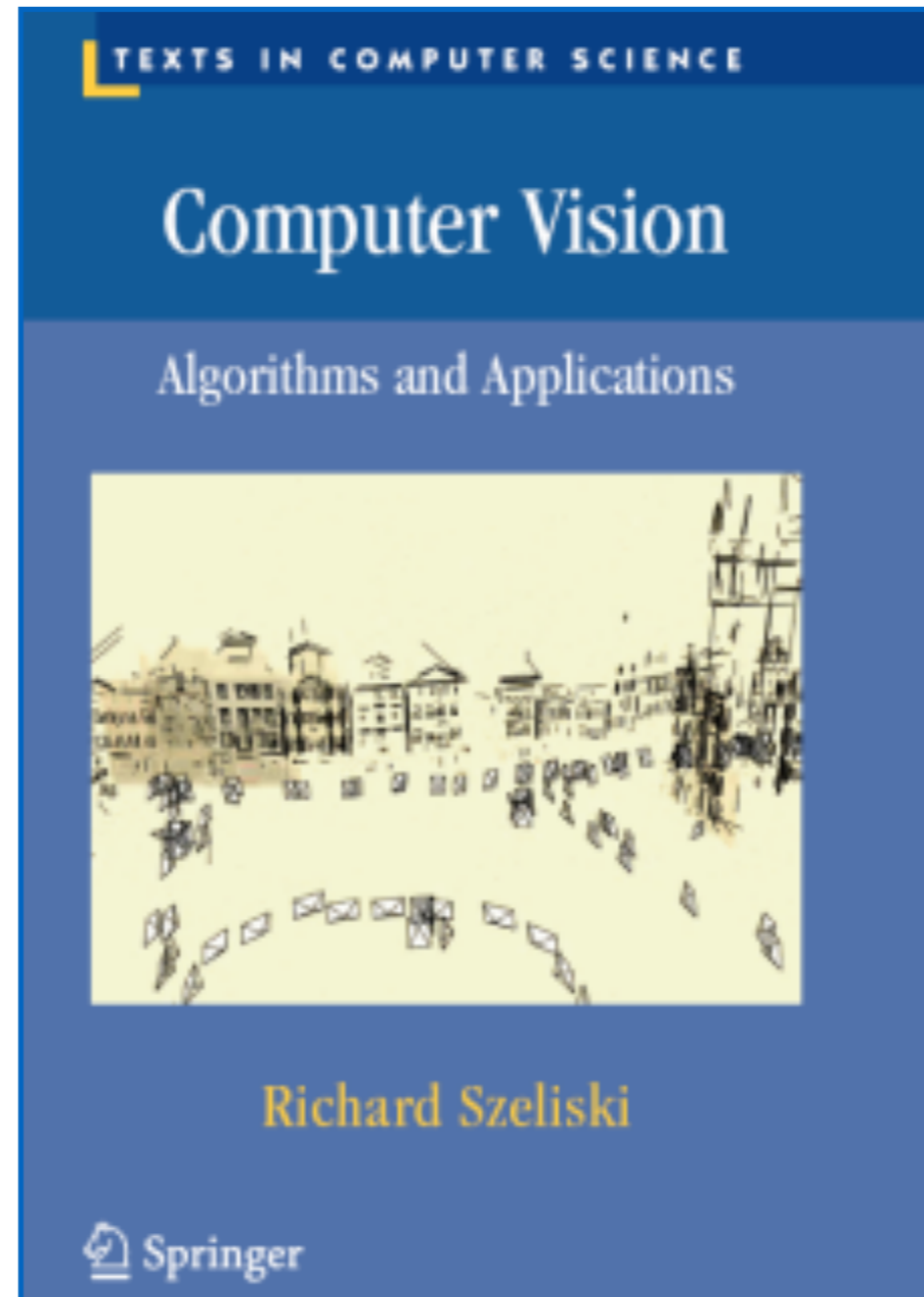
Late days for programming assignments:

- 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 Matt about additional office hours.

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

Please take the course survey
before the next lecture!



(also posted on Piazza)