

Introduction



Overview of today's lecture

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

Teaching staff introductions

Instructor: Ioannis (Yannis) Gkioulekas

I won't hold it against you if you mispronounce my last name



Originally from Greece



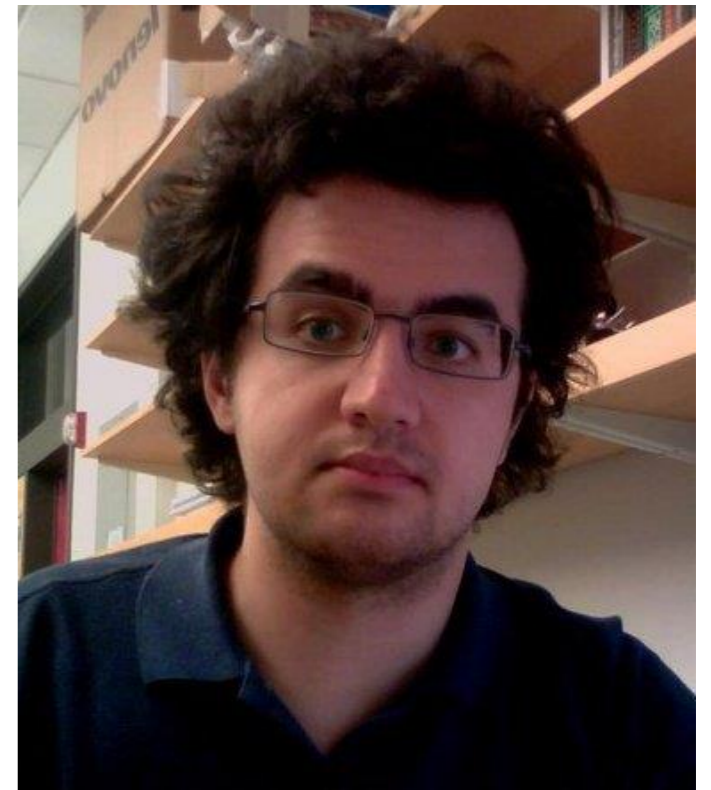
National Technical University of Athens (2004-09)



Harvard University (2009-17)



Carnegie Mellon University (2017-now)



me at Harvard in 2011
(obviously need new photo)

My website: <http://www.cs.cmu.edu/~igkioule>

Building a scatterometer

Camera for measuring parameters of scattering materials

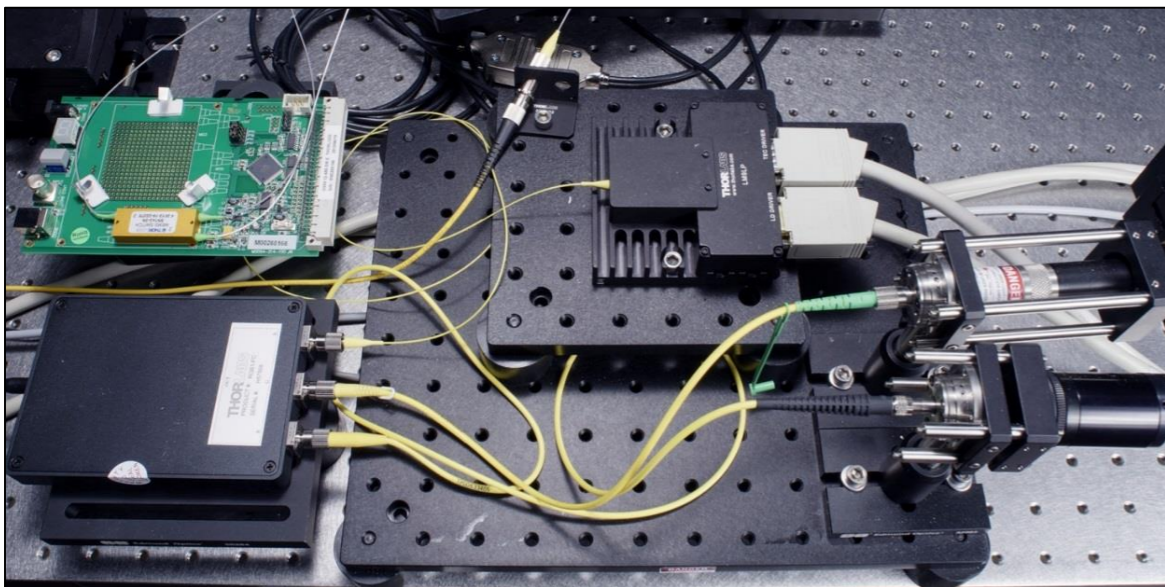
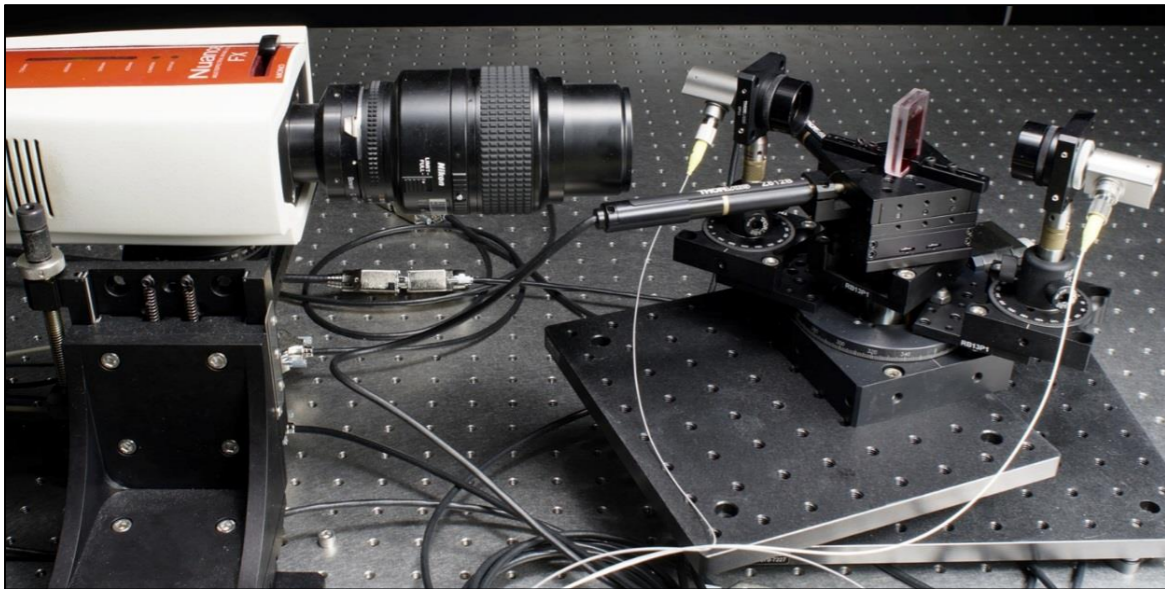
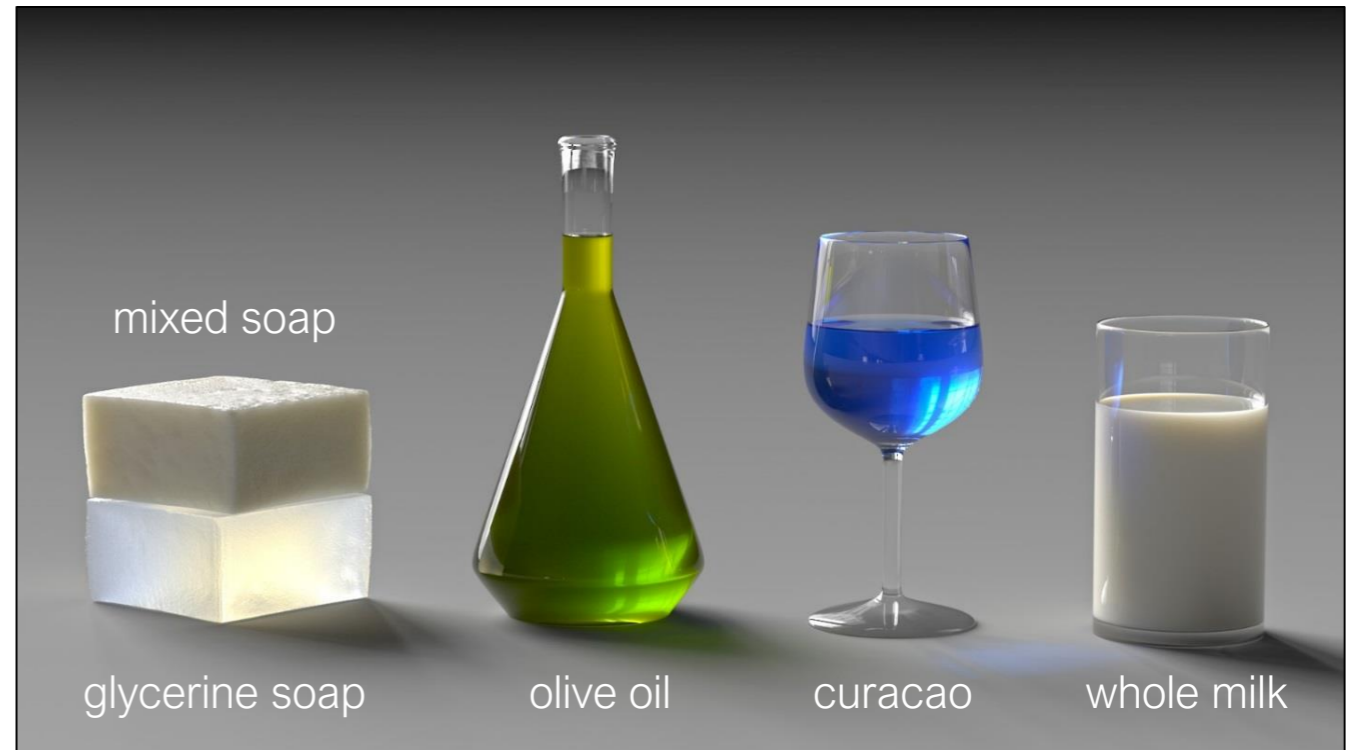
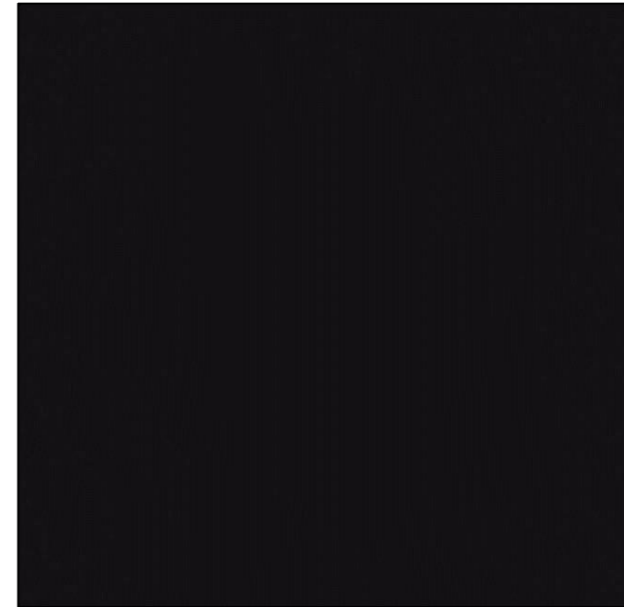
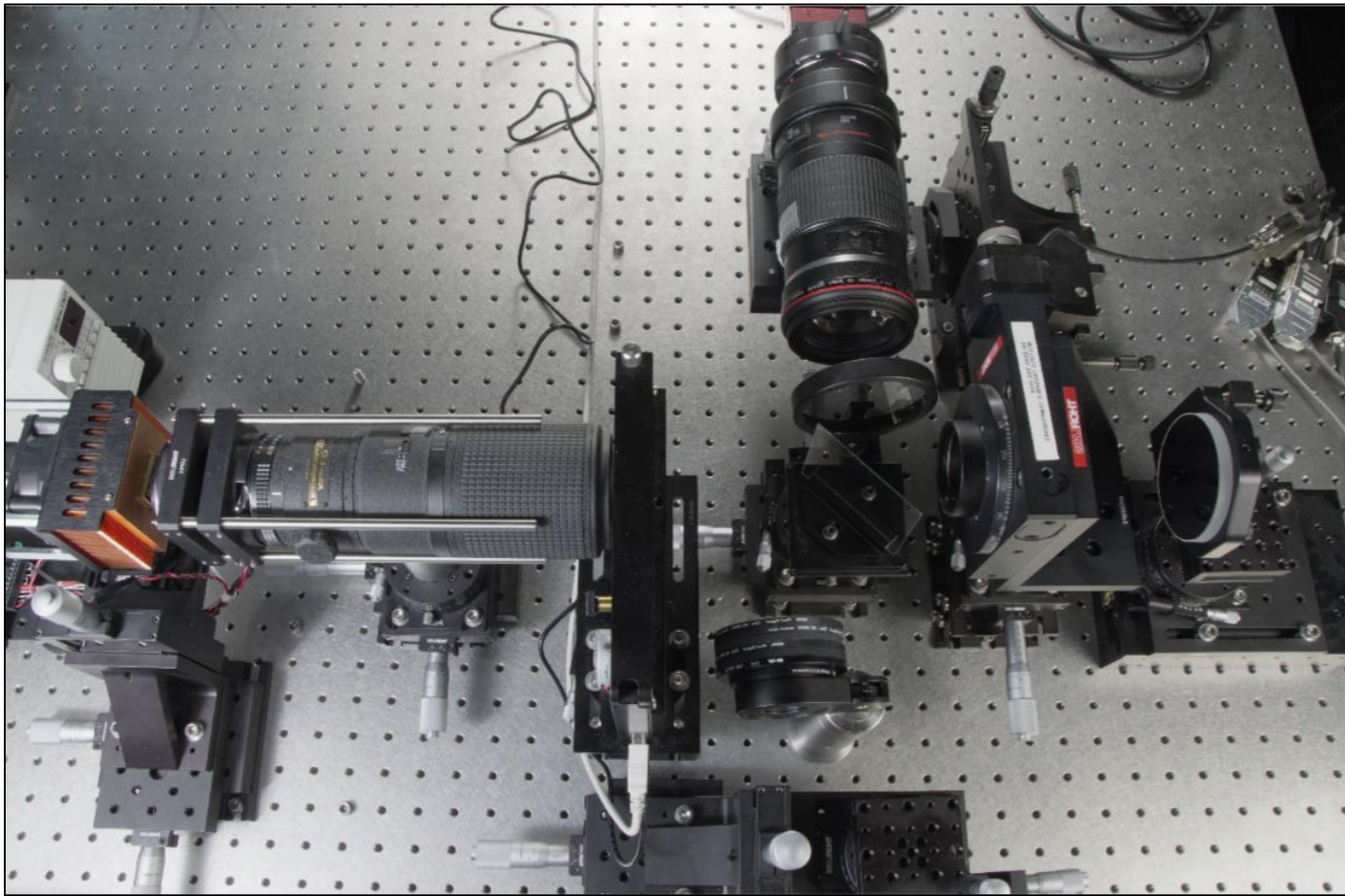


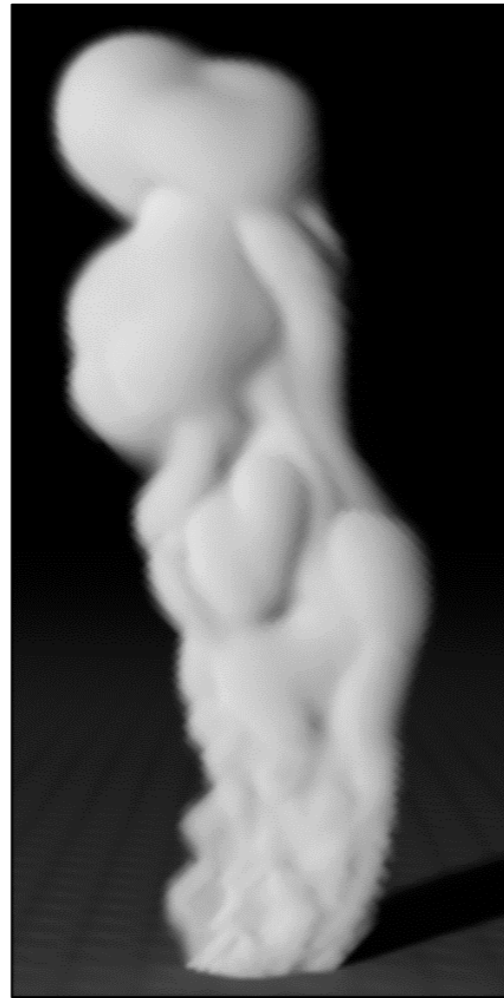
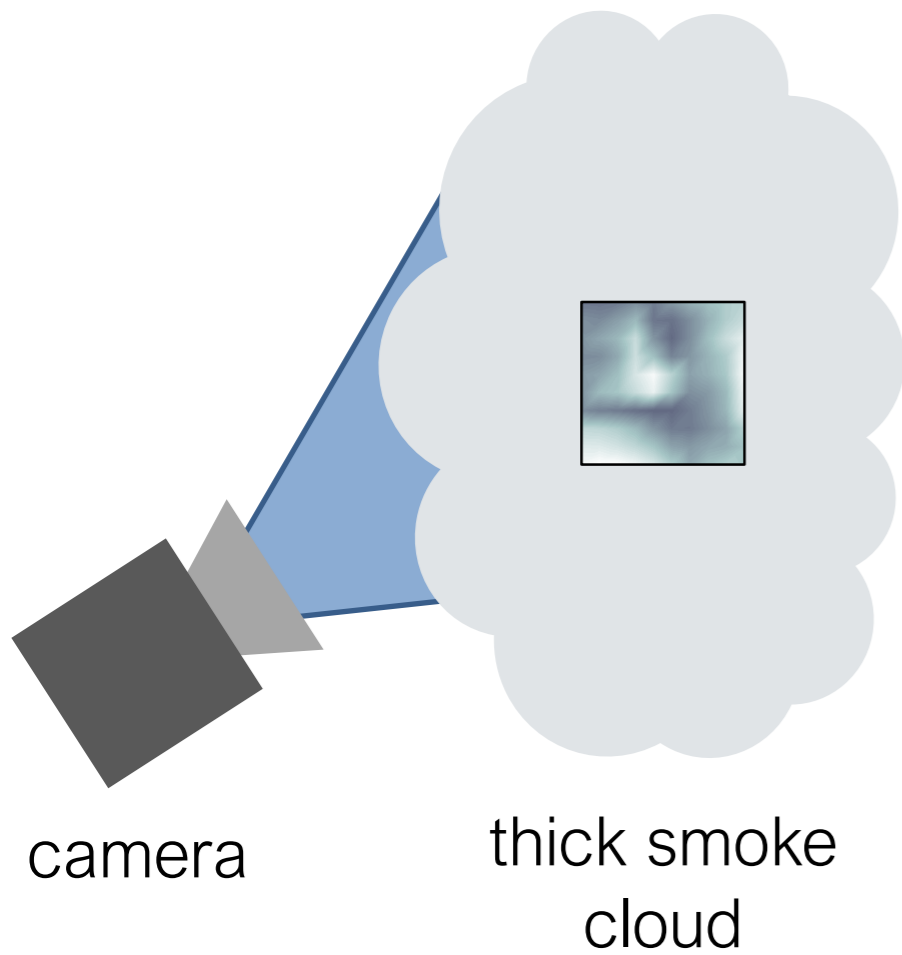
image synthesized from measurements



Quadrillion FPS video



Seeing inside objects



what a regular camera sees

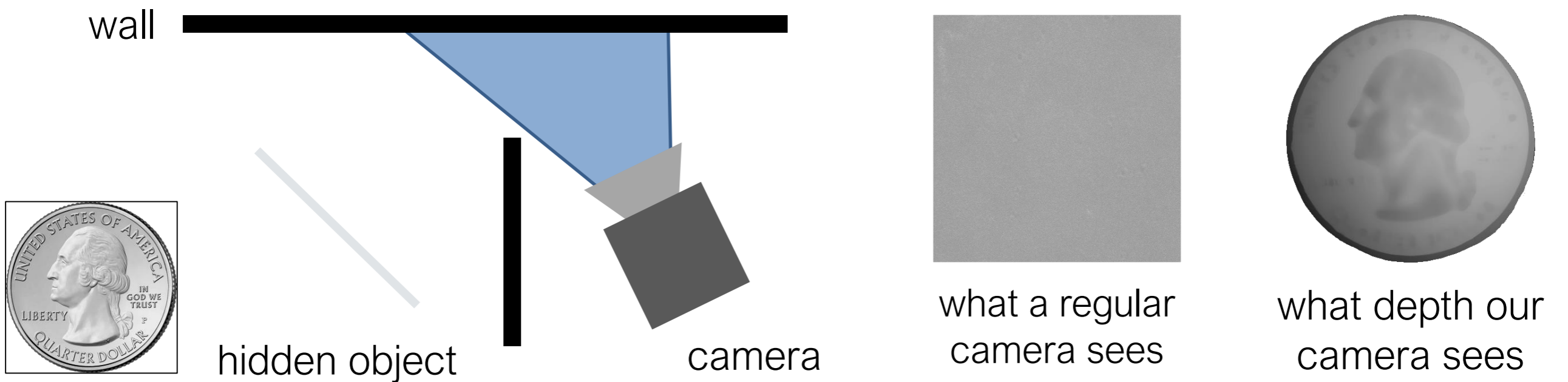
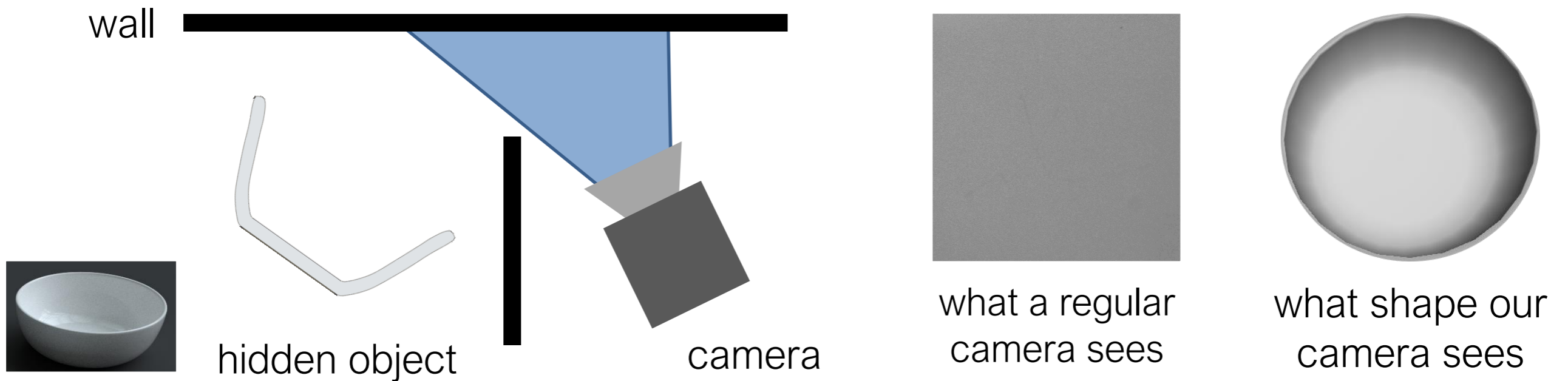


what our camera sees



a slice through the cloud

Seeing around walls



TA: Sharvani Chandu

Master of Science in Computer Vision (MSCV)

Research Interests

Multimodal machine learning, Deep Learning,
Medical Image Processing

Current Area of Research

Sony Chef – Learning a Simulator for Cooking
(under Prof. Katerina)

Past Research

- Micro Aneurysm detection using deep learning
- Automatic target extraction from satellite images
- Text summarization and intent extraction from documents



TA: Chengqian Che(Bruce)

Ph.D in Robotics

Research Interests

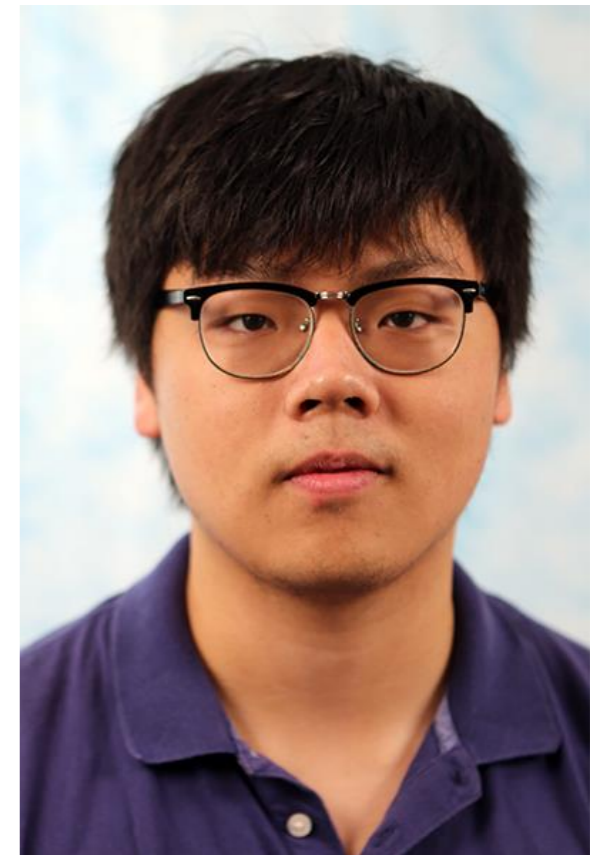
Physics-based Vision; Computer graphics; Deep learning

Current Research area

Inverse rendering/ Differentiable rendering; Material inference

Past Research

Medical imaging analysis; Ultrasound imaging segmentation/registration



TA: Abhay Gupta

- **Master of Science in Computer Vision (MSCV)**
- **Research Interests:**
 - Multi-View Stereo, Video Context Understanding, Visual Reinforcement Learning
- **Current Areas of Research:**
 - Trajectory Prediction for Self-Driving Cars
- **Past Research:**
 - Partial Face Segmentation and Recognition
 - Action Recognition in Videos
 - Emotion Recognition in Videos



TA: Anshuman Majumdar

Master of Science in Computer Vision

Research Interests

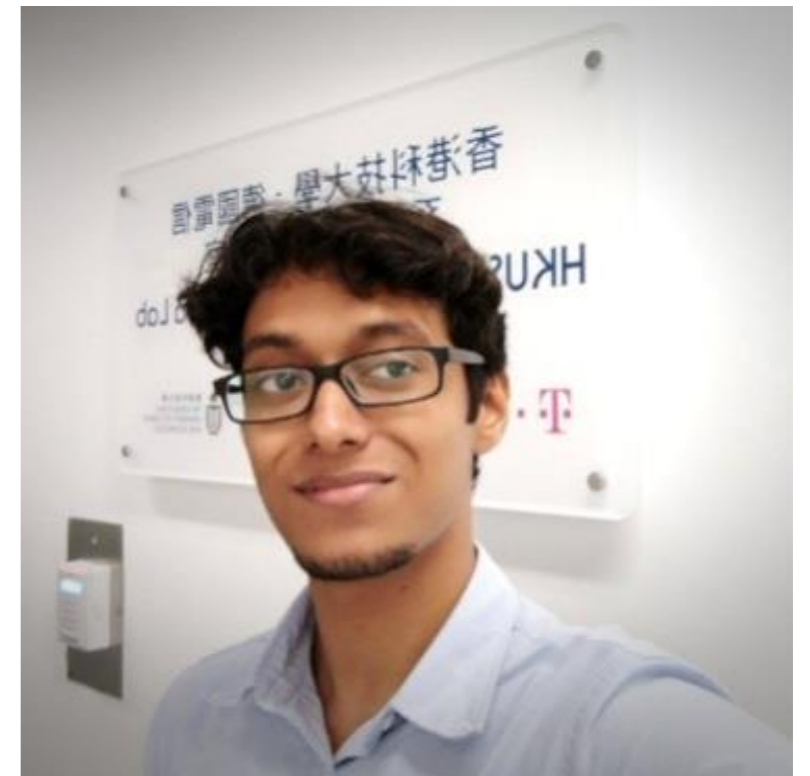
Object Detection, Tracking and Pose Estimation
SLAM and Tracking for AD/AR/VR
OCR and Analysis of Handwritten Document Images

Current Area of Research

Visual Inspection for Aircraft and Power Lines

Past Research

- Robust 6-DoF Positional Tracking in presence of Motion Blur for AR/VR
- Monocular Reconstruction of Vehicles on Graded Roads in Dynamic Scenes
- Roadsign Detection, Tracking and Classification
- Visual Aesthetic Analysis for Handwritten Document Images



TA: Neeraj Sajjan

Master of Science in Computer Vision[MSCV]

Research Interests:

3D Vision, Deep Learning, Object Detection and Tracking

Current Area of Research:

Deep 3D Mesh Reconstruction

Past Research:

- 3D Object Detection and Tracking
- Crowd Counting
- Overlapped Speech Detection



What is
computer vision?



What a person sees

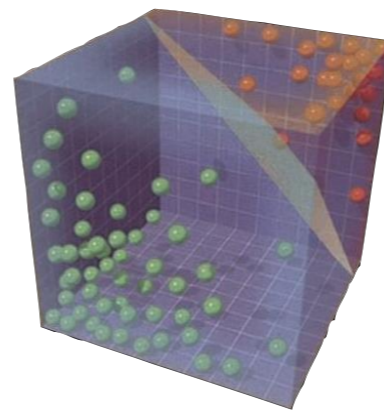


Why are we able to interpret this image?

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

typical perception pipeline

representation



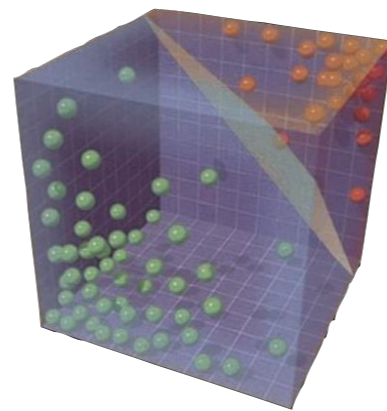
'fancy math'



output

typical perception pipeline

representation



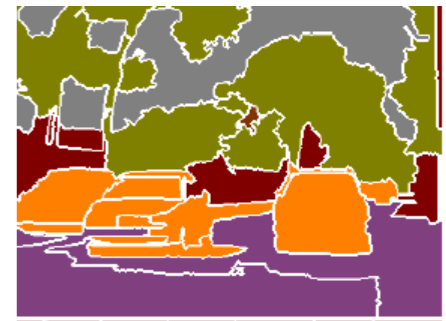
'fancy math'



output



what should we look at?
(image features)



what can we understand?
(semantic segmentation)

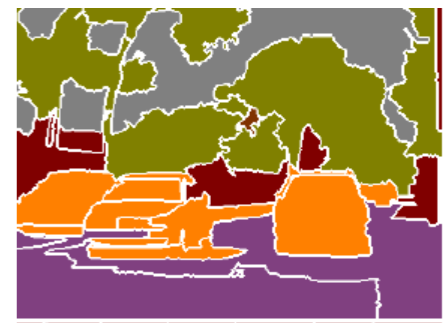
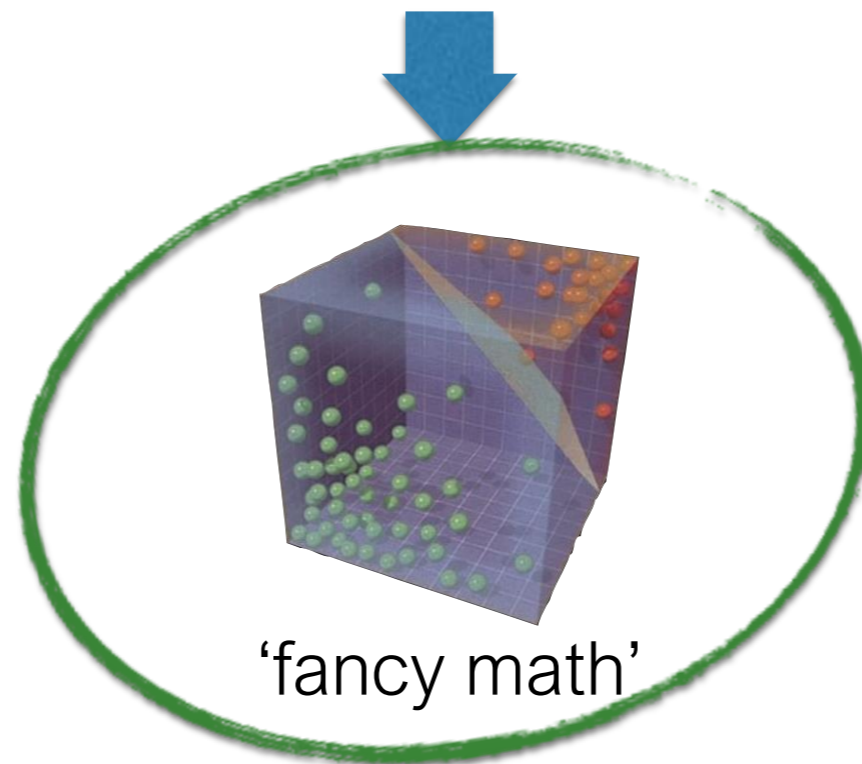
typical perception pipeline

representation



what should we look at?
(image features)

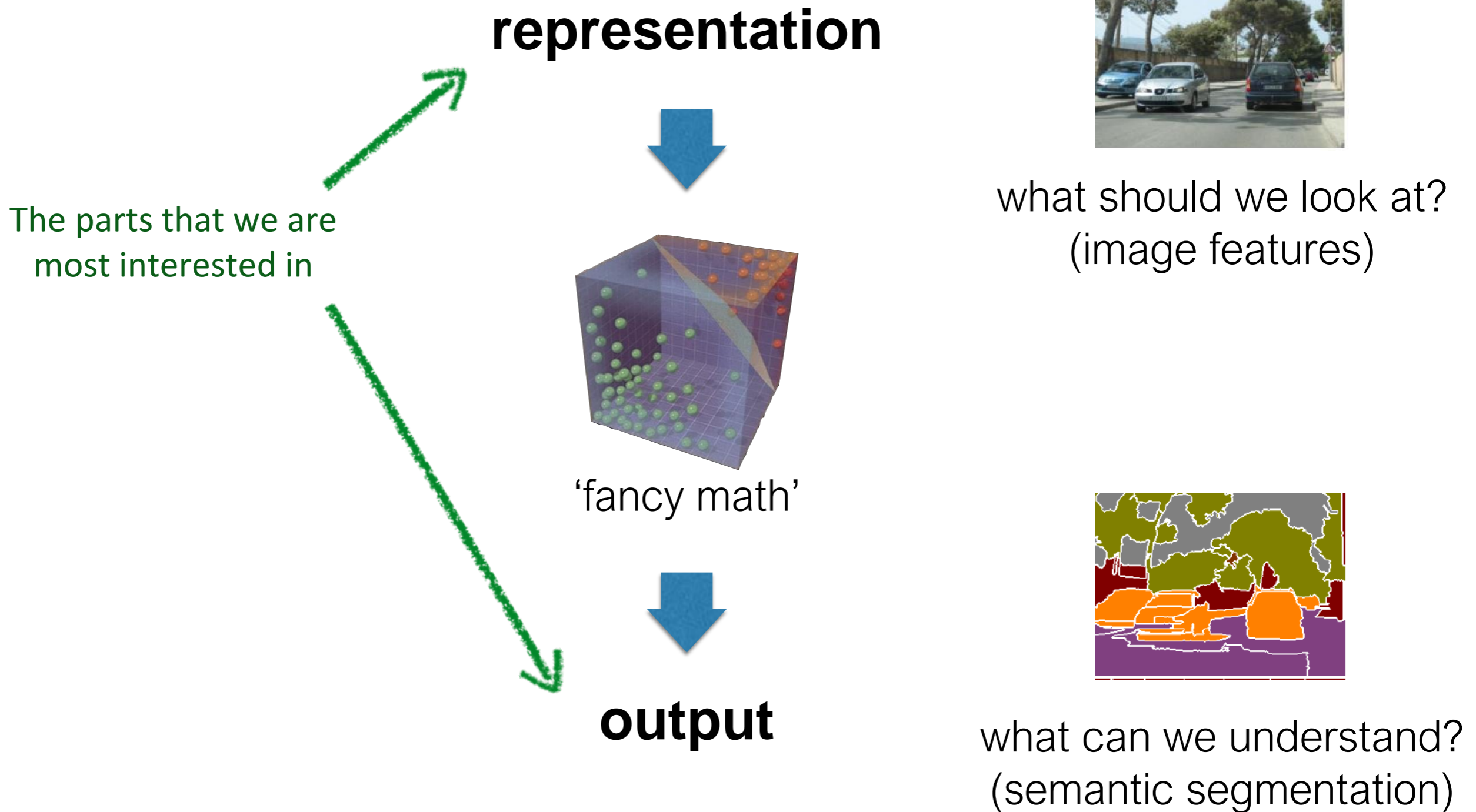
easy to get lost in
the techniques



what can we understand?
(semantic segmentation)

output

typical perception pipeline



Important note:

In general, computer vision does not work

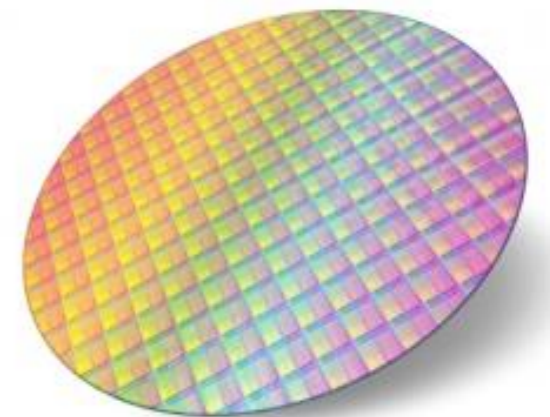
Important note:

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

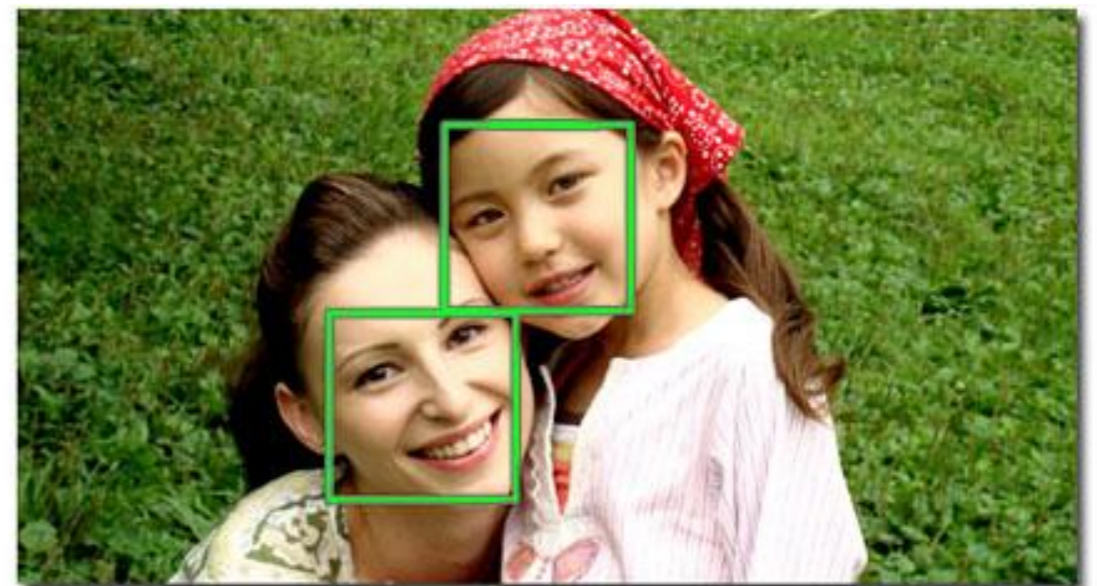
Face detection



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

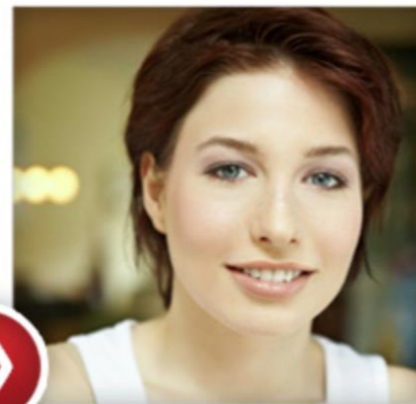
BROWSE LOOKS

TRENDS

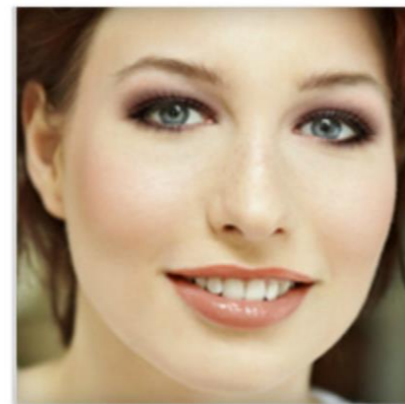
ADVICE

ABOUT

Creating
your own
new look
is easy



1. Upload your photo

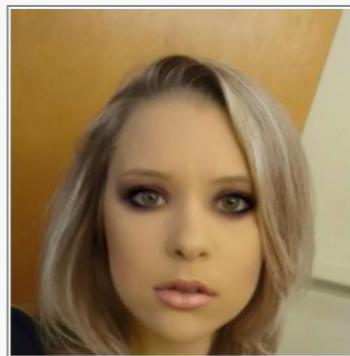


2. Apply some makeup



3. Choose a hairstyle

try
it
now!



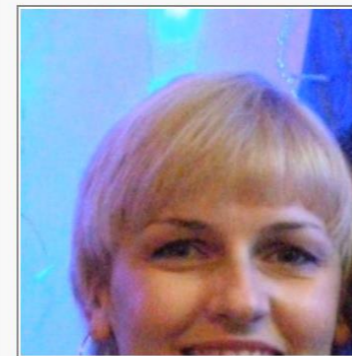
TODAY'S FEATURED MAKEOVER

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!





- Snap It! Results**
-  **Red Maple**
Acer rubrum
 -  **Striped Maple**
Acer pensylvanicum
 -  **Sycamore Maple**
Acer pseudoplatanus

- ⓘ
- ⓘ
- Ilex opaca*
- American Hornbeam**
Carpinus caroliniana
- American Linden**
Tilia americana
- American Sycamore**
Platanus occidentalis
- Amur Corktree**
Phellodendron amurense
- Q
A
B
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S
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U
V
W
Y
- Home Browse Collection Options Snap It!



Word Lens



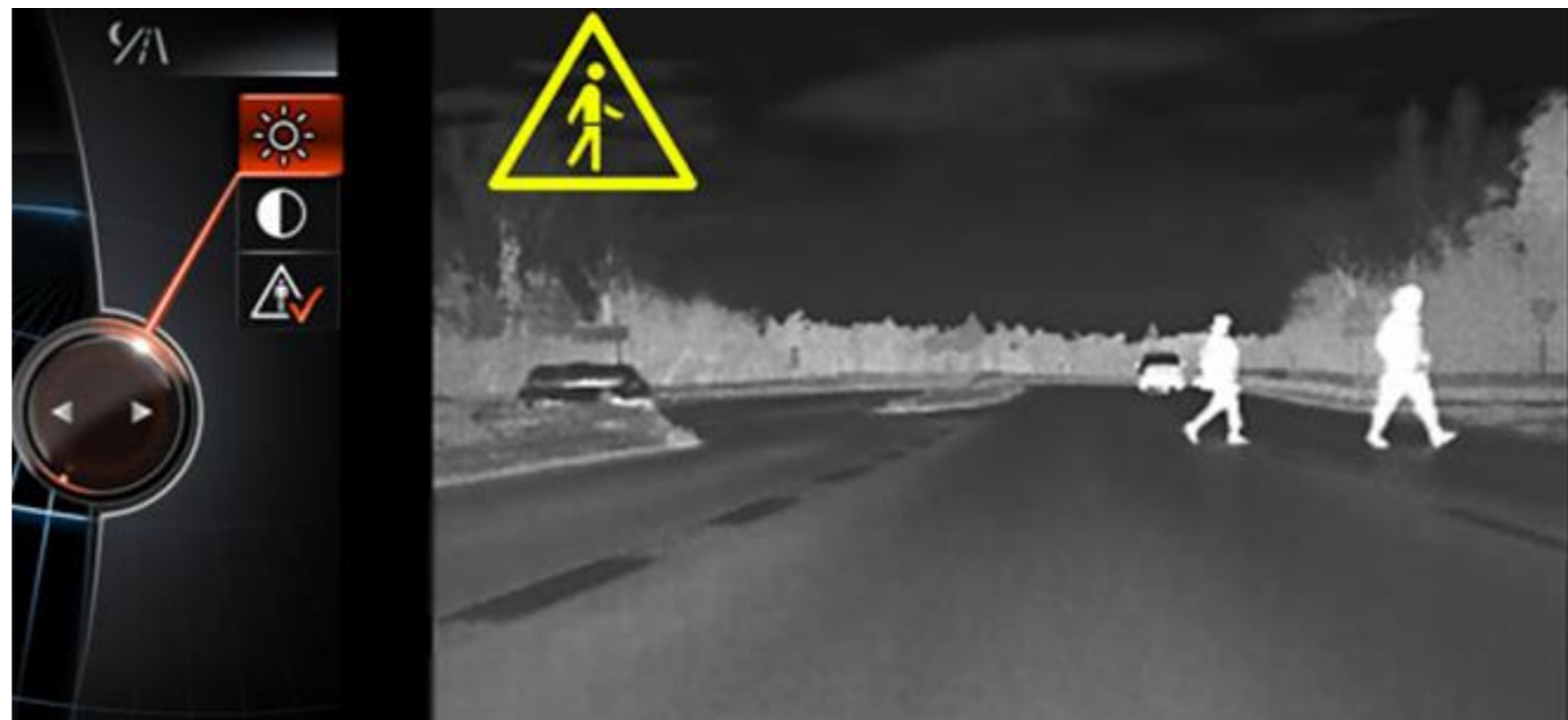
Word Lens

www.QuestVisual.com



BMW 5 series

BMW night vision





“Around view” camera

Infinity 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



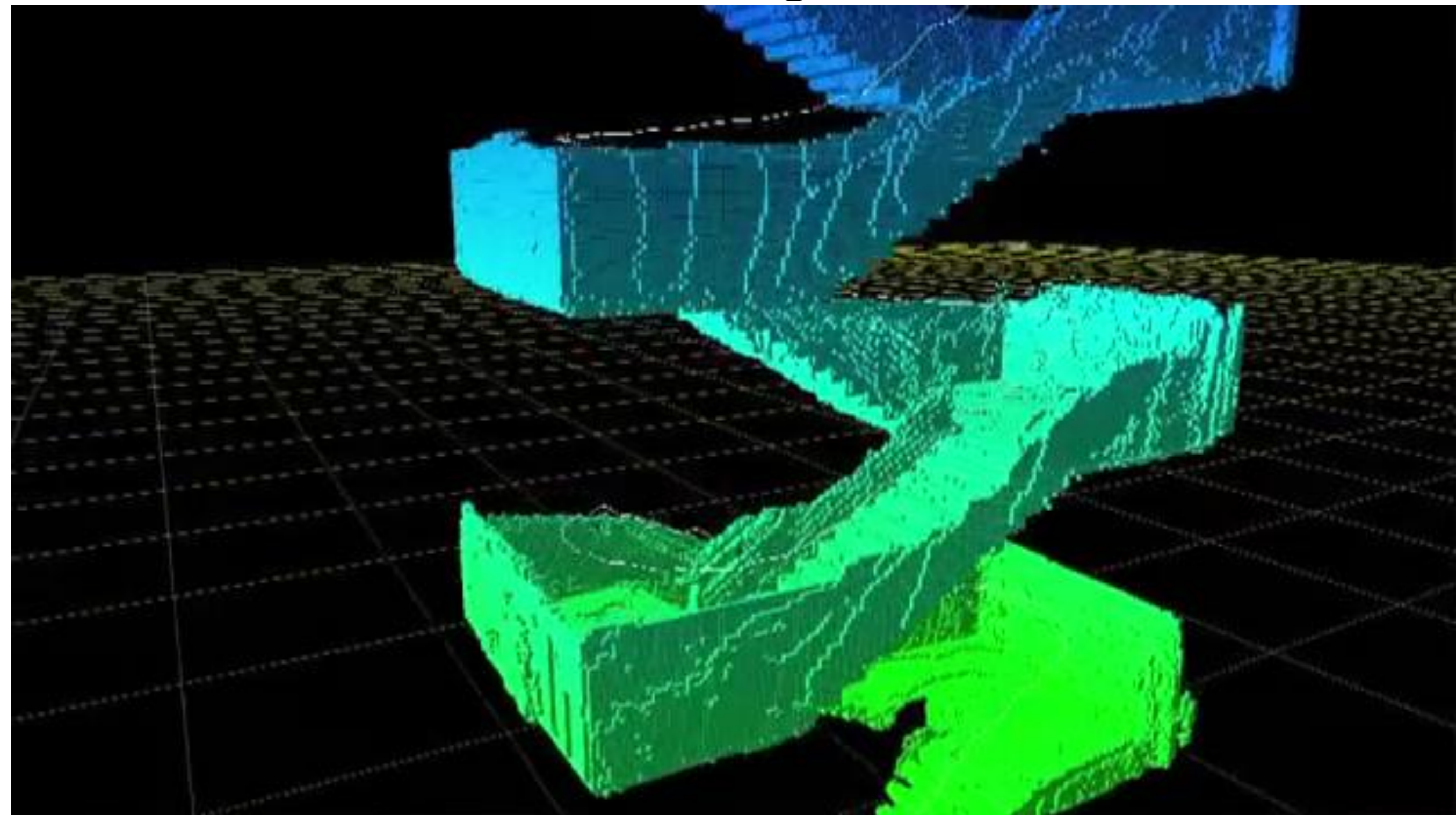
Image stitching



Photosynth



Tango



Virtual Fitting



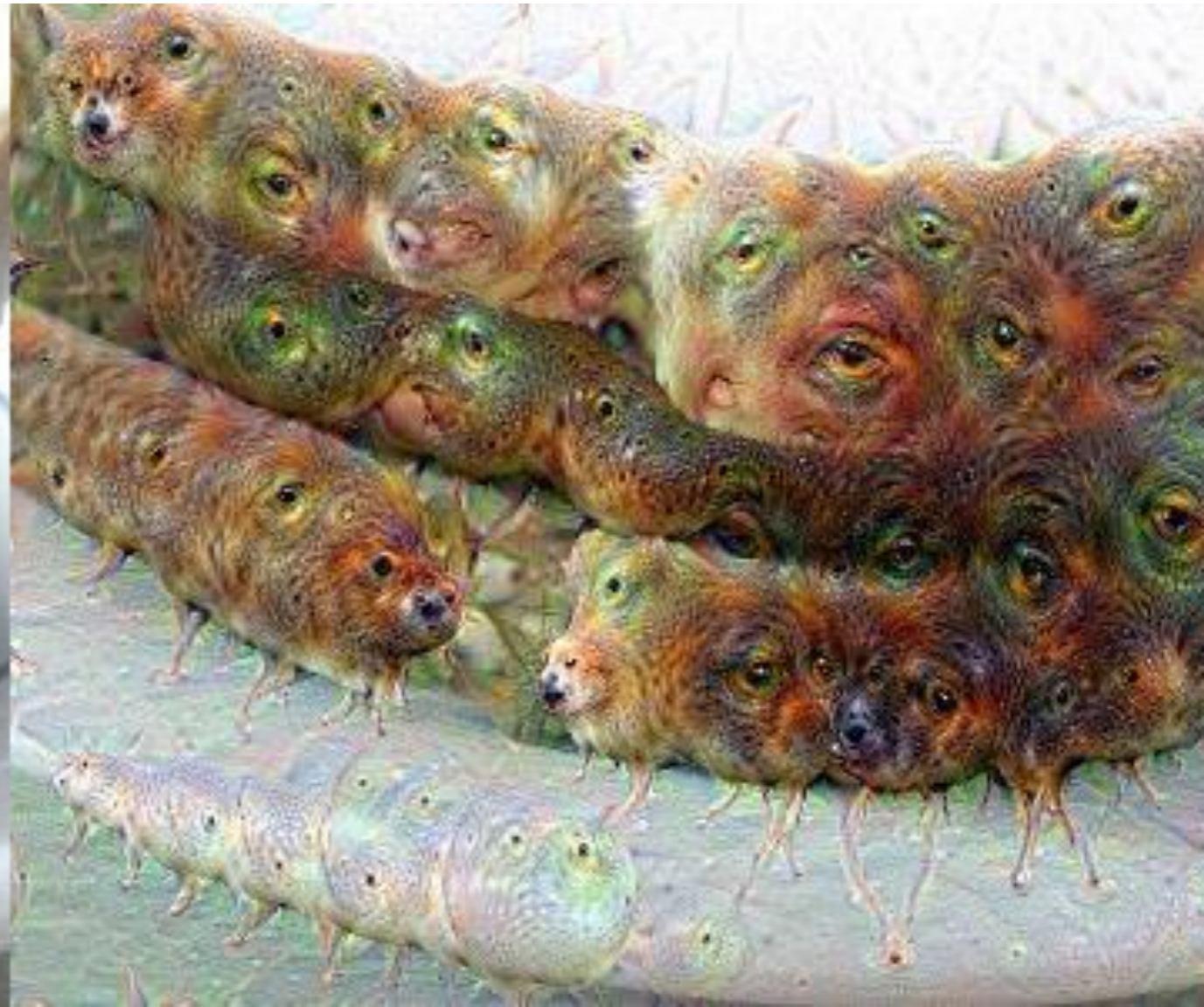
Computer Vision for VR



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

(this slide is already out of date by at least 3 CMU faculty)

The image displays a collection of portraits of university faculty members and logos of companies that have hired them. The companies shown include Amazon.com, Dropbox, Google, Oculus VR, and Uber. The universities listed are NYU, USC, UW, UCSD, Columbia, CMU, Stanford, Toronto, and UW. The portraits are arranged in a grid-like fashion, with some overlapping. The logos are placed between the portraits. The text 'amazon.com' is in a large, bold, black font with the orange arrow. The 'Dropbox' logo is a blue hexagon with a white 'D'. The 'Google' logo is in its multi-colored font. The 'Oculus VR' logo is a stylized eye. The 'Uber' logo is a black square with a white 'U'. The portraits are of various sizes and are placed around the logos. The text 'amazon.com' is in the center. The 'Dropbox' logo is to the right of the center. The 'Google' logo is below the center. The 'Oculus VR' logo is to the left of the center. The 'Uber' logo is below the center. The portraits are arranged in a grid-like fashion, with some overlapping. The text 'amazon.com' is in a large, bold, black font with the orange arrow. The 'Dropbox' logo is a blue hexagon with a white 'D'. The 'Google' logo is in its multi-colored font. The 'Oculus VR' logo is a stylized eye. The 'Uber' logo is a black square with a white 'U'. The portraits are of various sizes and are placed around the logos. The text 'amazon.com' is in the center. The 'Dropbox' logo is to the right of the center. The 'Google' logo is below the center. The 'Oculus VR' logo is to the left of the center. The 'Uber' logo is below the center. The portraits are arranged in a grid-like fashion, with some overlapping.

NYU USC UW UCSD Columbia

NYU UW amazon.com Dropbox

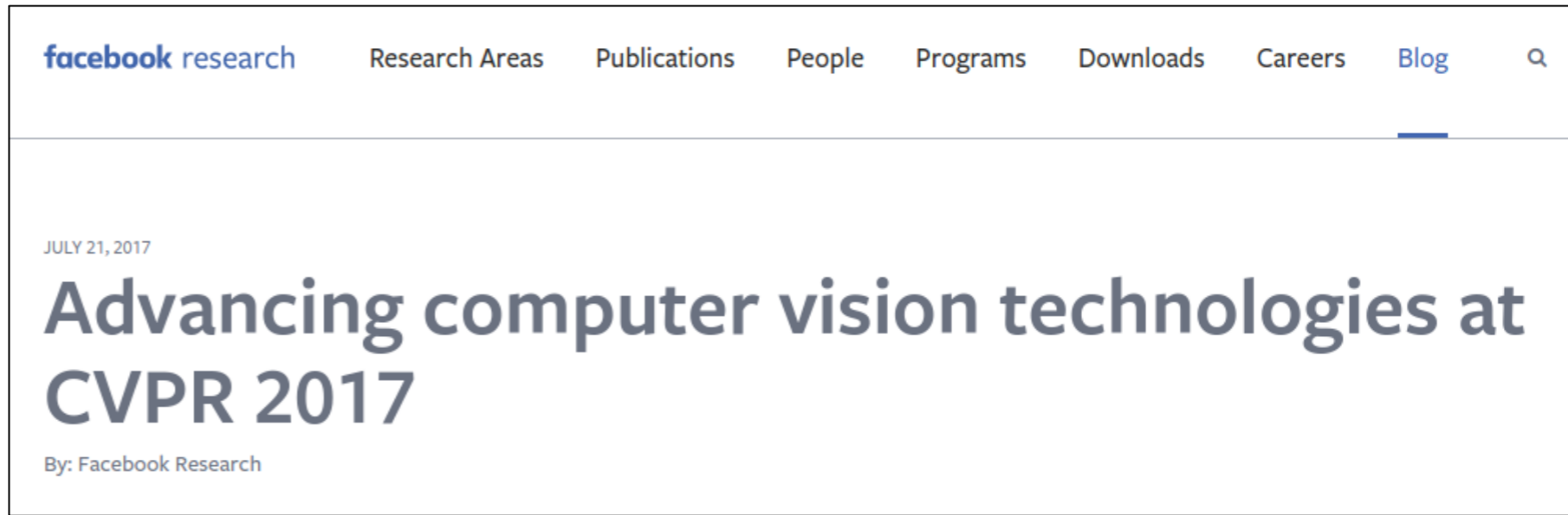
NYU UW

Oculus VR Uber Google

CMU CMU CMU CMU CMU Stanford Toronto UW

Industry aggressively hiring CV graduates, or even students!

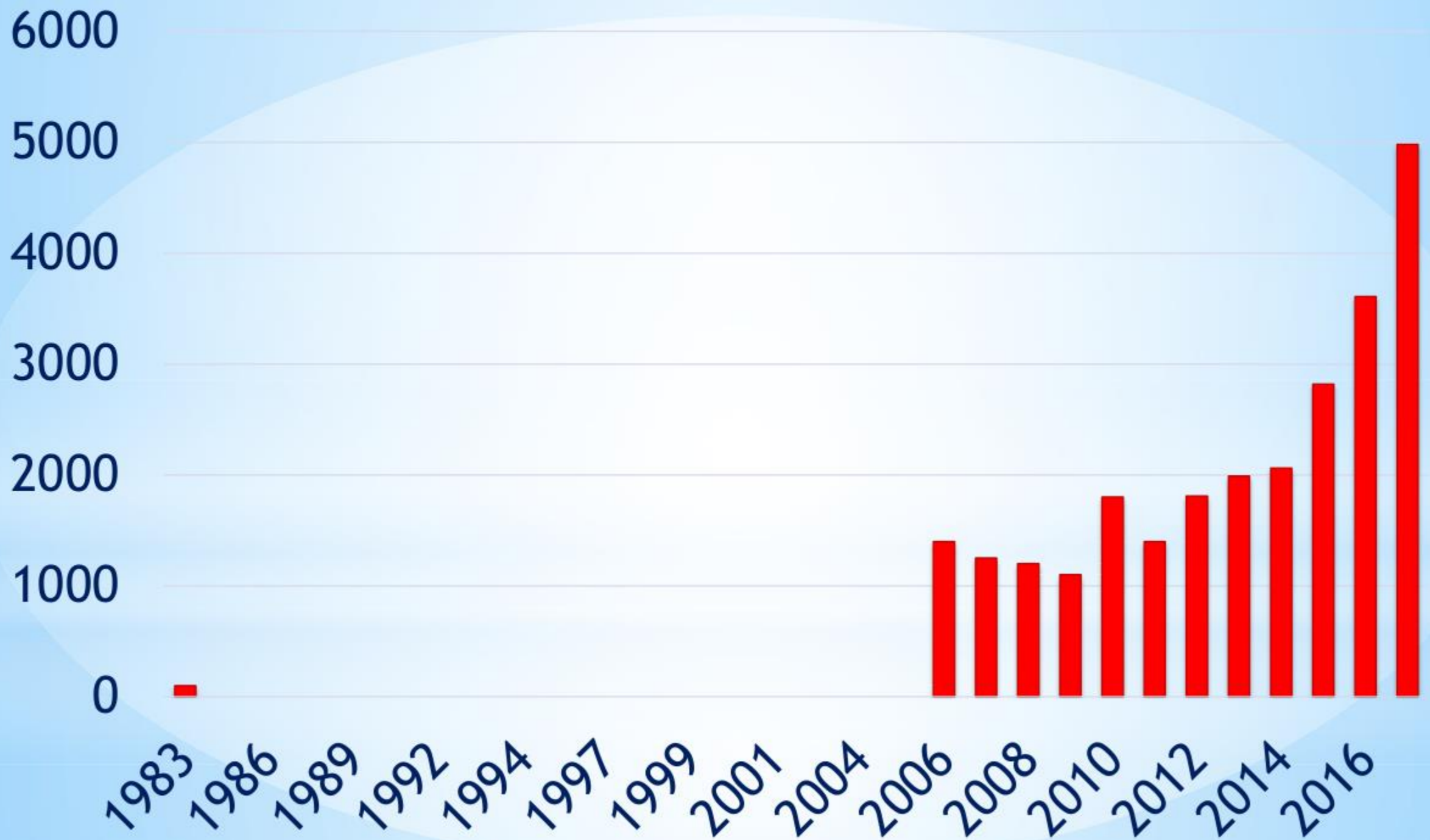
(strong dominant industrial presence at conferences for recruitment)



CVPR GROWTH

Number of **attendees** at CVPR

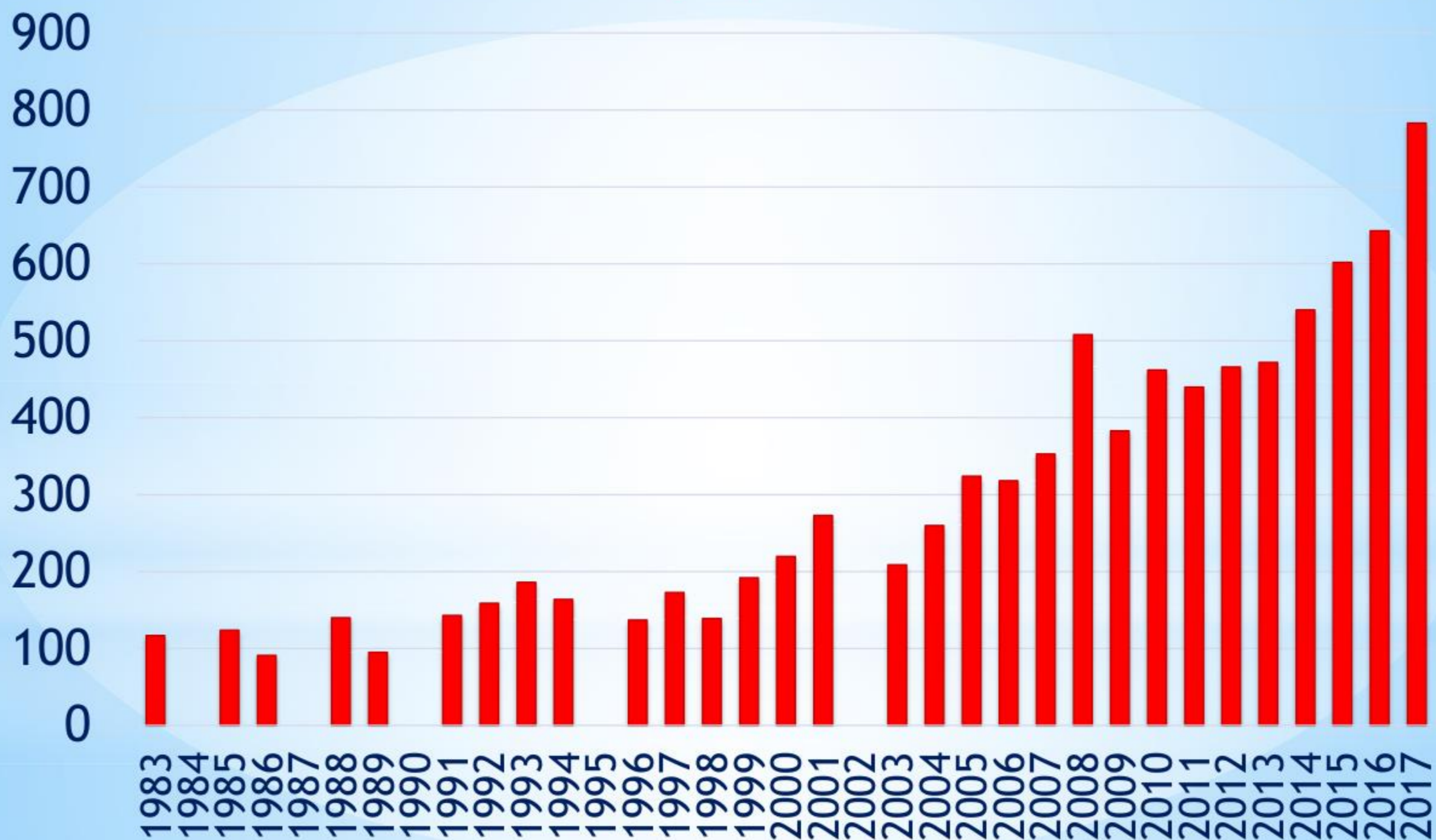
*Original slide
courtesy of
CVPR 2016*



CVPR GROWTH

Number of **papers** at CVPR

*Original slide
courtesy of
CVPR 2016*



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.

ICCV 2017: CMU was the second most
common academic affiliation among authors
(can you guess the first?)

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://www.cs.cmu.edu/~16385/>

Assignments Canvas

<https://canvas.cmu.edu/courses/8880>

Discussion¬es piazza

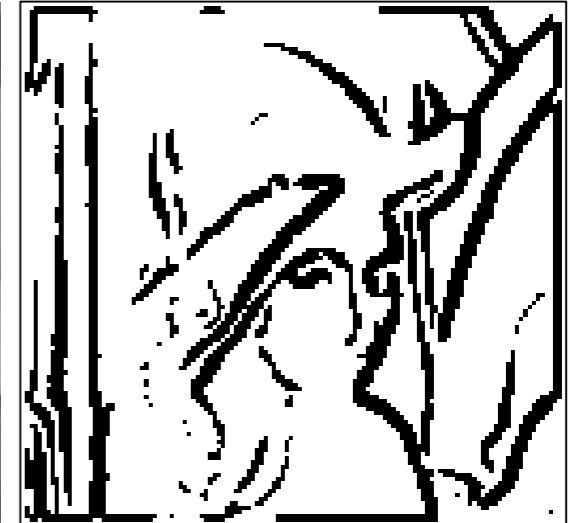
<https://piazza.com/class/jqmfa1yz38v2oc>

(you should sign up here on your own)

Topics to be covered

Image processing:

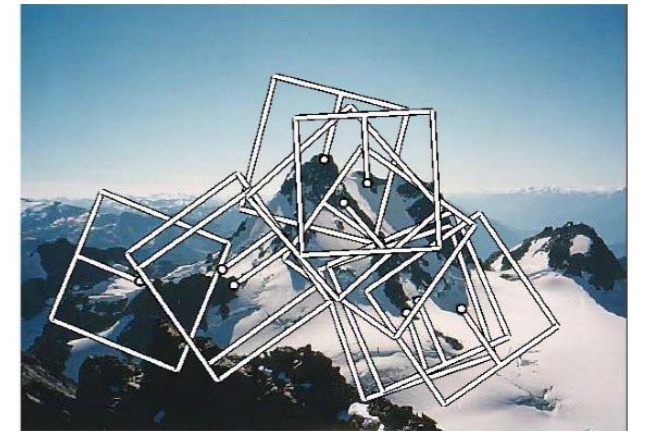
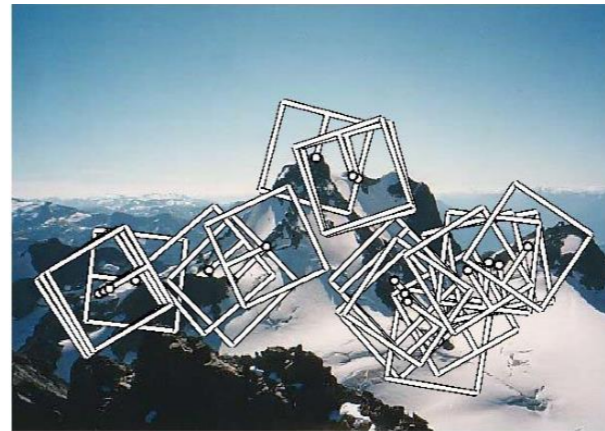
- Basics of filtering.
- Image pyramids.
- Gradients and lines.
- Hough transforms.



Topics to be covered

Feature detection and correspondences:

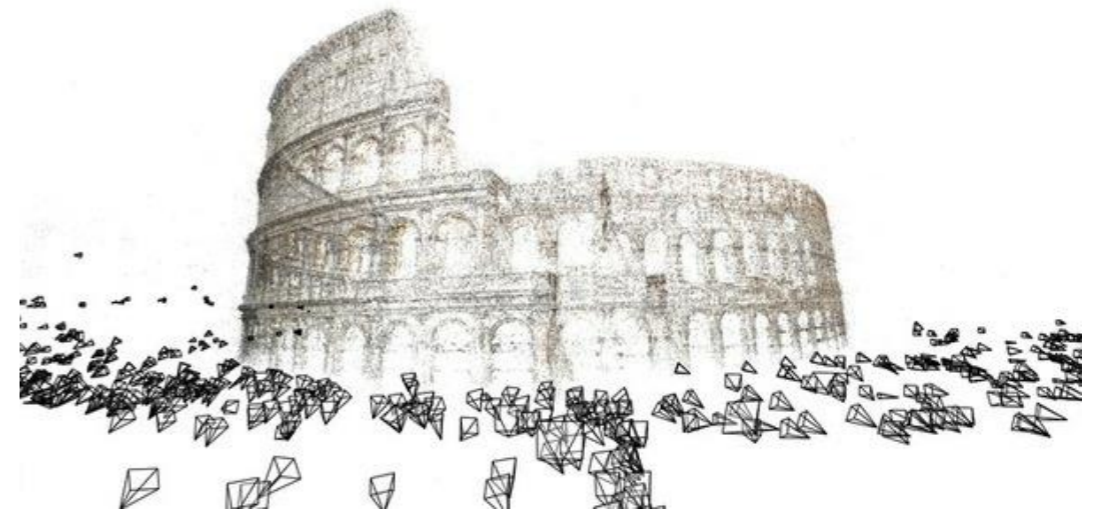
- Corner detection.
- SIFT et al.
- Feature descriptors.
- RANSAC.



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:

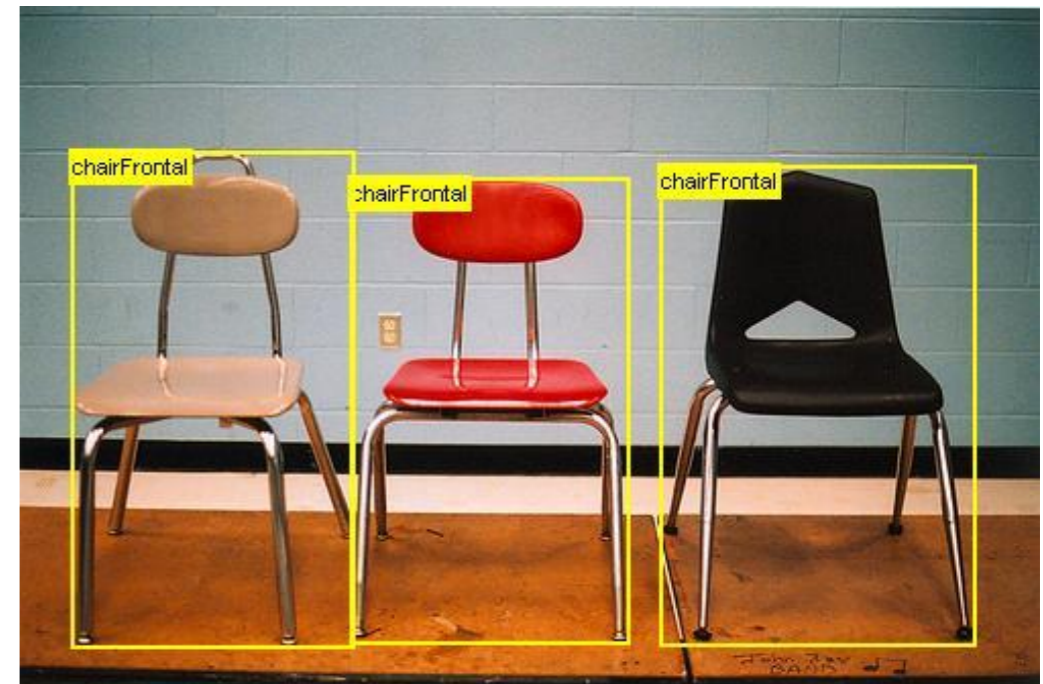
- Reflectance and image formation.
- Radiometry.
- Shape from shading.
- Photometric stereo.
- Color.



Topics to be covered

Objects, faces, and learning:

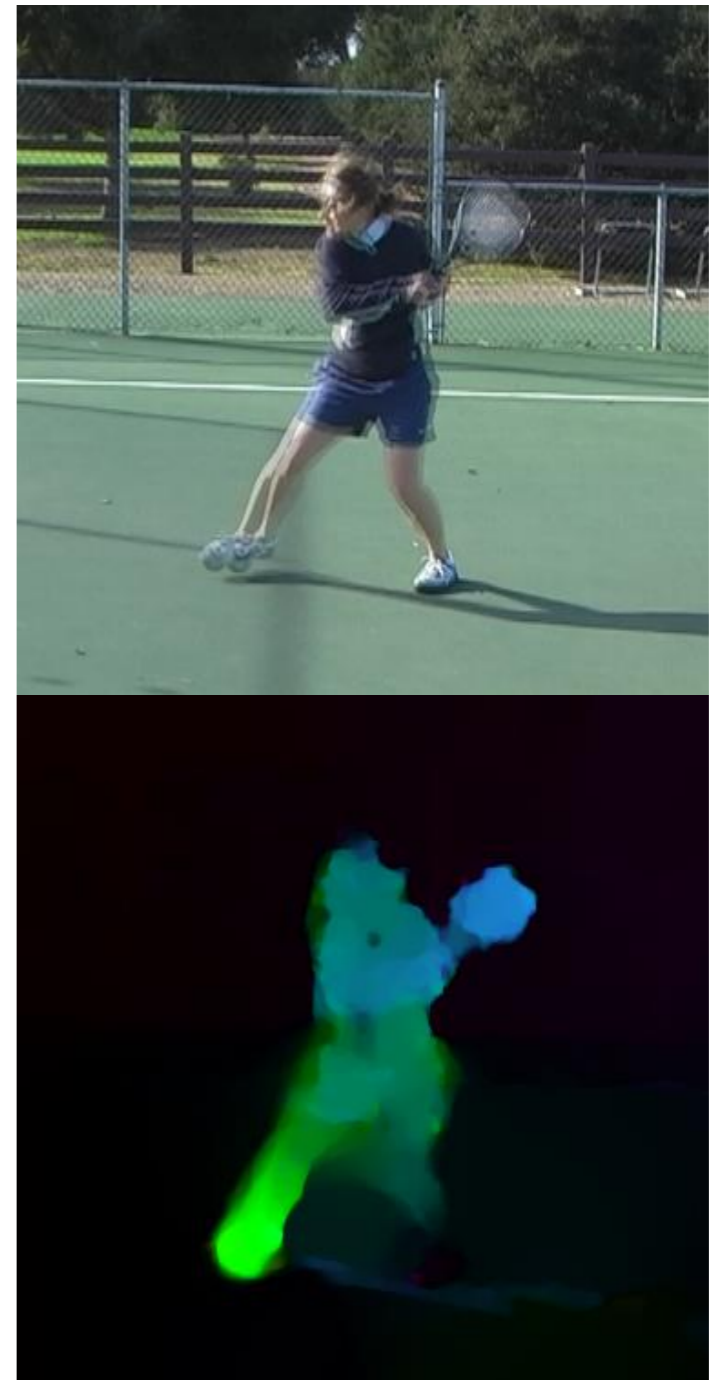
- Basics of probability.
- K-means, KNN, PCA, SVM.
- Bag of words.
- Viola-Jones face detection.
- Perceptron, backpropagation.
- Convolutional neural networks.



Topics to be covered

Dealing with motion:

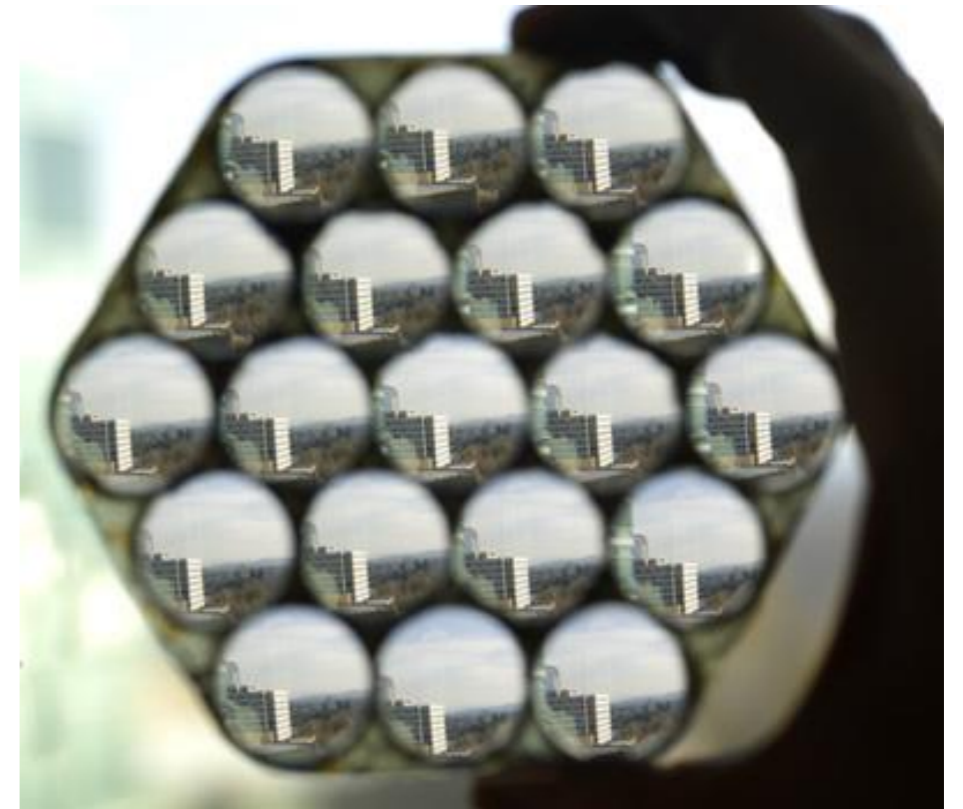
- Optical flow (LK, HS).
- Image registration.
- Kalman Filtering.
- Tracking (KLT, Mean-Shift).



Topics to be covered

Special topics:

- Computational photography.
- ???



Grading: Project-based

- Seven two-week projects: 95%
- Class and Piazza participation: 5%

Projects:

- a lot of programming in Matlab.
- hours and hours of programming.
- days and days of debugging.

Participation:

- Be around for lectures.
- Post on Piazza discussions.
- Ask and answer questions.

Tentative project schedule

Projects

Project 0 Matlab (optional, no credit)

Project 1 Hough Transform

Project 2 Homography

Project 3 Stereo

Project 4 Photometric Stereo

Project 5 Bag of Words

Project 6 Convolutional Neural Nets

Project 7 Lucas-Kanade Tracking

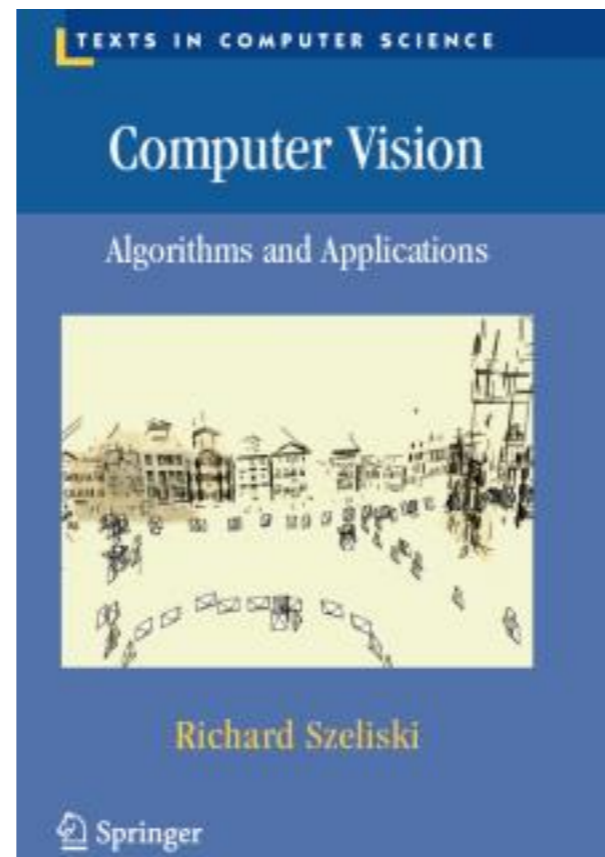
- Generous grading policy (like grad school)
- Getting an A vs. mastering the material
- Build your CV
- Take advantage of extra credit

Late days

- 10% reduction of points per late day
- 5 free late days total (not per project)
- use them wisely...

Book

We will be posting readings after each lecture



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 and office hours

- Feel free to email us about administrative questions.
 - please use [16385] in email title!
- Technical 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 Yannis about additional office hours.
 - you can also just drop by Yannis' office (Smith Hall (EDSH) Rm 225).

Yannis will announce office hours for this week.

Please take the course survey
before the next lecture!

(posted on Piazza)