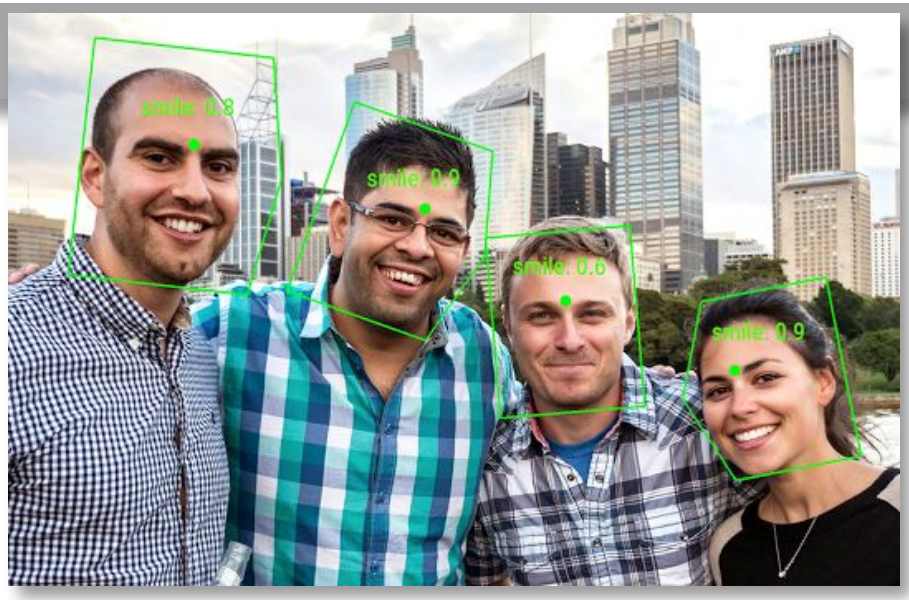
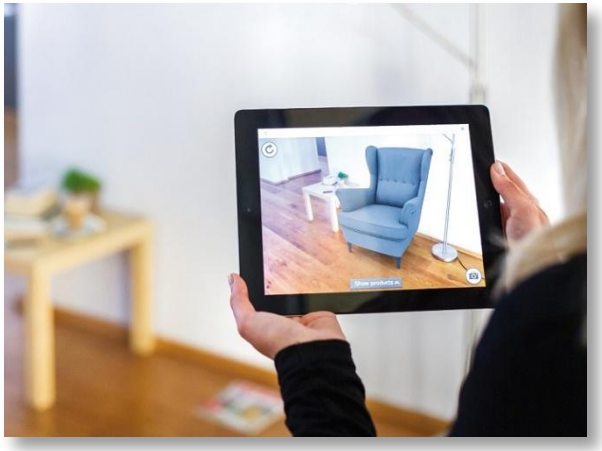
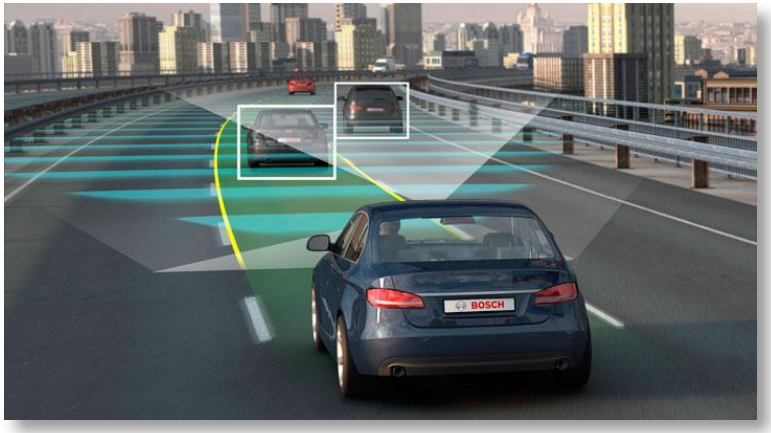
Introduction to Computer Vision

Universitatea Tehnică
"Gheorghe Asachi", Iași

Facultatea de
Automatică și Calculatoare







Today

1. What is computer vision?

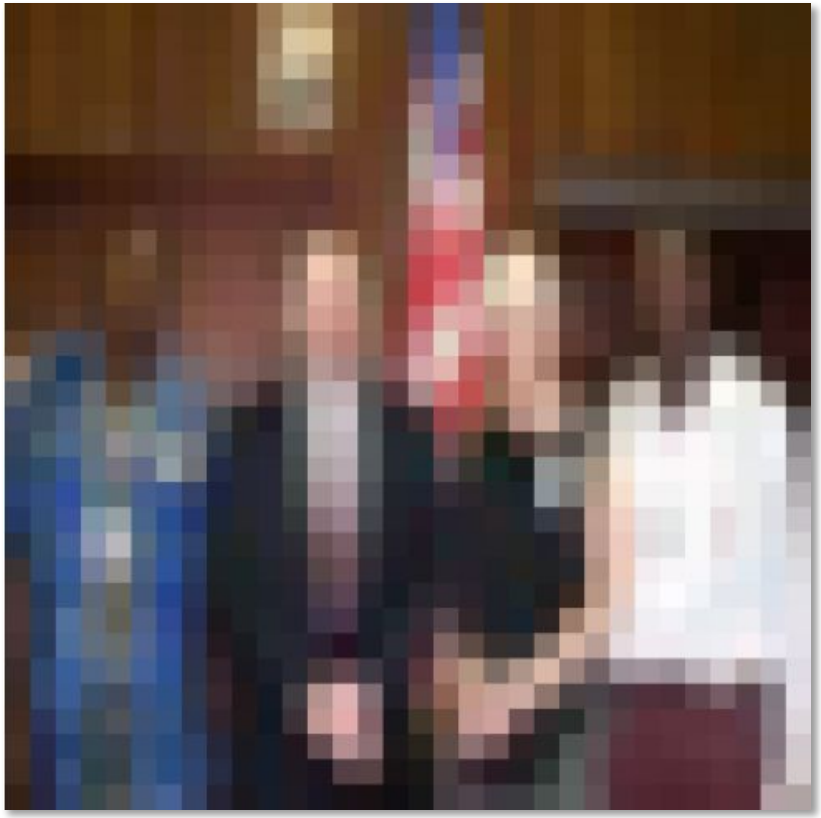
1. Why study computer vision?

1. Projects and grading policy

Every image tells a story

- Goal of computer vision: perceive the “story” behind the picture
- Compute properties of the world
  - 3D shape
  - Names of people or objects
  - What happened?

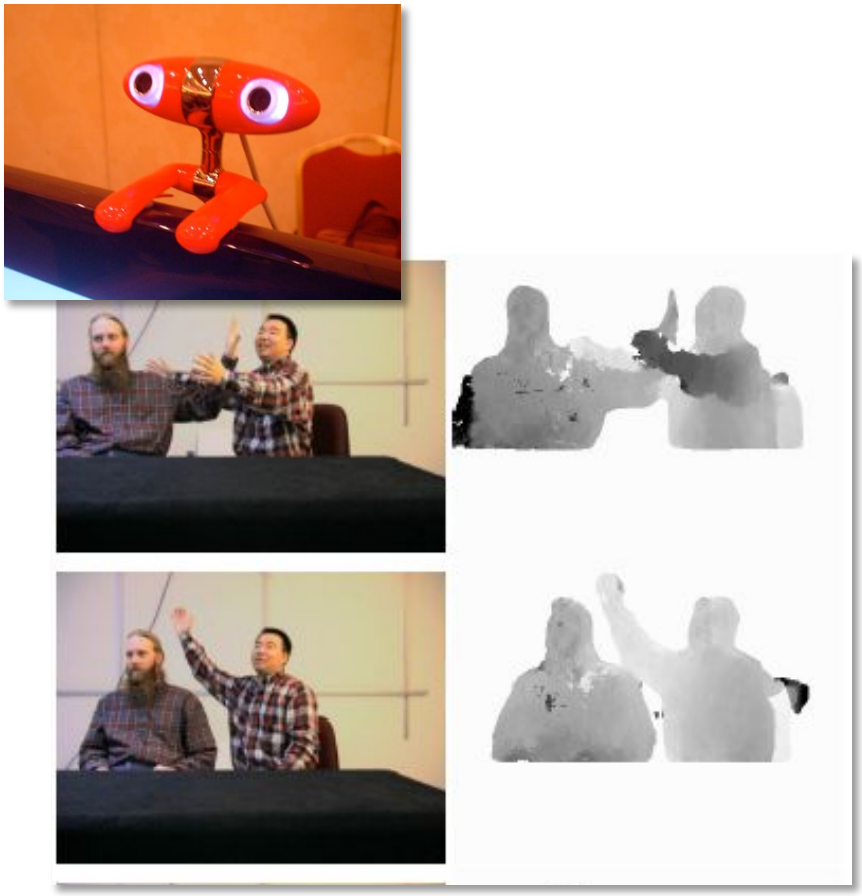
But humans can tell a lot about a scene from a little information…

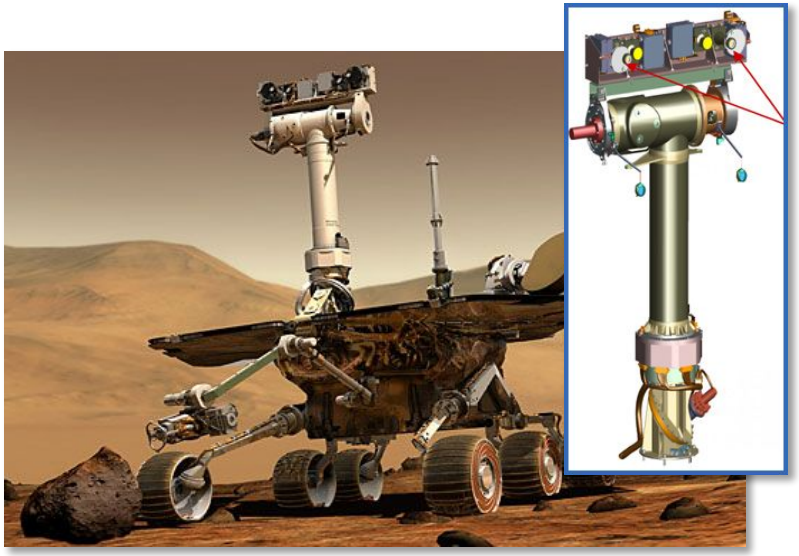


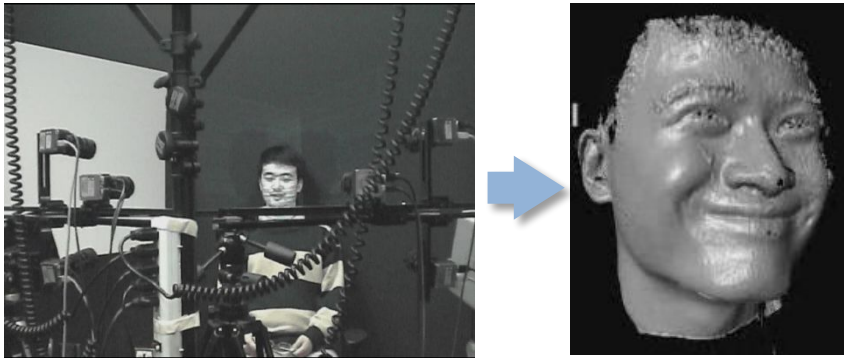
Source: “80 million tiny images” by Torralba, et al.

The goal of computer vision

- Compute the 3D shape of the world



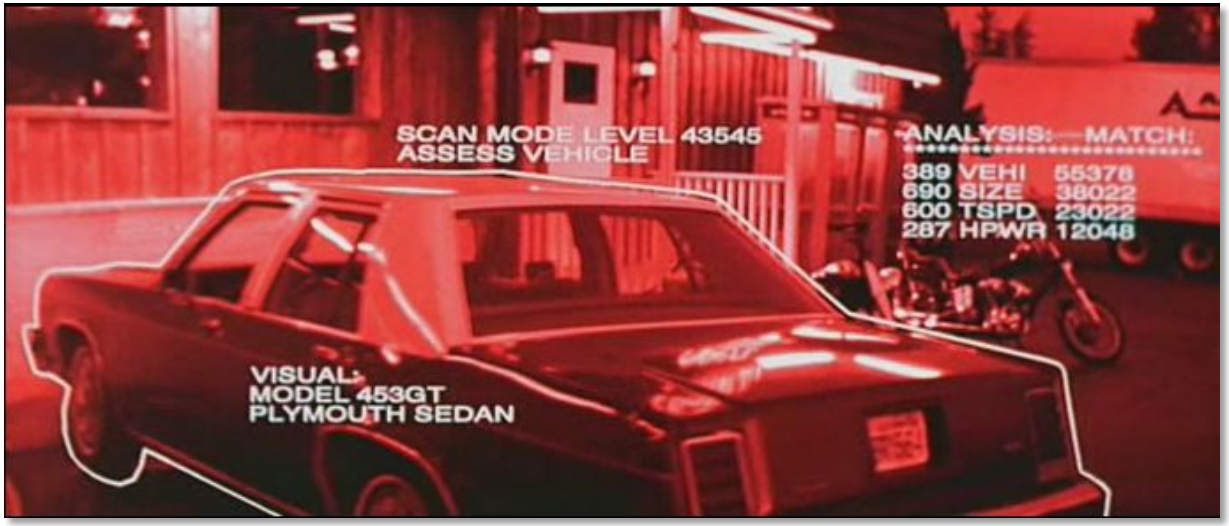




link

The goal of computer vision

- Recognize objects and people



Terminator 2, 1991


中华人民
和国万岁
世界
民大团结万岁


sky
building
flag
face
banner
wall
street lamp
bus
bus
cars
slide credit: Fei-Fei, Fergus & Torralba

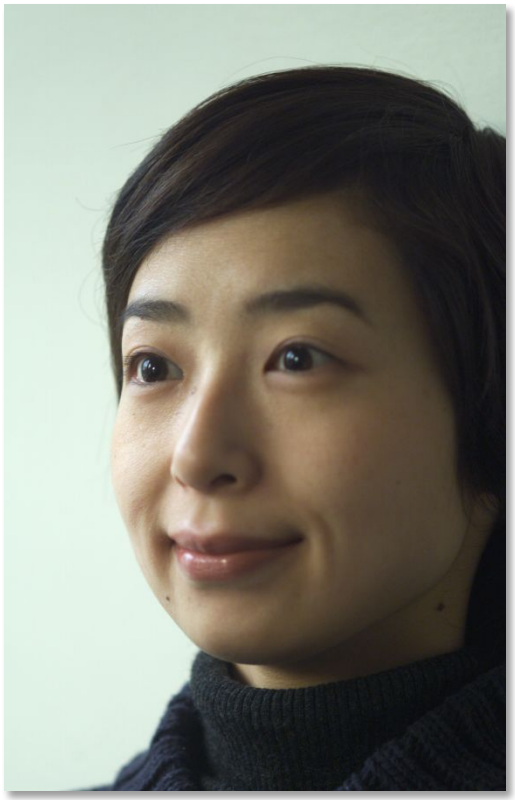
The goal of computer vision

- “Enhance” images

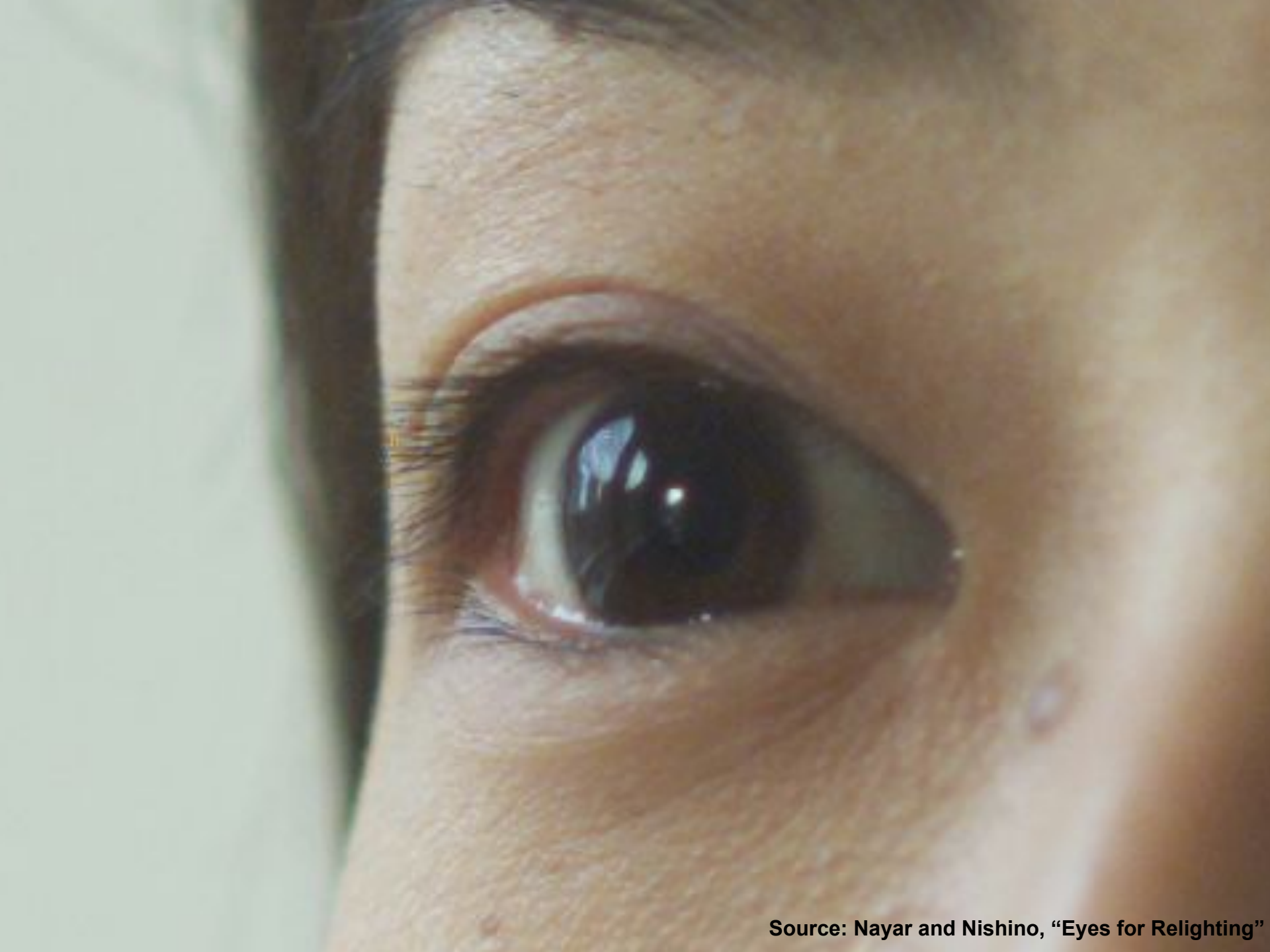

CSI:NY

The goal of computer vision

- Forensics



Source: Nayar and Nishino, “Eyes for Relighting”



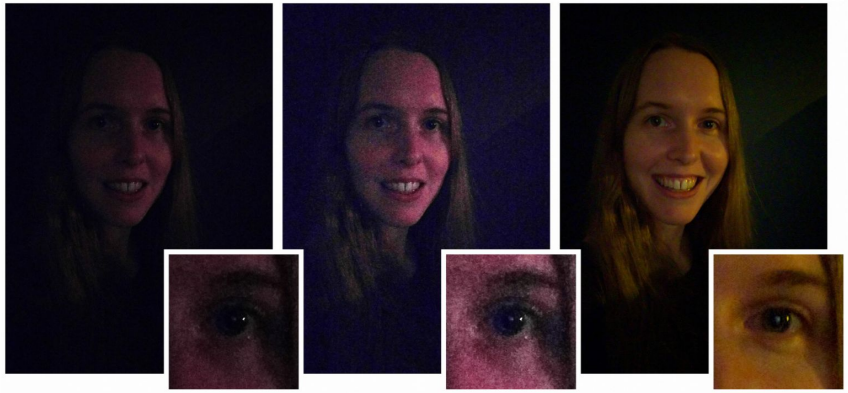
Source: Nayar and Nishino, “Eyes for Relighting”

Source: Nayar and Nishino, “Eyes for Relighting”

The goal of computer vision

- Improve photos (“Computational Photography”)

Super-resolution (source: 2d3)



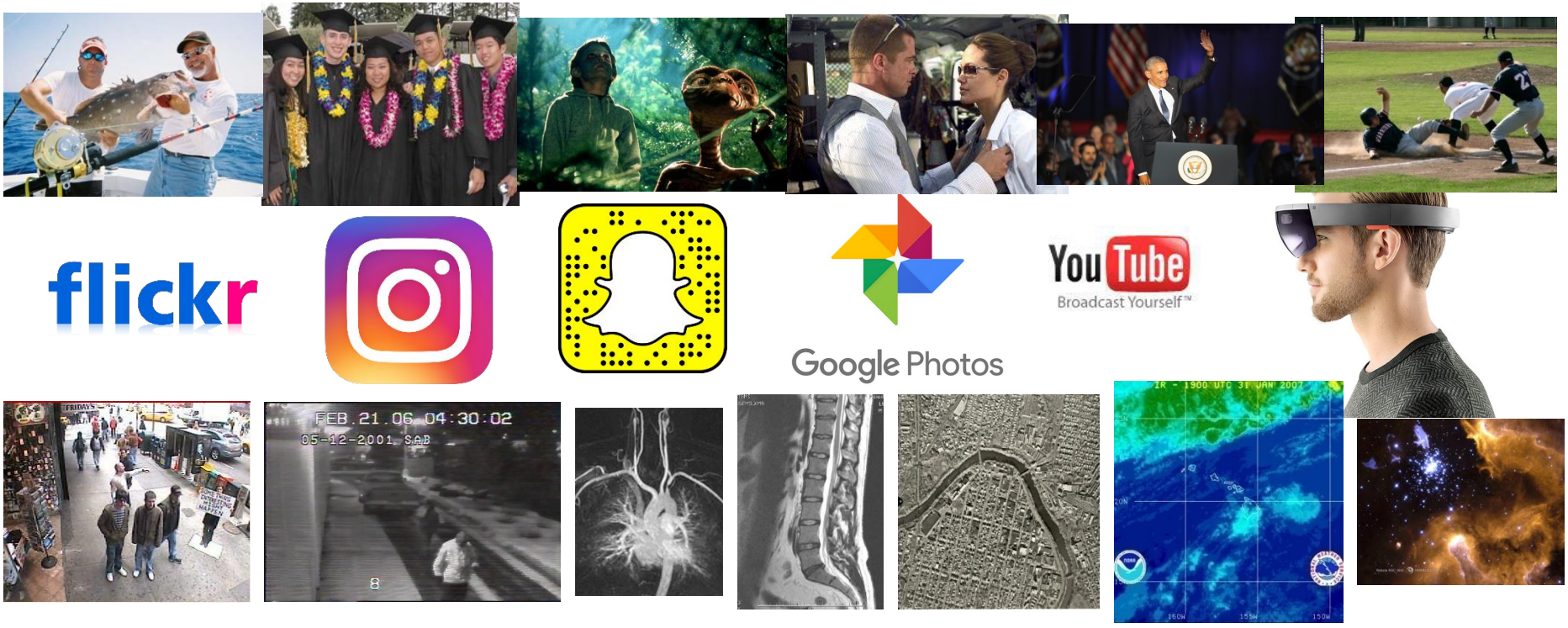
Low-light photography
(credit: Hasinoff et al., SIGGRAPH ASIA 2016)

Depth of field on cell phone camera
(source: Google Research Blog)

Inpainting / image completion
(image credit: Hays and Efros)

Why study computer vision?

- Billions of images/videos captured per day



- Huge number of useful applications
- The next slides show the current state of the art

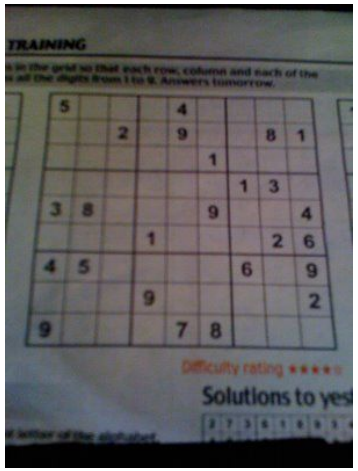
Optical character recognition (OCR)

- If you have a scanner, it probably came with OCR software

Digit recognition, AT&T labs (1990's)
http://yann.lecun.com/exdb/lenet/

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Automatic check processing

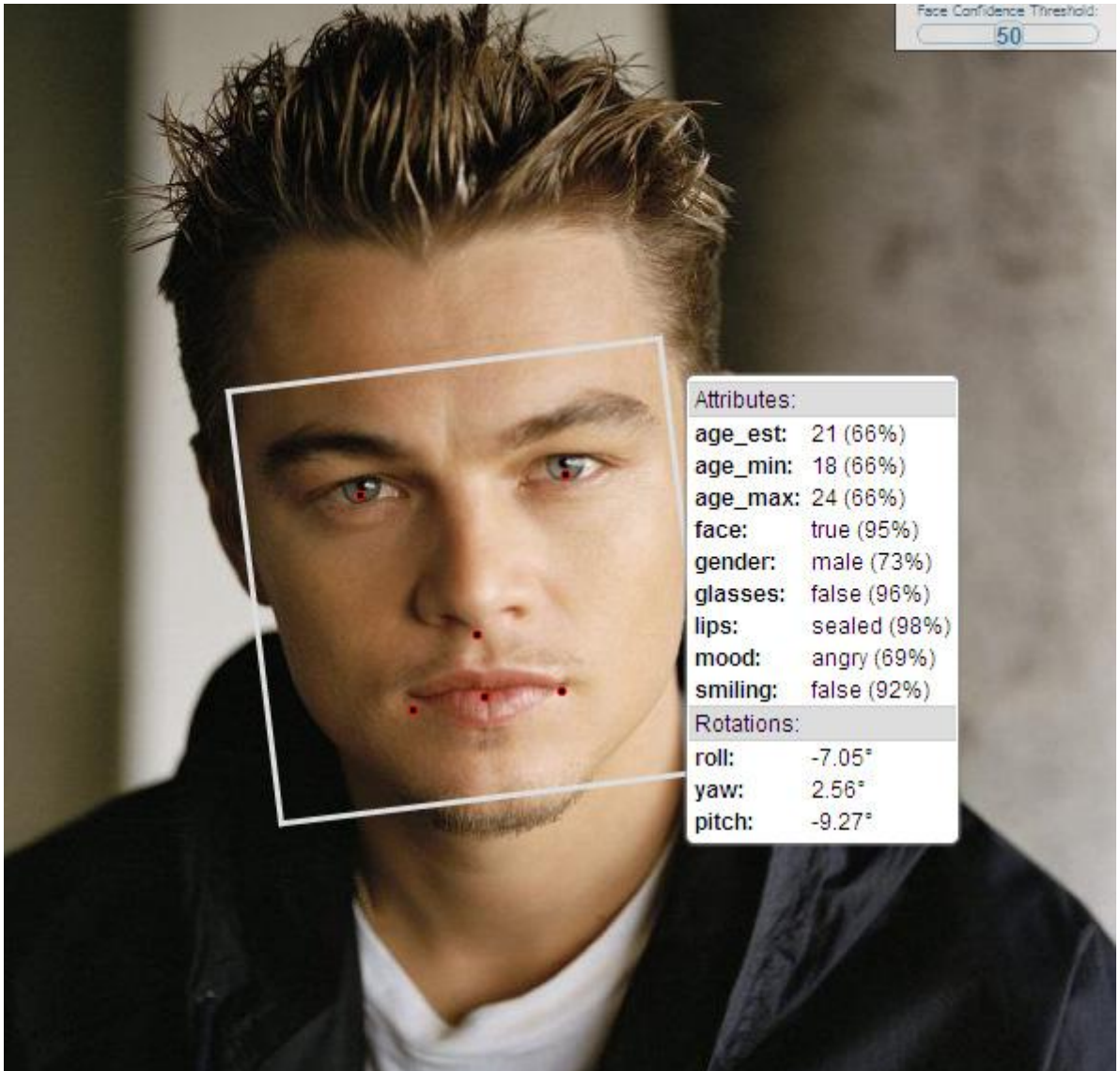


Sudoku grabber
http://sudokugrab.blogspot.com/

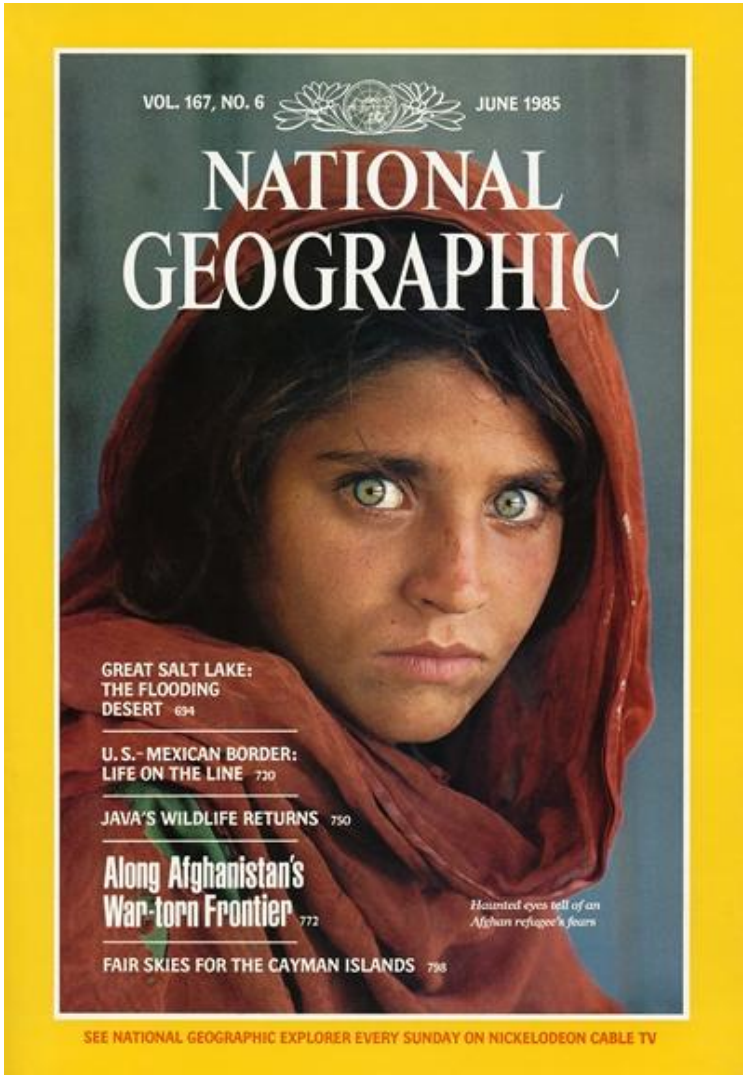
Face detection

- Nearly all cameras detect faces in real time

Face analysis and recognition



Face recognition

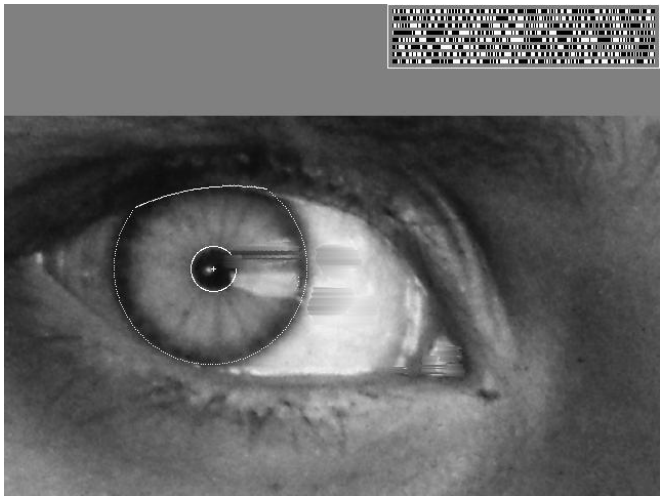


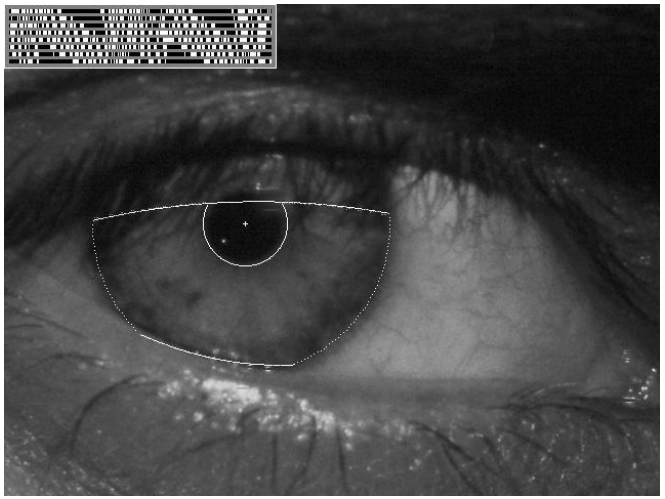
Who is she?

Source: S. Seitz

Vision-based biometrics

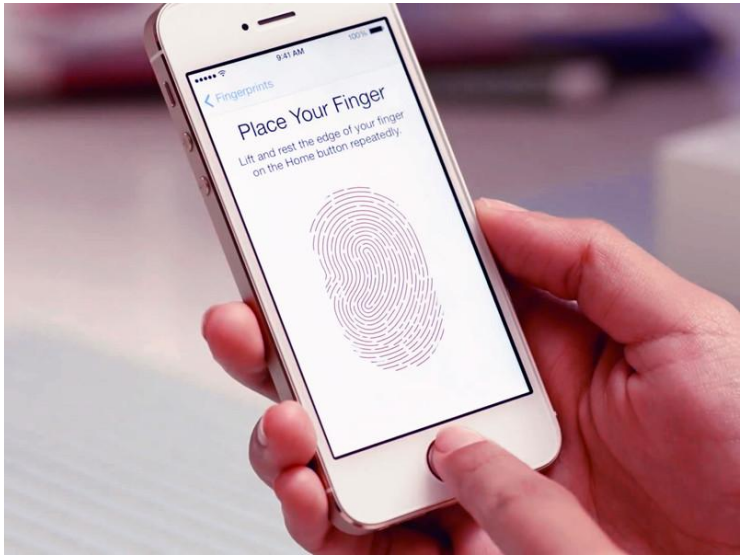
"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story





Source: S. Seitz

Login without a password



Fingerprint scanners on many new smartphones and other devices

Face unlock on Apple iPhone X
See also http://www.sensiblevision.com/ https://sensiblevision.com/videos

Researchers warn peace sign photos could expose fingerprints

But the likelihood of anyone actually using images to recreate prints is pretty slim.

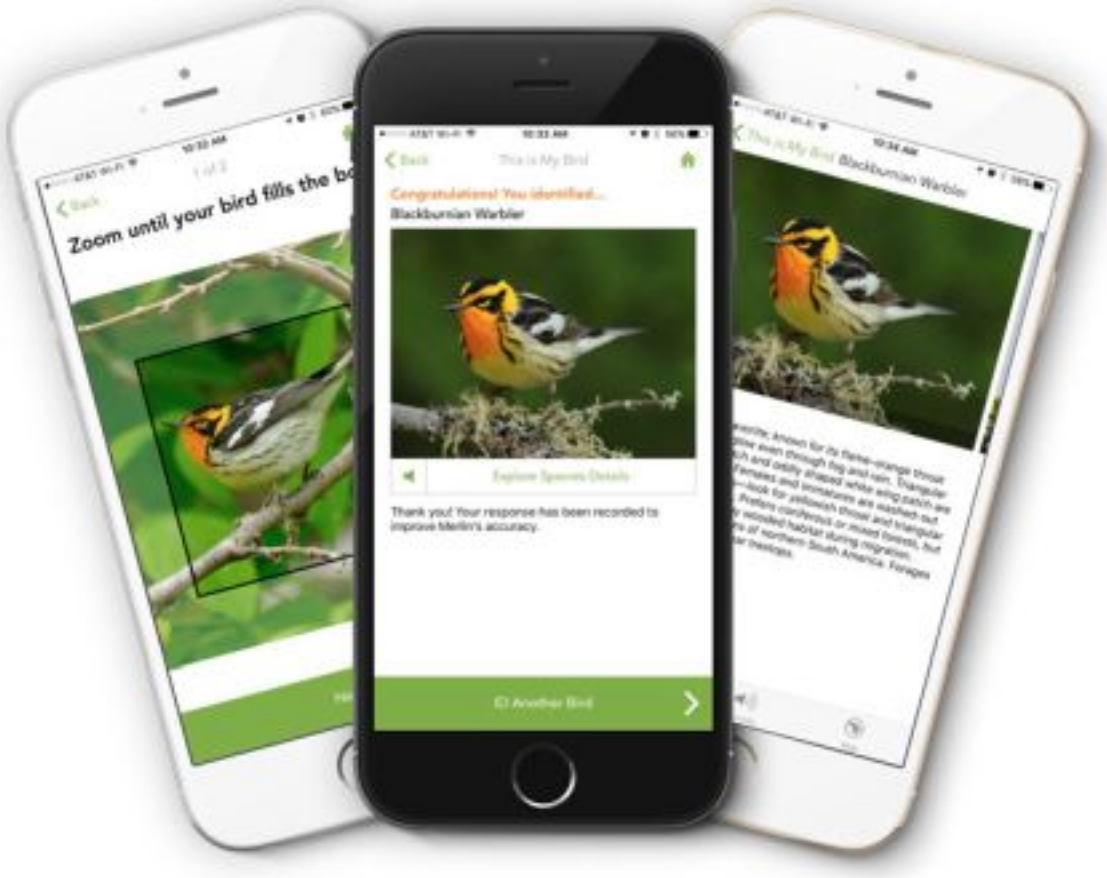
Jamie Rigg, @jmerigg
01.13.17 in Security

Comments

1721
Shares

Getty

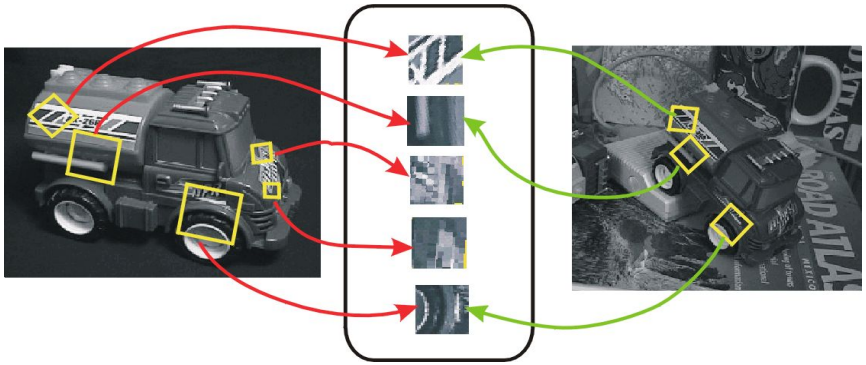
Bird identification



Merlin Bird ID

Recognition

Face detection and recognition



Single instance recognition

Category recognition

Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Source: S. Seitz

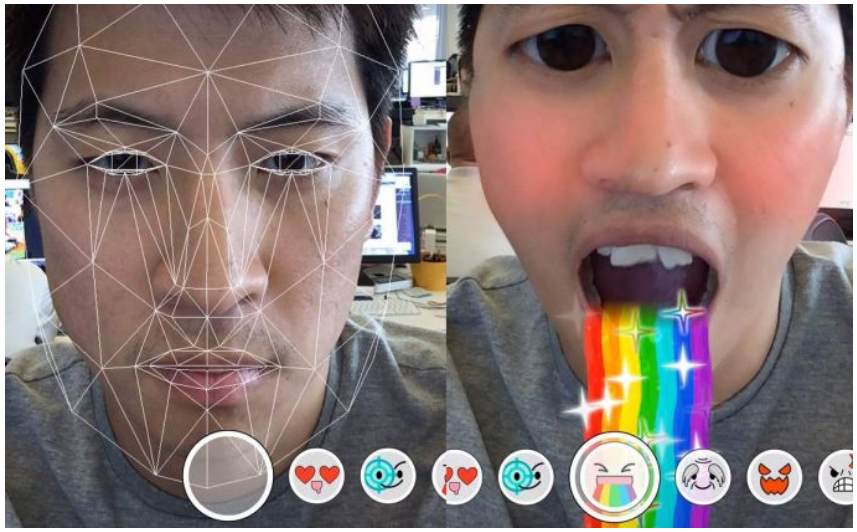
Special effects: motion capture

Pirates of the Carribean, Industrial Light and Magic

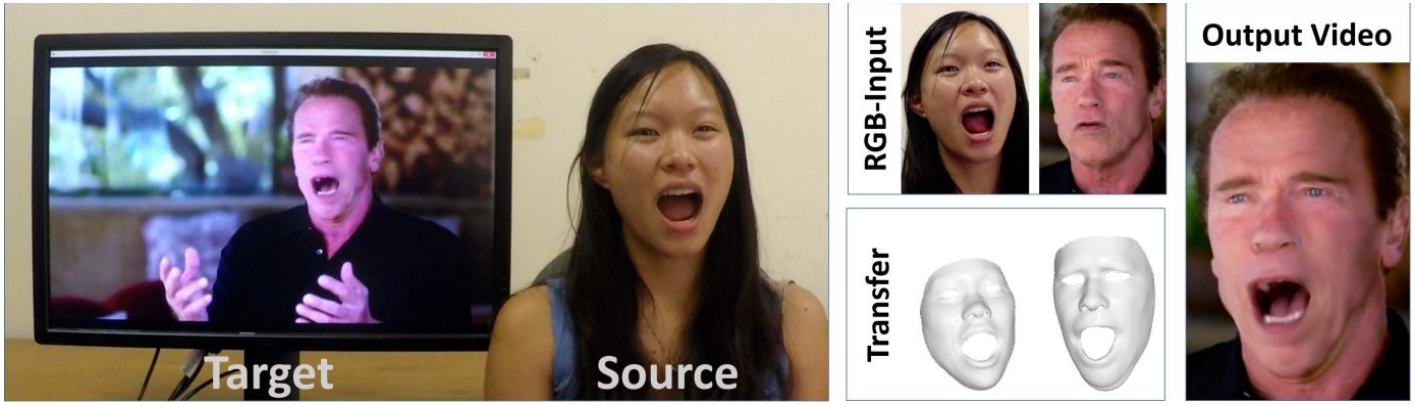
Source: S. Seitz

Los Angeles Times

3D face tracking w/ consumer cameras



Snapchat Lenses



Face2Face system (Thies et al.)

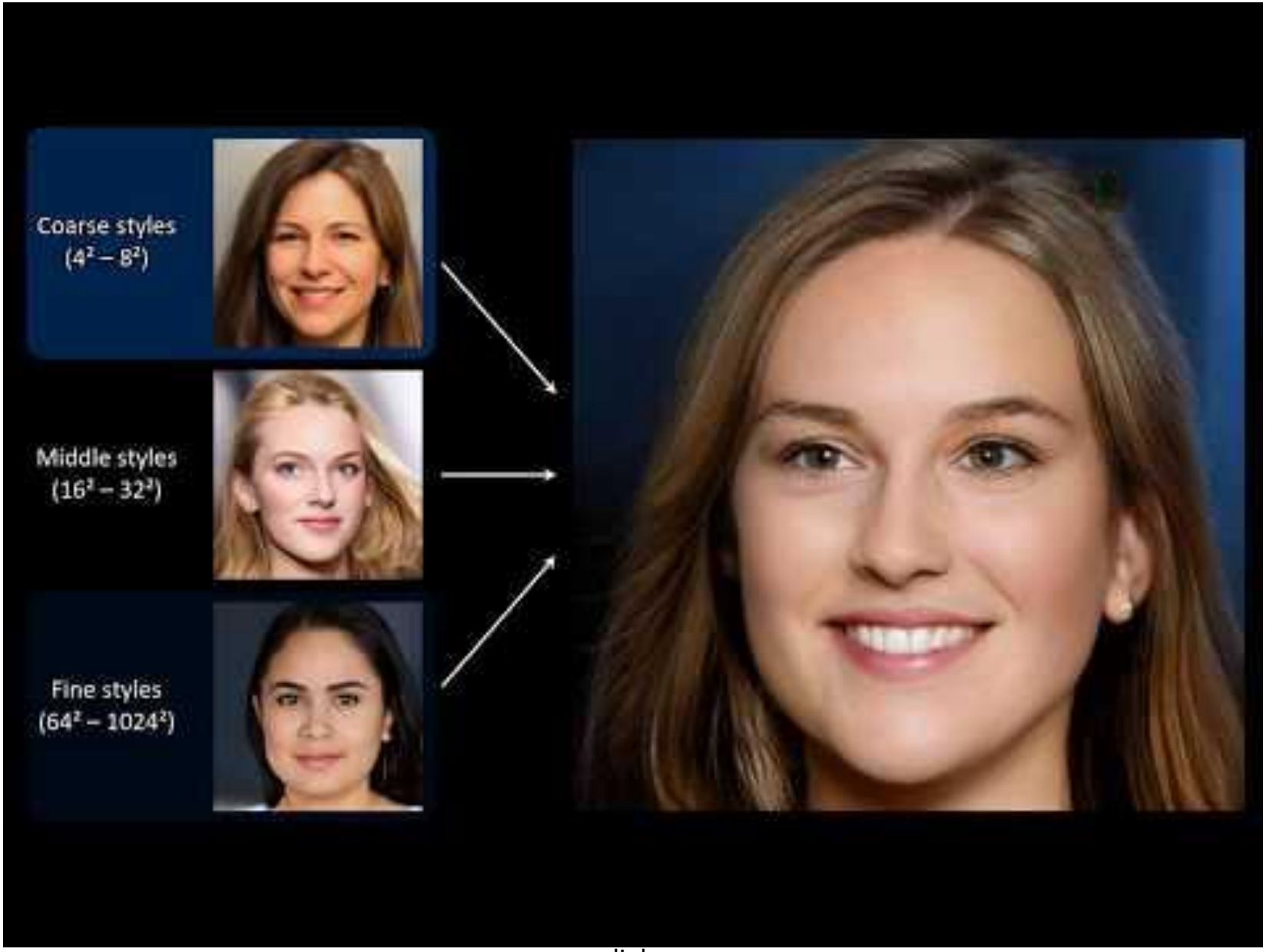
link


Source Actor
Real-time Reenactment
Reenactment Result
Target Actor

link

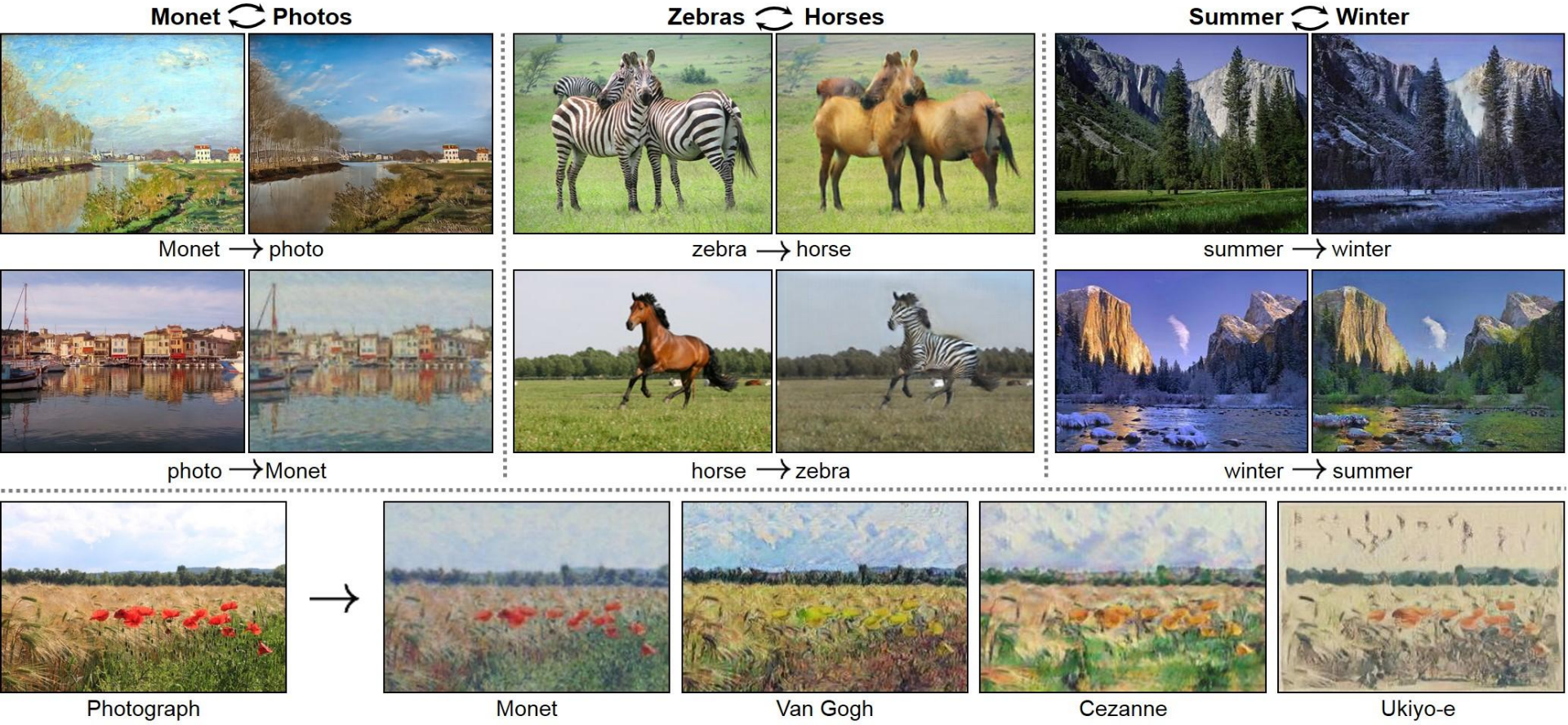
Image synthesis

Karras, et al., *Progressive Growing of GANs for Improved Quality, Stability, and Variation*, ICLR 2018


Coarse styles
(4² – 8²)
Middle styles
(16² – 32²)
Fine styles
(64² – 1024²)

link

Image synthesis



Zhu, et al., *Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks*, ICCV 2017

DALL-E from OpenAI

“an impressionist painting of students in their first class of introduction to deep learning”

link

Sports

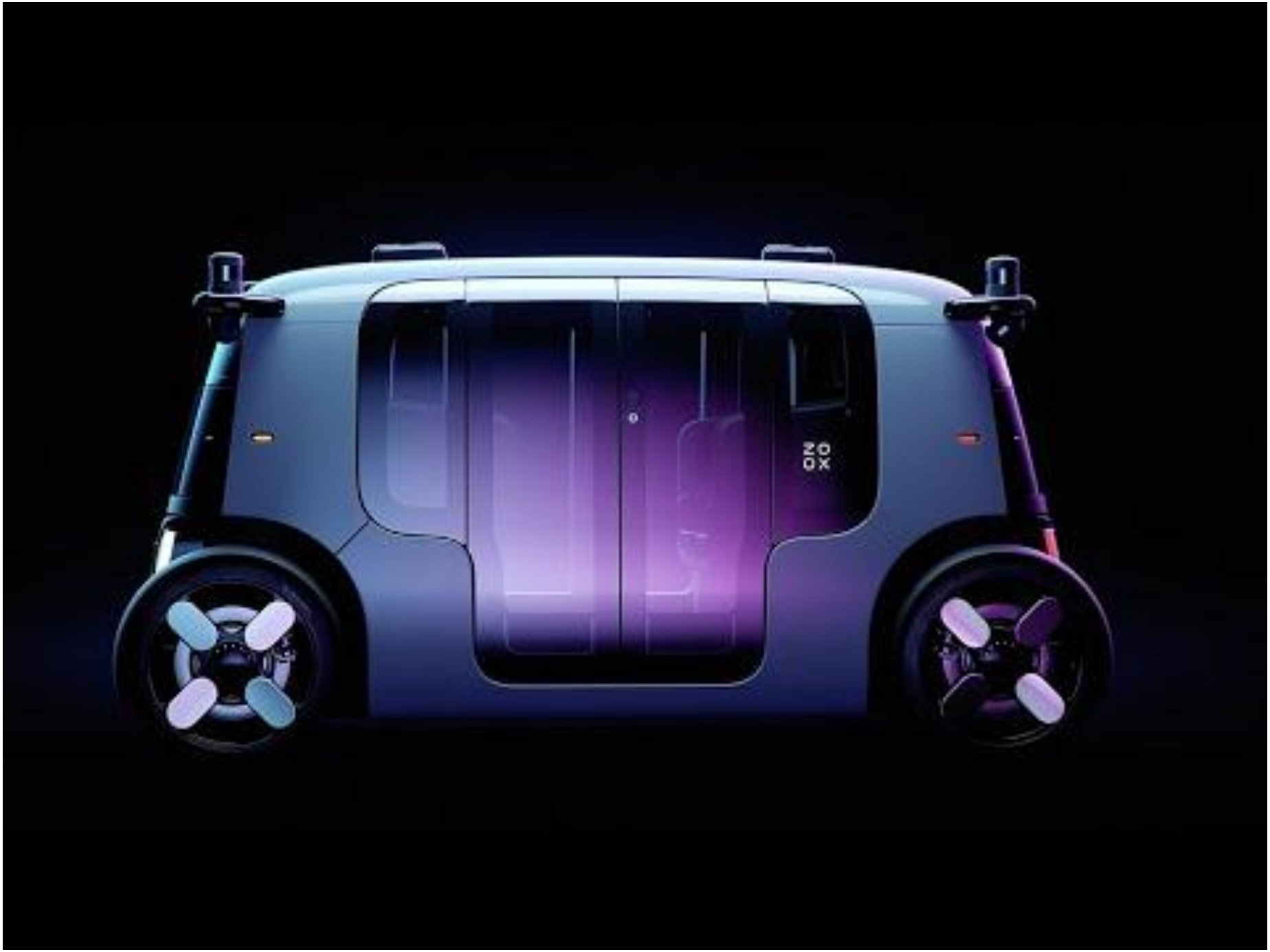
Sportvision first down line
Nice explanation on www.howstuffworks.com

Source: S. Seitz

Smart cars

- Mobileye
- ZooX by Amazon
- Tesla Autopilot
- Safety features in many high-end cars

link


OXO

Self-driving cars

Waymo (link)

Robotics

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

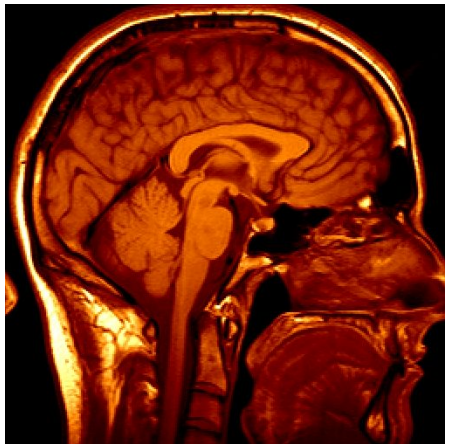
Amazon Picking Challenge
http://www.robocup2016.org/en/events/amazon-picking-challenge/

Amazon Prime Air

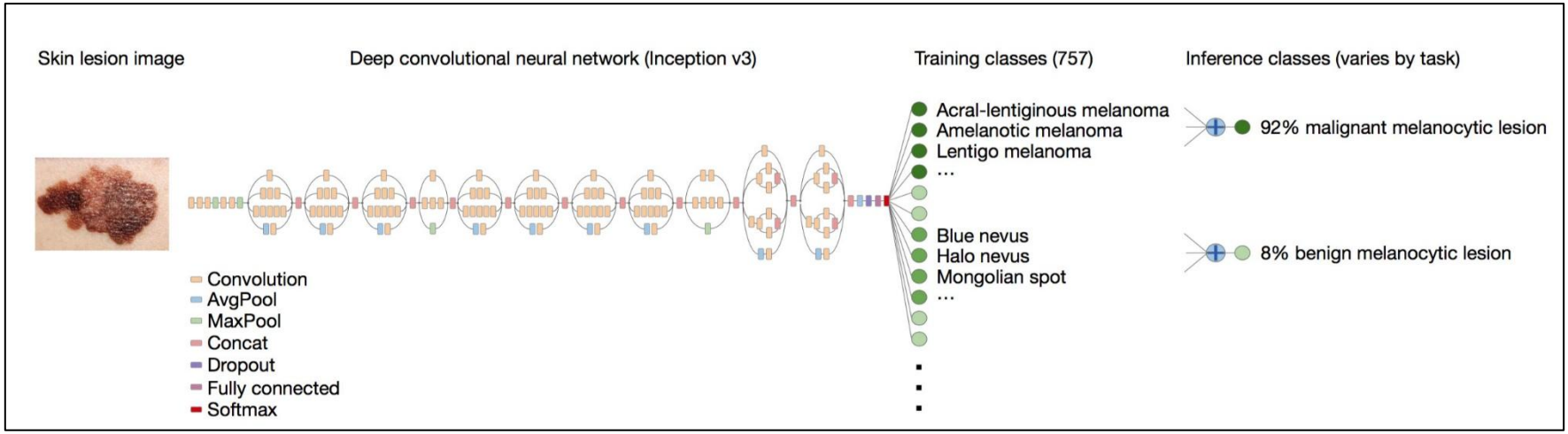
Amazon Scout

link

Medical imaging



3D imaging
(MRI, CT)



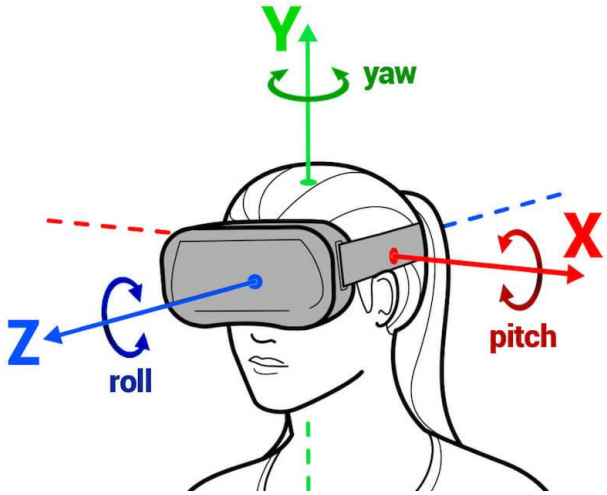
Skin cancer classification with deep learning
https://cs.stanford.edu/people/esteva/nature/

INVESTING 3/25/2014 @ 5:43PM | 70,399 views

Facebook Buys Oculus, Virtual Reality Gaming Startup, For $2 Billion

+ Comment Now + Follow Comments

Virtual & Augmented Reality



6DoF head tracking

Hand & body tracking

3D scene understanding

3D-360 video capture

Current state of the art

- You just saw many examples of current systems.
  - Many of these are less than 5 years old
- This is a very active research area, and rapidly changing
  - Many new apps in the next 5 years
  - Deep learning powering many modern applications
- Many startups across a dizzying array of areas
  - Deep learning, robotics, autonomous vehicles, medical imaging, construction, inspection, VR/AR, …

Why is computer vision difficult?

Viewpoint variation

Illumination

Scale

Why is computer vision difficult?

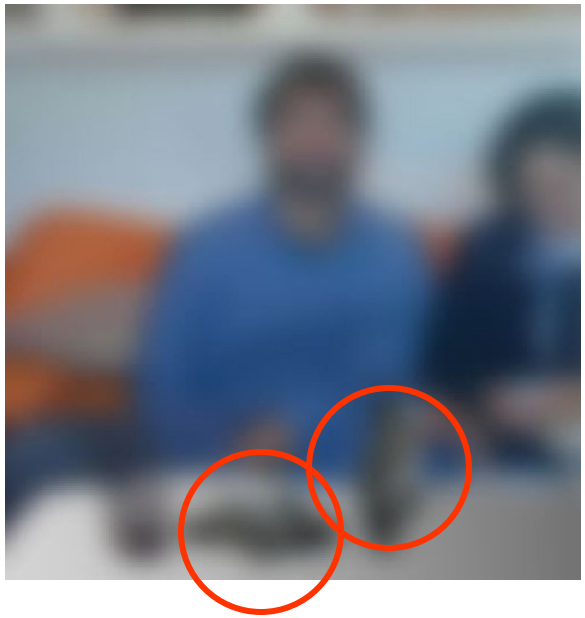
Intra-class variation

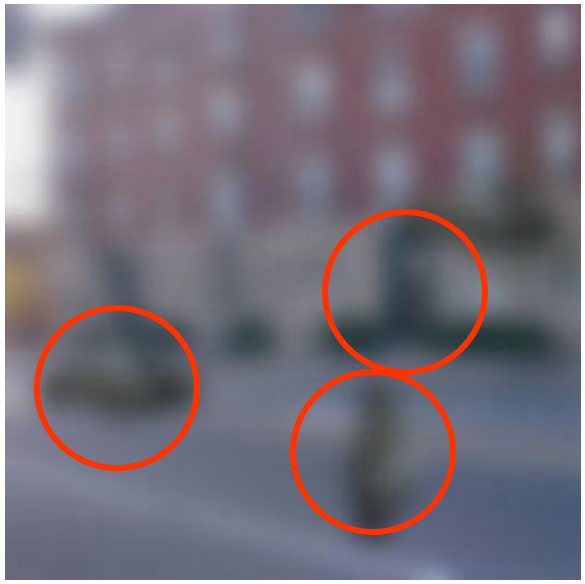
Motion (Source: S. Lazebnik)

Background clutter

Occlusion

Challenges: local ambiguity





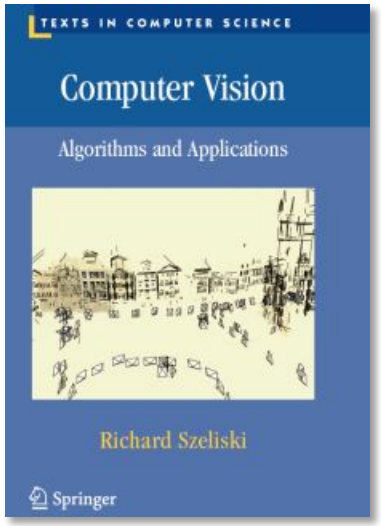
slide credit: Fei-Fei, Fergus & Torralba

Bottom line

- Perception is an inherently ambiguous problem
  - Many different 3D scenes could have given rise to a particular 2D picture

  - We often need to use prior knowledge about the structure of the world

Important information



- Textbook:

  Rick Szeliski, *Computer Vision: Algorithms and Applications*

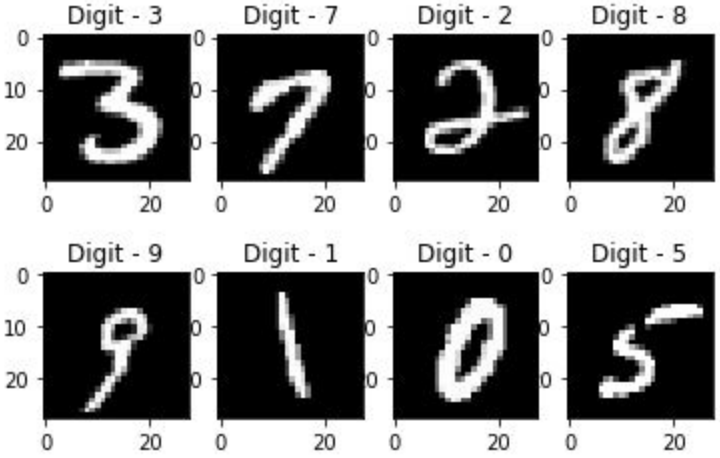
  online at: http://szeliski.org/Book/

Cuvânt înainte de Constantin Vică

Primul val al tehnologiilor informației a amplificat puterea de calcul și memoria, iar al doilea a redefinit relațiile umane și comunitățile. Astăzi, valul inteligenței artificiale încredințează algoritmilor decizii ce țin de bine și de rău, de viață și de moarte, de la armată și medicină la școli, trafic urban sau credite bancare. Creatori, dar și supuși ai algoritmilor, vom putea rămâne oare stăpâni ai propriei sorți? Sau vom deveni sclavi ai unei tehnologii tot mai greu de înțeles, chiar și pentru creatorii săi? Răzvan Rughiniș examinează noua societate digitală cu ochiul inginerului în calculatoare și cu lupa eticii aplicate, oferindu-ne un ghid care să ne ajute să navigăm prin noua societate digitală și, deopotrivă, să apărăm demnitatea umană în întâlnirea cu tehnologia.

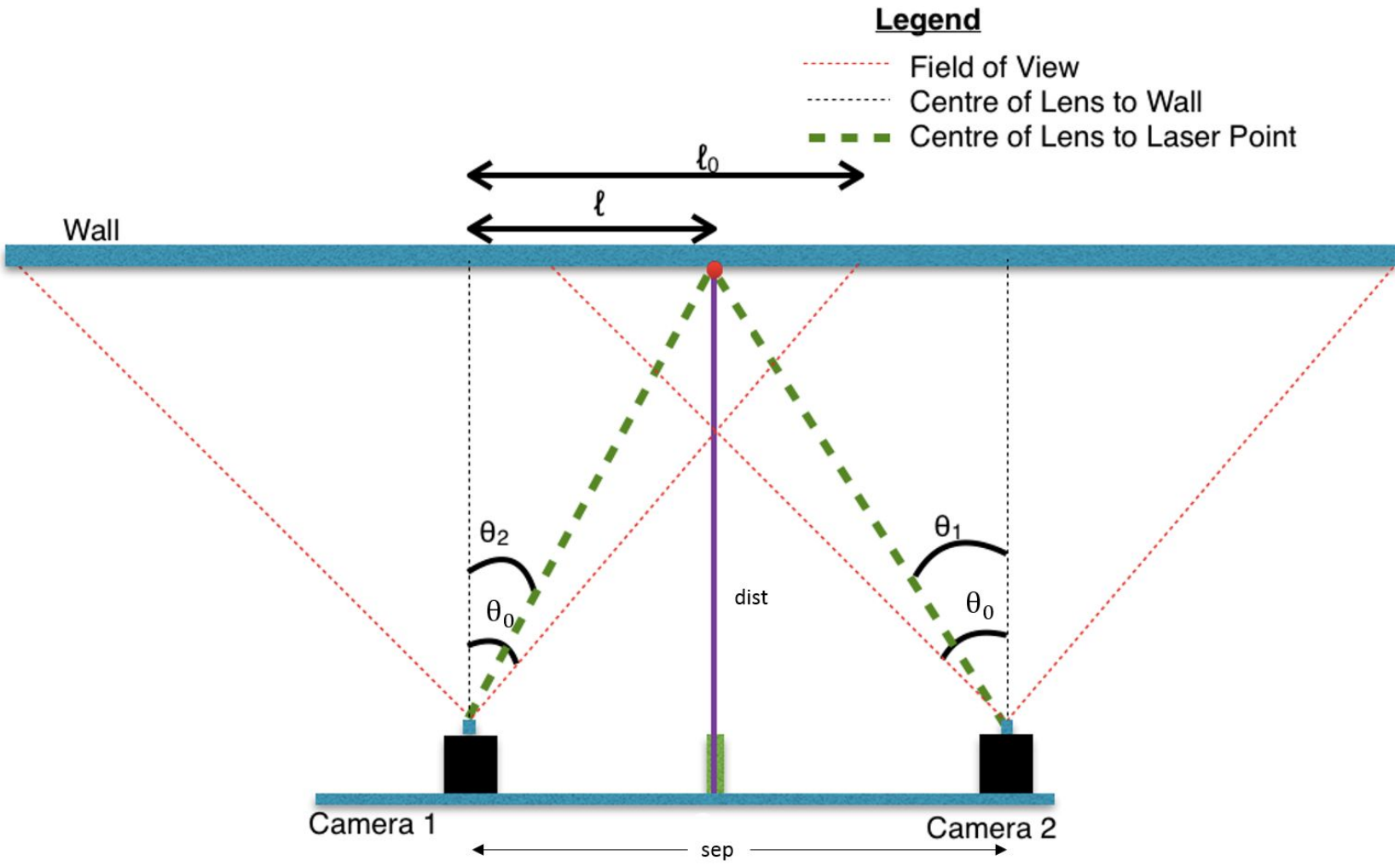
Project 1: Lane Detection

Project 2: Digit Recognition

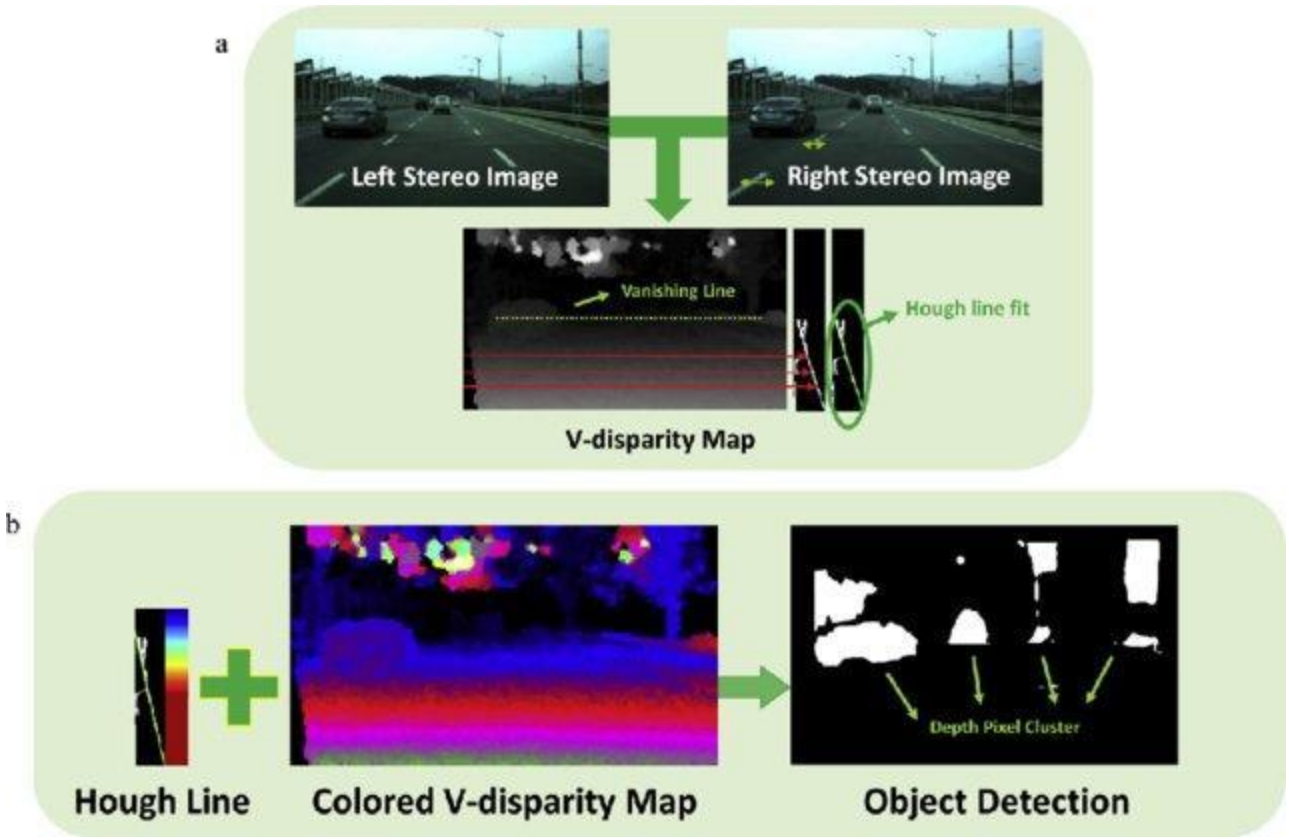


Project 3: Image Stitching
- creating panoramas -

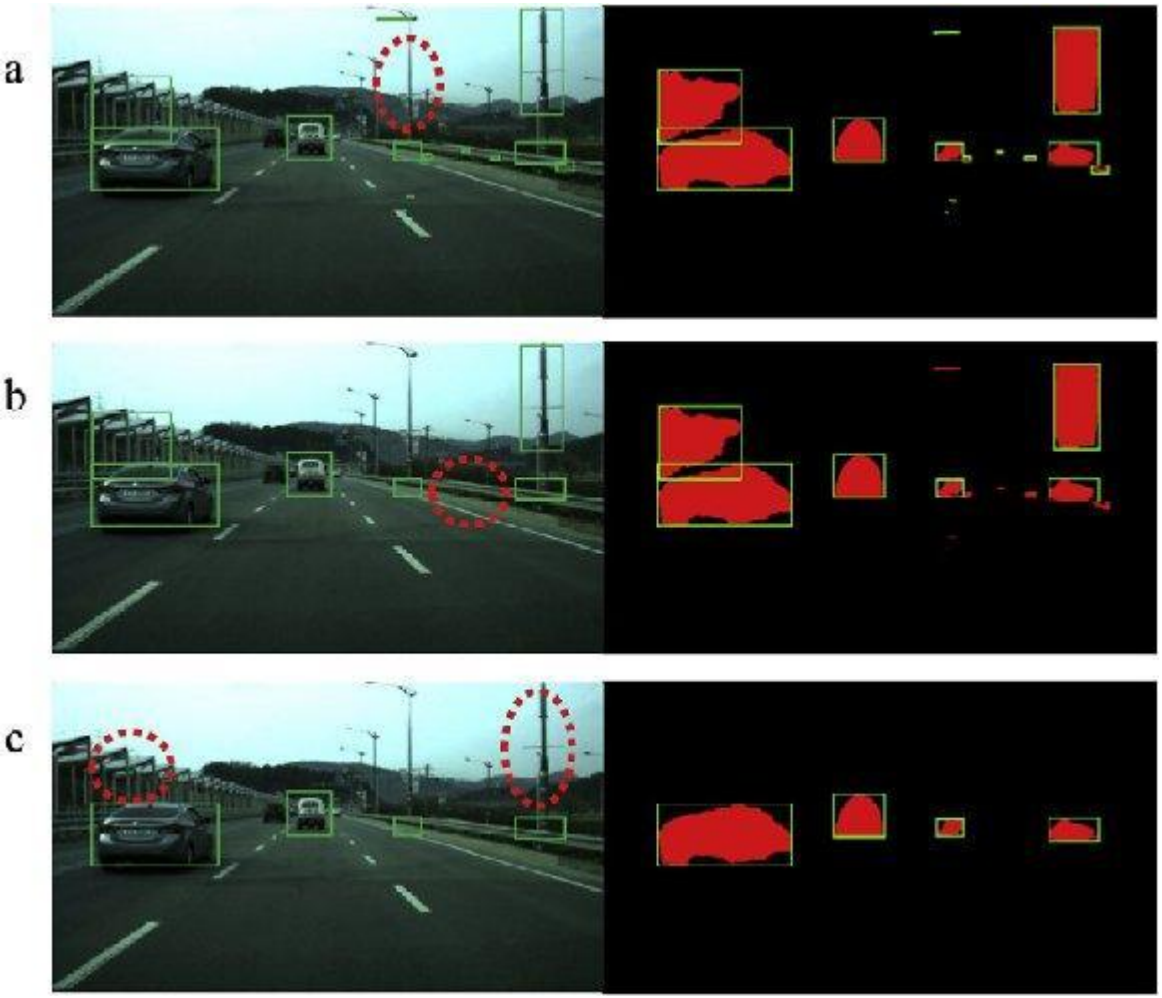
Project 4: Stereo



Project 4: Stereo



Project 4: Stereo

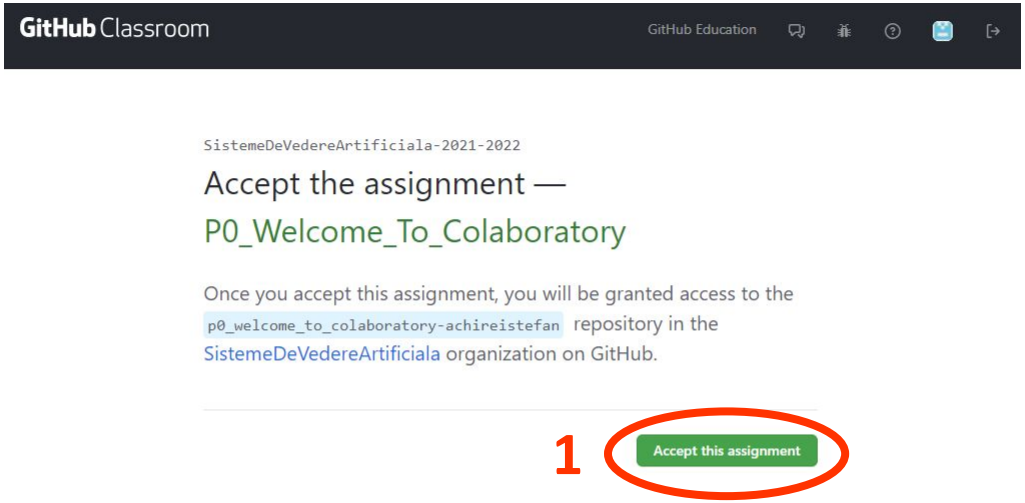


Project 5: Object Detection using neural networks

link

Grading policy for Projects

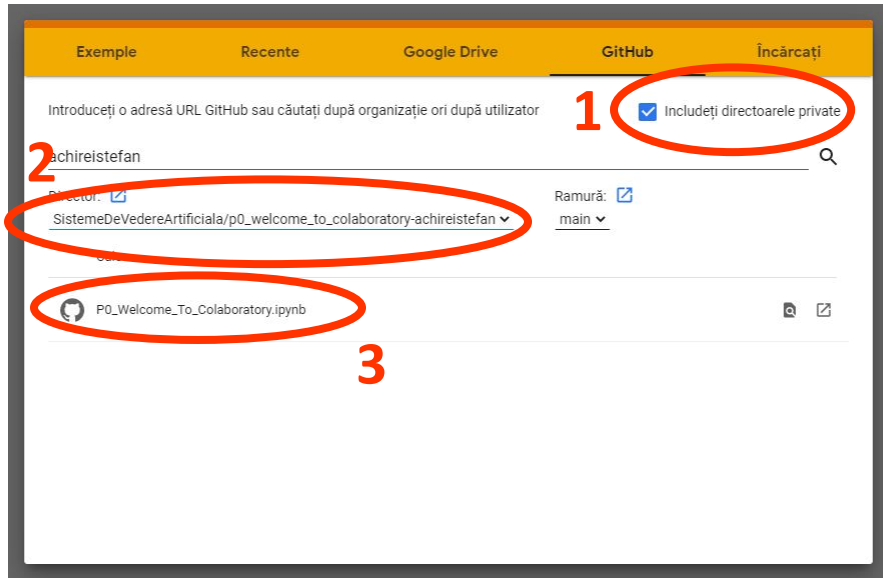
Project 0: 1 week ->
https://classroom.github.com/a/jXtbzh8n
Project 1: 3 weeks
Project 2: 2 weeks
Project 3: 2 weeks
Project 4: 2 weeks
Project 5: 3 weeks
Total: 13 weeks



Step 1: click on the assignment invite link (previous slide)

Step 2: "**Accept this assignment**"

Step 3: Refresh page -> repository is created automatically



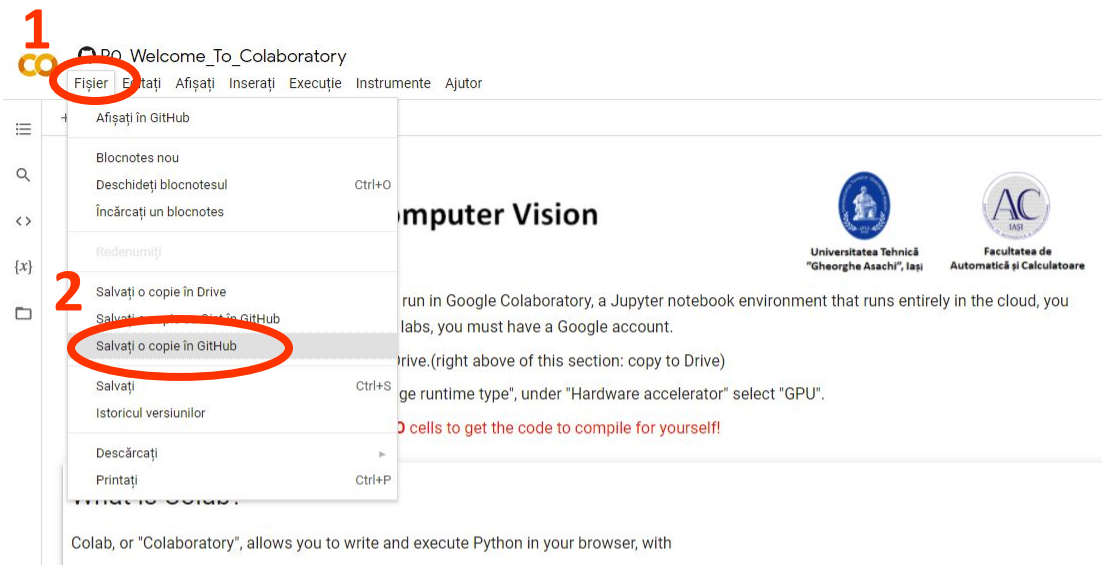
Step 4: Navigate to http://colab.research.google.com/github

Step 5: Click the "**Include Private Repos**" checkbox and **select the correct repository** (SistemeDeVedereArtificiala/assignment_name-student_name)

Step 7: Click on the **jupyter notebook of the assignment**

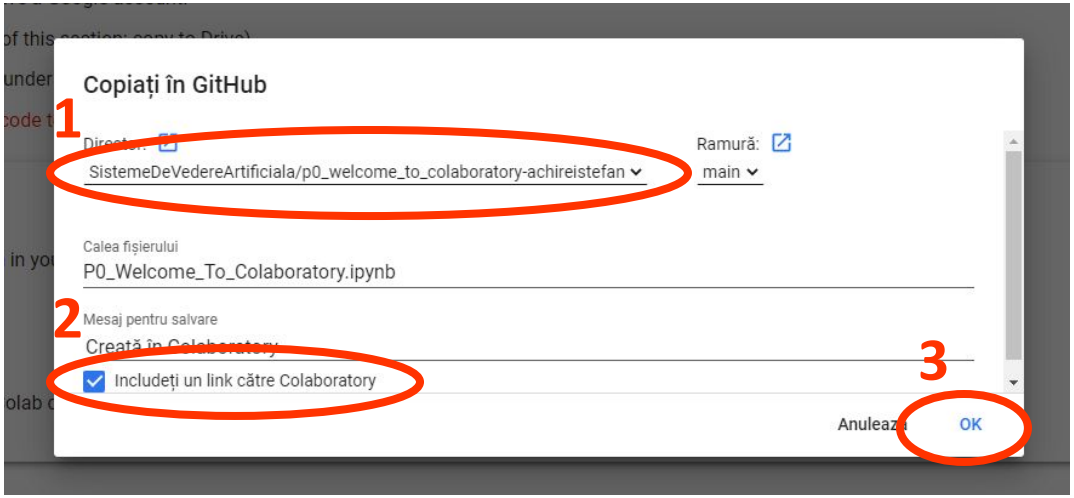
Step 6: In the popup window, sign-in to your Github account and authorize Colab to read the private files.

Step 7: Your private repositories and notebooks will now be available via the github navigation pane.



Once inside colab

Step 8: File -> **Save a copy to GitHub**



Step 9: Select the **correct repository for the SPECIFIC assignment**

Step 10: Tick the "**Include Colab Link**"

Step 11: Click "**OK**"

Read the suggestions and accomplish all tasks marked with #TODO

HARD DEADLINE at the end of each laboratory. REPEAT steps 8, 9, 10, 11 in order to SAVE the answers to your private GitHub repository (individual and different for each assignment)

Assignments considered for grading must have AT LEAST two commits:

1. **the initial one (Step 8)**
2. **the one at the end of the laboratory**