CS 6476:
Computer Vision

Instructor: Frank Dellaert

Tas: Cusuh Ham (head TA), and 8 (9?) more TAs

Image by
kirkh.deviantart.com

Today's Class

- Who am I?
- Specifics of this course
- What is Computer Vision?

A bit about me

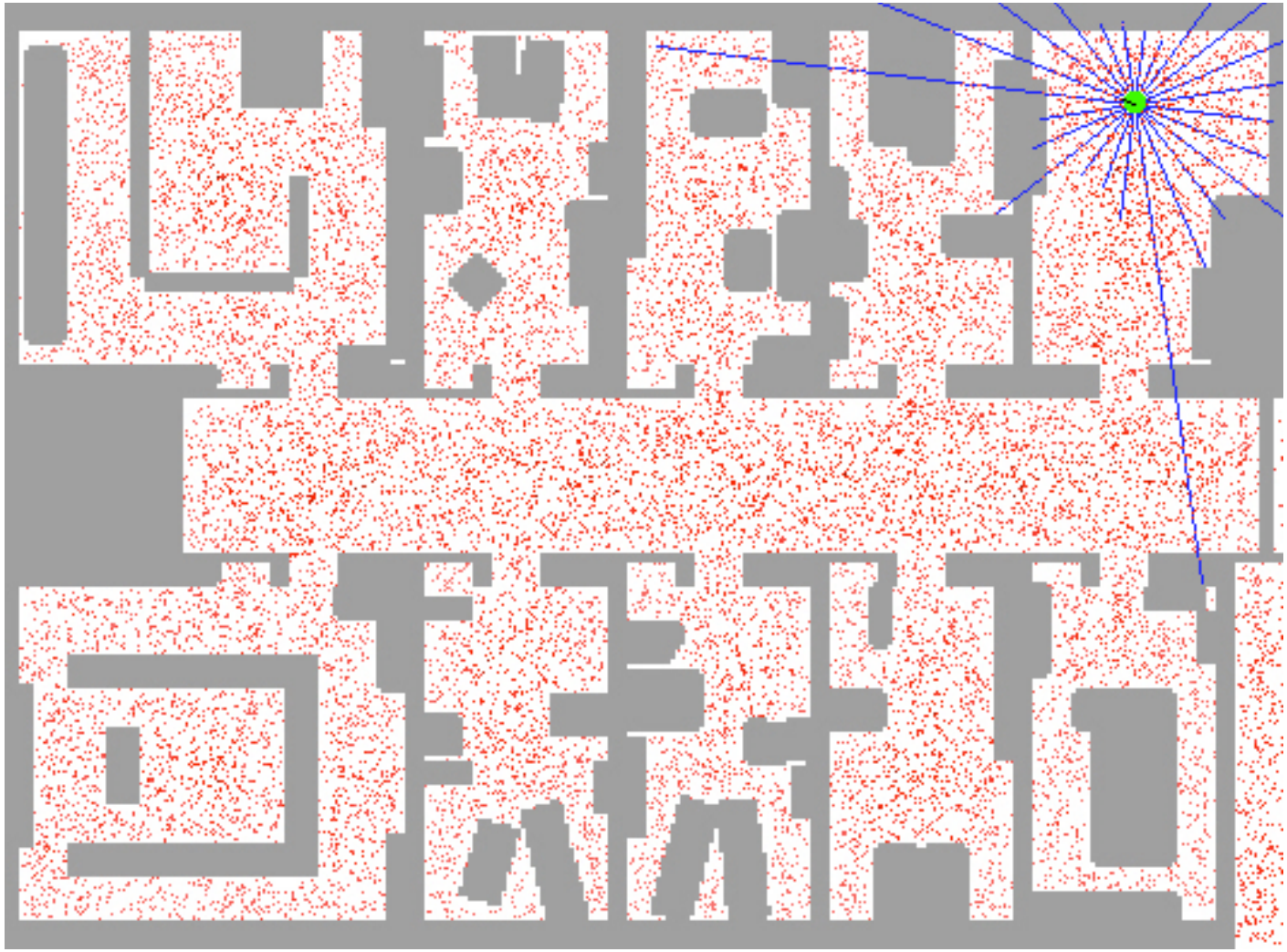
Originally from Belgium
1989 EE in Leuven
1993 M.Sc. ECE at CWRU
2001 Ph.D. CS, Carnegie Mellon

Georgia Tech since August 2001

Teaching Computer Vision etc.:

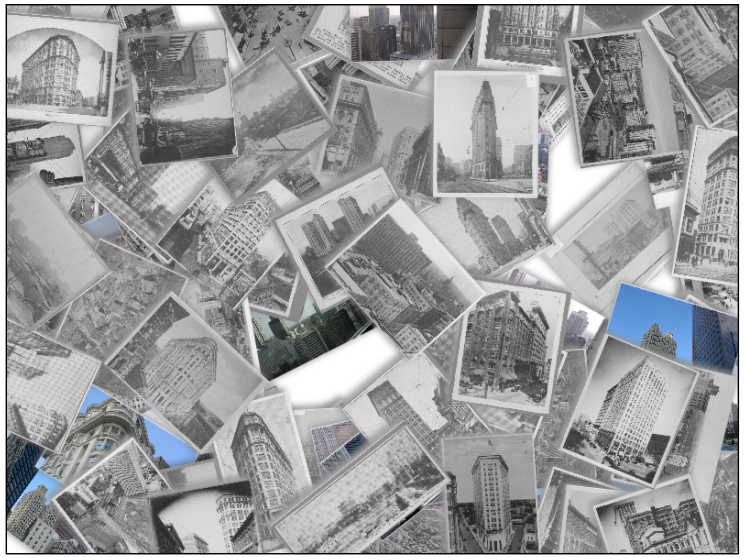
7641	Machine Learning	02, 03, 04	45
8803	3D Reconstruction and Mapping	02, 09, 10,12	70
4495	**Computer Vision**, undergraduate	04, 05, 06, 07	78
8803	Intro to Perception and Robotics	05, 06, 07,13,14	185
7495	**Computer Vision**, graduate	06, 07, 11, 12, 13	153
4475	Computational Photography	07, 09, **18**	155
4480	Digital Video Special effects	08, 09, 10, 11	146
			832

Monte Carlo Localization, at Carnegie Mellon!



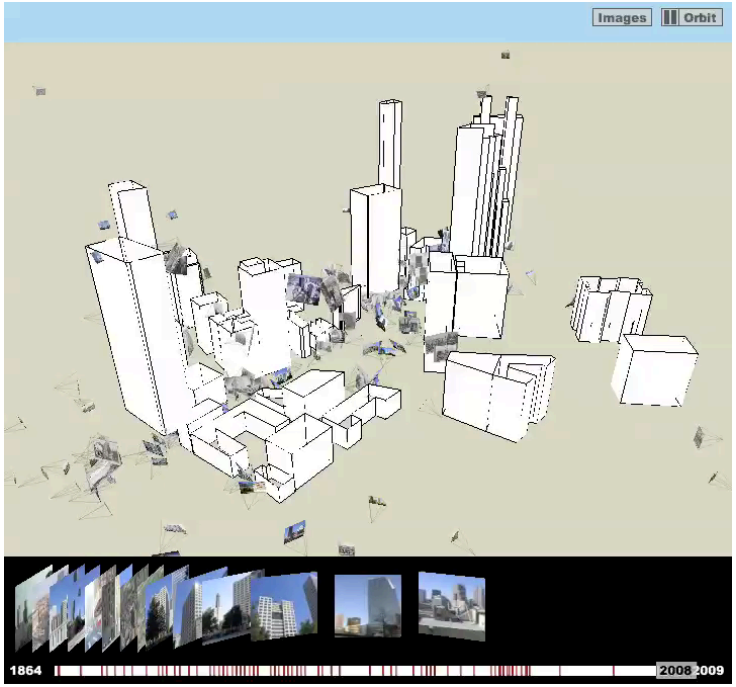
Dellaert, Fox, Burgard & Thrun, ICRA 1999
Fox, Dellaert, Burgard & Thrun, AAAI 1999

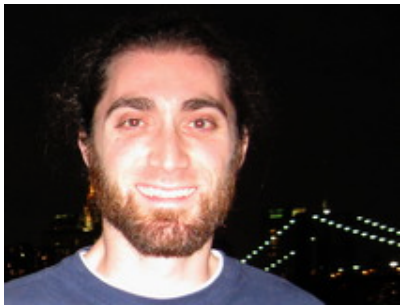
Spatiotemporal Reconstruction



Historical Image Collection

4D Cities: 3D + Time





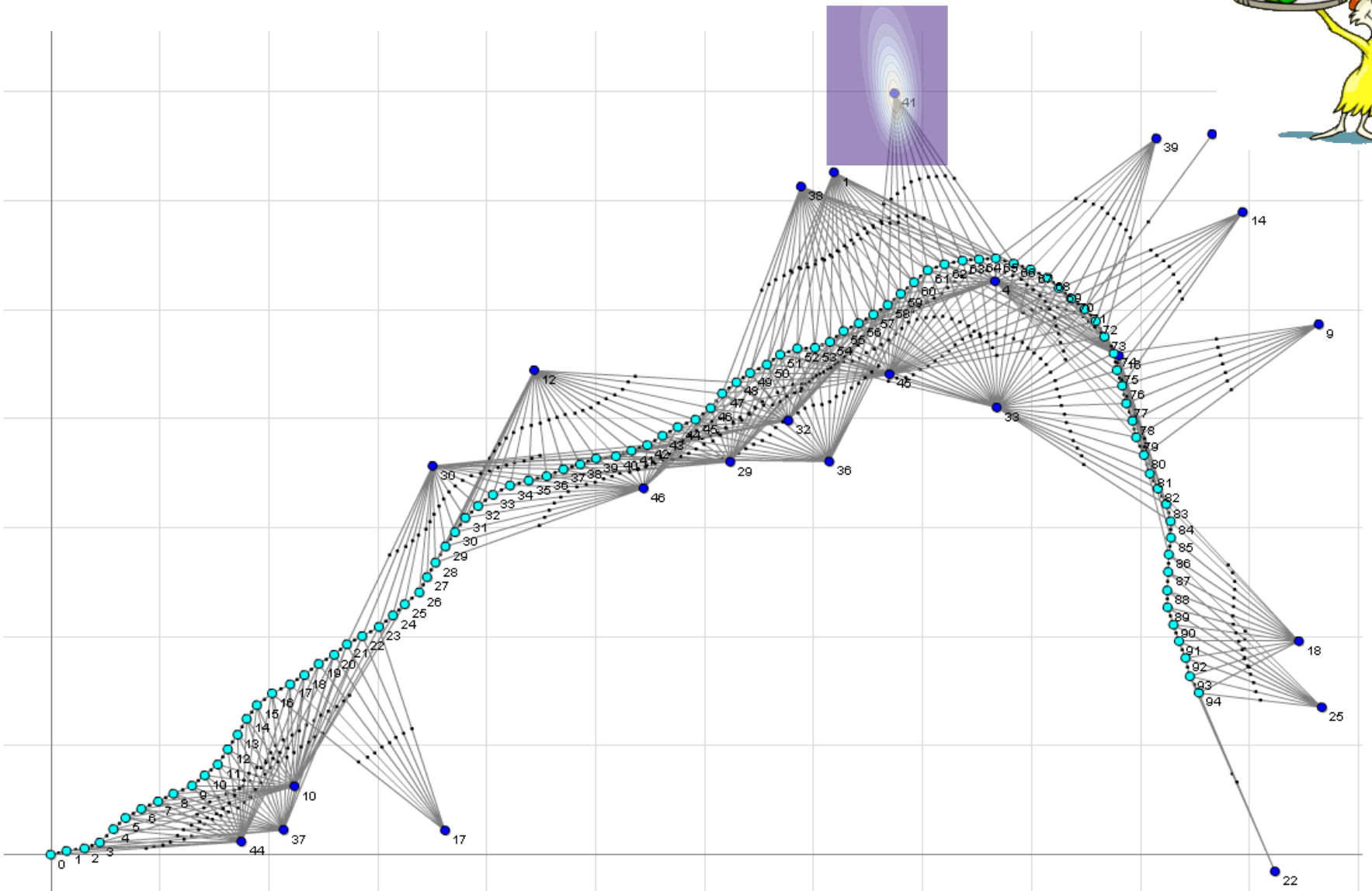
Grant Schindler

Supported by NSF CAREER, Microsoft

Recent revival: NSF NRI award on 4D crops for precision agriculture…

Factor Graphs and AD for Flexible Inference in Robotics and Computer Vision © 2008-2018 Dellaert et al

Factor Graphs -> GTSAM !

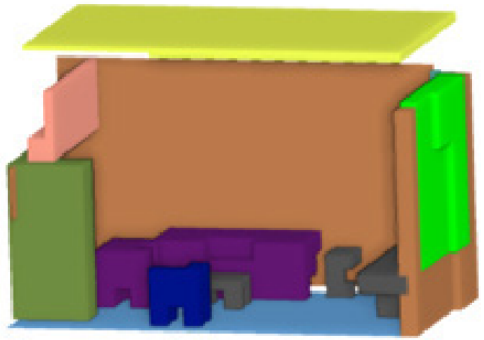


Silicon Valley intermission at Skydio

Silicon Valley intermission at Facebook

The Scene Understanding and Modeling Challenge

RGB-D 360 degree image

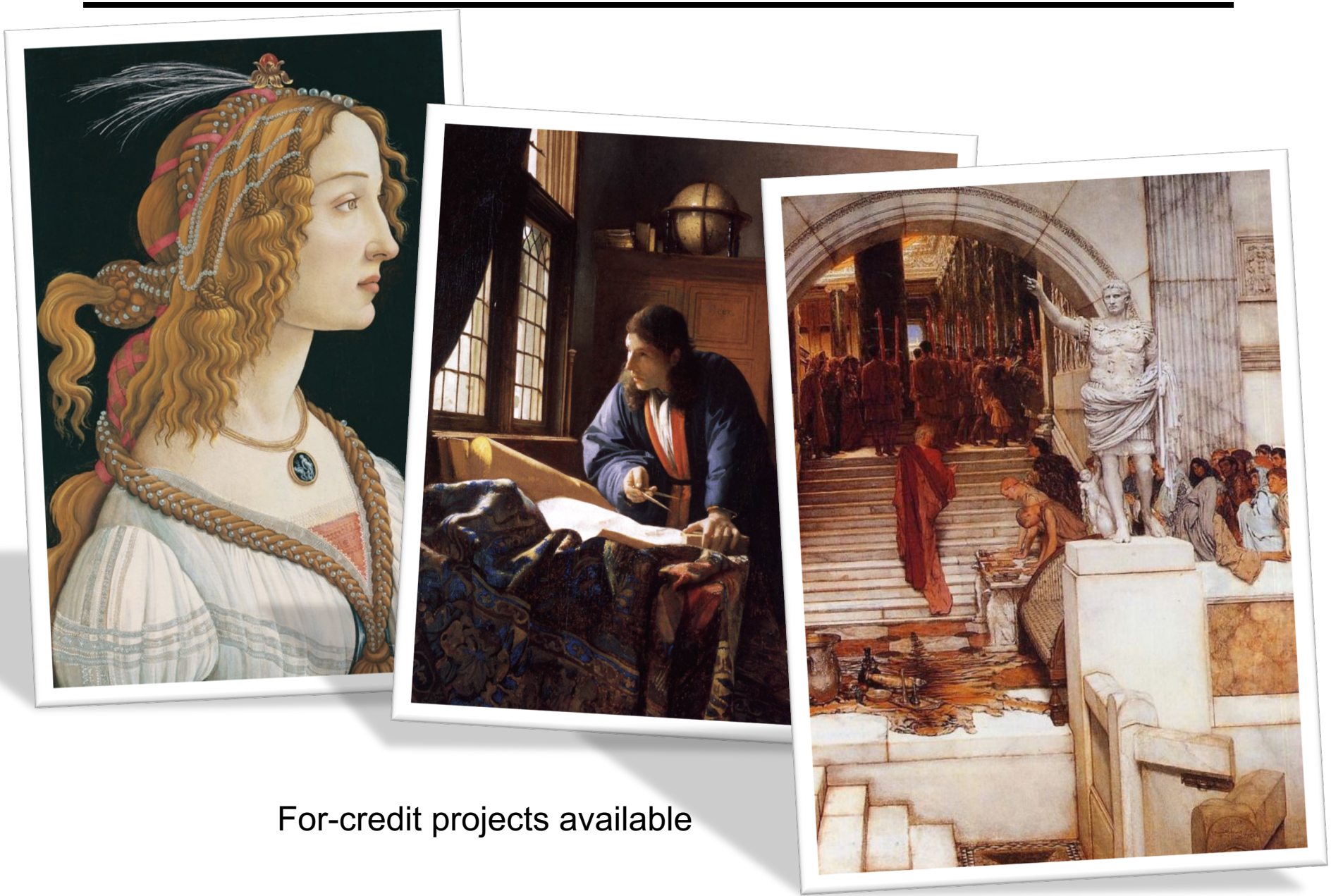


Object-based representation of a room

Organizers
Daniel Huber (Facebook)
Lyne Tchapmi (Stanford University)
Frank Dellaert (FB / Georgia Tech)

Vision Problems Addressed	
Object segmentation	6-DOF pose estimation
Object completion	Appearance modeling
Instance labeling	Layout estimation

What's next? Robot Painting!



For-credit projects available

Course Website/Syllabus

Fall ’19 Computer Vision

tinyurl.com/GT-19F-CS4476

or Google ”Dellaert”

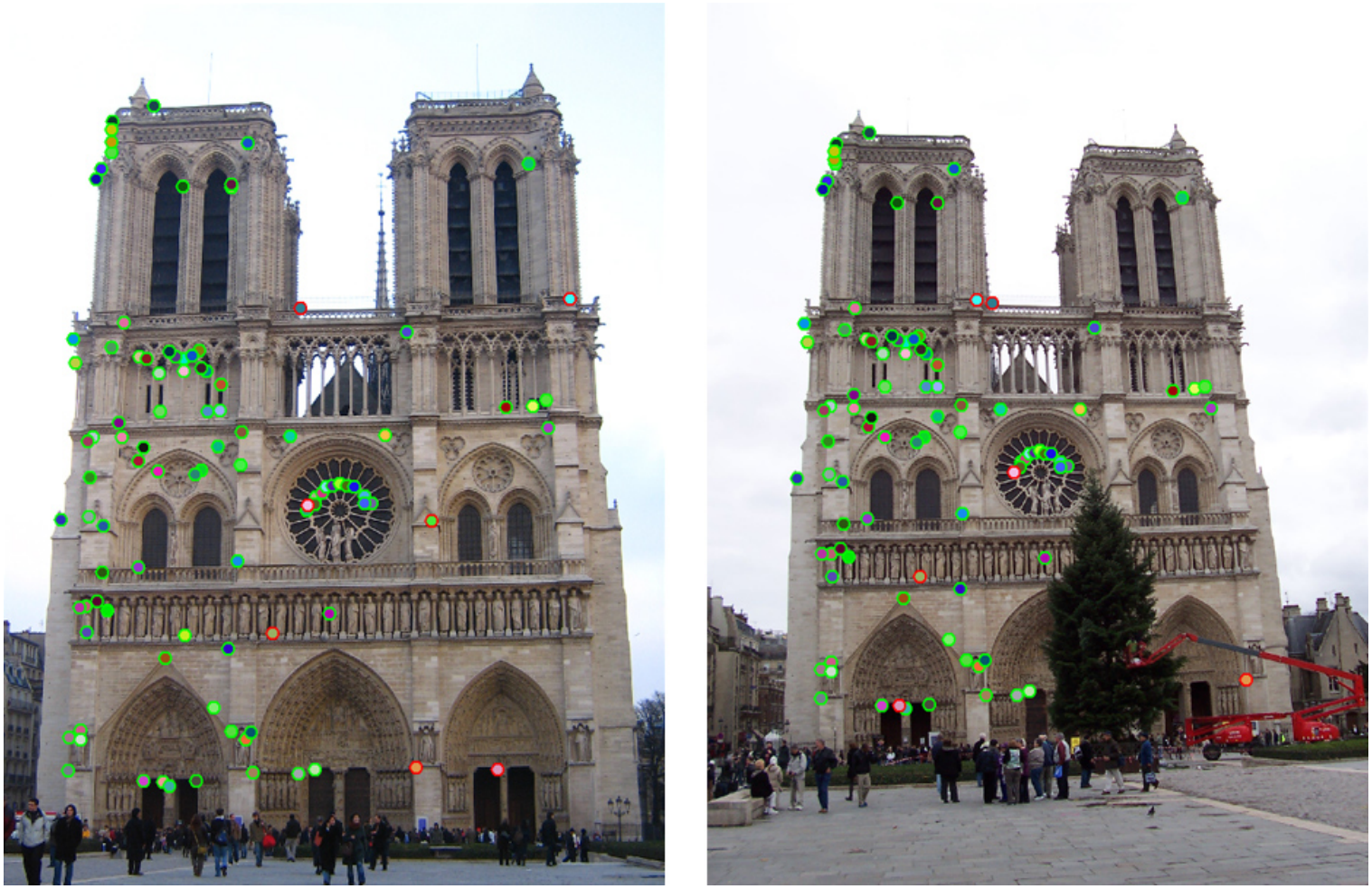
Proj1: Image Filtering and Hybrid Images

Implement image filtering to separate high and low frequencies

Combine high frequencies and low frequencies from different images to create an image with scale-dependent interpretation

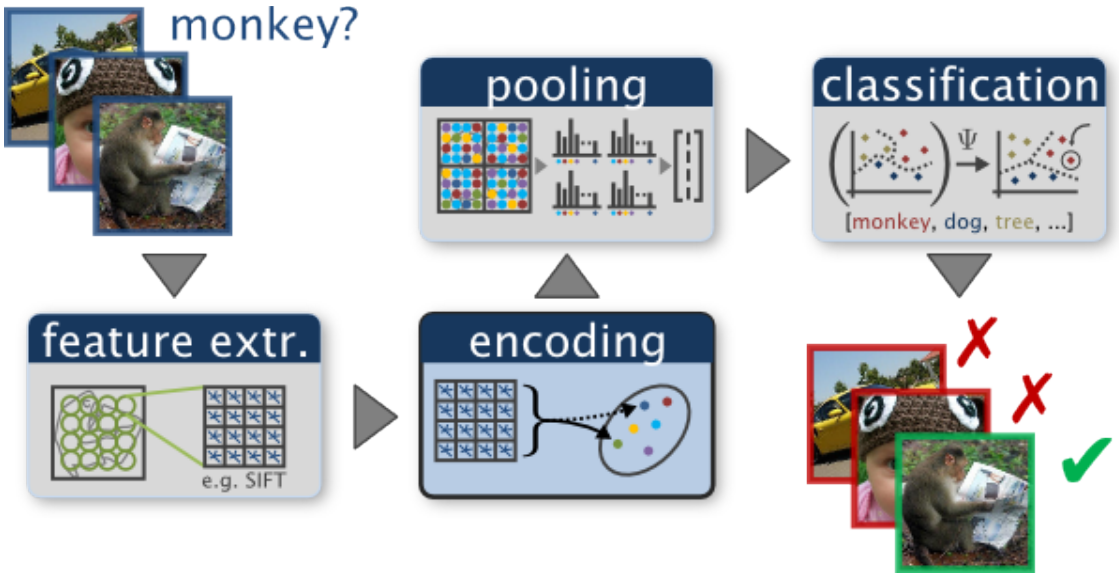
Proj2: Local Feature Matching

Implement interest point detector, SIFT-like local feature descriptor, and simple matching algorithm.



Proj5: Scene Recognition with Bag of Words

Quantize local features into a “vocabulary”, describe images as histograms of “visual words”, train classifiers to recognize scenes based on these histograms.

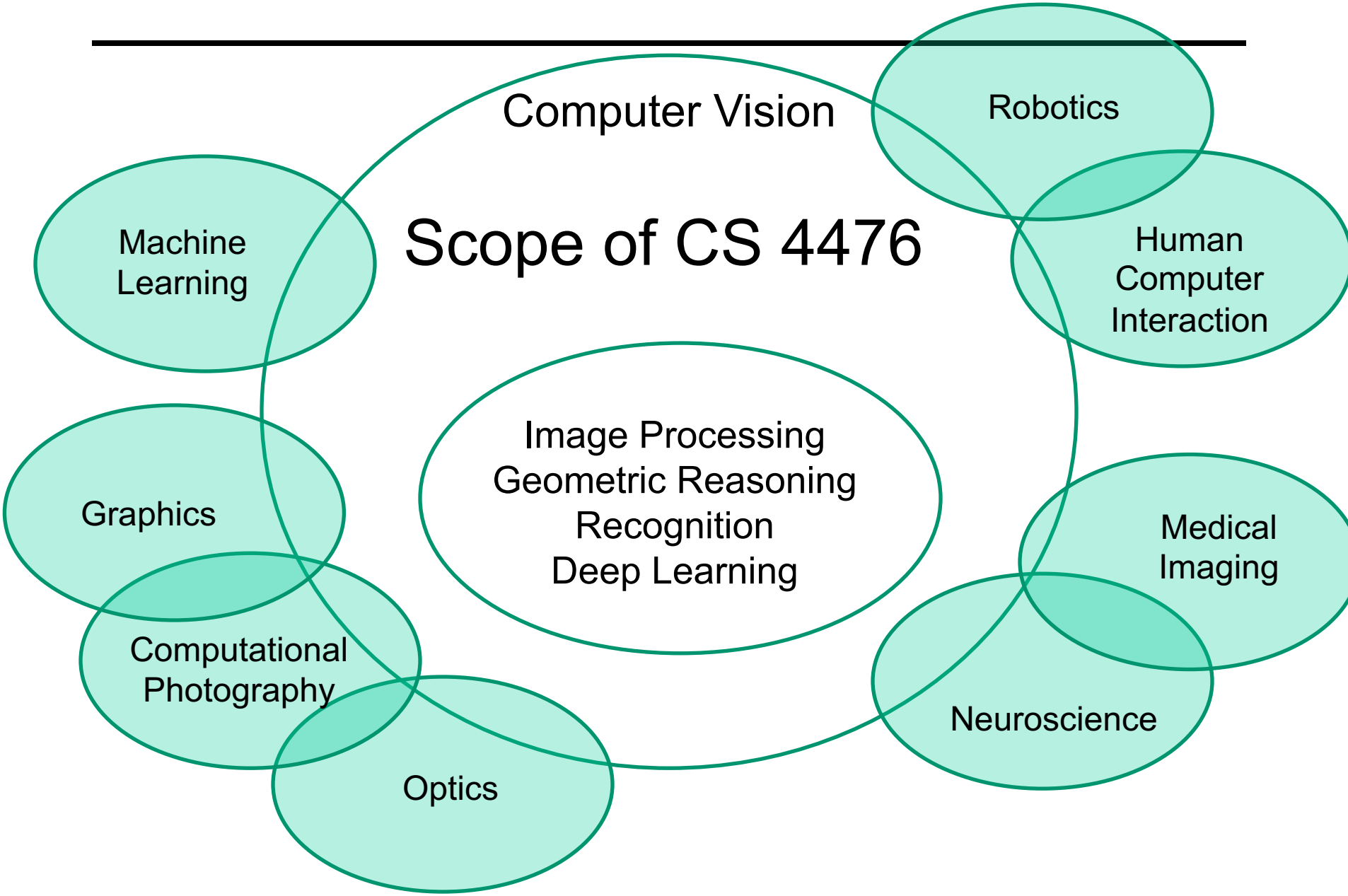


What is Computer Vision?

Computer Graphics: Models to Images

Comp. Photography: Images to Images

Computer Vision: Images to Models


Computer Vision
Robotics
Machine Learning
Scope of CS 4476
Human Computer Interaction
Image Processing
Geometric Reasoning
Recognition
Deep Learning
Graphics
Medical Imaging
Computational Photography
Neuroscience
Optics

Computer Vision

Make computers understand images and video or any visual data.

What kind of scene?

Where are the cars?

How far is the building?

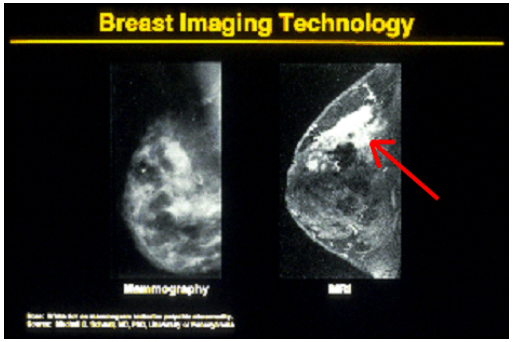
…

Vision is really hard

- Vision is an amazing feat of natural intelligence
  - Visual cortex occupies about 50% of Macaque brain
  - One third of human brain devoted to vision (more than anything else)

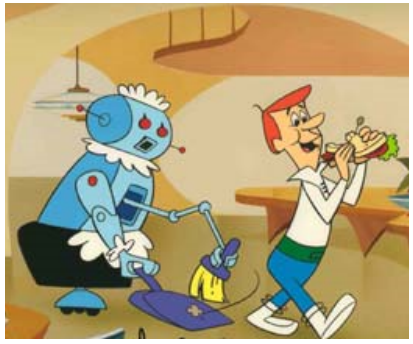
Why computer vision matters

Safety



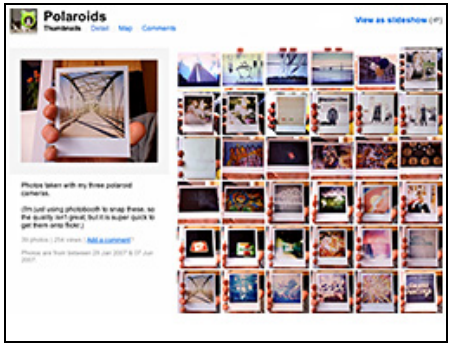
Health

Security



Comfort

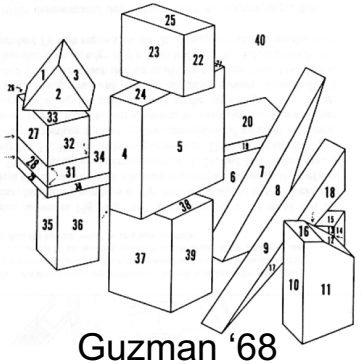
Fun



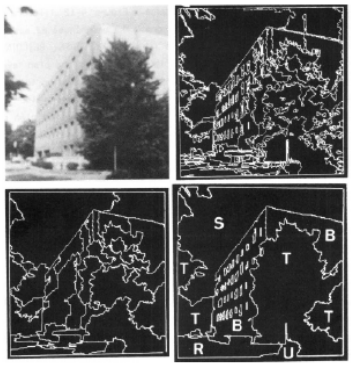
Access

Ridiculously brief history of computer vision

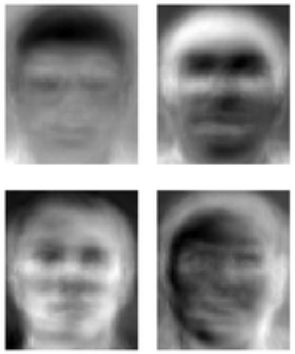
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960's: interpretation of synthetic worlds
- 1970's: some progress on interpreting selected images
- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990's: face recognition; statistical analysis in vogue
- 2000's: broader recognition; large annotated datasets available; video processing starts
- 2010's: Deep learning with ConvNets
- 2020's: Widespread autonomous vehicles?
- 2030's: robot uprising?



Guzman '68



Ohta Kanade '78



Turk and Pentland '91

How vision is used now

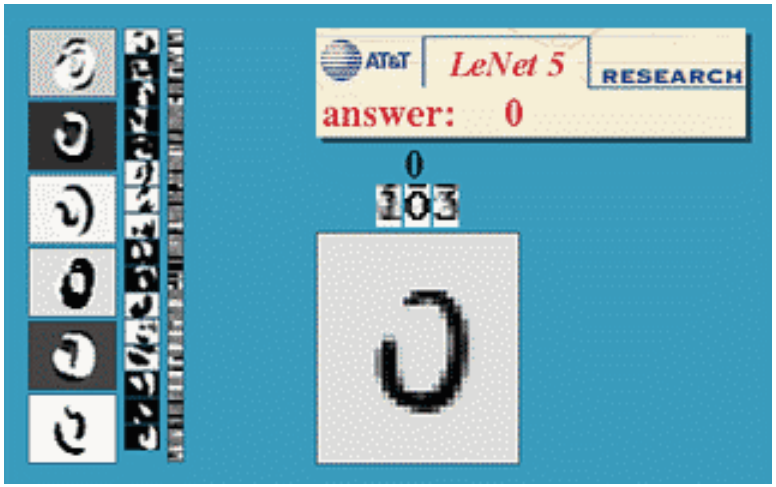
- Examples of real world applications

Some of the following slides by Steve Seitz

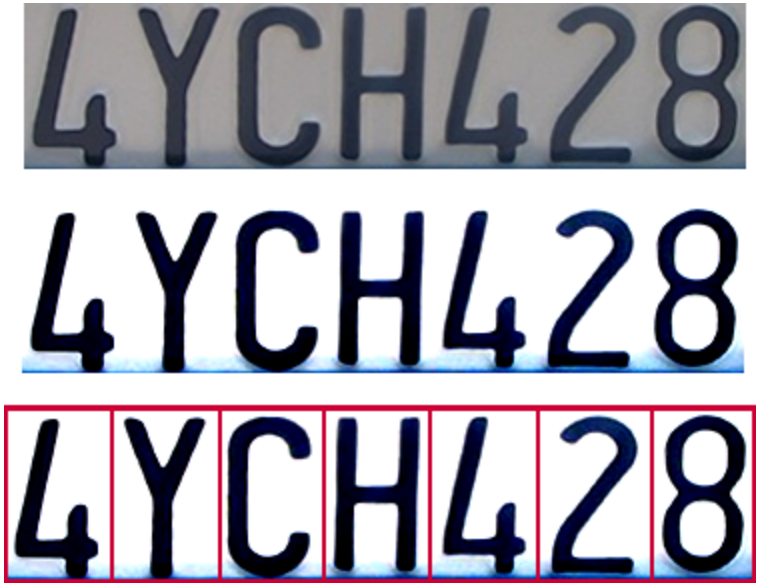
Optical character recognition (OCR)

Technology to convert scanned docs to text

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



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

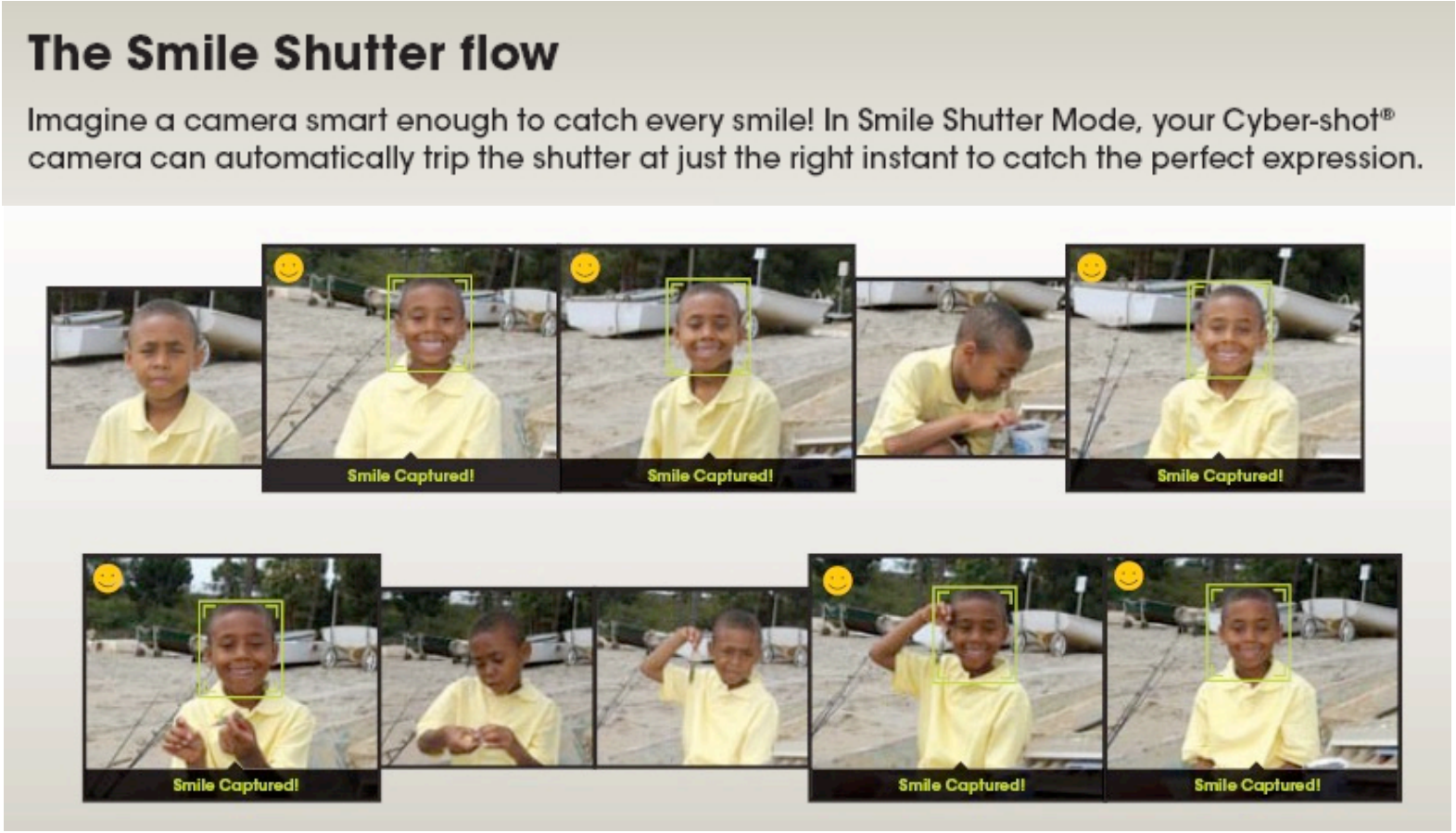


License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Face detection

- Digital cameras detect faces

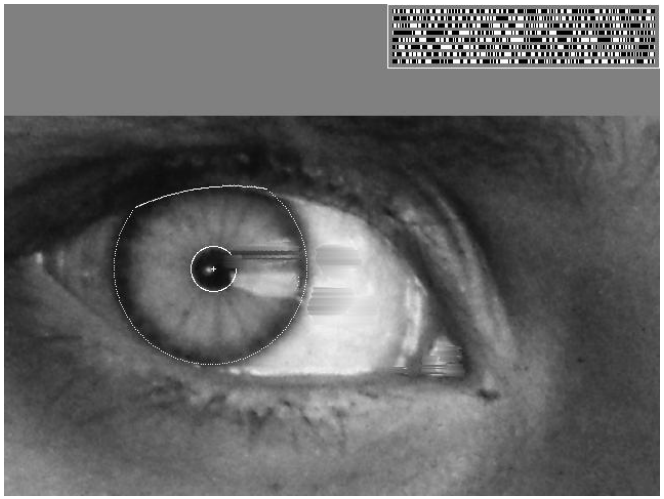
Smile detection

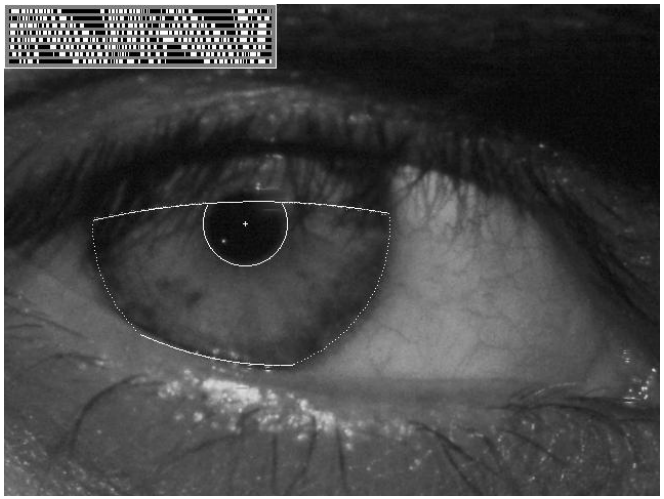


[Sony Cyber-shot® T70 Digital Still Camera]

Vision-based biometrics

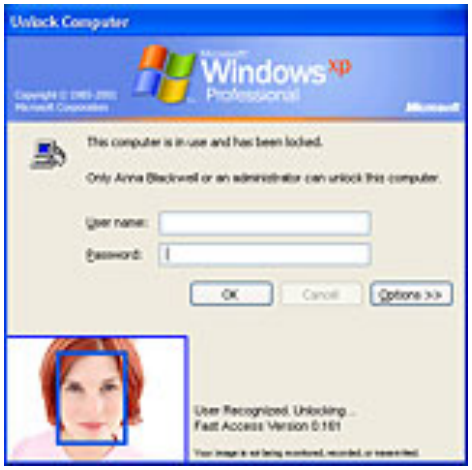
"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story wikipedia





Login without a password…

Fingerprint scanners on many new laptops, other devices



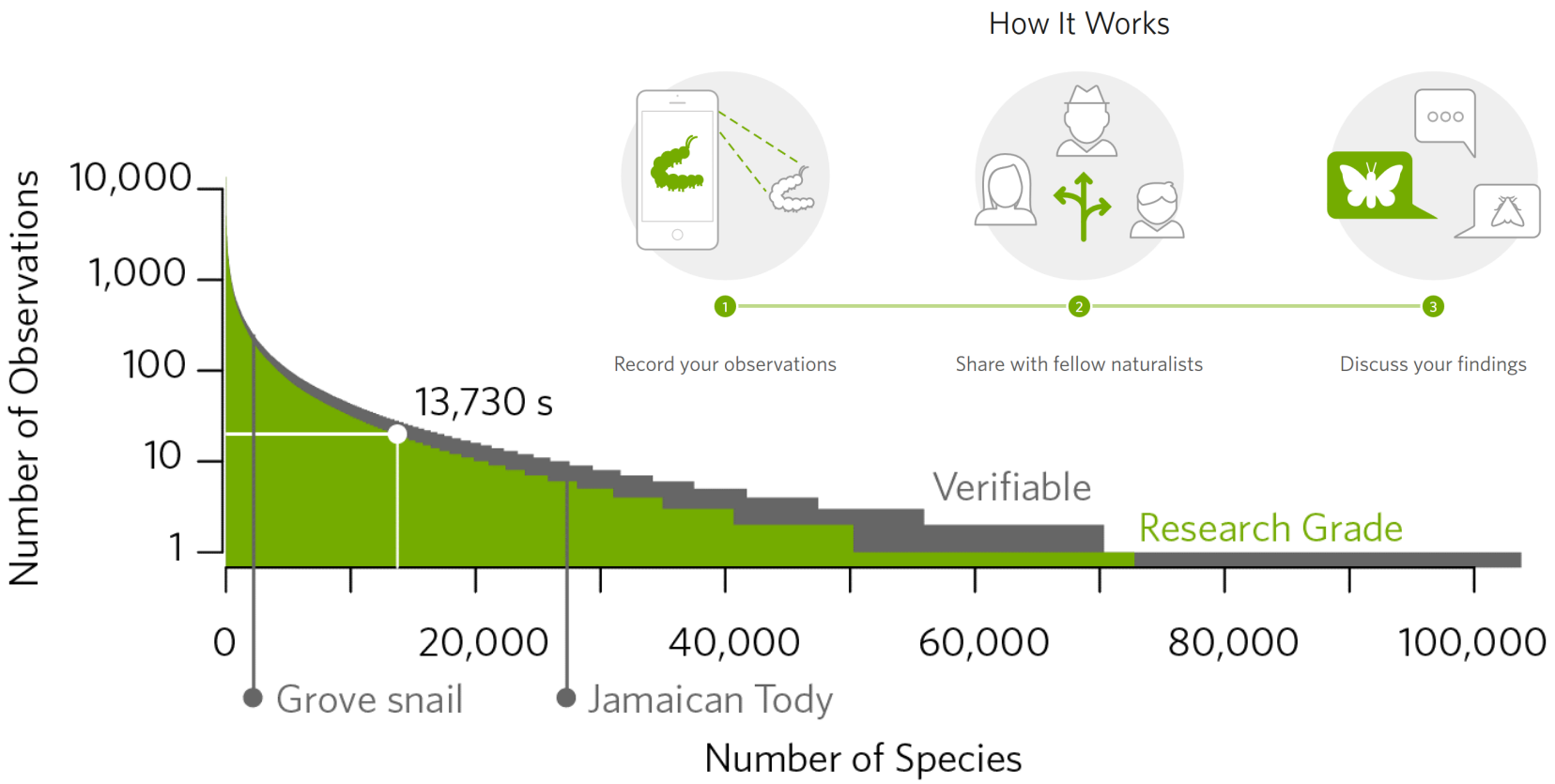
Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

Object recognition (in mobile phones)

[Point & Find](), [Nokia]()

[Google Goggles]()

iNaturalist



https://www.inaturalist.org/pages/computer_vision_demo

Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Special effects: motion capture

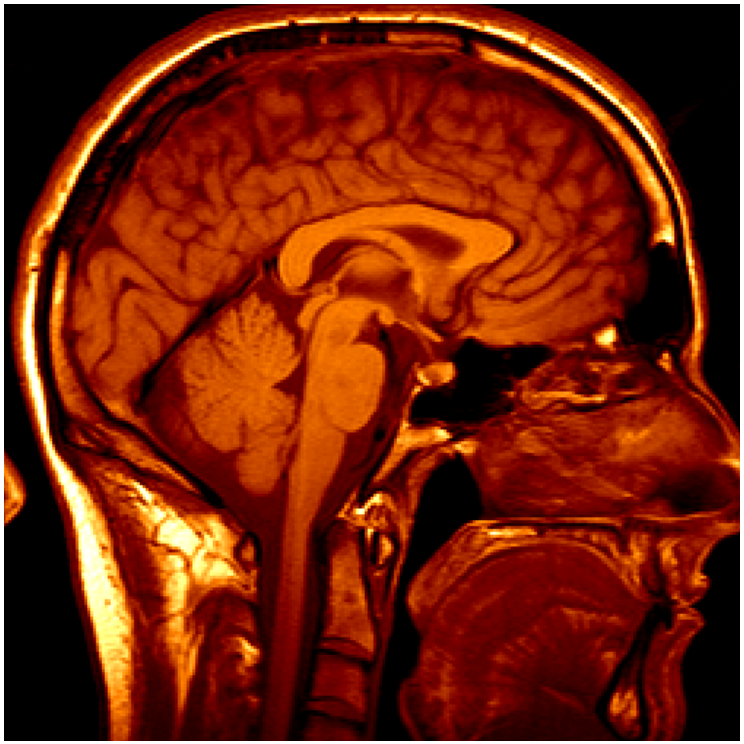
Pirates of the Carribean, Industrial Light and Magic

Sports

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

http://www.sportvision.com/video.html

Medical imaging



3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Smart cars

Slide content courtesy of Amnon Shashua

- Mobileye
  - ~~Market Capitalization: 11 Billion dollars~~
  - Bought by Intel for 15 Billion dollars

Google cars

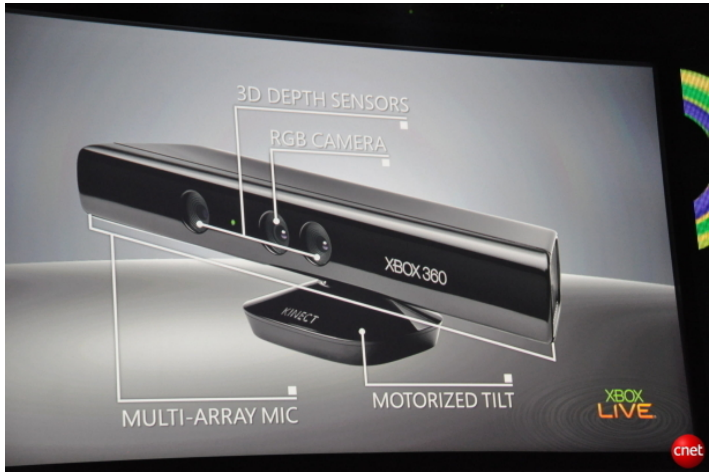
Oct 9, 2010. "Google Cars Drive Themselves, in Traffic". *The New York Times*. John Markoff

June 24, 2011. "Nevada state law paves the way for driverless cars". *Financial Post*. Christine Dobby

Aug 9, 2011, "Human error blamed after Google's driverless car sparks five-vehicle crash". *The Star* (Toronto)

Interactive Games: Kinect

- Object Recognition: http://www.youtube.com/watch?feature=iv&v=fQ59dXOo63o
- Mario: http://www.youtube.com/watch?v=8CTJL5lUjHg
- 3D: http://www.youtube.com/watch?v=7QrnwoO1-8A
- Robot: http://www.youtube.com/watch?v=w8BmgtMKFbY



Augmented Reality and Virtual Reality

Magic Leap, Oculus, Hololens, etc.

Industrial robots

Vision-guided robots position nut runners on wheels

Vision in space

NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Vision systems (JPL) used for several tasks

- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read "Computer Vision on Mars" by Matthies et al.

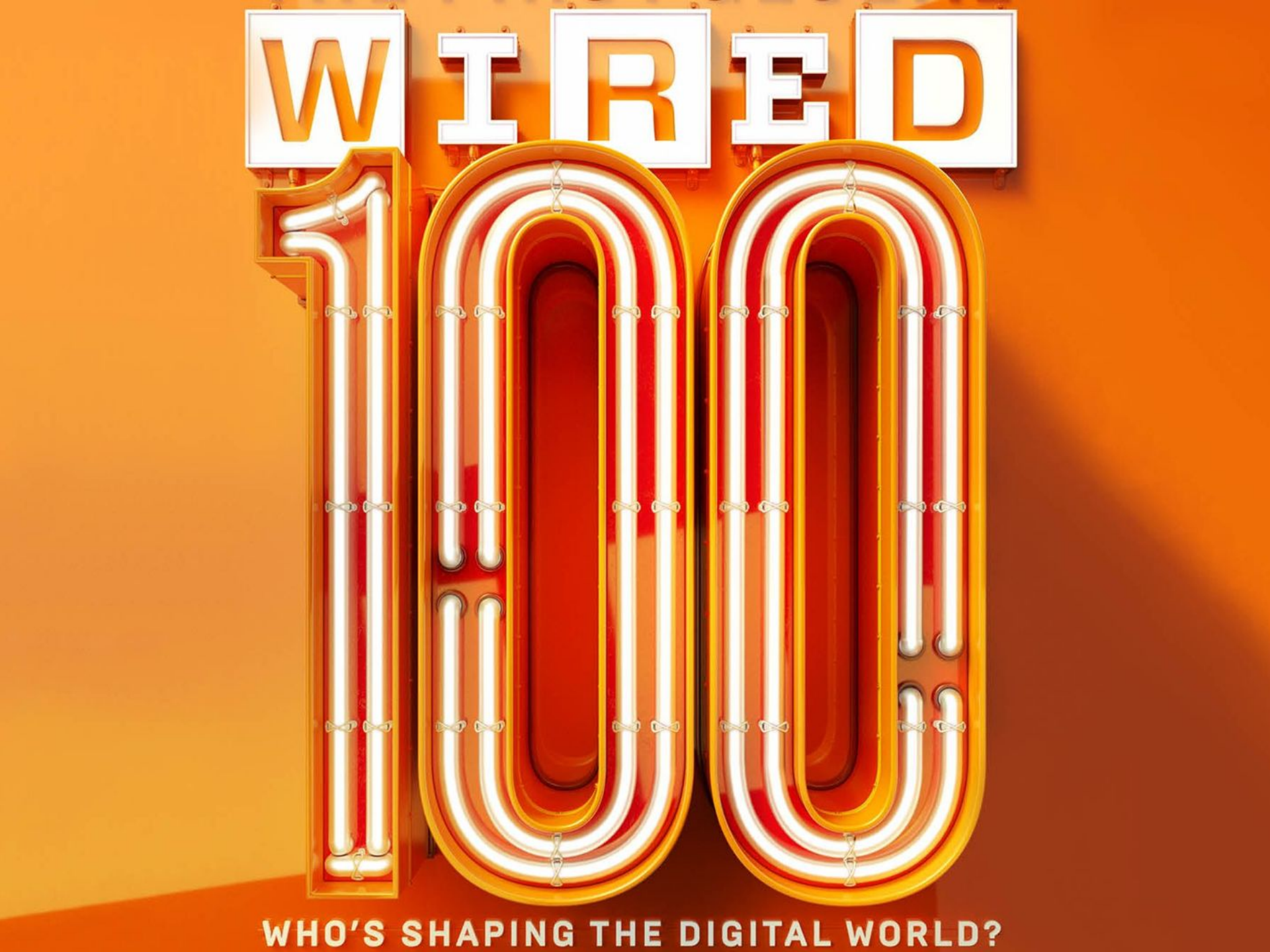
Amazon Prime Air

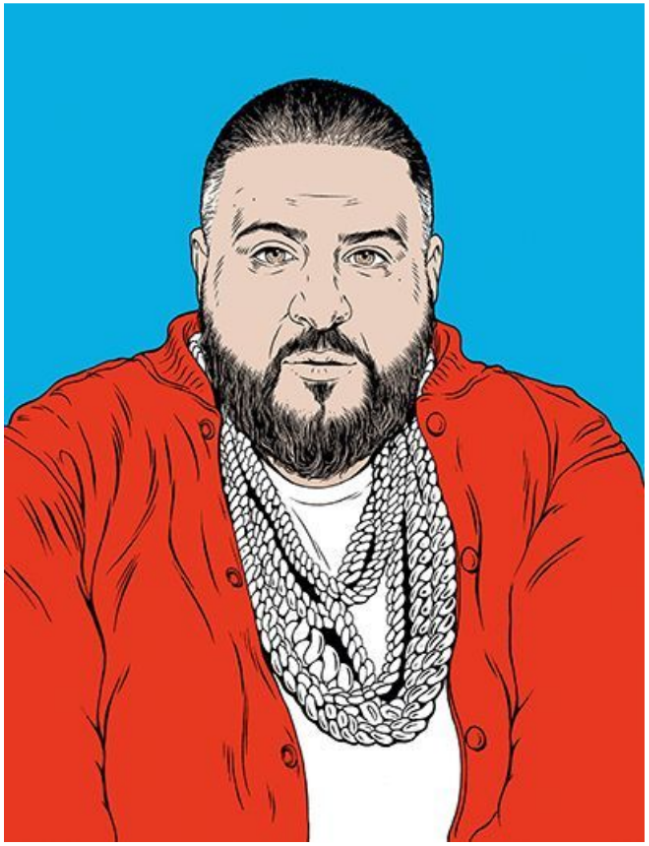
https://www.amazon.com/b?node=8037720011

State of the art today?

With enough training data, computer vision nearly matches human vision at most recognition tasks

Deep learning has been an enormous disruption to the field. More and more techniques are being “deepified”.


WIRED
100
WHO'S SHAPING THE DIGITAL WORLD?



DJ Khaled

Credit **Louise Zergaeng Pomeroy**

73. DJ Khaled

Snapchat icon; DJ and producer

Louisiana-born Khaled Mohamed Khaled, aka DJ Khaled, cut his musical chops in the early 00s as a host for Miami urban music radio WEDR. He proceeded to build a solid if not dazzling career as a mixtape DJ and music producer (he founded his label We The Best Music Group in 2008, and was appointed president of Def Jam South in 2009).

69. Geoffrey Hinton

Psychologist, computer scientist; researcher, Google Toronto

British-born Hinton has been dubbed the "godfather of deep learning". The Cambridge-educated cognitive psychologist and computer scientist started being an ardent believer in the potential of neural networks and deep learning in the 80s, when those technologies enjoyed little support in the wider AI community.

But he soldiered on: in 2004, with support from the Canadian Institute for Advanced Research, he launched a University of Toronto programme in neural computation and adaptive perception, where, with a group of researchers, he carried on investigating how to create computers that could behave like brains.

Hinton's work – in particular his algorithms that train multilayered neural networks – caught the attention of tech giants in Silicon Valley, which realised how deep learning could be applied to voice recognition, predictive search and machine vision.

The spike in interest prompted him to launch a free course on neural networks on e-learning platform Coursera in 2012. Today, 68-year-old Hinton is chair of machine learning at the University of Toronto and moonlights at Google, where he has been using deep learning to help build internet tools since 2013.

63. Yann Lecun

Director of AI research, Facebook, Menlo Park

LeCun is a leading expert in deep learning and heads up what, for Facebook, could be a hugely significant source of revenue: understanding its user's intentions.

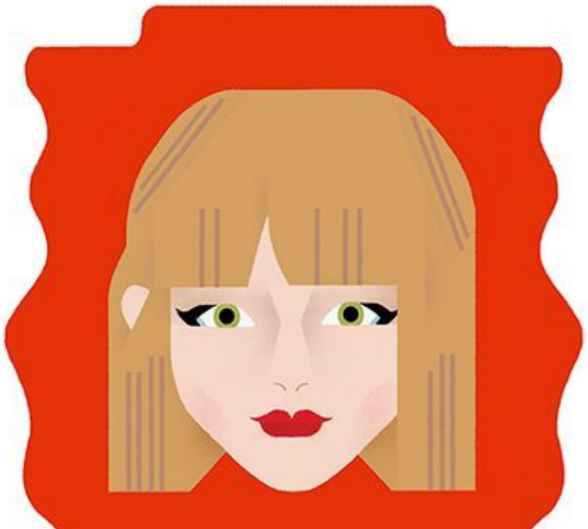
62. Richard Branson

Founder, Virgin Group, London

Branson saw his personal fortune grow £550 million when Alaska Air bought Virgin America for $2.6 billion in April. He is pressing on with civilian space travel with Virgin Galactic.

61. Taylor Swift

Entertainer, Los Angeles



Credit **Google DeepMind**

Google-backed startup DeepMind Technologies has built an artificial intelligence agent that can learn to successfully play 49 classic Atari games by itself, with minimal input.

The story of AlphaGo so far

AlphaGo is the first computer program to defeat a professional human Go player, the first program to defeat a Go world champion, and arguably the strongest Go player in history.

AlphaGo's first formal match was against the reigning 3-times European Champion, Mr Fan Hui, in October 2015. Its 5-0 win was the first ever against a Go professional, and the results were published in full technical detail in the international journal, **Nature**. AlphaGo then went on to compete against legendary player Mr Lee Sedol, winner of 18 world titles and widely considered to be the greatest player of the past decade.

AlphaGo's 4-1 victory in Seoul, South Korea, in March 2016 was watched by over 200 million people worldwide. It was a landmark achievement that experts agreed was a decade ahead of its time, and earned AlphaGo a 9 dan professional ranking (the highest certification) - the first time a computer Go player had ever received the accolade.

During the games, AlphaGo played a handful of **highly inventive winning moves,** several of which - including move 37 in game two - were so surprising they overturned hundreds of years of received wisdom, and have since been examined extensively by players of all levels. In the course of winning, AlphaGo somehow taught the world completely new knowledge about perhaps the most studied and contemplated game in history.

Since then, AlphaGo has continued to surprise and amaze. In January 2017, an improved AlphaGo version was revealed as the online player "Master" which achieved **60 straight wins in online fast time-control games** against top international Go players.

In May 2017, Alpha Go took part in The Future of Go Summit in the birthplace of Go, China, to delve deeper into the mysteries of Go in a spirit of mutual collaboration with the country's top players. You can read more about the five day summit **here**.

Exploring the mysteries of Go with AlphaGo and China's top players

› More on The Future of Go Summit in this video

Demis Hassabis on 'The Future of Go' Summit in China

› Watch the video here

BigGAN

2018 Arxiv, ICLR 2019

Large Scale GAN Training for High Fidelity Natural Image Synthesis

Andrew Brock, Jeff Donahue, Karen Simonyan

This person does not exist

https://www.thispersondoesnotexist.com/