What is Computer Vision?

Computer Graphics: Models to Images
Comp. Photography: Images to Images
Computer Vision: Images to Models
Scope of this class

Computer Vision
- Image Processing
- Geometric Reasoning
- Recognition
- Deep Learning

Robotics

Human Computer Interaction

Medical Imaging

Neuroscience

Optics

Graphics

Computational Photography

Machine Learning
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?
Examples of real-world applications

How vision is used now

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

The Smile Shutter flow

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.

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
Medical imaging

3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT
Smart cars

- **Mobileye**
  - Market Capitalization: 11 Billion dollars
  - Bought by Intel for 15 Billion dollars
Google cars


Zoox Computer Vision Demo

https://www.youtube.com/watch?v=BVRMh9NO9Cs
Interactive Games: Kinect

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

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.

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

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/