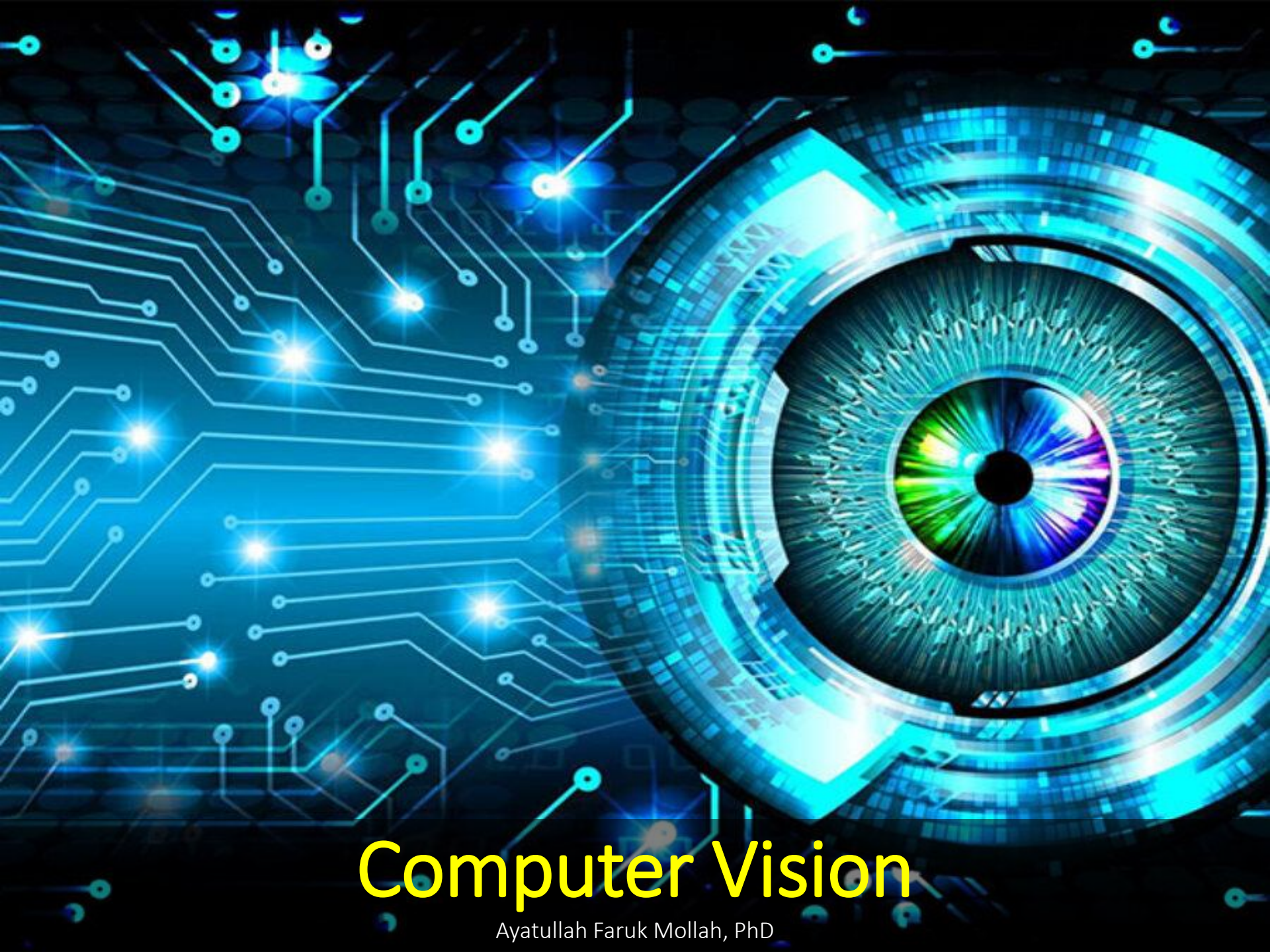


Computer Vision

Ayatullah Faruk Mollah, PhD

What is Computer Vision?

- Make computers understand images and videos.

- What kind of scene?
- Where are the cars?
- How far is the building?

What is Computer Vision?

- Make computers understand images and videos.

- What are they doing?
- Why is this happening?
- What is important?
- What will I see?

Visual data on the Internet

- Flickr
  - 10+ billion photographs
  - 60 million images uploaded a month
- Facebook
  - 250 billion+
  - 300 million a day
- Instagram
  - 55 million a day
- YouTube
  - 100 hours uploaded every minute

90% of net traffic will be visual!

Too big for humans

- Need automatic tools to access and analyze visual data!

Vision is Really Hard

- Vision is an amazing feature of natural intelligence
  - Visual cortex occupies about 50% of Macaque brain
  - More human brain devoted to vision than anything else

Challenges: Many nuisance parameters

Illumination

Object pose

Clutter

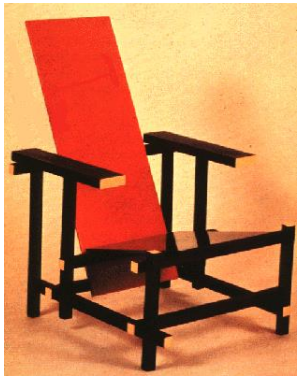
Occlusions

Intra-class appearance

Viewpoint

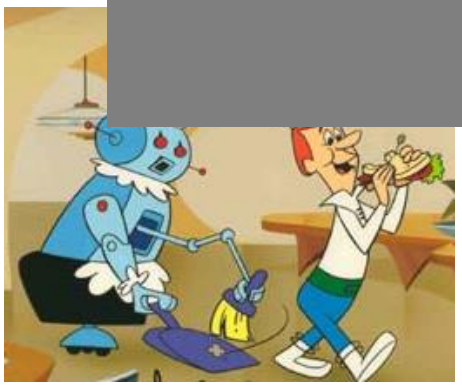
Challenges: Intra-class variation



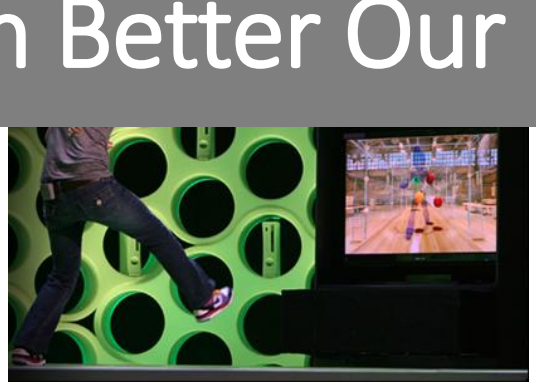



Challenges: Importance of context

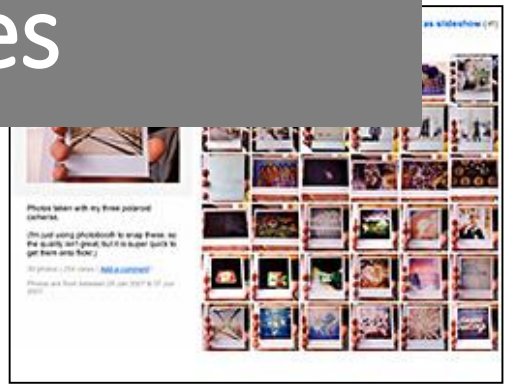
Computer Vision Technology Can Better Our Lives



Comfort



Fun



Access

History of Computer Vision

Marvin Minsky, MIT
Turing award, 1969

"In 1966, Minsky hired a first-year undergraduate student and assigned him a problem to solve over the summer:

connect a camera to a computer and get the machine to describe what it sees."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group
Vision Memo. No. 100.

July 7, 1966

Half a century later,
we're still working on it.

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

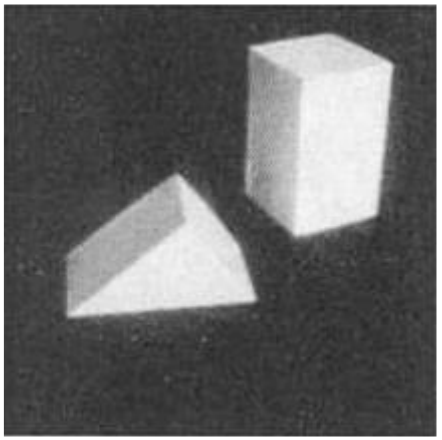
History of Computer Vision

Marvin Minsky, MIT
Turing award, 1969

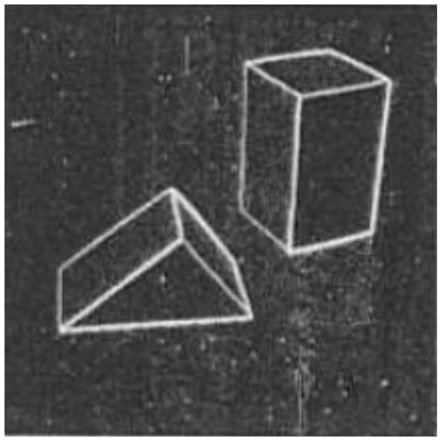
Gerald Sussman, MIT
AI Researcher since 1964

1960's: interpretation of synthetic worlds

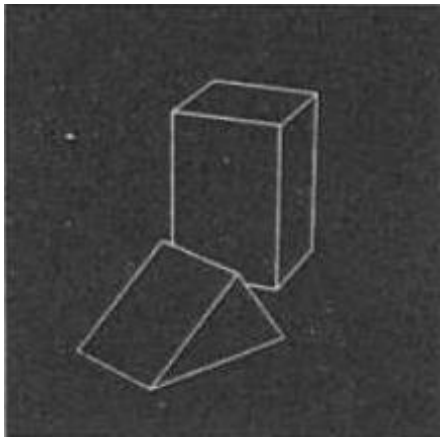
Larry Roberts
"Father of Computer Vision"



Input image



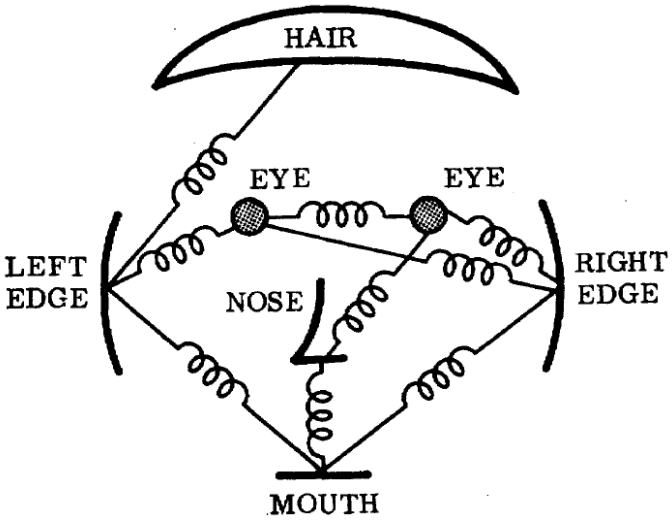
2x2 gradient operator

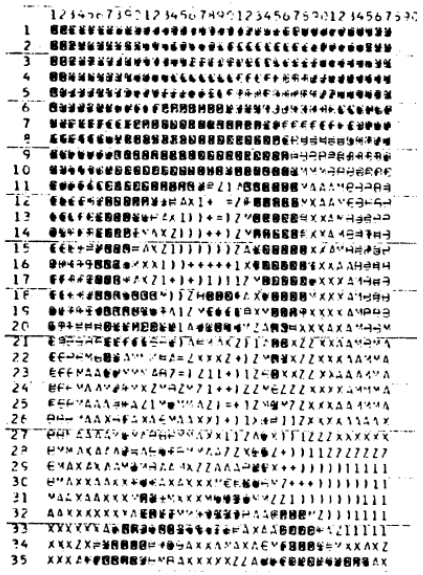


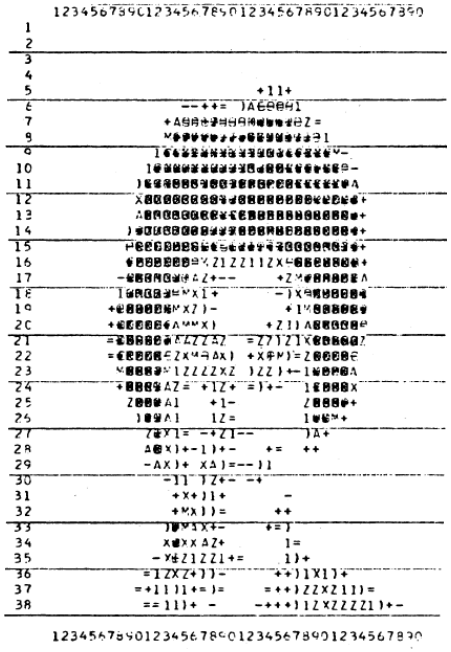
computed 3D model
rendered from new viewpoint

Larry Roberts PhD Thesis, MIT, 1963,
Machine Perception of Three-Dimensional Solids

1970's: some progress on interpreting selected images

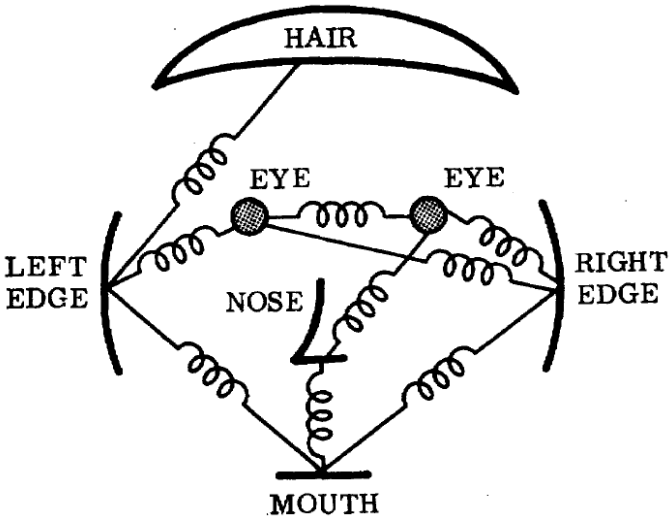


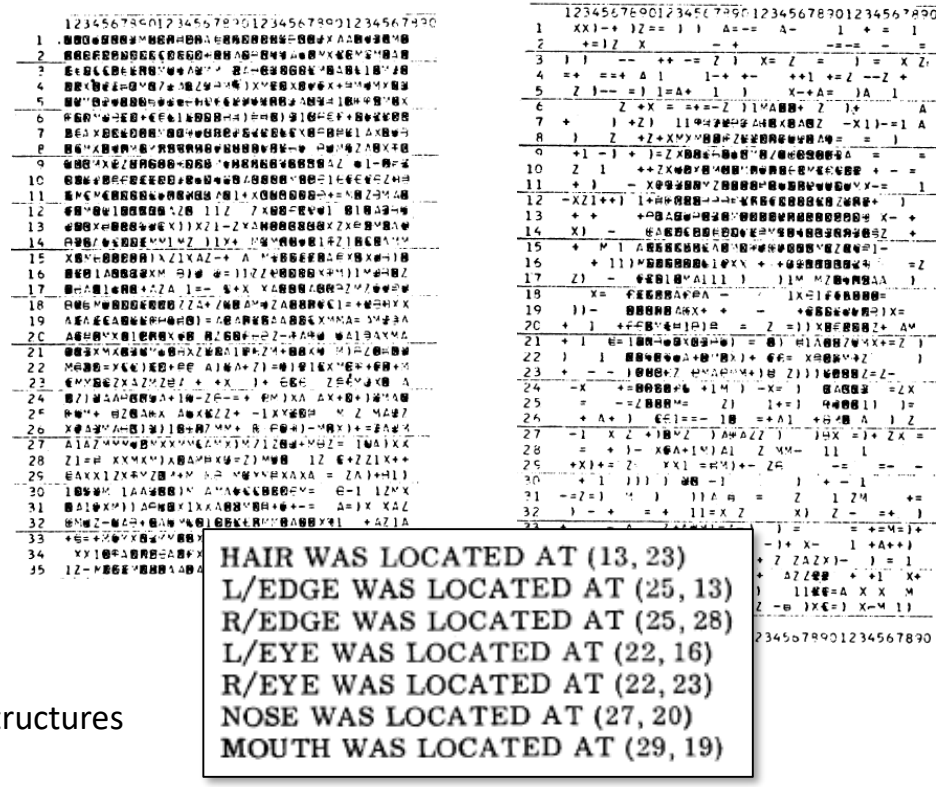




The representation and matching of pictorial structures
Fischler and Elschlager, 1973

1970's: some progress on interpreting selected images

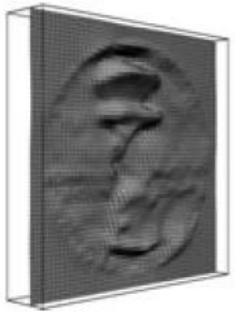




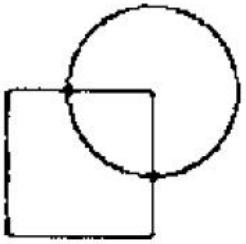
The representation and matching of pictorial structures
Fischler and Elschlager, 1973

1980's: ANNs come and go; shift toward geometry and increased mathematical rigor

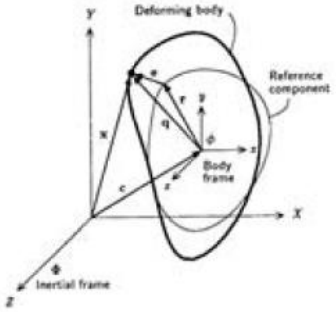
(a)



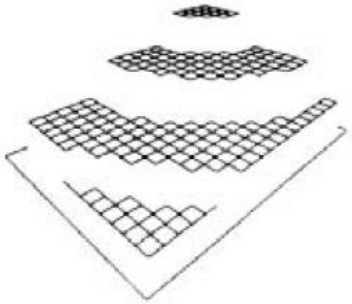
(b)



(c)



(d)



(e)

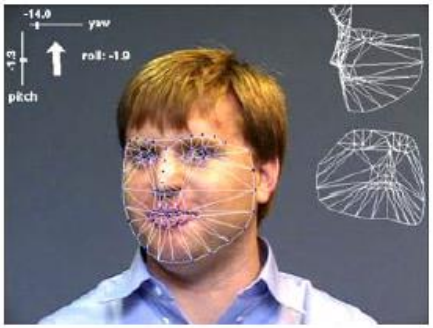
(f)

1990’s: face recognition; statistical analysis in vogue

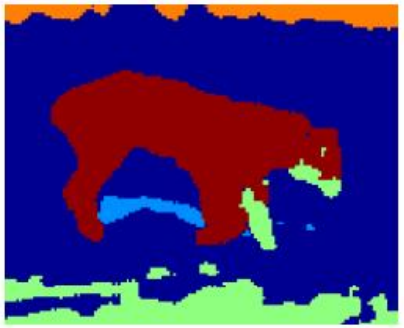
(a)

(b)

(c)



(d)

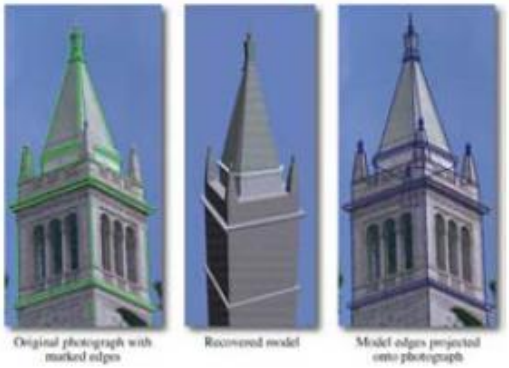


(e)

(f)

2000's: broader recognition; large annotated datasets available; video processing starts

(a)



(b)

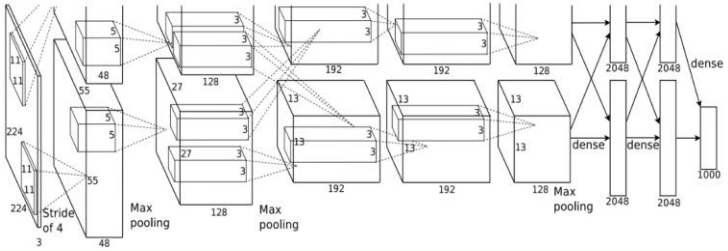
(c)

(d)

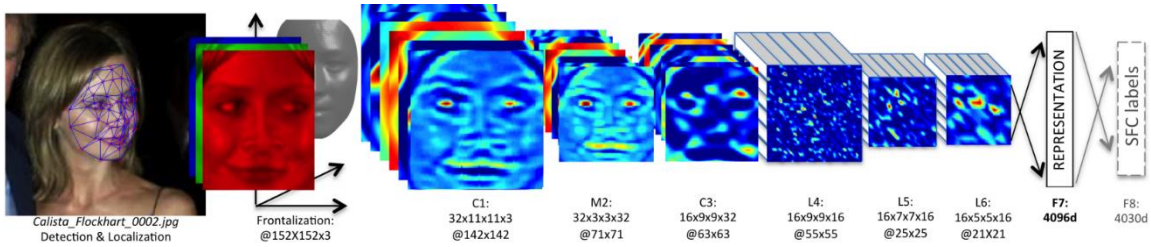
(e)

(f)

2010's: resurgence of deep learning

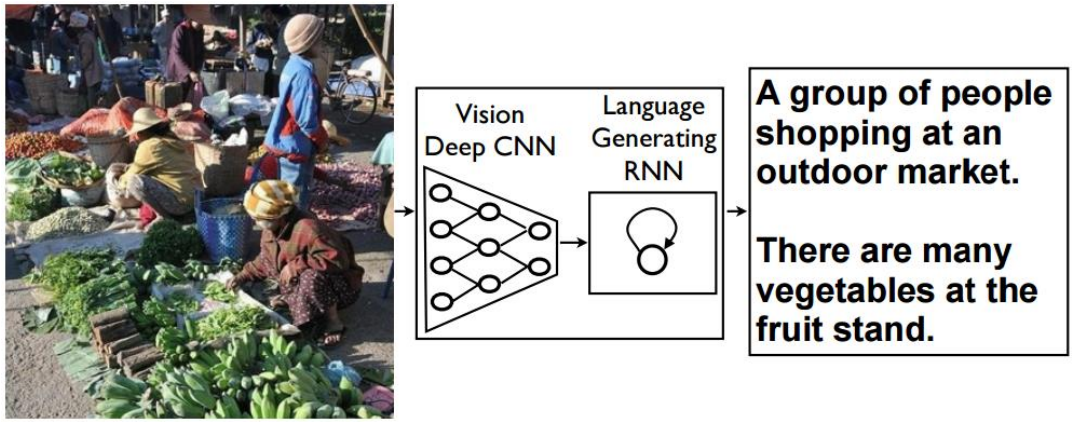


[AlexNet NIPS 2012]



[DeepFace CVPR 2014]

[DeepPose CVPR 2014]



[Show, Attend and Tell ICML 2015]

2020’s: autonomous vehicles

2030’s: robot uprising?

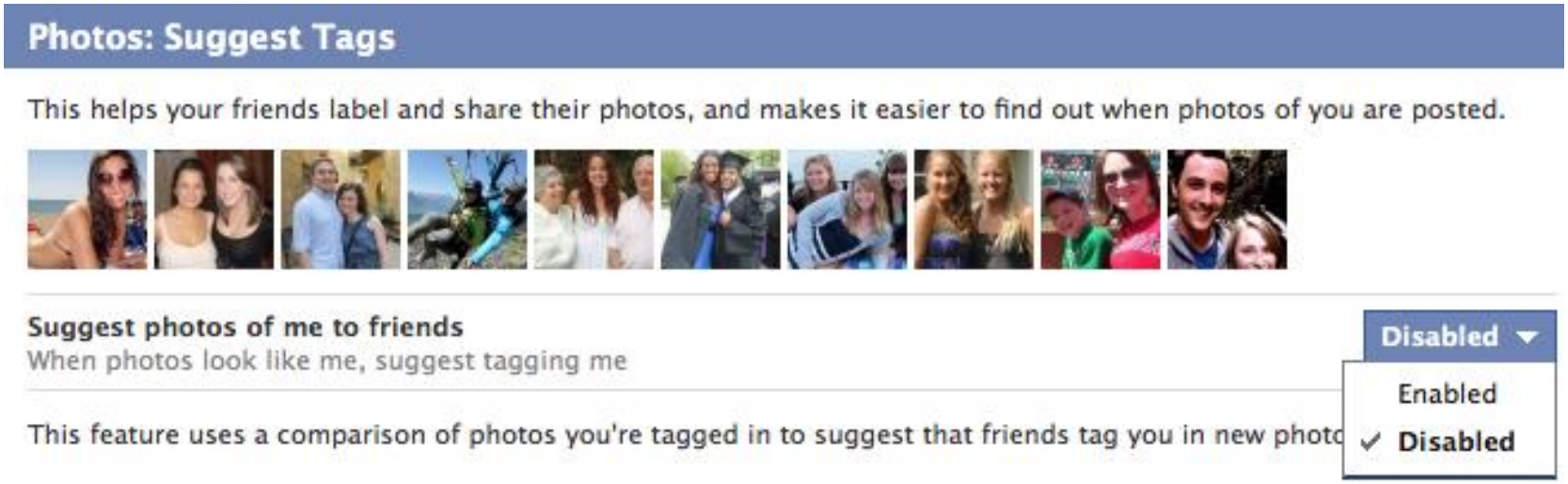
Examples of Computer Vision Applications

- How is computer vision used today?

Face detection

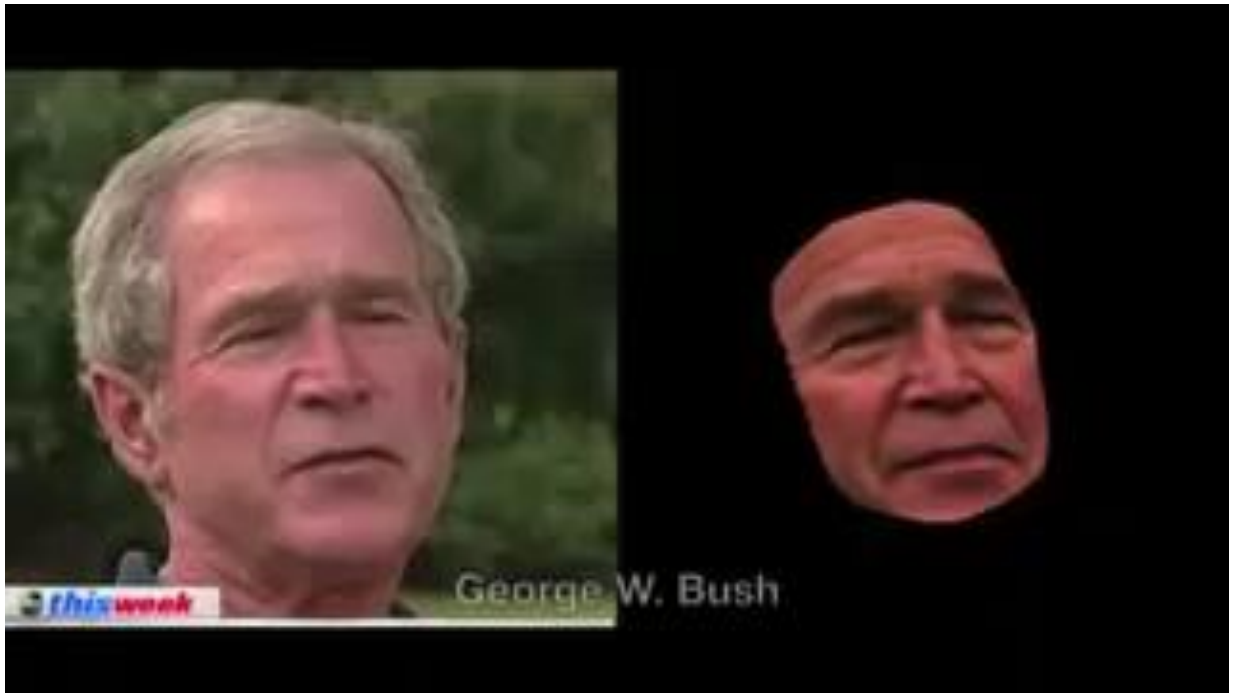
- Most digital cameras and smart phones detect faces (and more)
  - Canon, Sony, Fuji, …
- For smart focus, exposure compensation, and cropping

Face recognition



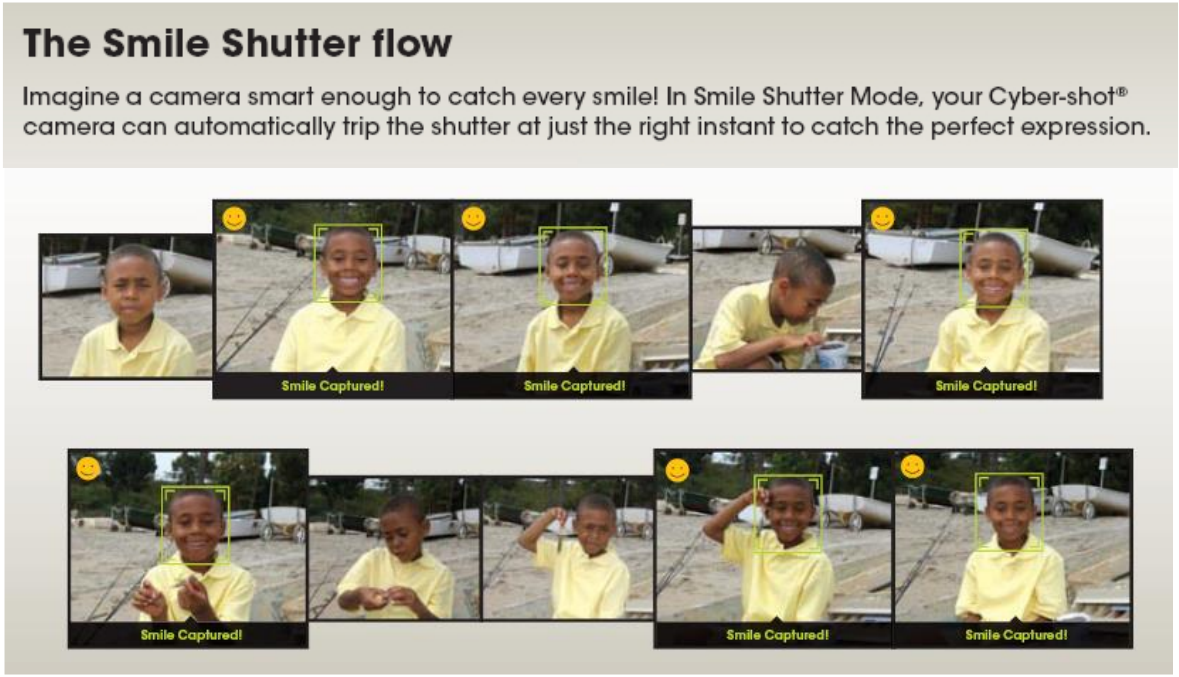
Facebook face auto-tagging

Face Landmark Alignment – 3D Persona



What Makes Tom Hanks Look Like Tom Hanks ICCV 2015

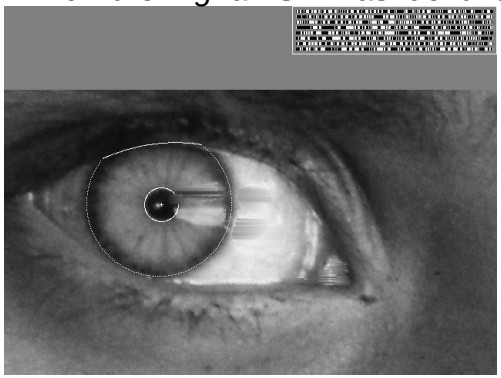
Smile Detection

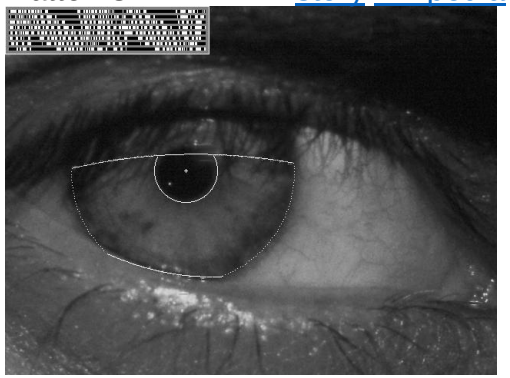


Sony Cyber-shot® T70 Digital Still Camera

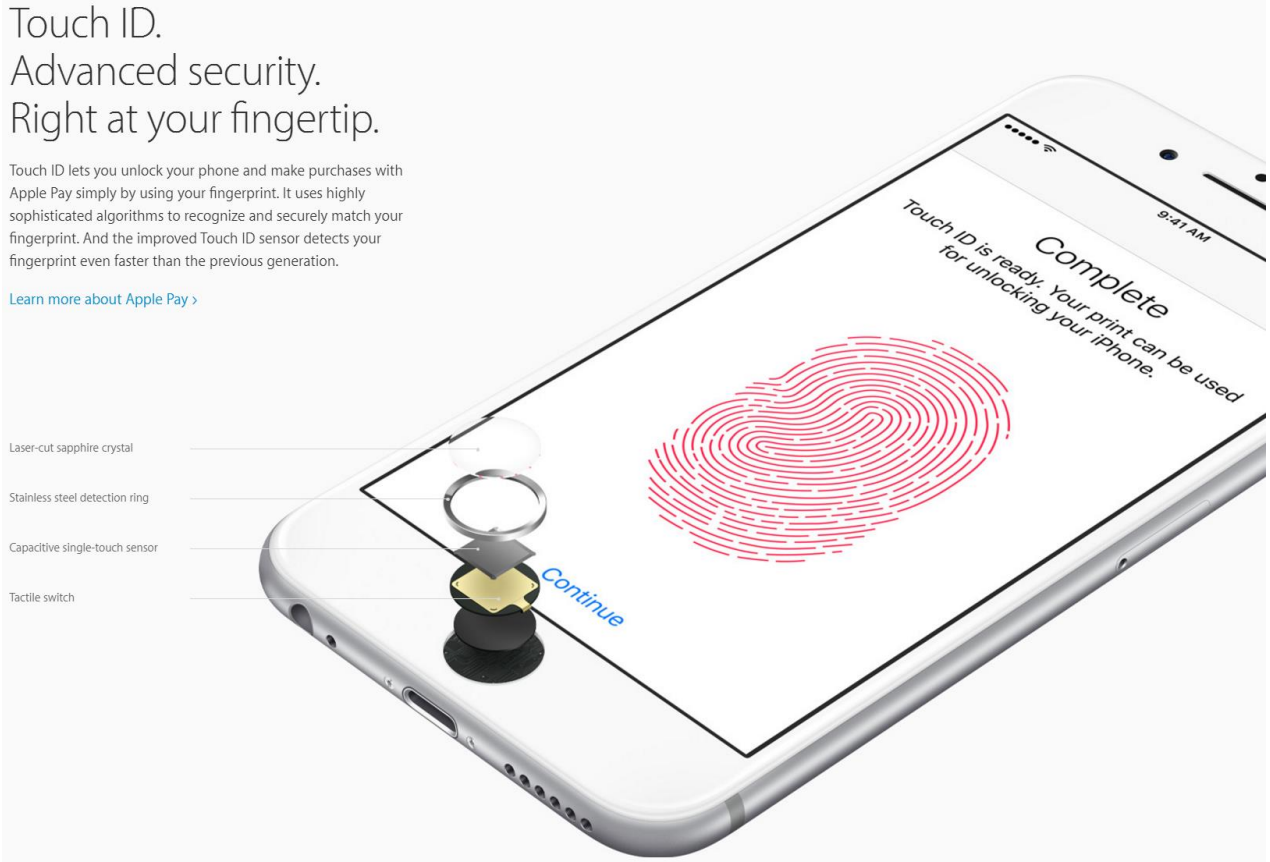
Vision-based Biometrics

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



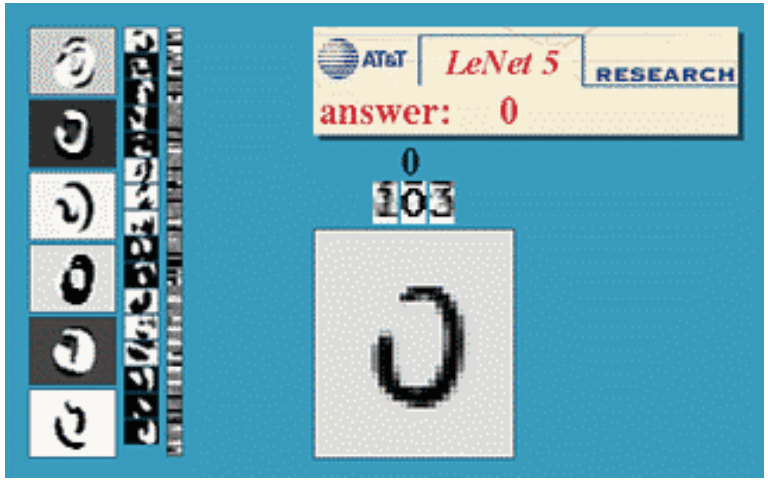


Vision-based Biometrics



Optical Character Recognition (OCR)

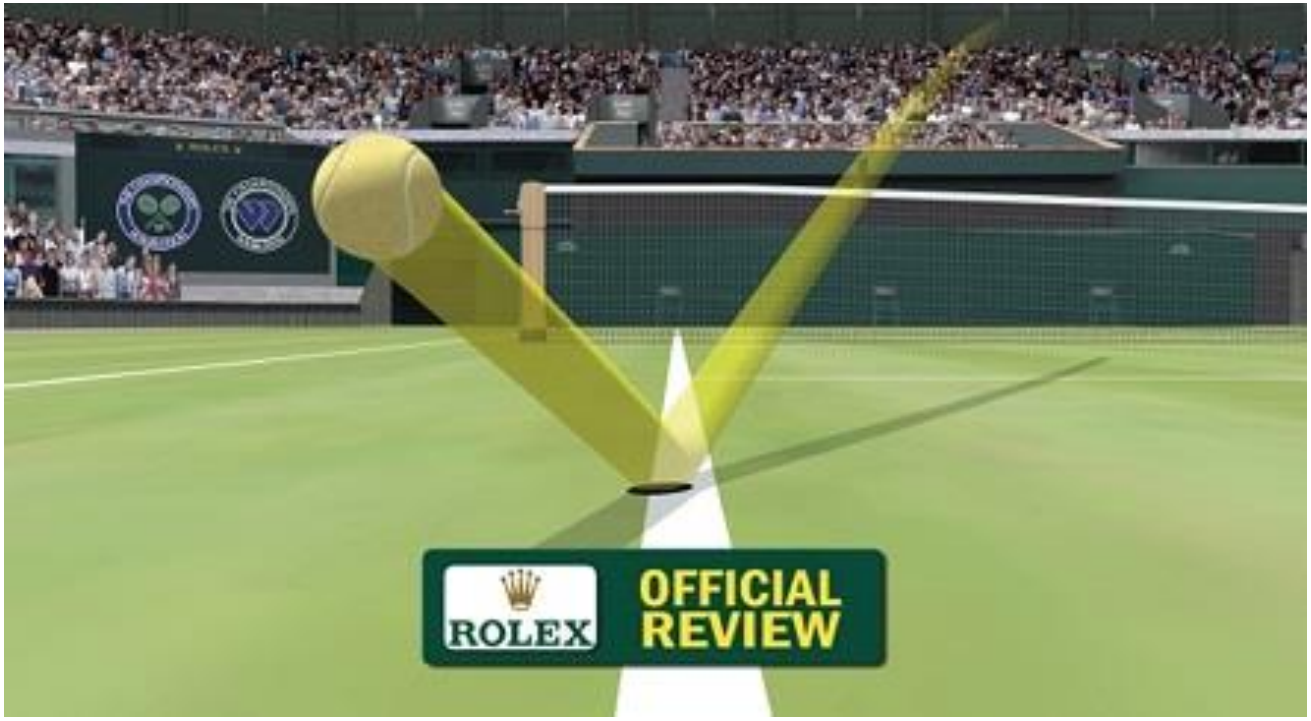
- Technology to convert scanned docs to text
  - If you have a scanner, it probably came with OCR software



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

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

Computer vision in sports



Hawk-Eye: helping/improving referee decisions

Computer vision in sports

SportVision: improving viewer experiences

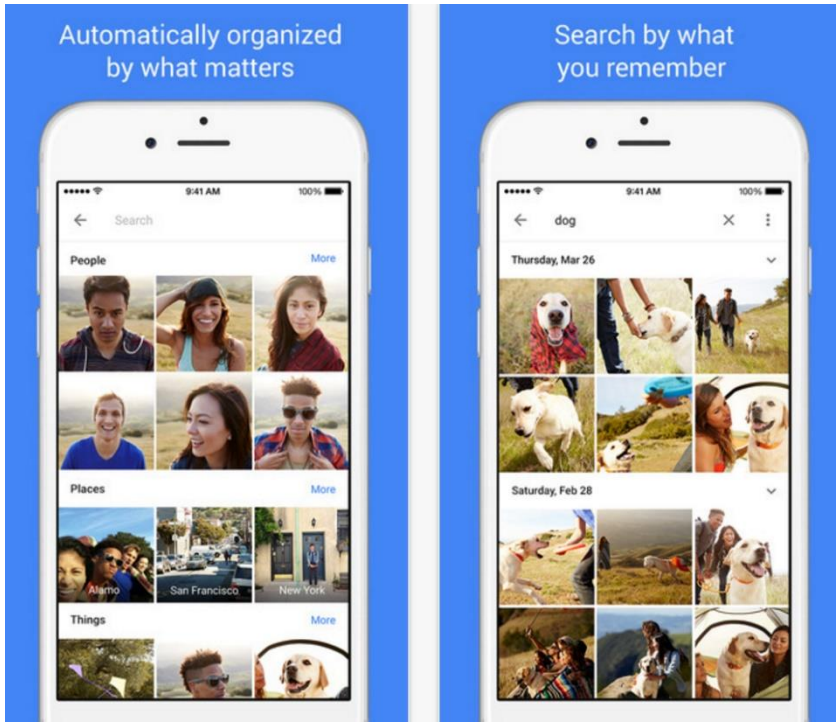
Computer vision in sports

Replay Technologies: improving viewer experiences

Computer vision in sports

Play tracking

Visual recognition for photo organization



Google photo

Earth viewers (3D modeling)

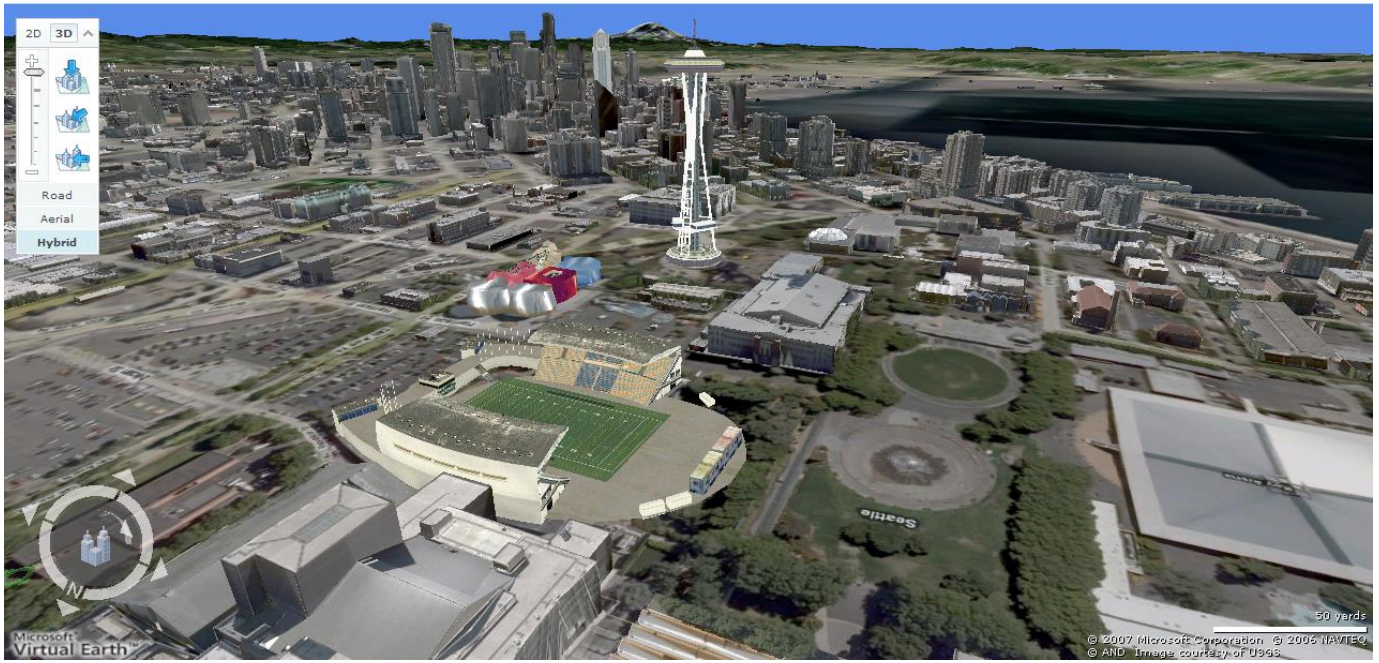


Image from Microsoft's Virtual Earth
(see also: Google Earth)

3D from thousands of images

[Furukawa et al. CVPR 2010]

Microsoft PhotoSynth: Photo Tourism

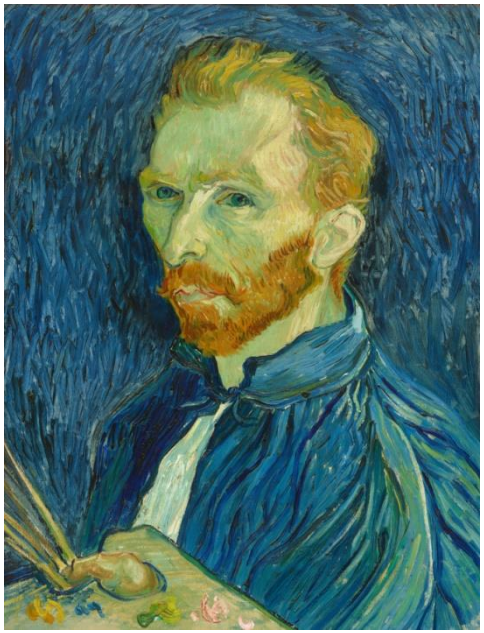
First-person Hyperlapse Videos

[Kopf et al. SIGGRAPH 2014]

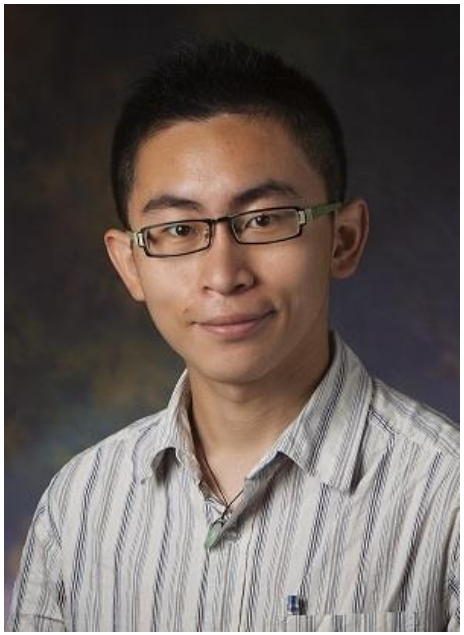
3D Time-lapse from Internet Photos

3D Time-lapse from Internet Photos, ICCV 2015

Style transfer



Source image (**Style**)



Target image (**Content**)

Output (deepart)

A Neural Algorithm of Artistic Style [Gatys et al. 2015]

Special effects: Matting and composition

Kylie Minogue - Come Into My World

Special effects: Shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Special effects: Motion capture

Pirates of the Carribean, Industrial Light and Magic

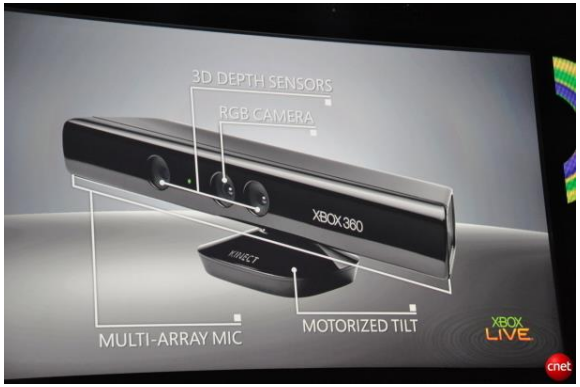
Google cars

Google in talks with Ford, Toyota and Volkswagen to realise driverless cars

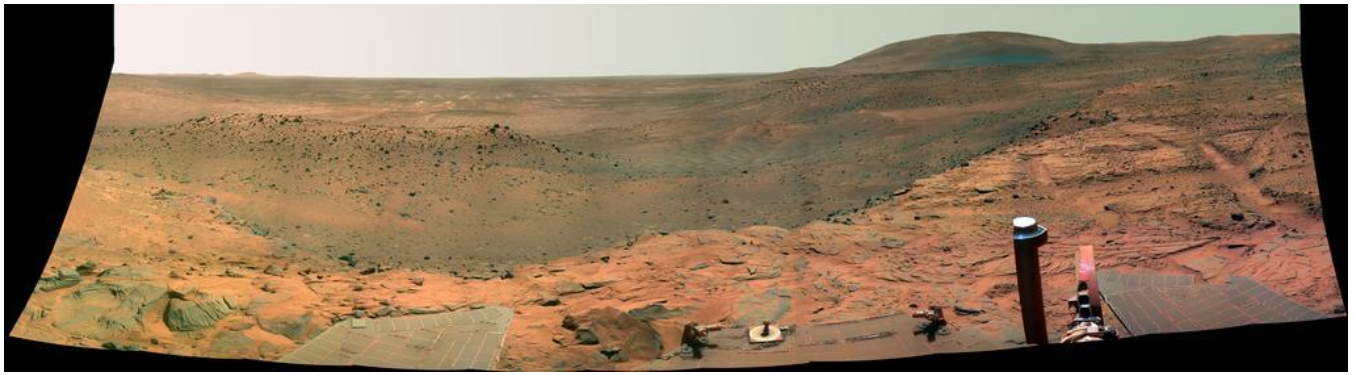
http://www.theatlantic.com/technology/archive/2014/05/all-the-world-a-track-the-trick-that-makes-googles-self-driving-cars-work/370871/

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



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

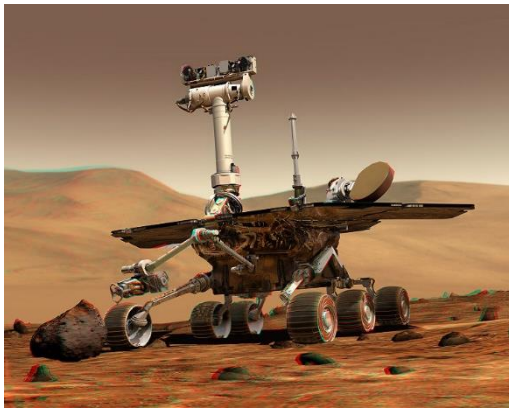
- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read "Computer Vision on Mars" by Matthies et al.

Industrial robots

Vision-guided robots position nut runners on wheels

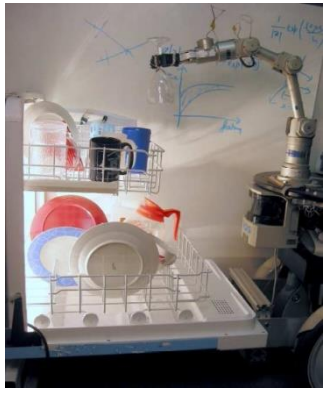
http://www.automationworld.com/computer-vision-opportunity-or-threat

Mobile robots



NASA's Mars Spirit Rover

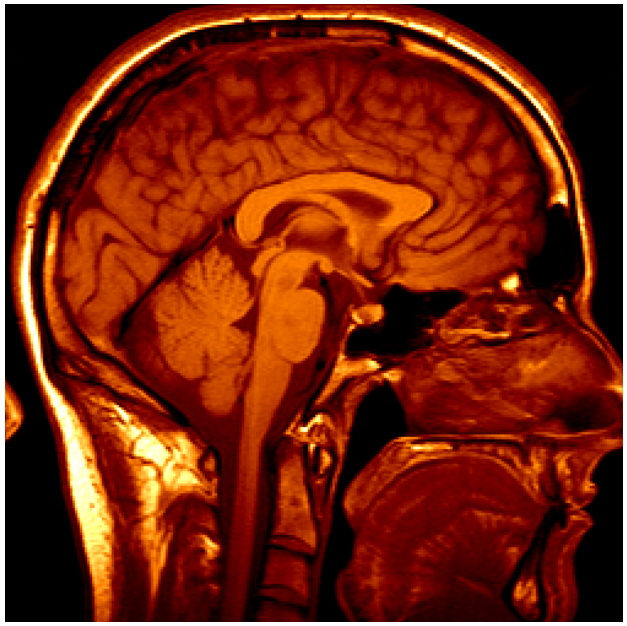
http://www.robocup.org/



Saxena et al. 2008
STAIR at Stanford

http://www.youtube.com/watch?v=DF39Ygp53mQ

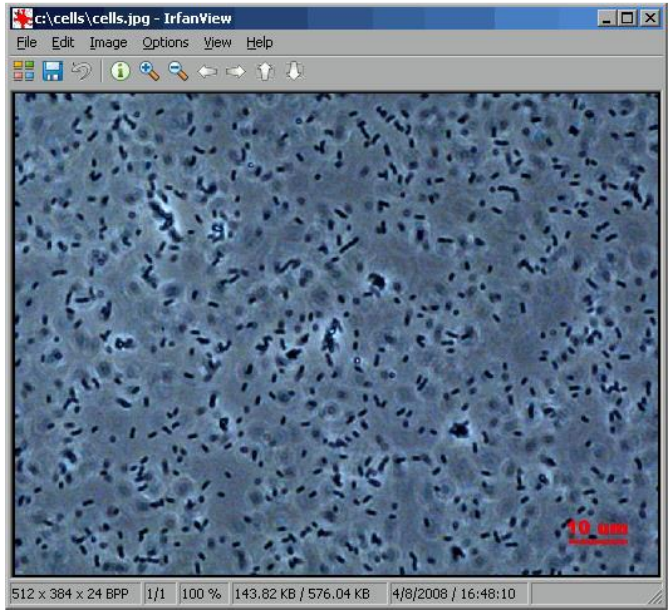
Medical imaging



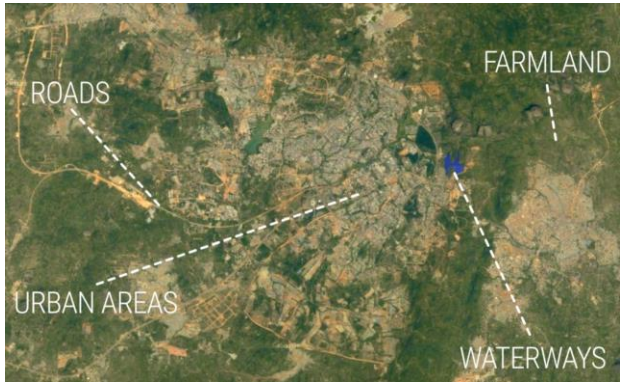
3D imaging
MRI, CT

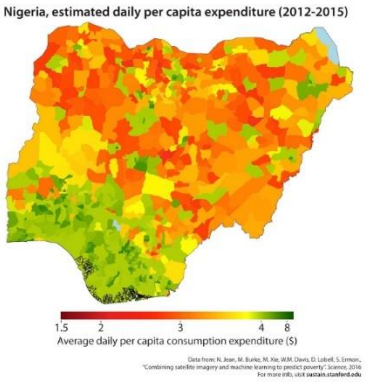
Image guided surgery
Grimson et al., MIT

Computer vision for the mass



Counting cells





[Predicting poverty]

Current state of the art

- Many of these are less than 5 years old
- Very active and exciting research area!
- To learn more about vision applications and companies
  - David Lowe maintains an excellent overview of vision companies
    - http://www.cs.ubc.ca/spider/lowe/vision.html

Thank you