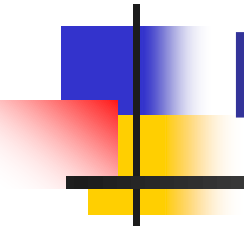
Deep Learning Using TensorFlow

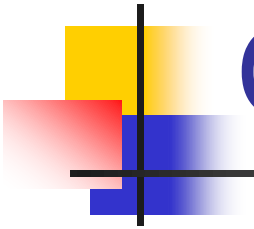


Dr. Ash Pahwa

Lesson 7:

Convolution Neural Network (CNN)

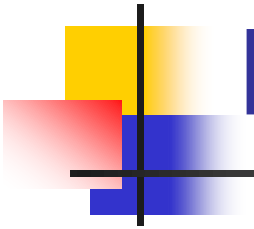
Lesson 7.1: Motivations for CNN



Outline

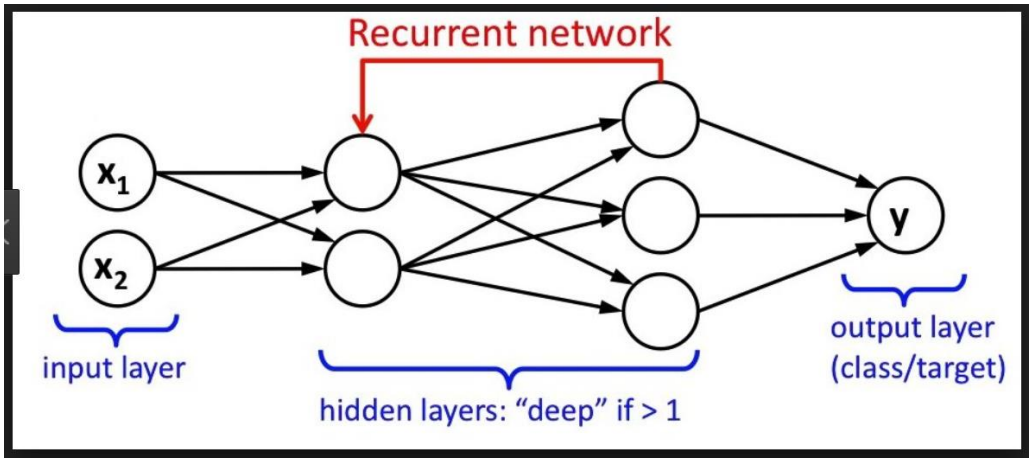
- Other Types of Neural Networks
  - Recurrent Neural Networks
  - Convolution Neural Networks
- Computer Vision Mile Stones
  - Convolution Neural Networks with Deep Learning
  - Availability of Billions of Images to Train Neural Network
  - Availability of GPU
- Building Vision for Autonomous Cars

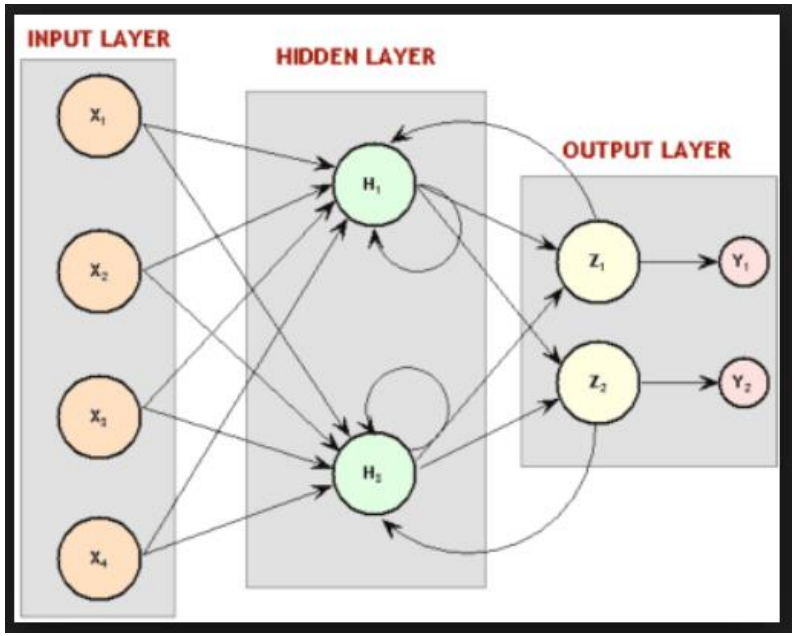
Other Types of Neural Networks



- Feed Forward Fully Connected
  - Covered in the Previous Lesson
- Recurrent Neural Networks (RNN)
  - Neural Networks with Feedback Loops
- Convolution Neural Networks (CNN)
  - Used for Image Recognition
  - Convolution Operation is Performed on an Image
  - Image Passes Through Pooling Layer

Recurrent Neural Networks (RNN)

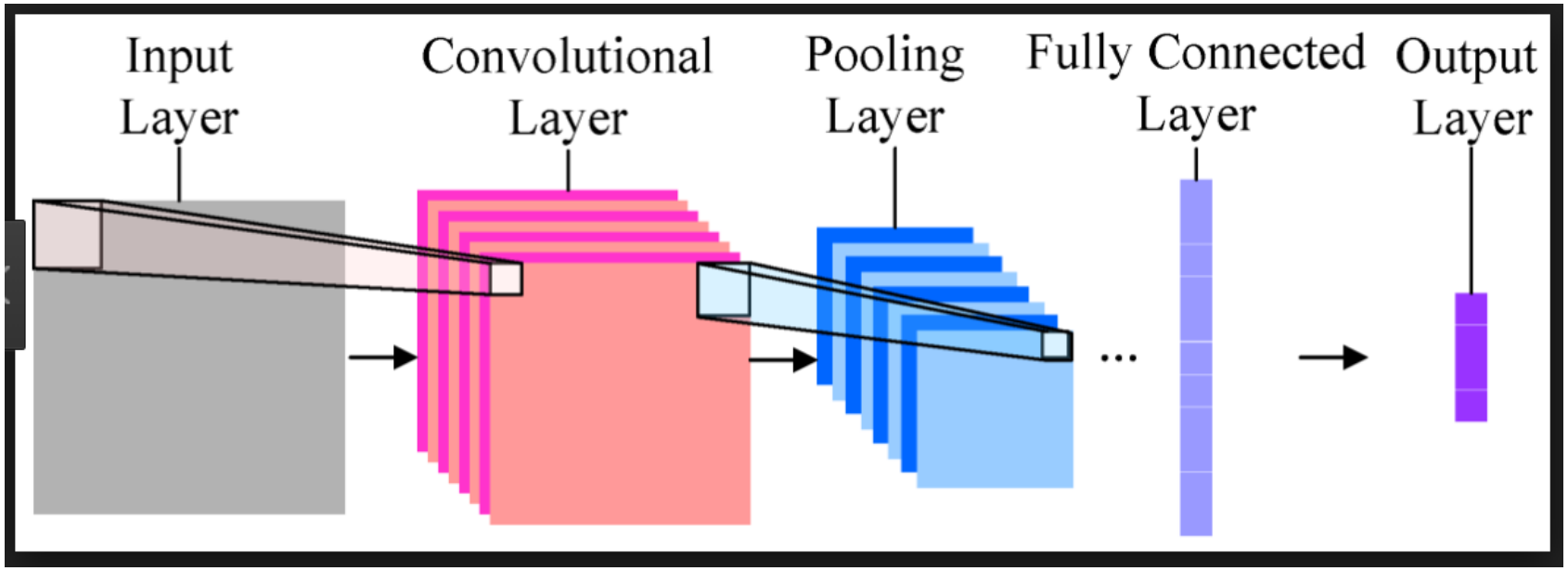


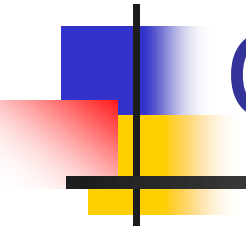


Recurrent Neural Networks (RNN)

- RNN allows Networks to have memory
- Primary Applications
  - Sequence Generation
  - Language Translation
    - From English to French
  - Speech Recognition
  - Time-Series Based Data

Convolution Neural Networks



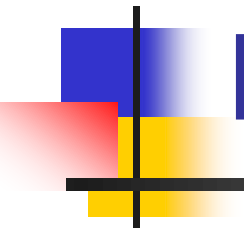


Computer Vision

Convolution Neural Networks

Computer Vision Mile Stones

- Convolutional Neural Networks
- Availability of Millions of Digital Images
- Availability of GPU



1. Convolution Neural Networks with Deep Learning

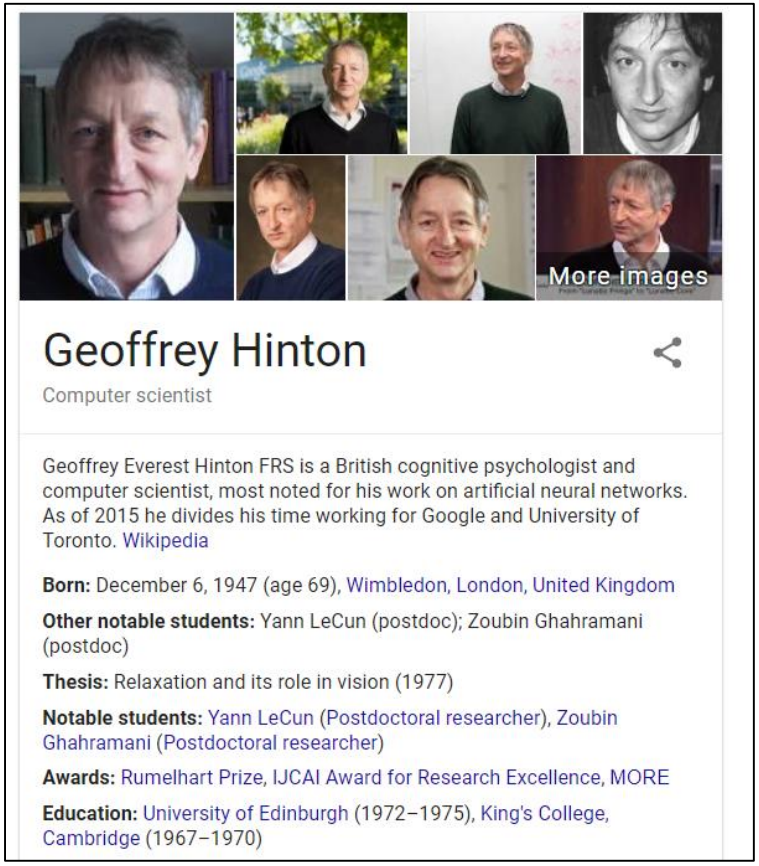
Neocognitron
Developer of Convolution Neural Network
K. Fukushima

- Neocognitron: Artificial Neural Network : 1980
- Kunihiko Fukushima received a B.Eng. degree in electronics in 1958 and a PhD degree in electrical engineering in 1966 from Kyoto University, Japan.
- Professor
  - Osaka University
  - University of Electro-Communications
  - Tokyo University of Technology
  - Kansai University

Kunihiko Fukushima

Senior Research Scientist, Fuzzy Logic Systems Institute (Iizuka, Fukuoka, Japan)
E-mail: fukushima@m.ieice.org

Geoffrey Hinton



Yann LeCun

Yann LeCun

Computer scientist

Yann LeCun is a computer scientist with contributions in machine learning, computer vision, mobile robotics and computational neuroscience. Wikipedia

Born: July 8, 1960 (age 57), Paris, France

Alma mater: Pierre-and-Marie-Curie University

Thesis: Modeles connexionnistes de l'apprentissage (connectionist learning models) (1987)

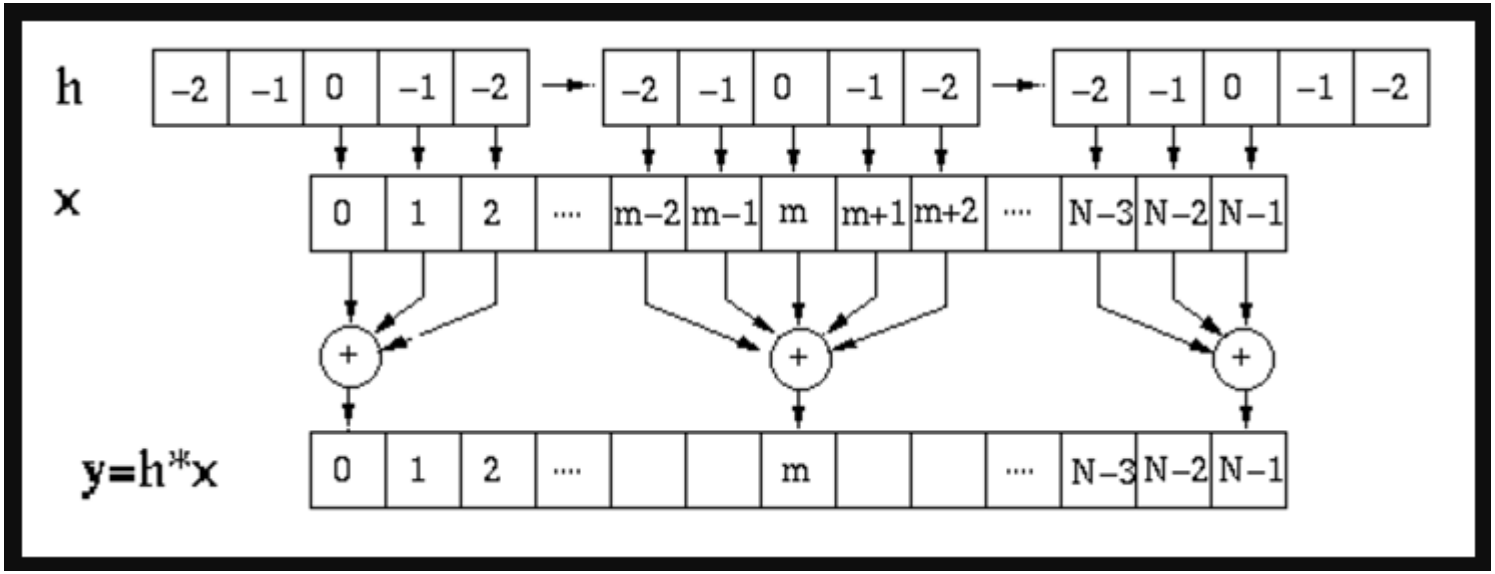
Known for: Deep learning

Academic advisor: Geoffrey Hinton

Institution: New York University

Convolution

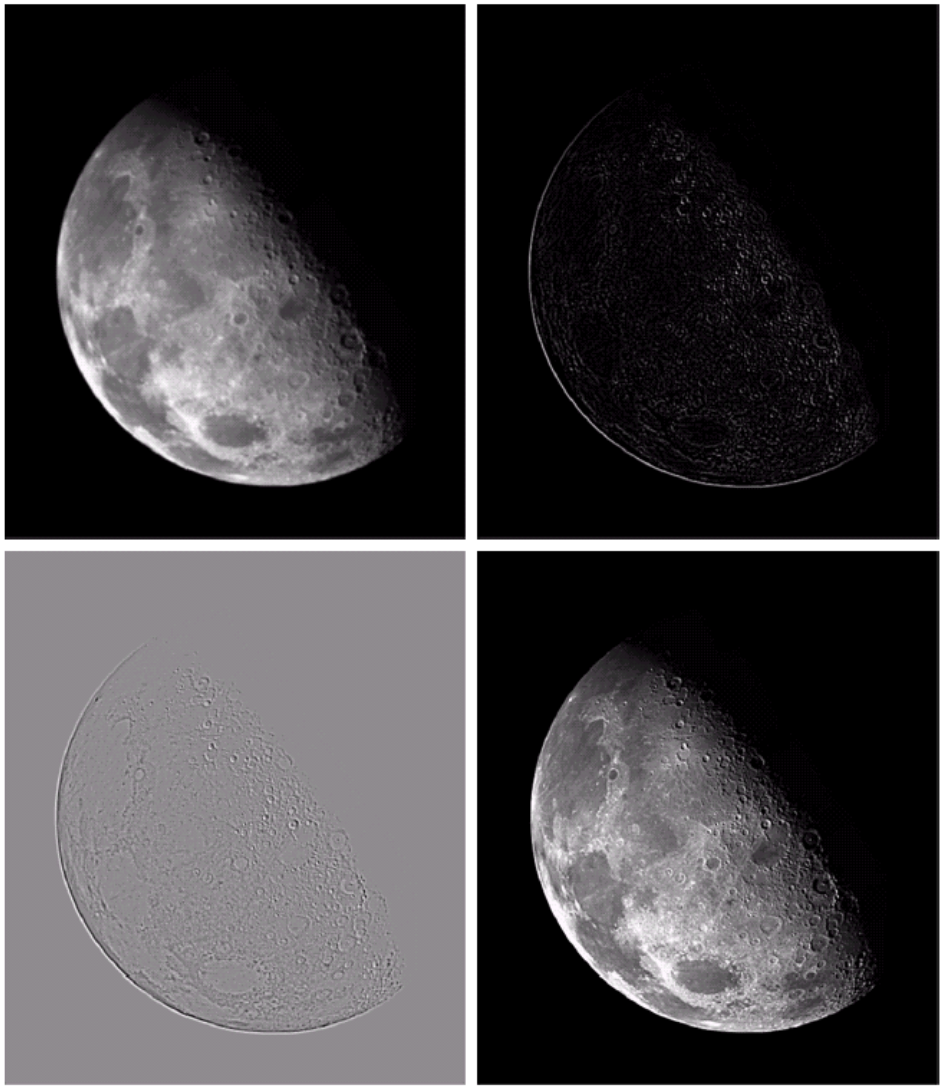
- In mathematics, convolution is a mathematical operation on two functions (f and g); it produces a third function
- Which is a modified version of one of the original functions



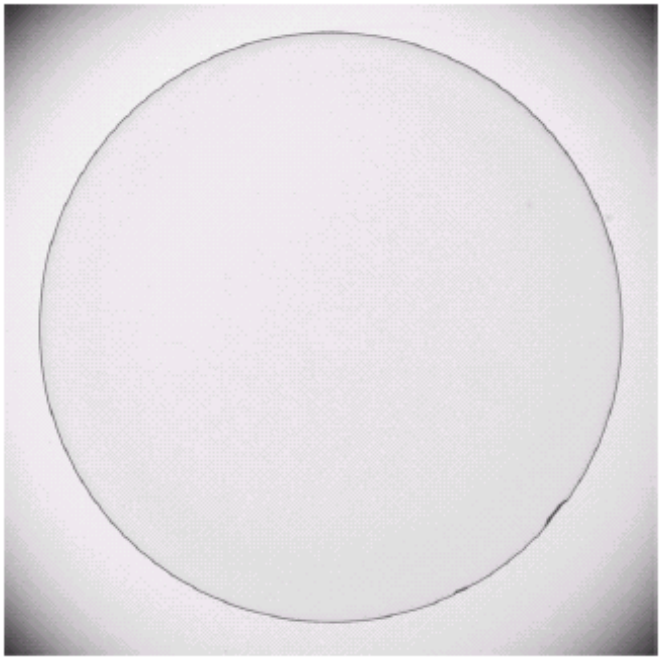
Laplacian Filter

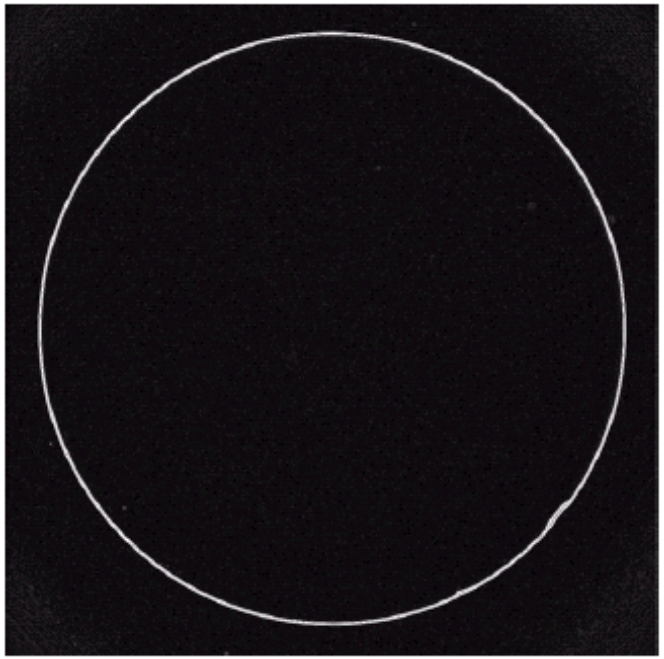
a b
c d

FIGURE 3.40
(a) Image of the North Pole of the moon.
(b) Laplacian-filtered image.
(c) Laplacian image scaled for display purposes.
(d) Image enhanced by using Eq. (3.7-5).
(Original image courtesy of NASA.)



Example: Sobel Filter





a b

FIGURE 3.45 Optical image of contact lens (note defects on the boundary at 4 and 5 o'clock). (b) Sobel gradient. (Original image courtesy of Mr. Pete Sites, Perceptics Corporation.)

Hubel & Wiesel

- 1960 - 1970
- Experimented with the Visual Systems of cats
- Cats retina responded to stripes but not on spots
- Biological visual system respond to edges
- John Hopkins School of Medicine
- Noble prize in Physiology in 1981

David H. Hubel

Torsten Wiesel (left) and Hubel (right), co-recipients of the 1981 Nobel Prize in Physiology or Medicine for their discoveries concerning information processing in the visual system, 1980

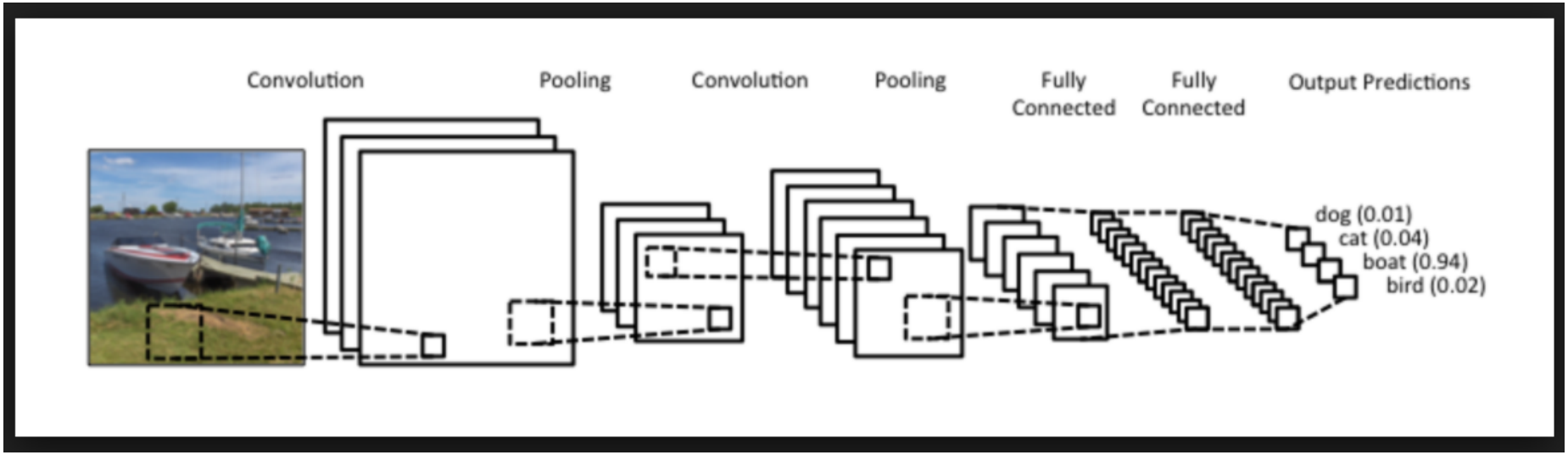
Born	David Hunter Hubel February 27, 1926 Windsor, Ontario, Canada
Died	September 22, 2013 (aged 87) Lincoln, Massachusetts, US
Nationality	American-Canadian[1]
Alma mater	McGill University
Known for	Visual system
Spouse(s)	Ruth Izzard (m. 1953)
Awards	Louisa Gross Horwitz Prize (1978) Dickson Prize (1980) Nobel Prize in Physiology or Medicine (1981) ForMemRS (1982)[2][3]
Scientific career	
Fields	Neurophysiologist
Institutions	Johns Hopkins School of Medicine Harvard University

Torsten Wiesel

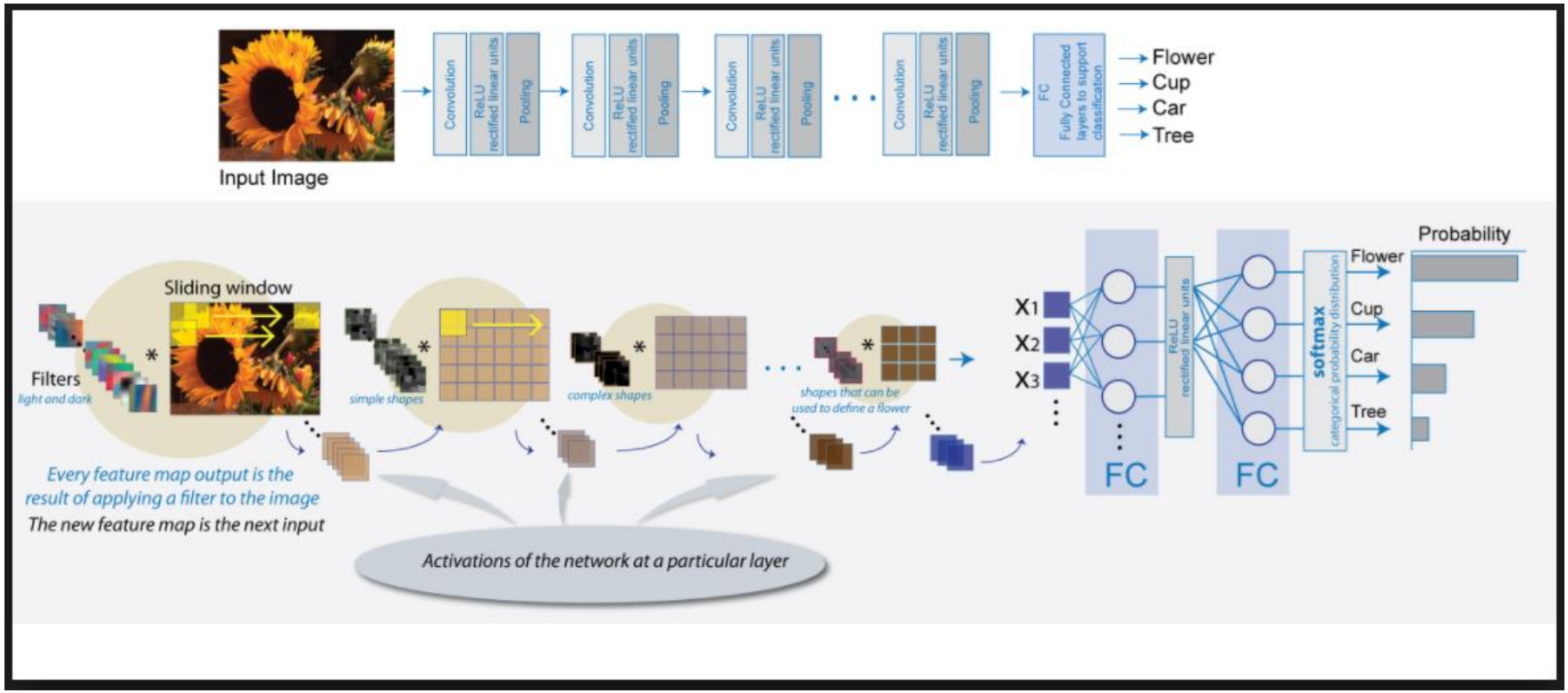
At a conference in 2011

Born	Torsten Nils Wiesel 3 June 1924 (age 93) Uppsala, Sweden
Nationality	Swedish
Alma mater	Karolinska Institute
Known for	Visual system
Spouse(s)	Lizette Mususa Reyes (m. 2008) Jean Stein (m. 1995; div. 2007) Ann Yee (m. 1973; div. 1981) Teeri Stenhammar (m. 1956; div. 1970)
Awards	Louisa Gross Horwitz Prize (1978) Dickson Prize (1980) Nobel Prize in Physiology or Medicine (1981)[1] ForMemRS (1982)[2][3] National Medal of Science[4] (2005)
Scientific career	
Institutions	Johns Hopkins School of Medicine Rockefeller University Harvard University

Convolution Neural Network



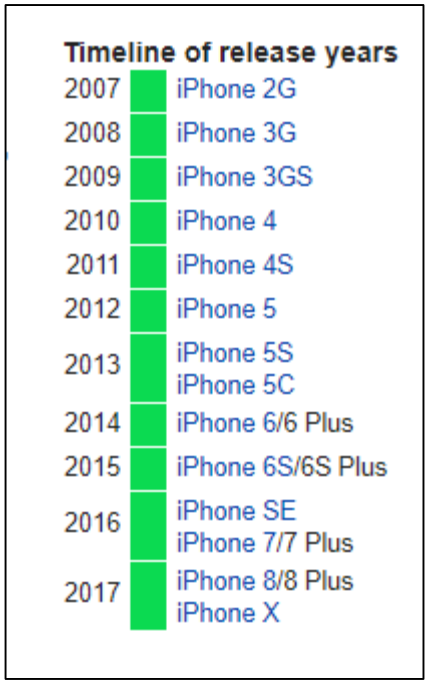
Convolution Neural Network



2. Availability of Billions of Images to Train Neural Network

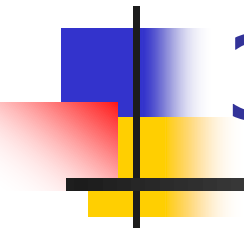
Data for Neural Network

- Without data neural networks are useless
- How to collect images for training the neural network?
- 2007
  - Digital cameras appeared on cell phones
- Google Image Search

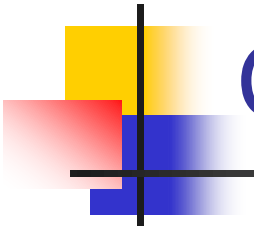


Birth of Deep Learning BigData

- Fei-Fei Li (Stanford) created ImageNet
  - Contains 14 million images of 20,000 categories
- These images were classified by Mechanical Turk workers on Amazon
- For pennies per image, labeled each one

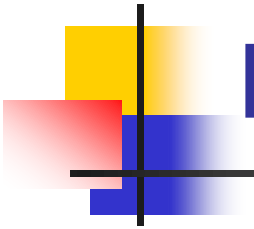


3. Availability of GPU



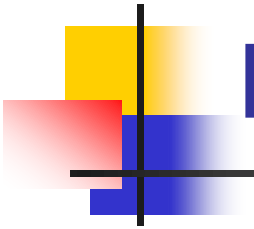
GPUS

- The heart of Deep learning is GPUS
  - Graphics Processing Units
- Developed in the gaming industry
- Gaming computers render 3D graphics scenes at high definition and rapid frame rates
- Run several processors in parallel



Nvidia

- Nvidia GPUs are used in **deep learning**, artificial intelligence, and accelerated analytics.
- They are included in all Tesla vehicles.



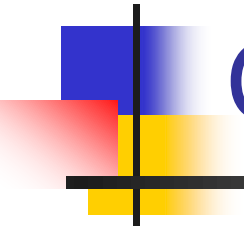
Neural Networks

- Neural networks lend themselves to parallelization
- GPUs provide parallel processors
- Training of Neural Network is faster using GPU, compared with CPU

Nvidia

The Nvidia GTX 1070 video card uses a 16 nm Pascal chip and was first released in June 2016.

Nvidia Supercomputer



Building Vision for Autonomous Cars

Autonomous Cars

- Pros
  - Productivity improvements
  - Fewer accidents
    - Less loss of property and life
- Cons
  - Loss of employment for taxi and truck drivers
  - Loss of privacy

Levels of Automation

State of the Art

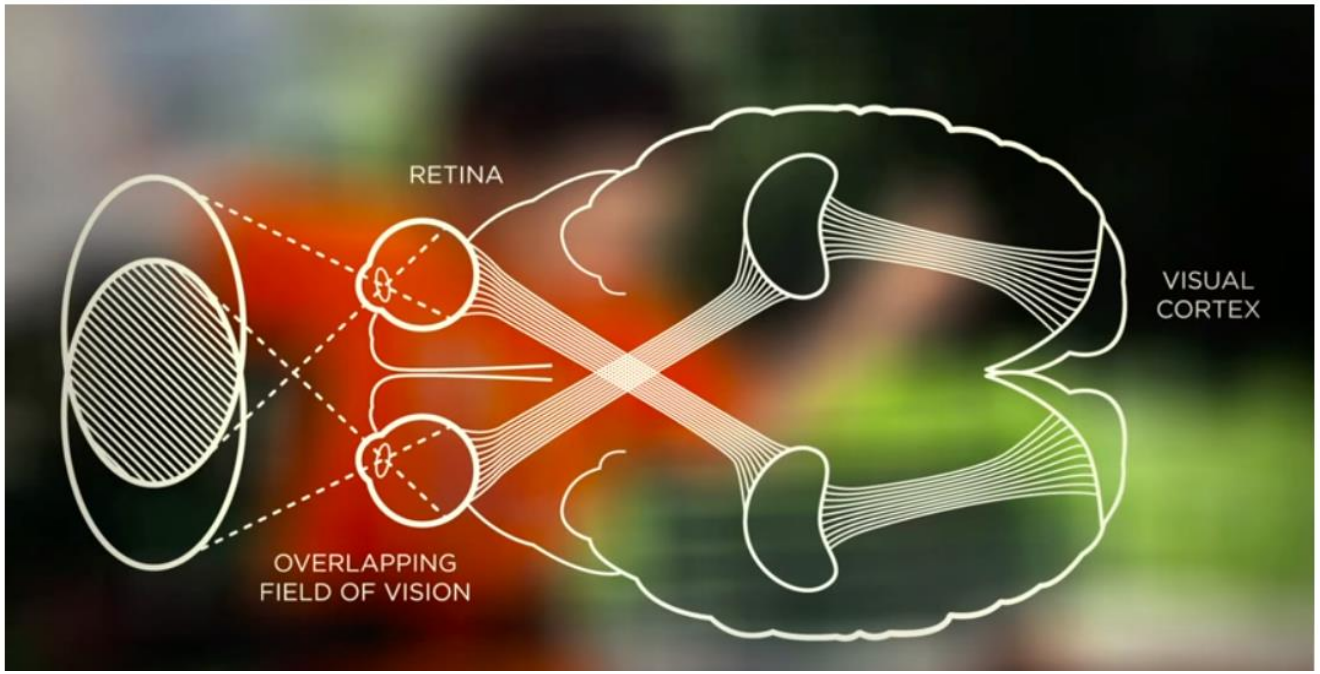
Ultimate Goal

	Features
Level 1	Cruz Control
Level 2	Self Parking
Level 3	Highway Autonomous driving + Steering Control
Level 4	Street driving
Level 5	Punch in the GPS coordinates of your destination and car will take you there

Level 5 Autonomous Car

Human Vision
* Eyes + Brain to Understand Images

Autonomous Cars
* Camera + Neural Networks with Deep Learning

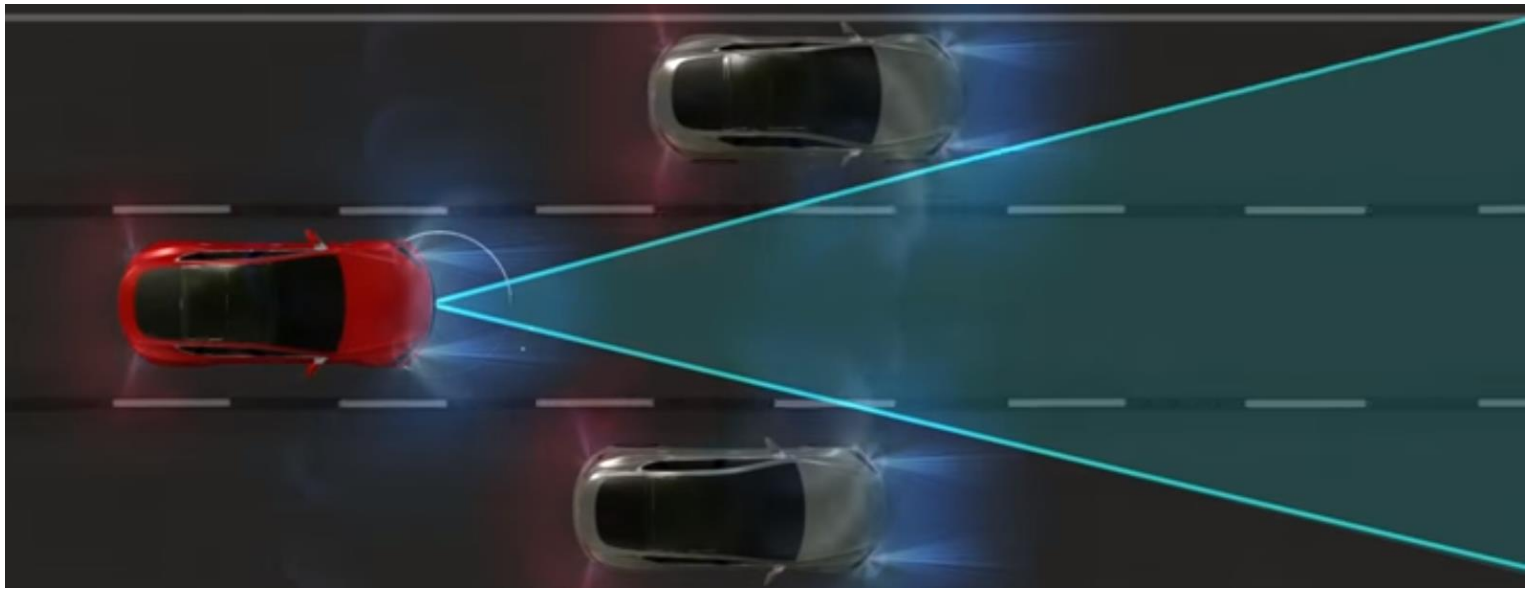


Components of Autonomous Cars that allow self-driving

Autonomous Car Hardware for Self-Driving Cars

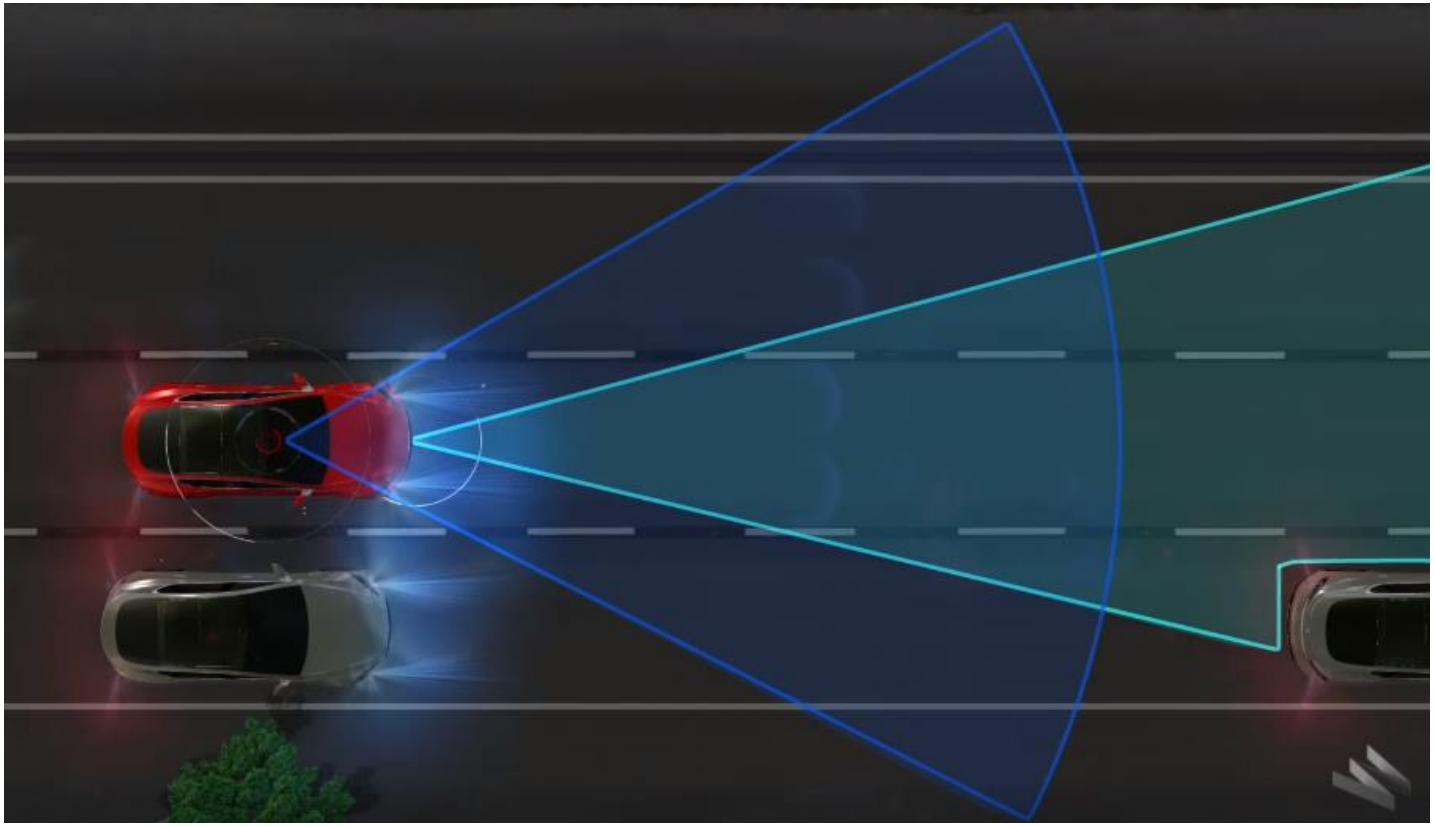
- LIDAR (Light Detection and Ranging)
- RADAR (Radio Detection and Ranging)
  - Located under the plastic front bumper
  - Looks @ 700 meters in front
- Ultrasonic Sensors
  - Count 12: Located all around the car
- Front Camera
- High Definition Digital Maps
- High Precision GPS

Radar (Radio Detection and Ranging) + LIDAR (Light Detection and Ranging)

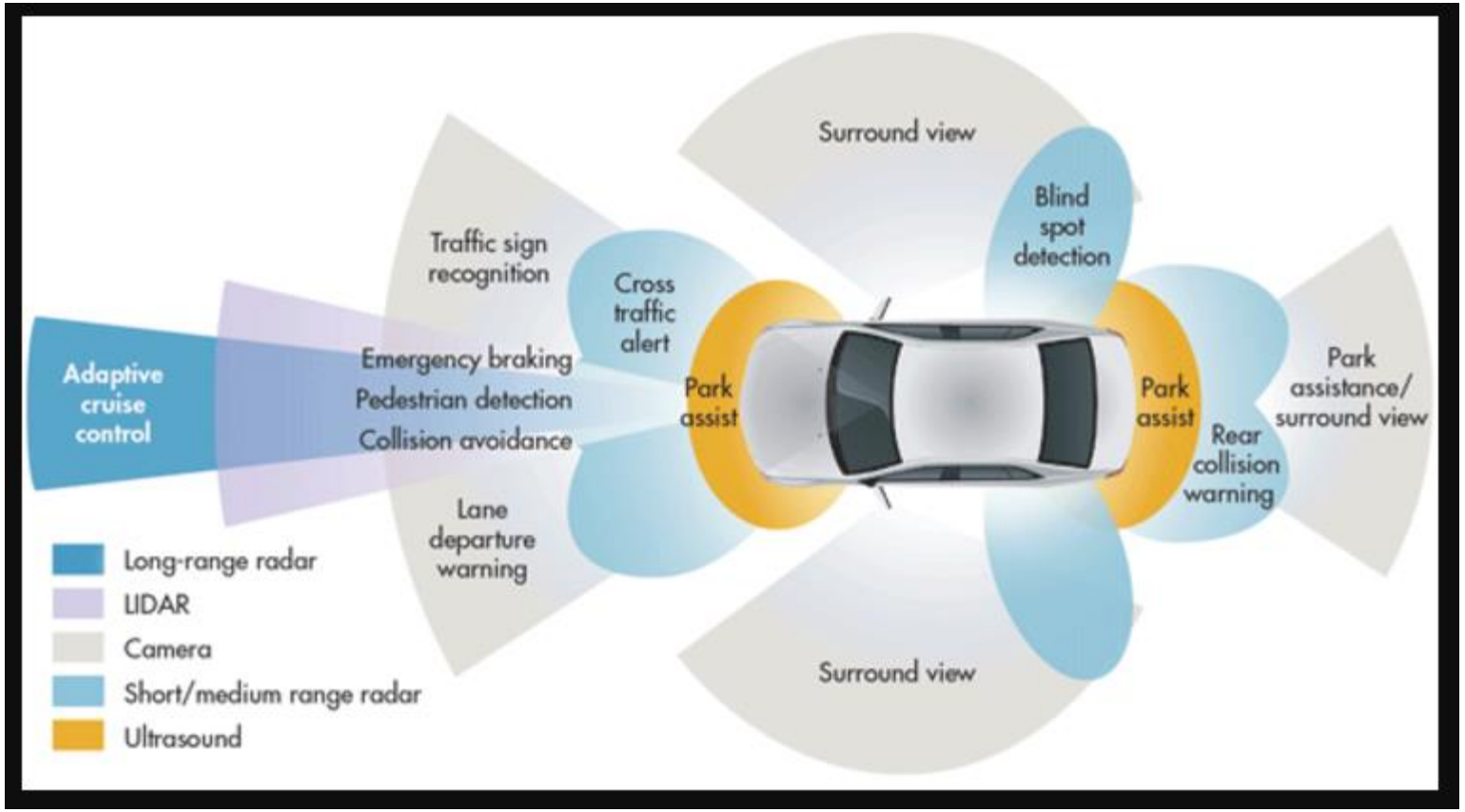


Ultrasonic Sensors

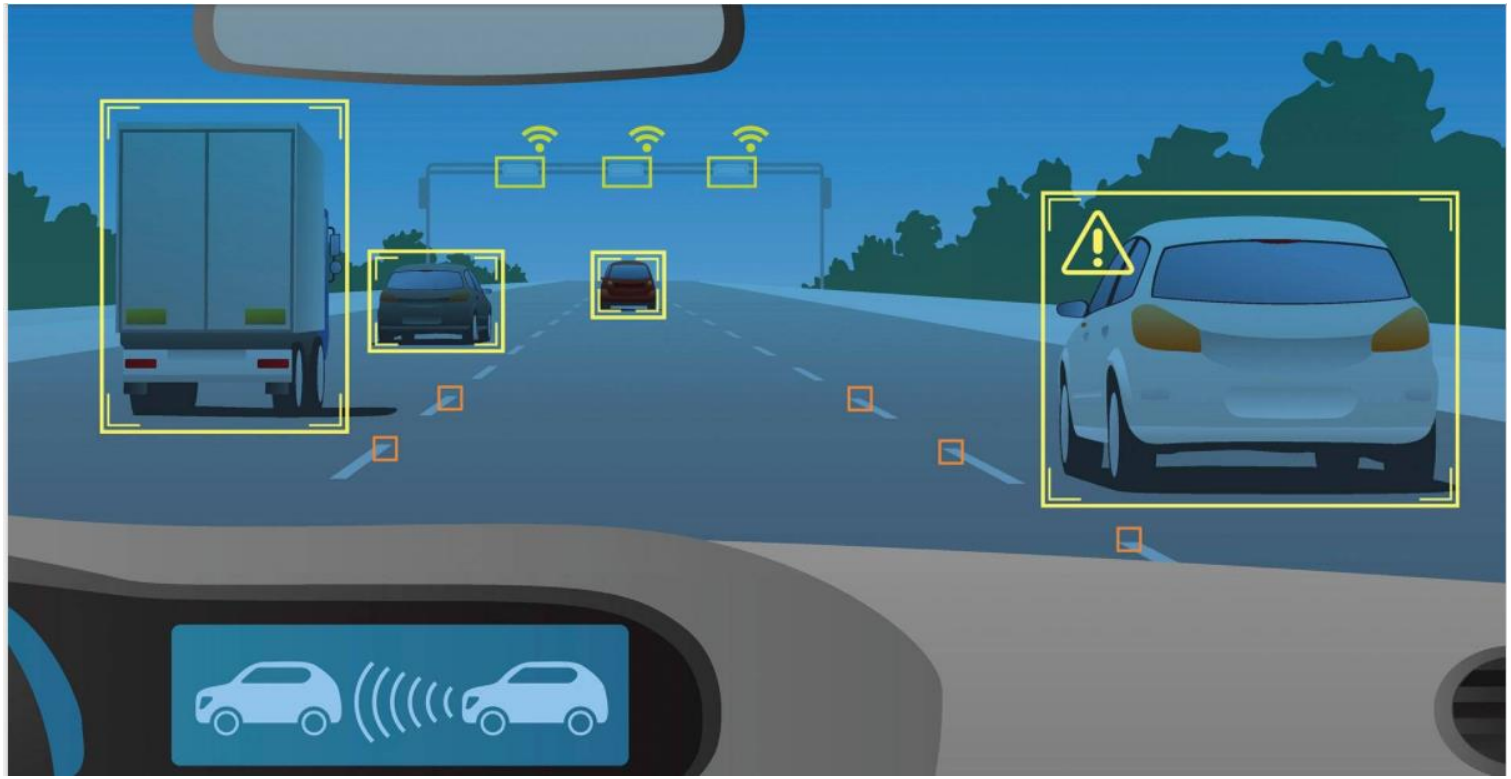
Camera



Sensor Range



Car's View

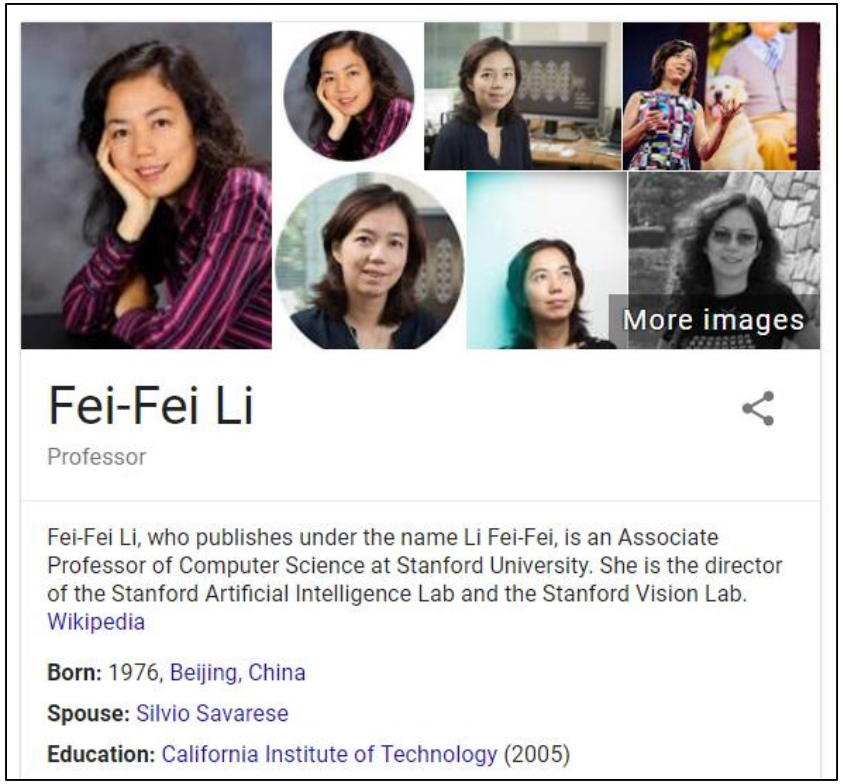


Modern Deep Learning

2010 - 2015

Modern Deep Learning

- Large Scale Visual Recognition Competition
- Database of Images: ImageNet
- Organized by
  - Fei-Fei Li
  - Stanford University
- Competition
  - 2011 – 2015
  - 100,000 new images
  - Who can identify them correctly

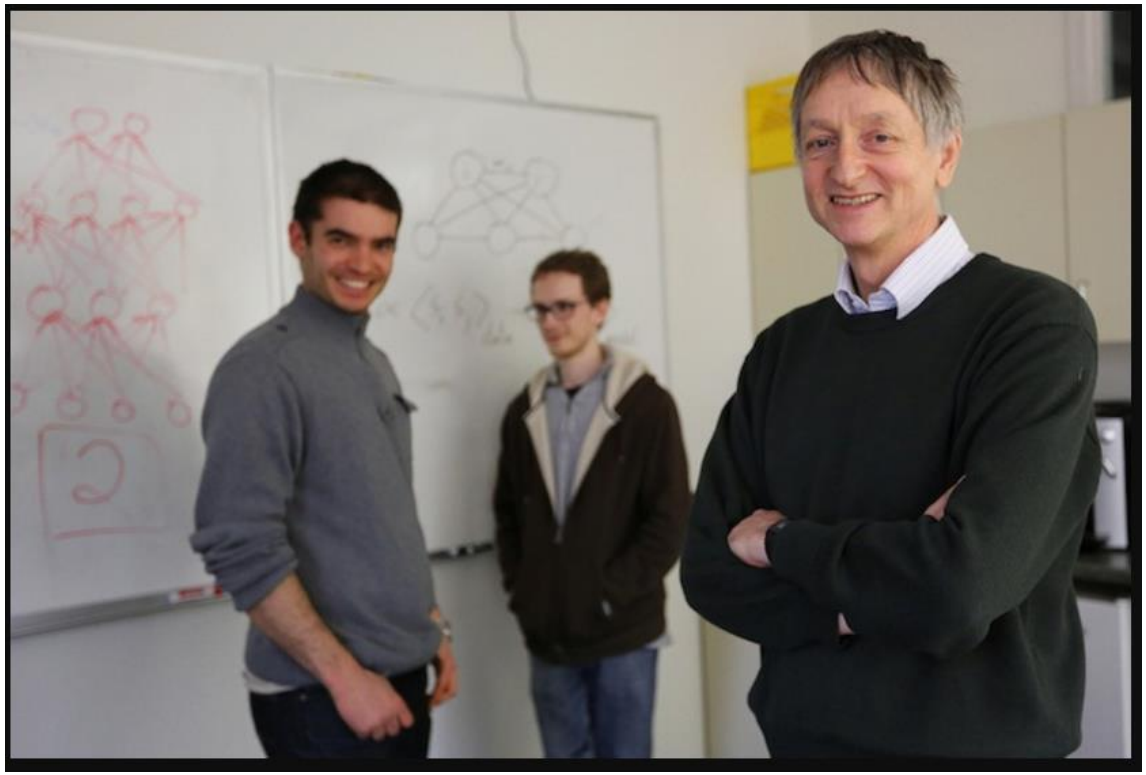


Large Scale Visual Recognition Competition

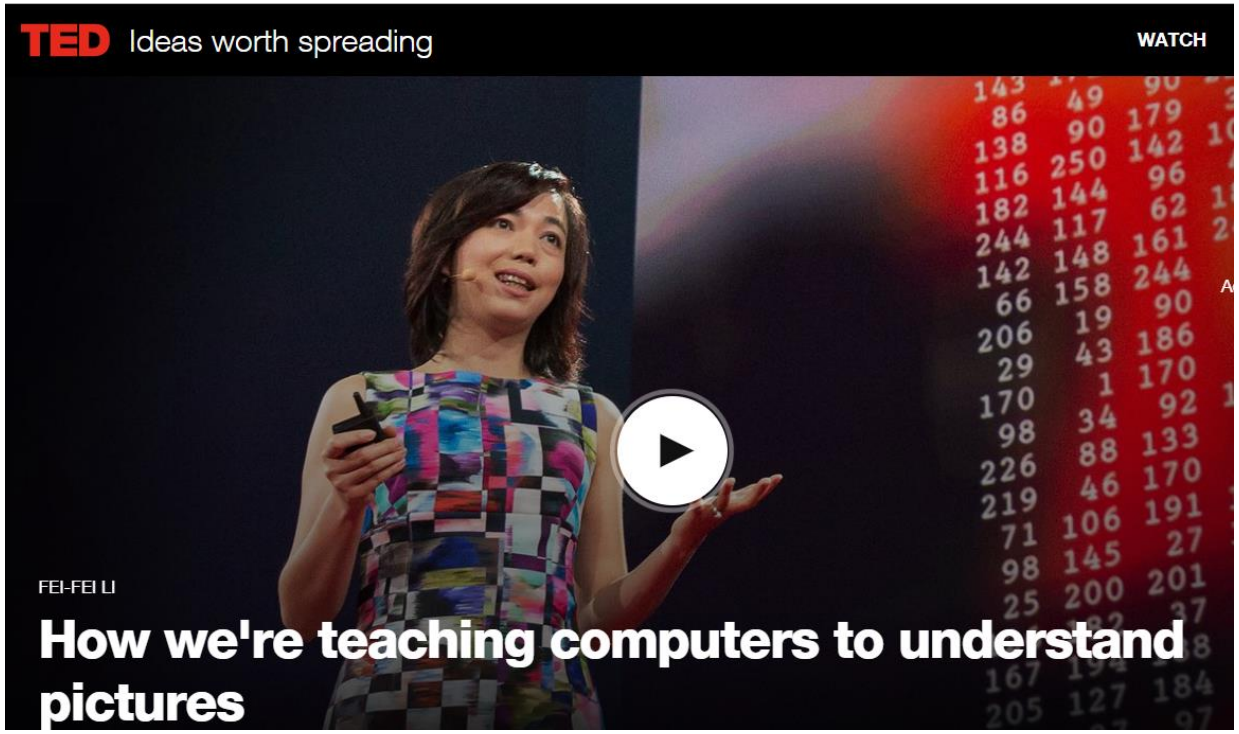
	% Incorrect	Winner	Technology Used
2010	28%	NEC	Neural Network
2011	25%	XRCE	
2012	15%	Supervision Univ. of Toronto Alex Krizhevsky Ilya Sutskever Geoffrey Hinton	Convolution Neural Network
2013	6.66%	Google	Convolution Neural Network
2014	3.57%	Microsoft	Convolution Neural Network

Supervision
University of Toronto

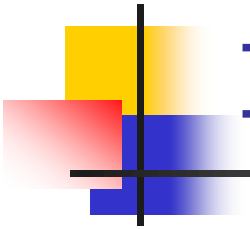
Alex Krizhevsky,
Ilya Sutskever,
Geoffrey Hinton



TED Talk by Prof. Fei-Fei Li



https://www.youtube.com/watch?v=40riCqvRoMs

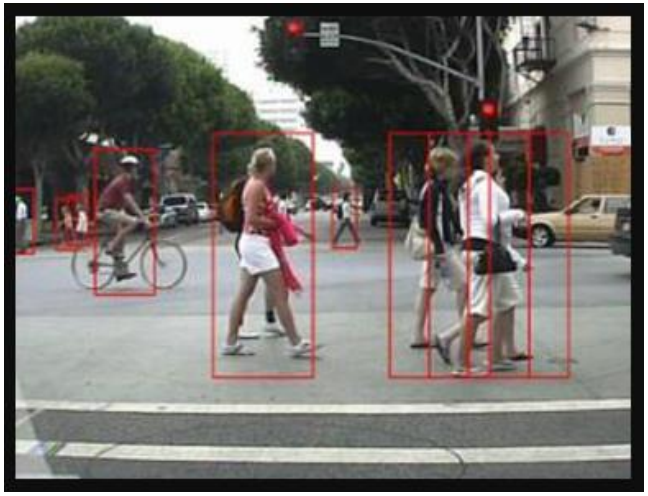


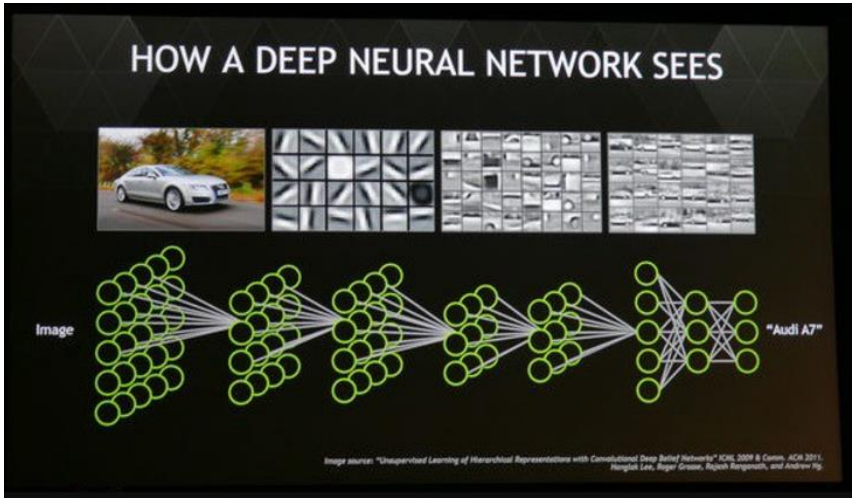
Inside the Network

- Every layer of the deep learning network contributes towards recognizing some aspect of an image
- Usually Neural Networks have greater than 100 layers of artificial neurons
- Contrast to Rosenblatt's Perceptron
  - Had a single layer of 8 neurons

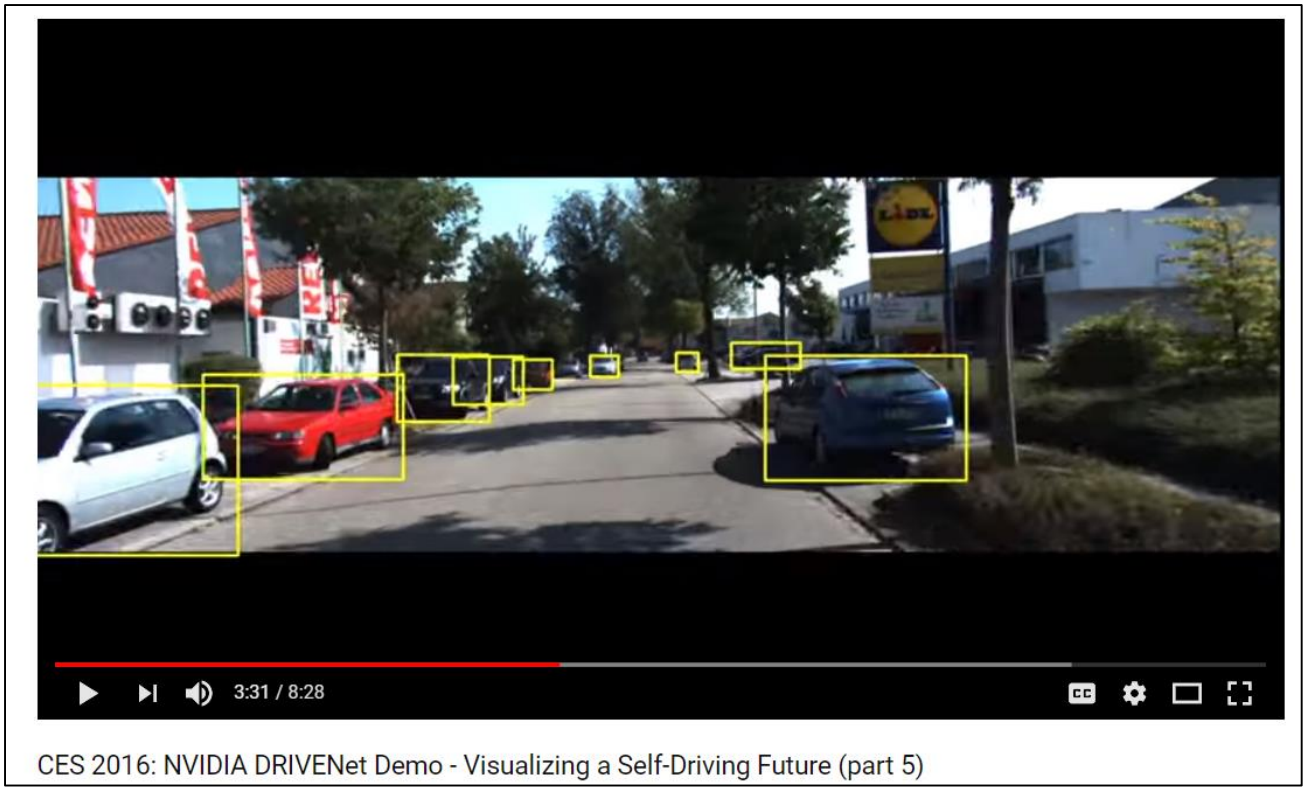
Deep Learning

- First layer of the deep learning is convolution which is used for edge detection
- Second Layer is pooling
- Third layer may respond to pattern resembling the round edges of wheels
- Fourth layer may respond to the shape of the cars





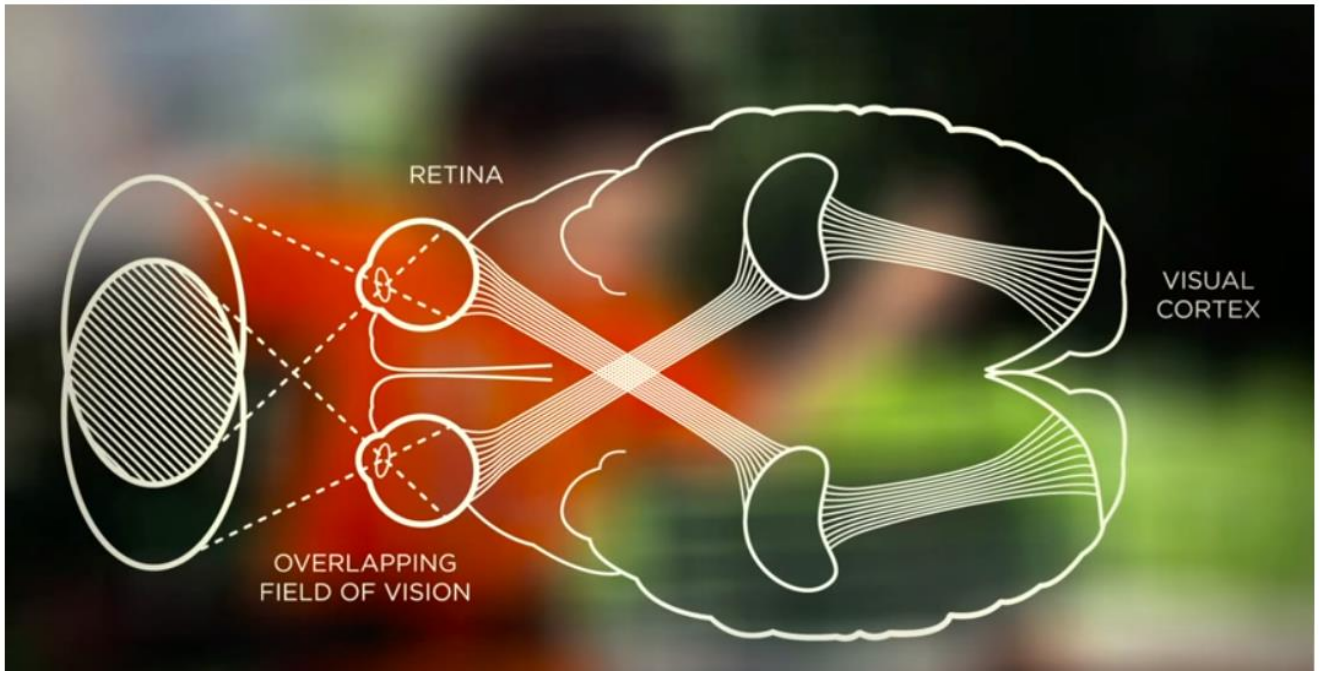
Nvidia
Video of Object Detection



- https://www.youtube.com/watch?v=HJ58dbd5g8g

Human Vision
* Eyes + Brain to Understand those Images

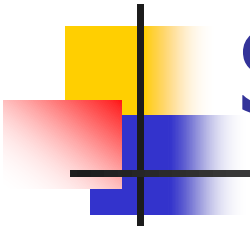
Autonomous Cars
* Camera + Neural Networks with Deep Learning



Amazon Deep Lens

- AWS DeepLens - Deep learning enabled video camera for developers
- AWS DeepLens - Deep learning enabled video camPrice: $249.00 & FREE Shipping. Details
- This item will be released on April 14, 2018.

- Deep learning in your hands - A fully programmable video camera designed to expand deep learning skills.
- Start learning right away - Learn the basics of deep learning through example projects, computer vision models, tutorials, and real world, hands-on exploration on a physical device.
- A new way to learn machine learning - Allows developers of all skill levels get started with deep learning in less than 10 minutes.
- Sample projects - AWS DeepLens can run custom models from Amazon SageMaker, and comes with a collection of pre-trained models ready to run on the device with a single click.era for developers



Summary

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  - Recurrent Neural Networks
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  - Availability of Billions of Images to Train Neural Network
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