The Dawn of the Age of Thinking Machines

COGNITIVE 2019
May 9, 2019
Venice, ITALY

JOHANNES KEPLER UNIVERSITÄT LINZ

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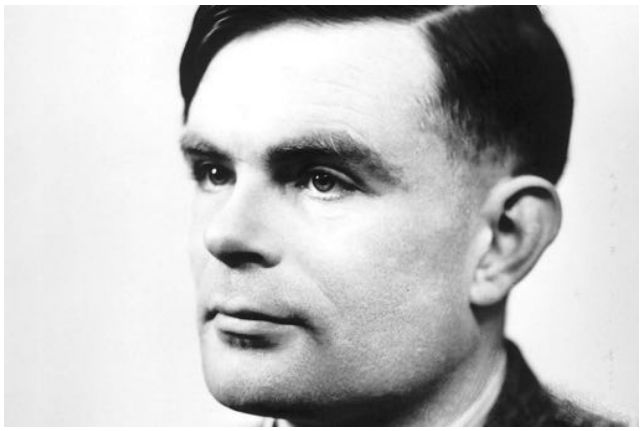
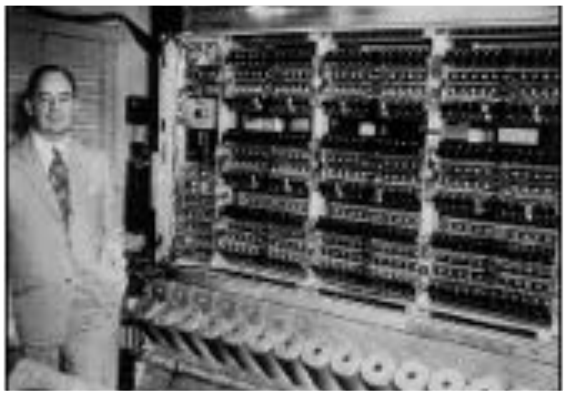
"Can Machines Think?"



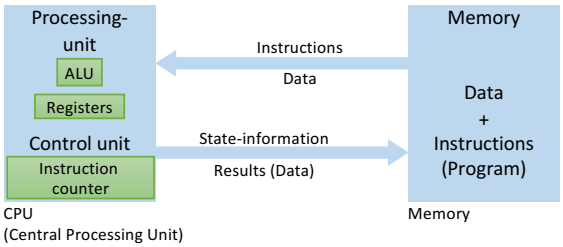
Computing Machinery and Intelligence
A. M. Turing
Computing Machinery and Intelligence.
Mind, Vol. 59, No. 236 (Oct., 1950), pp. 433-460

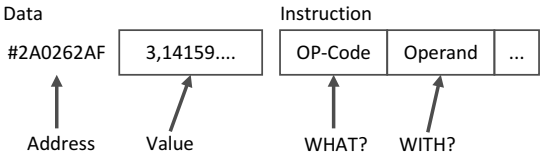
I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think?' is to be

von Neumann Architecture (1945)



John von Neumann
(1903 - 1957)



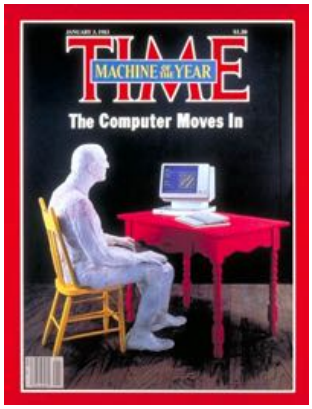


Personal Computer (1981)

*"A personal computer (PC) is any **general-purpose** computer whose size, capabilities, and original sales price make it **useful for individuals**, and which is intended to be **operated directly by an end-user** with no intervening computer operator …*

en.wikipedia.org
March 20, 2012

The Evolution of “Machine Thinking”



The Computer, Machine of the Year
Jan. 3, 1983

Can Machines Think?
Mar. 25, 1996

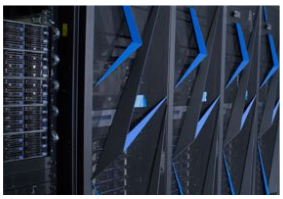
AlphaGo
Jan. 28, 2016

AI The Future of Humankind
Sep. 29, 2017

The „Fastest“ Computers Worldwide

Summit - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband

https://www.olcf.ornl.gov/olcf-resources/compute-systems/summit/
Cores: 2,397,824 Power (kW): 9,783
Rmax (TFlops/s): 143,500.0 Rpeak (TFlops/s): 200,794.9



Sierra - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband

https://hpc.llnl.gov/hardware/platforms/sierra
Cores: 1,572,480 Power (kW): 7,438
Rmax (TFlops/s): 94,640.0 Rpeak (TFlops/s): 125,712.0

Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway

http://www.nsccwx.cn/wxcyw/
Cores: 10,649,600 Power (kW): 15,371
Rmax (TFlops/s): 93,014.6 Rpeak (TFlops/s): 125,435.9

Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000

http://en.nscc-gz.cn/
Cores: 4,981,760 Power (kW): 18,482
Rmax (TFlops/s): 61,444.5 Rpeak (TFlops/s): 100,678.7

Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100

https://www.cscs.ch/computers/dismissed/piz-daint-piz-dora
Cores: 387,872 Power (kW): 2,384
Rmax (TFlops/s): 21,230.0 Rpeak (TFlops/s): 27,154.3

Trinity - Cray XC40, Xeon E5-2698v3 16C 2.3GHz, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect h

ttps://www.lanl.gov/
Cores: 979,072 Power (kW): 7,578
Rmax (TFlops/s): 20,158.7 Rpeak (TFlops/s): 41,461.2

AI Bridging Cloud Infrastructure (ABCI) - PRIMERGY CX2570 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR

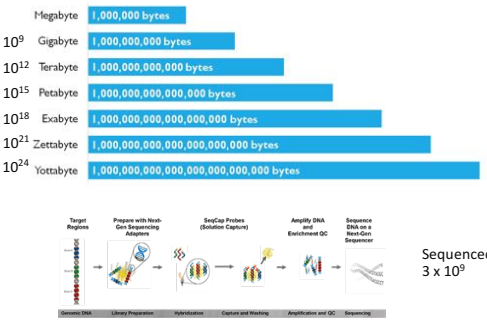
https://abci.ai/
Cores: 391,680 Power (kW): 1,649
Rmax (TFlops/s): 19,880.0 Rpeak (TFlops/s): 32,576.6

SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path

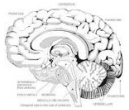
https://doku.lrz.de/display/PUBLIC/SuperMUC-NG
Cores: 305,856 Power (kW): na
Rmax (TFlops/s): 19,476.6 Rpeak (TFlops/s): 26,873.9

New Scientist, Thinking Machine
Aug. 5, 2017

"Co-Evolution" of Processing Power and Data

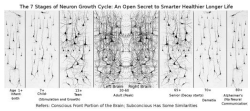


Sequenced DNA
3×10^9



Neurocortical Neurons
21×10^9

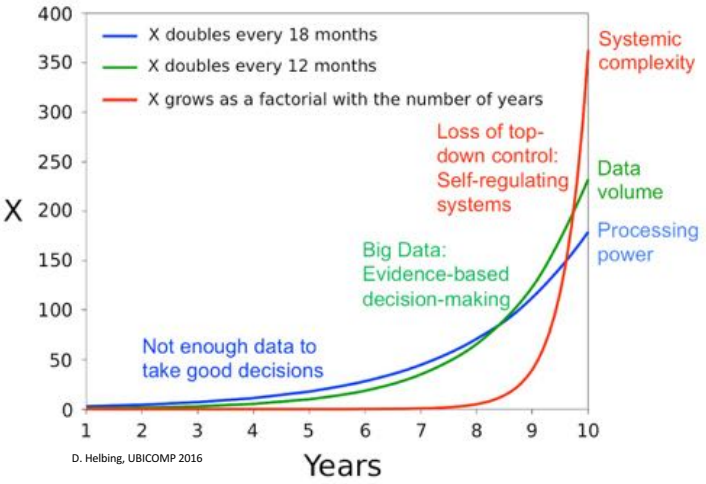
Synapses per Neuron
30×10^3



100 Years of Perception
3×10^{15}

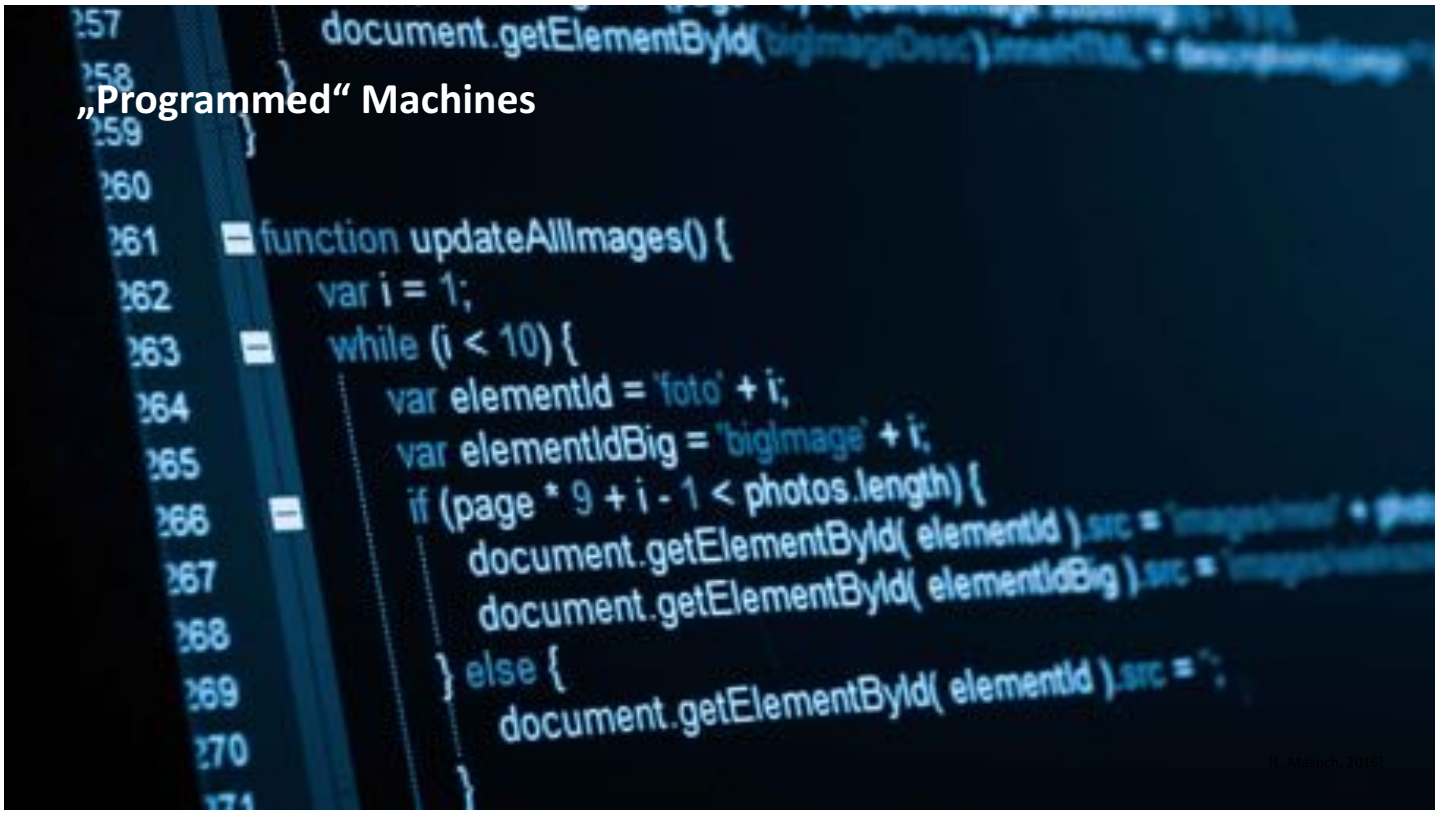
100 Years of Perception of all Mankind
21×10^{21}

All Perception of all Homo Sapiens
11×10^{29}



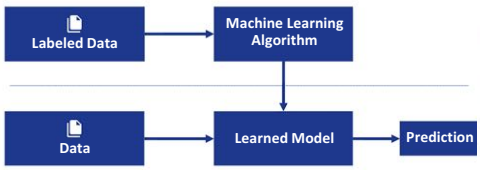
D. Helbing, UBICOMP 2016

Multilevel Organisation of the Human Brain

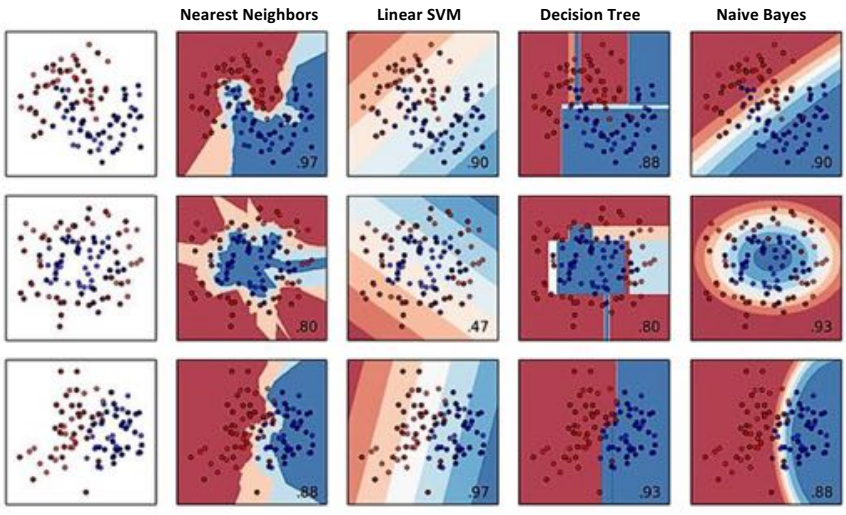


„Programmed“ Machines vs. „Trained“ Machines

Supervised Learning:
learning with a **labeled training set**
Example: E-mail spam detector with training set of already labeled E-mails

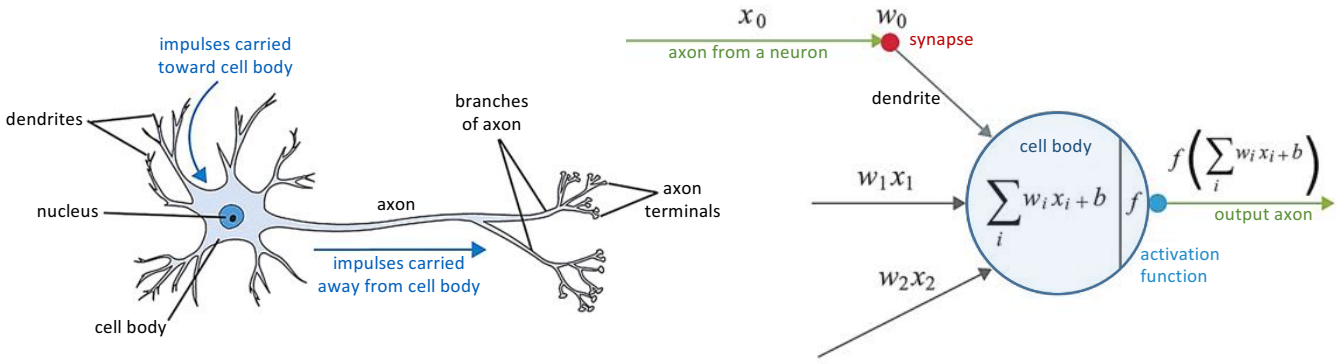


Reinforcement Learning:
learning based on **feedback** or reward
Example: learn to play chess by winning or losing



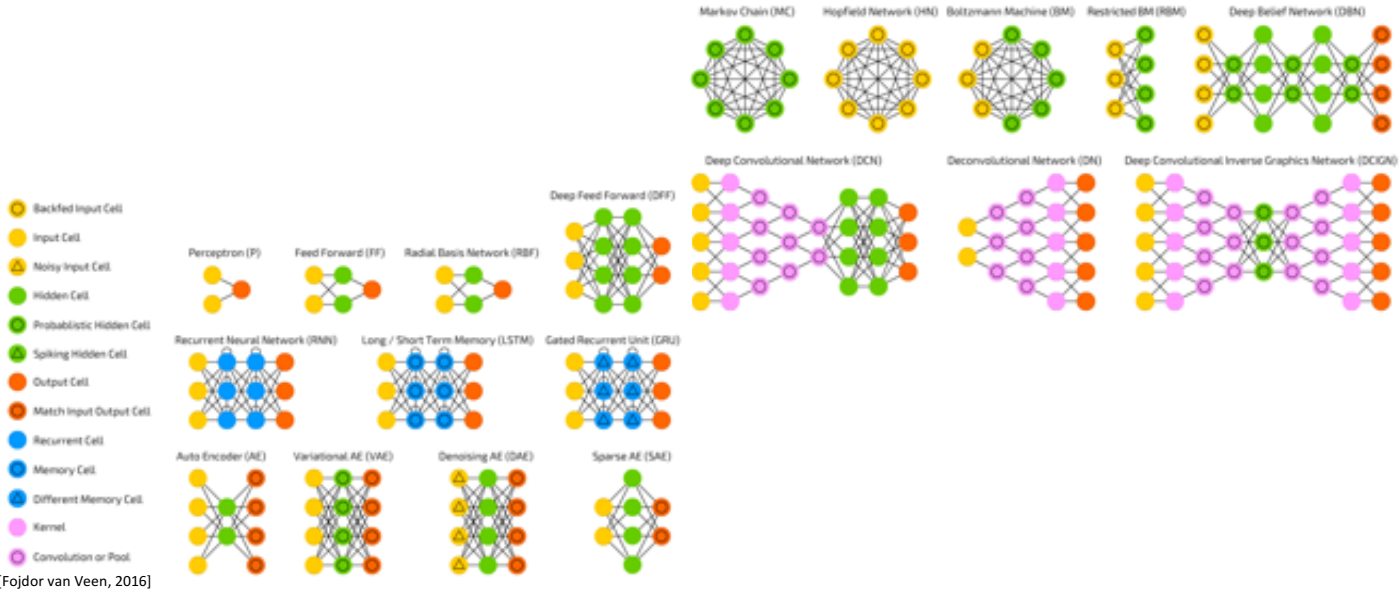
[L. Masuch, 2016]

Neural Networks



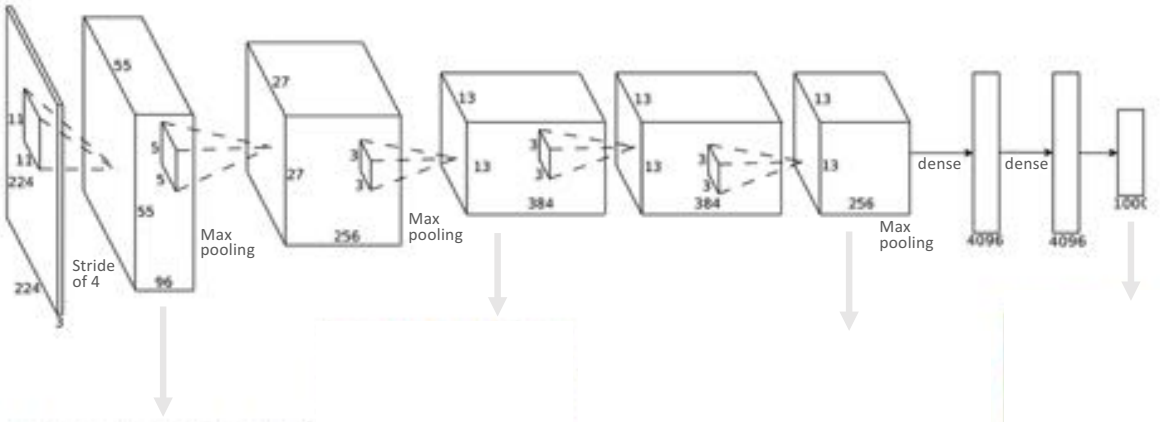
An artificial neuron contains a **nonlinear activation function** and has several incoming and outgoing **weighted connections**.

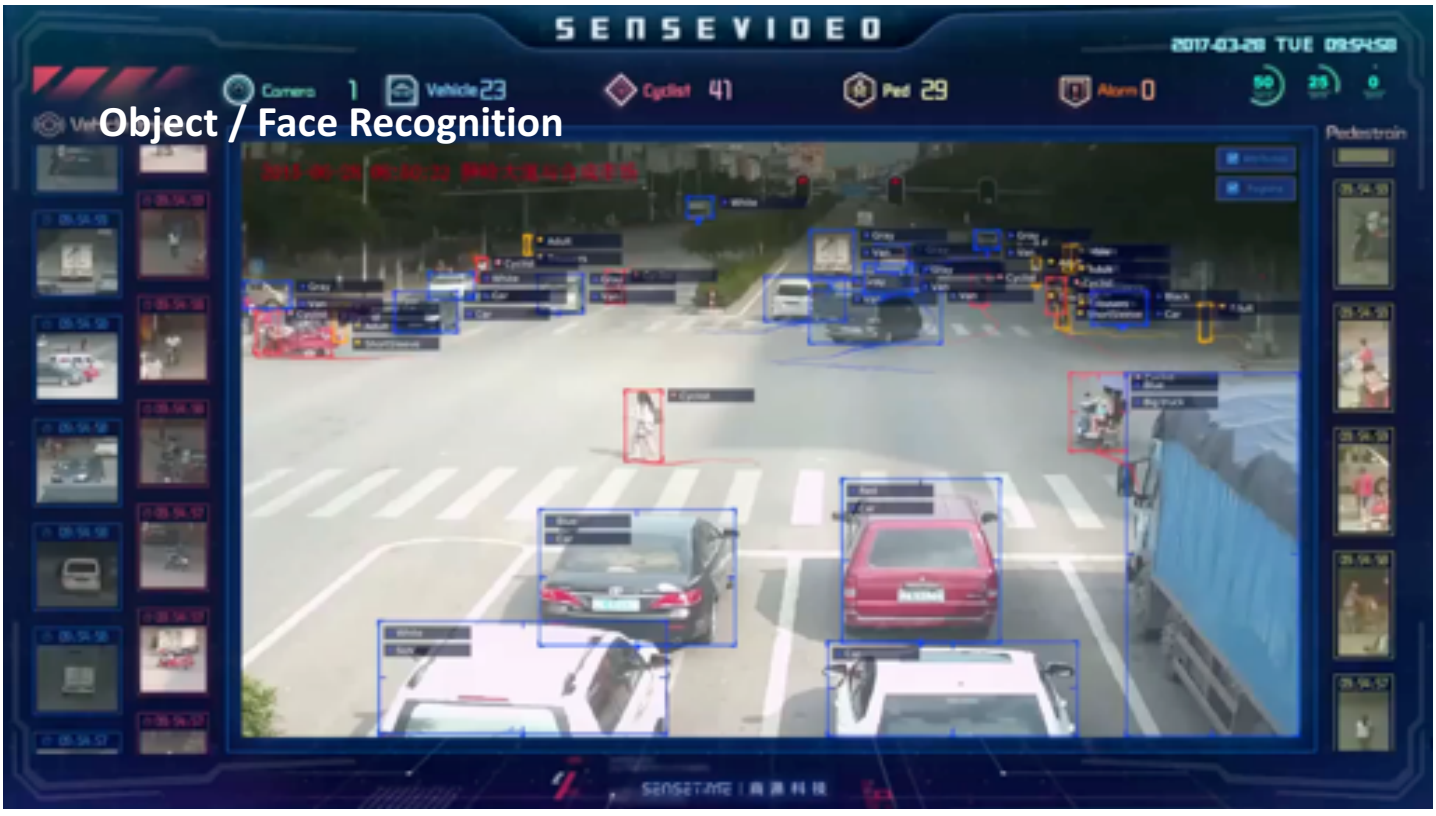
Neural Networks :: Deep Convolutional Network



[Fojdor van Veen, 2016]

Neural Networks :: Deep Convolutional Network





Object / Face Recognition

AI Image Processing

NVIDIA Multimodal Image Translation: unsupervised learning and generative adversarial networks (GANs)
April 2018

Multimodal Unsupervised Image-to-Image Translation

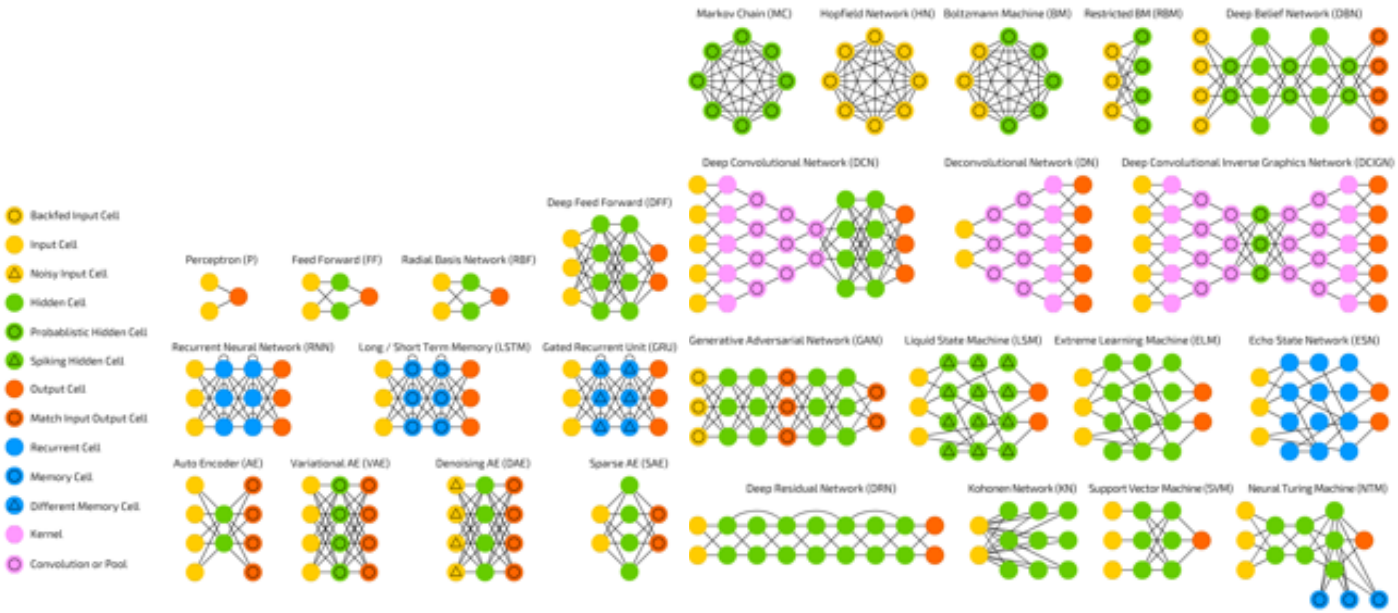
Xun Huang[1], Ming-Yu Liu[2], Serge Belongie[1], Jan Kautz[2]

Cornell University[1] NVIDIA[2]

In a picture of a cat, for example, the pose of the cat is the content and the breed is the style. The pose is fixed. If you're converting a picture of a housecat to a leopard or a dog, the position of the animals must remain identical. What varies is the breed or species — domestic shorthair, leopard or collie, for example.

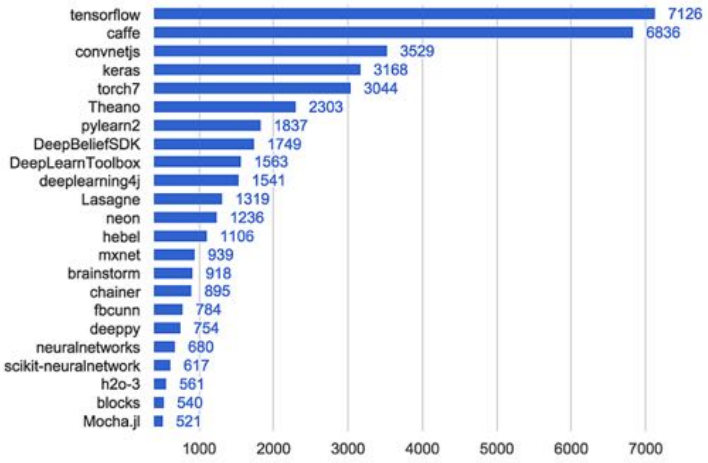
Microsoft AI image generator: Attentional Generative Adversarial Network (AttnGAN) creates an image using text input.
Janary 2018

Neural Networks

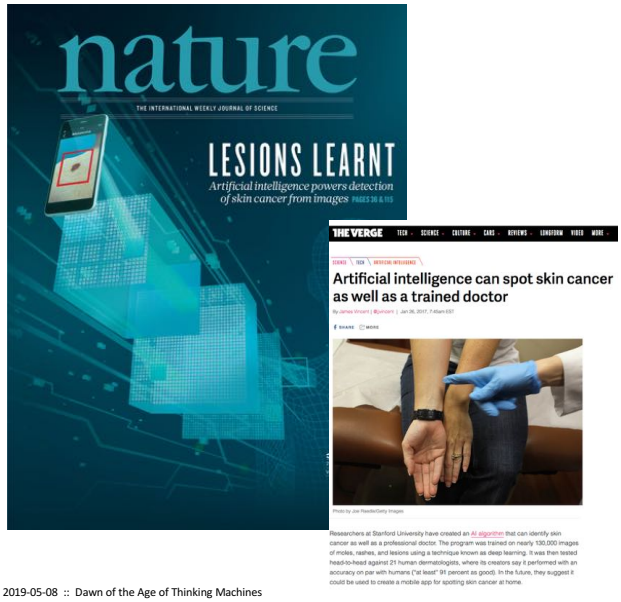


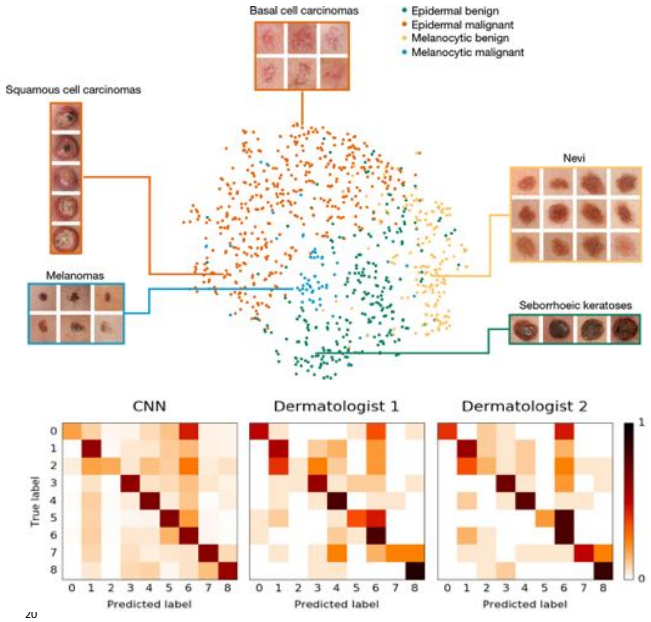
Deep Learning Tools

Open Source



AI achieves the Accuracy of Board-Certified Dermatologists



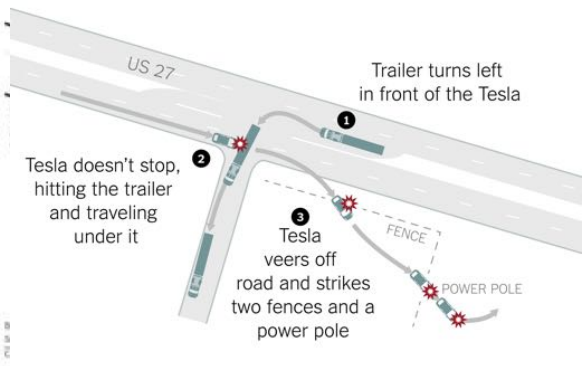


AI Drives „Autonomous“ Cars

Home > News > 'Featured' > Tesla Driver Involved in Fatal Crash while Using Autopilot Mode

Tesla Driver Involved in Fatal Crash while Using Autopilot Mode

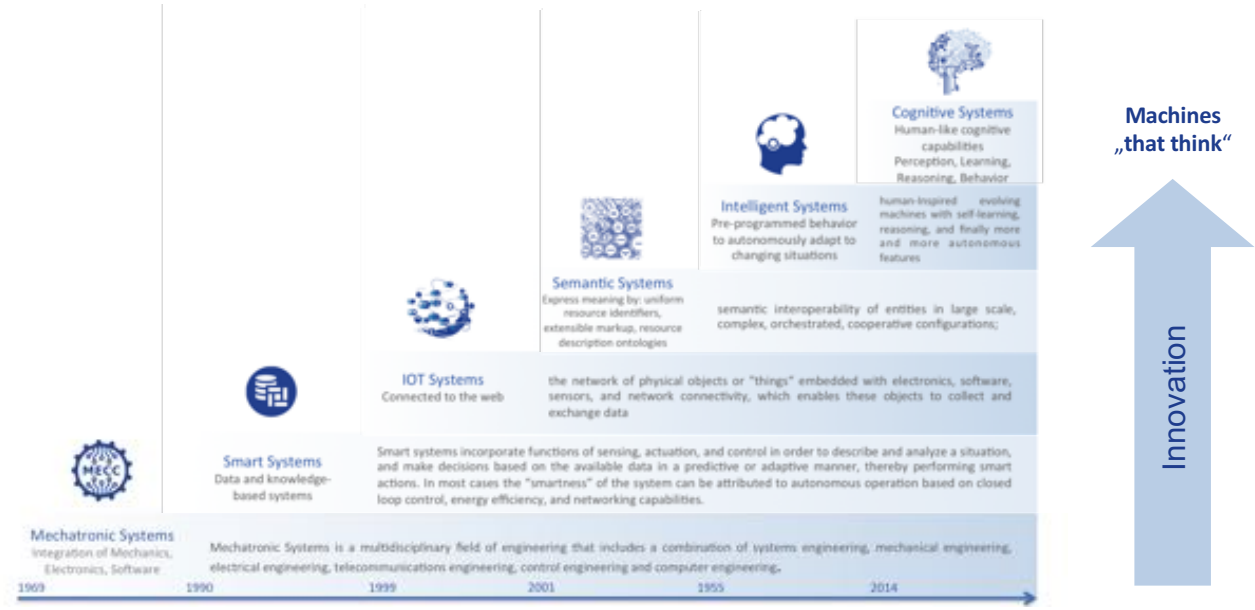
JUNE 30, 2016 AT 6:02 PM BY PETE BIGELOW | PHOTOGRAPHY BY MICHAEL SIMARI




Falcon Heavy Test Flight (Feb. 2018)
Tesla Roadster as Dummy Payload


DON'T
PANIC!

Towards Machines that „Think“



Towards Machines that „Think“

Features

- Personalized
- Online / Real-Time
- Smart Materials
- Lot-Size 1
- Embedded Intelligence
- Self-Configuration
- Self-Management
- Product Memory
- Autonomous Behavior

Towards Machines that „Think“

Cognitive Abilities

- Perception
- Awareness
- Reasoning
- Learning
- Planning
- Prediction
- Decision Making
- Autonomous Acting

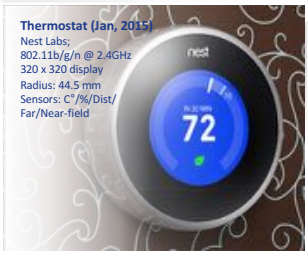
Features

- Personalized
- Online / Real-Time
- Smart Materials
- Lot-Size 1
- Embedded Intelligence
- Self-Configuration
- Self-Management
- Product Memory
- Autonomous Behavior

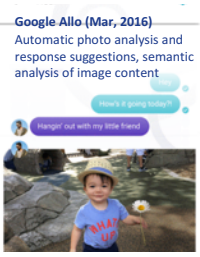
Early Signs of “Thinking Things” Already Seen Today …

Self Driving Robot (Mar, 2016)
BMW; Recycled i3 batteries, Lifting 500KG, Production logistics, Autonomous Obstacle Detection

Thermostat (Jan, 2015)
Nest Labs; 802.11b/g/n @ 2.4GHz 320 x 320 display Radius: 44.5 mm Sensors: C°/%/Dist/ Far/Near-field



Google Allo (Mar, 2016)
Automatic photo analysis and response suggestions, semantic analysis of image content

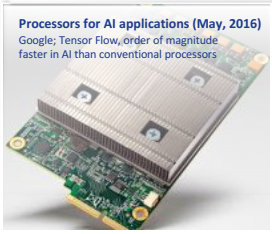


Power Tools (Jan, 2015)
Bosch; Reactive Technologies, User Centered Design, Embedded Computing and Storage Capacity

Autonomous Logistics (Apr, 2016)
Concept; Faster Delivery Times, Optimized traffic flow, Synchronized transit, Improved Airodynamics

Sony Smart Racket (Aug, 2015)
Smart Tennis Sensor lets you improve your game based on hard science. Analyze each shot and rediscover your tennis experience.

Processors for AI applications (May, 2016)
Google; Tensor Flow, order of magnitude faster in AI than conventional processors



Watson
IBM; Cognitive Architecture, NLP, Deep Learning

KUKA LBR-iiwa (2016)
Intelligent Industrial Work Assistant – Human-Robot-Cooperation Sensory capabilities for safety, Bionic Kinematics, 7 axes, Programmable Sensitivity

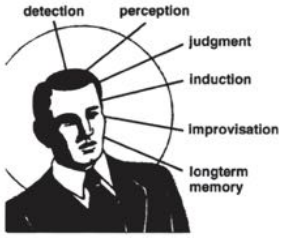
Cogitai (May, 2016)
Sony, Cogtai; technology which enables smart machines to continuously learn from the real world interactions

Cognitive Computing Market worth $12,550.2 Million by 2019

The report **"Cognitive Computing Market by Technology (Natural Language Processing, Machine Learning, Automated Reasoning), by Deployment Model (On-Premises, Cloud) & by Regions - Global Forecast to 2019"**, provides a comprehensive market and forecast analysis of the overall market, segmented by technology. The market has **(Apr, 2016)**

Humans-Are-Better-At :: Machines-Are-Better-At (HABA-MABA)

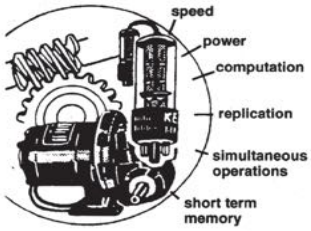
HUMANS SURPASS MACHINES IN THE:



Worker Strengths
- Cognition
- Reaction
- Adaptation
- Improvisation

Worker Limitations
- Modest speed
- Modest force
- Weak repeatability
- Inconsistent quality

MACHINES SURPASS HUMANS IN THE:



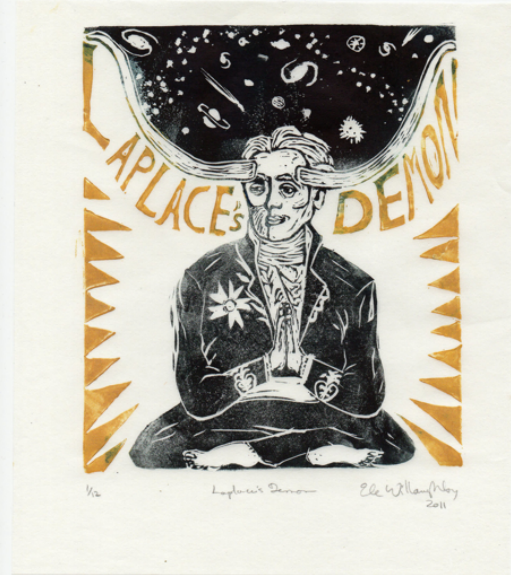
Robot Strengths
- High speed
- High force
- Repeatability
- Consistent quality

Robot Limitations
- No cognitive capability
- No autonomous adaptation
- Modest working envelope

Figure 1. The Fitts HABA-MABA (humans-are-better-at/machines-are-better-at) approach. Reprinted with permission from *Human Engineering for an Effective Air Navigation and Traffic Control System*, 1951, by the National Academy of Sciences, courtesy of the National Academies Press, Washington, D.C.

The Entanglement of Industrial and Cognitive System Technologies

1814: Laplace's Demon -- Pierre-Simon, Marquis de Laplace (1749-1827)



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