



Robotics & Data Mining Summer School Lesson 01. Introduction

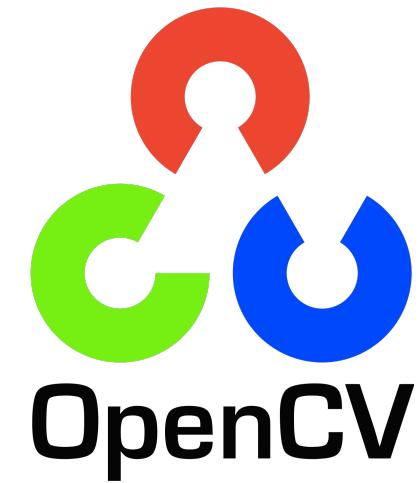
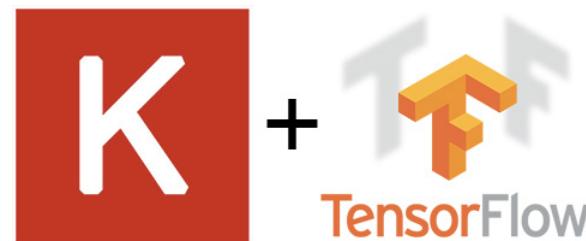
Kirill Svyatov, Alexander Miheev

Ulyanovsk State Technical University,
Faculty of Information Systems and Technologies,
Simcase, LLC

- 11 lessons
- 1. Intro to robotics and data mining.
- 2. Intro to math and machine learning
- 3. Intro to Python programming
- 4. Intro to ROS. ROS programming with python. Nodes, services, odometry
- 5. ROS programming with python. Mapping, positioning
- 6. ROS programming with python. Path planning
- 7. OpenCV library with python for image processing
- 8. Intro to neural networks. Perceptron Neural networks.
- 9. Convolutional networks. Keras library
- 10. Final project. Integration with ROS
- 11. Final project competition.

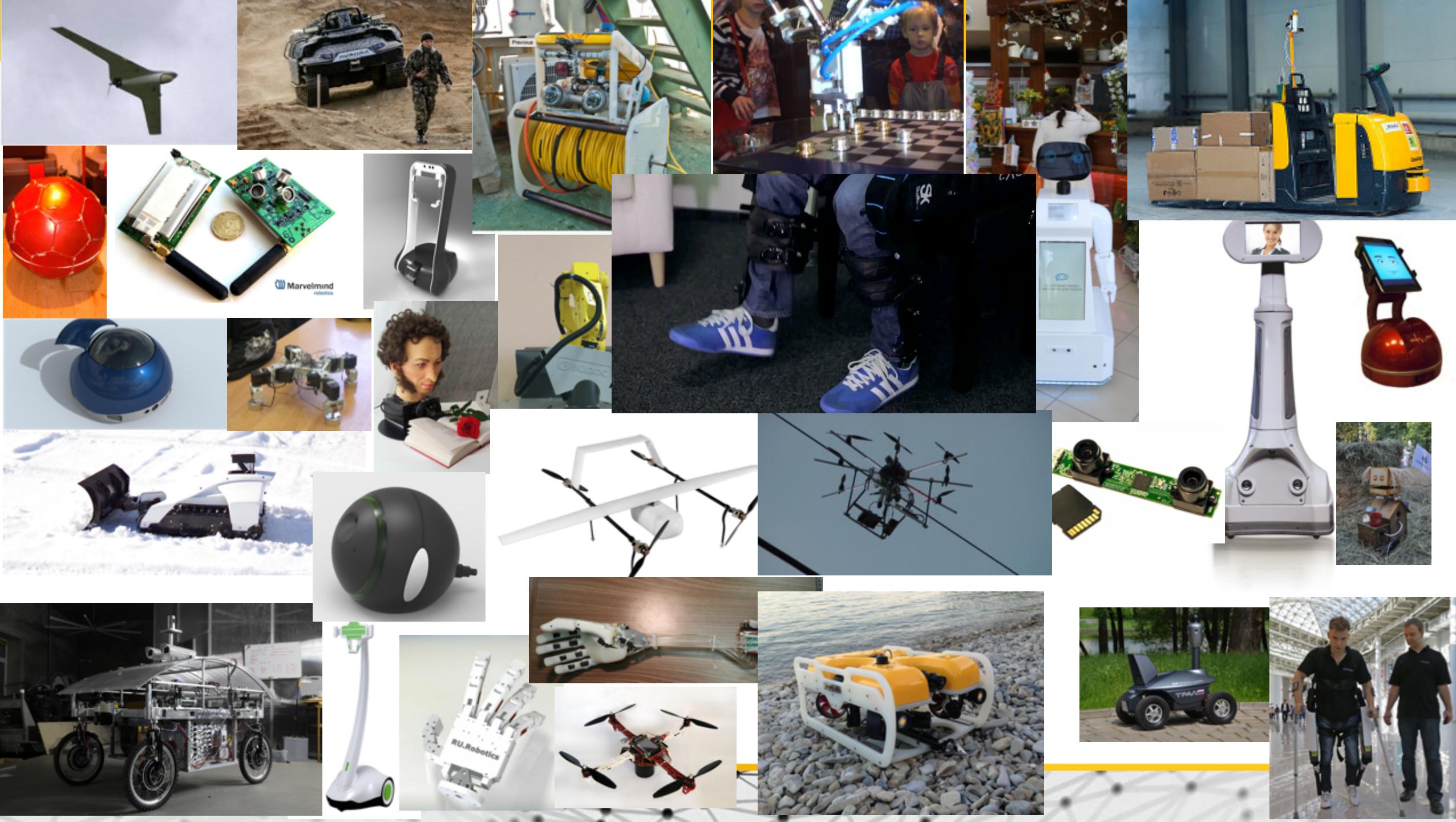
- Prediction & classifying tools
- Mobile robot programming & modeling tools
- Image recognition tools

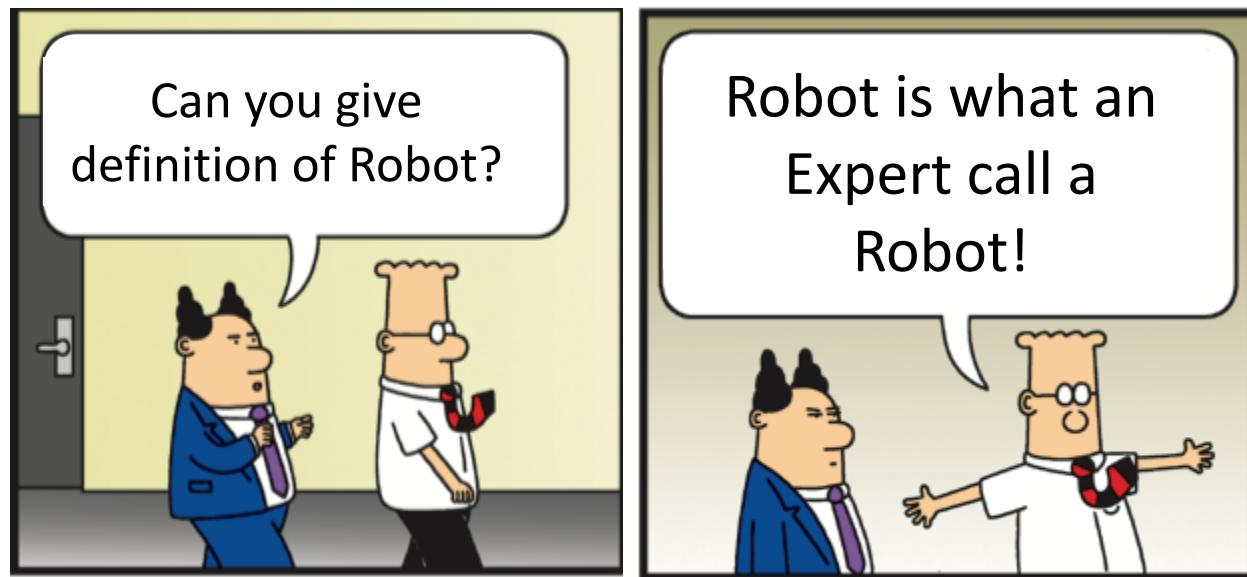




- Control theory
- Math basics of Machine Learning
- Calculus
- Optimization theory
- Mechatronics
- Electronics
- Statistics
- Linear algebra
- ...







- No precise definition.
So we take a broad, inclusive definition. Some soft requirements:
 - > 2 DOF
 - Sensors
 - Autonomy



What is not a robot?



Dish washer



*Delta Maker
3D printer*



RC buggy

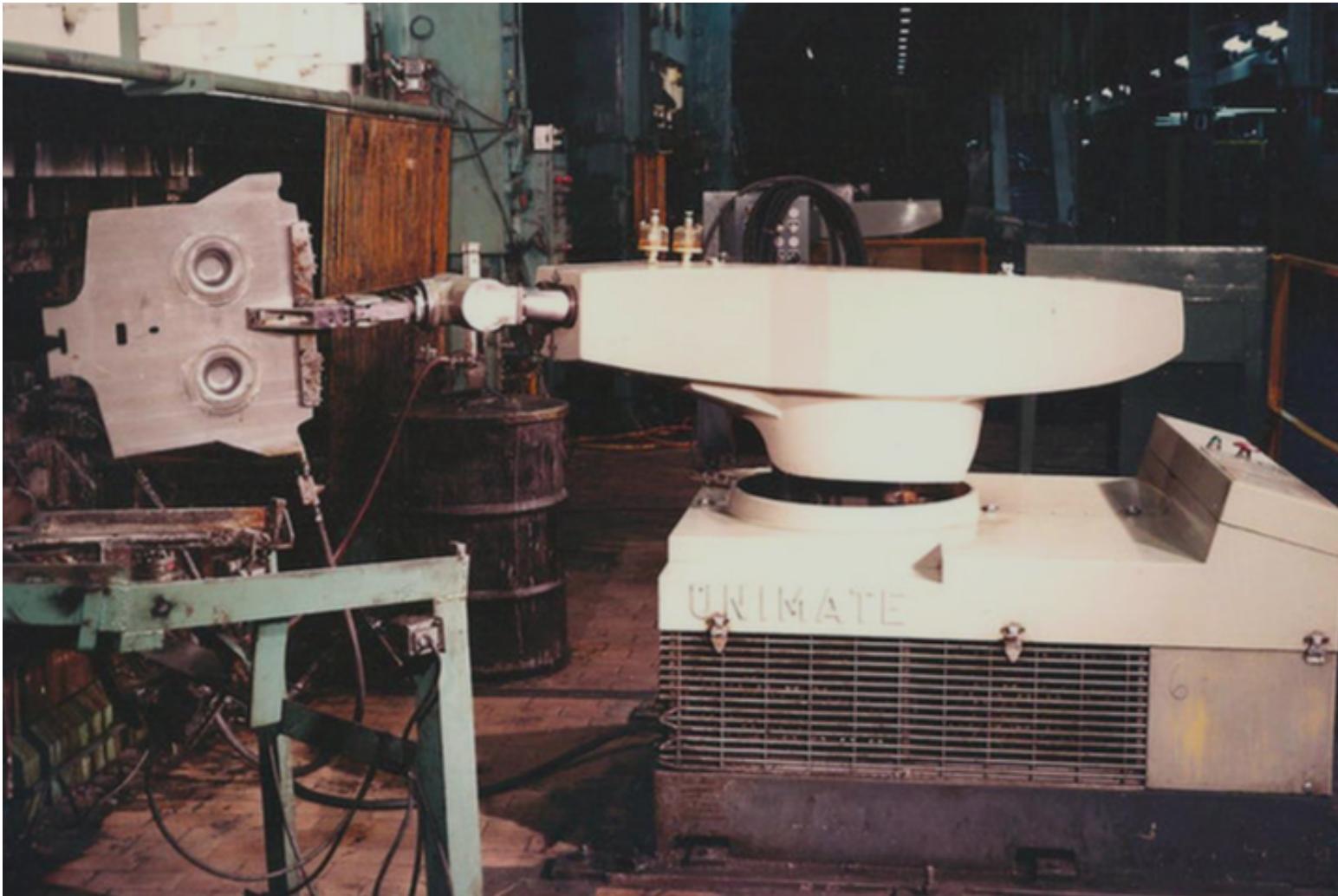


Washing machine

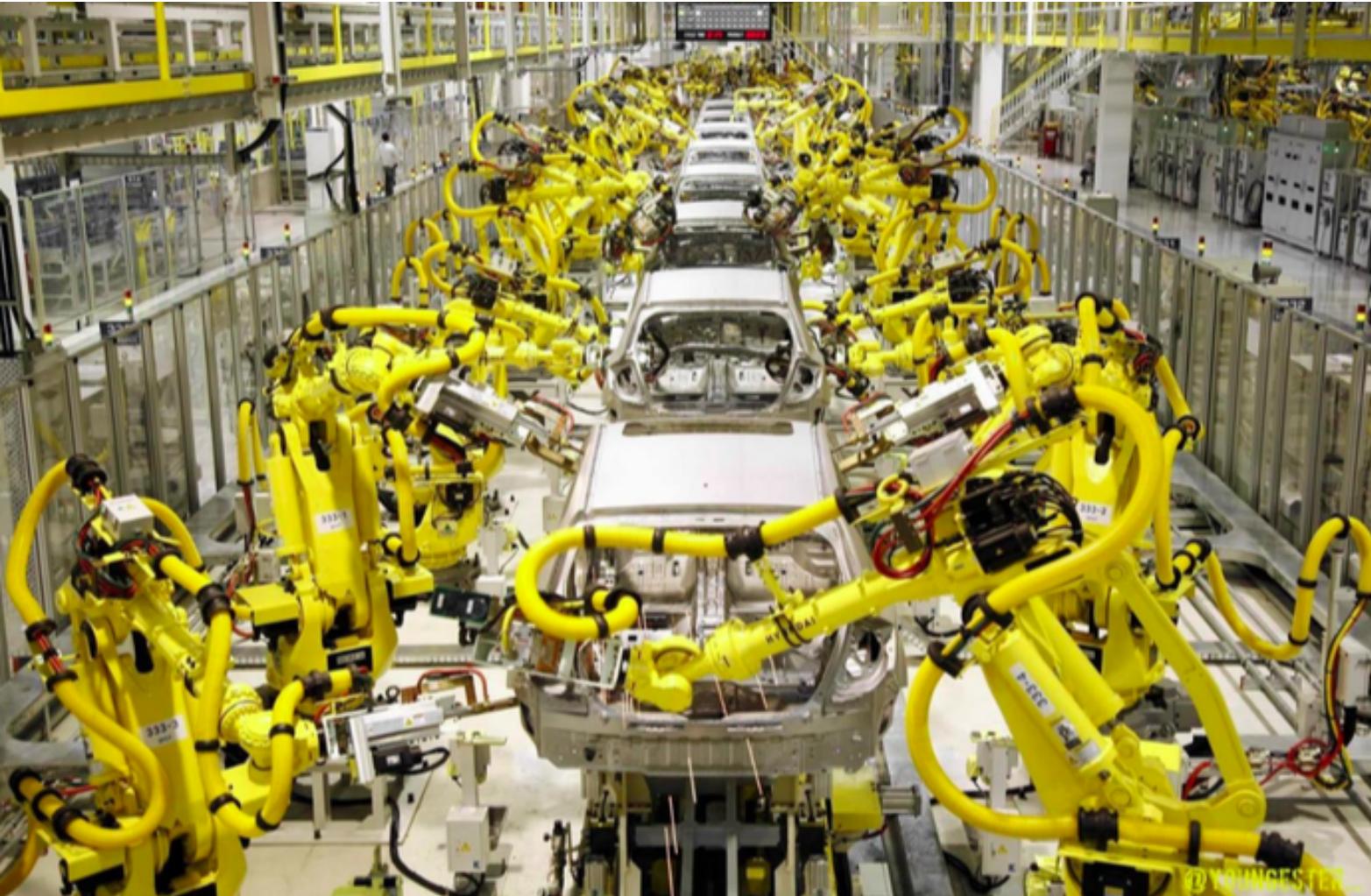


CNC milling machine

General Motors, Unimate robot, 1961



- Robotics markets were dominated by industrial robot arms for decades



- Solar panels assembling by An *ABB FlexPicker robot*



- Food industry



Cambrian Moment of Modern Robotics



- Moor's Law
- Digitalization of everything, including production
- Better Battery
- Huge communication bandwidth increase
- Cloud robotics
- 3 devices/human in 2019
- Storage is cheap commodity





Constructing walls

Robotics & Data Mining



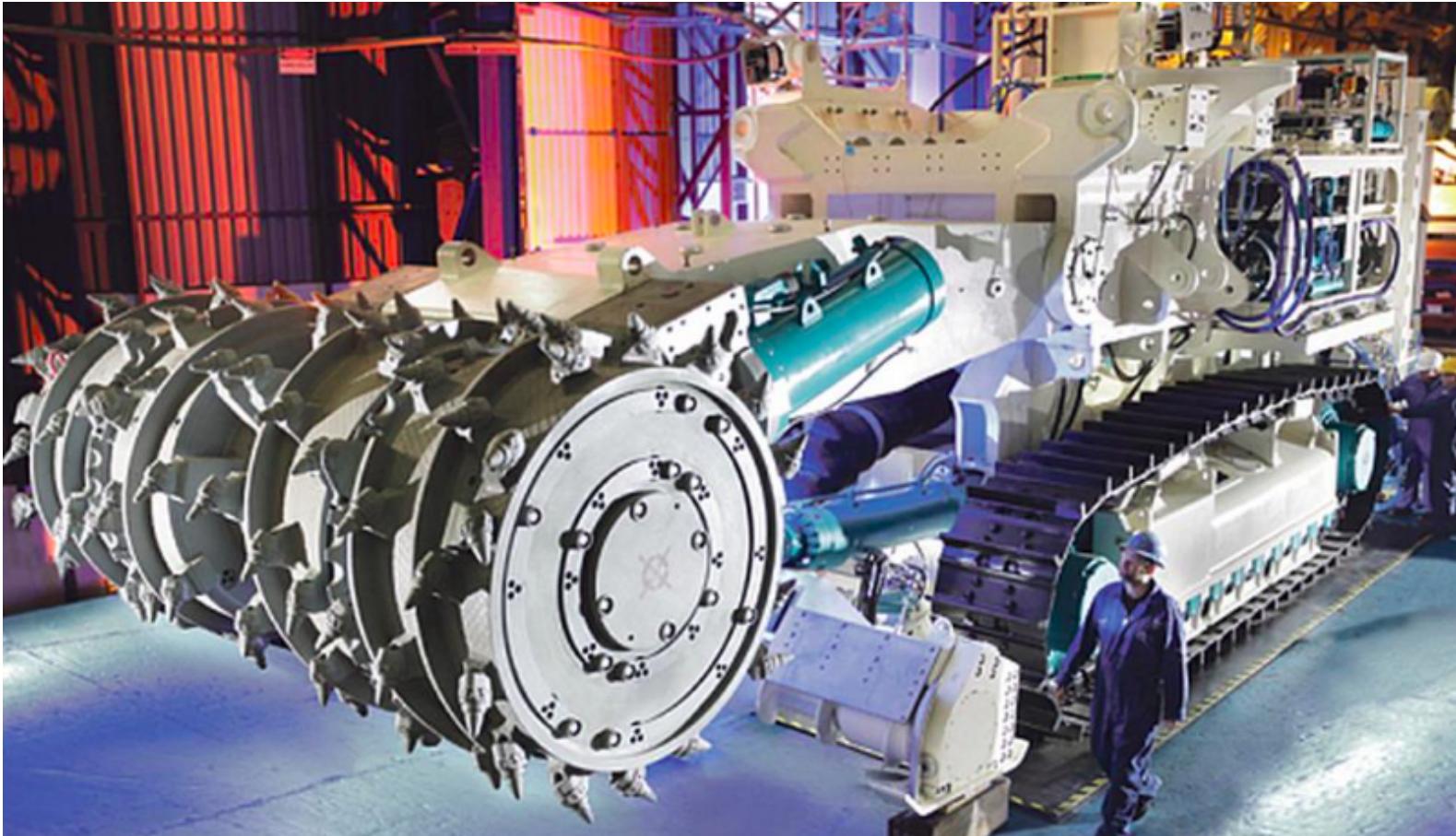
- *WinSun* use giant 3D printers to construct buildings such as this villa



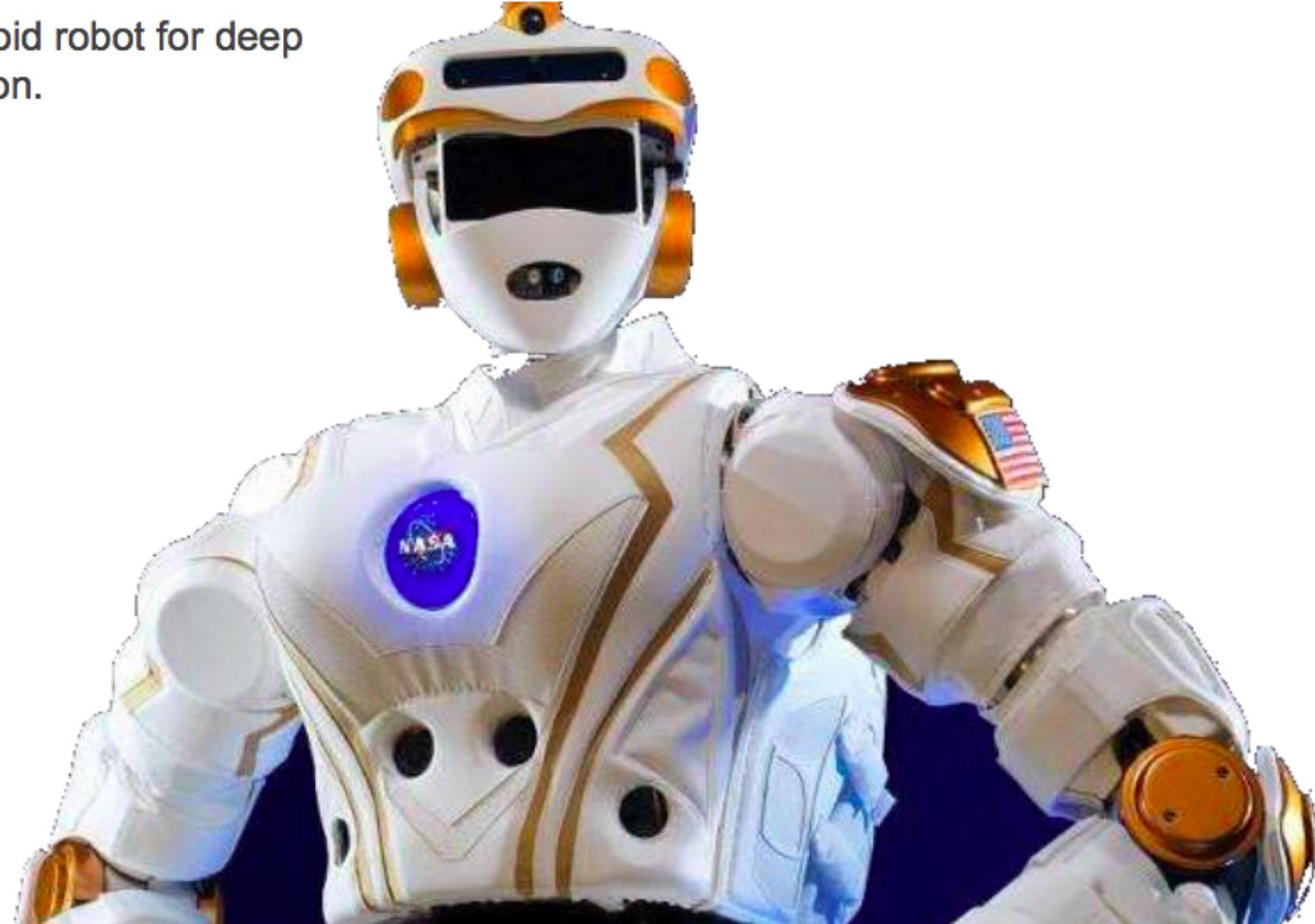
- Japanese company *Spread* are building the world's first fully autonomous lettuce farm in Kyoto, scheduled to open in 2017



- *Nautilus Minerals* are the first company in the world to obtain a license for deep sea mining using robots



NASA's humanoid robot for deep space exploration.



- Russian robot Feodor



Human Soldier vs Robot Soldier

Robotics & Data Mining

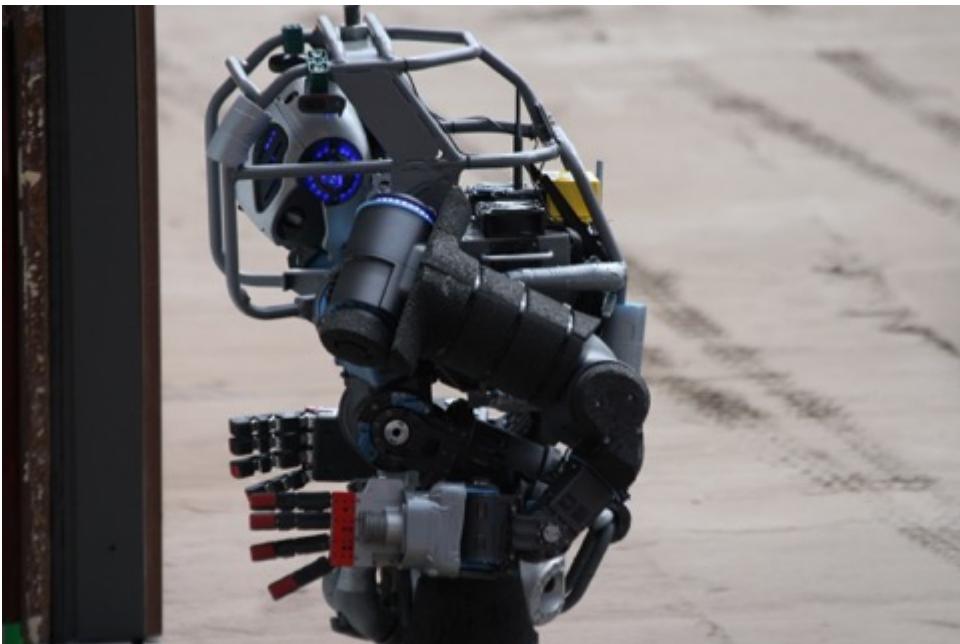
	Human	Robot
Listening	16 -20 000 Hz	1 - unfinity
Viewing	160 mlns of colors	150 MP
Touching	13 nm	Depends on materials
If feels cold, hot or hunger	unhappy	Doesn't care
Emotions	A lot of	Not at all



- It is so easy to jam communications of tele/supervised robots or drones.

Examples:

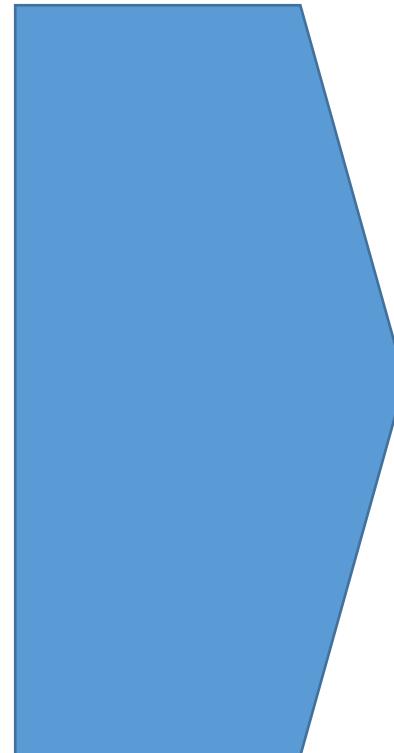
DARPA Robotics Challenge



Iran–U.S. RQ-170 incident



- Dramatically increase firepower with fewer personnel



- Run, fly and swim



- Level of Autonomy is very high
- Range is limited
- No weapons
- Only reconnaissance missions

Sanpa



Remora



Autonomy: Mission level

Duration: 20-120 h

Speed: 1-2 M/s

Connection: radio, hydroacoustic

Depth: 3-6km

Range: 200-300 km

Examples: Klavesin (Ru), Remus (US), Autosub (GB),

Hugin (Nw)

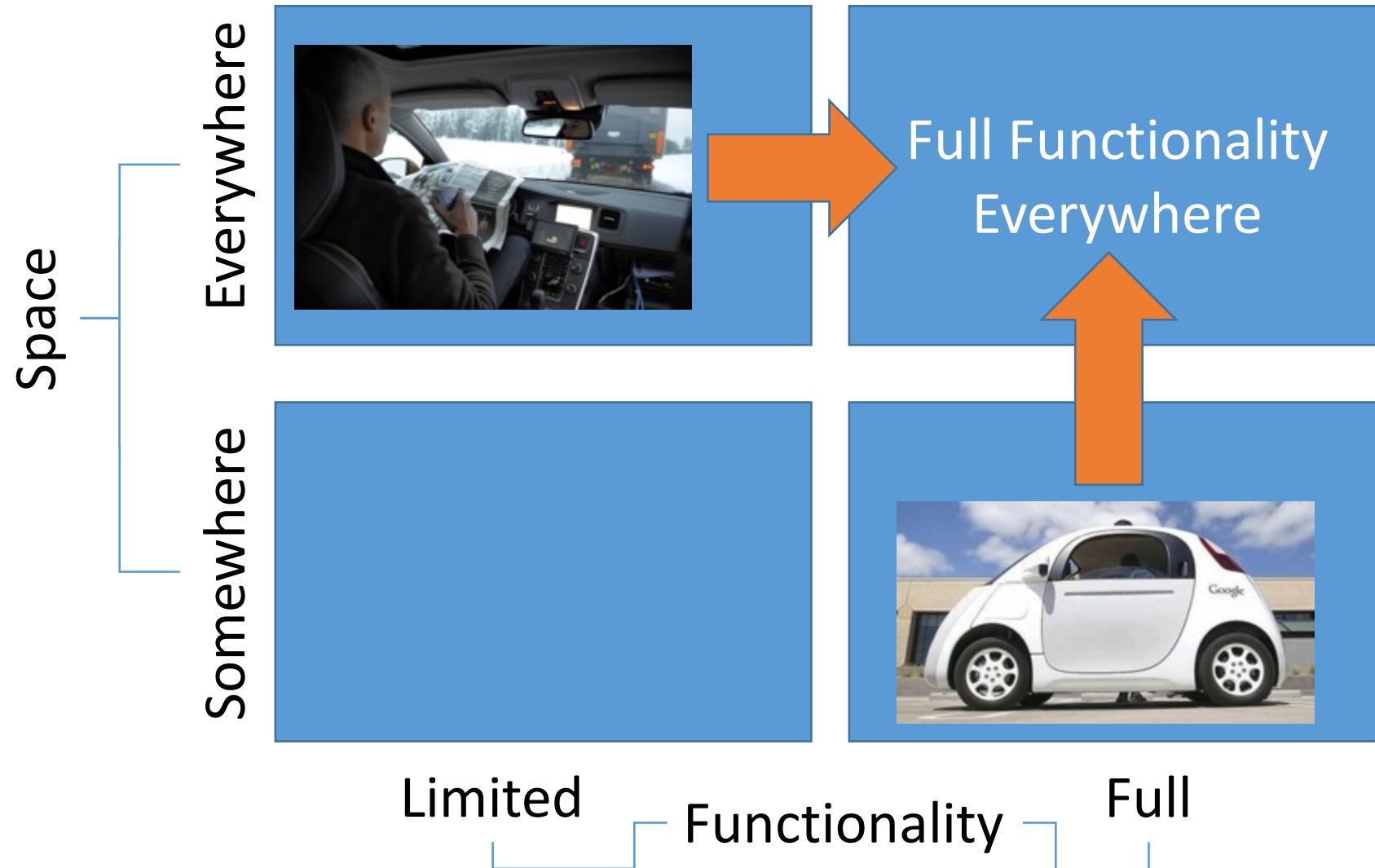
Klavesin



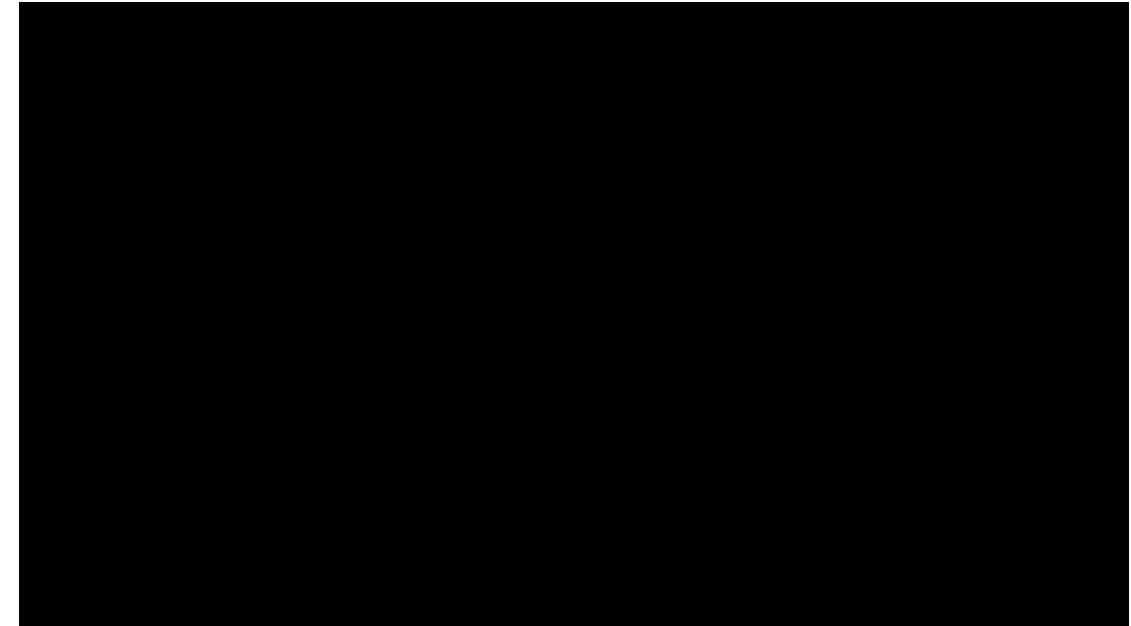
ACTUV Sea Hunter



Reliable
communications are
needed!



- Weight and power source is the biggest limiting factor
- Hydrogen Cells are coming to market very soon



- The following market sectors will grow rapidly over the next decade:
 - Agriculture
 - Autonomous transport
 - Collaborative robotics
 - Healthcare robots in countries with demographic time bombs Industrial robot arms in developing countries
 - Logistics
 - Military
 - Mining
 - Personal robots



State of Machine Learning



© A feast for the Eyes



"If intelligence was a cake, unsupervised learning would be the cake, supervised learning would be the icing on the cake, and reinforcement learning would be the cherry on the cake. We know how to make the icing and the cherry, but we don't know how to make the cake."

Yann LeCun

Director of AI Research at Facebook

Hypothetical ‘Full AI’ would need ~ 10 exaFLOPS,
~500 MW



Cray Titan ~18 pFLOPS



Tianhe-2 ~34 pFLOPS, ~25 MW



Cray-2 (1985)

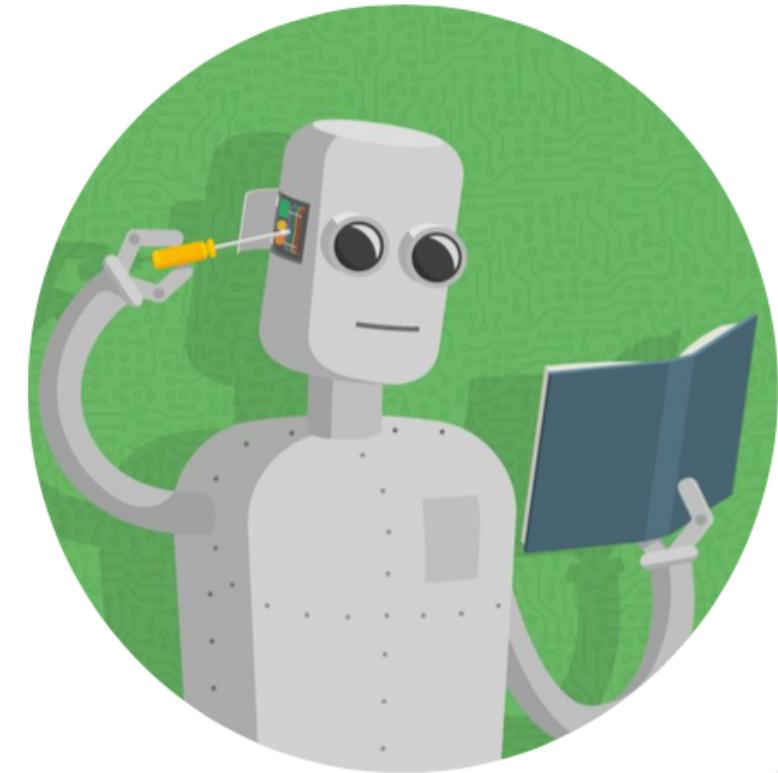
2.7 times more powerful



iPhone 5 (2012)

27 years

Subfield of computer science that
"gives computers the ability to learn
without being explicitly programmed"
(Arthur Samuel, 1959)

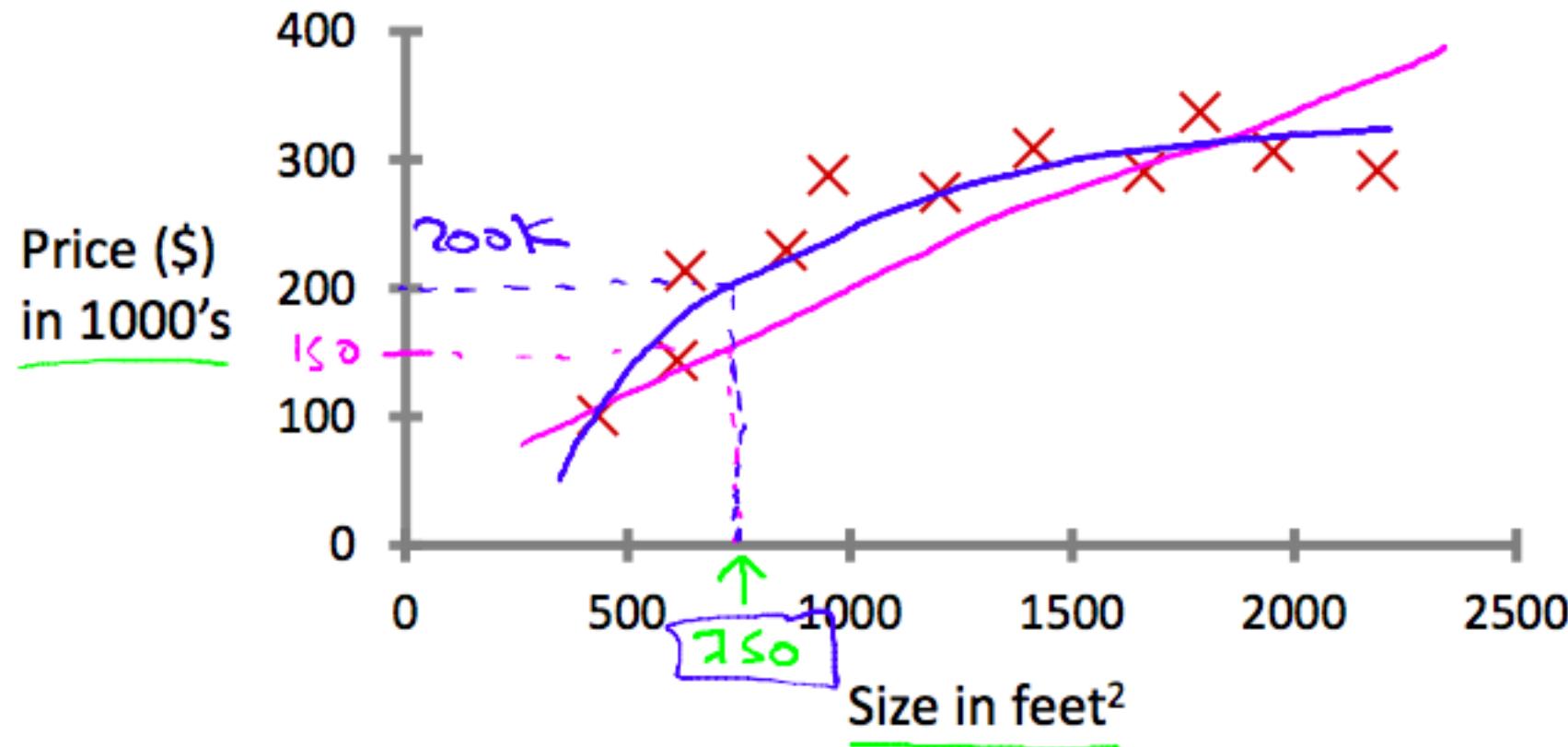


- Supervised learning
- Unsupervised learning

Others: reinforcement learning, recommender systems



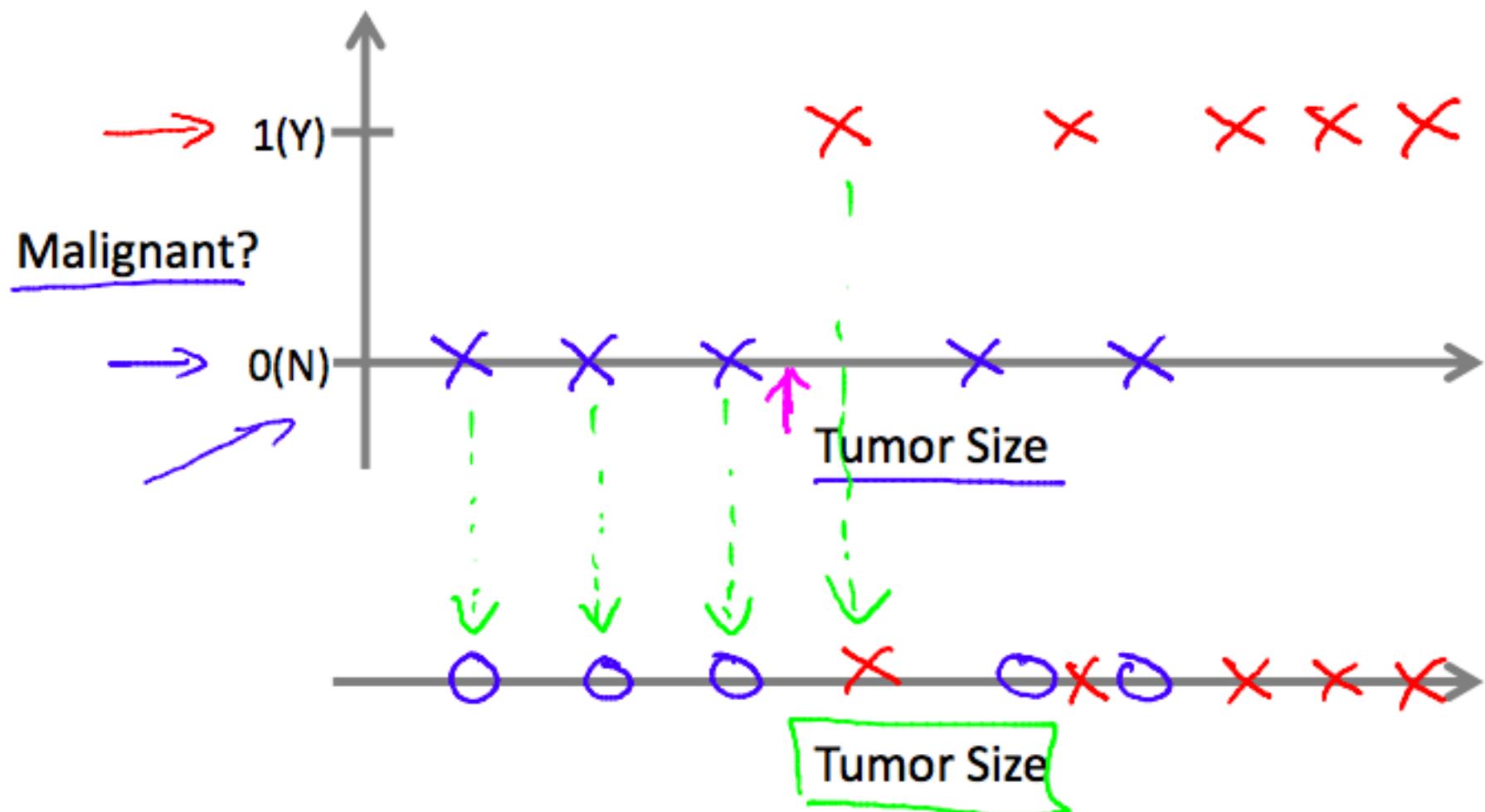
Housing price prediction.



Supervised Learning
"right answers" given

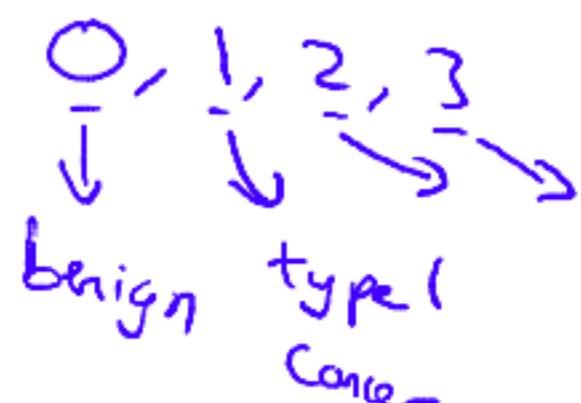
Regression: Predict continuous valued output (price)

Breast cancer (malignant, benign)

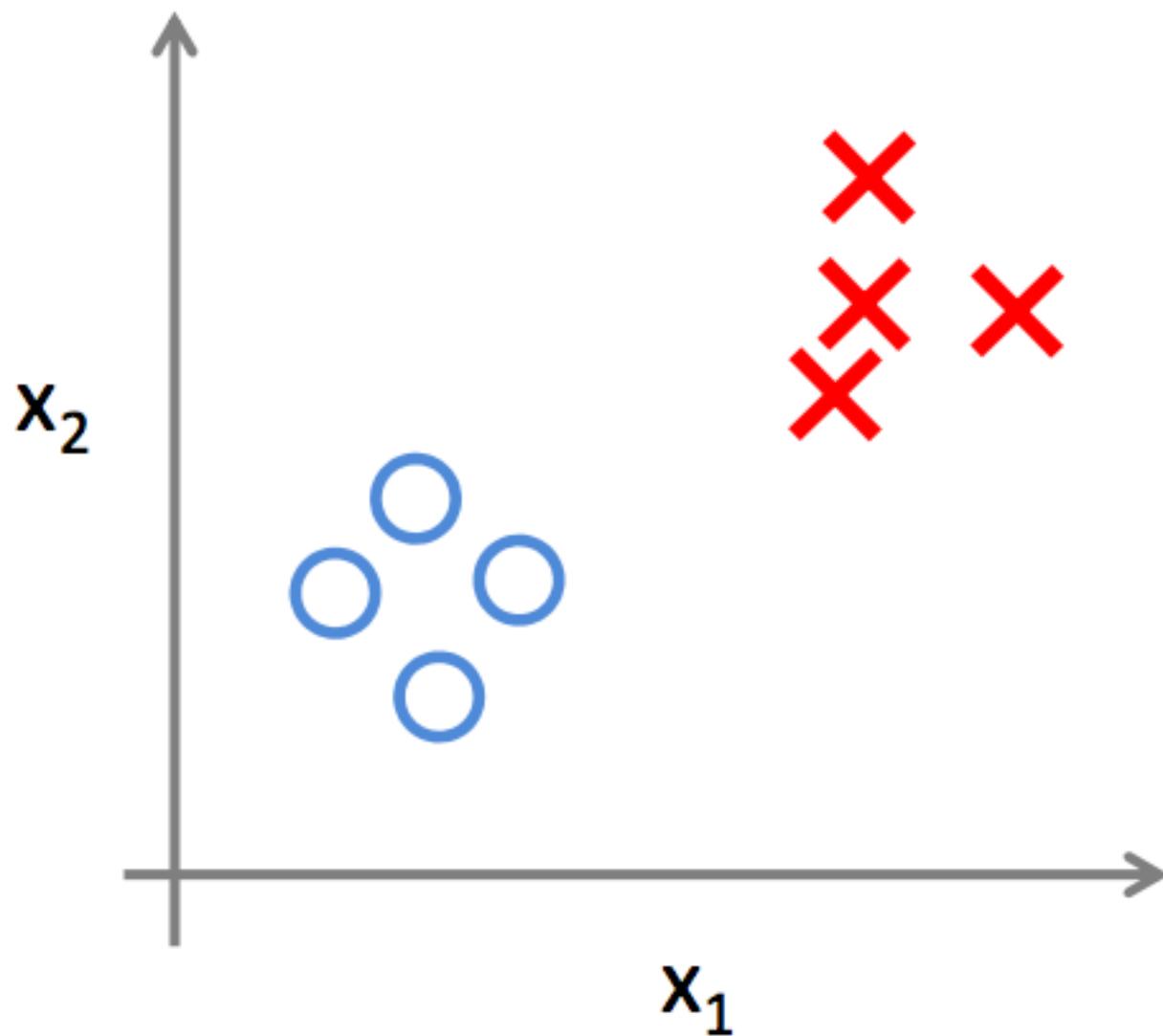


Classification

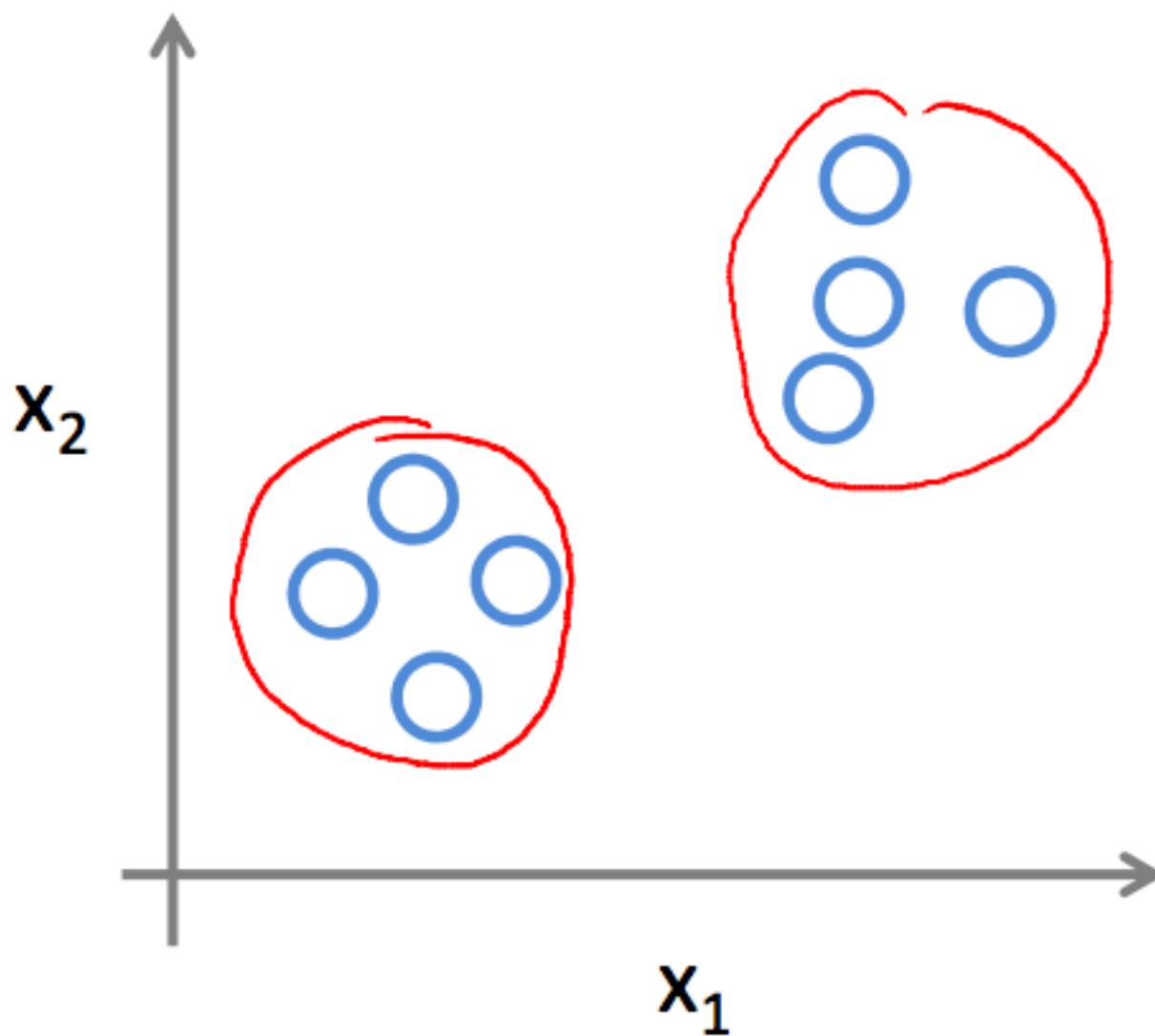
Discrete valued output (0 or 1)



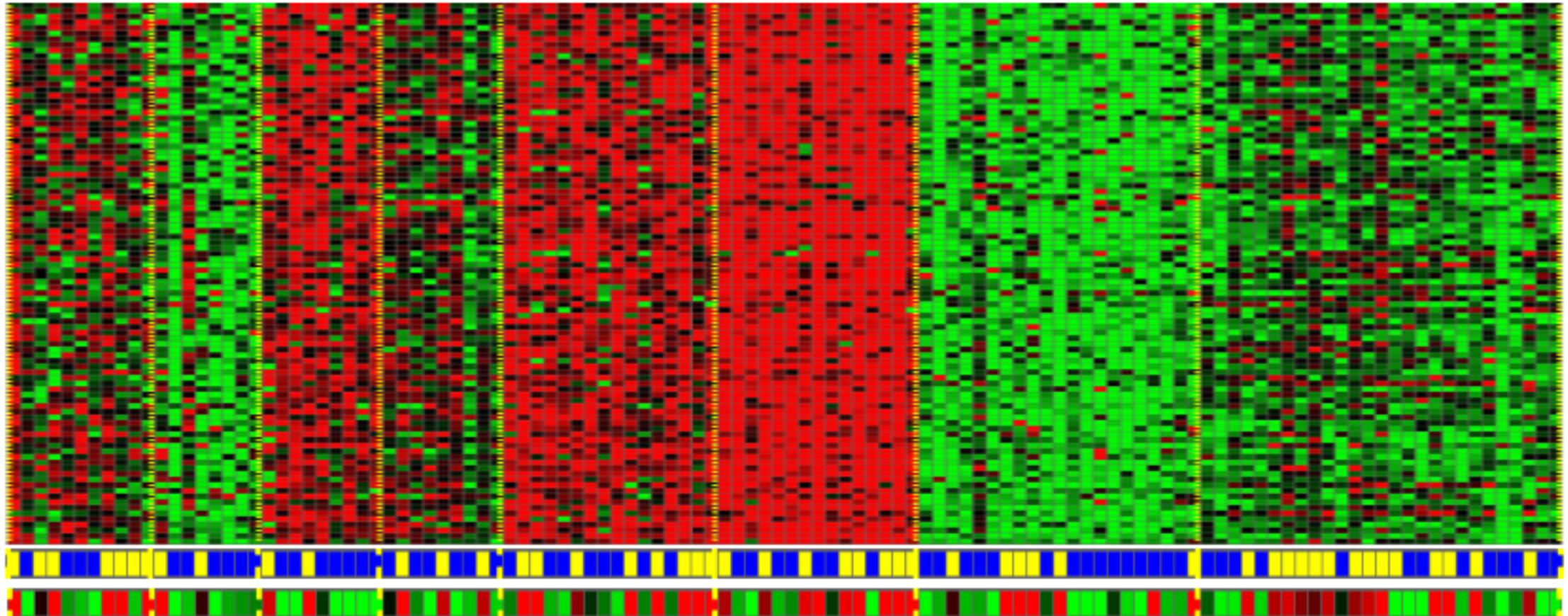
Supervised Learning



Unsupervised Learning



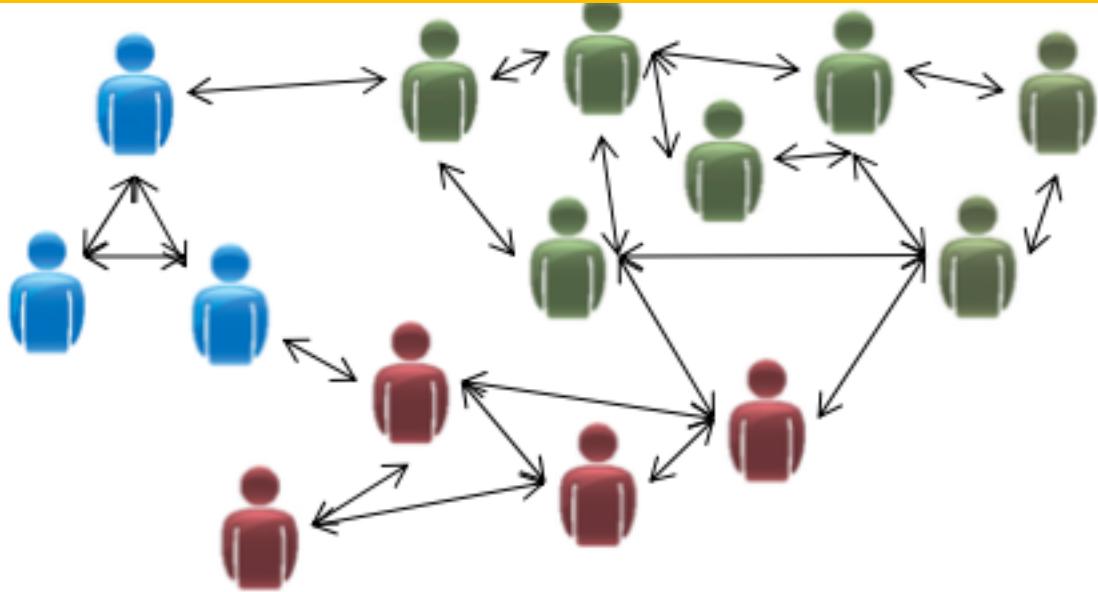
Genes



Individuals



ining



Organize computing clusters



Market segmentation

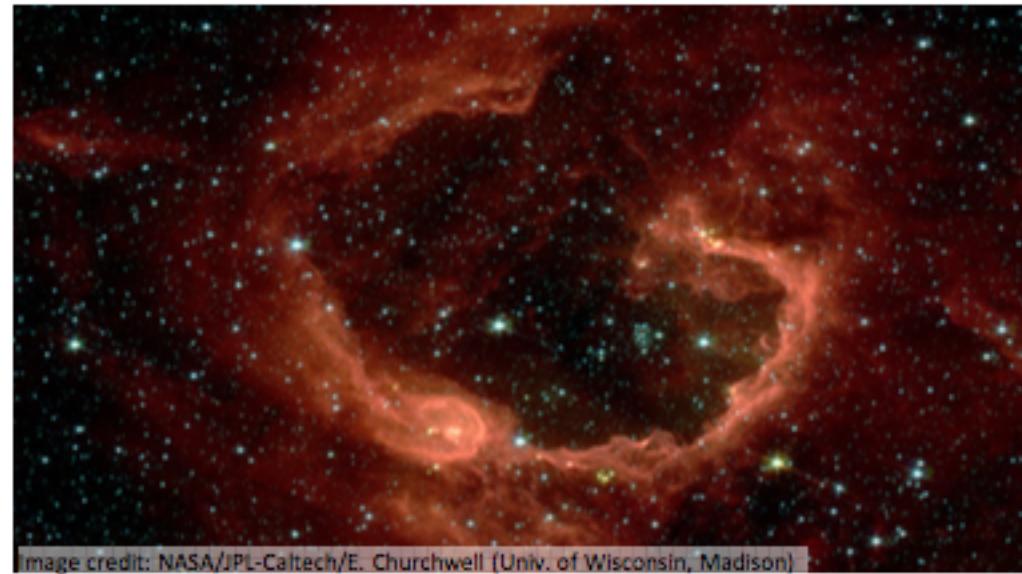
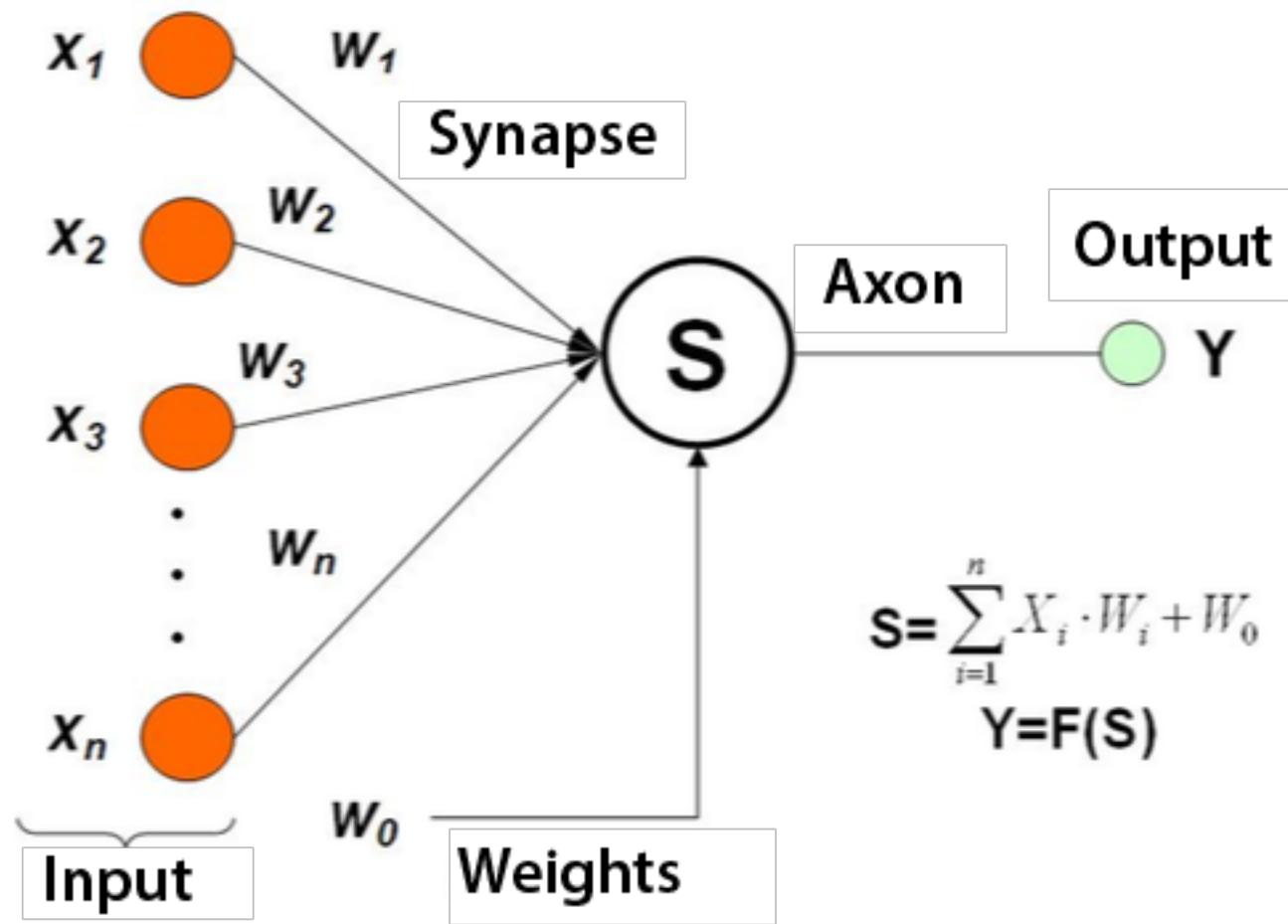
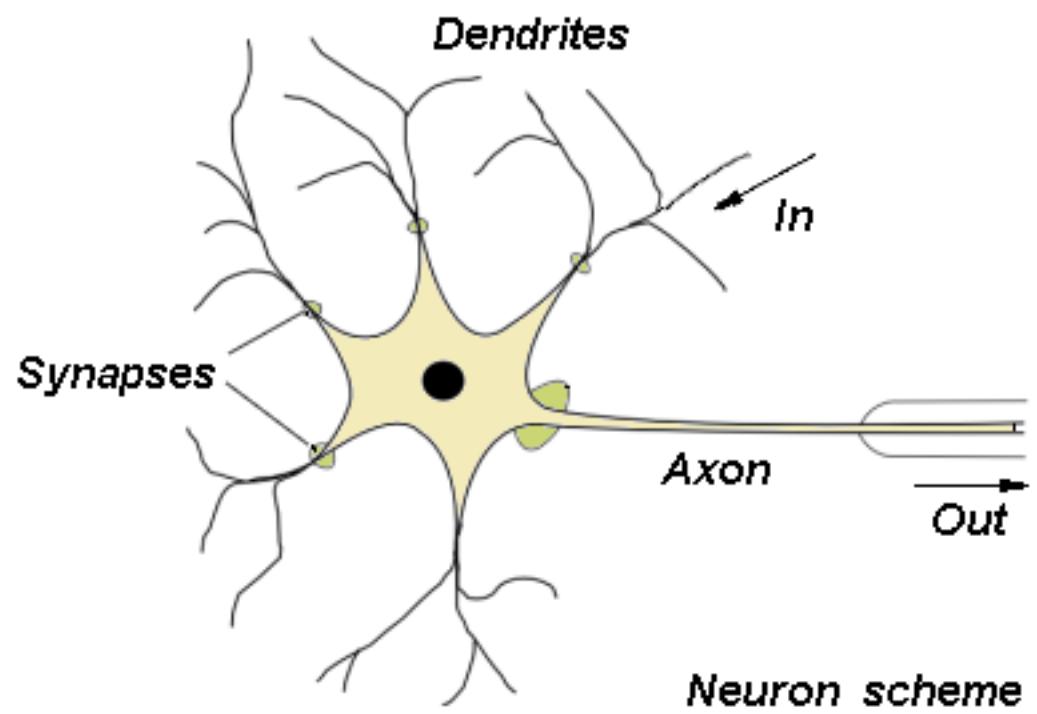


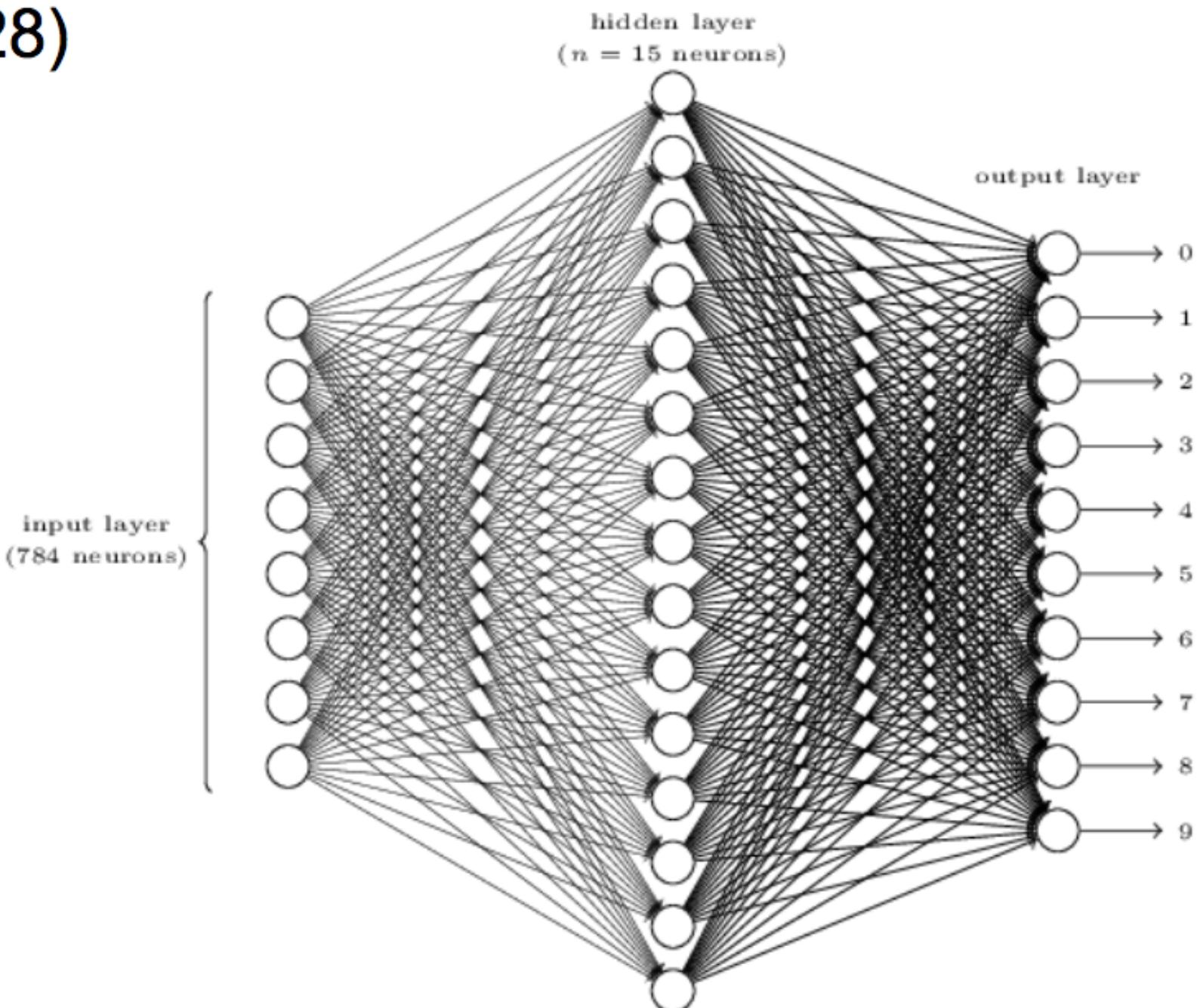
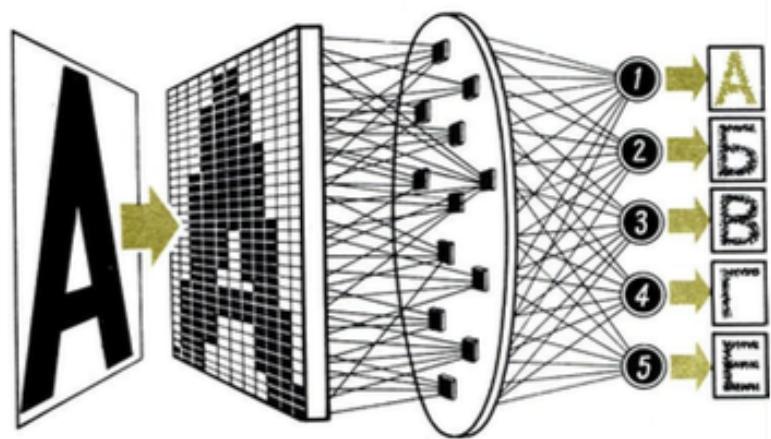
Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

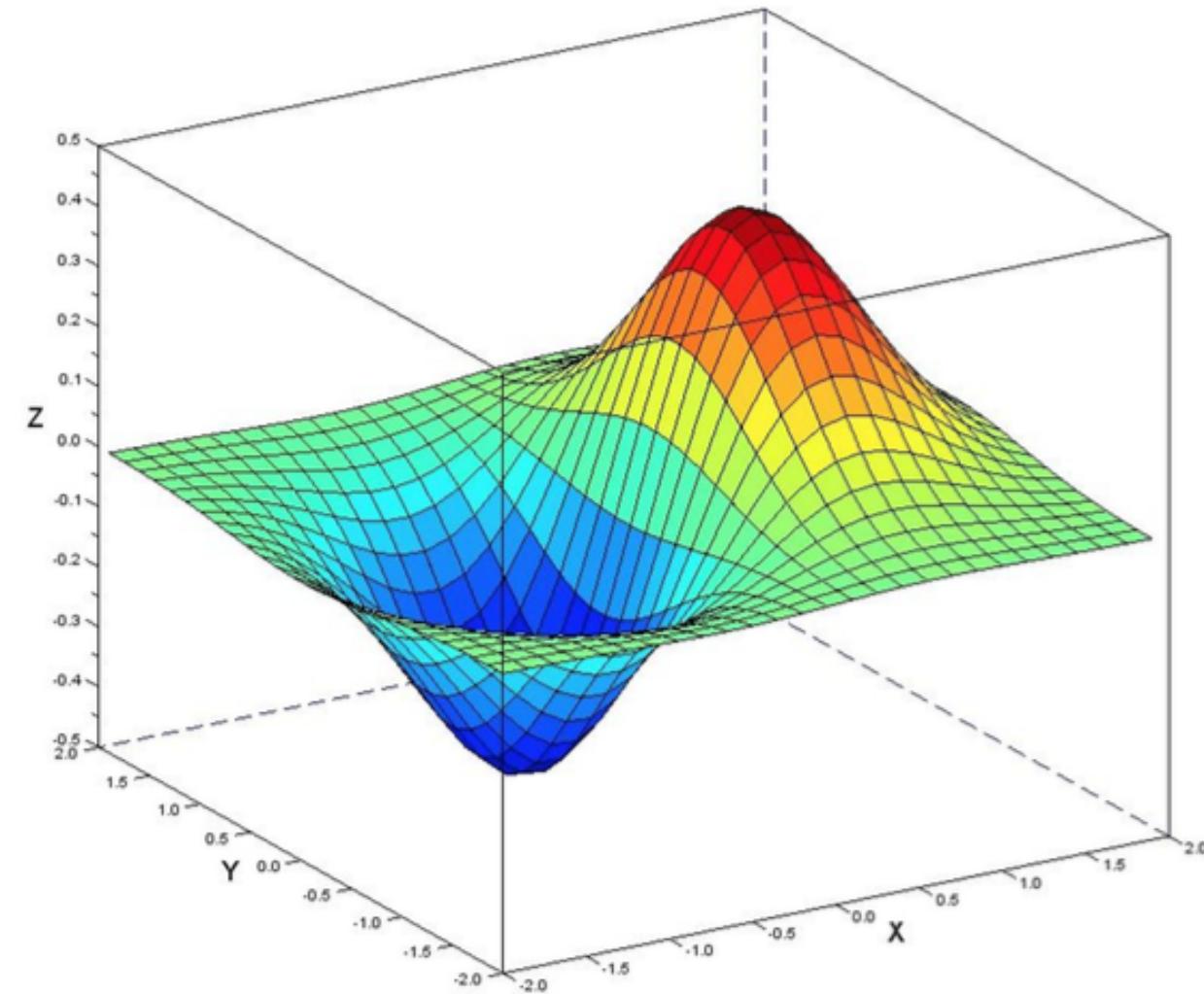
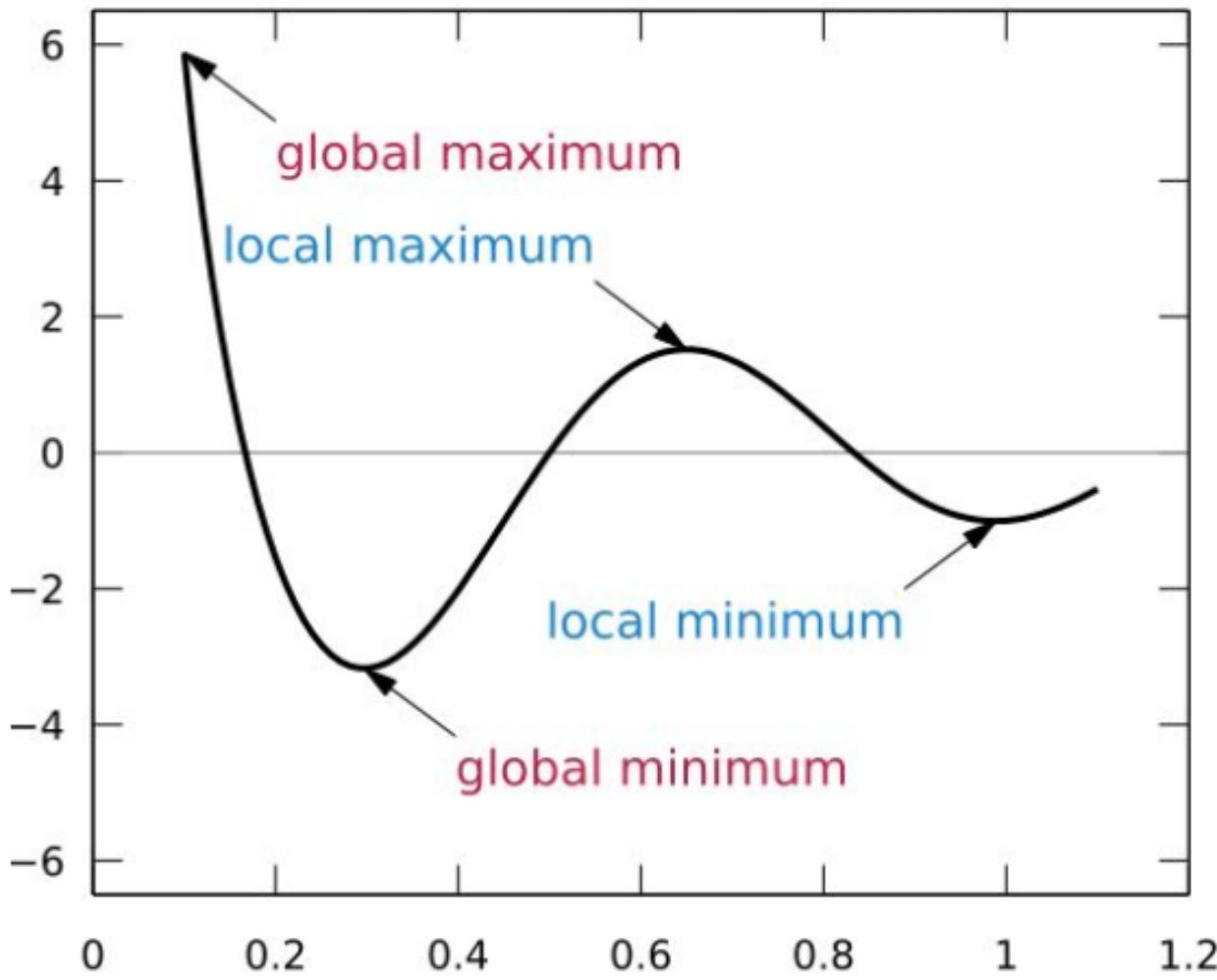
Astronomical data analysis



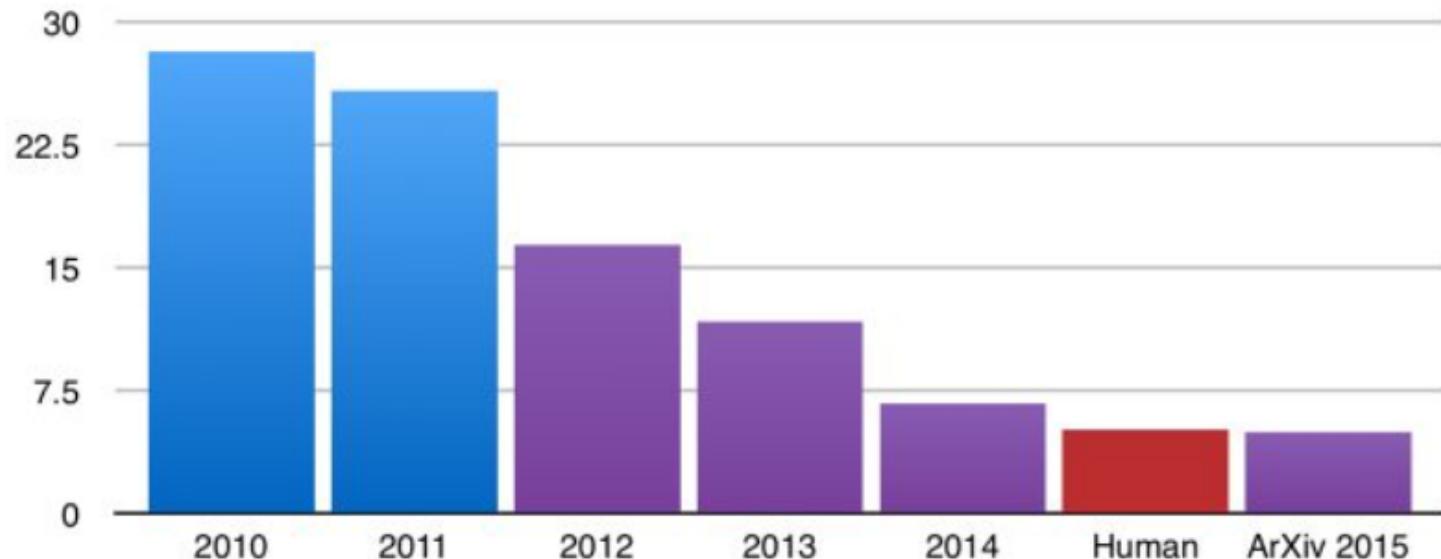
MNIST Dataset (28x28)

0	4	1	9	2	1	3	1	4	3
5	3	6	1	7	2	8	6	9	4
0	9	1	1	2	4	3	2	7	3
8	6	9	0	5	6	0	7	6	1
8	7	9	3	9	8	5	9	3	3
0	7	4	9	8	0	9	4	1	4
4	6	0	4	5	6	1	0	0	1
7	1	6	3	0	2	1	1	1	9
0	2	6	7	8	3	9	0	4	6
7	4	6	8	0	7	8	3	1	5

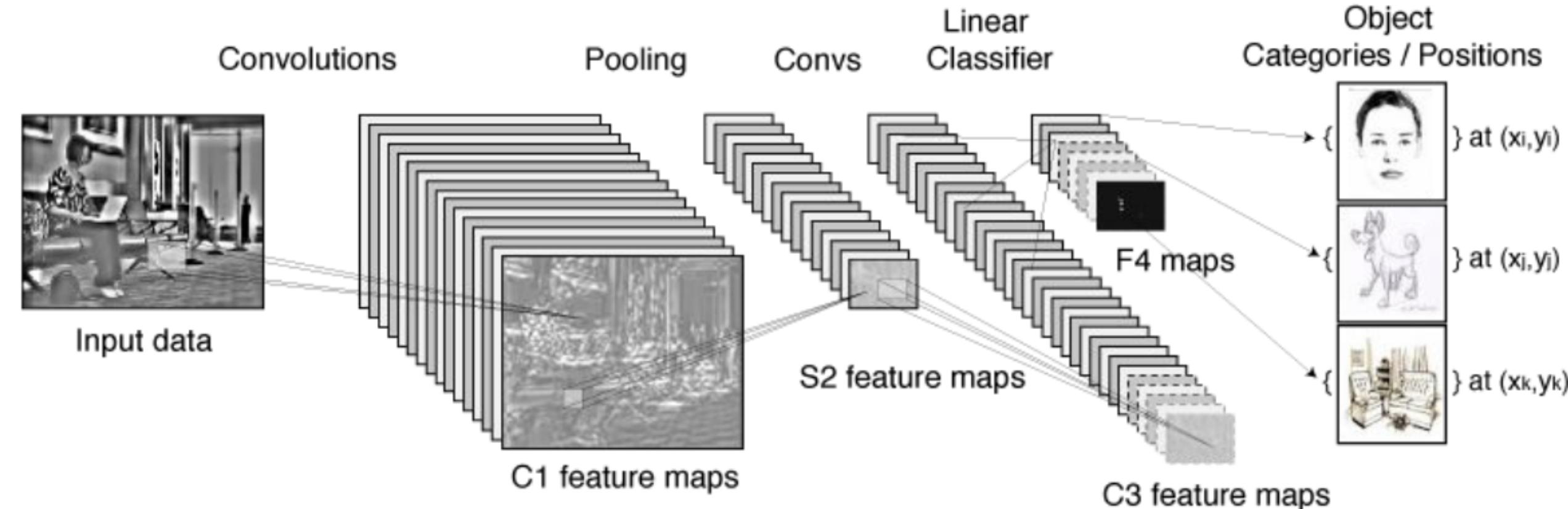




ILSVRC top-5 error on ImageNet

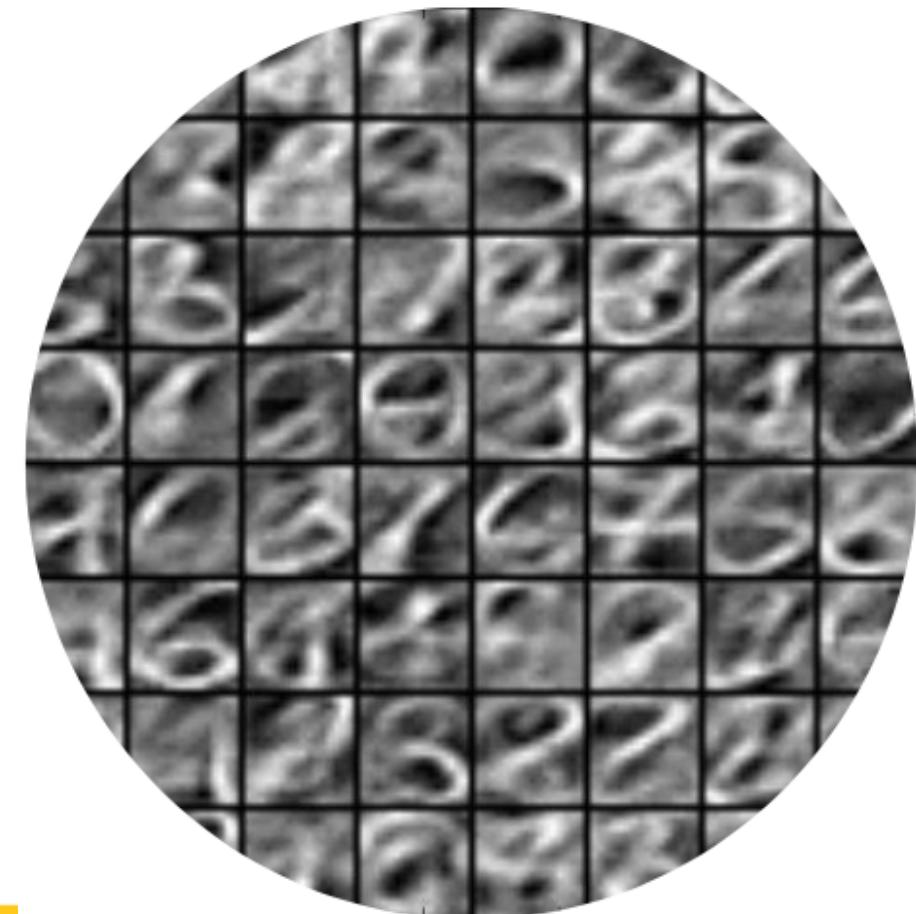


Convolutional neural networks

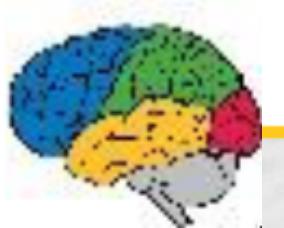
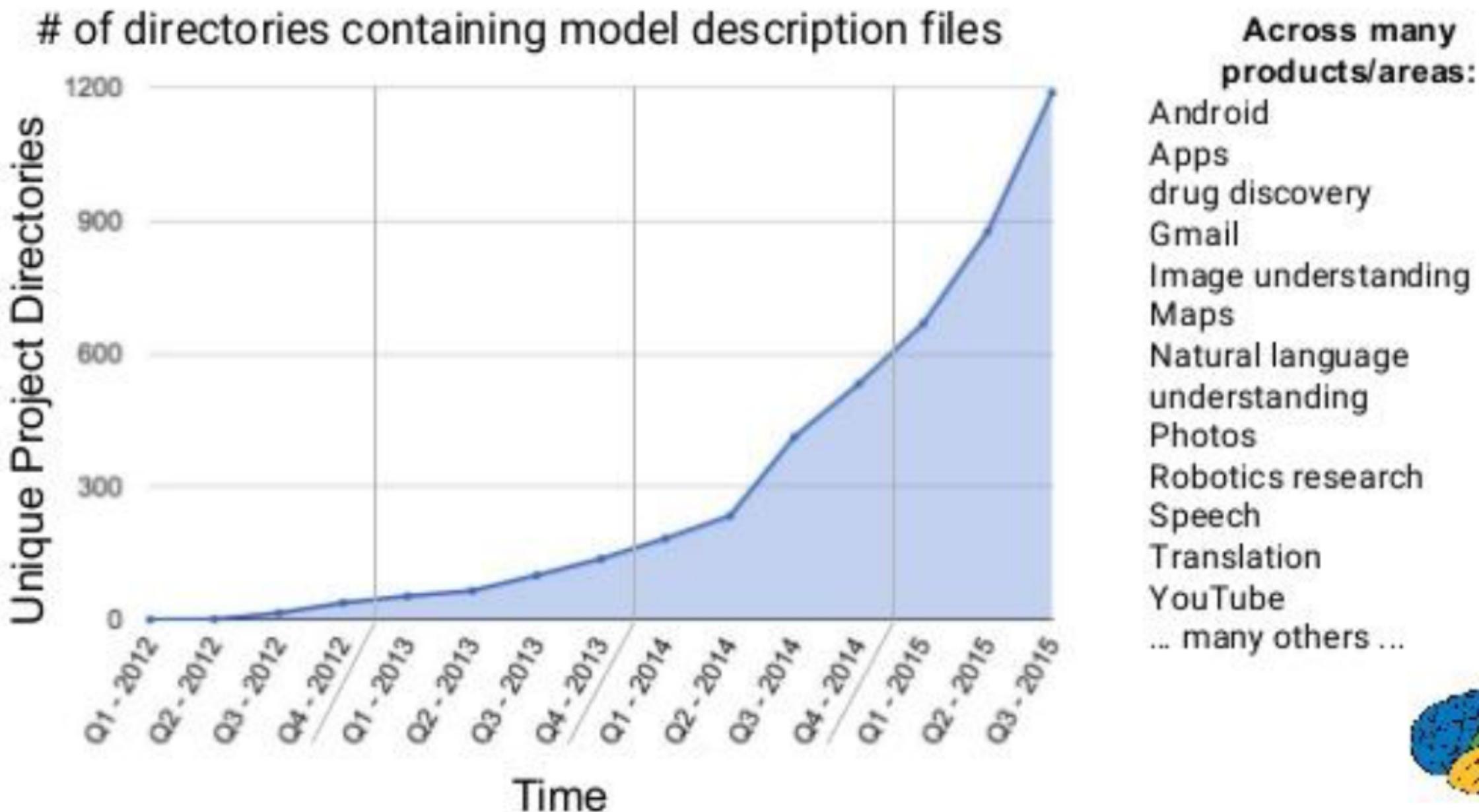


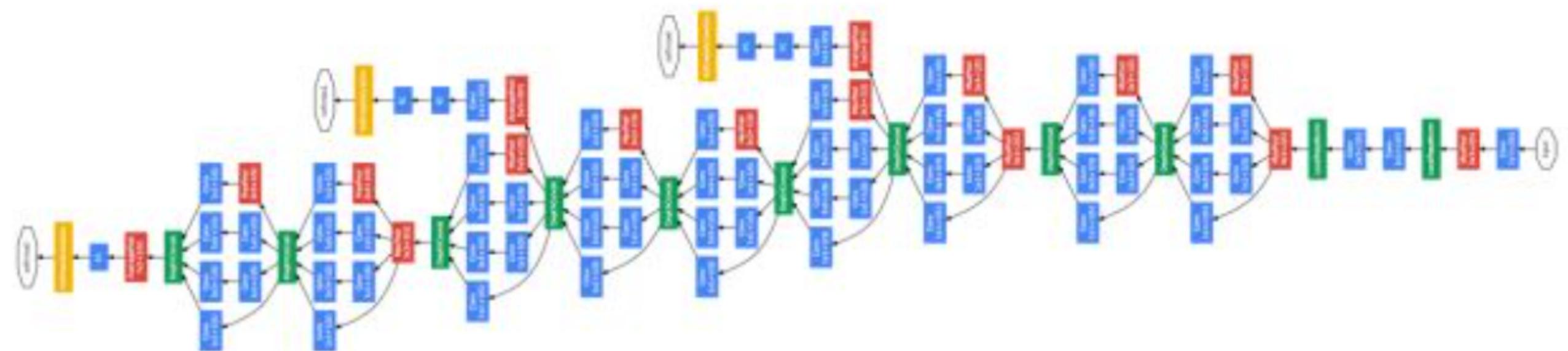
Type of feed-forward artificial neural network in which the connectivity pattern between its neurons is inspired by the organization of the animal visual cortex.

Branch of machine learning based on a set of algorithms that attempt to model high level abstractions in data by using a deep graph with multiple processing layers, composed of multiple linear and non-linear transformations.



Growing Use of Deep Learning at Google



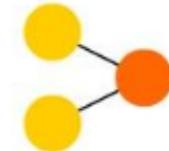


- Backfed Input Cell
- Input Cell
- △ Noisy Input Cell
- Hidden Cell
- Probabilistic Hidden Cell
- △ Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- △ Open Memory Cell
- Scanning Filter
- Convolution

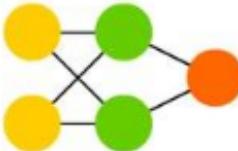
Neural Networks

A mostly complete chart of architectures

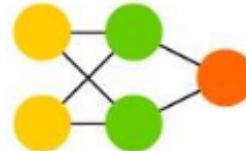
Feed Forward And



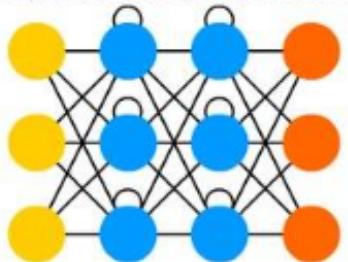
Feed Forward Xor



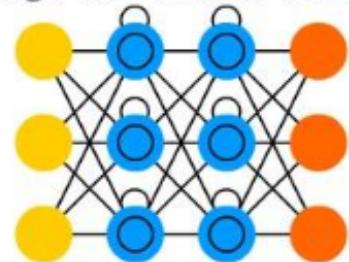
Radial Basis Network



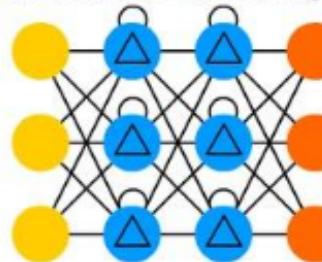
Recurrent Neural Network (bi)



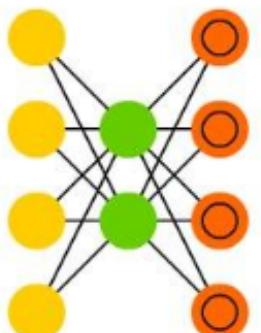
Long / Short Term Memory (bi)



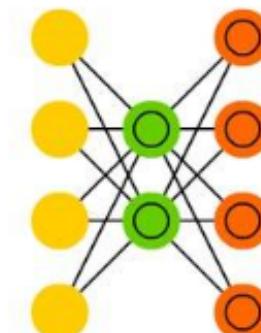
Gated Recurrent Unit (bi)



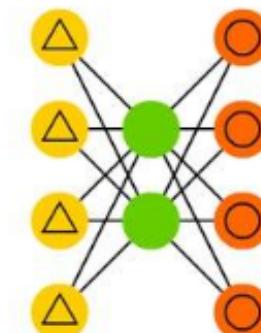
Auto Encoder



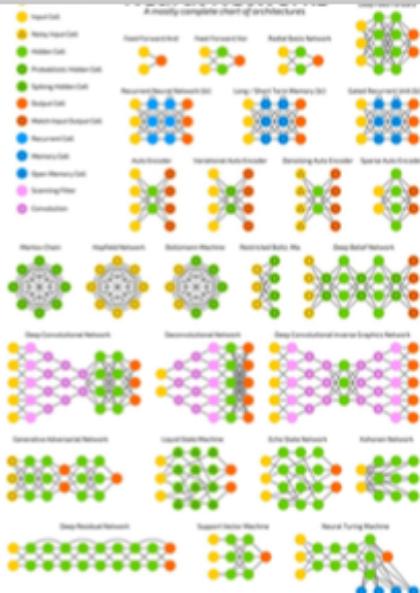
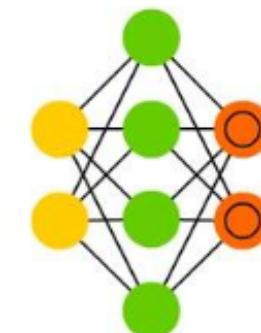
Variational Auto Encoder



Denoising Auto Encoder



Sparse Auto Encoder



OpenSource

TensorFlow

Theano

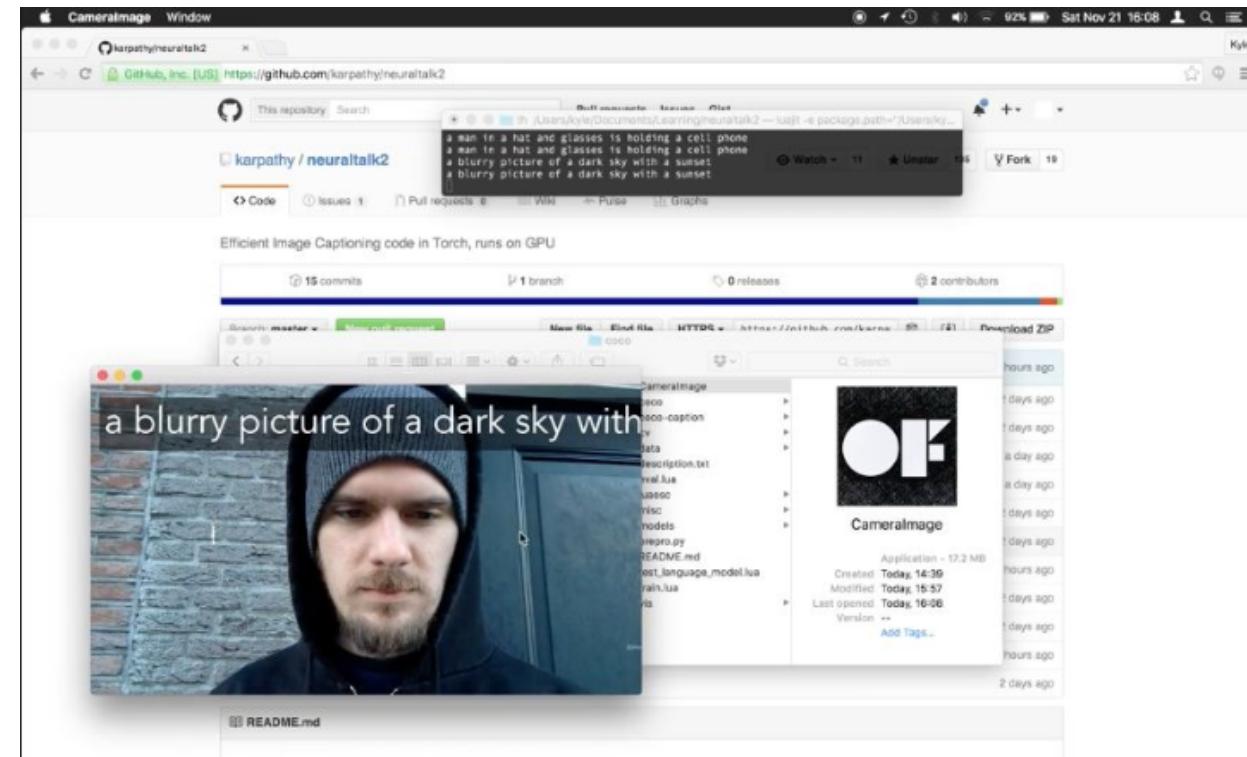
Torch

Caffe

DL4J

И даже на JavaScript -
ConvNetJS





<https://github.com/karpathy/neuraltalk2>

<https://vimeo.com/14649200>



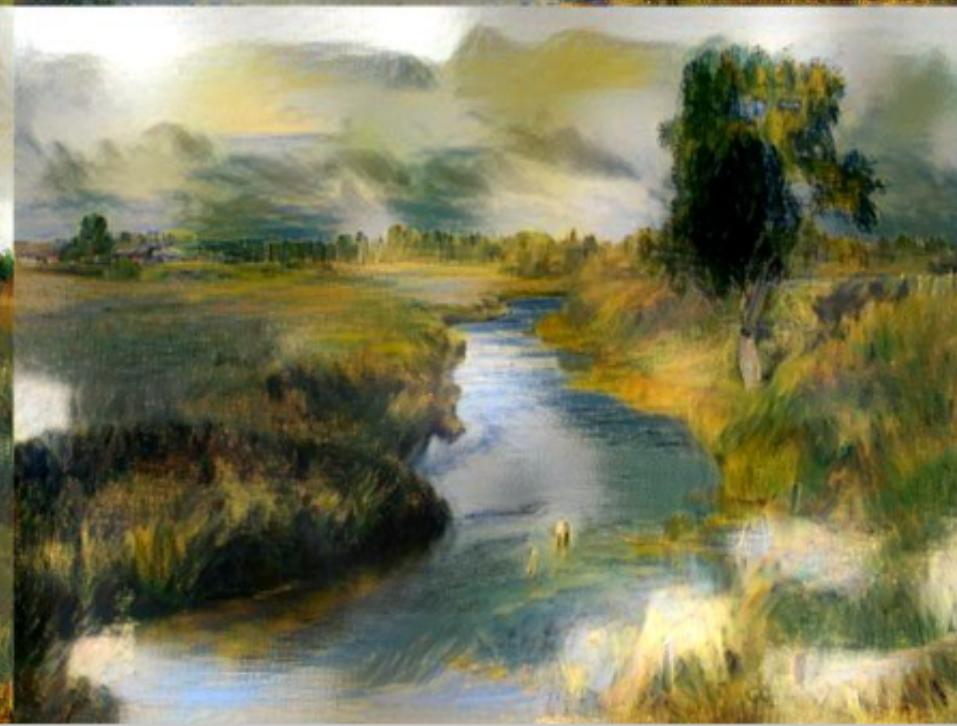
[jcjohnson / neural-style](#)[Watch](#) 527[Unstar](#) 10,339[Fork](#) 1,409[Code](#)[Issues 175](#)[Pull requests 17](#)[Wiki](#)[Pulse](#)[Graphs](#)

Torch implementation of neural style algorithm

[152 commits](#)[1 branch](#)[0 releases](#)[13 contributors](#)Branch: [master](#) ▾[New pull request](#)[Create new file](#)[Upload files](#)[Find file](#)[Clone or download](#) ▾

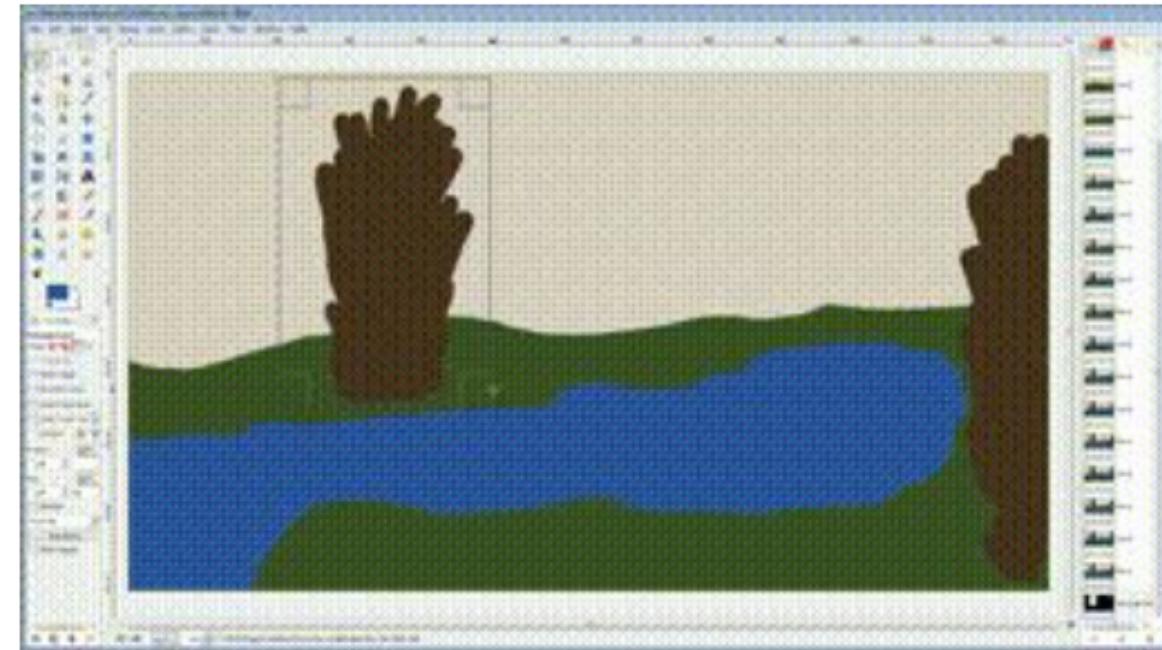
 jcjohnson committed on GitHub	Add Pascal Titan X benchmarks	Latest commit <code>ec5ba3a</code> 12 days ago
 examples	add support for transering style but not color	2 months ago
 models	Merged from jcjohnson/neural-style master branch	8 months ago
 .gitignore	Merged from jcjohnson/neural-style master branch	8 months ago
 INSTALL.md	Update INSTALL.md	6 months ago
 LICENSE	add license	a year ago
 README.md	Add Pascal Titan X benchmarks	12 days ago
 neural_style.lua	add support for transering style but not color	2 months ago

[README.md](#)



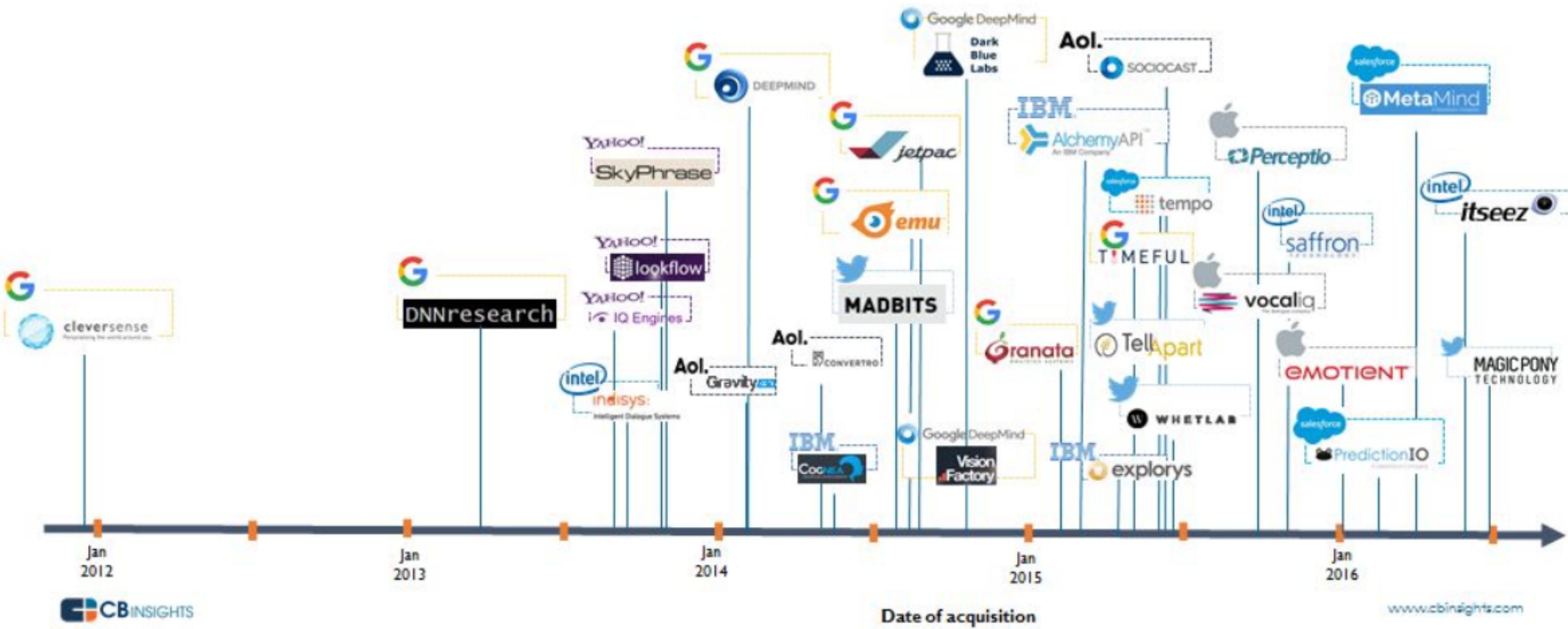


https://www.youtube.com/watch?v=YRm_kqClxFY



<https://github.com/alexjc/neural-doodle>
<https://github.com/DmitryUlyanov/fast-neural-doodle>

Race For AI: Most Active Acquirers In Artificial Intelligence



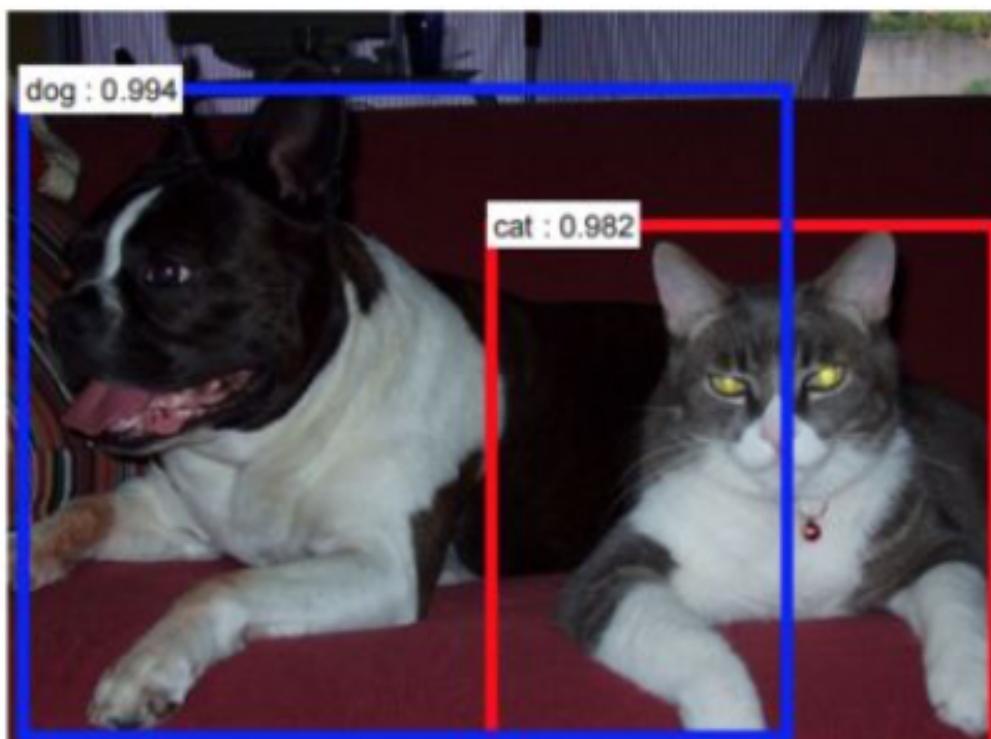
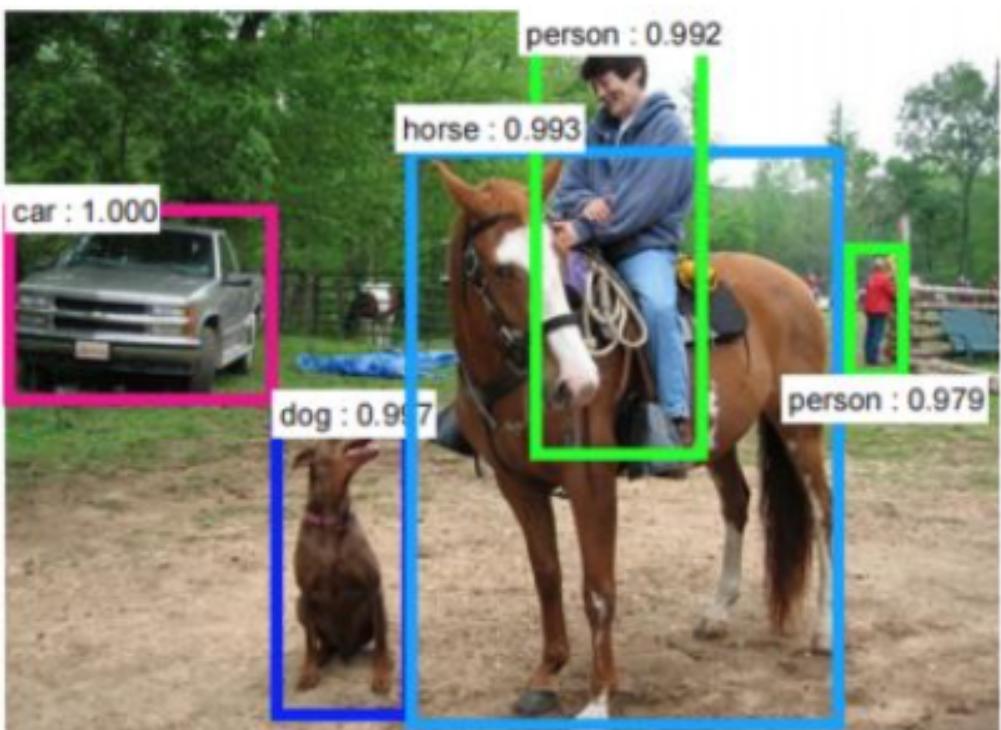
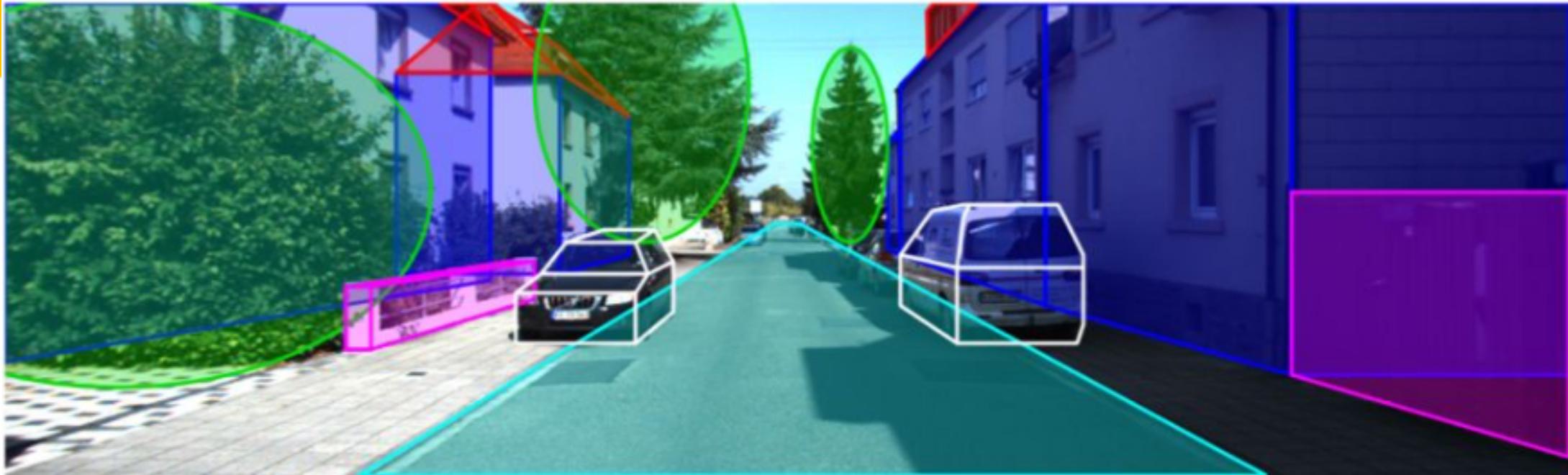
<https://www.cbinsights.com/blog/top-acquirers-ai-startups-ma-timeline/>

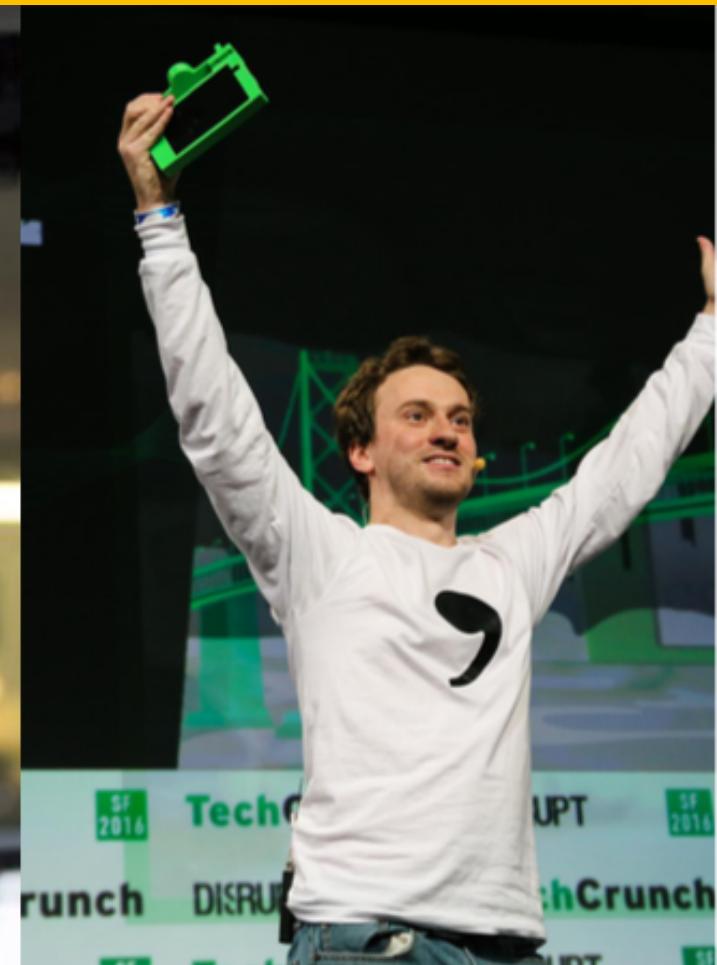
Get Taxi investments ~ \$300M

Taxi drivers in Moscow: 55000
Salary: \$10000 / year

Economy: \$550M

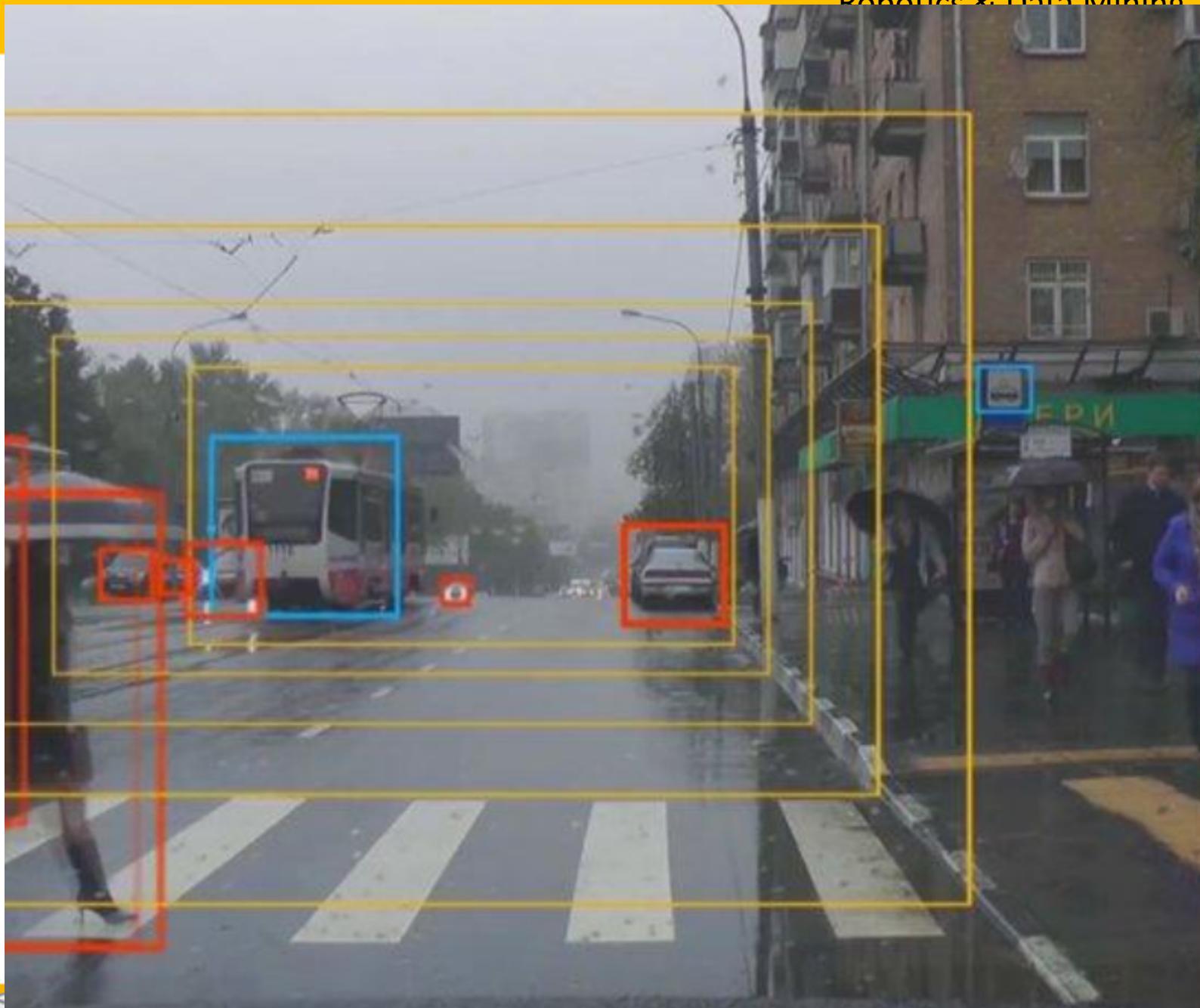






George Hotz
<http://comma.ai>

Russian trucks KAMAZ &
Cognitive company
2014 - 2020



- Image recognition & classification- done
- Speech recognition & generation – done*
- Speech translate in realtime – 2017 - 2018
- Creative Systems as a commercial product – 2017 – 2018
- Self-driving cars as a product – 2017 - 2018

What's the next? Technological singularity or not?



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