Machine Learning

Lesson 01. Introduction

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About program

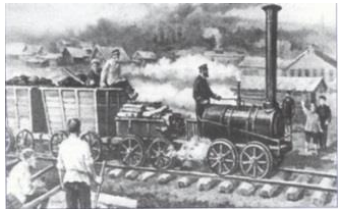
- 8 lessons

1. Intro to machine learning
2. Intro to Python programming & linux
3. Intro to math and machine learning
4. Regression problem
5. Logistic regression
6. Model evaluating
7. Intro to neural networks.
8. Convolutional networks. Keras library
9. Final notice

What will not we learn?

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

Смена платформы технологий меняет требования к инфраструктурам

	«0-я» ПР XVII в.	I ПР XVIII – 1-я пол. XIX в	II ПР 2-я пол. XIX – XX в.
Технологии	▸ лес, камень ▸ торф, ветер ▸ флайт	▸ чугун, железо ▸ уголь, пар ▸ пароход, паровоз ▸ хирургия, наркоз ▸ с/х аппараты	▸ сталь, алюминий, пластик ▸ нефть, газ, гидро- и э/э ▸ а/м, самолет, спутник ▸ антисептика, антибиотики, ранняя диагностика ▸ минеральные удобрения
Инфра-структуры	▸ Каналы ▸ трекварты ▸ каналы для доб., тр-ки торфа ▸ почтовая связь ▸ польдеры	▸ дороги с твердым покрытием ▸ железные дороги ▸ телеграф 	▸ аэродромы, сист. РЛС, свет. сигналов ▸ высокоскоростные ж/д ▸ ЛЭП, газо- и нефтепроводы ▸ телефон, радио, телевидение
Соц. структура	Буржуа (городской класс)	Фабричный рабочий класс	Класс менеджеров
	Нидерланды	Англия	США

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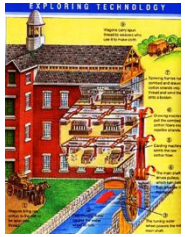
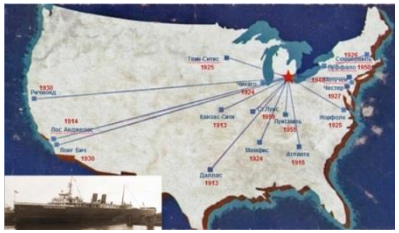
Складывание знаний начинается с формирования «клеточки» новой промышленной революции

	«0-я» ПР XVII в.	I ПР XVIII – 1-я пол. XIX в	II ПР 2-я пол. XIX – XX в.
Технологии мышления	Конструирование	Проектирование	Исследование
Форма кооперации	Кластер 	Фабрика 	ТНК 
Роль системы подг. и обр. в ЦЖ знания	Подготовка инженеров-конструкторов	Подготовка оргпроектировщиков (разработчиков проекта организации работ по реализации проекта)	Подготовка исследователей-конструкторов новых технологических процессов
	Нидерланды	Англия	США

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Минимум 3 российских рывка догоняющего развития совершались в зазорах между двумя большими технологическими и экономическими «волнами»

По крайней мере 3 из российских "рывков" догоняющего развития осуществлялись на стыке эпох: в зазорах между двумя большими технологическими и экономическими "волнами". Каждый из них сопровождался серьёзными общественными дискуссиями, каким окажется наше будущее, куда идти и что делать.

	«0-я» ПР XVII в.	I ПР XVIII – 1-я пол. XIX в.	II ПР 2-я пол. XIX – XX в.	III ПР XXI в.
Технологии	▸ выращивание леса ▸ сжигание торфа ▸ ветряной двигатель, насос и лесопилка ▸ флайт	▸ чугун, железо ▸ сжигание угля ▸ паровая машина ▸ пароход ▸ паровоз ▸ хирургия, наркоз ▸ с/х машины	▸ сталь, алюминий, пластик ▸ сжигание нефтепродуктов и газа, гидро- и э/э ▸ а/м ▸ самолет ▸ спутник ▸ антисептика, антибиотики, ранняя диагностика ▸ минеральные удобрения	▸ проектируемые материалы для 3D-печати, умные, биоразлагаемые ▸ PV ячейка и пленка ▸ ветровая турбина ▸ э/м ▸ малый спутник ▸ роботизированные операции ▸ органическое с/х
		Паровоз Тревитика		
	Нидерланды	*Англия*	*США*	

Петровские реформы пришлись на эпоху перехода от 0-й к I промышленной революции, выдвинувшей в лидеры мирового развития Англию

Реформы кон. XIX - нач. XX вв. с двумя тесно связанными друг с другом попытками догоняющего развития Витте - Столыпина и первых 5-леток СССР

Мы опять находимся на переходе - на этот раз от II-й к III промышленной революции

[1] http://www.tv2.tomsk.ru/sites/www.tv2.tomsk.ru/files/mobil.jpg

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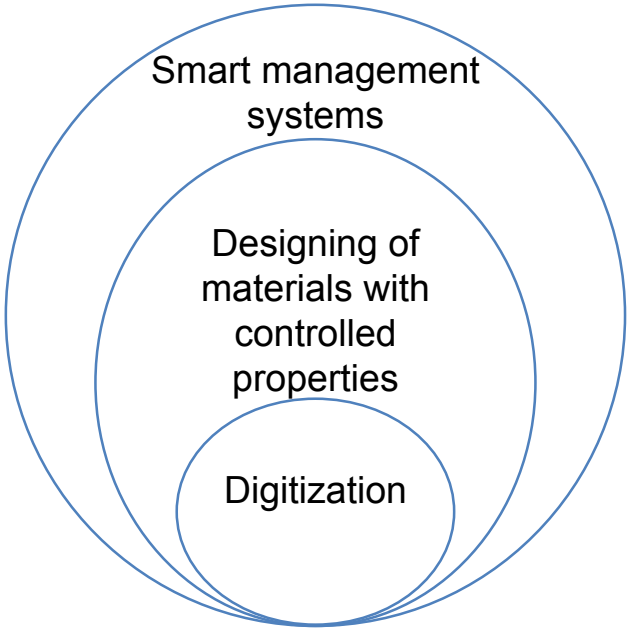
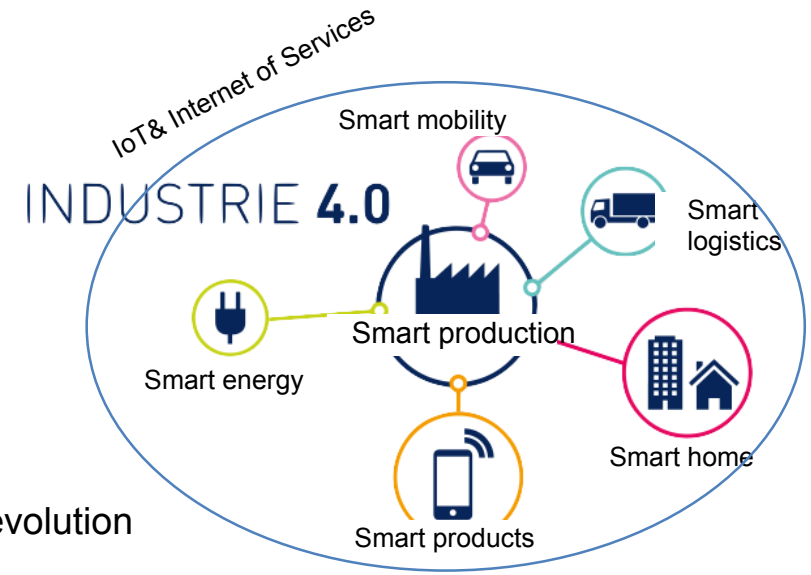
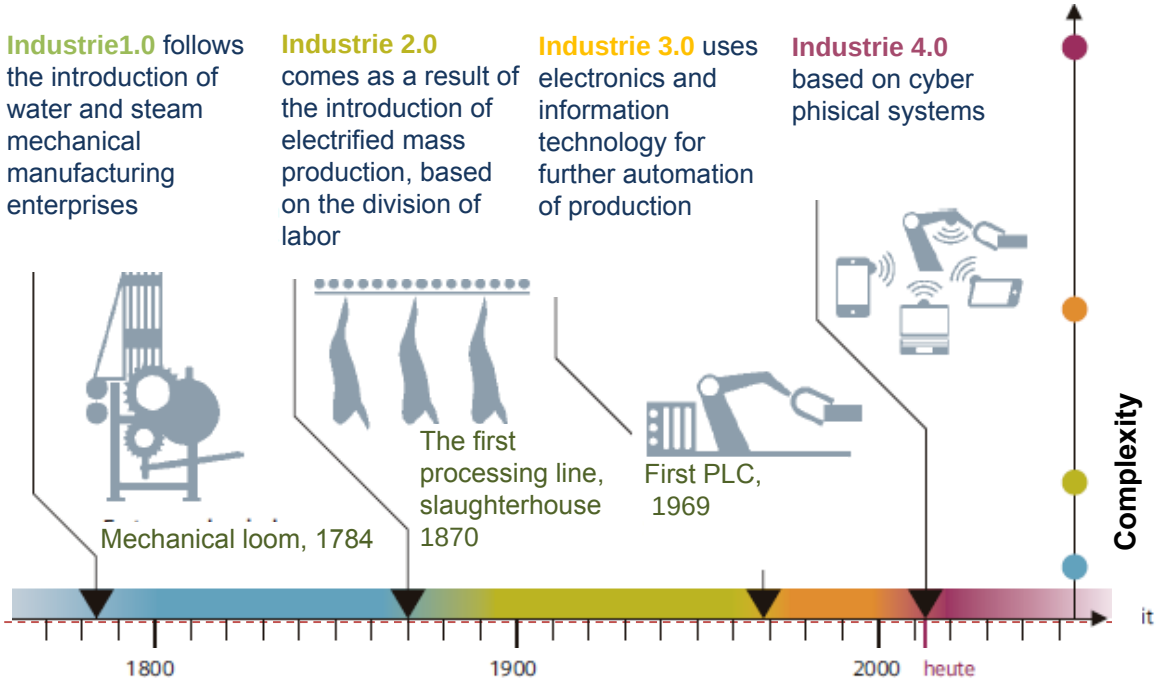
Industry 4.0

Corridors for the development of technology and activities:





4 stages of industrial revolution

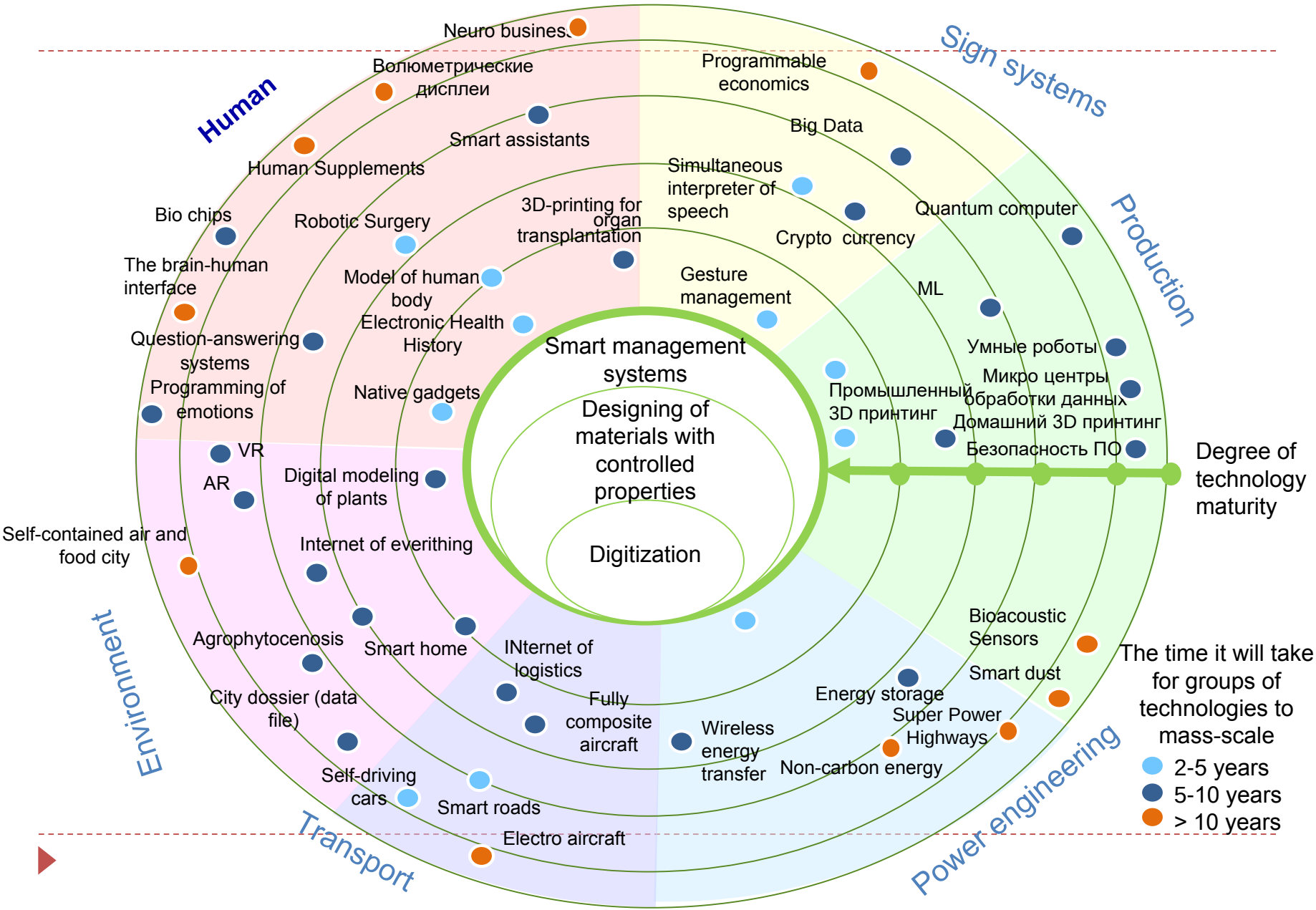


Assessment of the growth of labor productivity from the development of new technologies in production

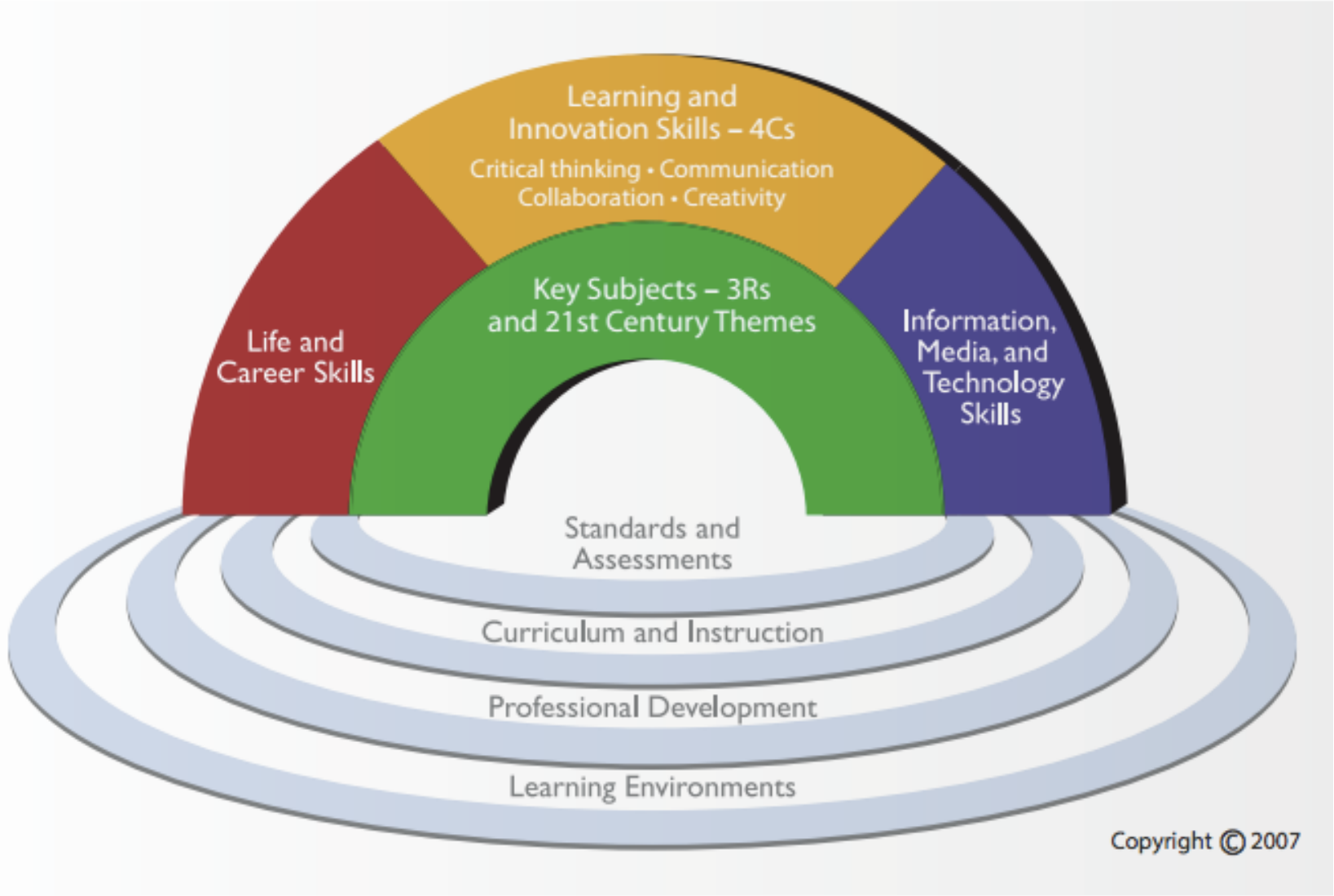
Steam engine	Early robotics	IT	Robots, AI, ML
1850-1910	1993-2007	1995-2005	2015-2065
Growth in labor productivity per year			
0,3%	0,4%	0,6%	0,8 - 1,4%

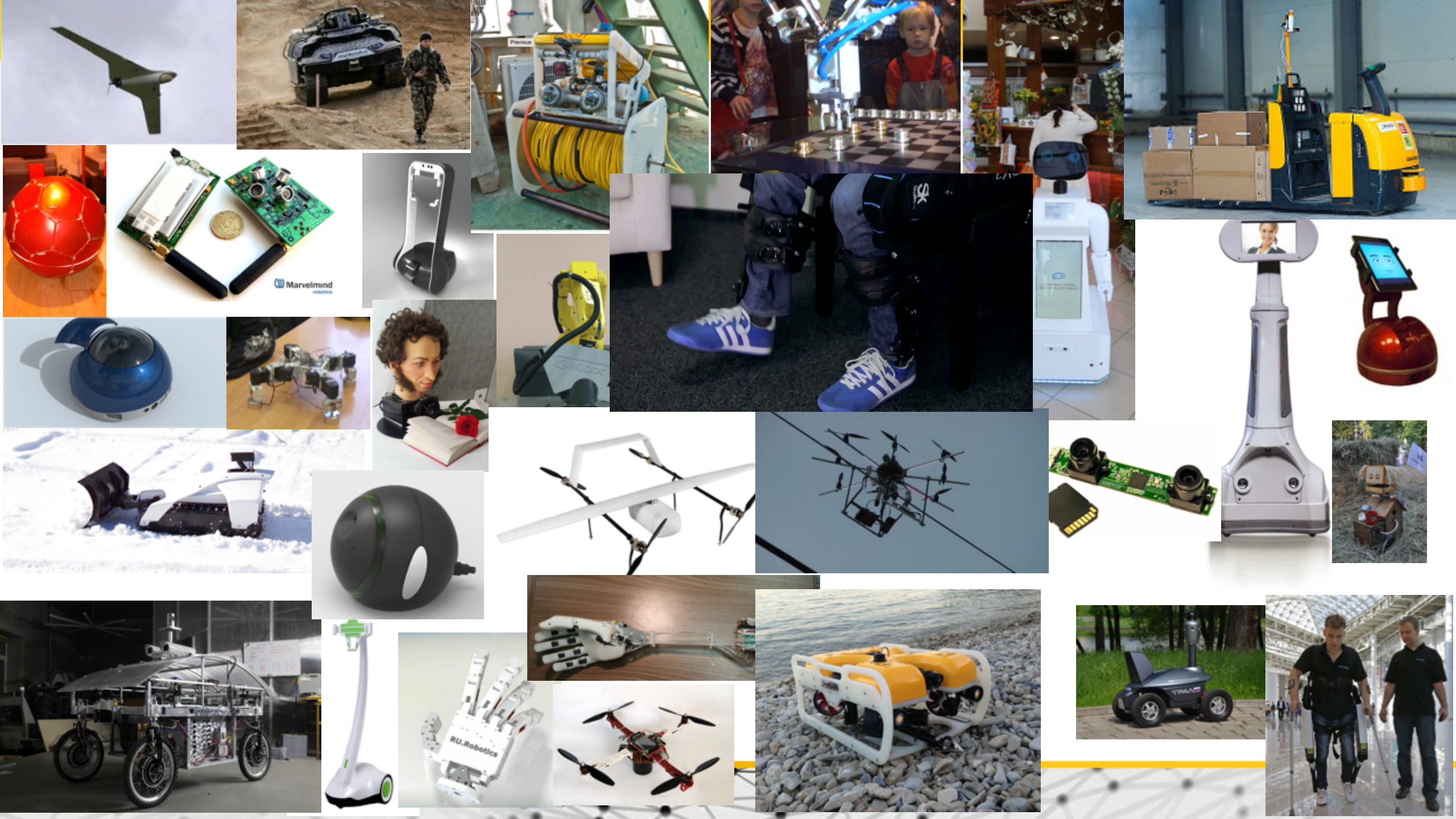
[1] McKinsey & Company, http://www.mckinsey.com/global-themes/digital-disruption/harnessing-automation-for-a-future-that-works

Today there is a new platform of technologies of the New Industrial Revolution

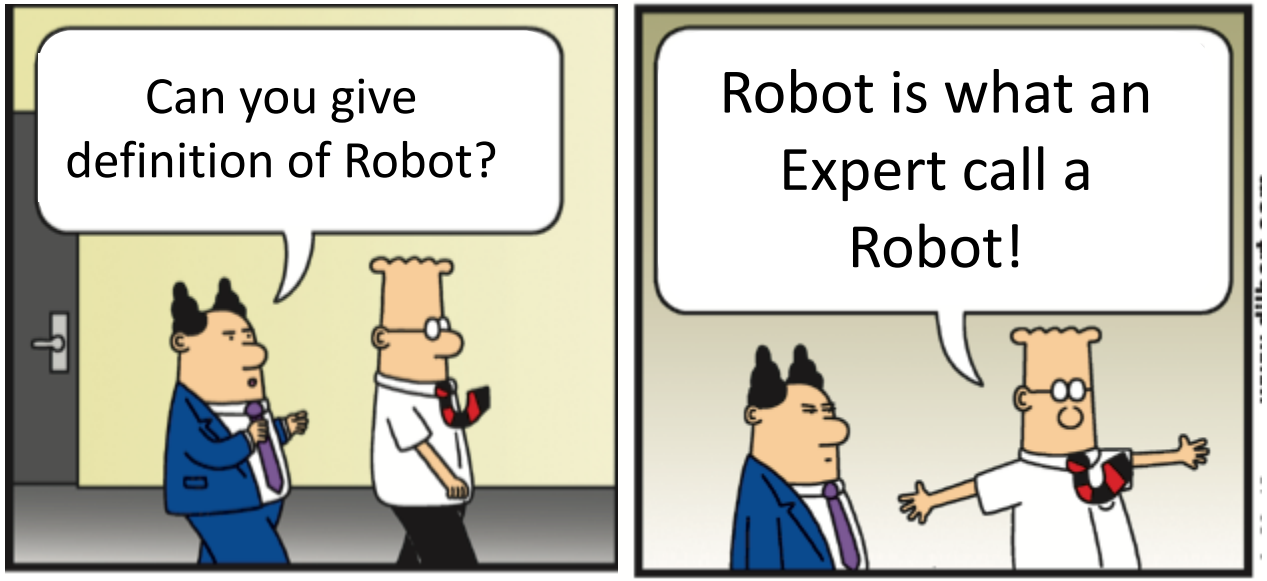


21 century skills (Concept P21, USA)




Marvelmind
robotics
RU.Robotics

Robot definition is very difficult



What is a robot?

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

What is not a robot?

Dish washer

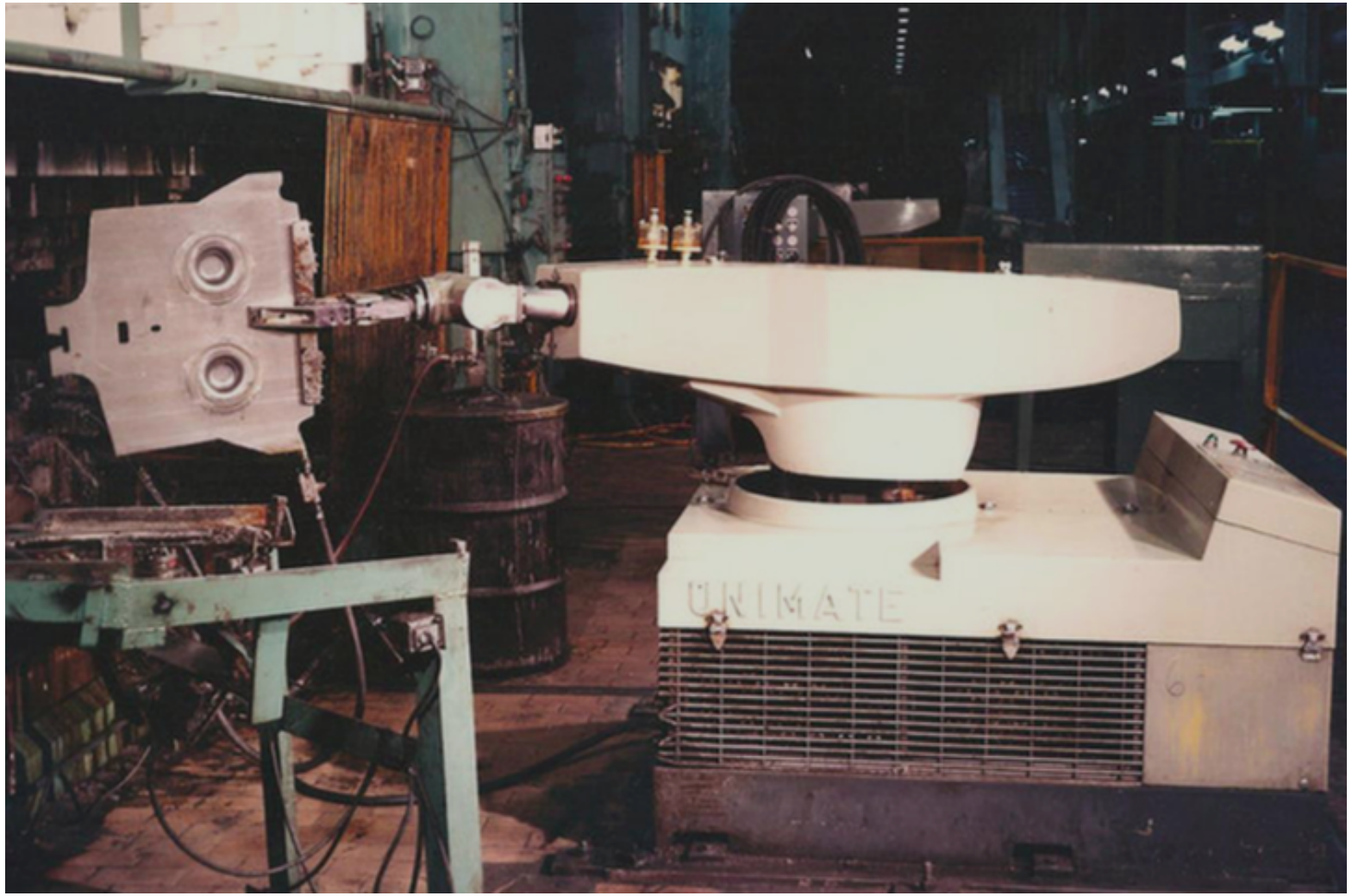
Delta Maker 3D printer

Washing machine

RC buggy

CNC milling machine

General Motors, Unimate robot, 1961



Brief history of Robotics

- Robotics markets were dominated by industrial robot arms for decades

Brief history of Robotics

- Solar panels assembling by *An ABB FlexPicker robot*

Brief history of Robotics

- Food industry

Cambrian Moment of Modern Robotics

Enabling trends in 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

Aerial inspection

Constructing walls

Contructing buildings

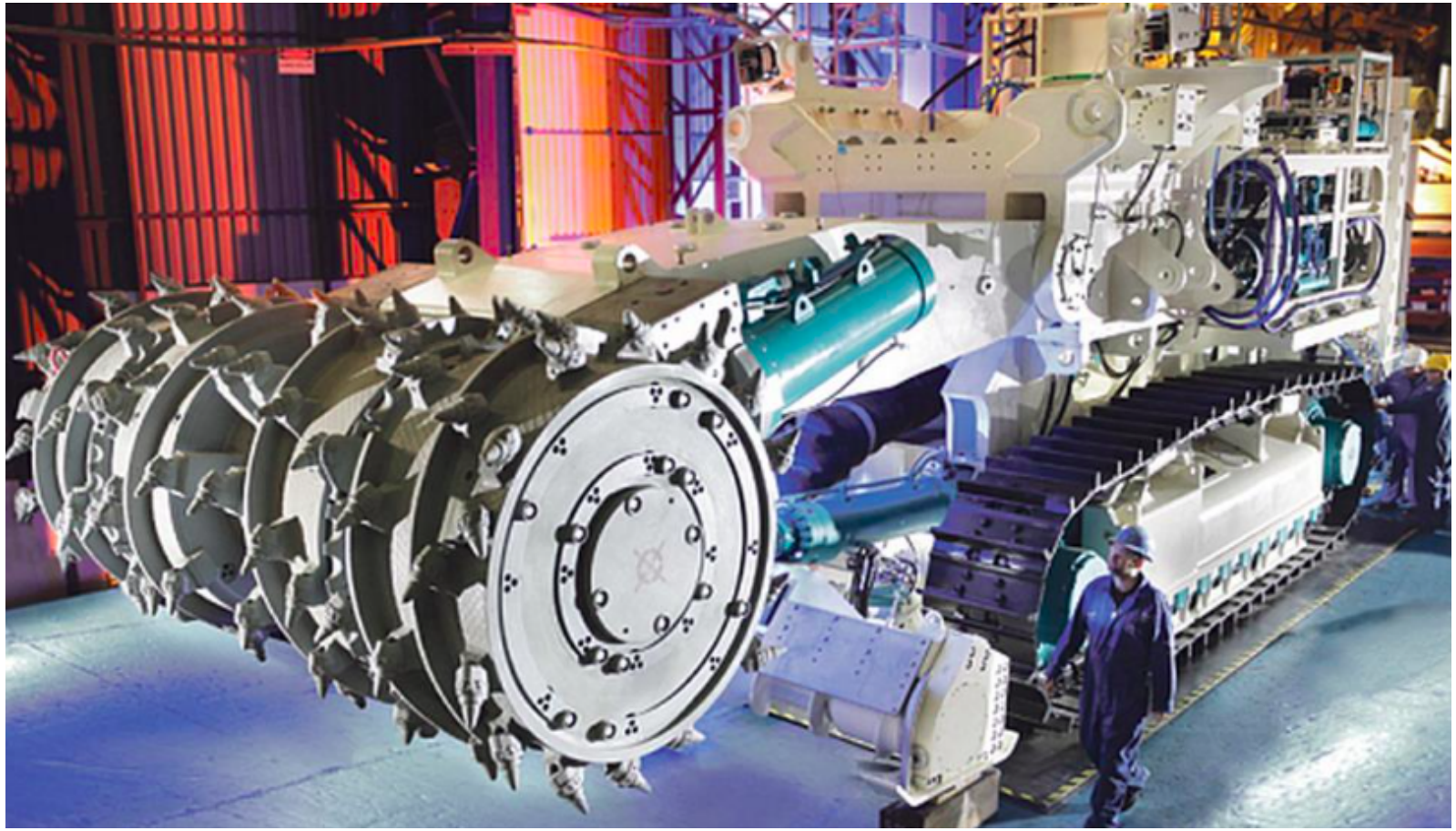
- *WinSun* use giant 3D printers to construct buildings such as this villa

Autonomous farming

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

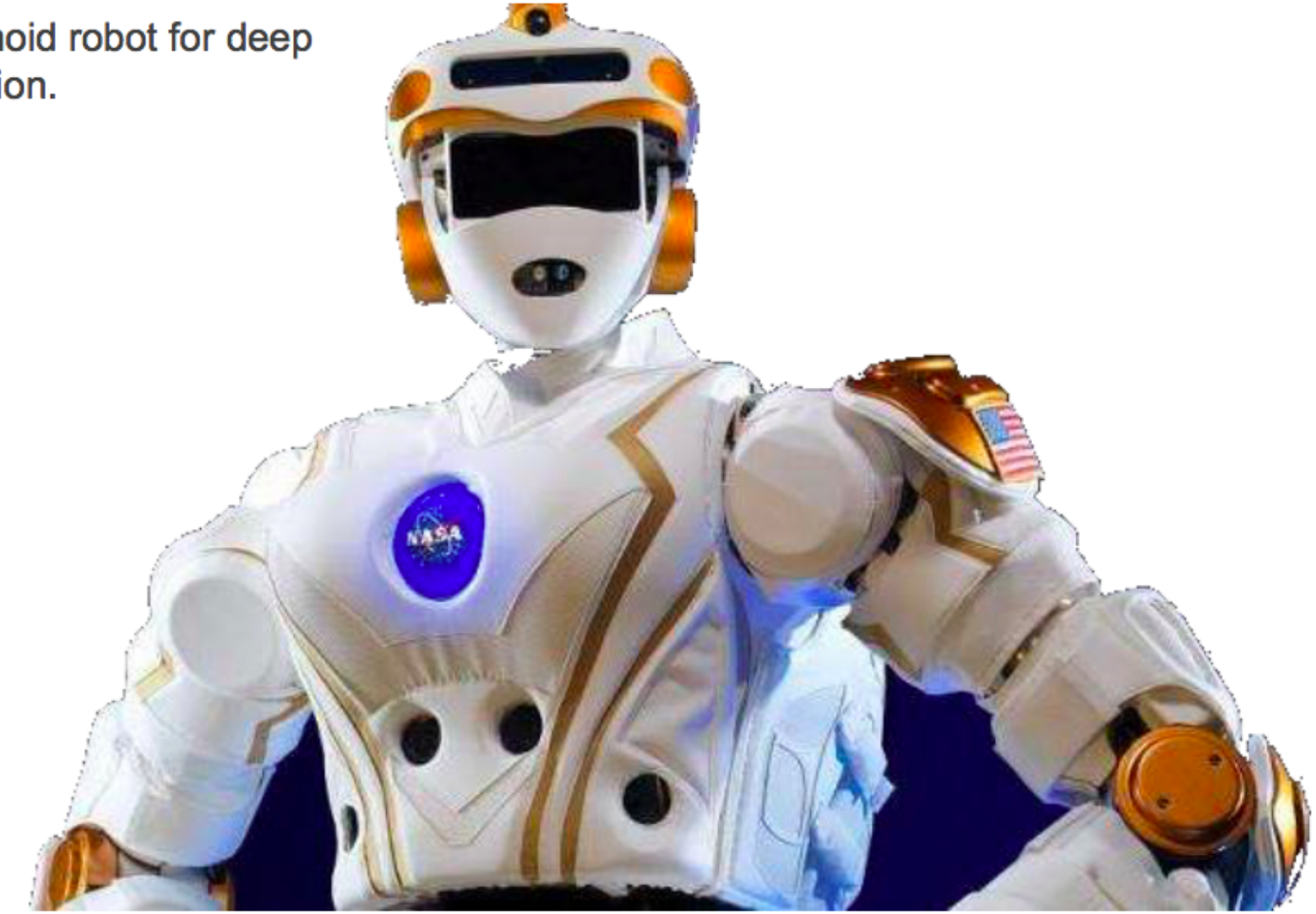
Mining

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



Exploration

NASA's humanoid robot for deep space exploration.



Exploration

- Russian robot Feodor

Human Soldier vs Robot Soldier

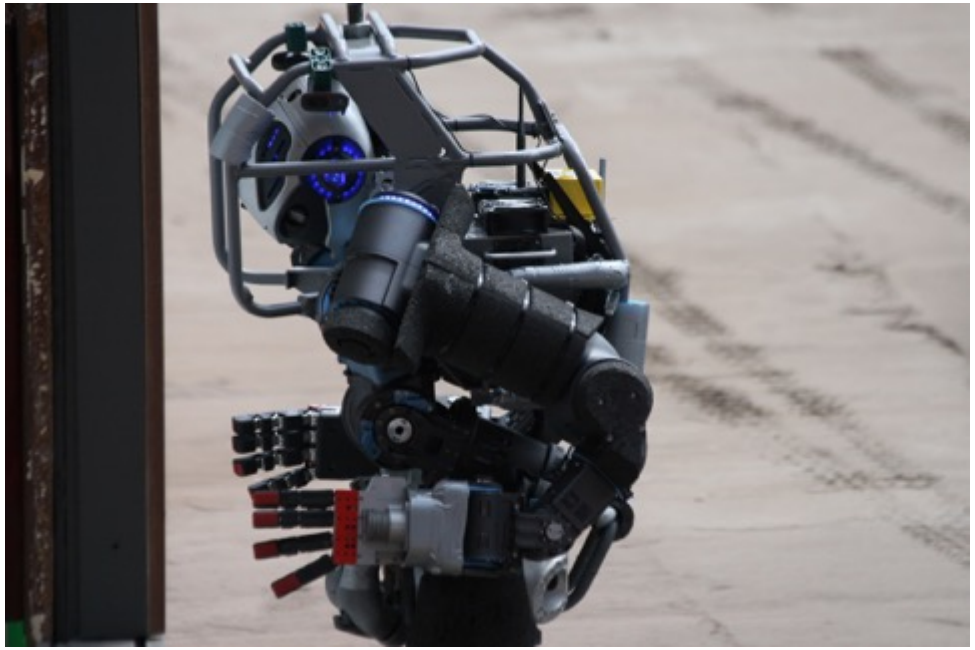
	Human	Robot
Listening	16 -20 000 Hz	1 - unfinity
Viewing	160 mlns of colors	150 MP
Touching	13 nm	Depends on materials
If feels cold, hot or hunger	unhappy	Doesn’t care
Emotions	A lot of	Not at all

Drivers to full autonomy in military robotics

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

Examples:

DARPA Robotics Challenge



Iran–U.S. RQ-170 incident

Drivers to full autonomy in military robotics

- Dramatically increase firepower with fewer personnel

Brief history of Robotics

- Run, fly and swim

Autonomous robots at Sea

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

ACTUV Sea Hunter

Sanpa

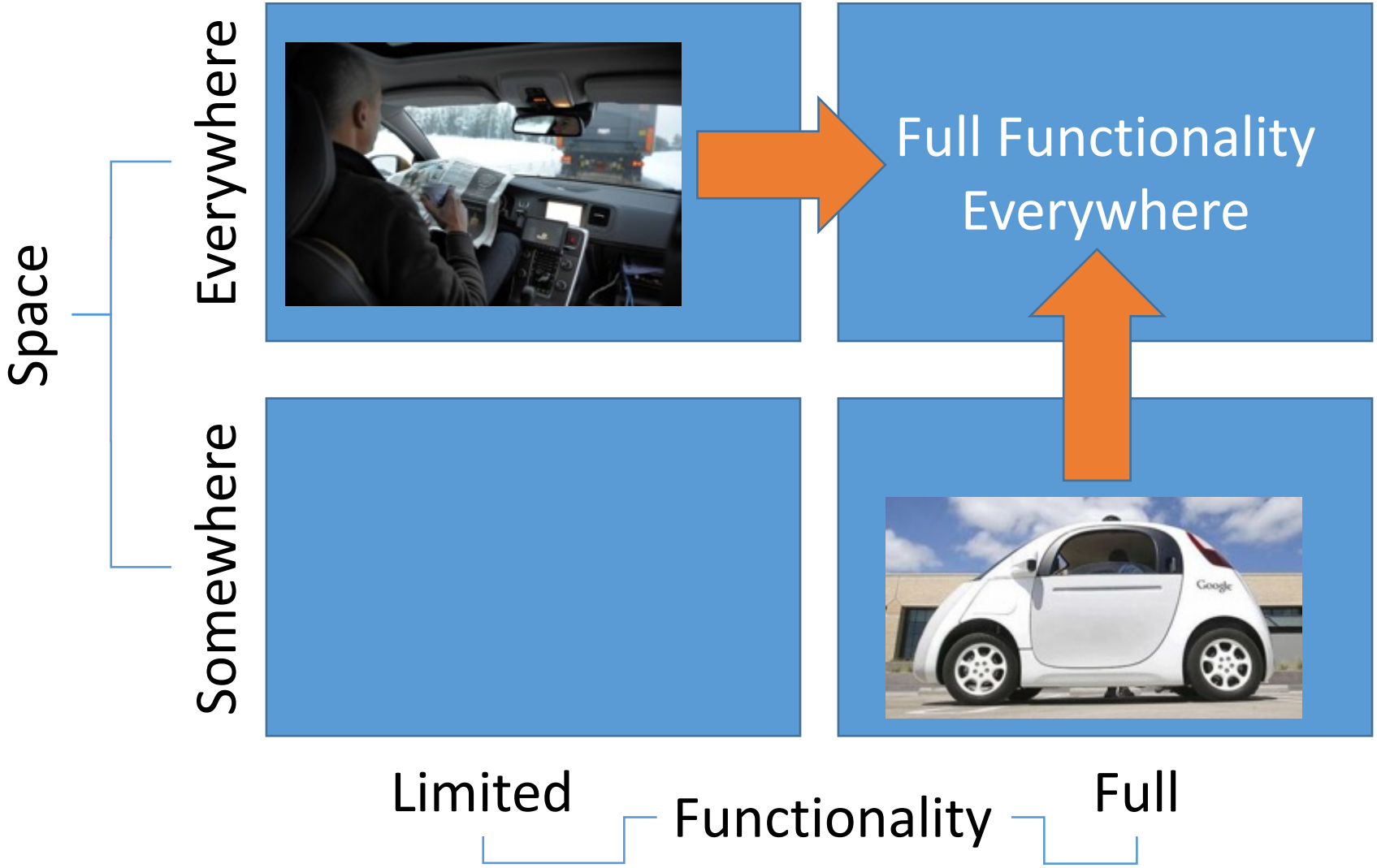
Remora

Klavesin

Autonomy: Mission lev
Duration: 20-120 h
Speed: 1-2 M/s
Connection: radio, hydroacoustic
Deepth: 3-6km
Range: 200-300 km
Examples: Klavesin (Ru), Remus (US), Autosub (GB), Hugin (Nw)

Reliable communications are needed!

Autonomous ground vehicles



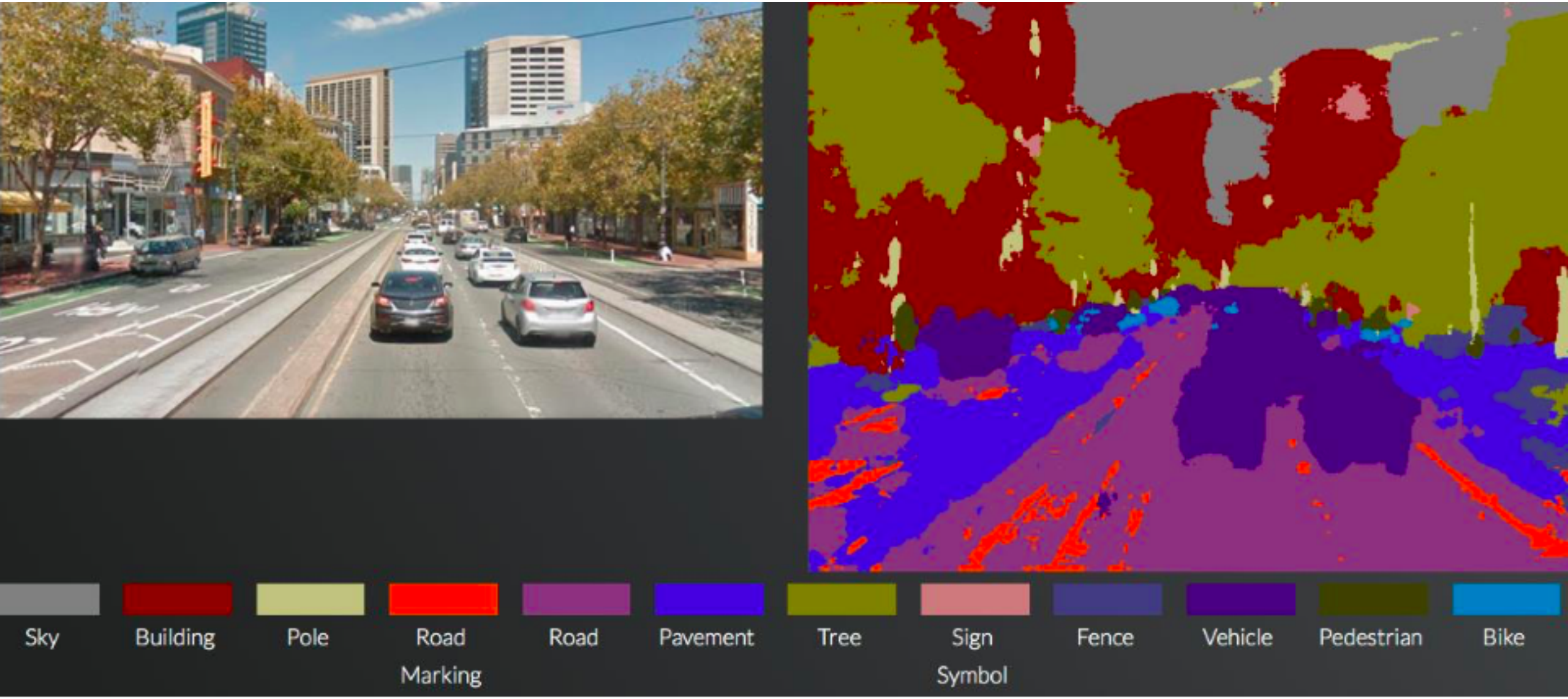
Unmanned Aerial Vehicles

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

Major growth areas

- 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

Artificial intelligence



State of Machine Learning

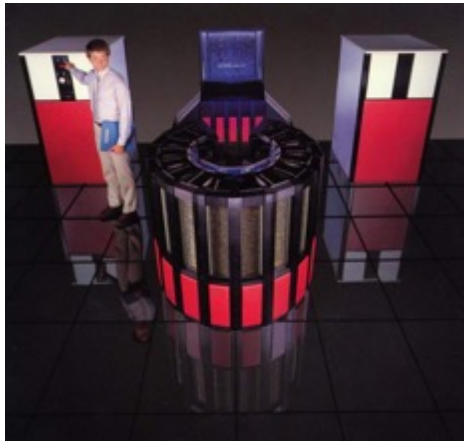
”If intelligence was a cake, unsupervised learning would be the cake, supervised learning would be the icing on the cake, and reinforcement learning would be the cherry on the cake. We know how to make the icing and the cherry, but we don't know how to make the cake.”

Yann LeCun

Director of AI Research at Facebook

Hardware for Artificial Brains

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



Cray-2 (1985)

2.7 times more powerful

iPhone 5 (2012)

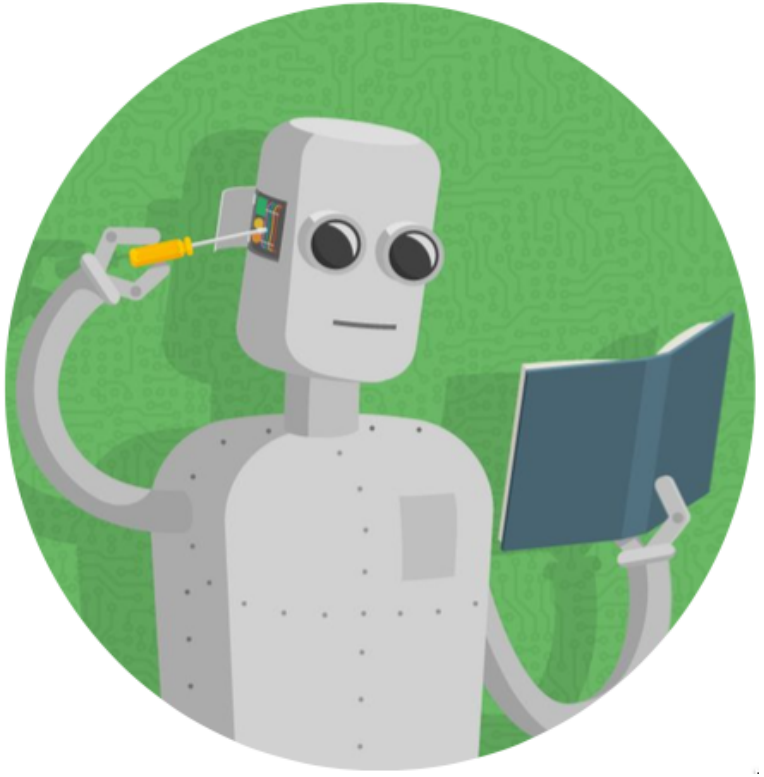
27 years

Cray Titan ~18 pFLOPS

Tianhe-2 ~34 pFLOPS, ~25 MW

Machine Learning

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

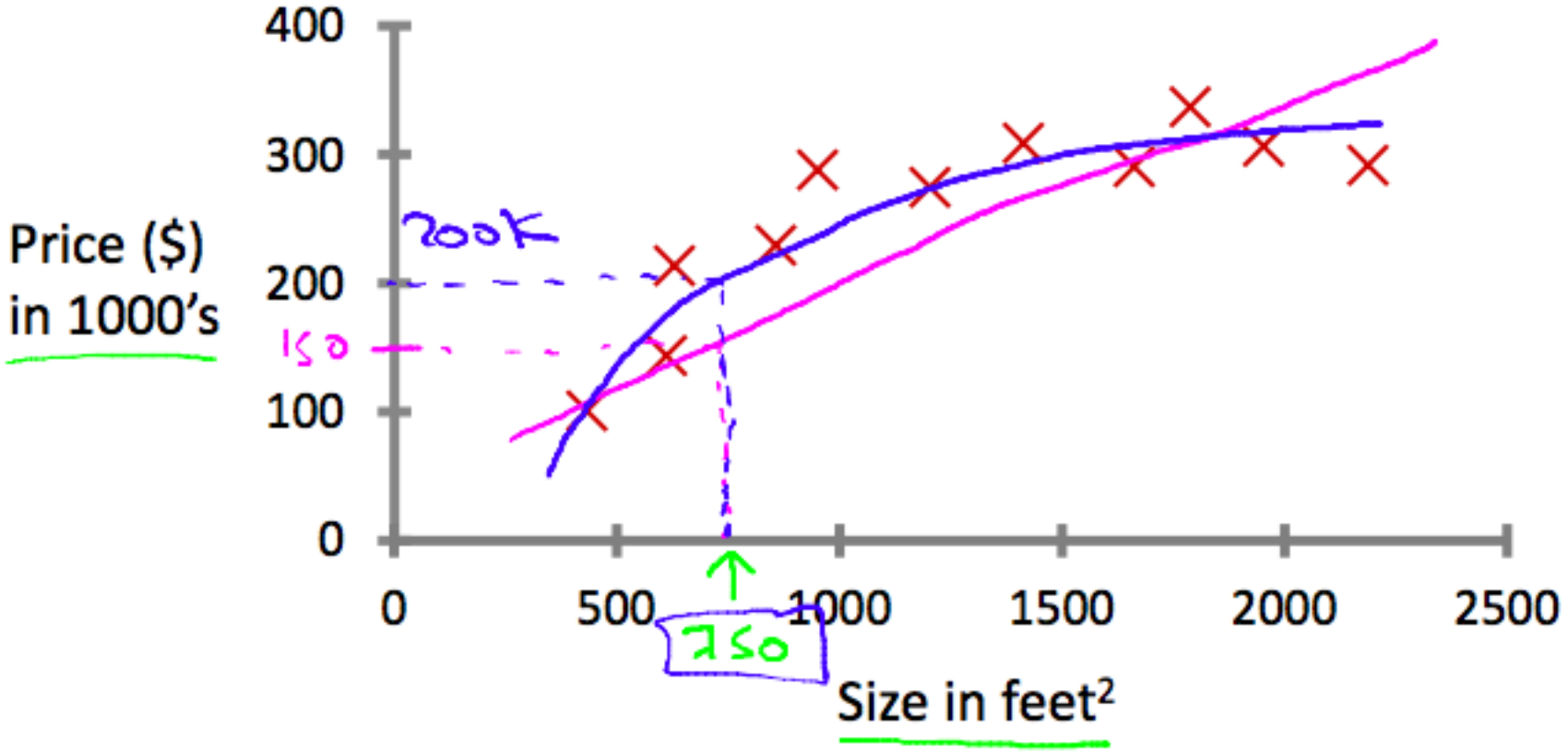


Algorythms

- Supervised learning
- Unsupervised learning

Others: reinforcement learning, recommender systems

Housing price prediction.

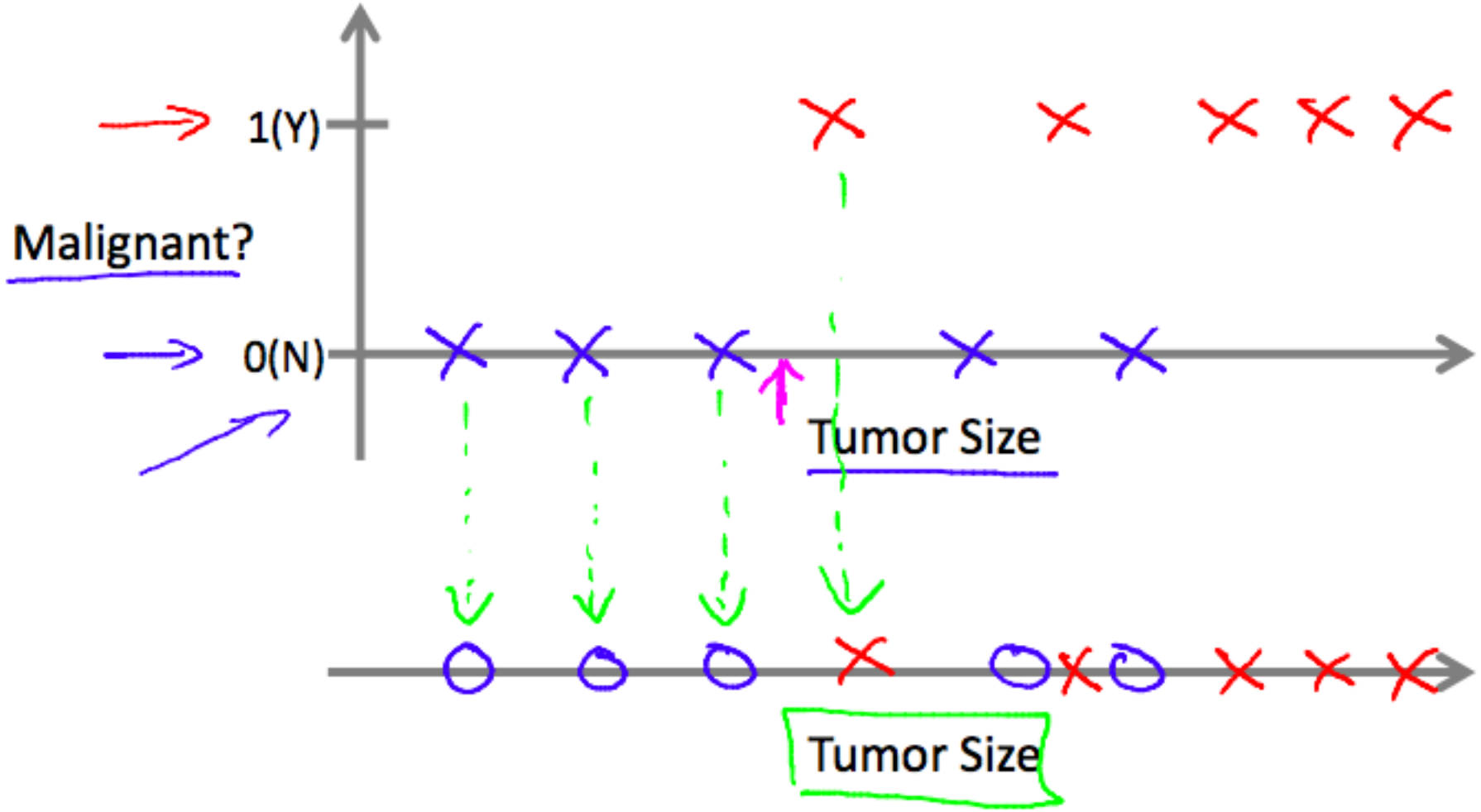


Supervised Learning

"right answers" given

Regression: Predict continuous valued output (price)

Breast cancer (malignant, benign)



Classification

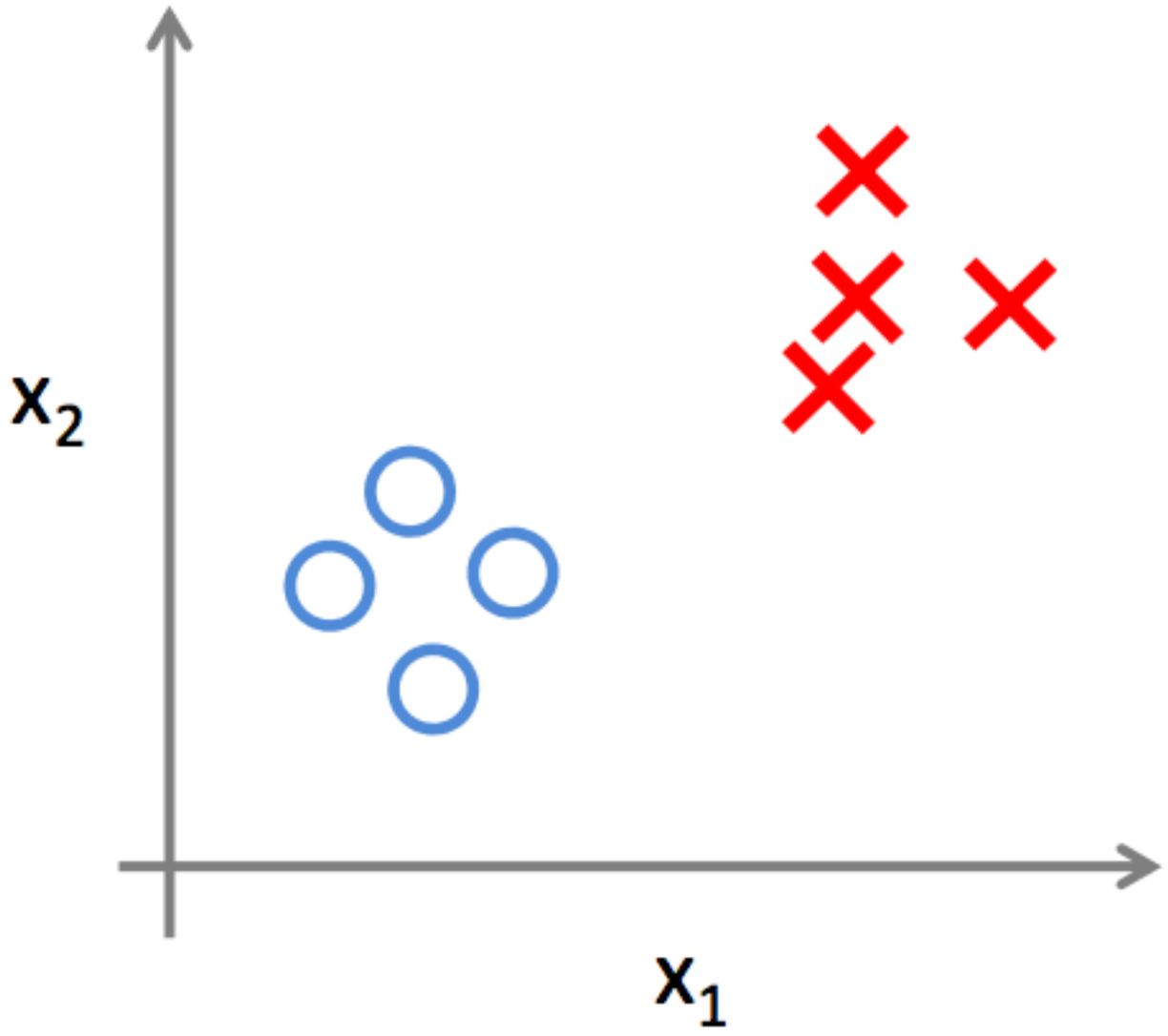
Discrete valued output (0 or 1)

0, 1, 2, 3

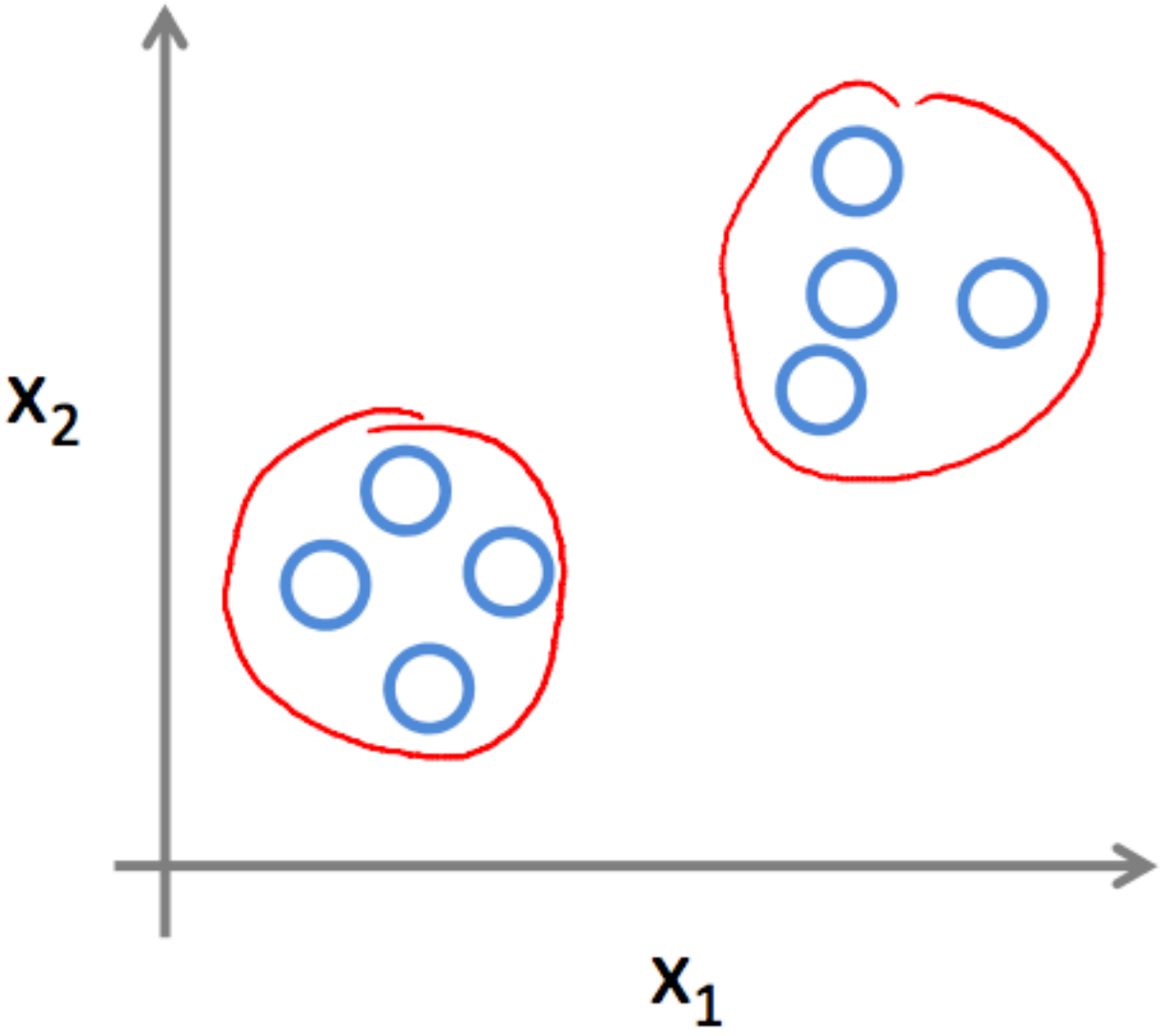
benign

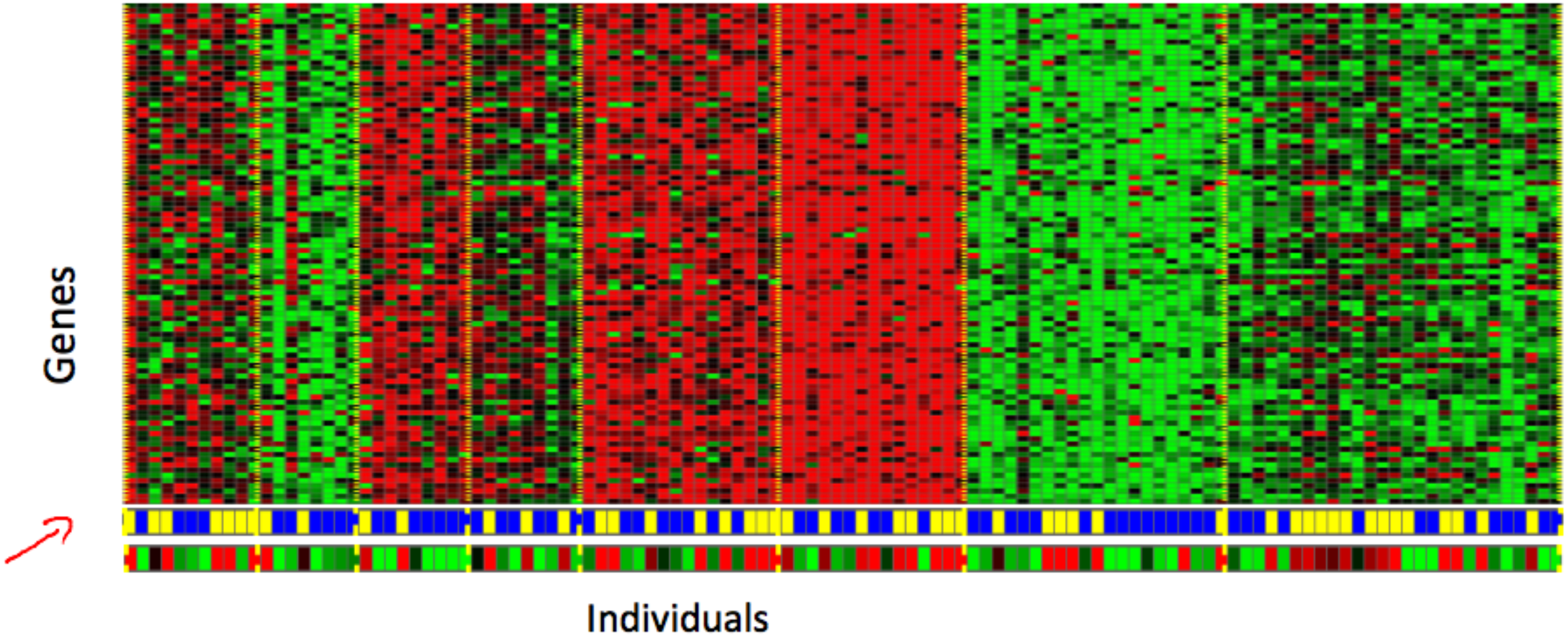
type 1 cancer

Supervised Learning



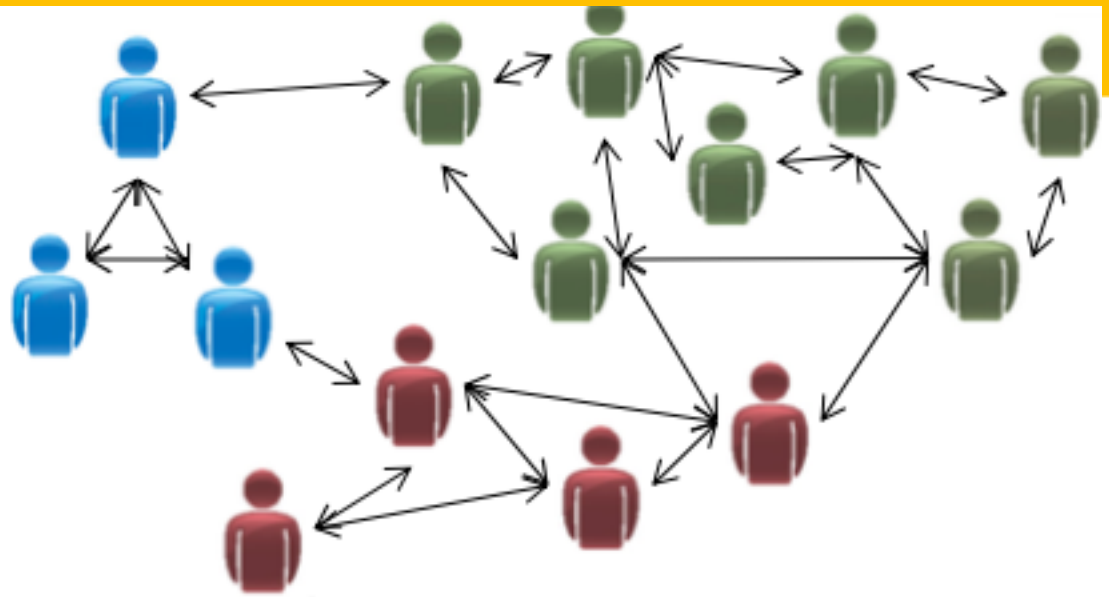
Unsupervised Learning





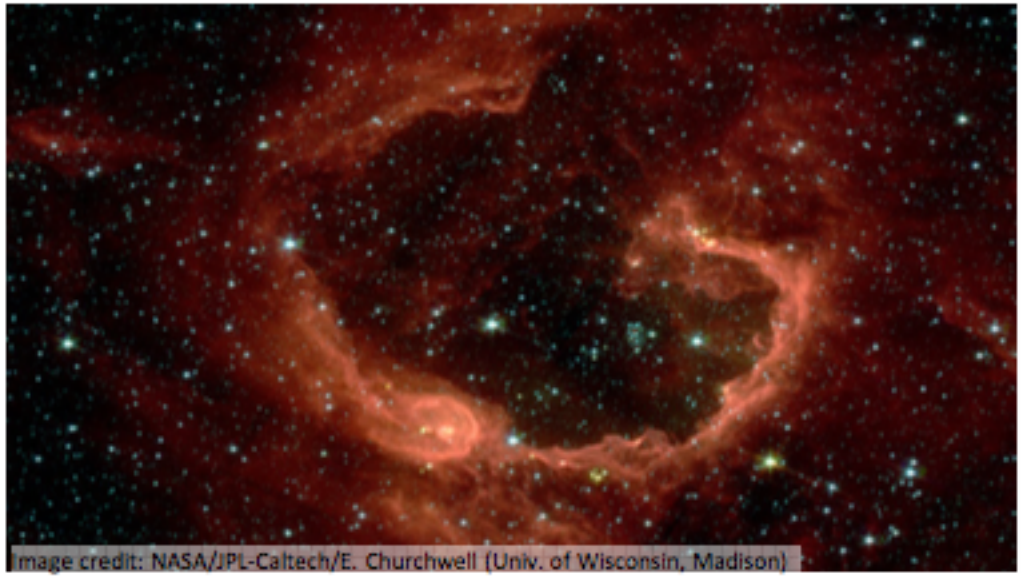
[Source: Daphne Koller]

Organize computing clusters

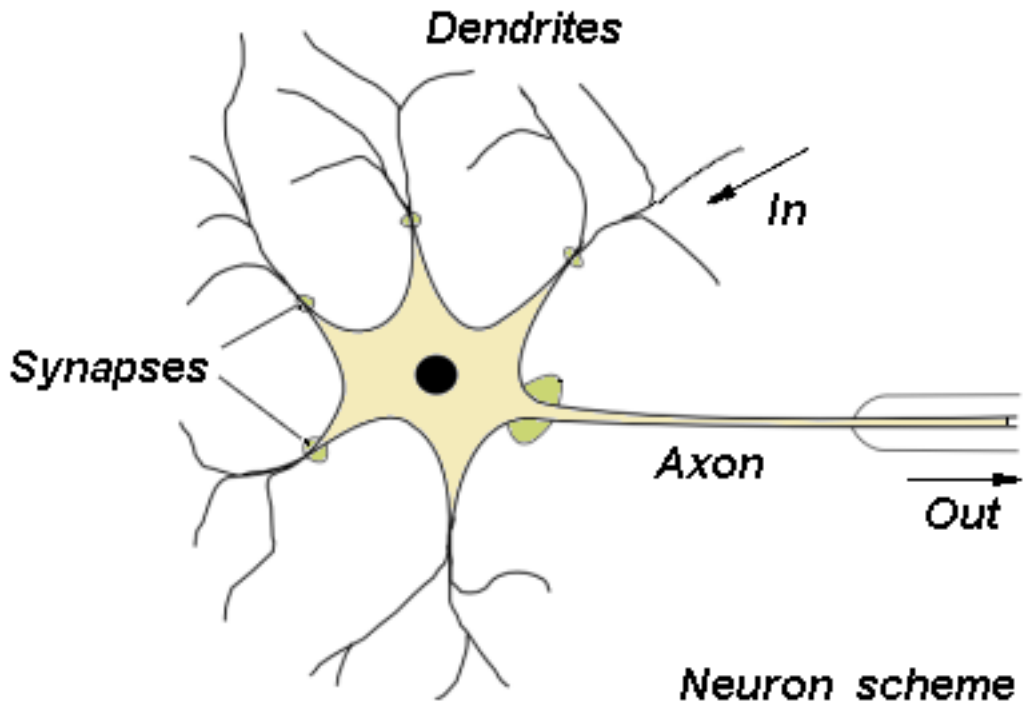


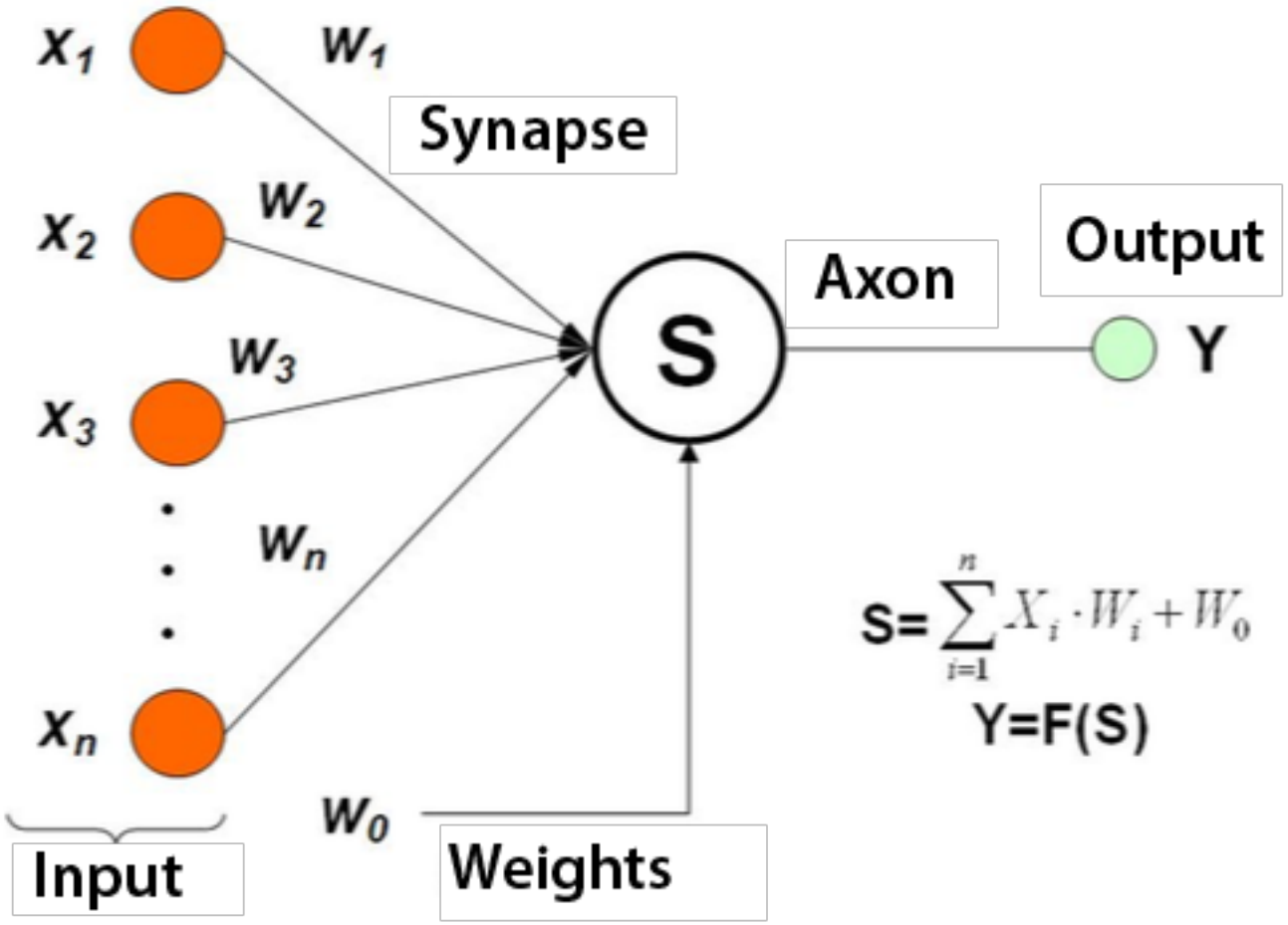
Social network analysis

Market segmentation

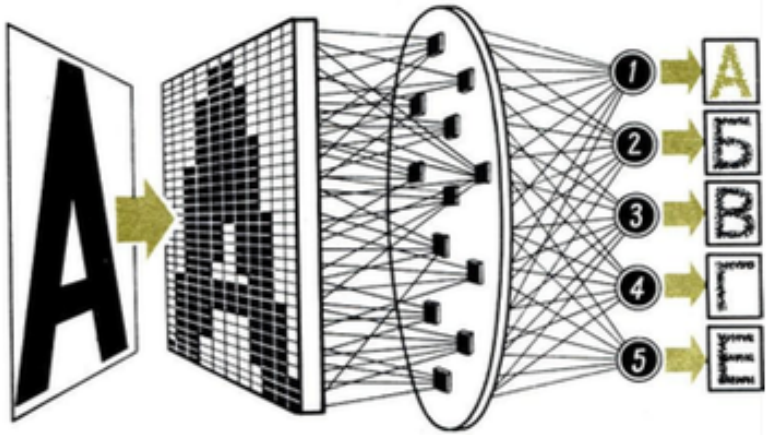


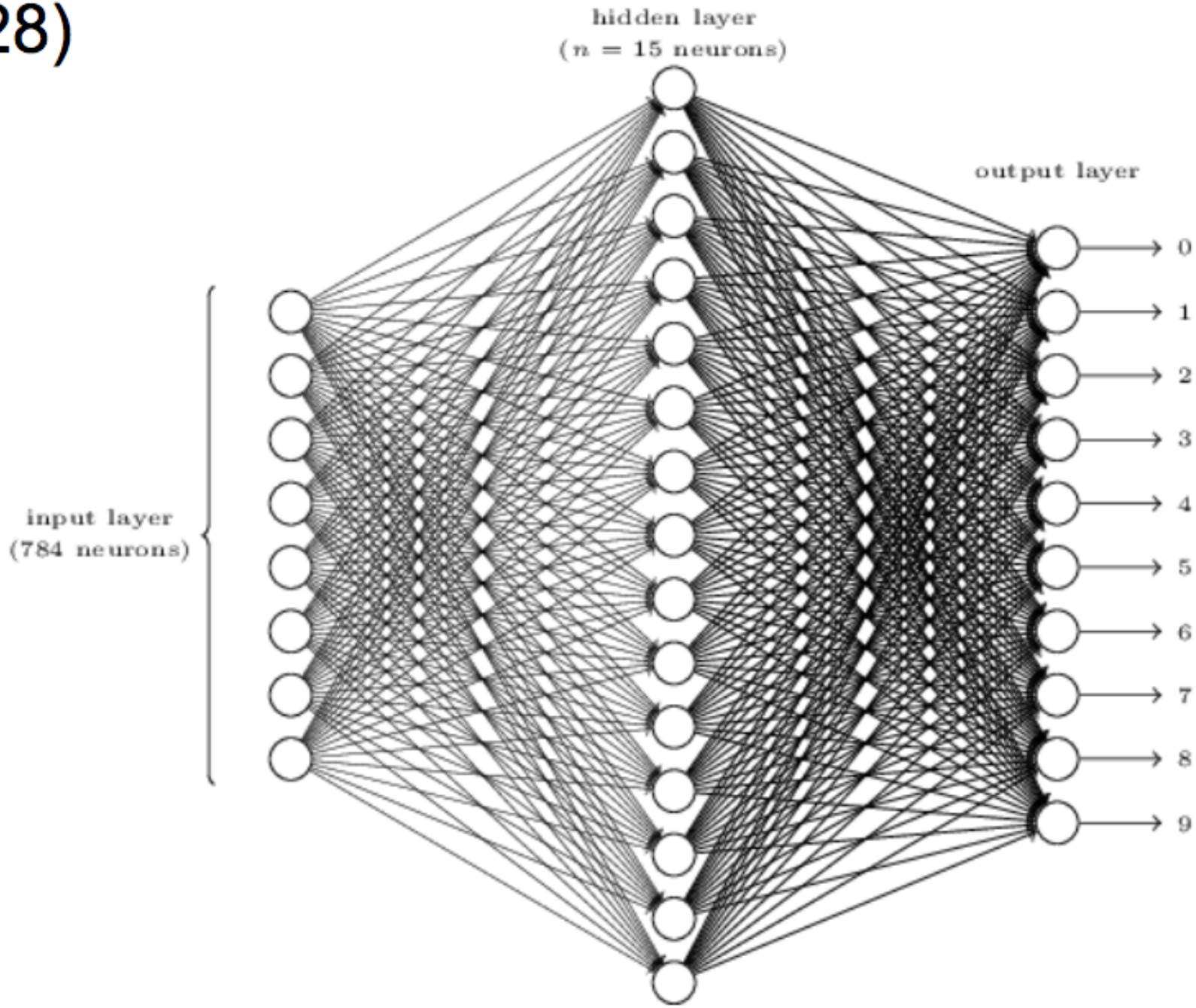
Astronomical data analysis


Dendrites
In
Synapses
Axon
Out
Neuron scheme


x_1
x_2
x_3
x_n
w_1
w_2
w_3
w_n
w_0
Synapse
S
Axon
Output
Y
Input
Weights
$S=\sum_{i=1}^{n} X_i \cdot W_i + W_0$
Y=F(S)

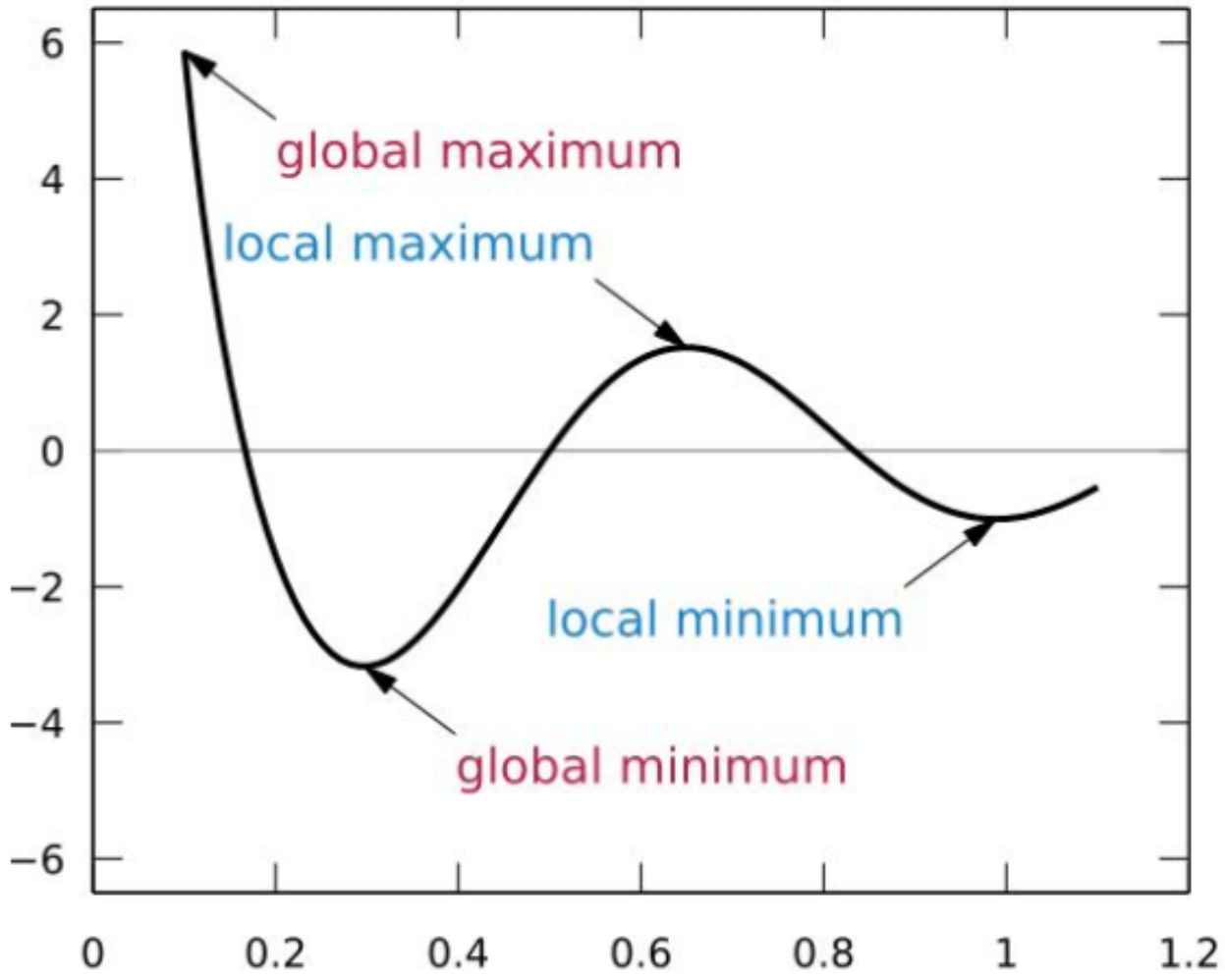
MNIST Dataset (28x28)





http://neuralnetworksanddeeplearning.com/chap1.html

Gradient descent



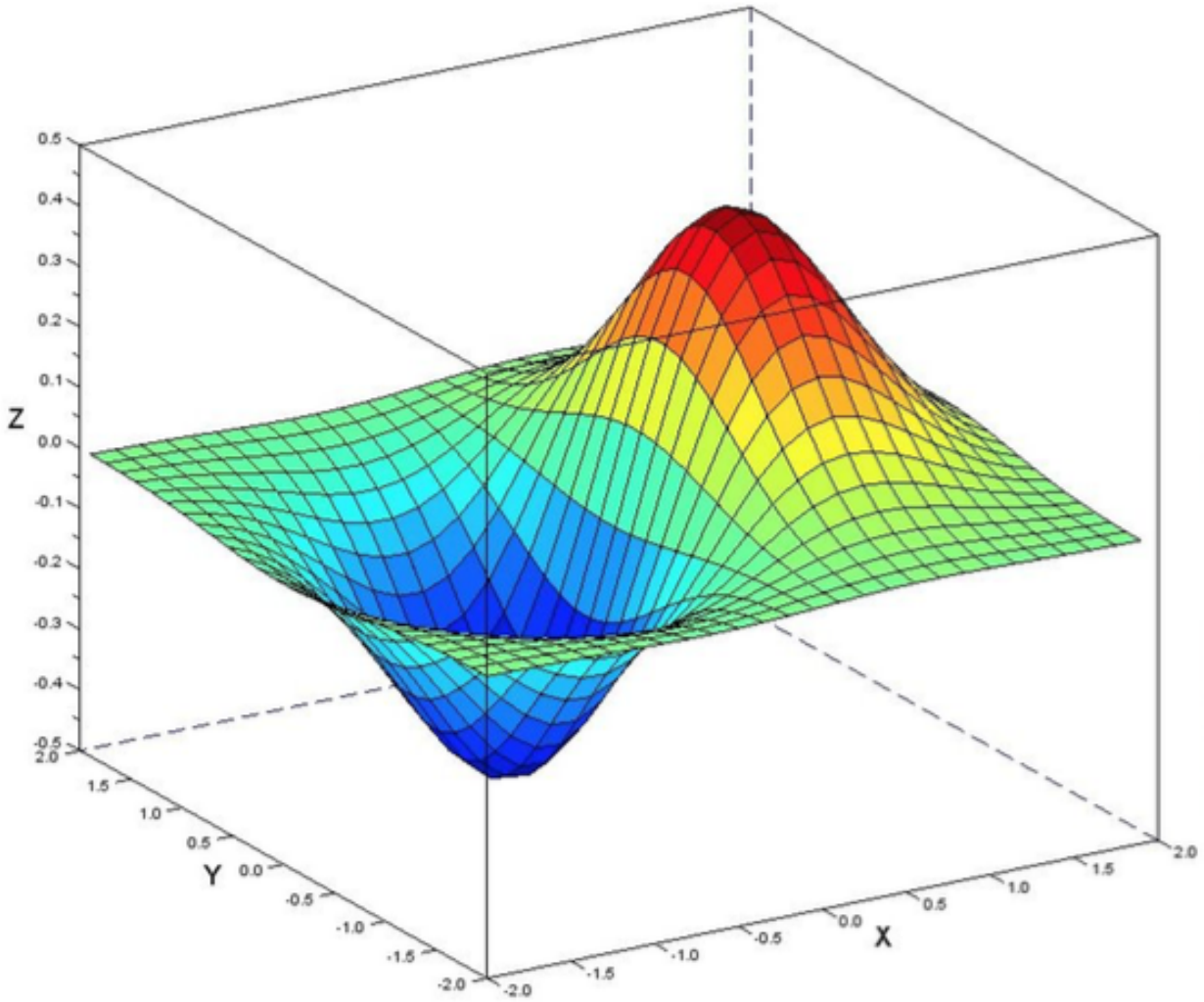
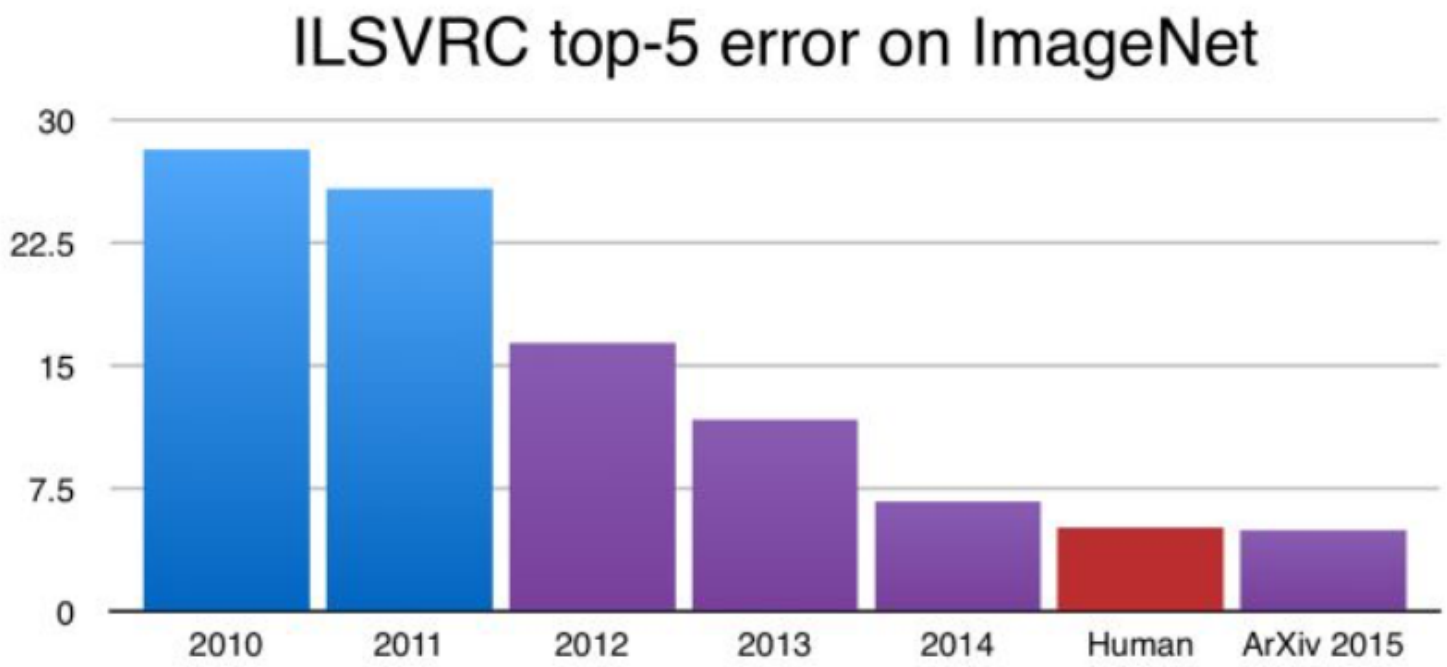
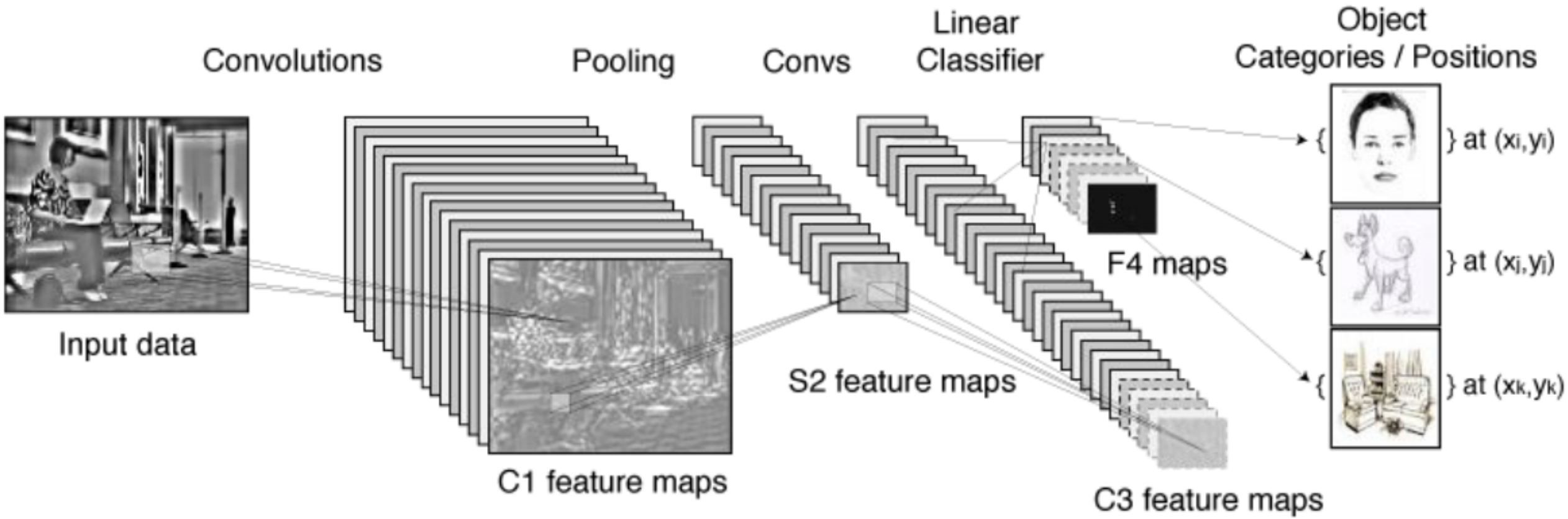


Image recognition. Machine vs Human



NVIDIA blog: https://devblogs.nvidia.com/parallelforall/mocha-jl-deep-learning-julia/

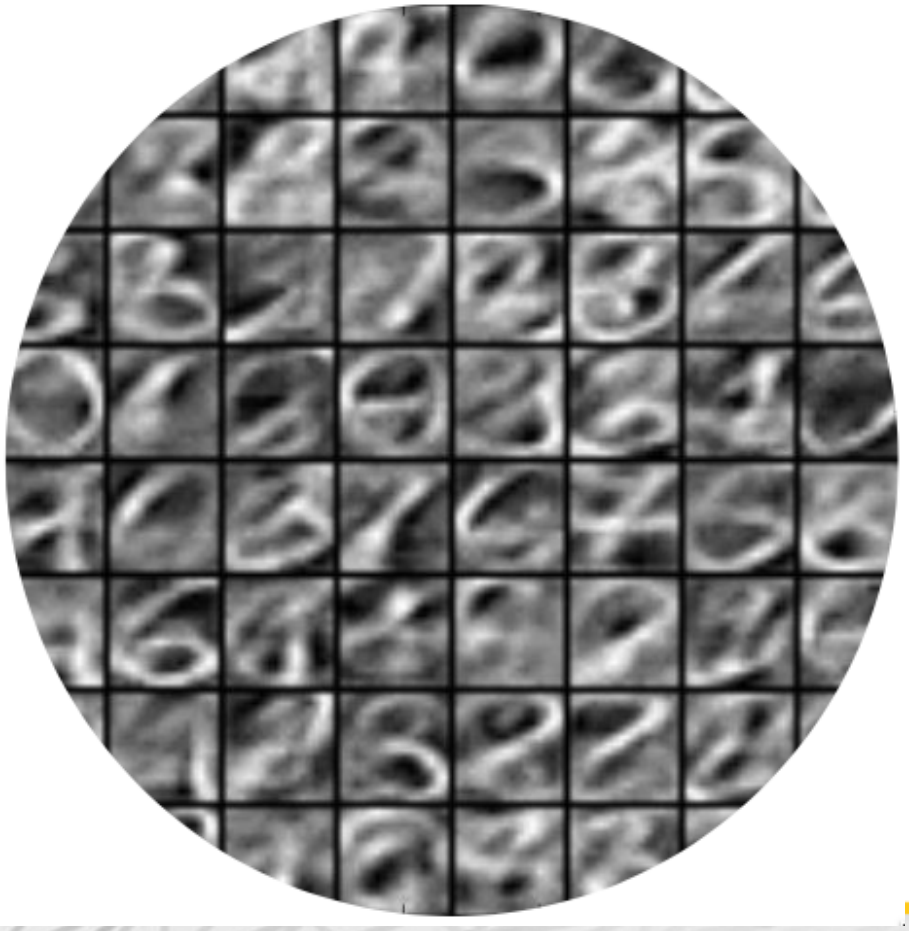
Convolutional neural networks



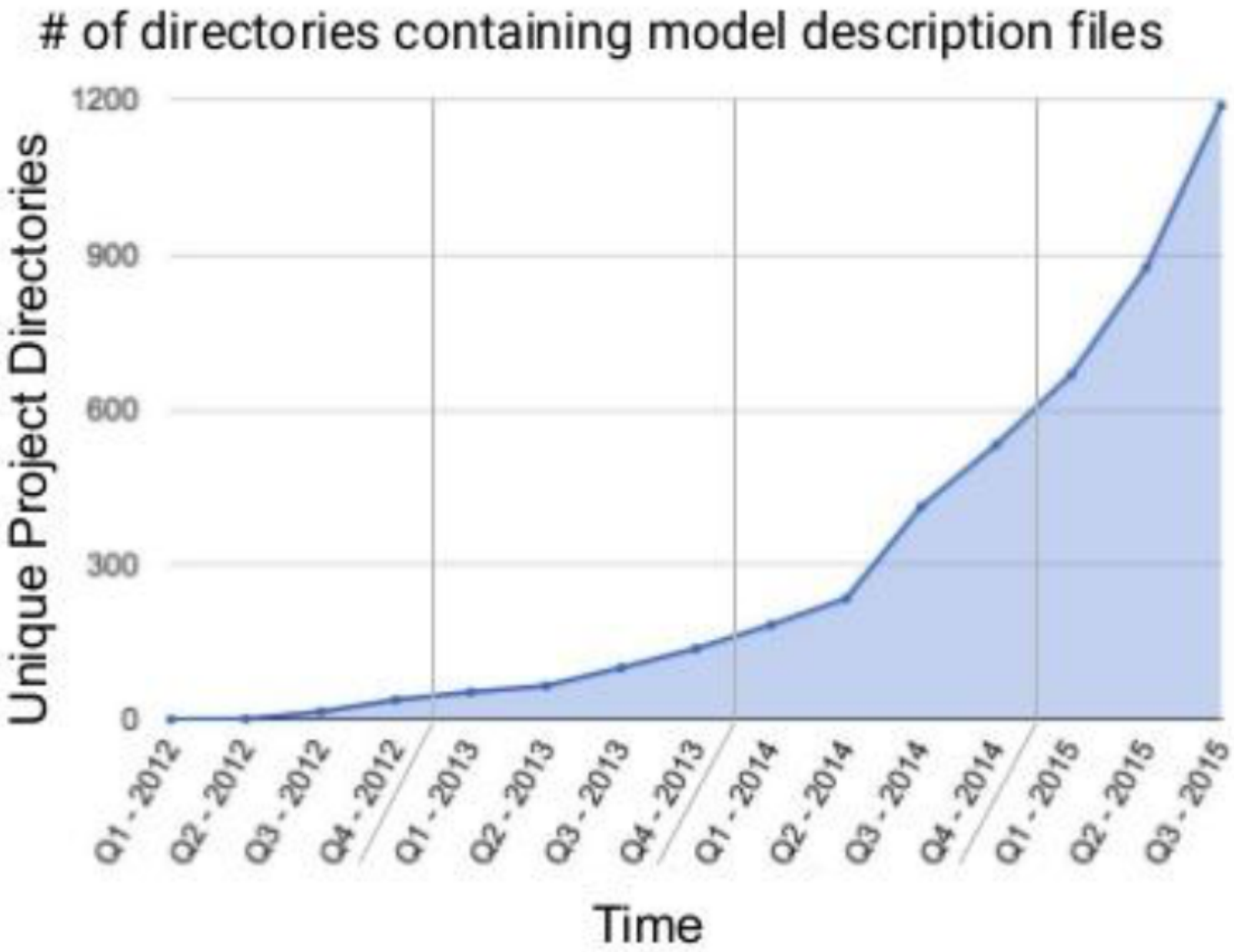
Type of feed-forward artificial neural network in which the connectivity pattern between its neurons is inspired by the organization of the animal visual cortex.

Deep learning

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.

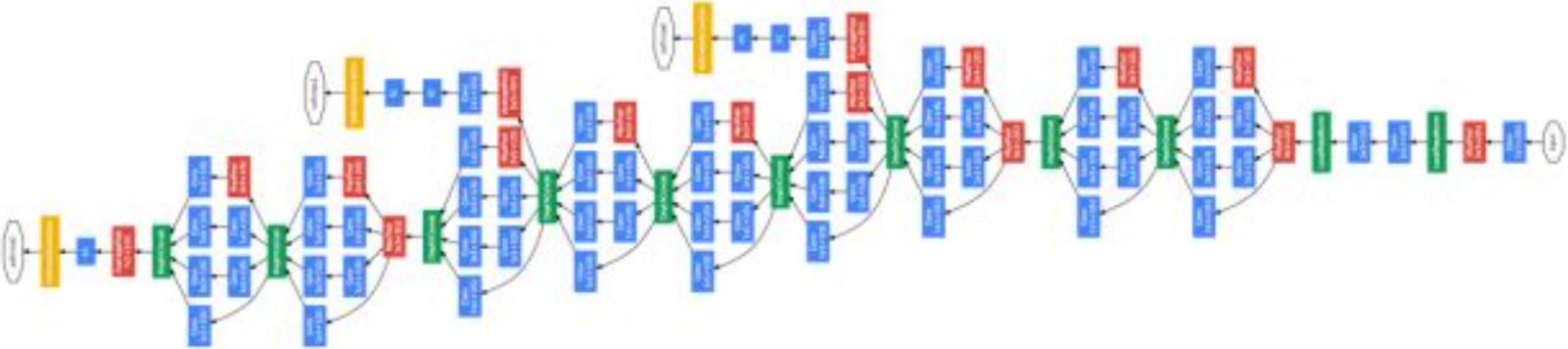


Growing Use of Deep Learning at Google



Across many products/areas:

Android
Apps
drug discovery
Gmail
Image understanding
Maps
Natural language understanding
Photos
Robotics research
Speech
Translation
YouTube
... many others ...



Neural Networks

A mostly complete chart of architectures

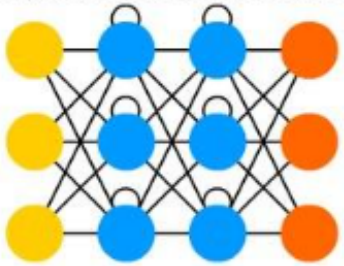
- Backfed Input Cell
- Input Cell
- Noisy Input Cell
- Hidden Cell
- Probablistic Hidden Cell
- Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Open Memory Cell
- Scanning Filter
- Convolution

Feed Forward And

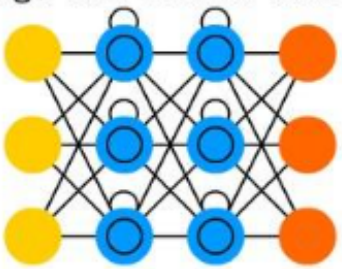
Feed Forward Xor

Radial Basis Network

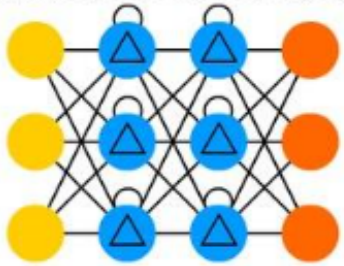
Recurrent Neural Network (bi)



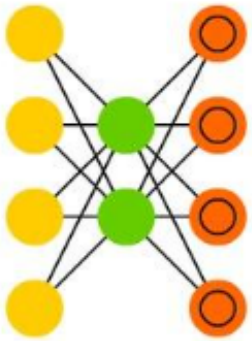
Long / Short Term Memory (bi)



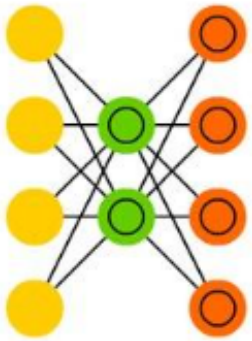
Gated Recurrent Unit (bi)



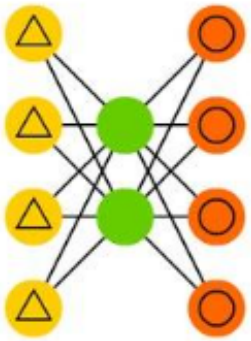
Auto Encoder



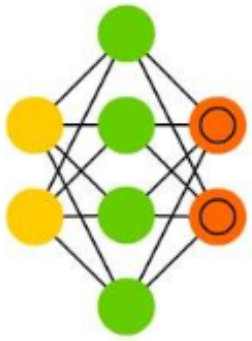
Variational Auto Encoder



Denoising Auto Encoder



Sparse Auto Encoder



OpenSource

TensorFlow

Theano

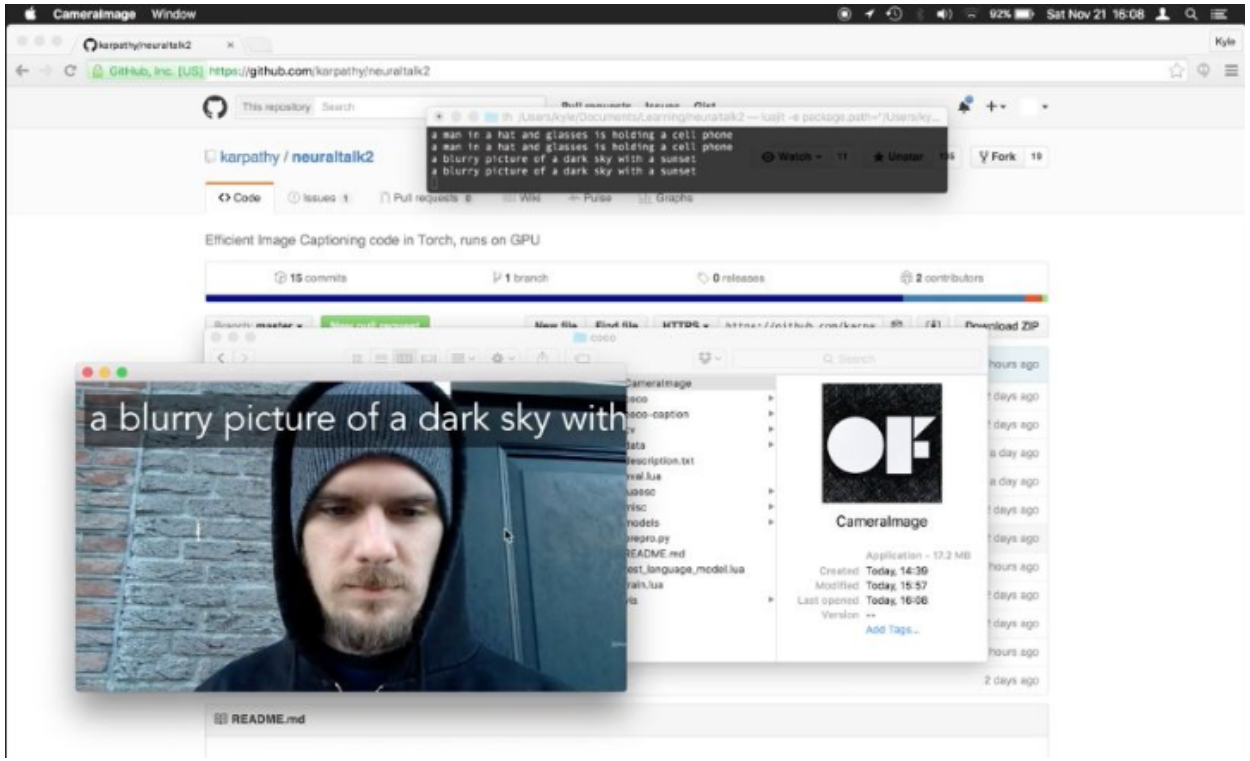
Torch

Caffe

DL4J

И даже на JavaScript - ConvNetJS

NeuralTalk



a man is playing tennis on a tennis court

a train is traveling down the tracks at a train station

a cake with a slice cut out of it

a bench sitting on a patch of grass next to a sidewalk

https://vimeo.com/14649200

https://github.com/karpathy/neuraltalk2

This repository Search Pull requests Issues Gist

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

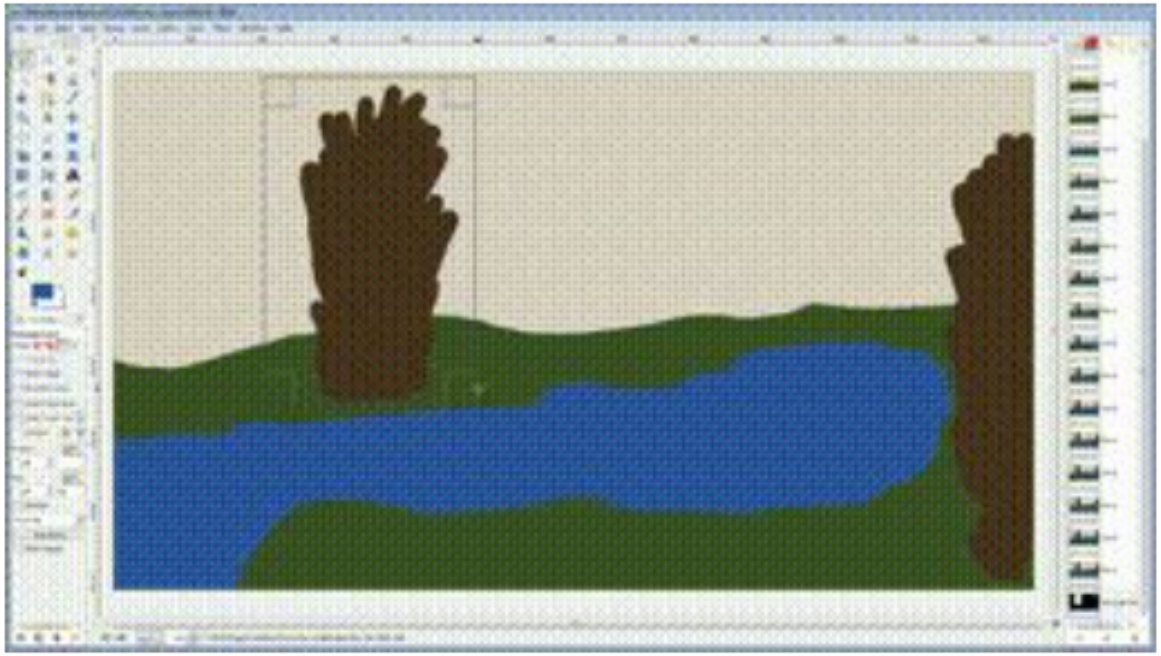
Branch: master New pull request Create new file Upload files Find file Clone or download

jcjohnson committed on GitHub Add Pascal Titan X benchmarks Latest commit ec5ba3a 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

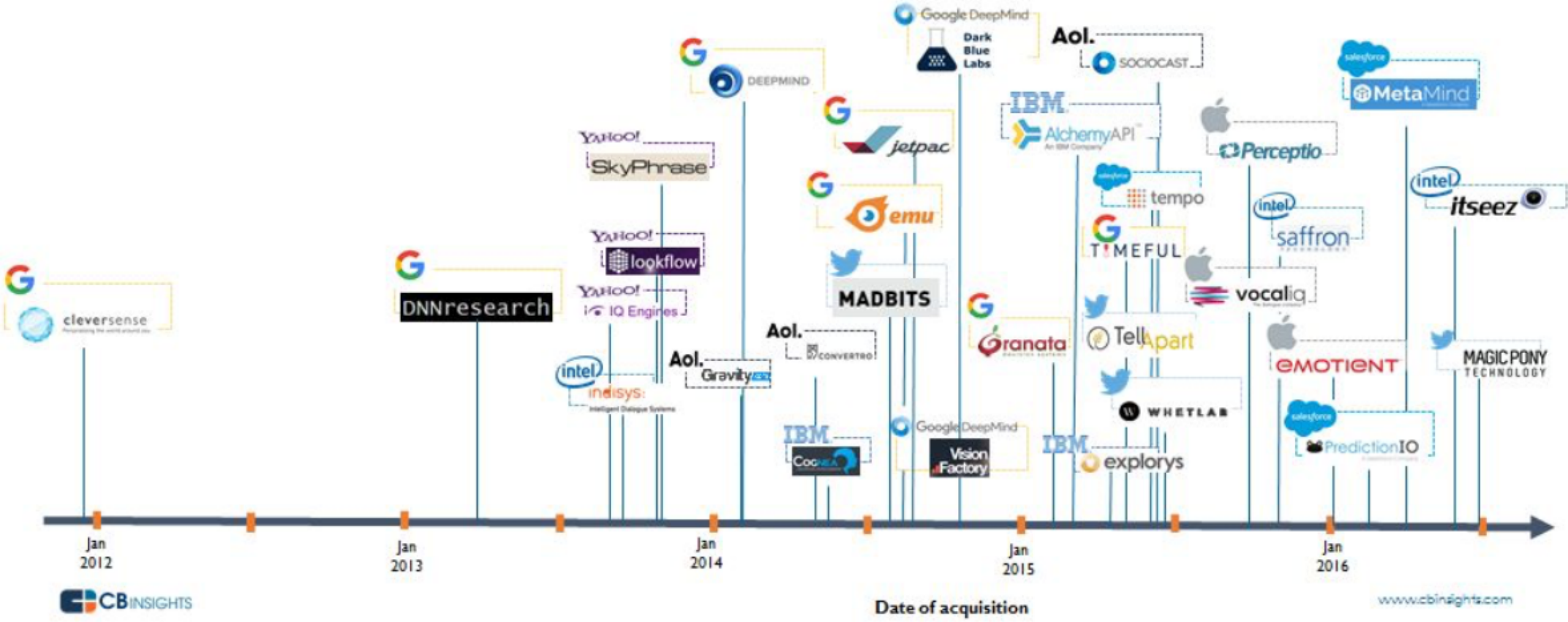
README.md

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



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

Race For AI: Most Active Acquirers In Artificial Intelligence



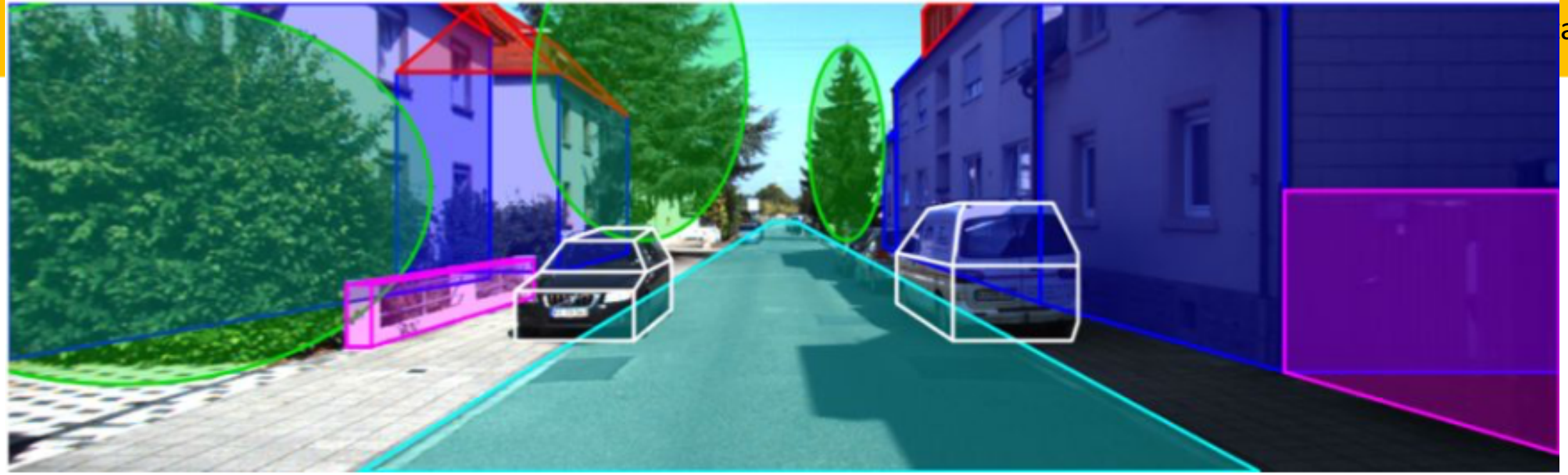
https://www.cbinsights.com/blog/top-acquirers-ai-startups-ma-timeline/

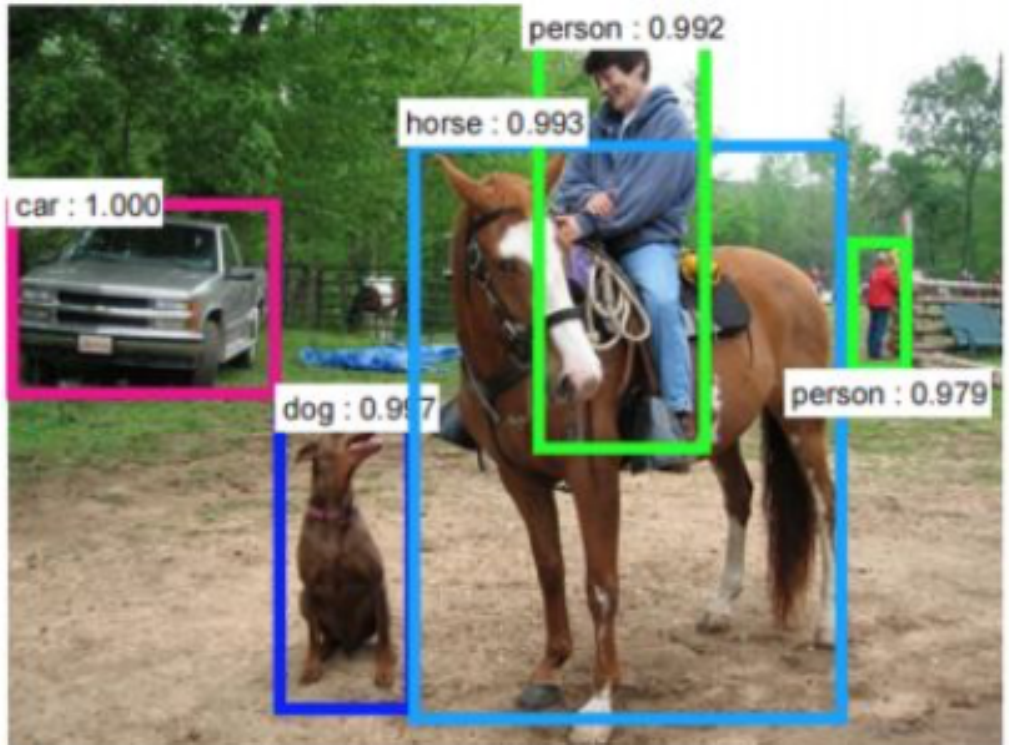
Self-driving cars

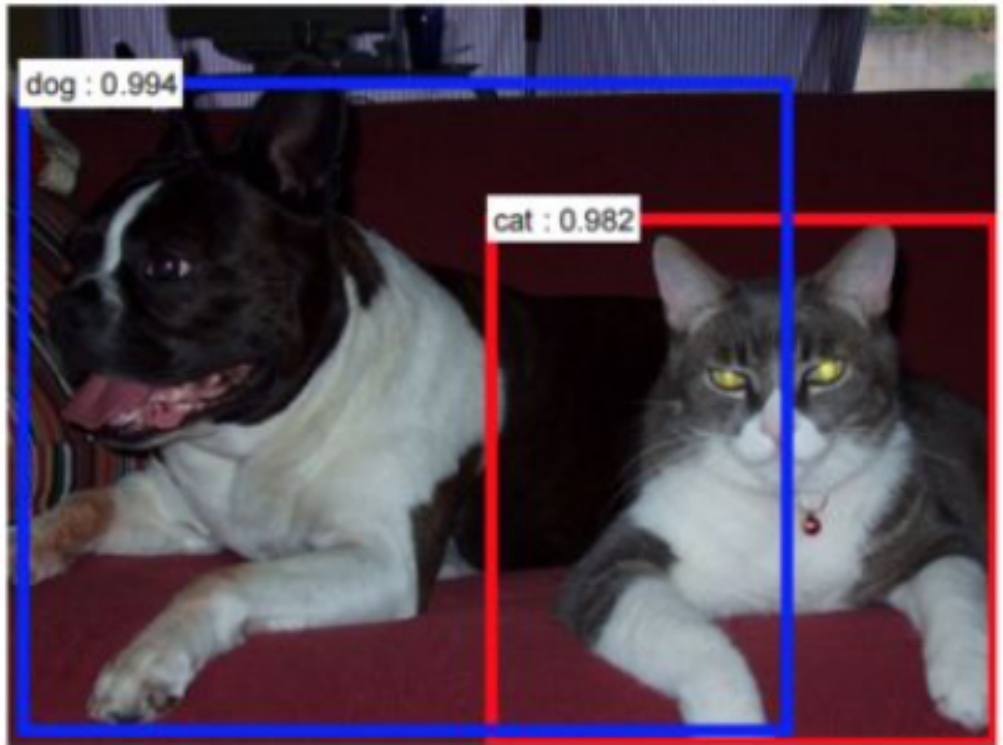
Get Taxi investments ~ $300M

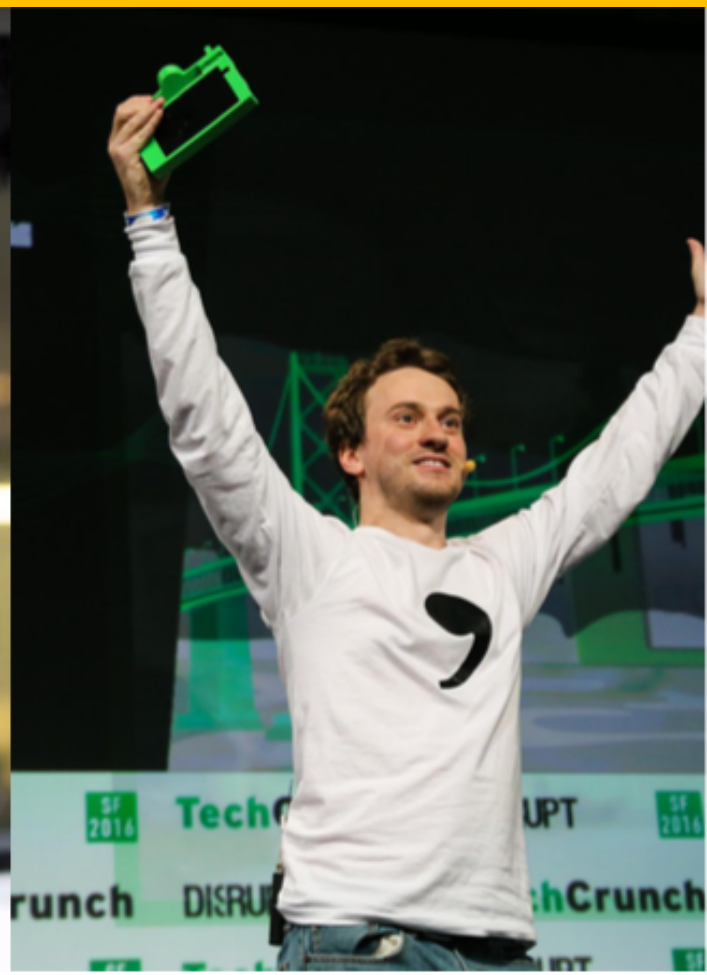
Taxi drivers in Moscow: 55000
Salary: $10000 / year

Economy: $550M



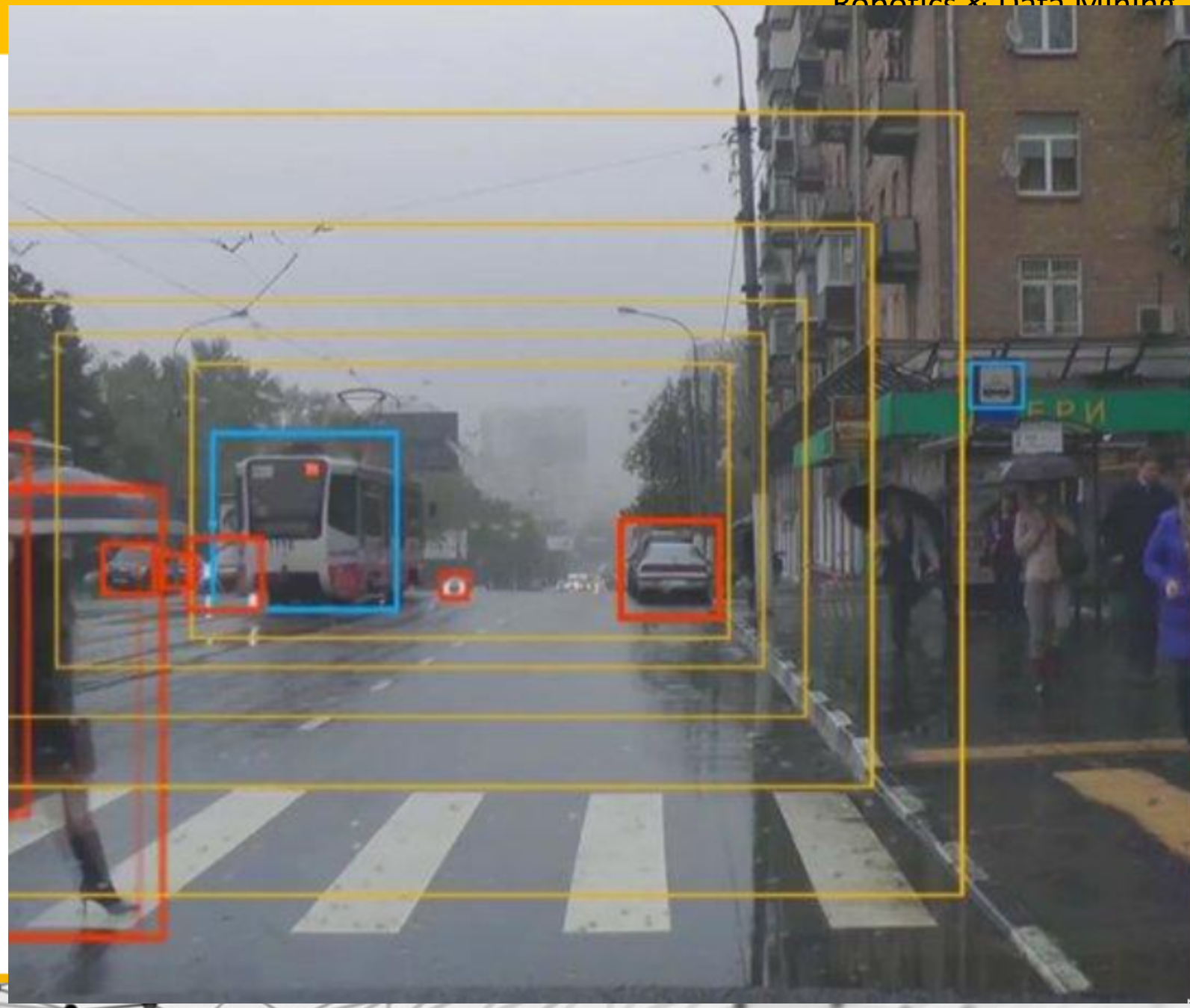

person : 0.992
horse : 0.993
car : 1.000
dog : 0.997
person : 0.979


dog : 0.994
cat : 0.982



George Hotz
http://comma.ai

Russian trucks KAMAZ &
Cognitive company
2014 - 2020



Today & tomorrow

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

Whats the next? Technological singularity or not?

Thank you!

- Kirill Svyatov
- k.svyatov@ulstu.ru

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