Practical AI: history and perception

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Harbour.Space

What do we do here?

Study theoretical and practical basics of what is called “AI”.

Implement AI using different techniques.

We write code every day. And night.

We work together and help each other with solutions.

Grading

- You do **labs** in class. Labs help you to prepare for home tasks.
  - *Friday labs* are graded (pass/fail).
  - Last lab (15^{th}) aka “exam” is also graded. Mandatory.
- **Home tasks** are given **every day**.
  - Usually there will be 2 levels - mandatory and advanced.
  - **To pass complete 10/14** of mandatory hometasks.
- **Final grade** is computed as 40% of hometasks, 30% of graded Friday labs and 30% of exam. *(may be changed)*
  - But you still have to solve 10/14 hometasks and attend exam

Agenda

- Artificial intelligence
  - Major milestones
  - People comprehending AI
  - AI in culture
- Machine learning - major tool
  - Simple examples
  - Artificial neural networks
  - Neuromorphic computations
- How AI influences society: open question

AI

Are these artificial intelligence?

1) Game bots (DeepBlue, AlphaGo/Zero, shooters)
2) Machine translation
3) Speech (voice) and music generation
4) Q&A systems
5) Expert and decision support systems
6) Smart assistants and chat-bots
   (Google Home, Siri, Yandex.Alisa, ...)
7) Trade bots
8) Identification and authentication systems
9) Symbolic computations (Wolfram|Alpha)

AI Milestones

- **1940s** - first general electrical computers (Konrad **Zuse**)
- **1950** - Alan **Turing** presented imitation game in "computing machinery and intelligence"
- **1956** - Dartmouth workshop, John **MacCarthy** proposed neutral "umbrella" definition for AI as a set of technologies for "***thinking machines***": it covers symbolic computations, expert systems, ANNs, ...
- **1957** - neuroscientist Frank **Rosenblatt** implemented first ANN - **perceptron** - based on W. McCulloch & W. Pitts neuron model (1943)

AI Milestones

- **1950/60e** - Edward **Feigenbaum**, father of **expert systems**
- **1958** - **LISP** by John MacCarthy, (1972 - Prolog)
- **1950e** - start of **generative grammar** (Noam Chomsky)
- **1969** - start of the first “ANN winter” after the book by M. Minski, which has proven limits of perceptron models
- 1974/**86** - invention of **Backpropagation method** for relatively fast ANN parameter search — end of “winter”
- **1990**, **97** - **Recurrent ANNs** including LSTM (long short-term memory)

AI Milestones

- **2001** - Viola-Jones method for object detection (faces)
- **2006** - Q&A system IBM **Watson**
  (2010 - won Jeopardy competition)
- **2009** - Q&A system **Wolfram|Alpha**
- **2012** - "synergistic effect" of **AlexNet** =
  - ImageNet (Li Fei-Fei, 2010) +
  - GPGPU (NVidia Cuda 2007) +
  - Deep networks (~2007) +
  - Convolutional networks (Yann LeCun, 1988+)
- **2017** - neural (and hybrid) **machine translation**
- **2016+ -** Face2Face**,** Tacatron2, FakeApp

AI comprehension

- Games and competitions
  - *Can a machine **beat/replace** a human?*
- Turing test
  - *Can a machine **fool** a human?*
  - Annual competition
  - Physical symbol system hypothesis (Newell & Simon): "A **physical symbol system** has the necessary and sufficient means for **general intelligent action**"
  - Other tests (coffee, enrollment, ...)
- Chinese room argument
  - ***Even if machine fools** a human, is this an intelligence?*
  - *Weak and strong AI*
  - *Dialog systems: just an interface*
  - *Google Duplex*

AI comprehension

- Ship of Theseus paradox:
  - *If we **re**construct human **brain** as a machine - is this an intelligence?*
  - Neuromorphic computations
- Uncanny valley effect:
  - *How will a human react on the indistinguishable machine?*
  - Humanoids, dialog systems
- Moravec's paradox:
  - *It is easy to pass Turing test, but nearly impossible to achieve 1-year-old human capabilities*

AI comprehension: scenarios

- **Positive**
  - S. Thrun
  - AI is a tool that makes humanity more efficient
  - History survived steam machines, urbanization, etc - no need to be afraid of progress
- **Negative**
  - Musk, Hawking etc
  - AI is a threat. Not because it will be smarter and kill/slave all people.
  - As a powerful technology it will dramatically change social structure and can even cause new wars
- **Synergistic**
  - Ray Kurzweil, J. Licklider (1960)
  - There will be no humanity in a hundred years. We will merge with machines

AI in culture

- **Smarter** (won, achieved, ...)
  - DeepBlue, DeepMind, AlphaGo/Zero
- **More capable** (achieves better-than-human results)
  - Boston Dynamics, Kuka Robotics
- **Dangerous** (kills)
  - Autonomous cars, UAVs

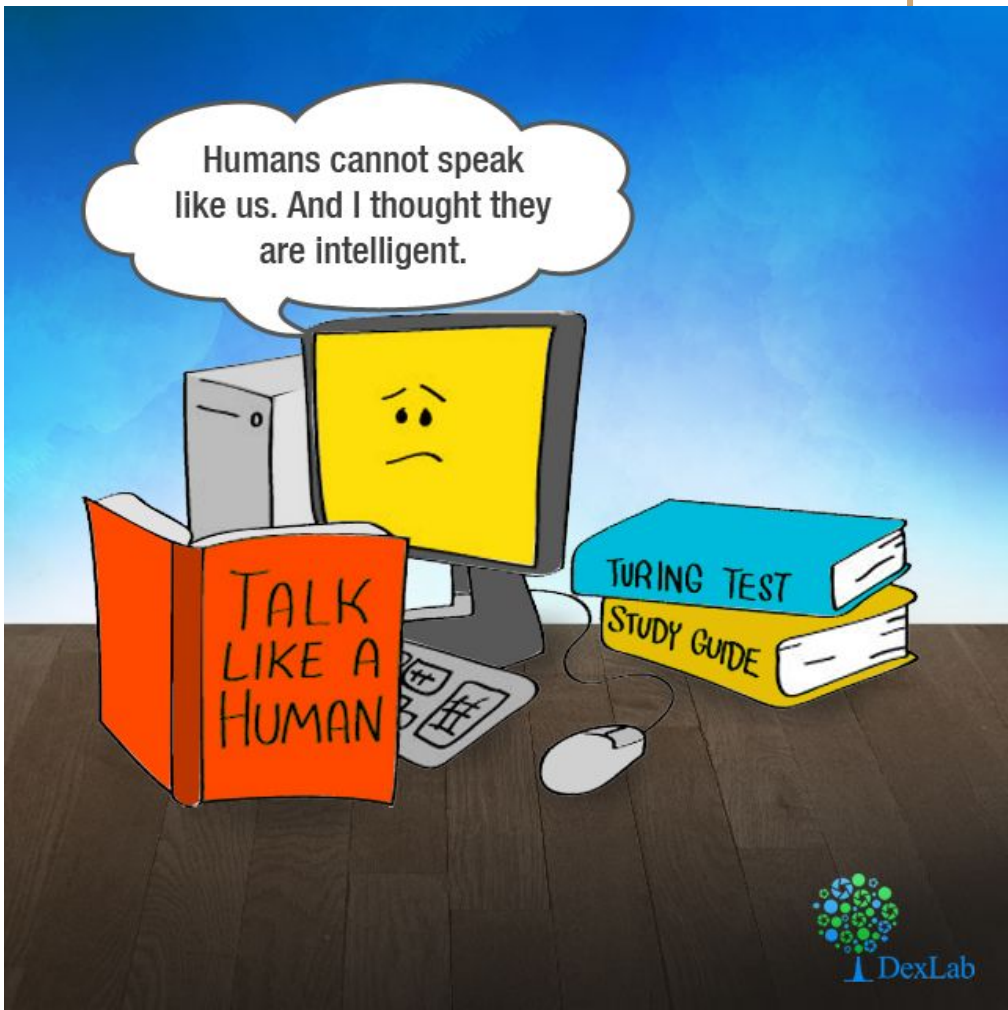
Class task #1. Technology ahead of ethics

Read this article:
https://www.abacusnews.com/digital-life/facial-recognition-camera-catches-top-businesswoman-jaywalking-because-her-face-was-bus/article/2174508

Let's discuss:

1. Is **passive** identification ok?
2. Is it ok to show automatically captured a (face + name) on a screen/**publish**?
3. Is it ok to **fine/imprison** a person based on fully **automatic** decision?
4. Is it possible to **reduce** such errors **to zero**?

Machine Learning



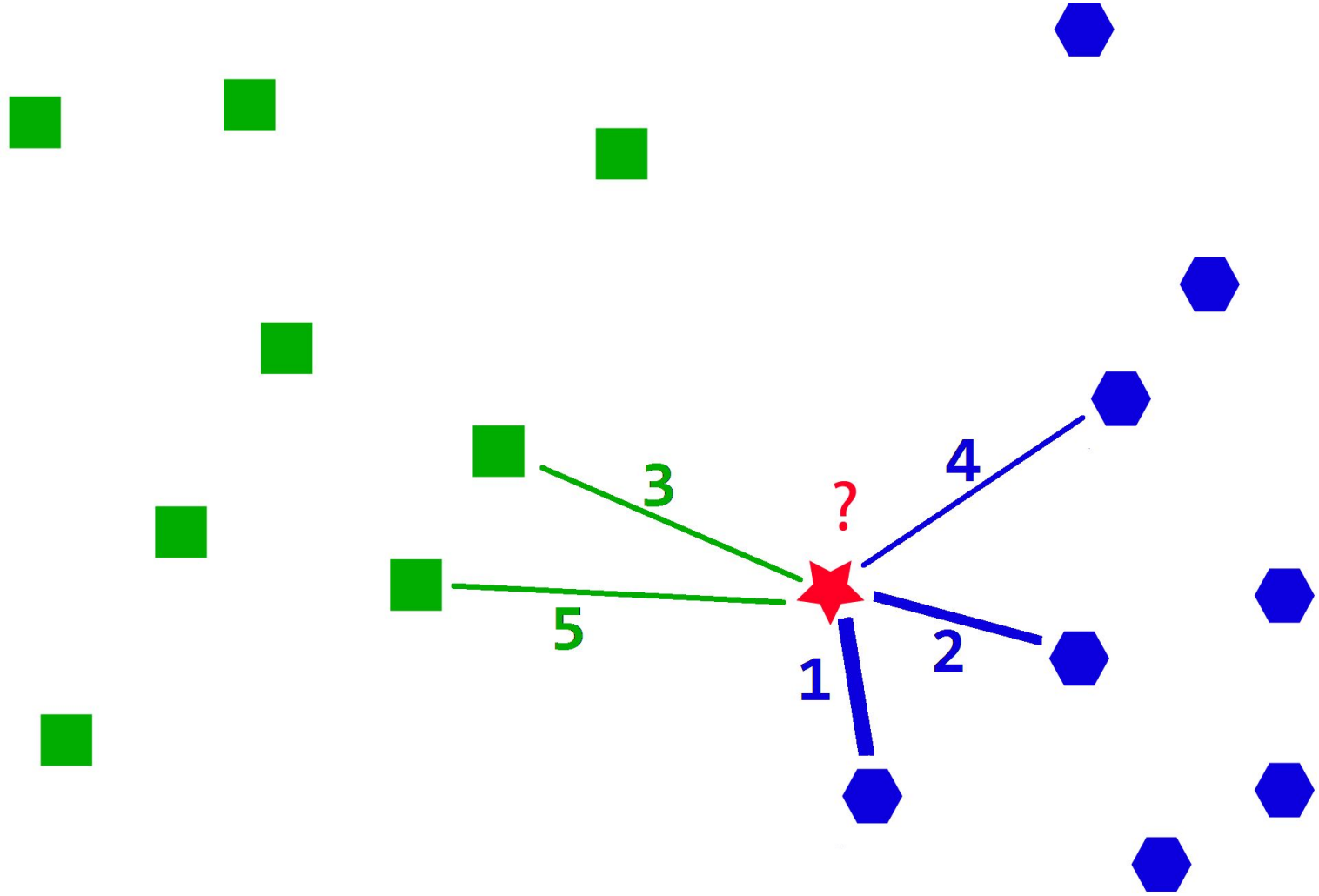
Machine learning

Machine learning, ML — learning [functions] from precedents (cases), from experience. The aim of ML mathematics — restore complex **functions** with minimal error.

Most of ML problems are from these 3 groups:

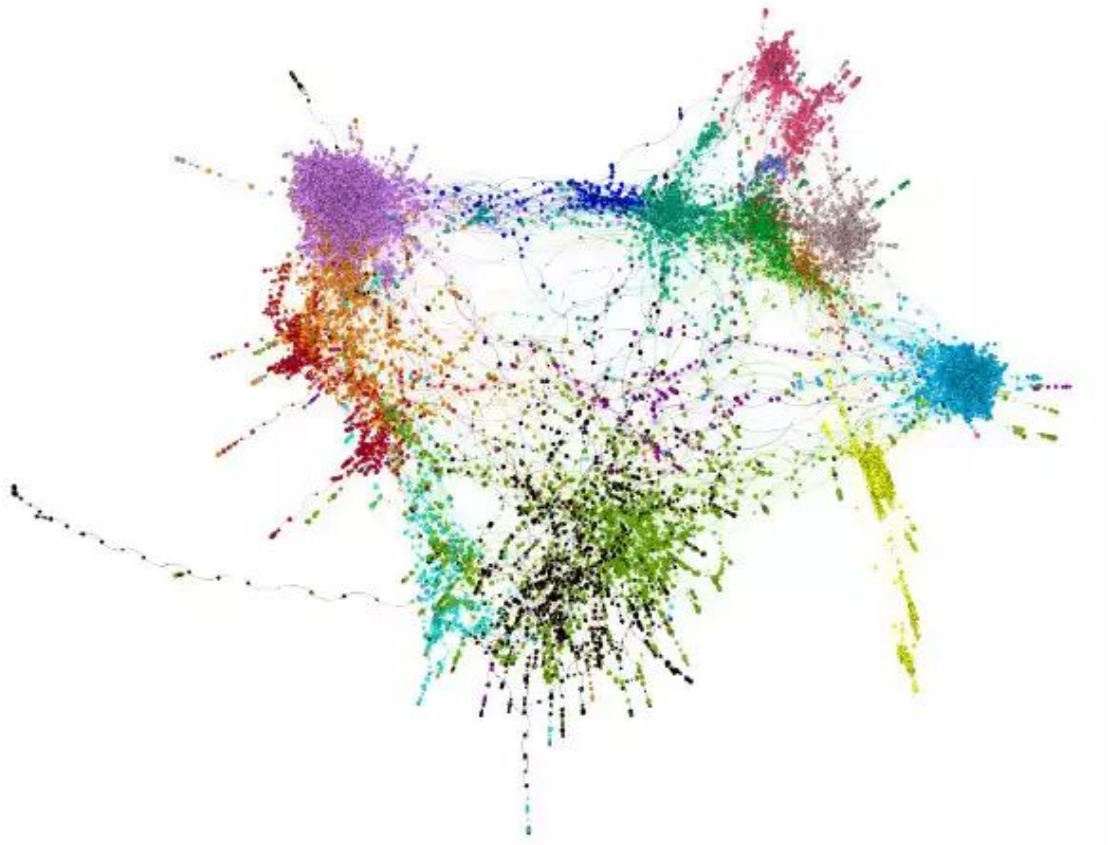
- **Classification** (including 1-class)
- **Clustering**
- **Dimensionality reduction,** including
  - *regression*
  - data dimensionality reduction
  - representation learning: example

Classification:
k nearest neighbors



Clustering: graph connectivity

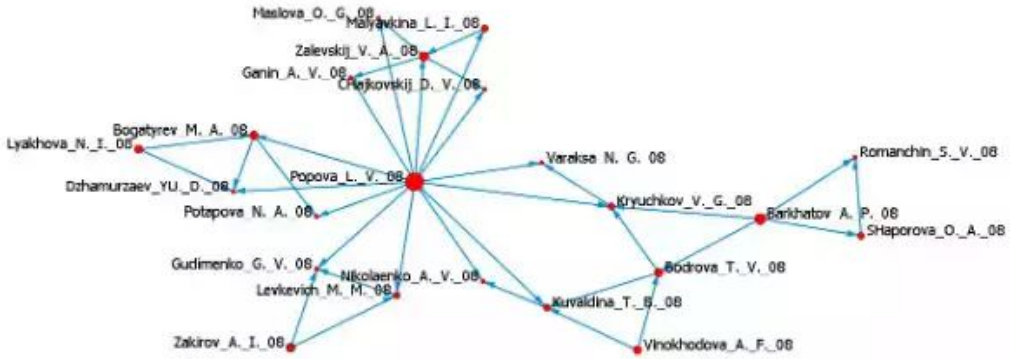
http://polit.ru/article/2016/03/20/safonova_sokolov/

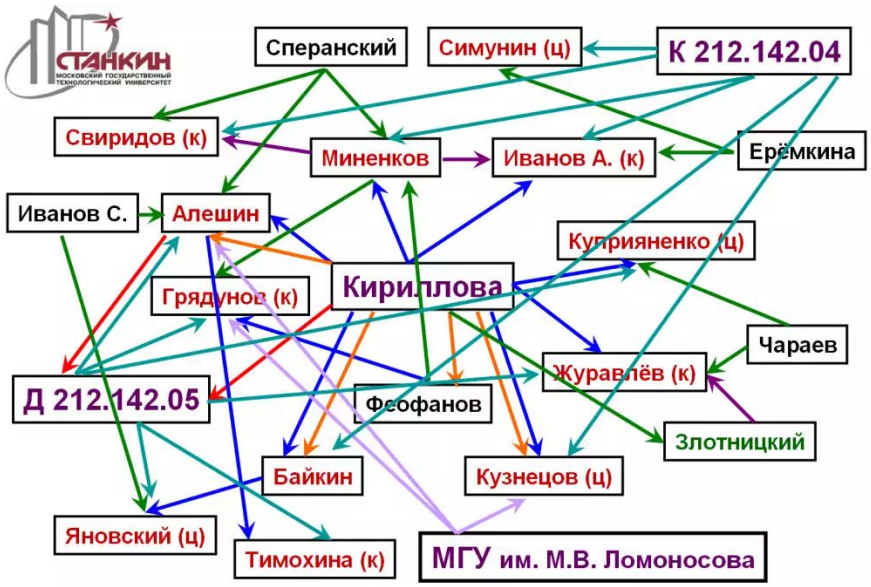


Clustering: graph connectivity

https://www.dissernet.org/publications/livejournal_mv_4s5.htm

1. Орловские экономисты

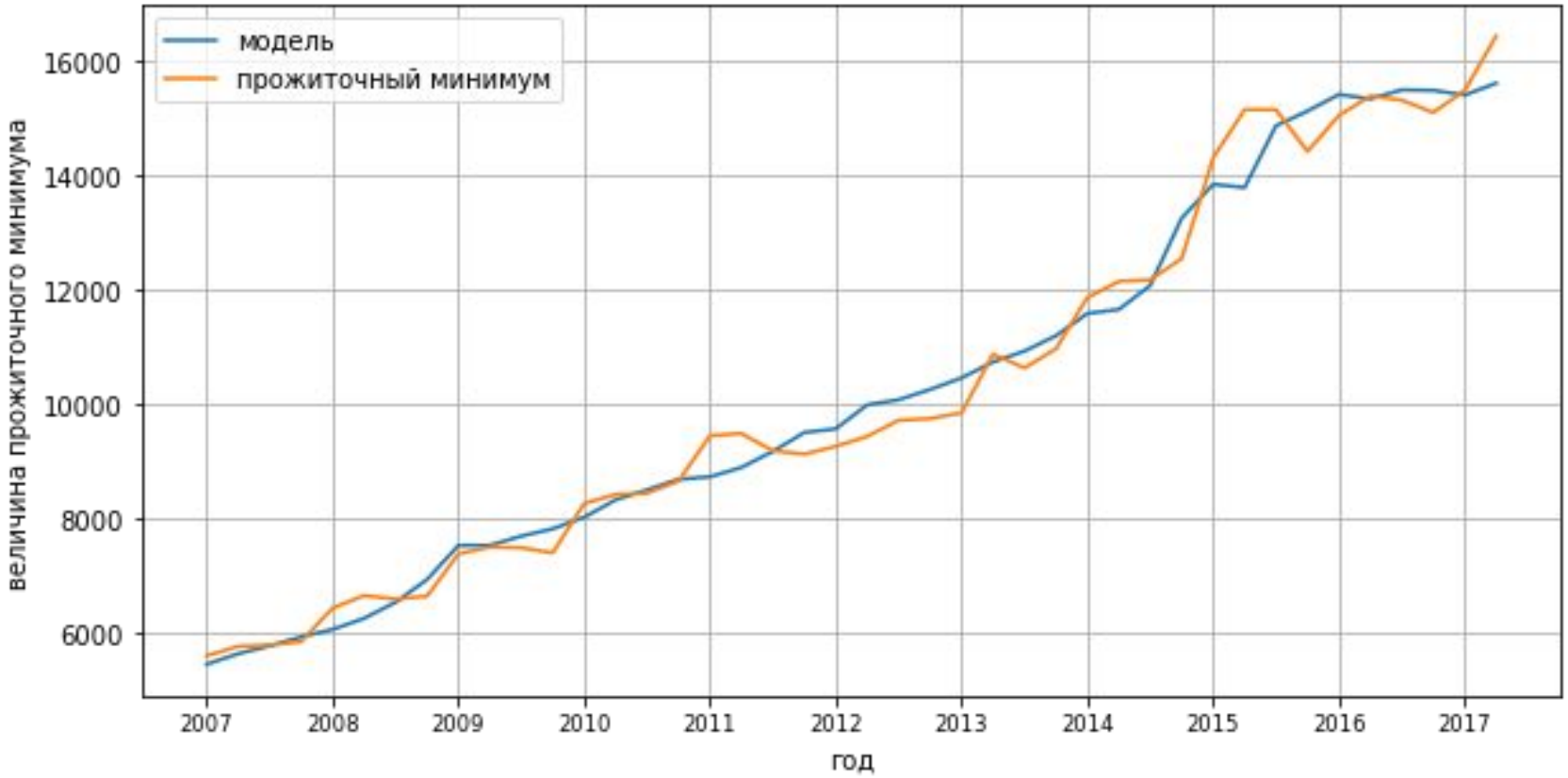




Regression: least squares method

$$\hat{\boldsymbol{\beta}} = (X^T X)^{-1} X^T \boldsymbol{y}.$$

Living wage = 2.13*(year-2007) + **70.36*[₽/$]** + 3632.47



Machine learning

Machine learning generally requires to run lots of **similar operations** over training data.

GPGPU — using GPU for massive parallel computations (NVidia CUDA)

Intel Nervana NNP, Google TPU — specialized chips for training [deep] ANNs (optimized for tensor computations)

https://youtu.be/40riCqvRoMs

AI and ML marketing

- **AI as a product:**
  - Trading bots
  - Speed cameras
- **AI as a service** (model serving):
  - Wolfram|Alpha
  - AmazonAI
  - IBM Watson
  - Chat bots, smart assistants
- **ML as a service** (framework/architecture serving):
  - GoogleML
  - Azure
- **ML as s product**:
  - Caffe, Torch
  - TensorFlow
  - CatBoost

Class task #2. Machine learning

Play the game in pairs (nim): You have **N <= 20 stones**. Each player should grab 1-4 stones at the move. Player who grabs **the last stone loses**. Let's train AI to play this game!

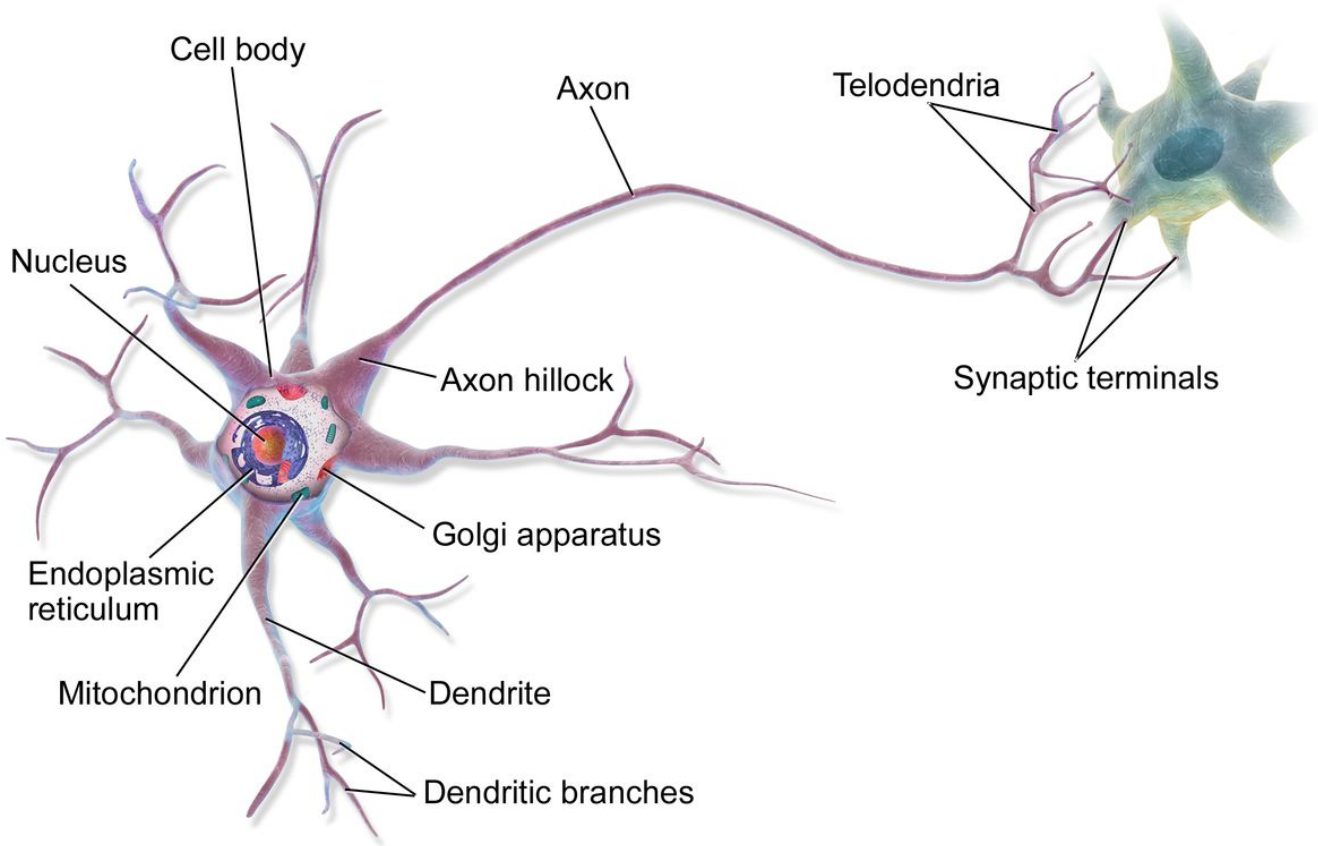
Select random N from [1, 20]. Play in pairs 2-3 rounds and write results on the whiteboard:

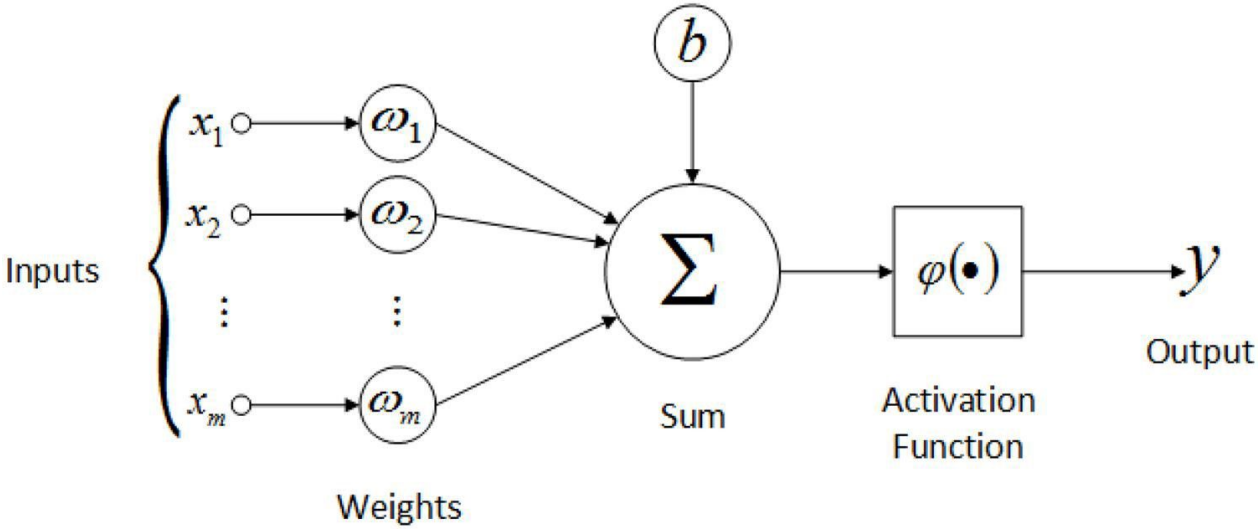
```
[N] [first move] [N mod 5] [first wins/loses]
```

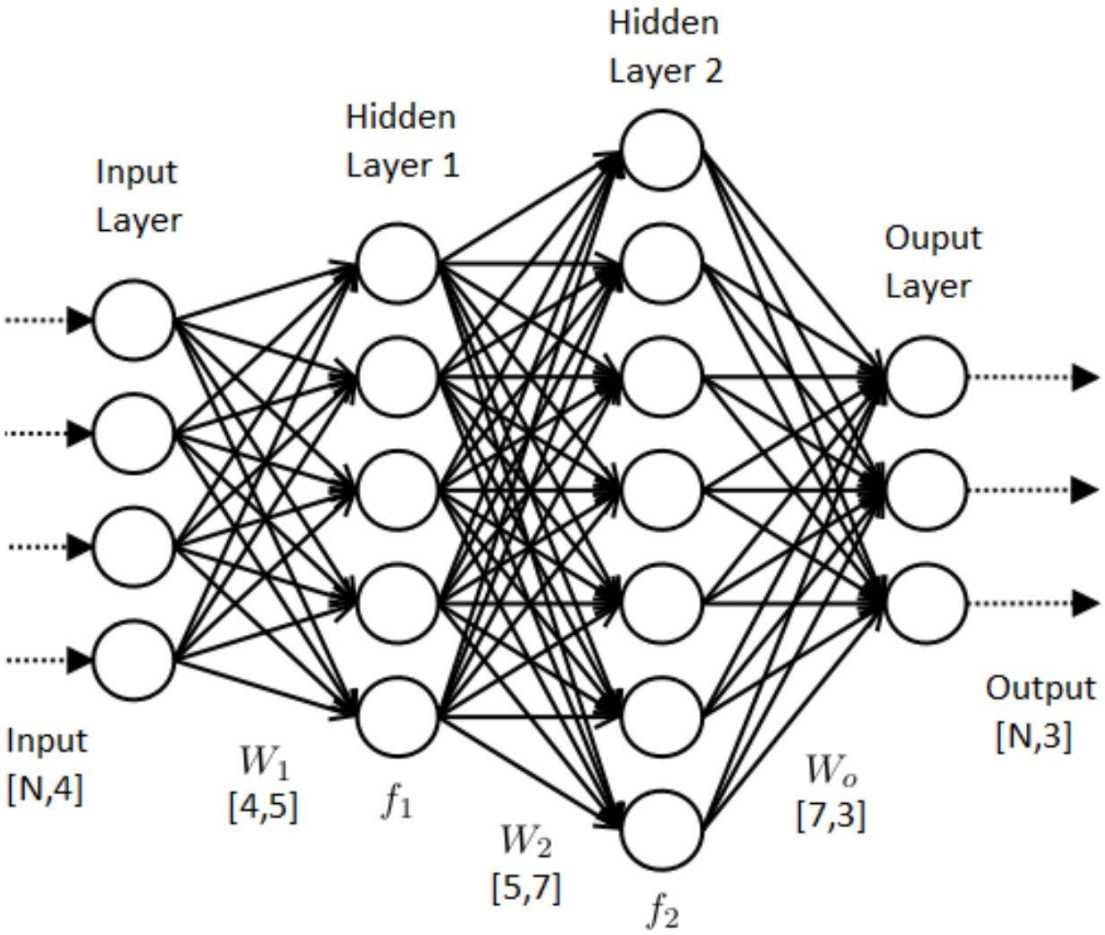
E.g.

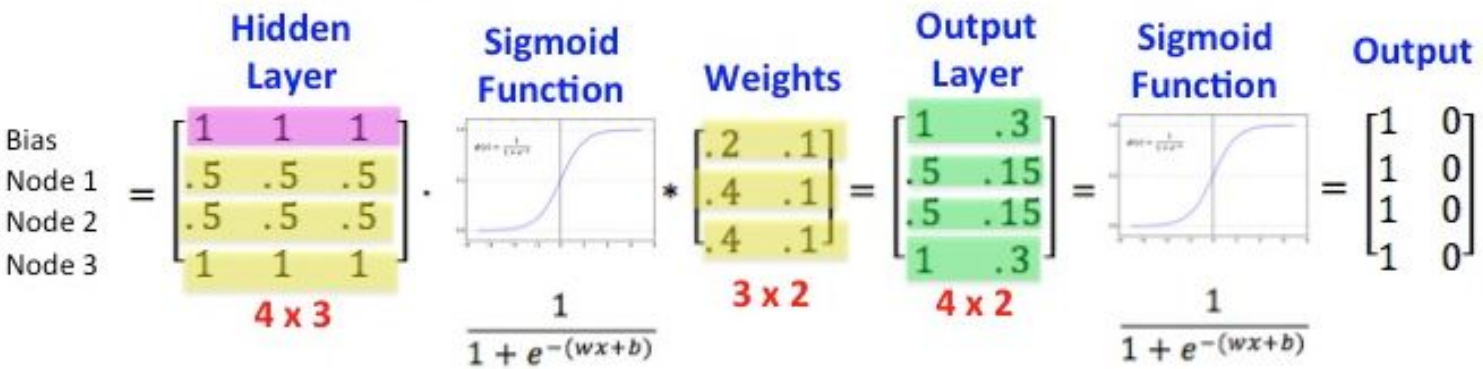
```
1 1 1 loses

2 1 2 wins
```

Neural and “neural” networks


Cell body
Axon
Telodendria
Nucleus
Axon hillock
Synaptic terminals
Golgi apparatus
Endoplasmic reticulum
Mitochondrion
Dendrite
Dendritic branches


b
x1
x2
xm
ω1
ω2
ωm
Inputs
Σ
φ(•)
y
Output
Sum
Activation Function
Weights


Hidden
Layer 2
Hidden
Layer 1
Input
Layer
Ouput
Layer
Input
[N,4]
W_1
[4,5]
f_1
W_2
[5,7]
f_2
W_o
[7,3]
Output
[N,3]


Hidden Layer
Sigmoid Function
Weights
Output Layer
Sigmoid Function
Output
Bias
Node 1
Node 2
Node 3
4 x 3
3 x 2
4 x 2
$\frac{1}{1+e^{-(wx+b)}}$

Biological and non-biological intuitions behind ANNs

Biological

- MacCulloch-Pitts model (1 neuron)
- Perceptron (connections, layers, specialization)
- Convolutions (visual cortex)
- Recurrent networks (feedback connections - good for sequence processing)

Non-biological

- Parallelism (not asynchronous)
- No in-cell memory
- GAN (generative adversarial networks)
- Very deep networks
- Repeating blocks (Google Inception)
- Autoencoders

Neuromorphic computing and chips

ANNs implement basic intuitions about how brain works, but their architecture is not necessarily inspired by brain

Neuromorphic computations — building [*analog*] systems that are similar to brain. Major task is to fully emulate brain (projects exploiting this idea: Human Brain Project, Blue Brain Project, BRAIN)

Neuromorphic chips — digital and analog systems, which can be used as building blocks for neuromorphic computations

- Memristor chips
- SpiNNaker — spiking ANNs built upon ARM CPUs
- IBM TrueNorth, Intel Loihi — neuromorphic chips
- BioDynaMo — cloud neuromorphic computing

Social consequences

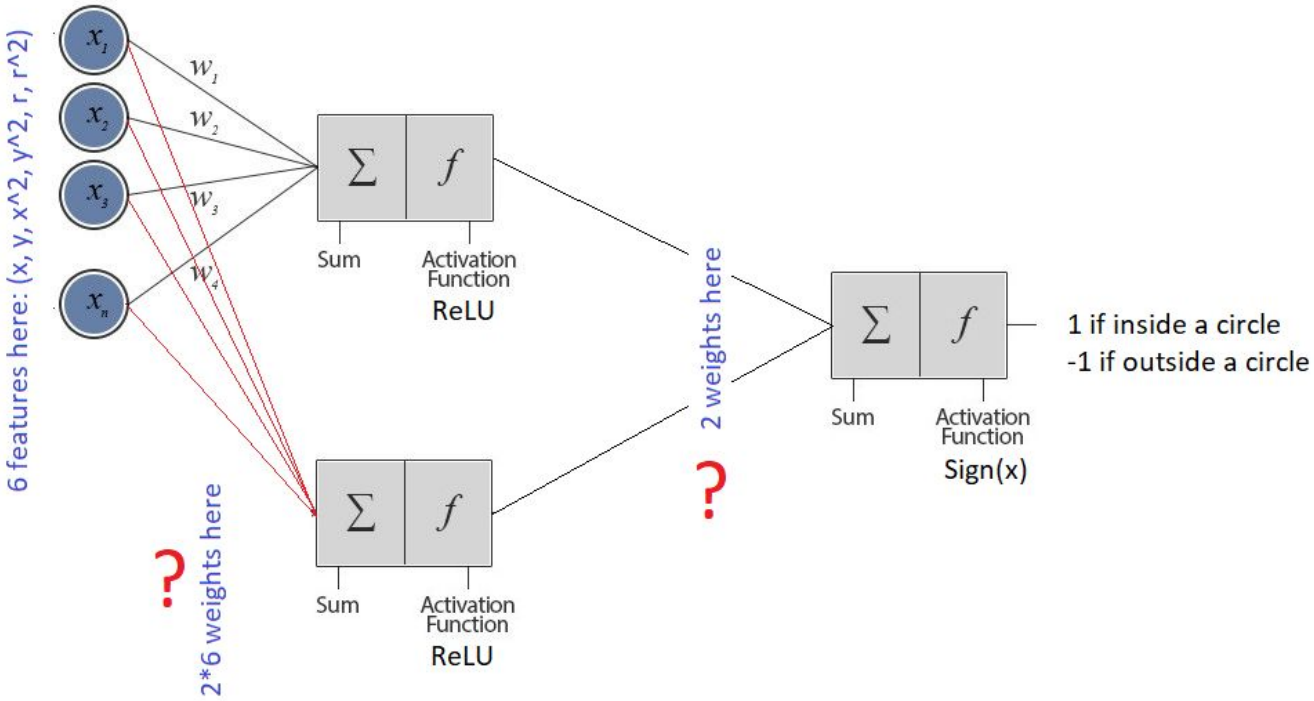
- AI **replaces** people
  - Traffic police
  - Salesmen, personal assistants
- **Breaks privacy**
  - Advertisement technologies (targeting)
  - Passive identification (FindFace)

———————-

- AI **improves** people
  - Centaur chess
  - Traders
  - Medical expert systems
- ML **creates jobs** in data markup
  - Amazon Mechanical Turk (ImageNet)
  - Assessors, Yandex.Toloka
- AI **creates new jobs**

Lab #3. Small ANN

This ANN classifies (x,y)-points into 2 classes: inside and outside a circle of radius R. It says “1” if point is inside and “-1” if point is outside. Find 14 numbers :)



Hometask

1. Follow some links in the slides
2. Watch this video: https://go.ted.com/CdFD
3. Read this article https://www.sciencemag.org/news/2018/07/computer-programs-can-learn-what-other-programs-are-thinking
   Find a source. Write **0.5-1-page report**, where you answer following questions:

- What **actually** was done?
- What was the **experiment** (with numbers and results)?
- What **ideas from ToM** were used?
- What is the **solution architecture**?

It is prohibited to use words “Artificial Intelligence”

Submit your texts here
https://github.com/str-anger/hsu.ai/tree/master/homeworks/01