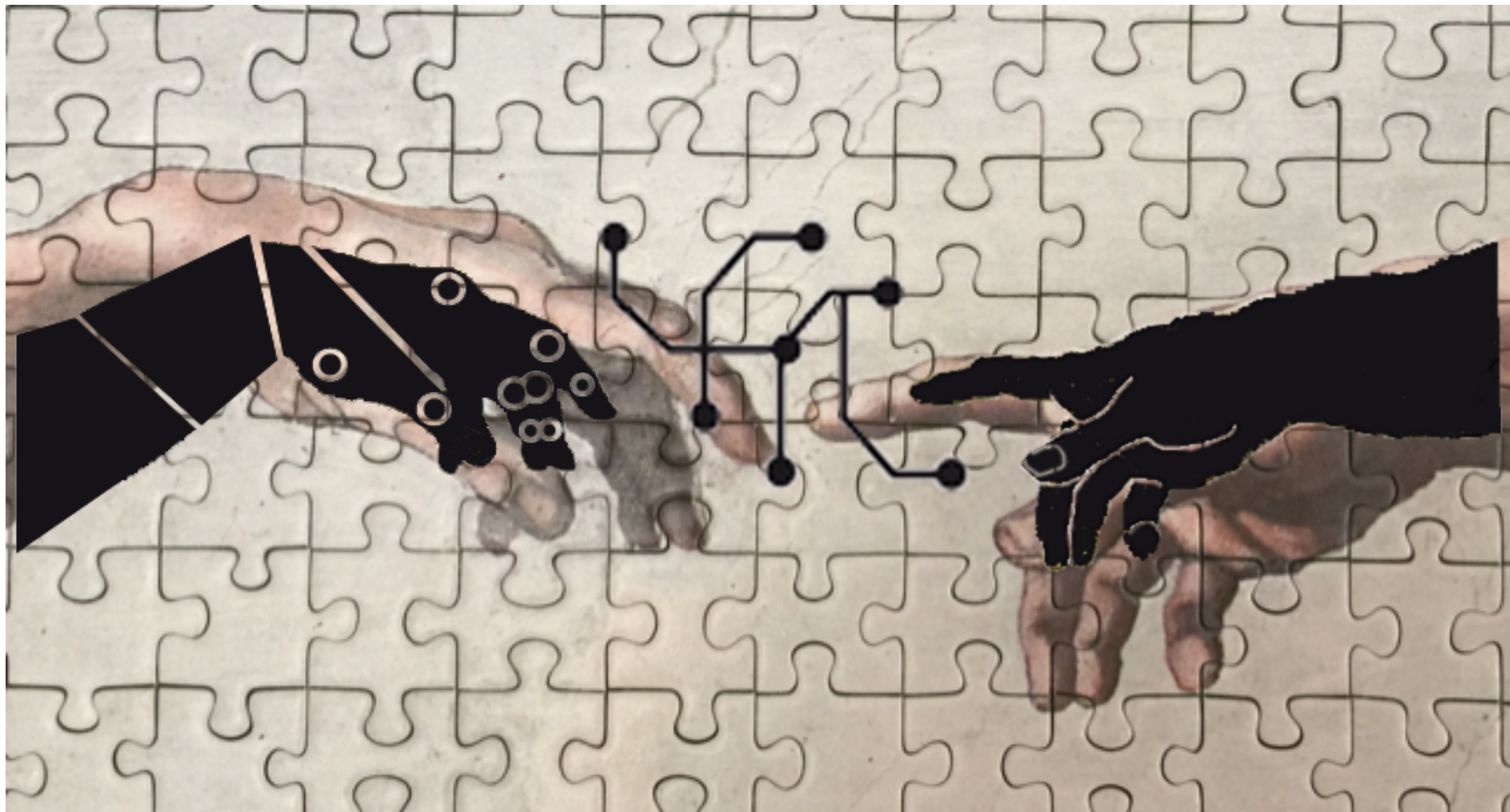
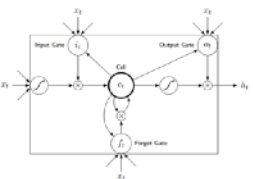


AI Artificial Intelligence +

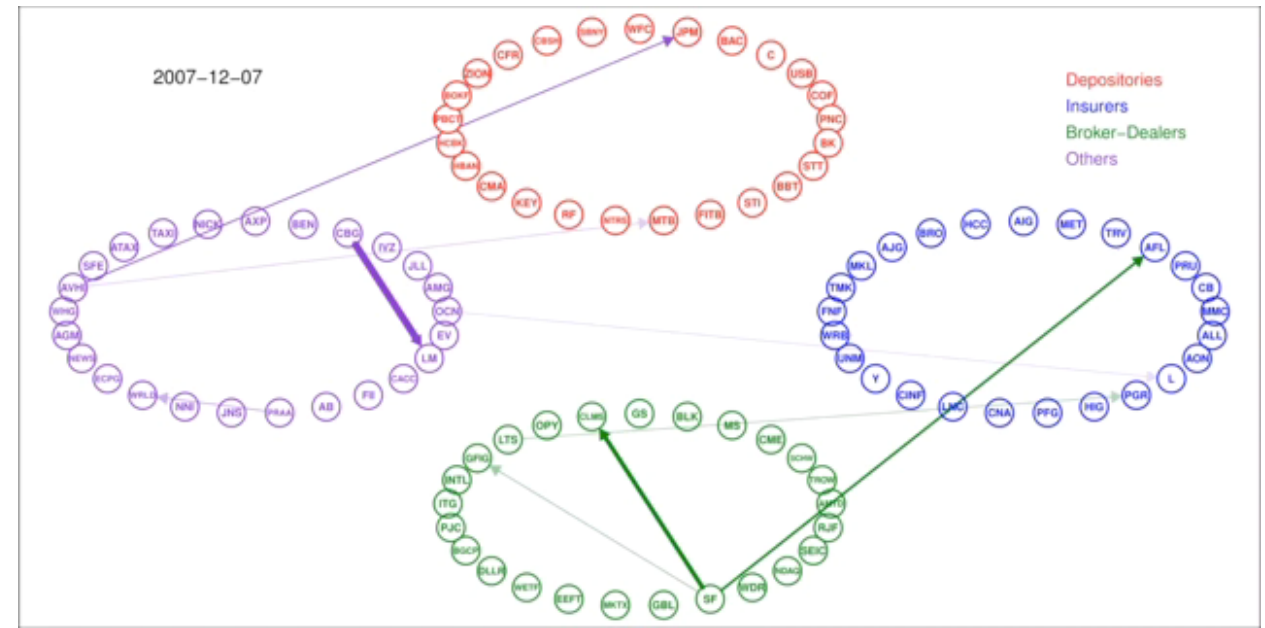
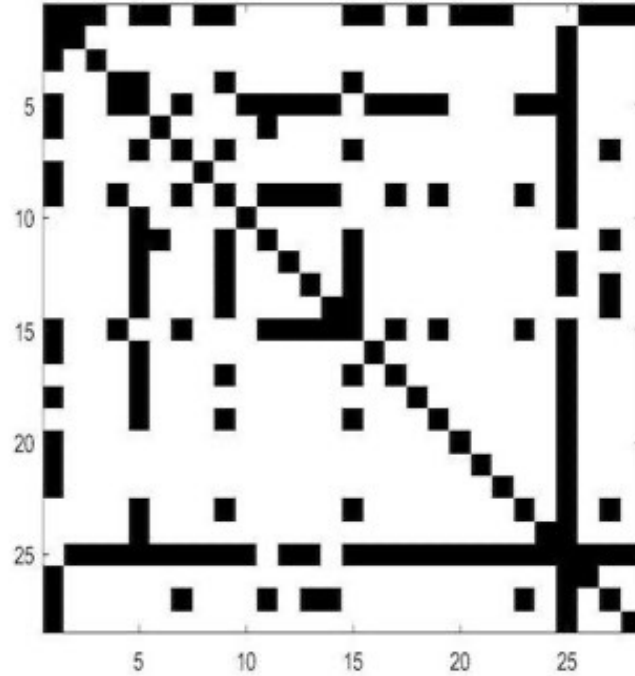


The future of AI?

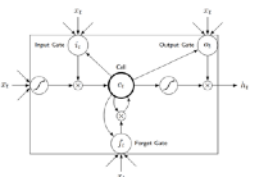




Micro to Macro



- ▣ AI technologies connect, empower and expose individuals
- ▣ Dynamic interactions ask for smart data science
- ▣ Digital society creates new economic opportunities

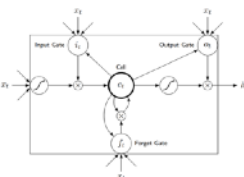
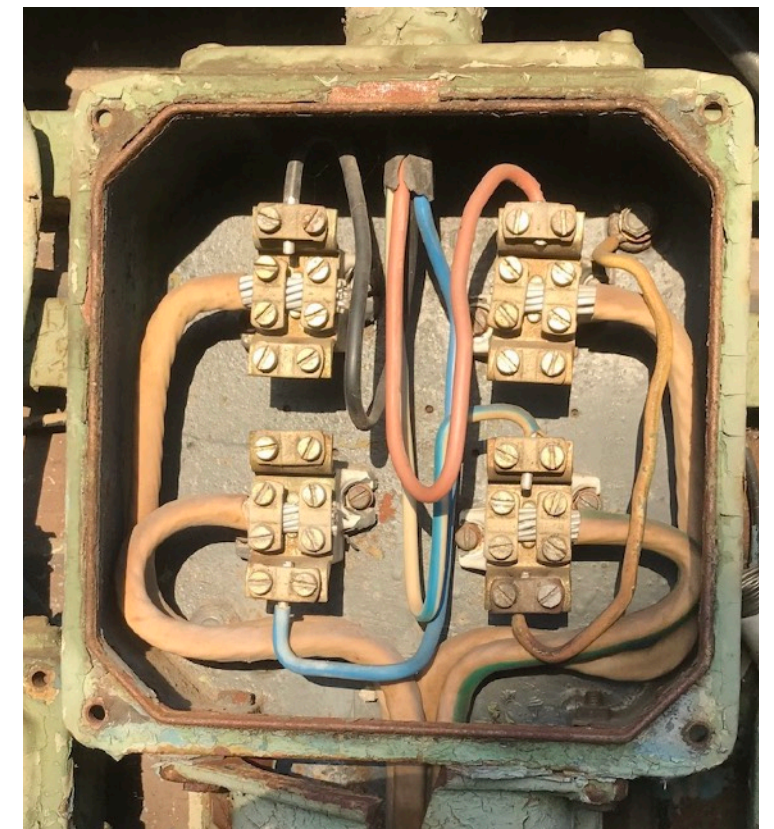


Basic element of Artificial Intelligence

...is a buzzer or a switch!



Combined with other switches ...

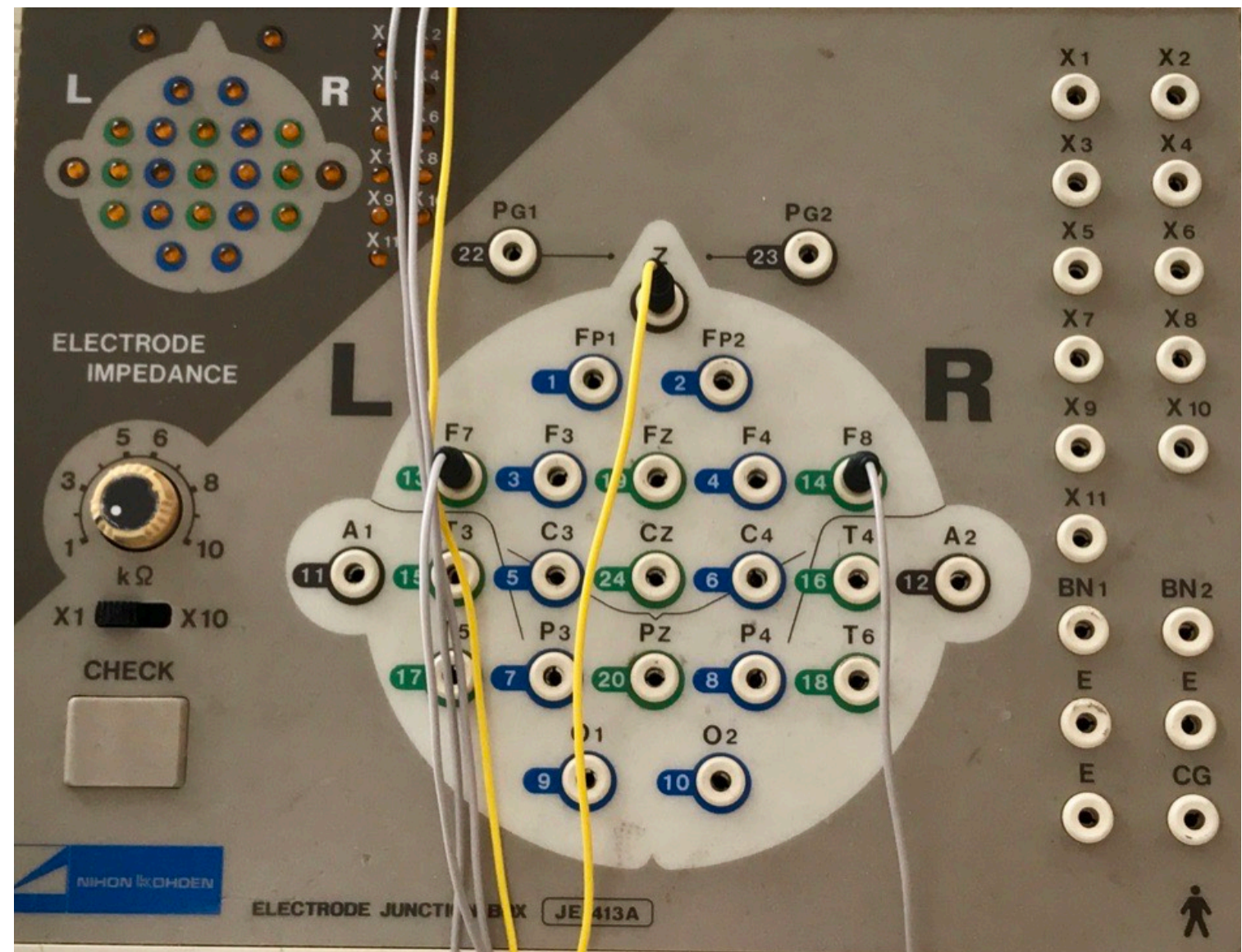


Basic elements combined

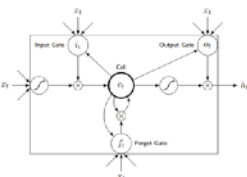
...it can do complex stuff!

...like recording an EEG

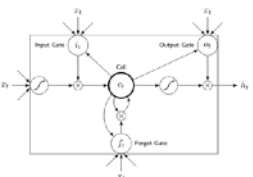
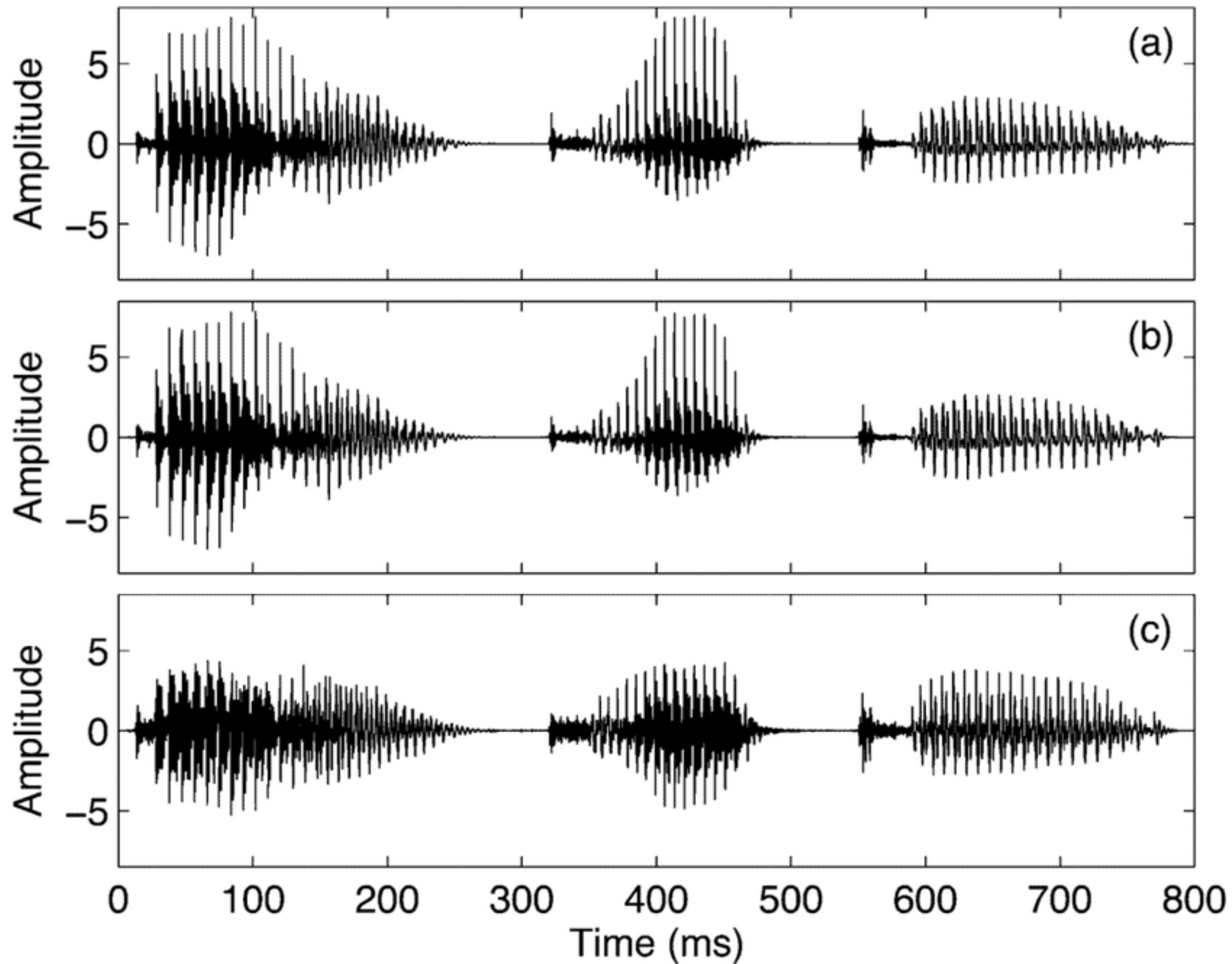
...classifying it



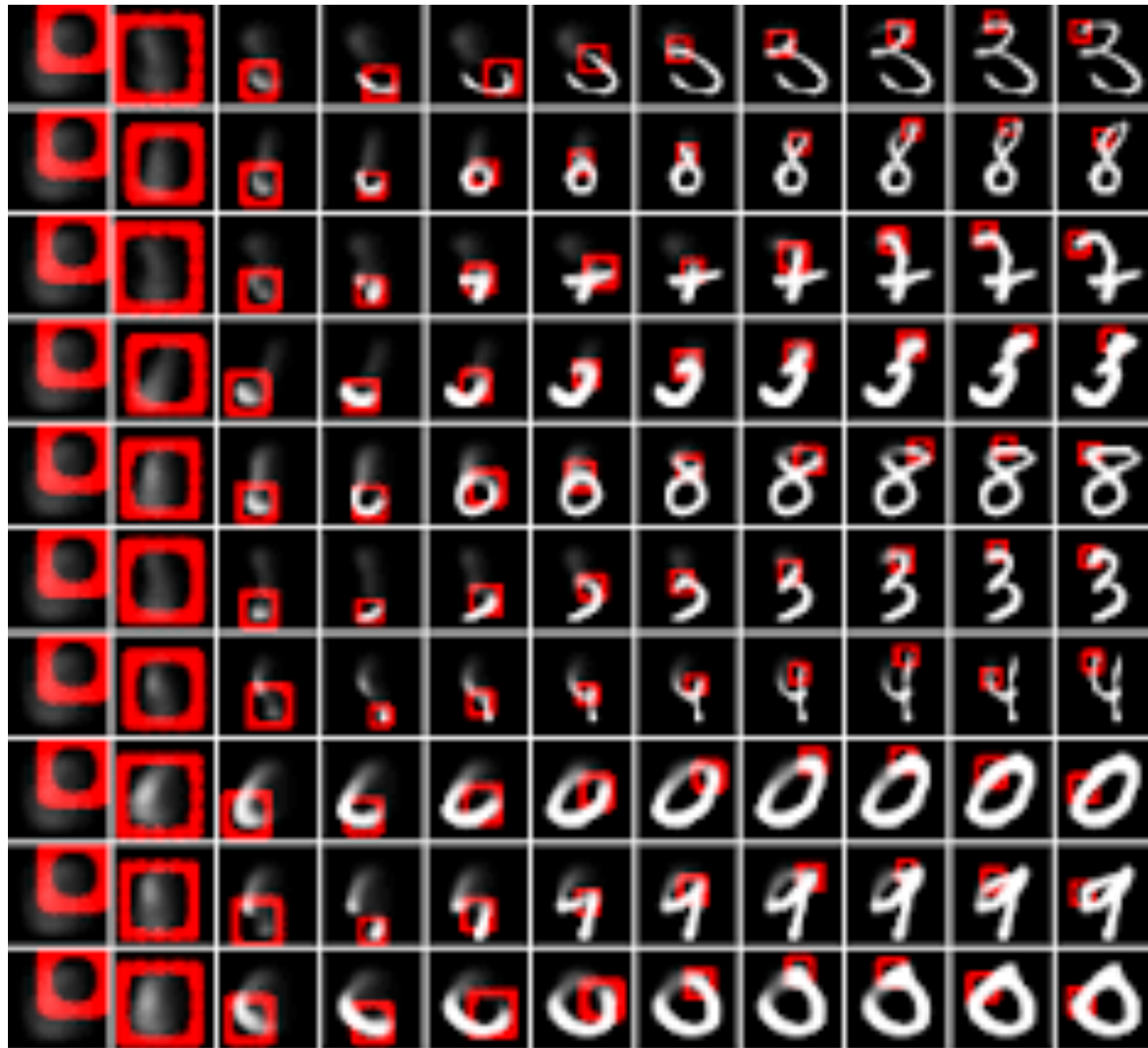
...and propose diagnostic follow ups!



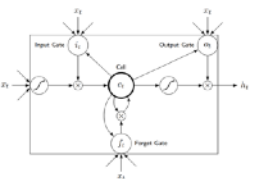
AI is good at: EEG, speech, handwriting, ...



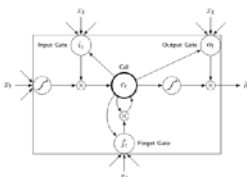
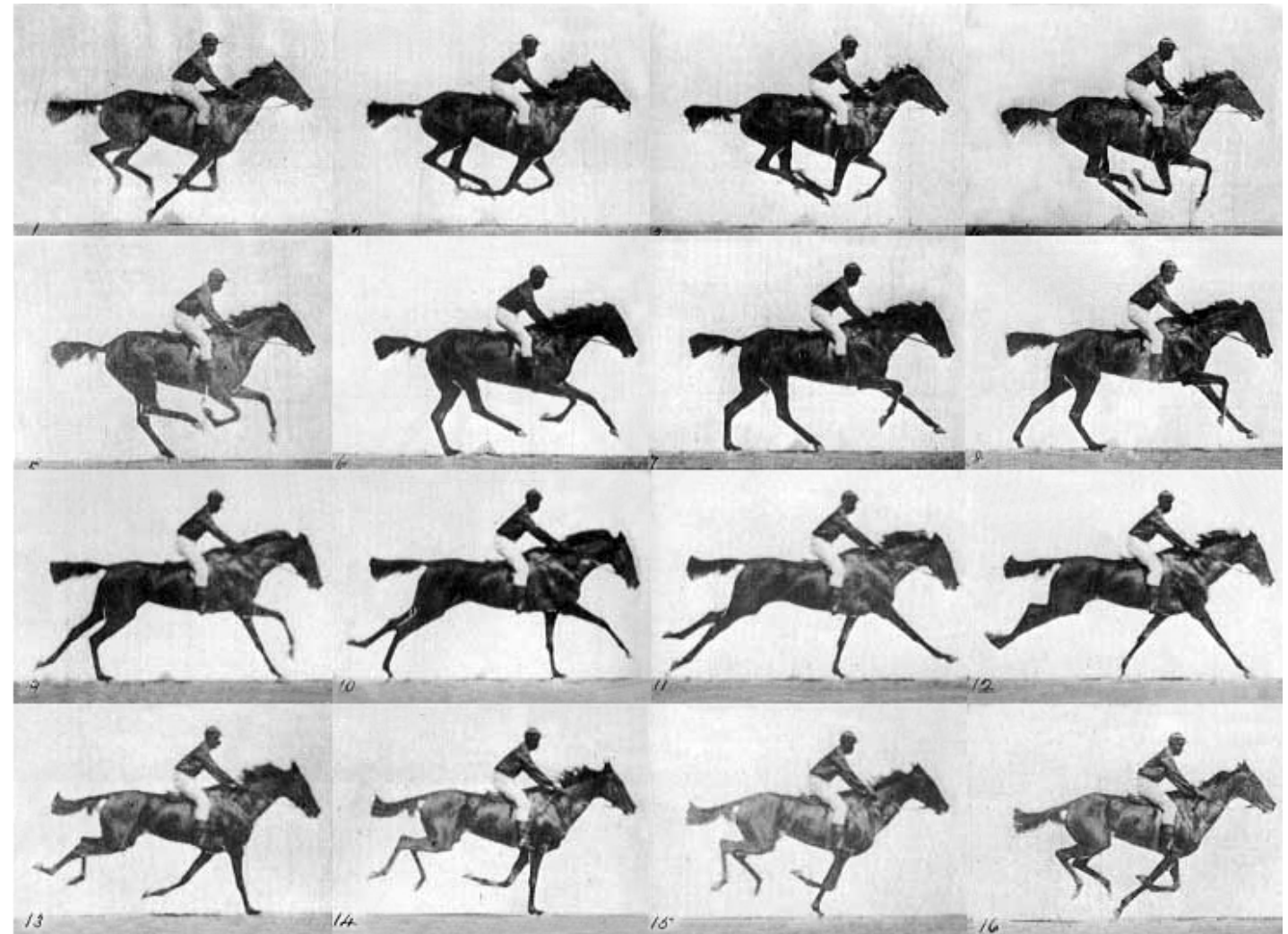
AI is good at: speech, handwriting, moves, ...



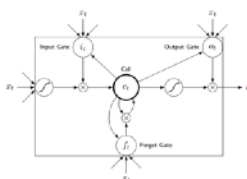
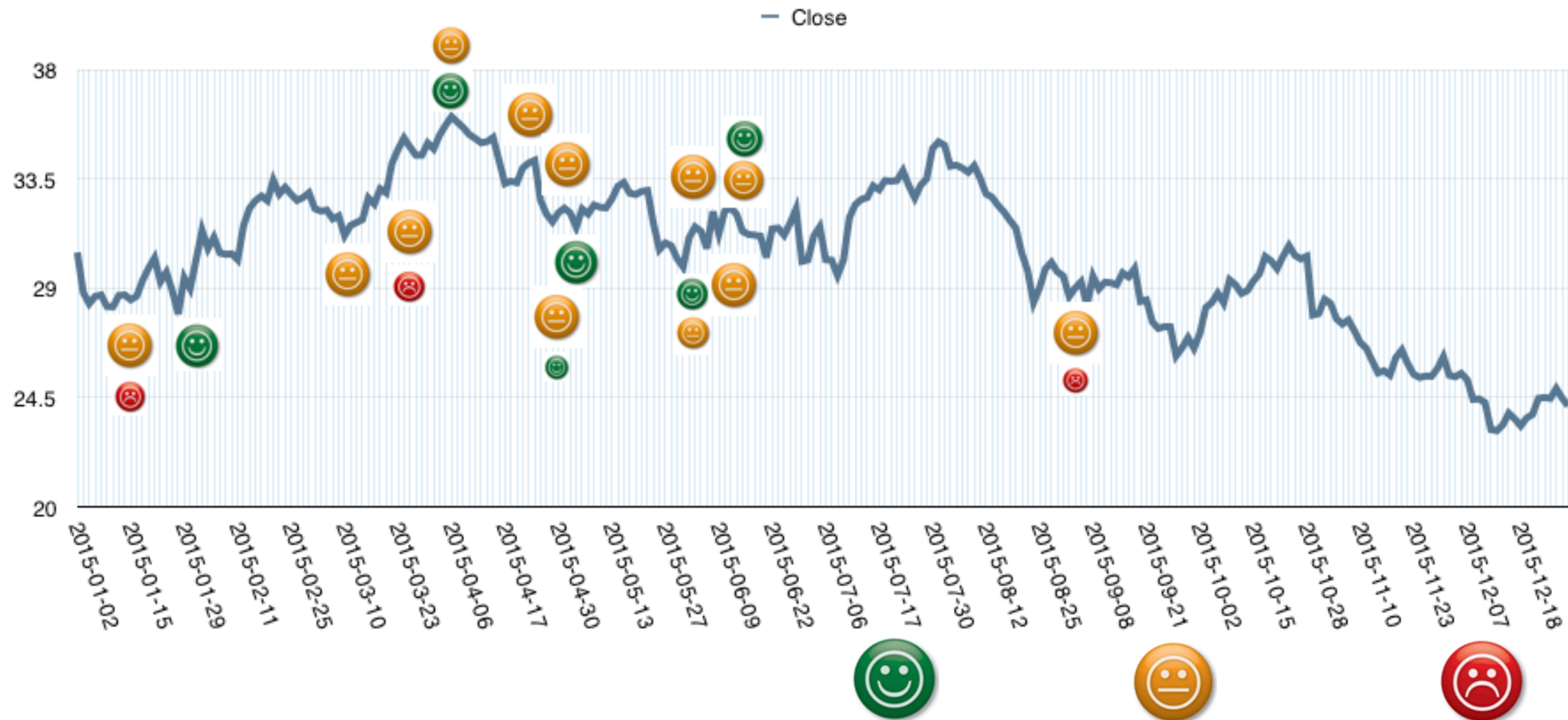
A trained DRAW network generating MNIST digits:
Each row shows successive stages in the generation of a single digit



AI is good at: moves, x-rays, faces, ...



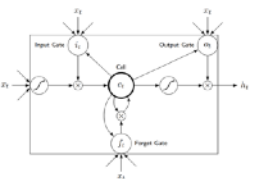
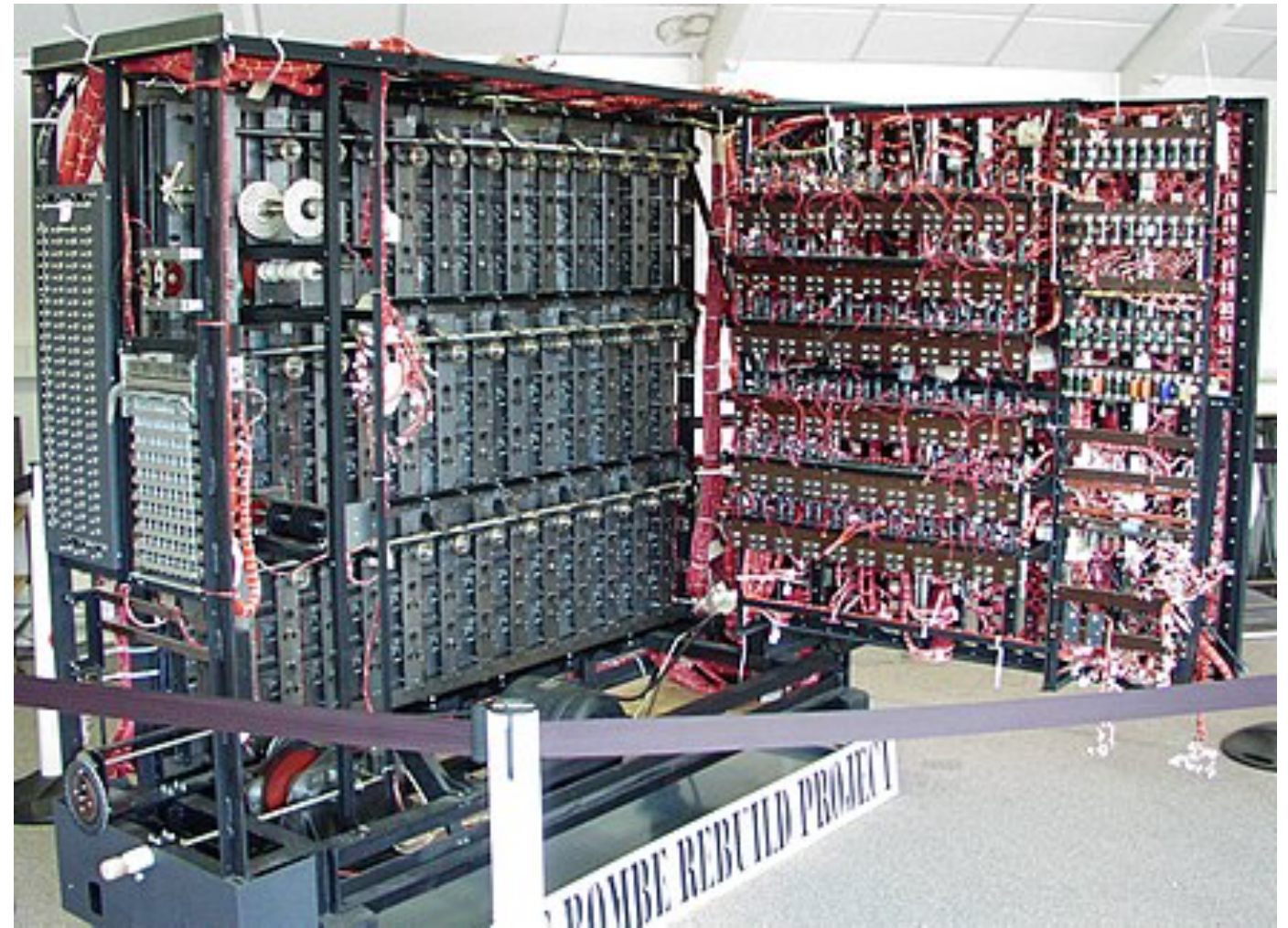
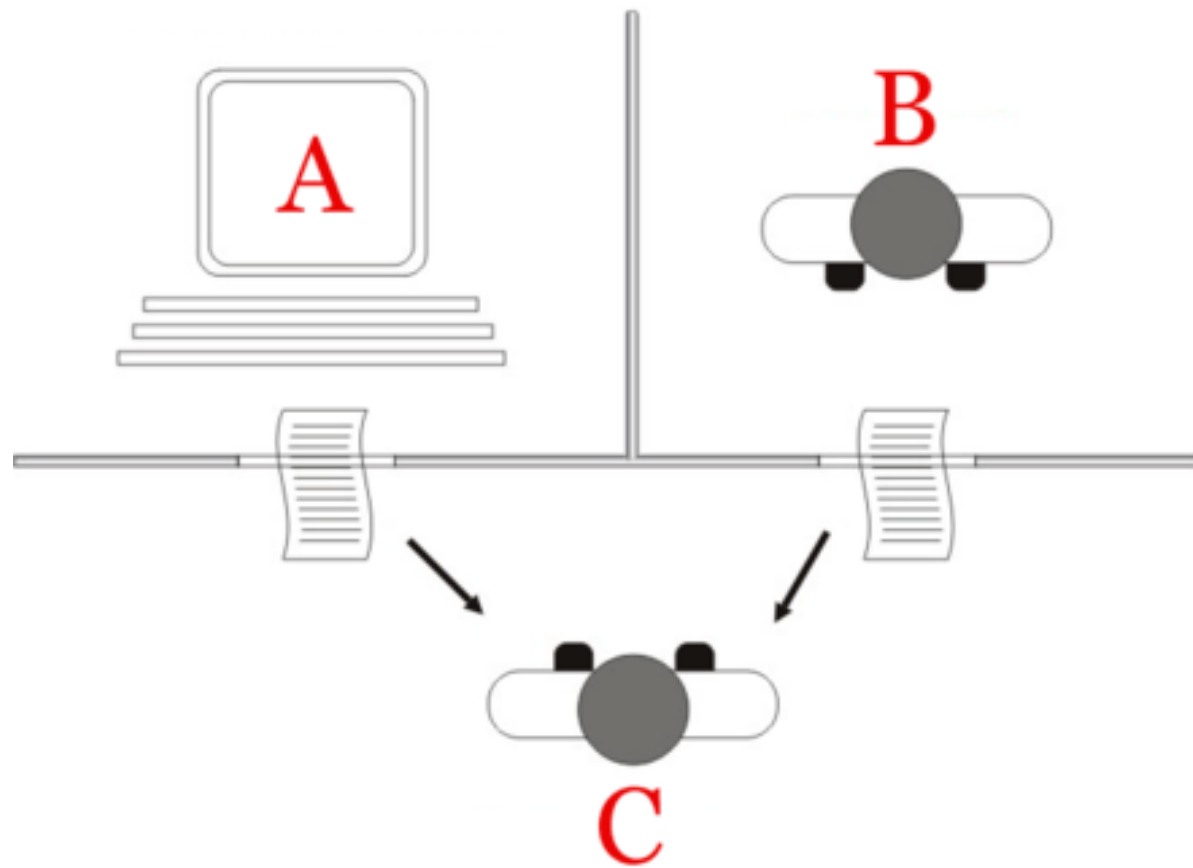
AI is good at: x-rays, face values, birds, ...





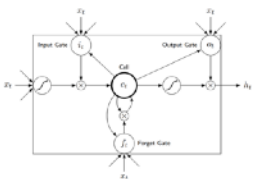


AI is not human: Turing Test



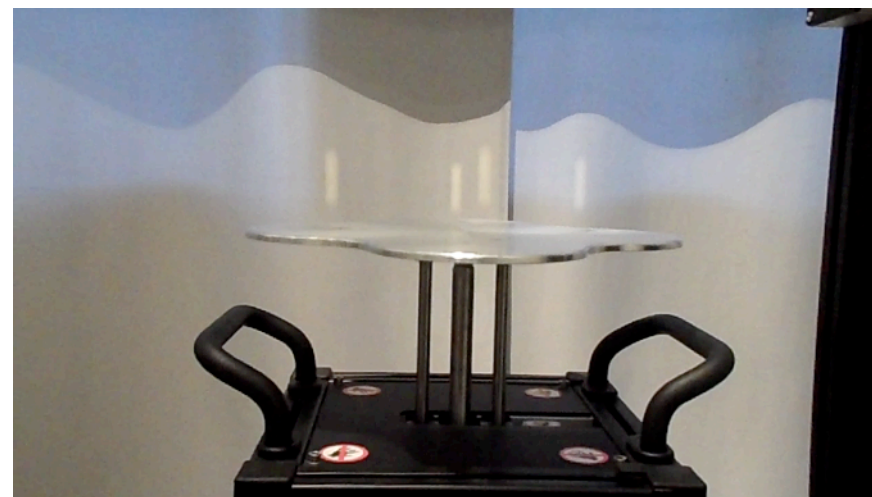
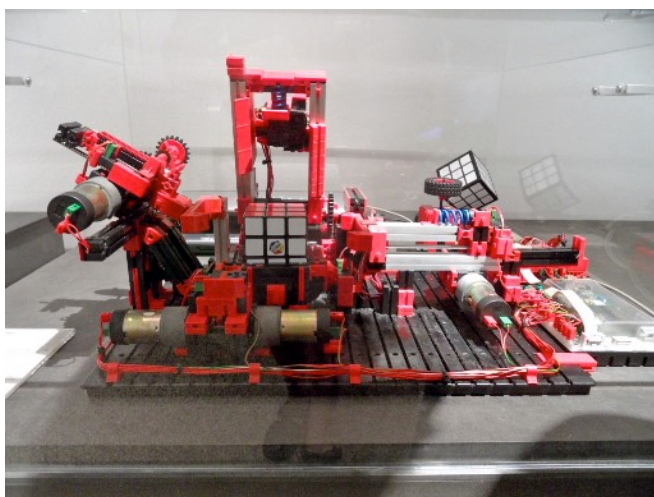
Outline

1. Motivation ✓
2. AI applications
3. AI Details
4. AI -> ?
5. References



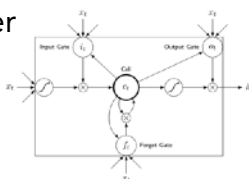
ML Machine Learning an old idea !

semi-supervised learning **overfitting** stochastic gradient descent **SVM** *Q learning*
 Gaussian processes **deterministic noise** data snooping learning curves
distribution-free linear regression VC dimension mixture of experts
 collaborative filtering **decision trees** nonlinear transformation **sampling bias** neural networks no free lunch
 active learning RBF training versus testing noisy targets Bayesian prior
 ordinal regression linear models bias-variance tradeoff weak learners
 ensemble learning cross validation logistic regression **data contamination**
 exploration versus exploitation error measures types of learning perceptrons hidden Markov models
 kernel methods graphical models
 is learning feasible? soft-order constraint
 clustering regularization weight decay Occam's razor Boltzmann machines



work.caltech.edu/library/181.html

W Phillips (curve), hydro engineer/economist, MONIAC
 Monetary National Income Analogue Computer



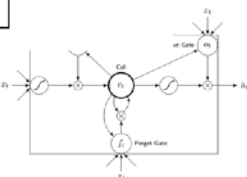
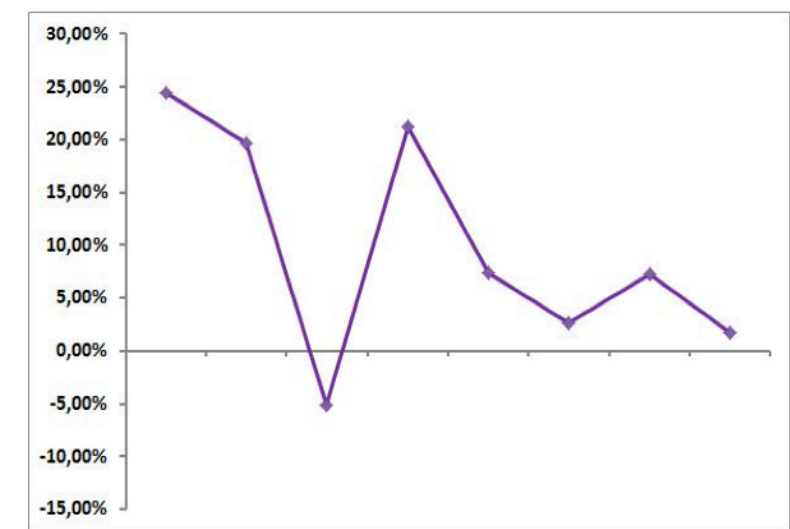
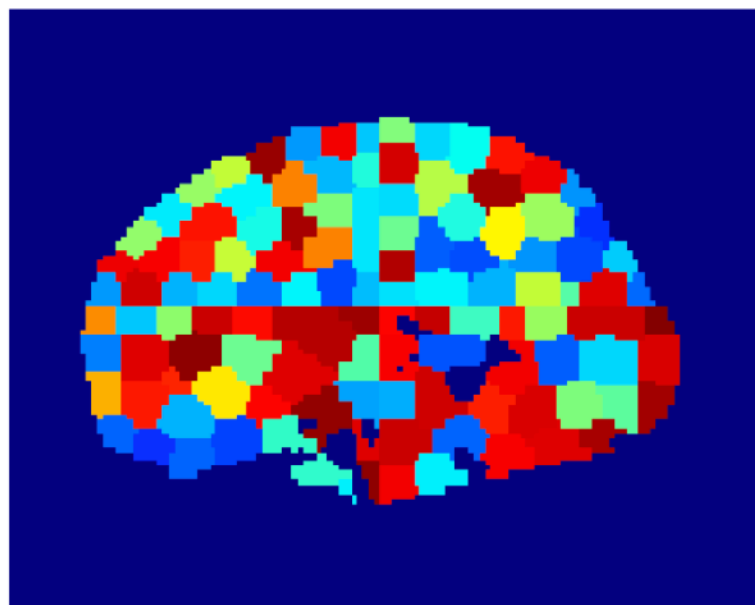
Risk Perception

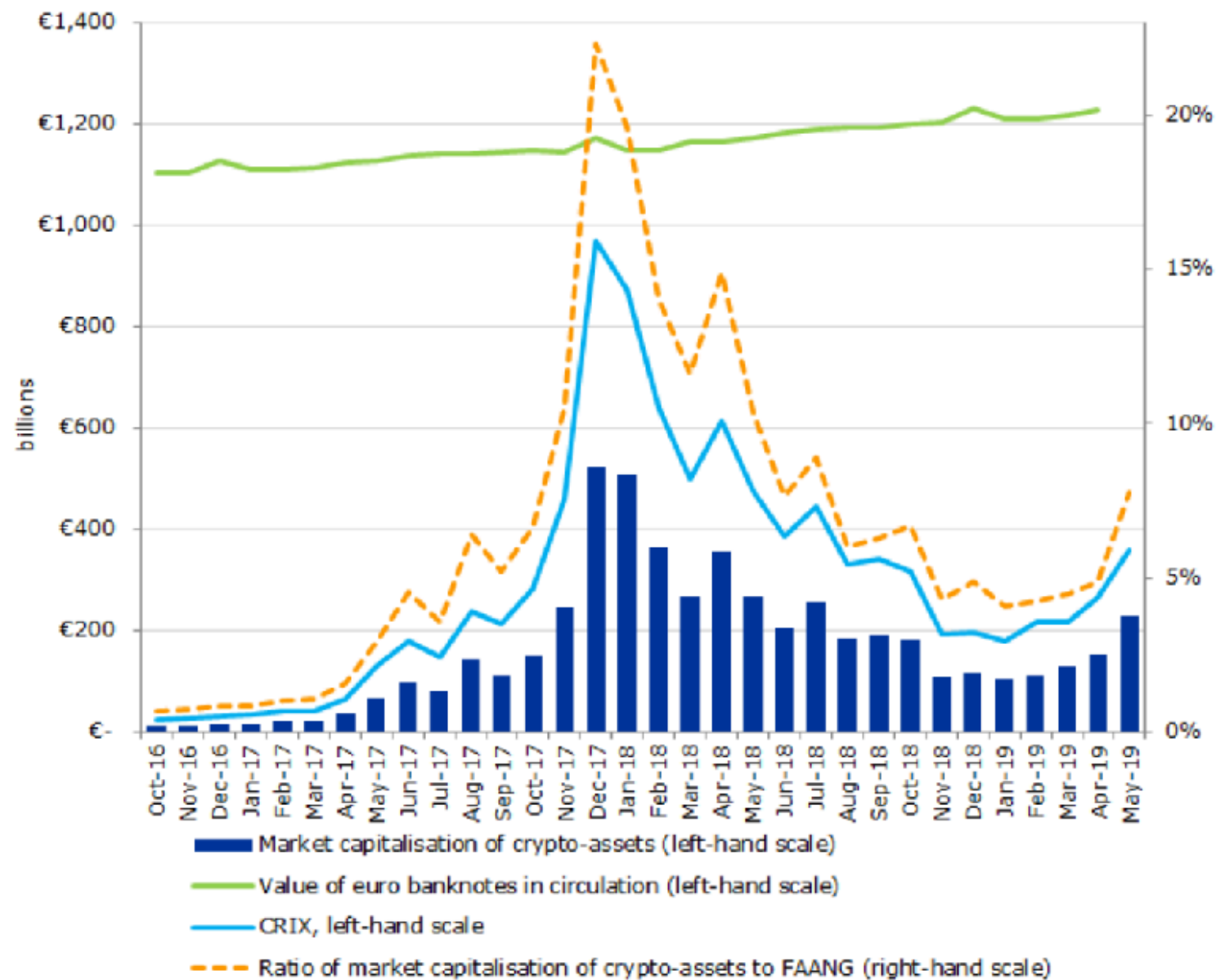
- ▣ RMI brain records 1M data points per 2 sec
- ▣ RMI on RPID tasks correlates with RP
- ▣ Stationary inputs, AI copies your RP!



bull?

Chen Y, Härdle WK, Qiang H, Majer, P (2018)
Risk Related Brain Regions Detected with 3D Image FPCA, Statistics and Risk Modeling,

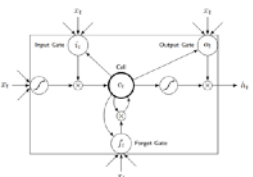




royalton-crix.com,



- ▣ CRYPTOCURRENCY INDEX / **CRIX**
- ▣ An ECB benchmark index
- ▣ Used by ETFs and Investment funds

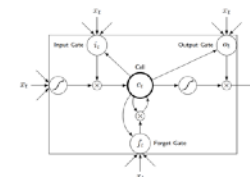


The unstoppable rise of robo-advisors

- ▣ Online, automated portfolio management service
- ▣ Based on risk tolerance and time horizon select investments
- ▣ Automatic portfolio rebalancing, tax-loss harvesting
- ▣ Translates into higher net returns for investors.
- ▣ FT (2016) estimates the market grows to \$16.3 trillion worldwide



Figure 3: Quarterly returns of CRIX (blue), LSTM (green) and RNN (orange) portfolios



Predictive Policing

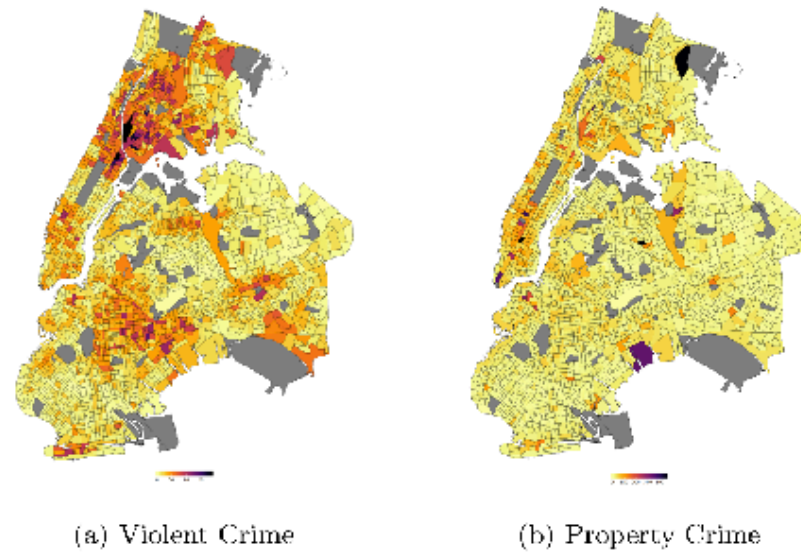


Figure 1: Number of crime incidents between June and November 2015. In the property crime map, the area around Penn Station (largest outlier with 2002 incidents) is excluded for more consistent colour scaling.

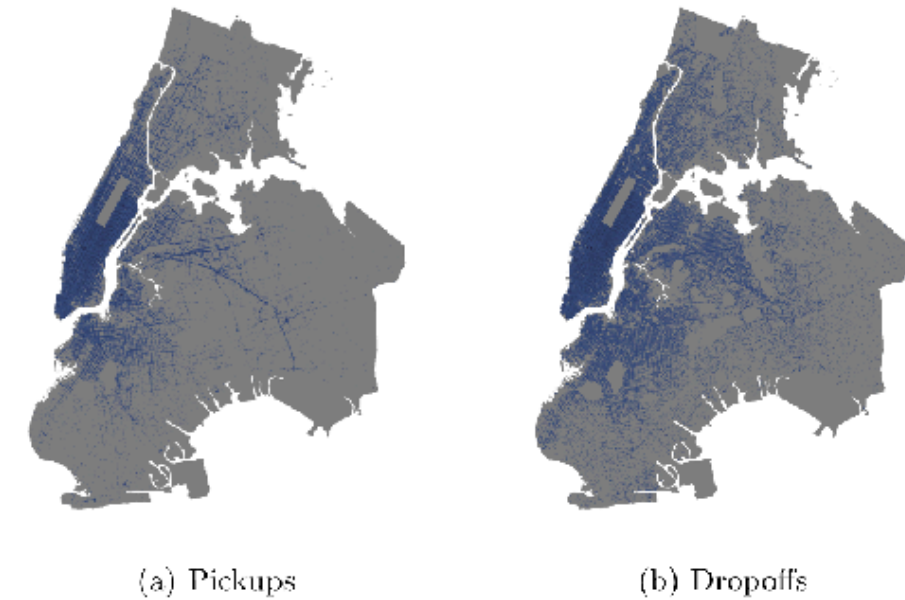
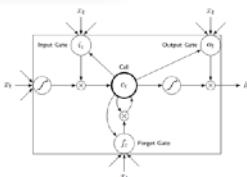


Figure 2: Coordinates of complete taxi trips in New York City in week 46 in 2015.

- ▣ Crime Forecasting
- ▣ Social Media Data
- ▣ Spatial E'trics



Vomfell L, Härdle WK, Lessmann, S (2018) Improving Crime Count Forecasts Using Twitter and Taxi Data, Decision Support Systems, <https://doi.org/10.1016/j.dss.2018.07.003>

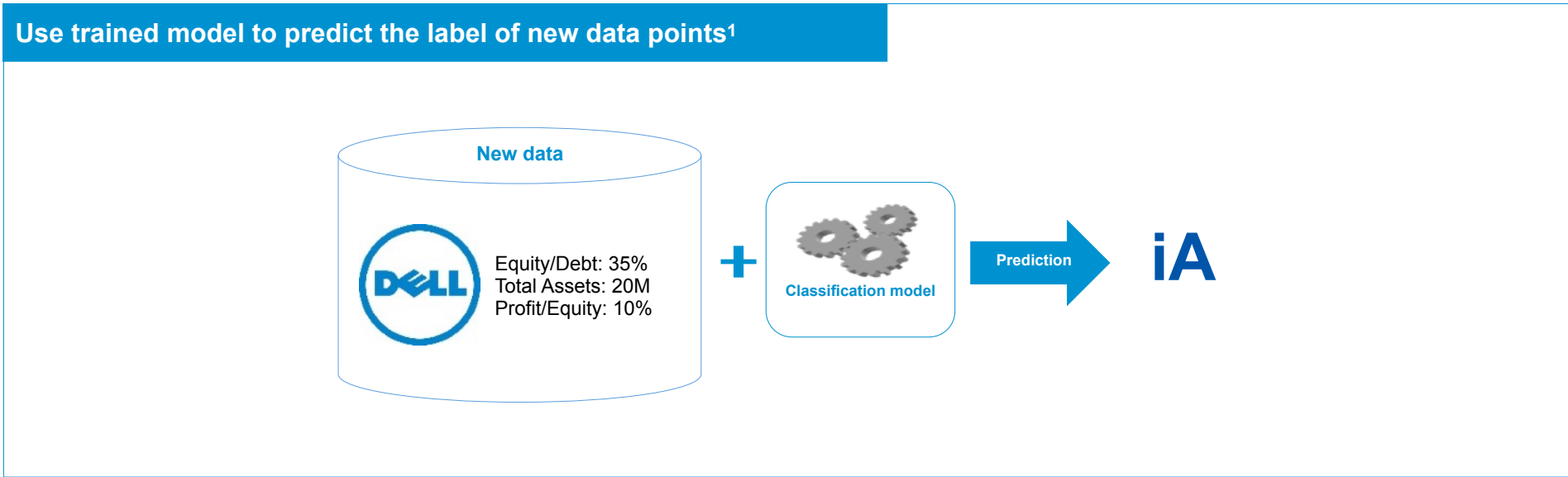
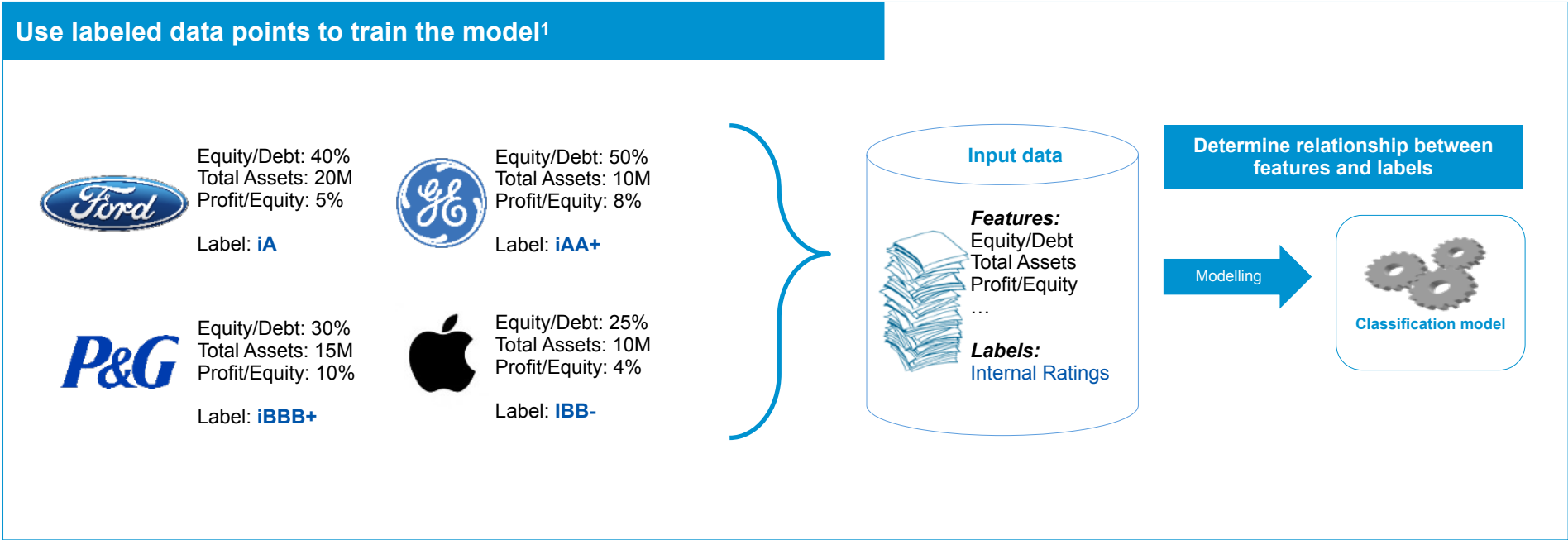




Machine Learning Based Credit Rating Methodology

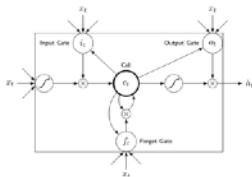
Corporate Credit Rating Prediction

... as a Supervised Learning Problem



Internal DB Rating	Assigned PD in %
iAAA	> 0.00, ≤ 0.01
iAA+	> 0.01, ≤ 0.02
iAA	> 0.02, ≤ 0.03
iAA-	> 0.03, ≤ 0.04
iA+	> 0.04, ≤ 0.05
iA	> 0.05, ≤ 0.07
iA-	> 0.07, ≤ 0.11
iBBB+	> 0.11, ≤ 0.18
iBBB	> 0.18, ≤ 0.30
iBBB-	> 0.30, ≤ 0.50
iBB+	> 0.50, ≤ 0.83
iBB	> 0.83, ≤ 1.37
iBB-	> 1.37, ≤ 2.27
iB+	> 2.27, ≤ 3.75
iB	> 3.75, ≤ 6.19
iB-	> 6.19, ≤ 10.22
iCCC+	> 10.22, ≤ 16.87
iCCC	> 16.87, ≤ 27.84
iCCC-	> 27.84, ≤ 99.99

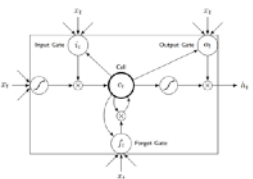
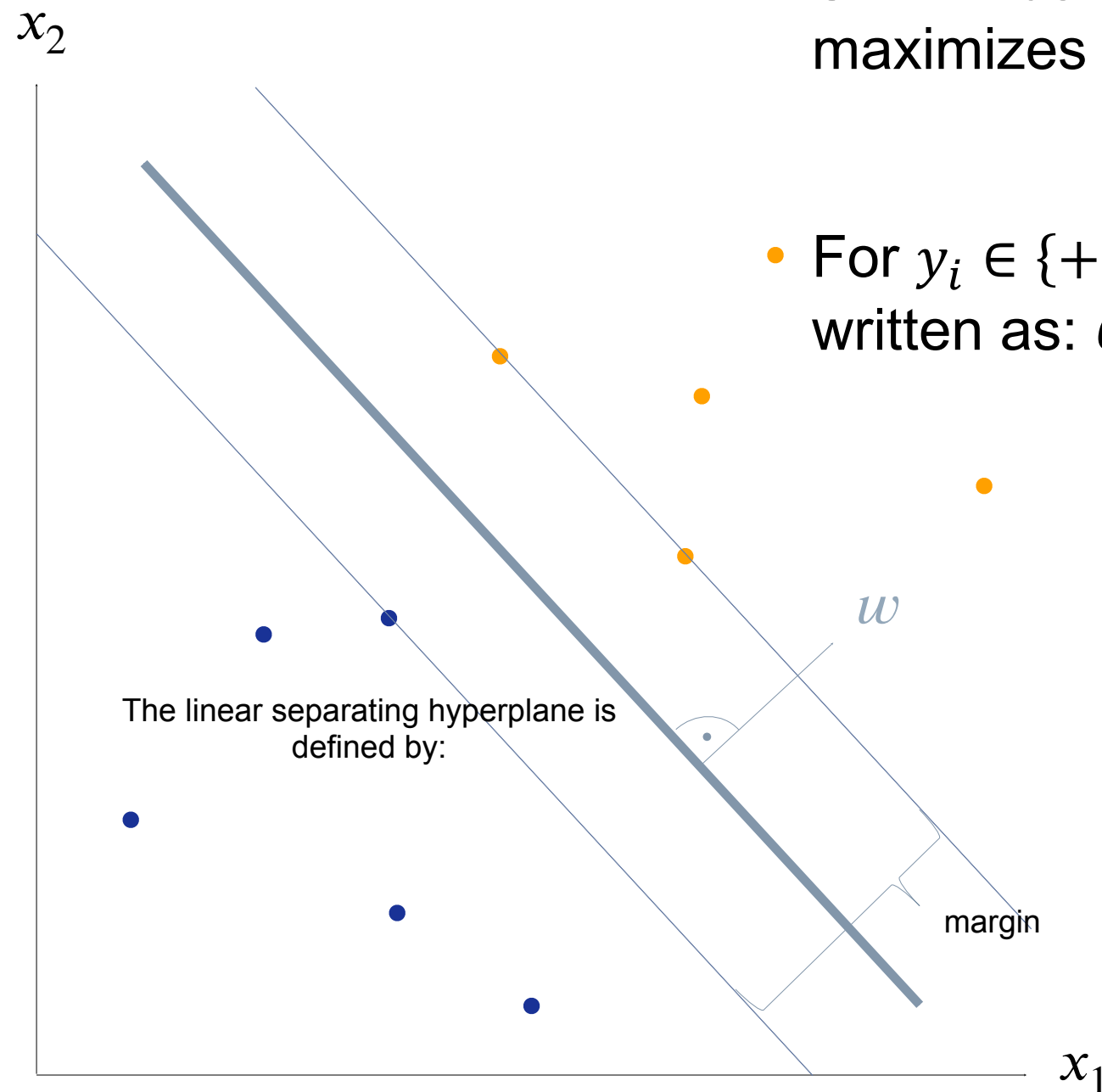
¹Depicted company characteristics and internal ratings were set arbitrarily and do not reflect real data.



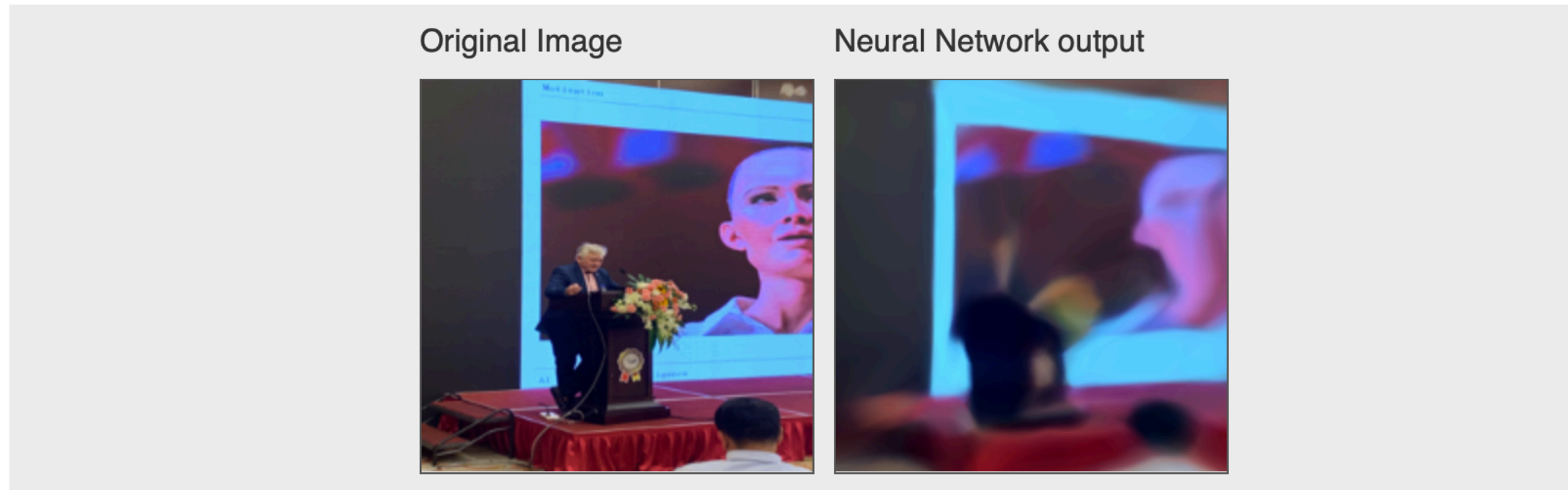
Support Vector Machine

SVM finds a separating hyperplane that maximizes the margin between the two classes

- For $y_i \in \{+1, -1\}$, the decision function may be written as: $\hat{G}(x) = \text{sgn}(w^T x - b)$



AI draws pictures



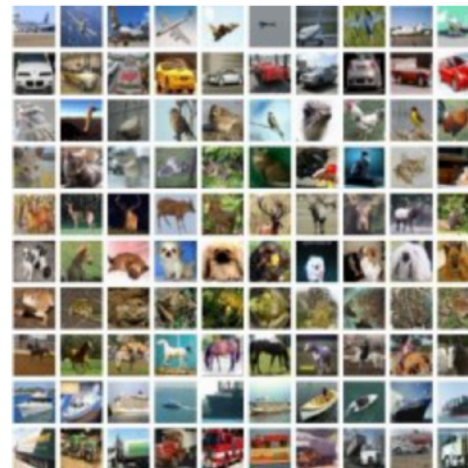
loss: 0.012254625661909253
iteration: 2957

<https://cs.stanford.edu/people/karpathy/convnetjs/>

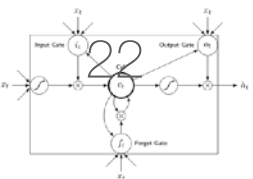
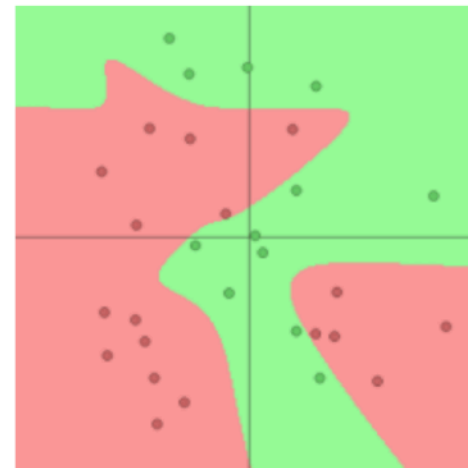
Classify **MNIST** digits with a Convolutional Neural Network



Classify **CIFAR-10** with Convolutional Neural Network



Interactively classify toy 2-D data with a Neural Network

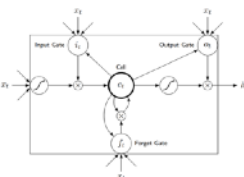
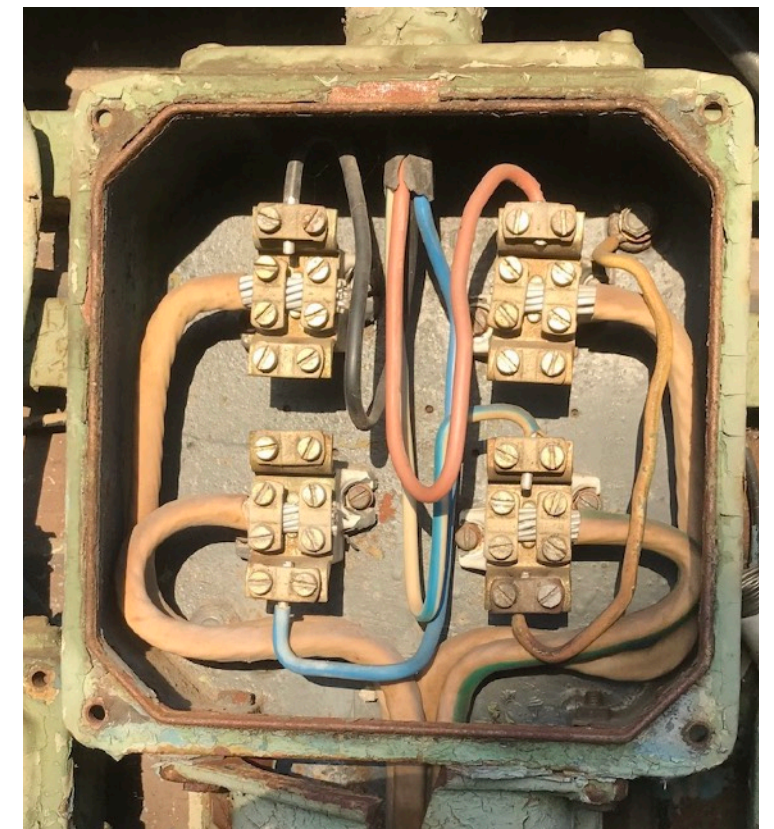


Basic element of Artificial Intelligence

...is a buzzer or a switch!

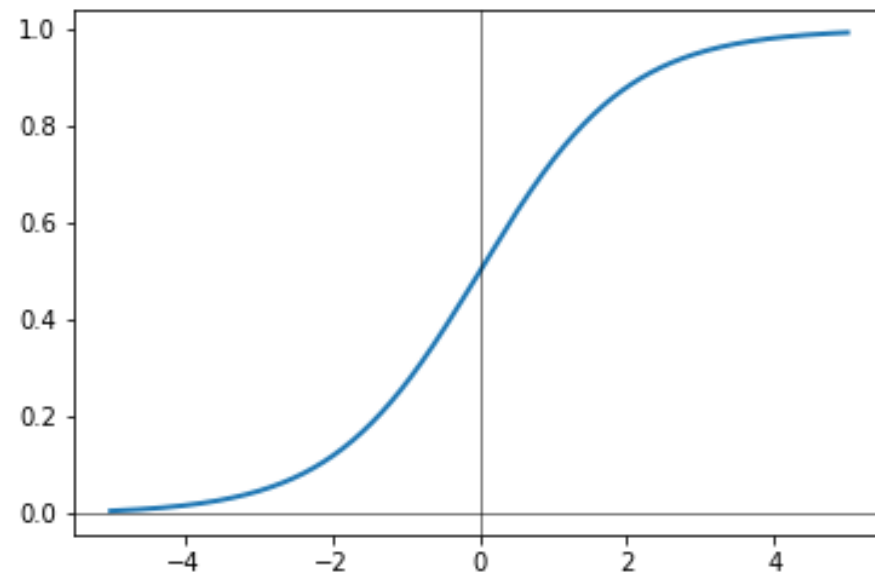


Combined with other switches ...



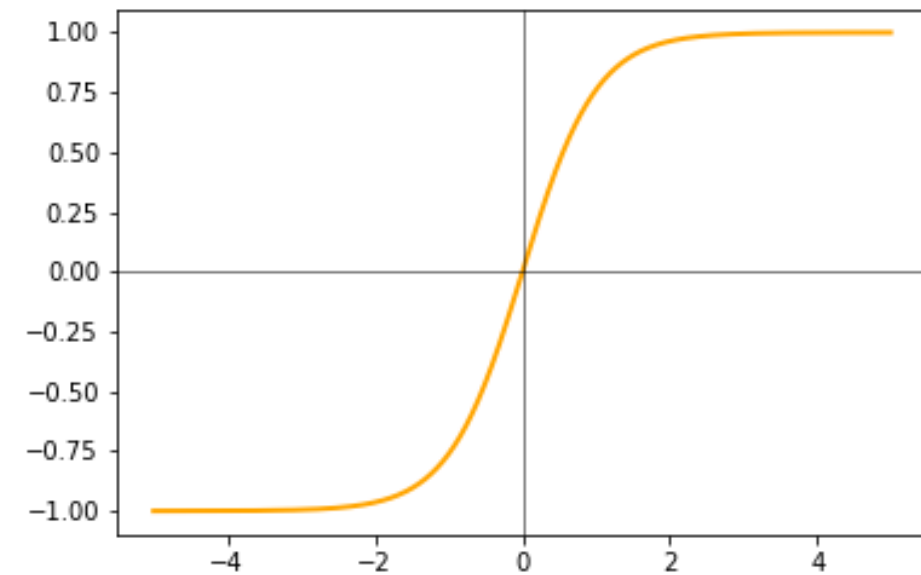
LSTM memory block: activation functions

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$



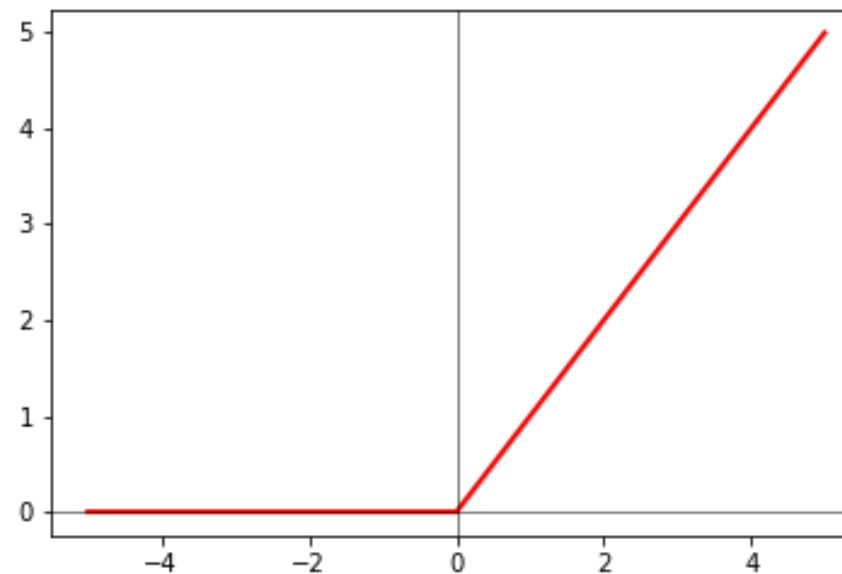
For forget gates

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

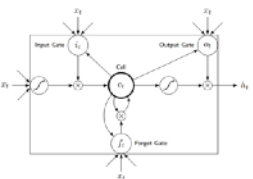


for input and output gates

Or

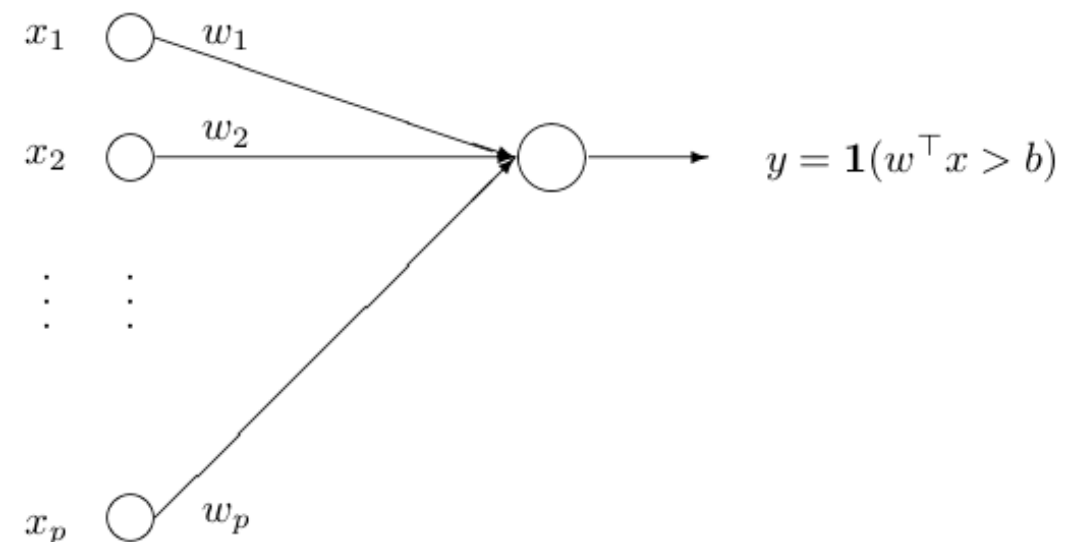
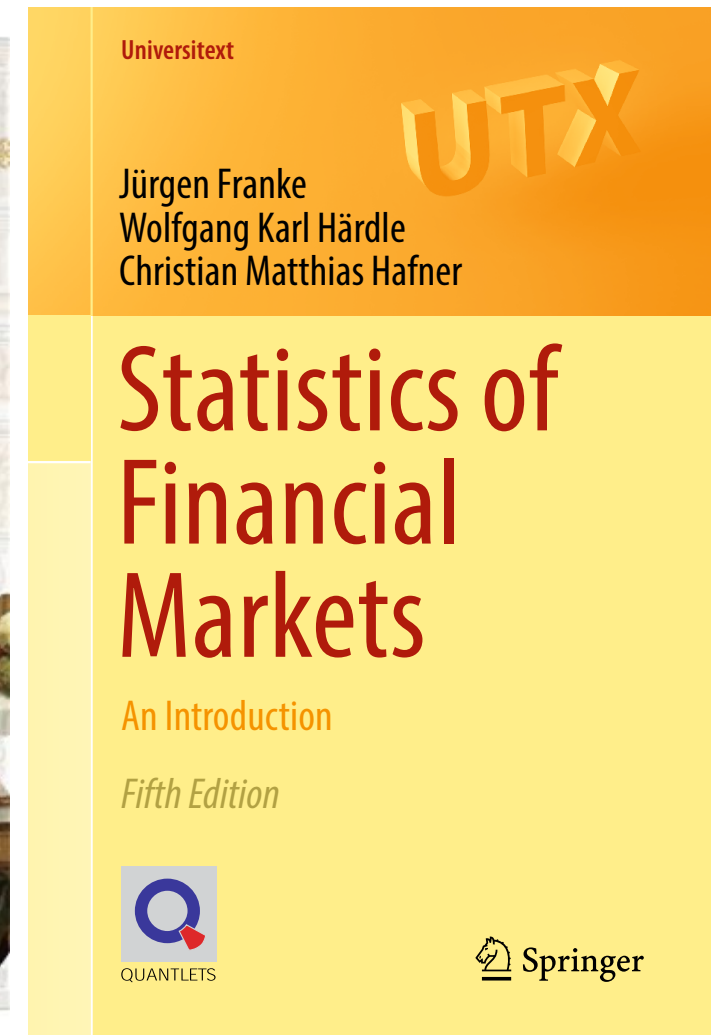
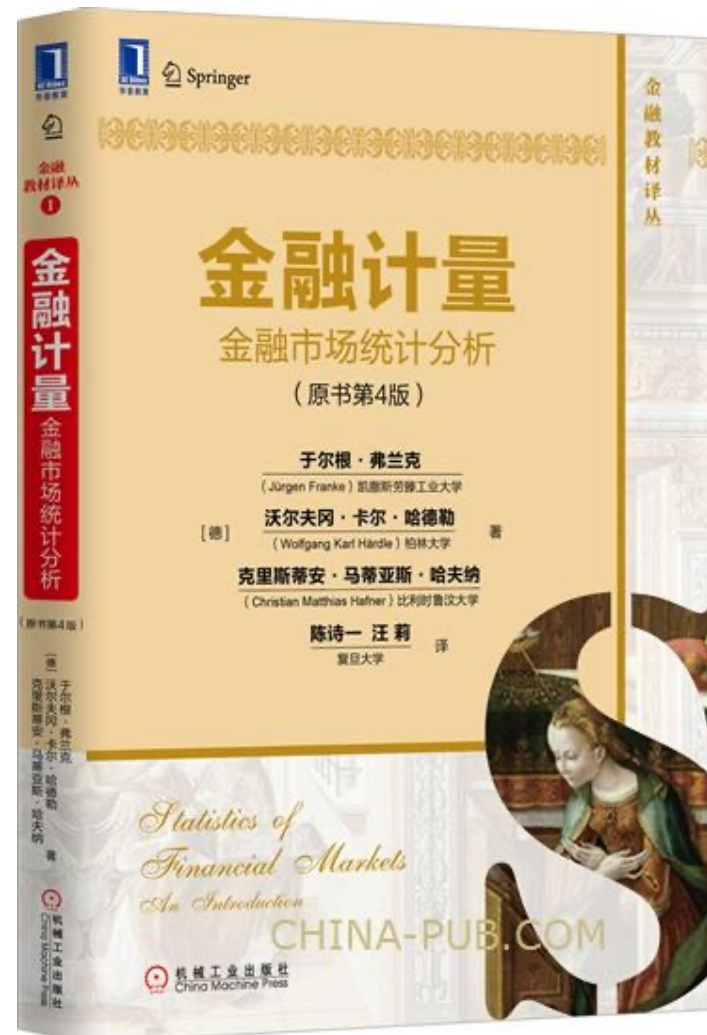


$$ReLU(x) = \max(0, x)$$

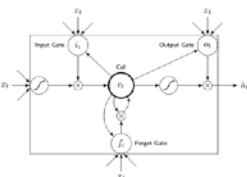


The perceptron

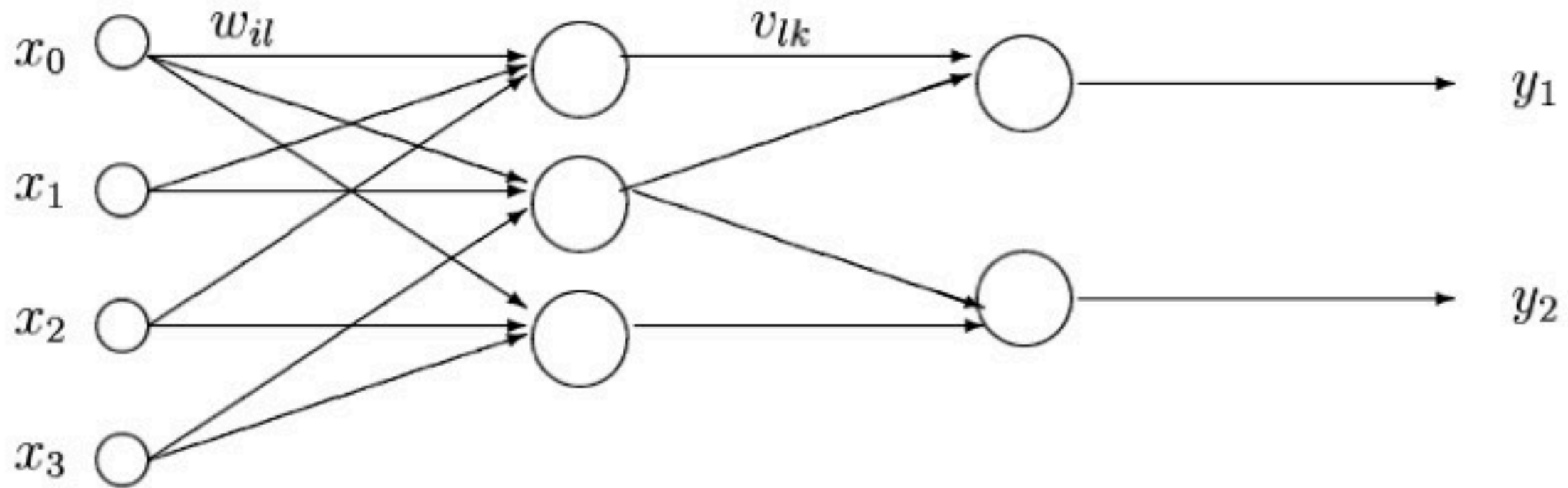
- ▣ Mimic human biological neurons
- ▣ Take some variables as input
- ▣ Apply linear threshold operations
- ▣ The output is the perceptron
- ▣ Cannot represent XOR function



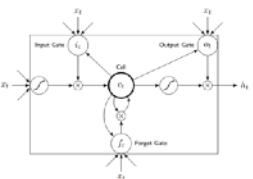
where $x = (x_1, \dots, x_p)$, $p \in \mathbb{N}^*$ and $w = (w_1, \dots, w_p)$, $p \in \mathbb{N}^*$



Multilayer perceptron

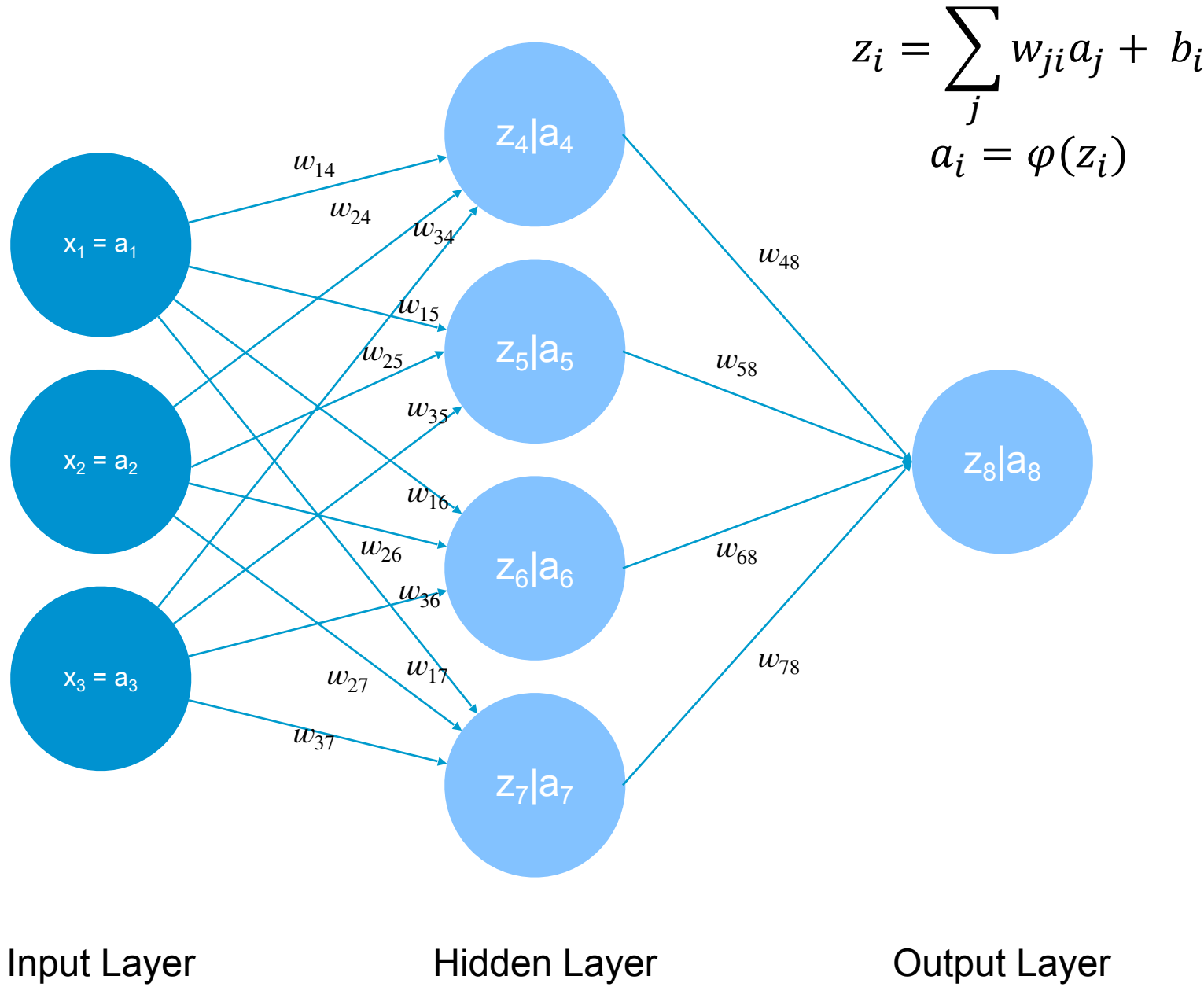


- ▣ One input layer, multiple hidden layers and one output layer
- ▣ Non-linear activation function (*sigmoid, tanh, relu*)
- ▣ Feedforward flow of information: no cyclic connection



Neural Network

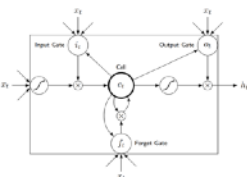
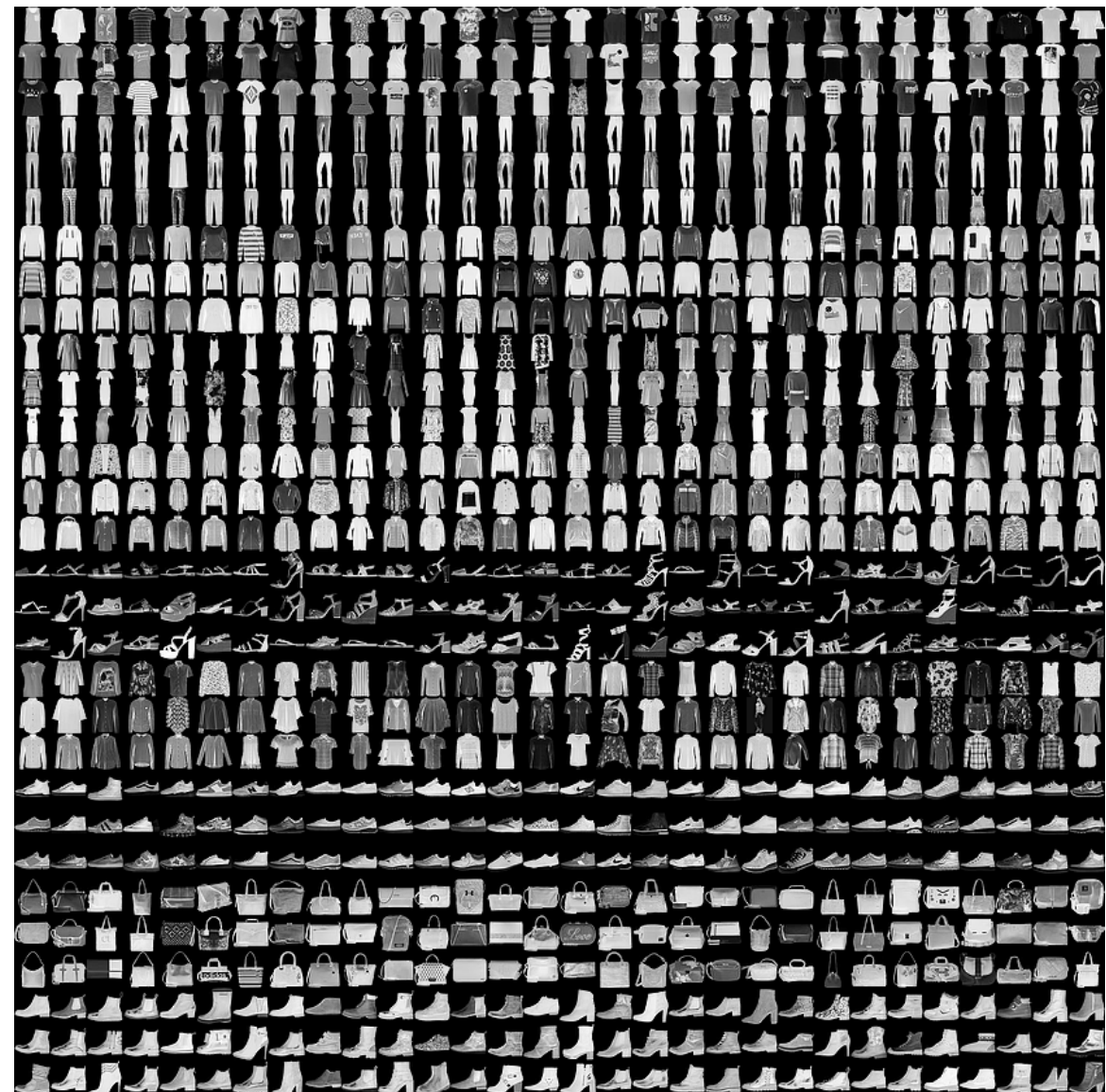
Example: 2-Layer Feed-Forward NN for Binary Classification



Implementation: one classical example

- ▣ MNIST fashion dataset: 60000 training samples, 10000 test samples
- ▣ Input: 28x28 grayscale images
- ▣ Output: 10 classes (T-shirt, trouser, pullover, dress, coat, sandal, shirt, sneaker, bag, ankle boot)

SIRI + „Schuhe“= Viola Härdle, 16 Y



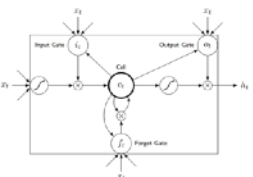
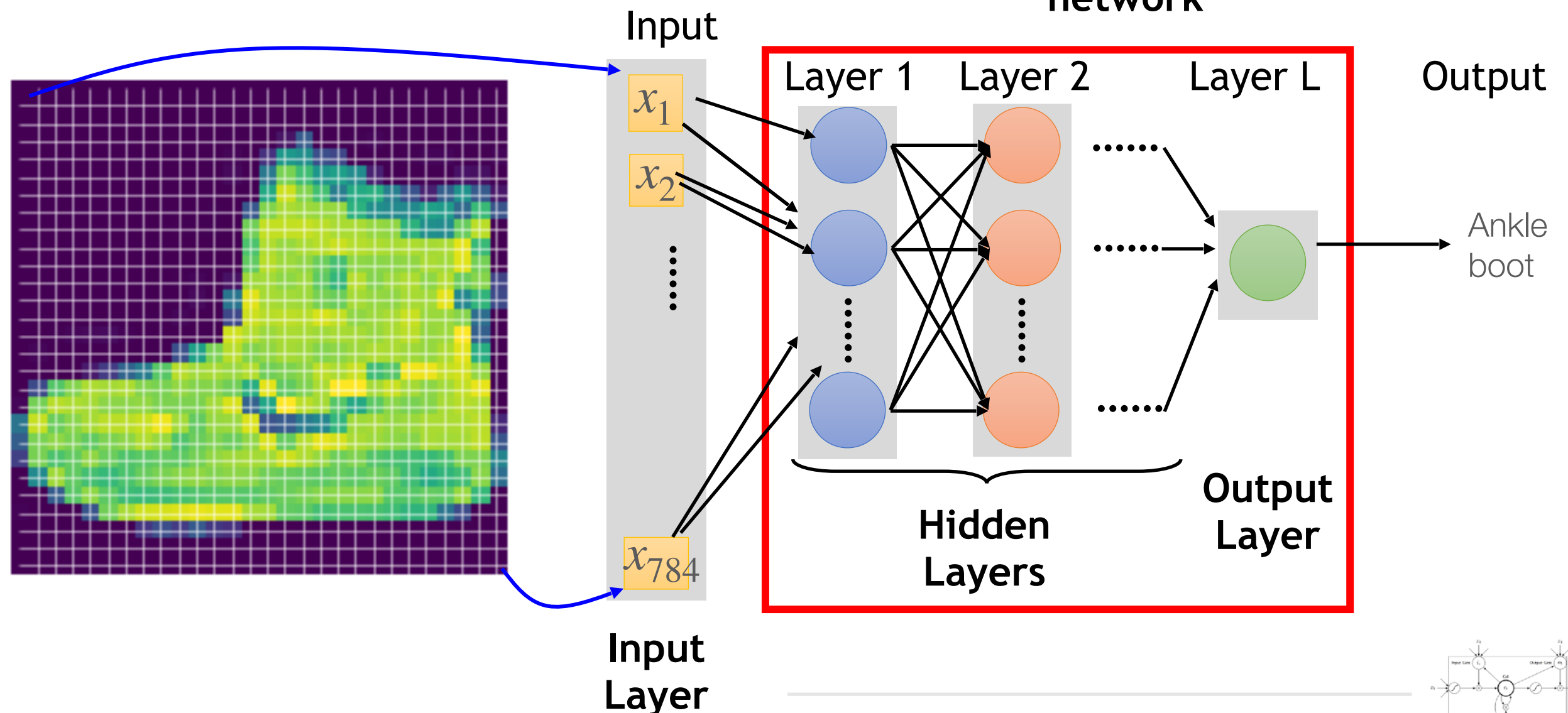
Implementation: dense layer

Input transformation into a vector of length
 $28 \times 28 = 784$

Each new pixel is treated as an independent
 feature

$$\begin{pmatrix} x_{1,1} & \dots & x_{1,784} \\ \vdots & \ddots & \vdots \\ x_{n,1} & \dots & x_{n,784} \end{pmatrix}$$

Fully connected neural
 network



Implementation: sequence learning

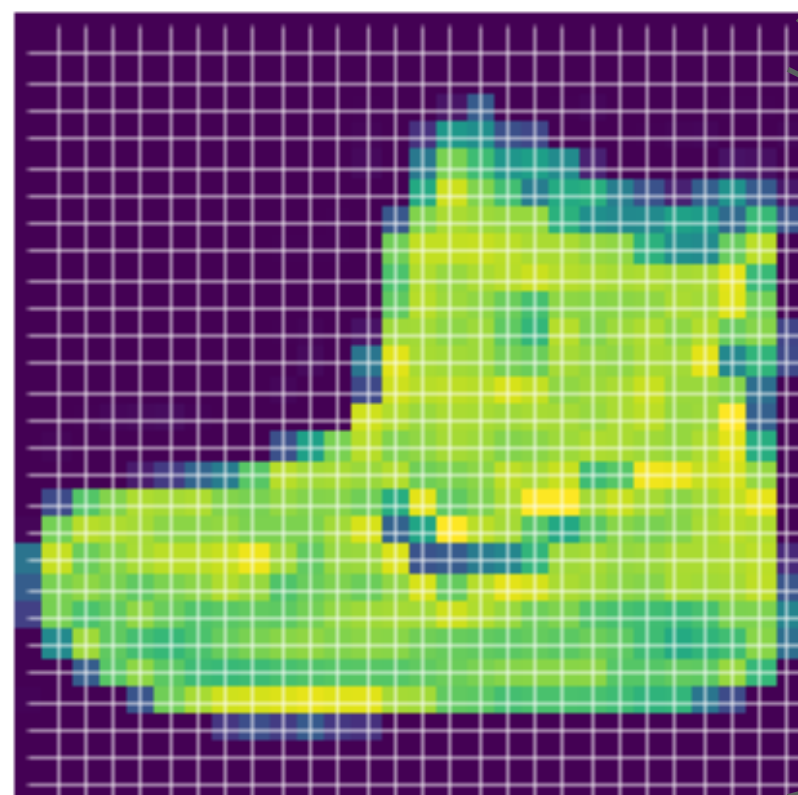
Input transformation into a 3D array for recurrent networks:

$(n_samples, time\ steps, n_features)$

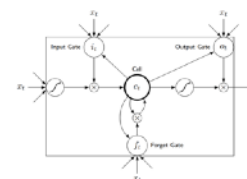
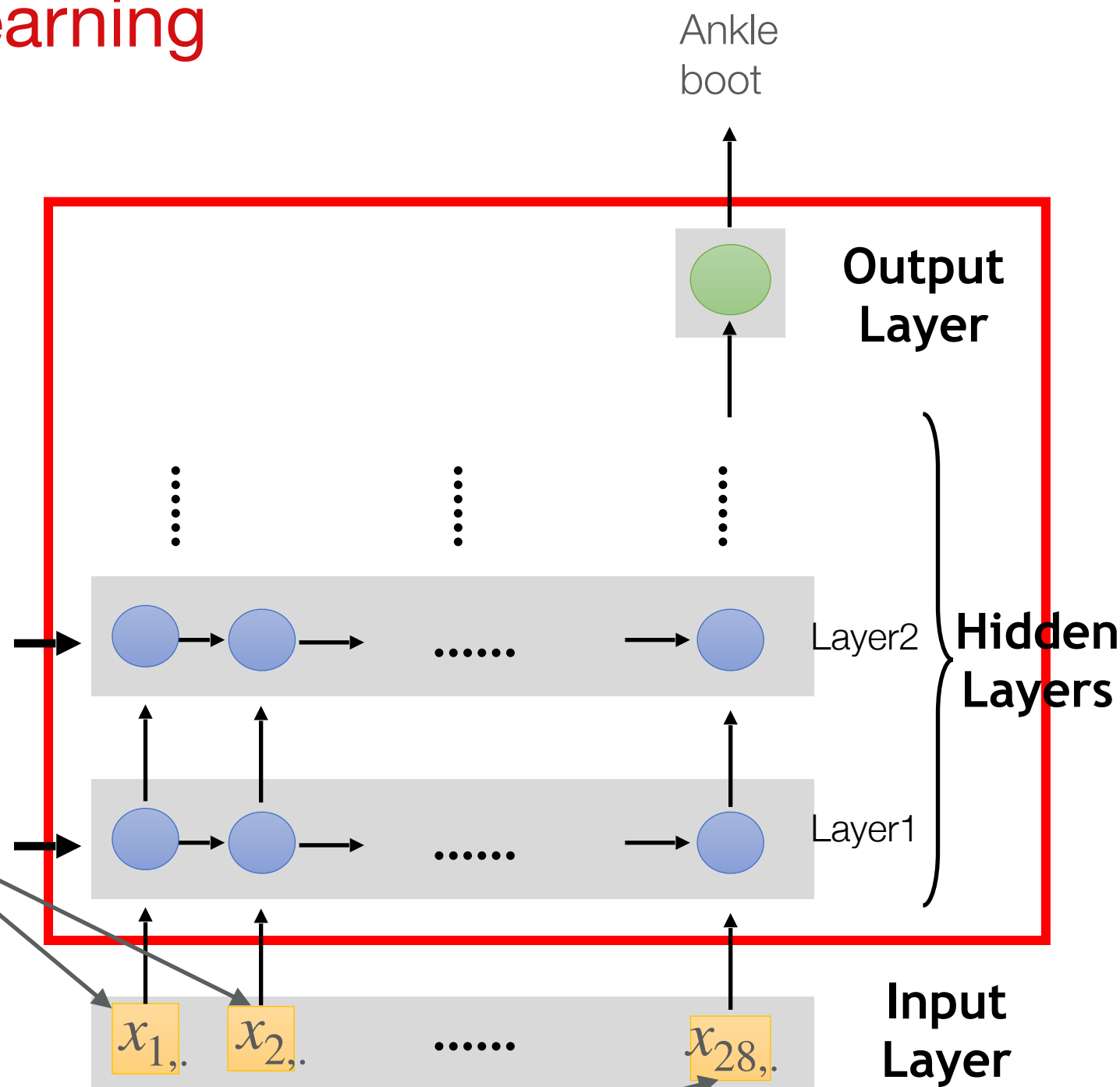
Each new input is a matrix of size

$(time\ steps, n_features)$

Sequence structure: each new row is treated as a new step



Previous steps

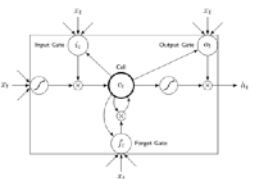


Rise of the machines



- ▣ 1981 - \$300,000
- ▣ 1987 - \$50,000
- ▣ 1990 - \$10,000
- ▣ 1994 - \$1,000
- ▣ 1997 - \$100
- ▣ 2000 - \$10
- ▣ 2004 - \$1
- ▣ 2010 - \$0.10
- ▣ 2017 - \$0.01
- ▣ 2018 - \$0.004*

Cost per GB storage p/m

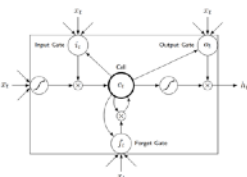


Blockchain

- ▣ Computers
- ▣ Digital Economy
- ▣ New Models.DE



```
> library(digest)
> digest("blockchain", "sha256")
[1] "b960c3a766e37e8eaa76574f7bfd031b5d1fa63bfba8dc5004fa4d0a9eccbee1"
> digest("digital economy", "sha256")
[1] "7204ecd0b6c2d9f463822e081f54d9773ff53fbdc1752841f5d68d7e2a301127"
> digest("newmodels.DE", "sha256")
[1] "ae46ede37d5c0148f0327e67015ee63b797eb1d84258bfff636ff4347793c62f9"
```

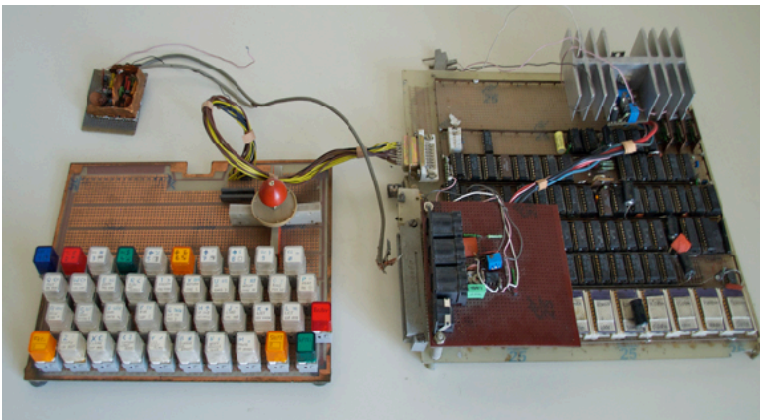


Rise of the machines

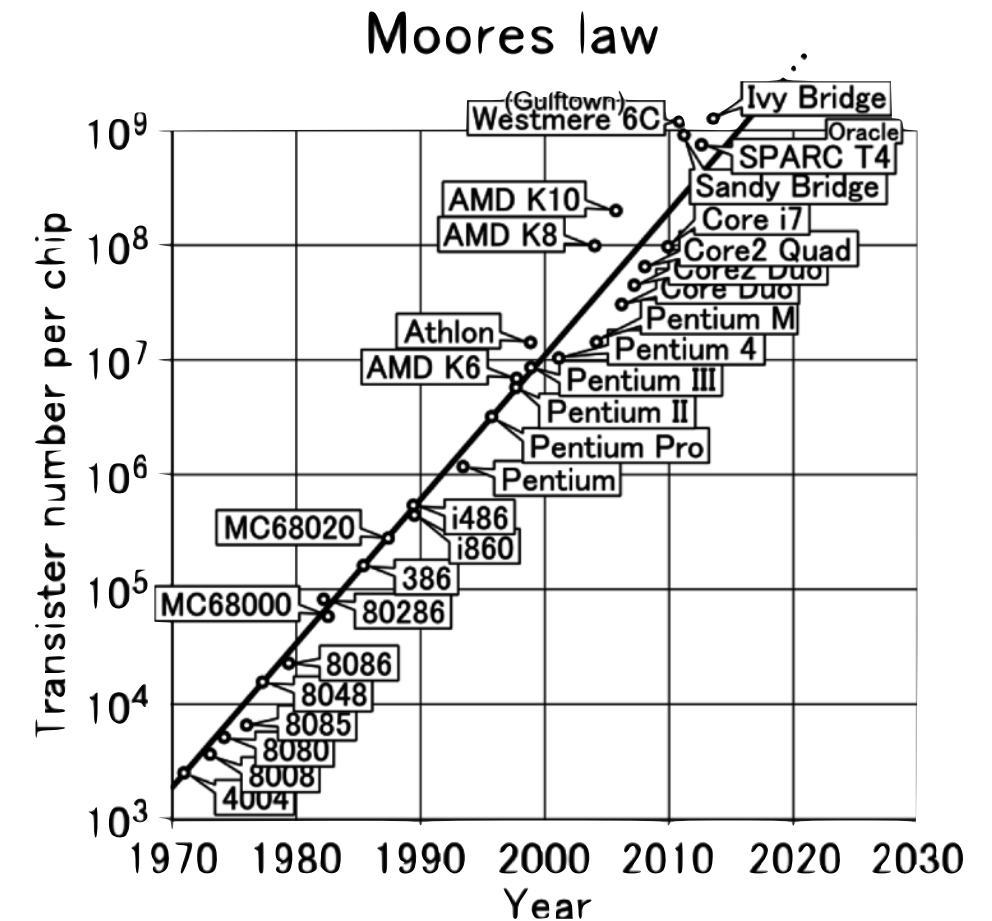
Mechanical calculator MADAS
H.W. Egli S.A., Zurich, 1965



VEB Röhrenwerk Mühlhausen, 1975
8 digits

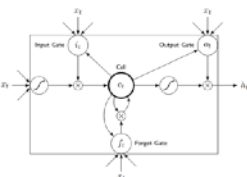


ZX Spectrum East / West 1982



<https://phys.org/news/2015-08-silicon-limits-power-electronics-revolution.html>

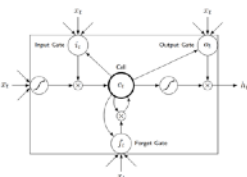
▣ <http://computermuseum.wiwi.hu-berlin.de>



Rise of the machines

- ▣ Cray 2 is the world's fastest supercomputer: 1985-1990
- ▣ 1.9 GFLOPs*
- ▣ 5,500 pounds
- ▣ \$32 million (current \$)
- ▣ 舞 锡市 太湖之光,
(wu3xi1shi4tai4hu2zhi1guang1)
95 PFLOPS**

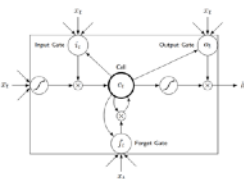
* 10^9 Floating point Operations per Second ** 10^{15} FLOPS



Rise of the machines

- ▣ 2016 iPhone 7* , 178 GFLOPs
- ▣ 2017 iPhone X* , 600 GFLOPs
- ▣ A11 Bionic chip, 256 GB storage
- ▣ 174 g
- ▣ 1.3 K EUR

*A10 Fusion. The Apollo guidance system had only 4K of RAM.

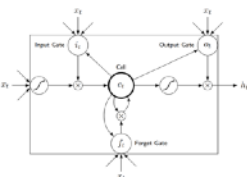
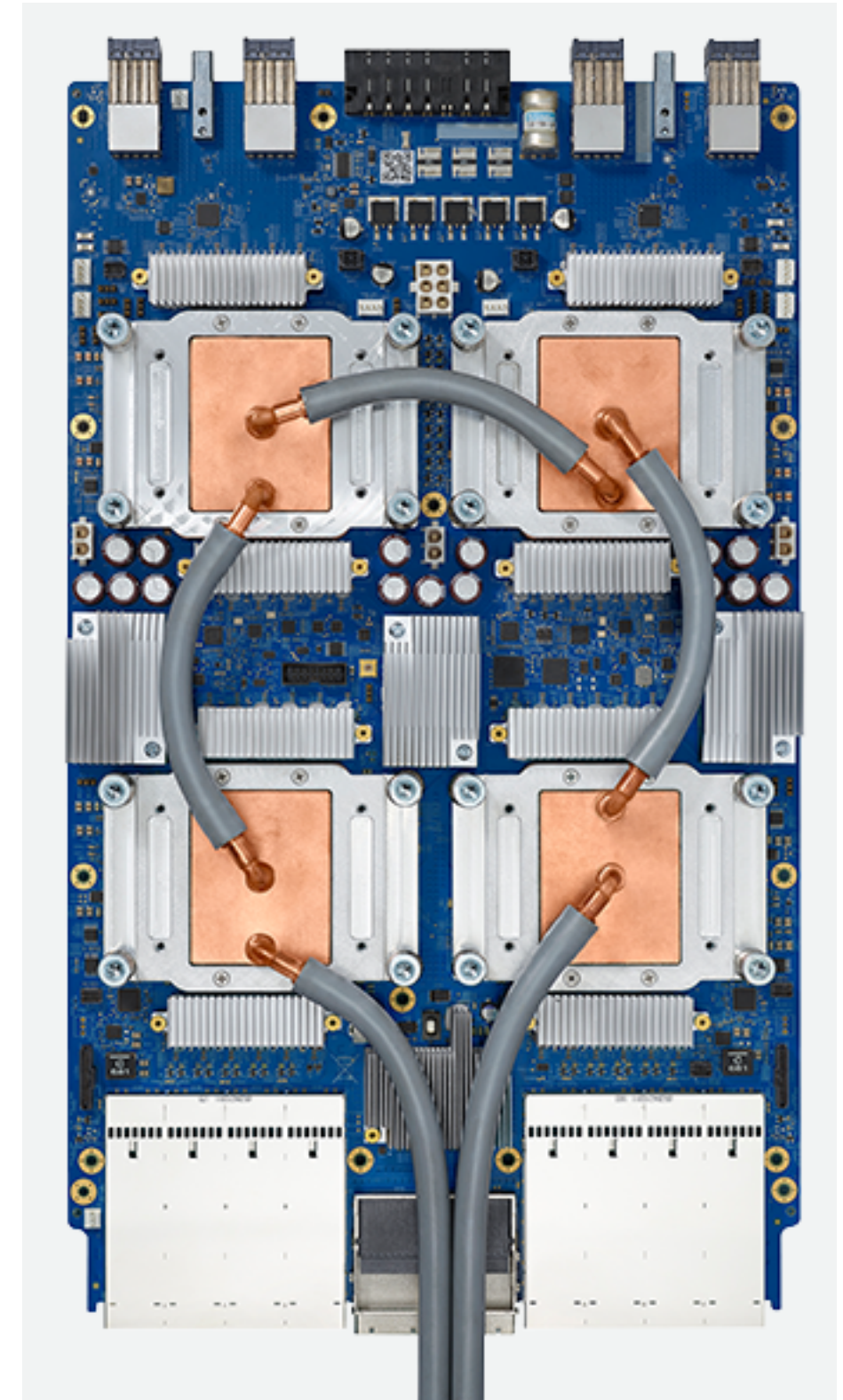


Rise of the machines

- ▣ 2017 Nvidia Titan Xp
- ▣ 125 TFLOPs, 16 GB
- ▣ 1.1 K USD
- ▣ ASICS, Antminer
- ▣ Google's Tensor Processing Unit (TPUv2)
- ▣ 180 TFLOPs, 64GB per TPU
- ▣ TPUs important for MLE*

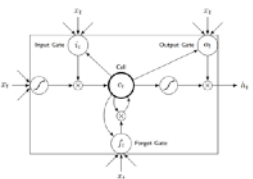
*MLE = „Maximum Likelihood Estimation“ (age $\geq$ 45)

MLE = „Machine Learning in Economics“ (age $\leq$ 45)



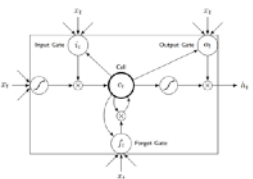
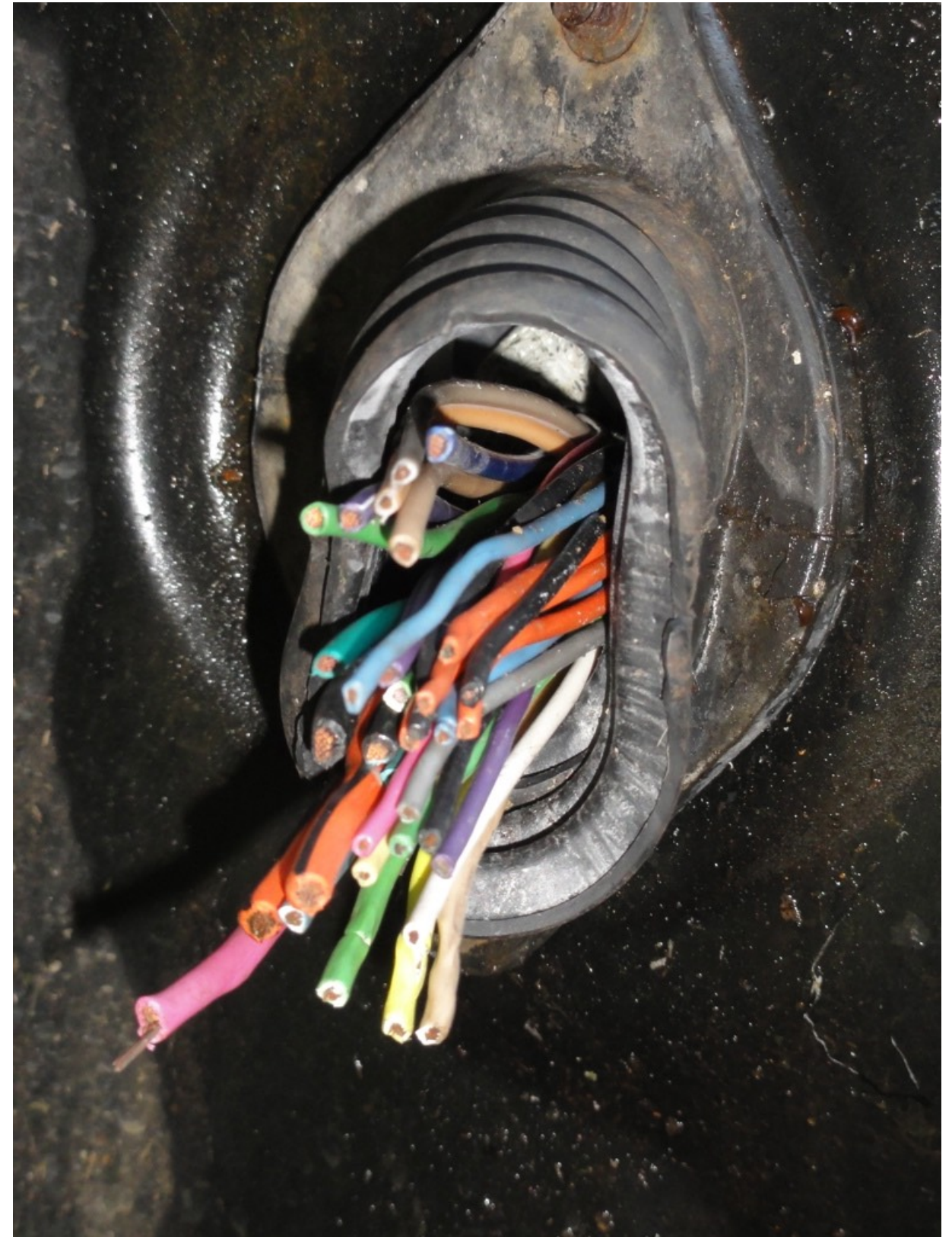
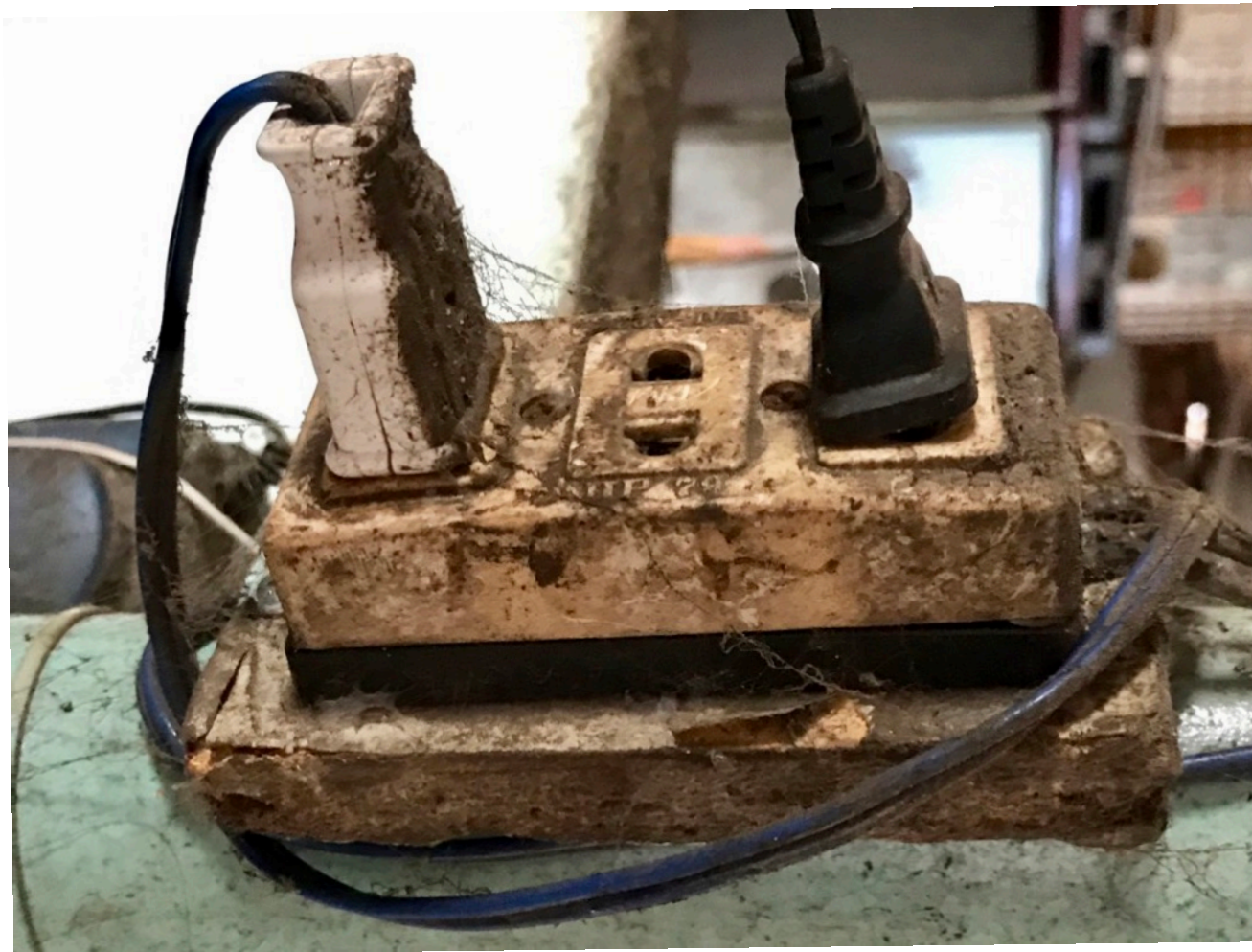
Infrastructure

- ▣ badly maintained switch
- ▣ corrupted node sequence
- ▣ biased training sample



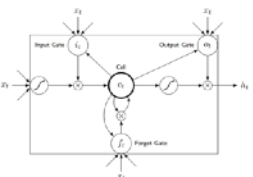
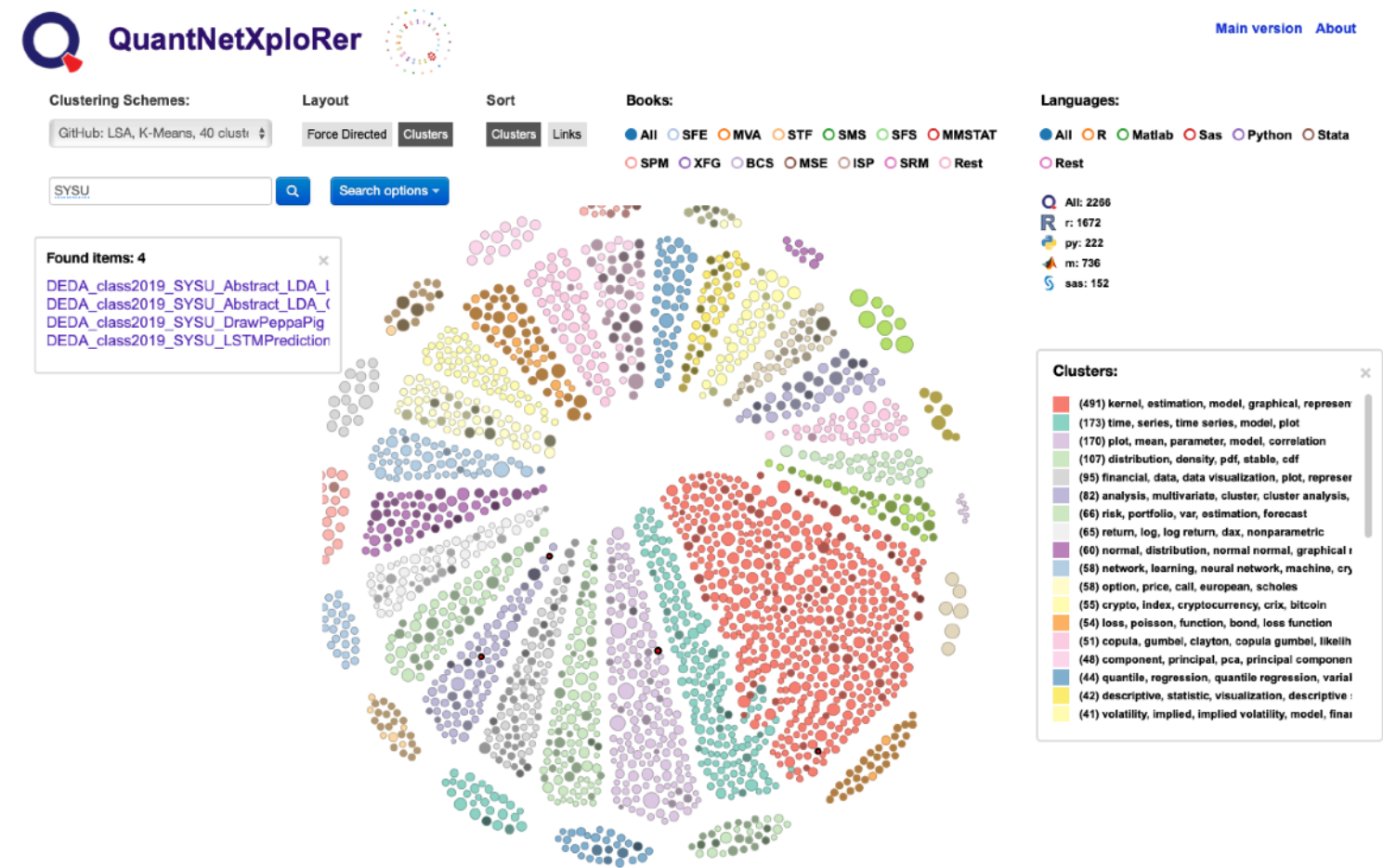
Maintenance

- ▣ do not overweigh your switch
- ▣ keep the electricity running
- ▣ invest in human brains



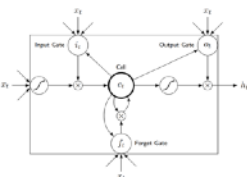
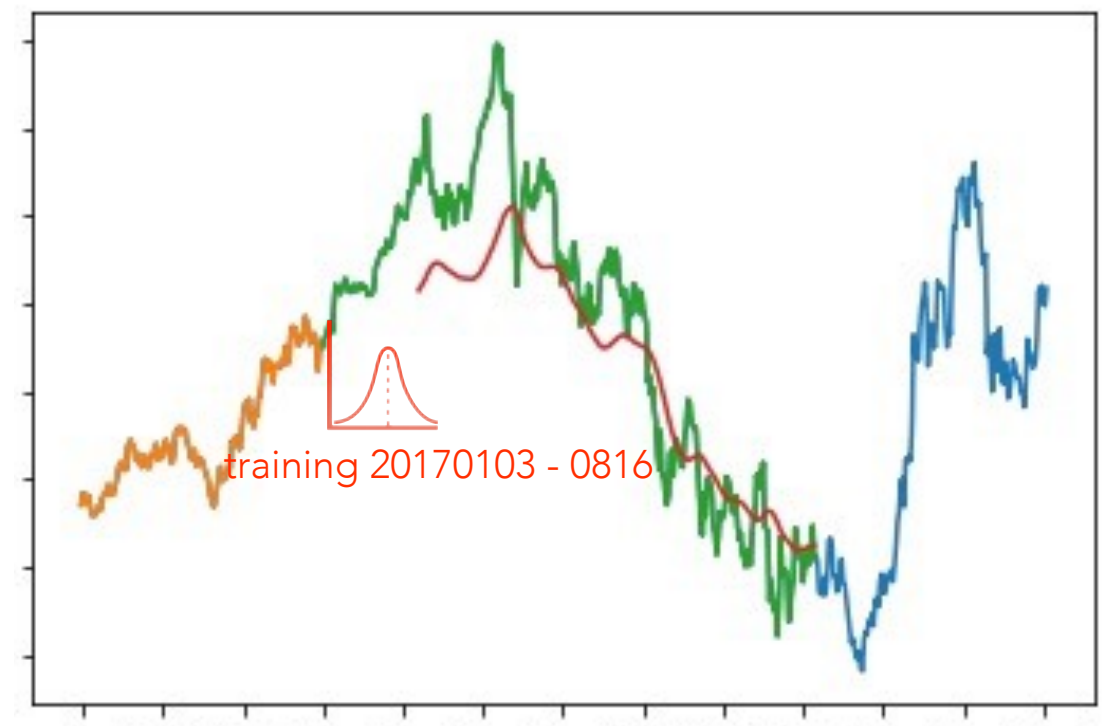
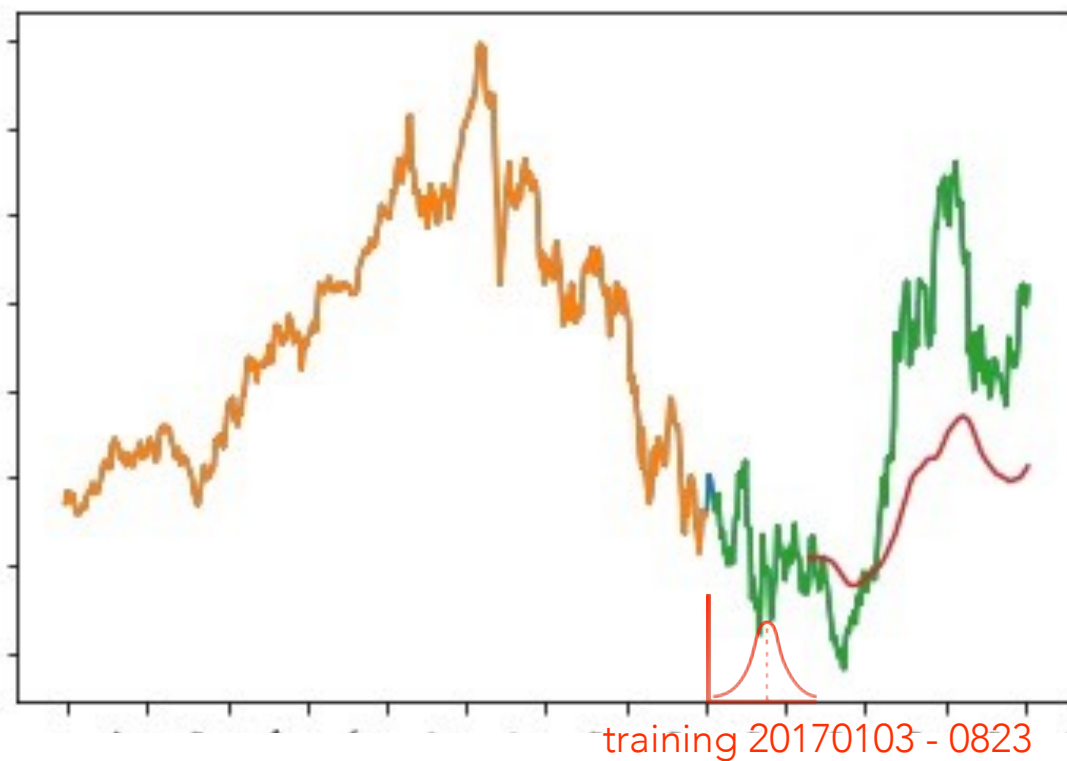
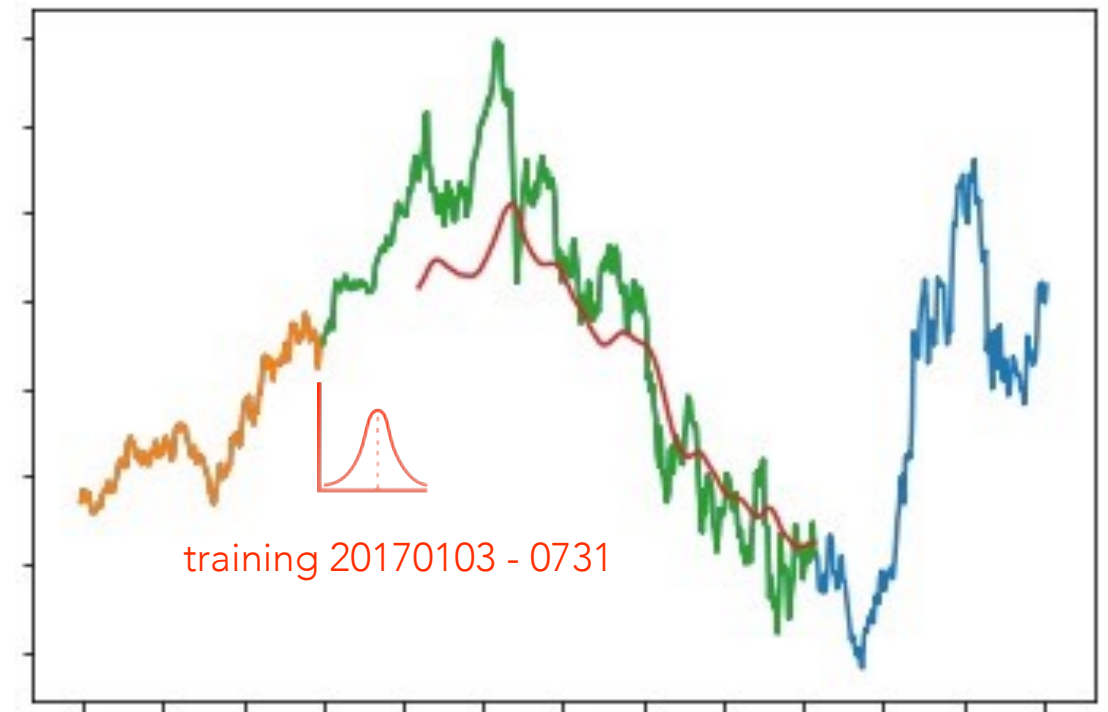
ML on Time Series

- ▣ quantlet.de
- ▣ *SYSU, LSTM prediction*
- ▣ train on different time periods



ML on Time Series

- ▣ quantlet.de
- ▣ *SySUN, LSTM prediction*
- ▣ train on different time periods



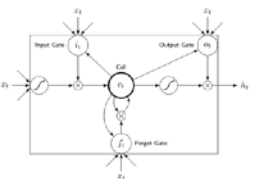
Will AI classify this correctly?



Danish FSA muffin



Training machines to "see" - to recognise and differentiate between objects and faces - is notoriously difficult.



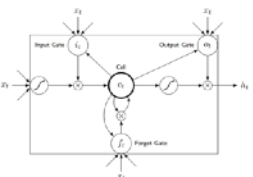
Will AI classify this correctly?



Stift Melk, AU

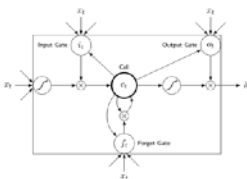
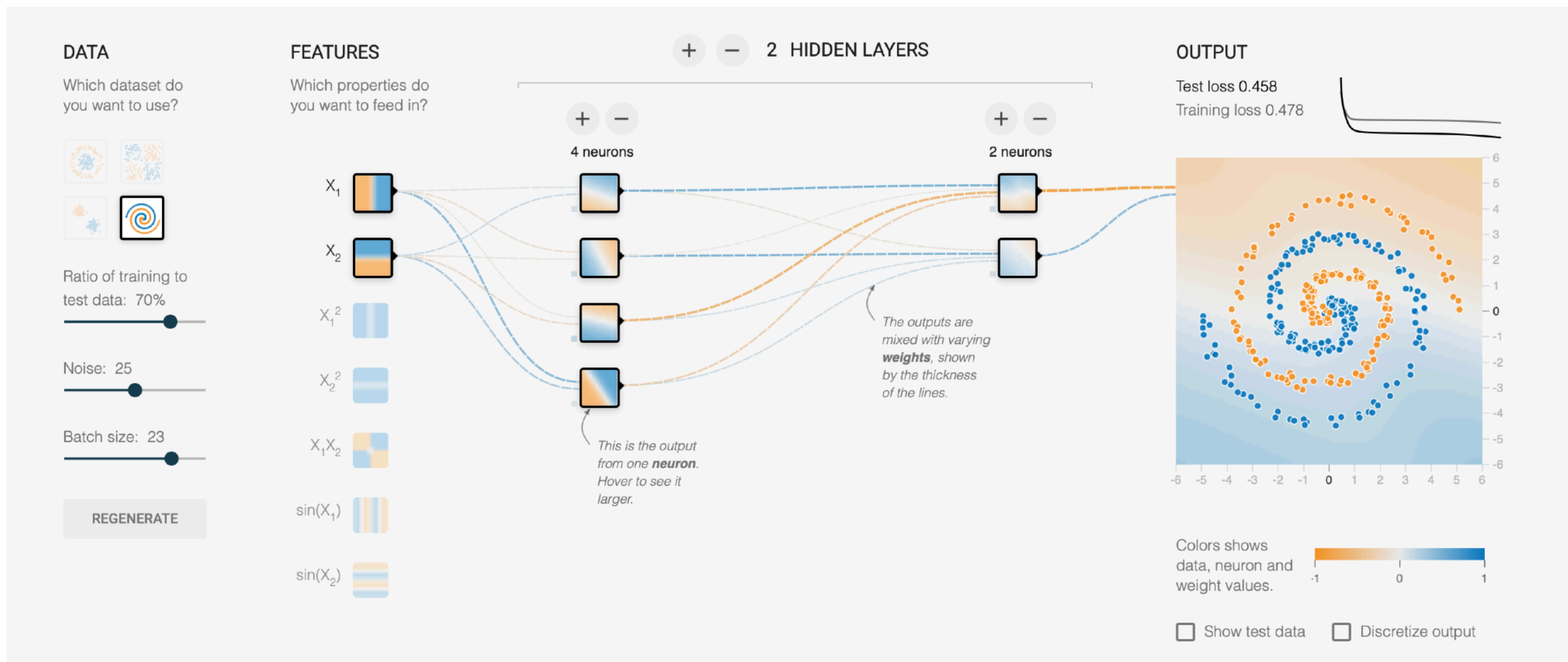


Centro storico Palermo, I



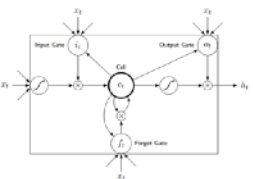
The difficulty of getting it right

Neural Network Tensorflow Playground



The 7 AI principles

- ▣ AI has to be useful for the society
- ▣ AI must be safe
- ▣ AI has to avoid bias
- ▣ AI should be made castigatable
- ▣ AI must respect individual privacy
- ▣ AI has to follow highest scientific standards
- ▣ AI should only be employed for applications that fulfill the above principles



Future

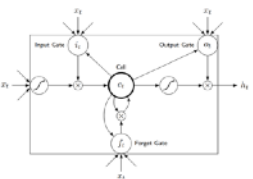
Should we wait: NO, go for it!

Will you take a standard air plane on long distance that is flown by an AI robot pilot?

You do it already.

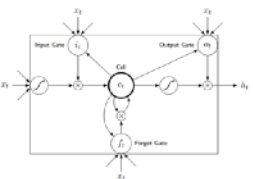
But...

Will you take a standard air plane on long distance that is flown by an AI robo pilot, knowing that there is no additional human pilot?



Questions

- ▣ How do we make AI ethical ?
- ▣ How do we react to AI „colleagues“ ?
- ▣ Can an AI robot be happy ?
- ▣ What must politics and business do ?
- ▣ How long is human intelligence superior to AI ?

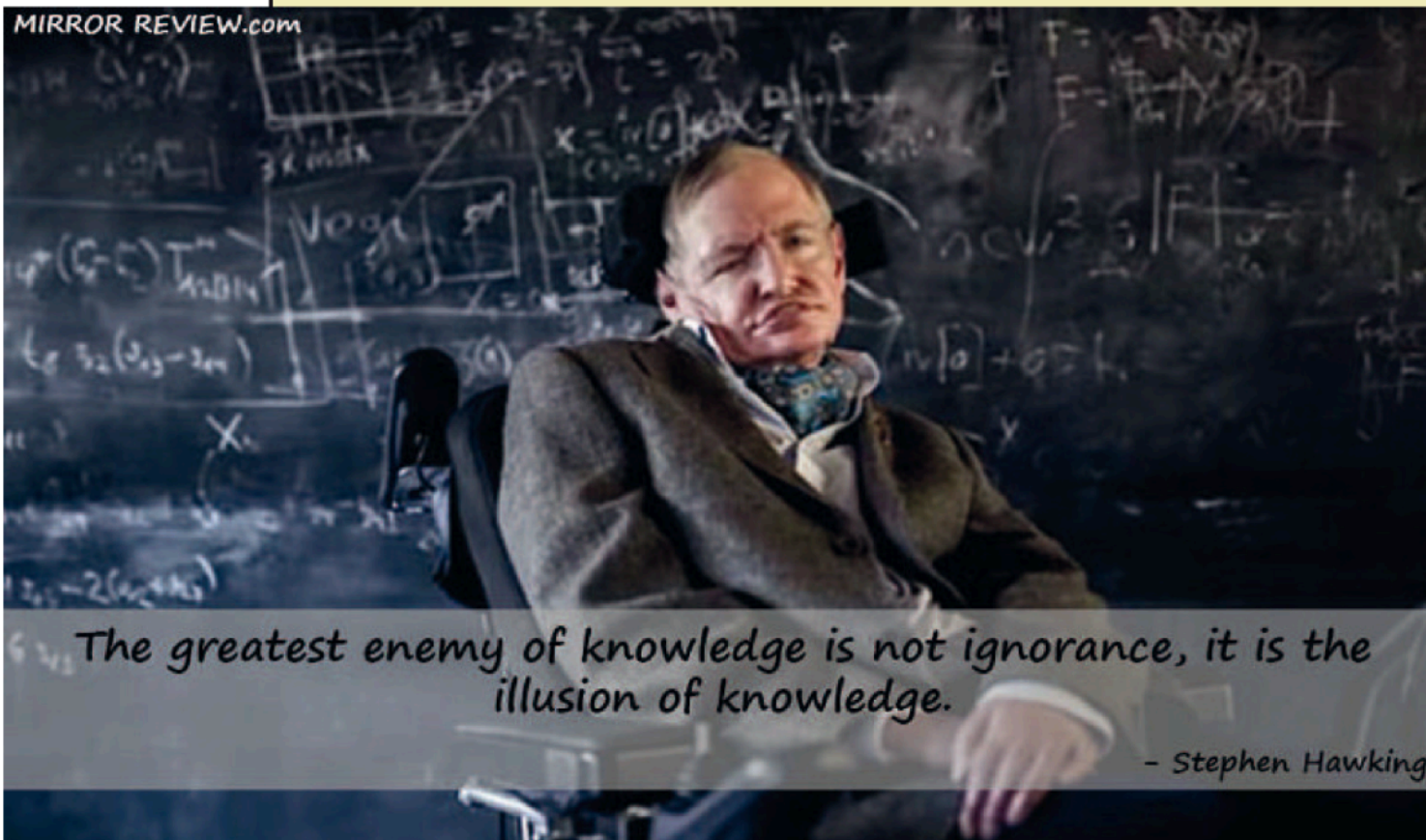


AI Artificial Intelligence +



„Ali Rahimi, a researcher in artificial intelligence (AI) at Google in San Francisco, California, took a swipe at his field last December—and received a 40-second ovation for it. Speaking at an AI conference, Rahimi charged that machine learning algorithms, in which computers learn through trial and error, have become a form of „alchemy.“ Researchers, he said, do not know why some algorithms work and others don't, nor do they have rigorous criteria for choosing one AI architecture over another....“

Science, May 2018



AI Artificial Intelligence +

SMART (Specific, Measurable, Achievable, Relevant, Timely) Data Analytics

Wolfgang Karl Härdle

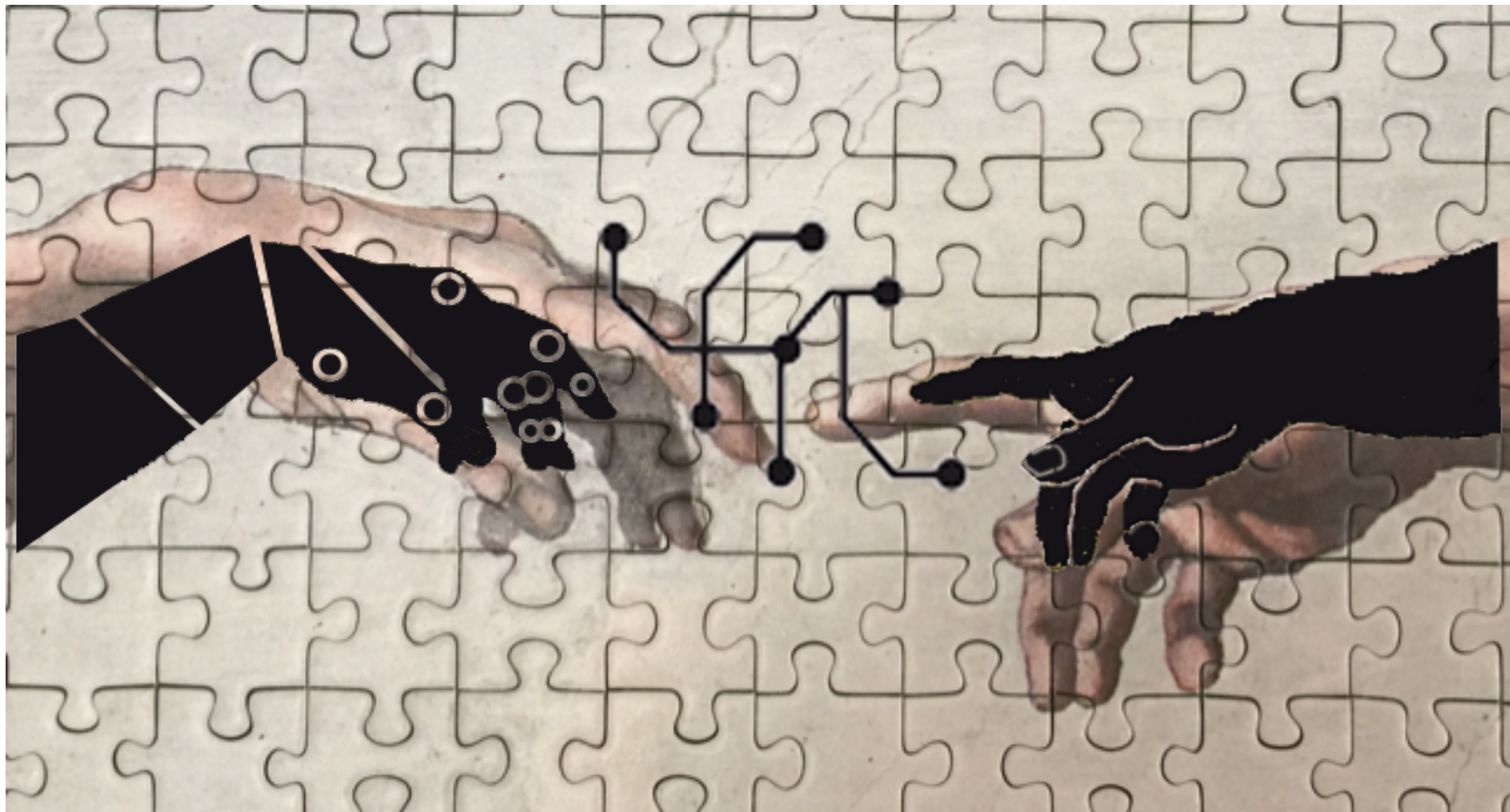
[hu.berlin/wkh](https://www.hu-berlin/wkh)

switches, neurons, networks, nodes,
deep-, machine-, supervised learning, computer, LSTM,
Python, statistics, data mining, analytics, smart data,
cluster analysis, crypto currencies, robo advising, FinTech

AI Artificial Intelligence +



The future of AI?



AI Artificial Intelligence +

Event Stream

- ▣ 20181020 HKG Banker's Club WALEX Diamond Class event
- ▣ 20190919 HBF Jinan QiLu conference
- ▣ 20190921 HBF Beijing
- ▣ 20200207 Danish FSA, Copenhagen
- ▣ 20200210 Bundesbank Frankfurt
- ▣ 20210324 ML FINTECH Class, NUS, Singapore