

Lec12 Deep Learning

I2-I Basics of Deep Learning

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[Acknowledgement: Slides are adapted from Deep Learning Course, Mingsheng Long, THU]



Outline

- Deep Learning
- Why Deep Learning

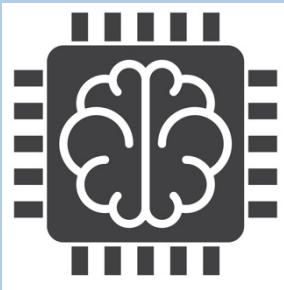


Deep Learning

(44100102)

ARTIFICIAL INTELLIGENCE

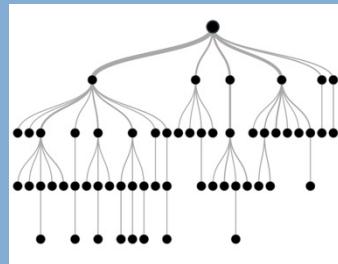
Any technique that enables computers to mimic human behavior



(44100552)

MACHINE LEARNING

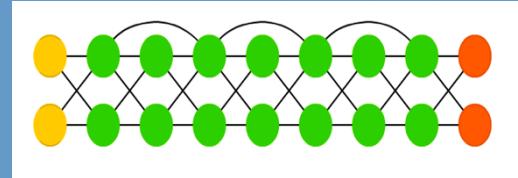
Ability to learn without explicitly being programmed



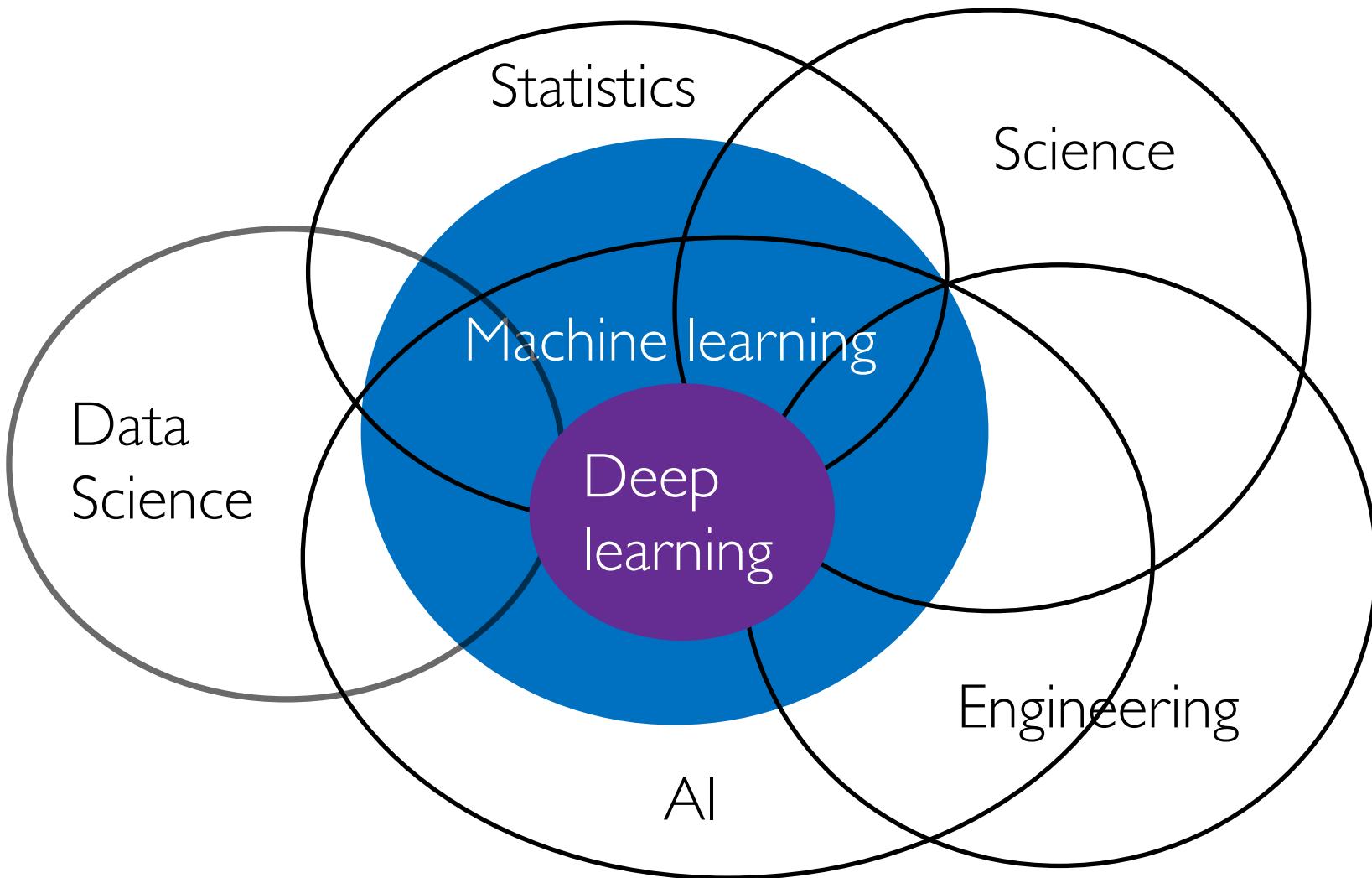
(84100343)

DEEP LEARNING

Learn underlying features in data using neural networks



Where is Deep Learning?



Computer Vision

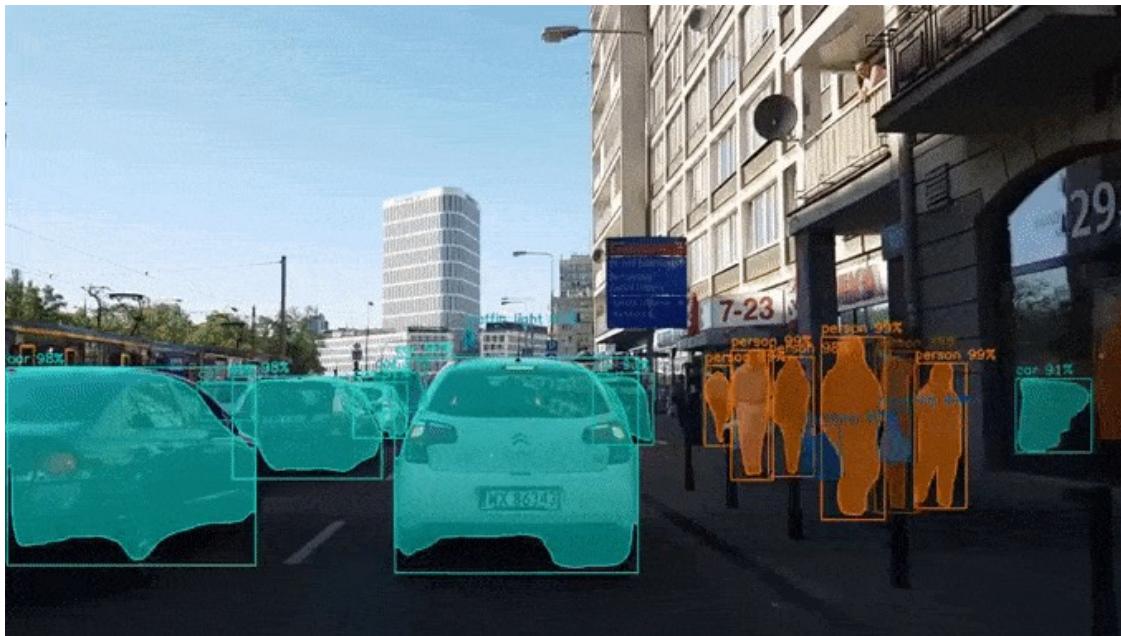
Classify Images



<http://www.image-net.org/>

Computer Vision

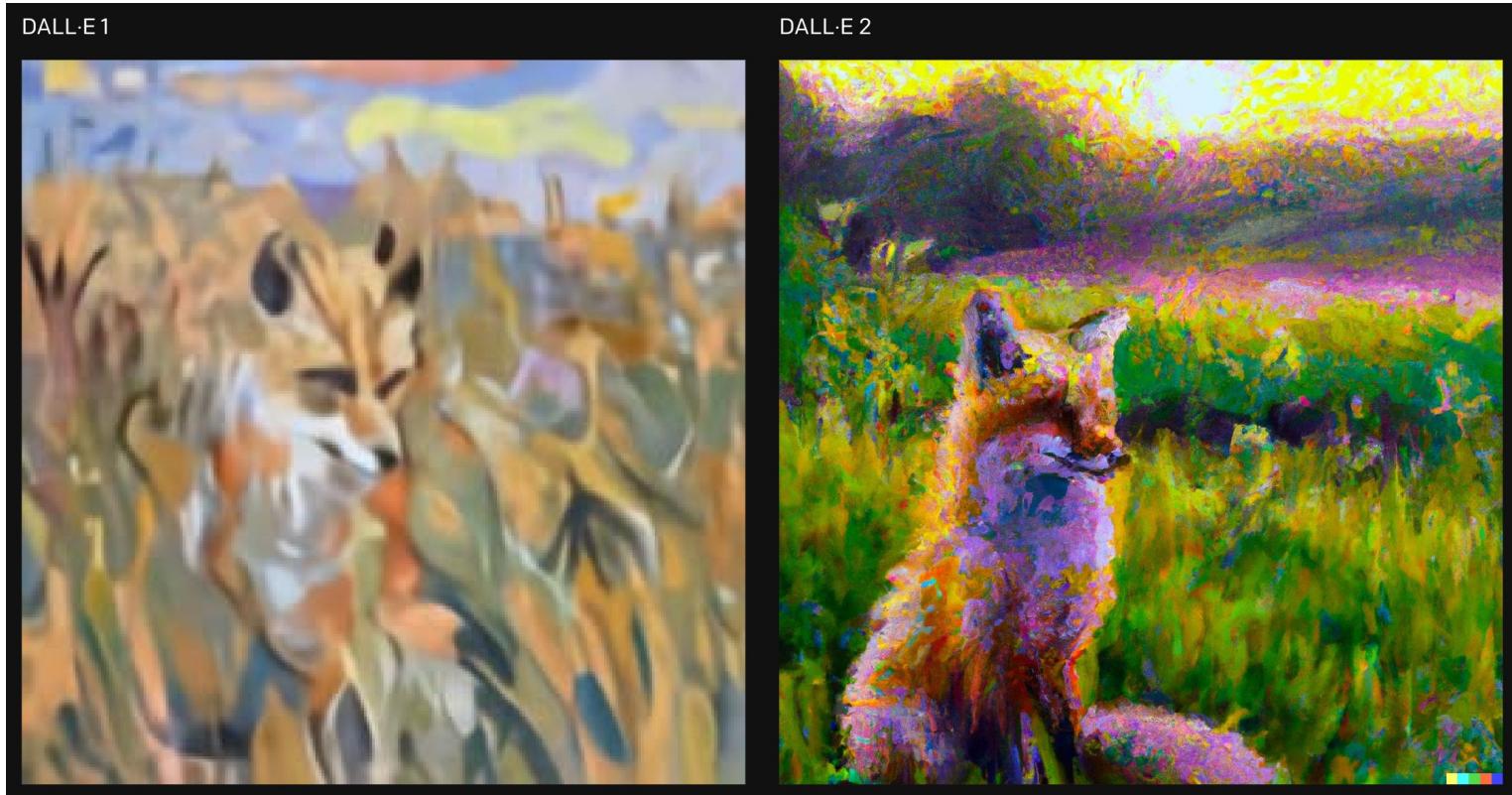
Detect (检测) and segment (分割) objects from images and videos



https://github.com/matterport/Mask_RCNN

Computer Vision

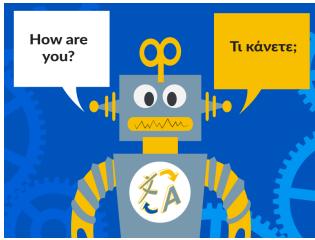
Neural arts by generative models



“A painting of a fox sitting in a field at sunrise in the style of Claude Monet”

<https://openai.com/dall-e-2/>





Natural Language Processing

Neural Machine Translation (NMT)

≡ Google 翻译

登录

2019

What's happened?

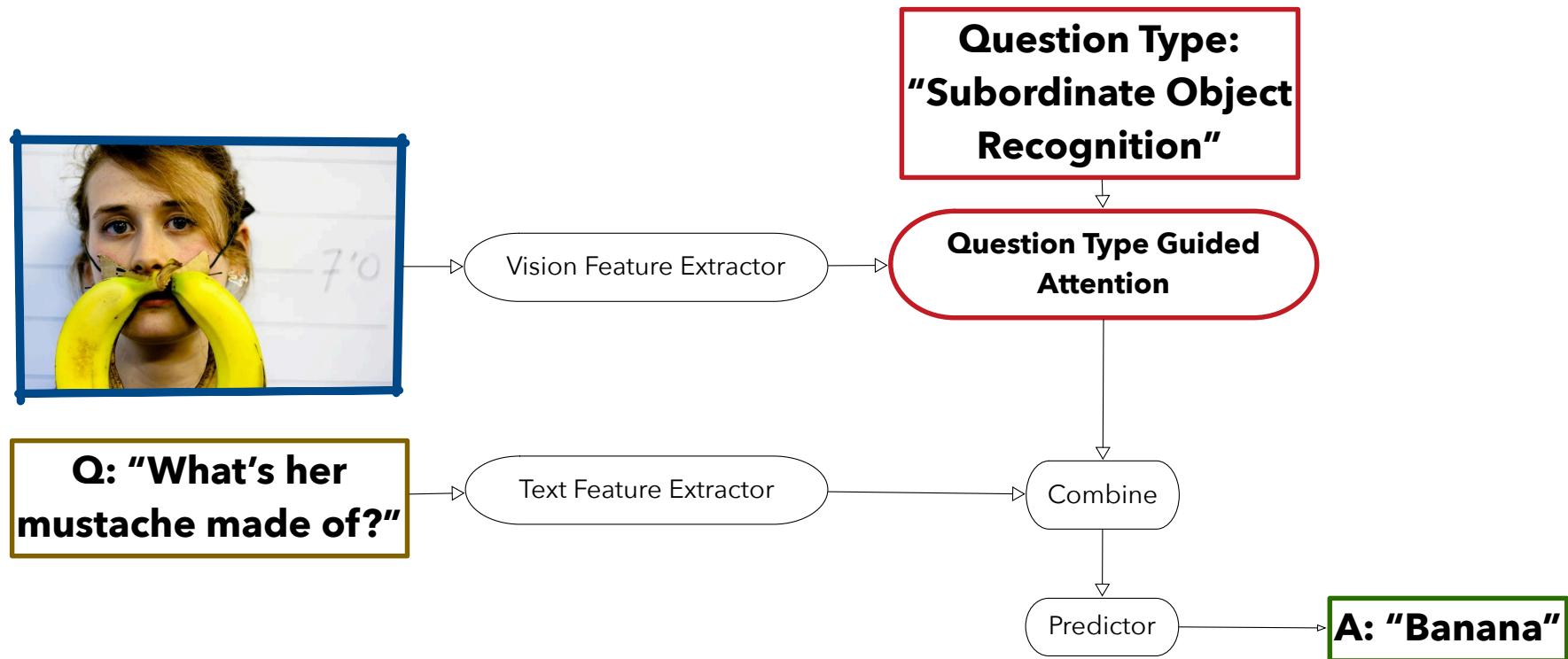
2020

<https://translate.google.com/#view=home&op=translate&sl=zh-CN&tl=en&text=%E7%8E%AF%E7%8E%AF%E7%8E%AF%E7%8E%AF%E7%8E%AF%E7%8E%AF%E7%8E%AF%E7%8E%AF>



Natural Language Processing

Question answering

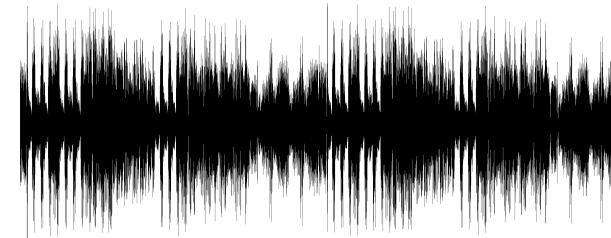


Shi et al, 2018, Arxiv

Natural Language Processing



What can I help
you with?



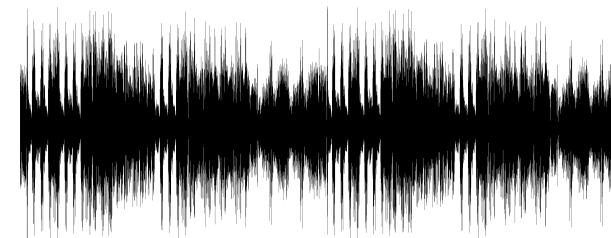
↓ Speech Recognition (ASR)

What's the weather today?

↓ Question Answering

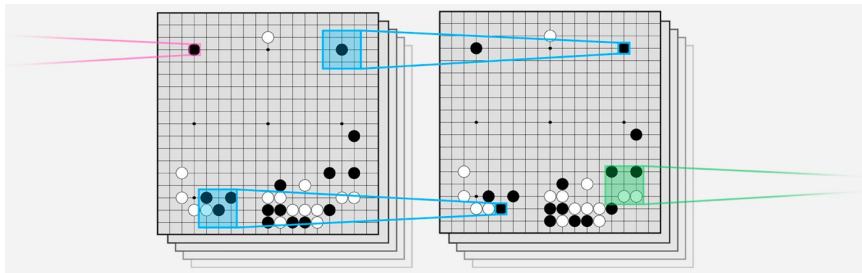
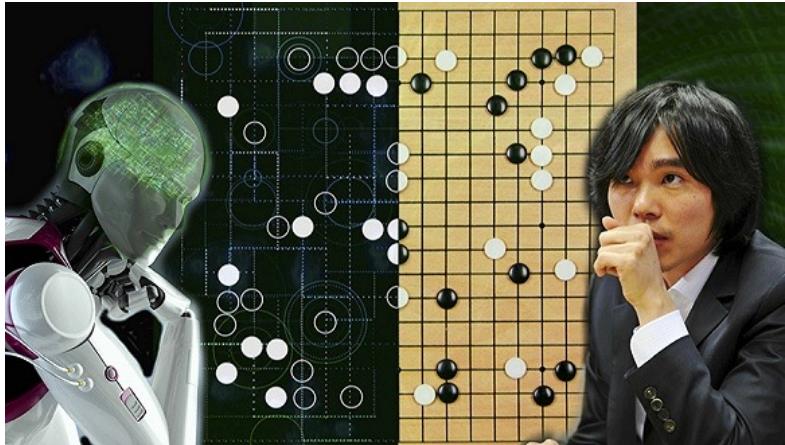
It's a sunny day.

↓ Text to Speech (TTS)

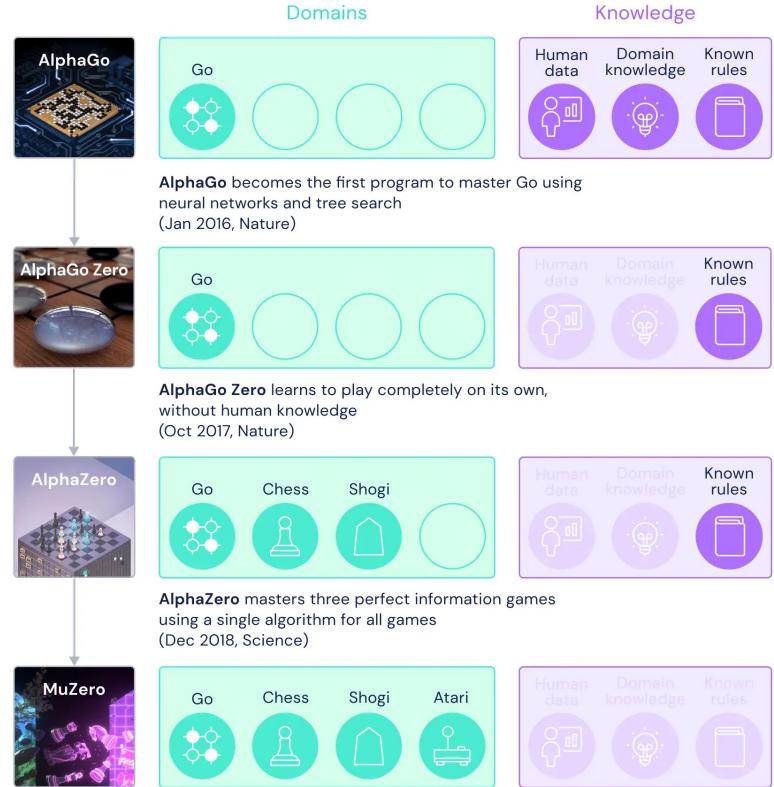


Games

AlphaGo



MuZero



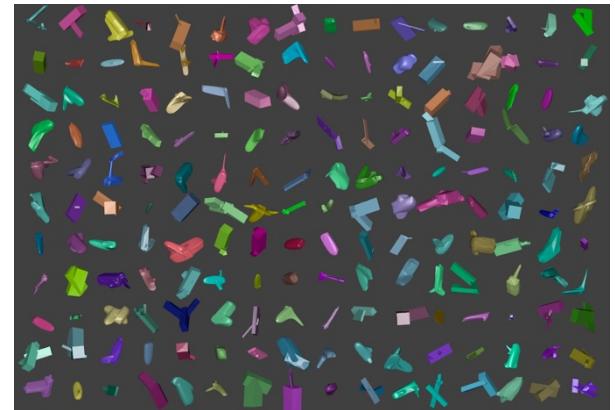
<https://deepmind.com/research/alphago/>

<https://deepmind.com/blog/article/muzero-mastering-go-chess-shogi-and-atari-without-rules>



Robotics

Closing the Simulation-to-Reality Gap
for Deep Robotic Learning



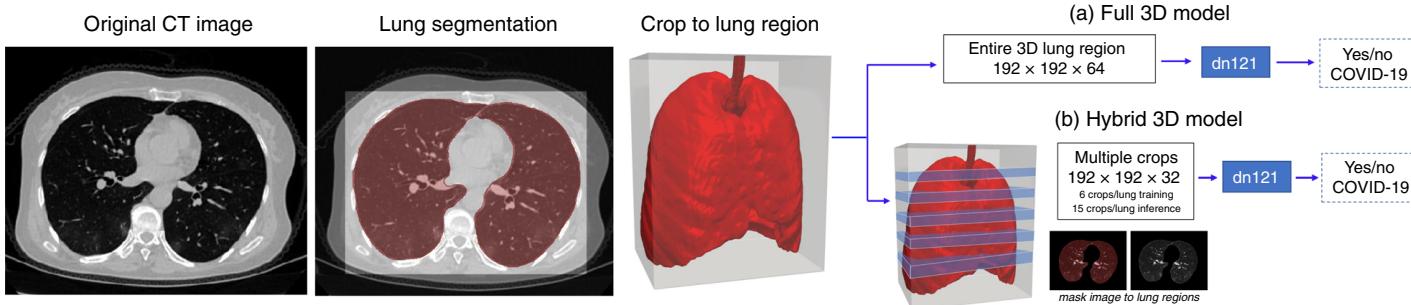
Simulated data



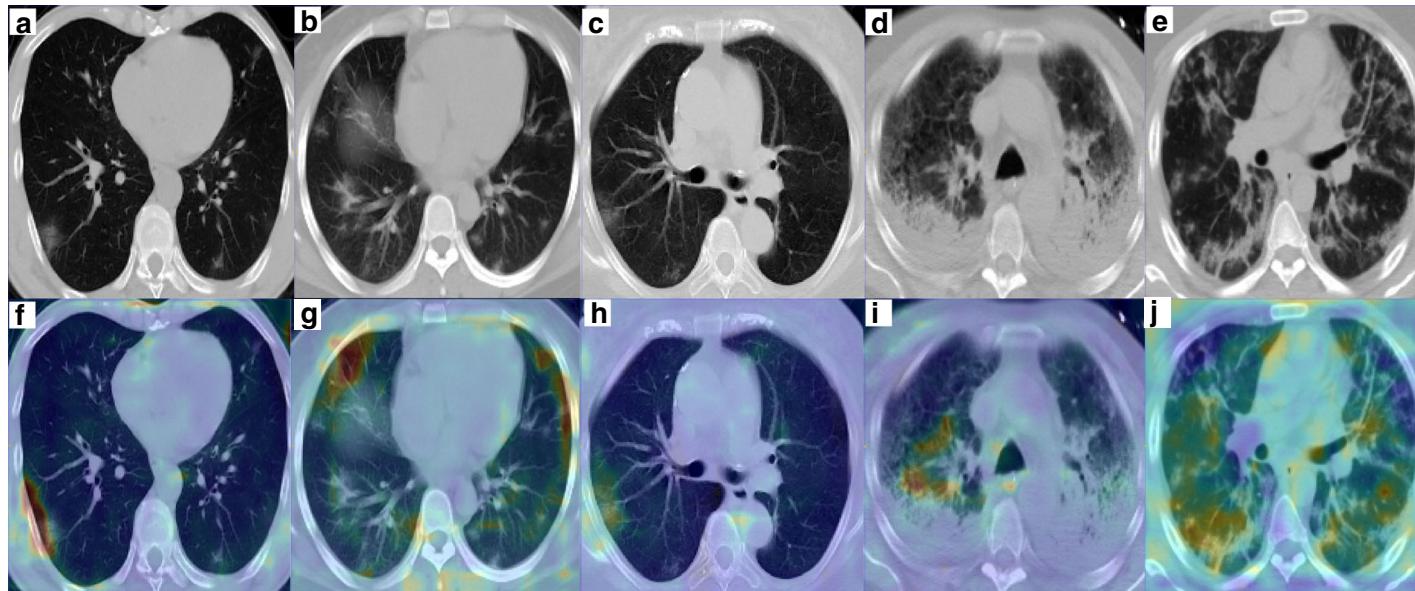
Real data

<https://ai.googleblog.com/2017/10/closing-simulation-to-reality-gap-for.html>

Medicine



3D
Classification
workflow



Grad-CAM
saliency
maps for
COVID-19
patients

Expressive!

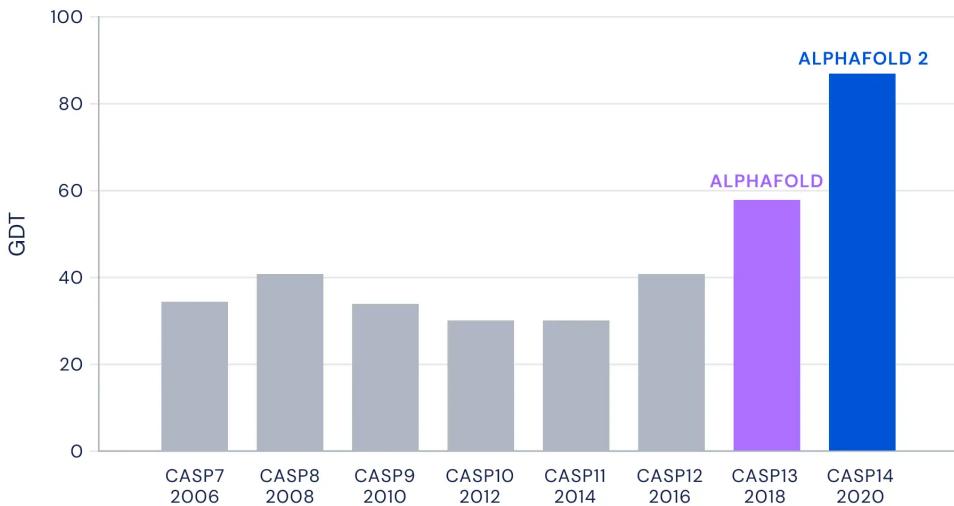
Artificial intelligence for the detection of COVID-19 pneumonia on chest CT using multinational datasets. *Nature Comm.* 2020.



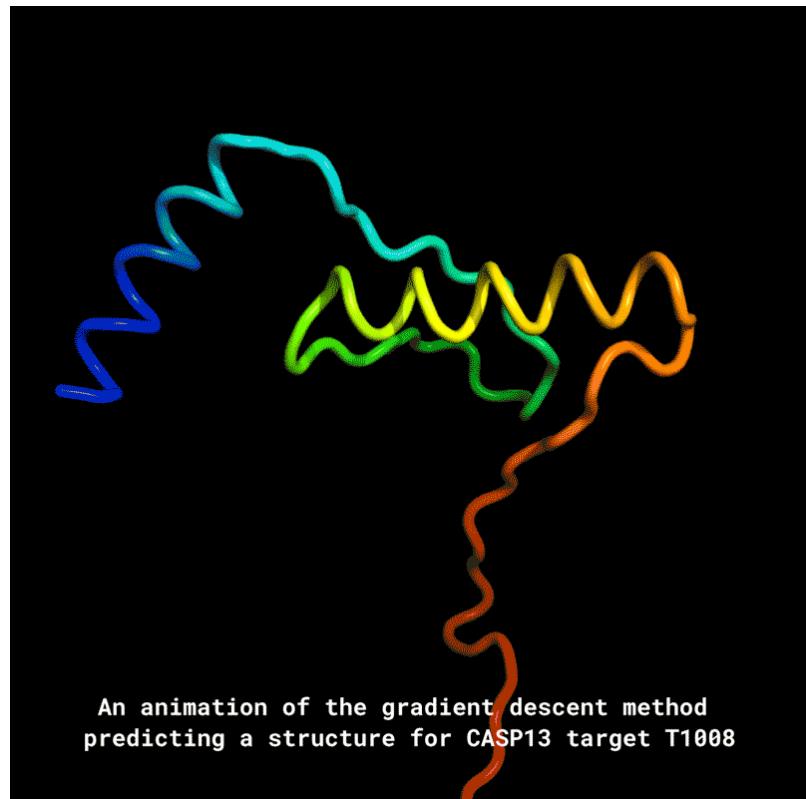
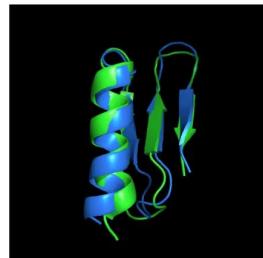
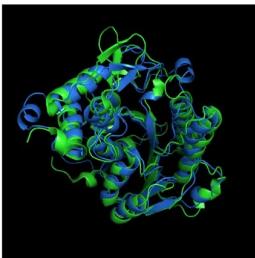
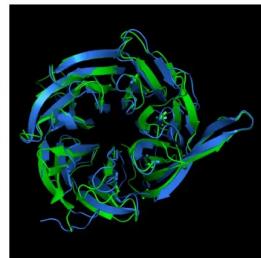
Biology

AlphaFold

Median Free-Modelling Accuracy



Structures:
Ground truth (green)
Predicted (blue)

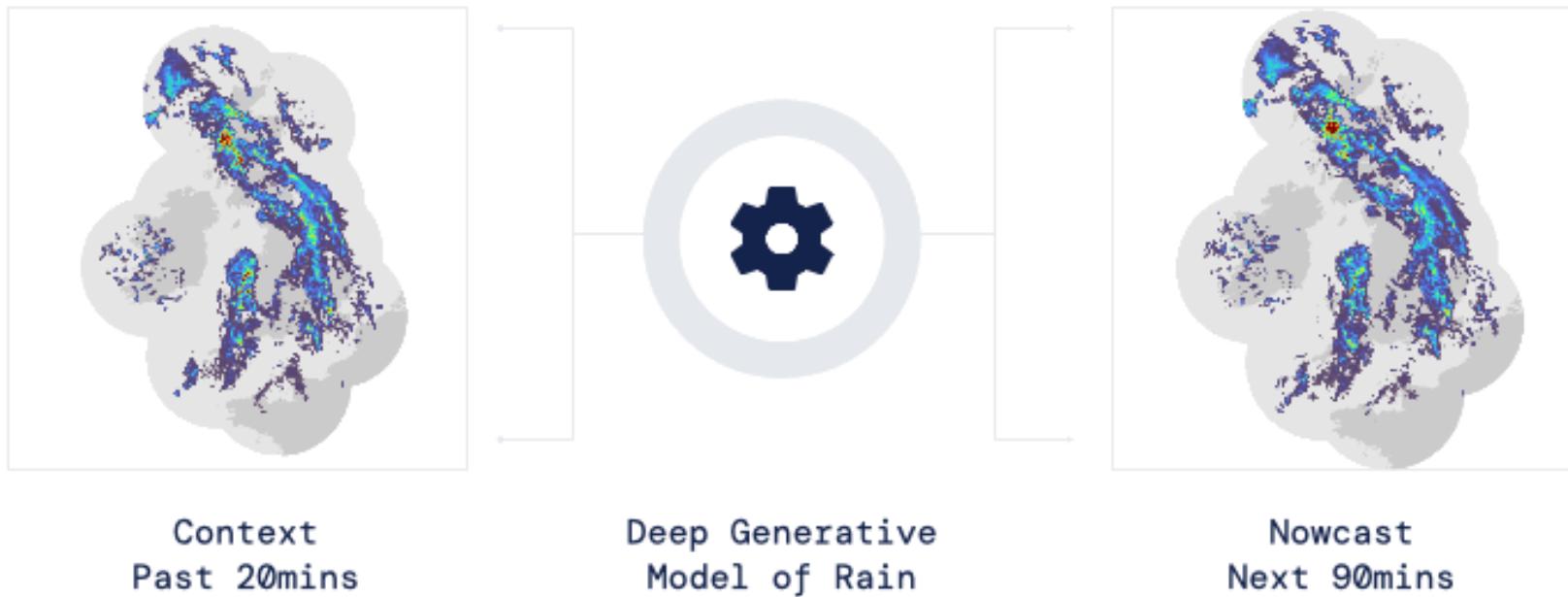


<https://deepmind.com/research/case-studies/alphafold>



Geoscience

Radar echo trace forecasting with predictive learning

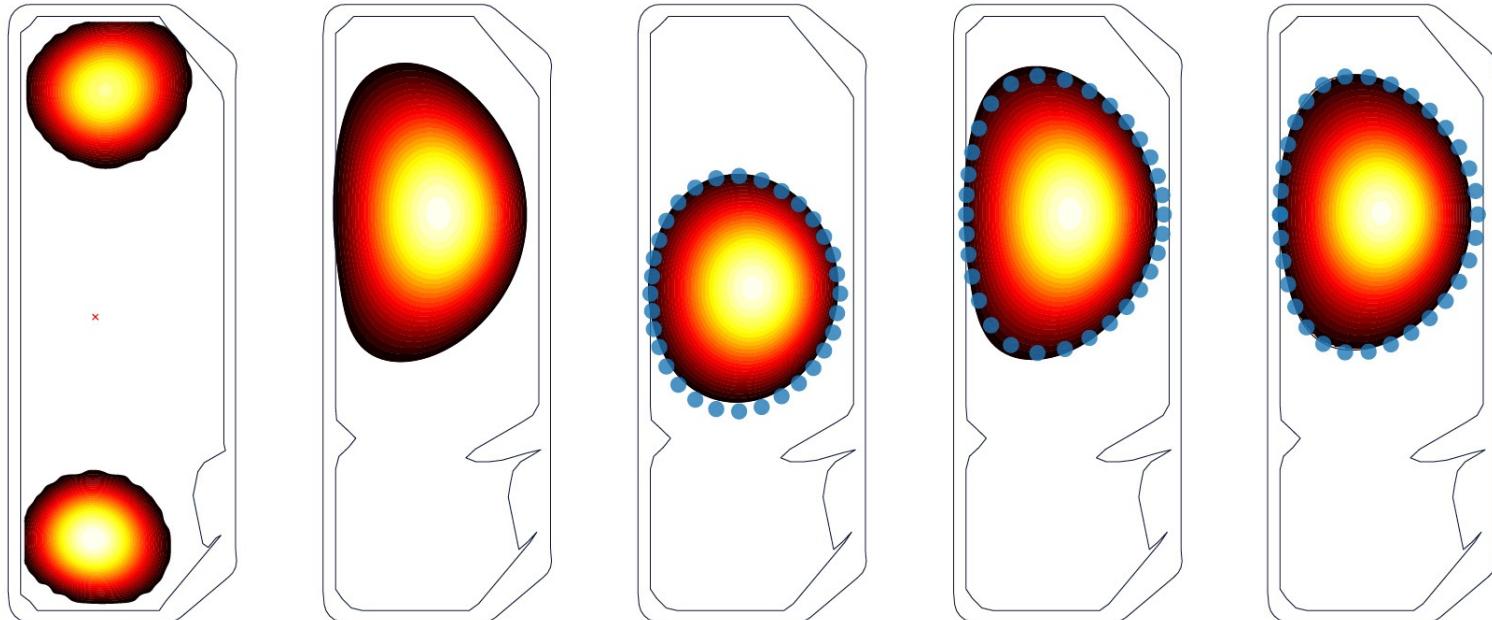


Ravuri, S. et al. Skilful precipitation nowcasting using deep generative models of radar. *Nature* 597, 672–677 (2021).



Physics

Nuclear fusion plasma controlling with deep reinforcement learning



Droplets

Negative
Triangularity

ITER-like
shape

Snowflake

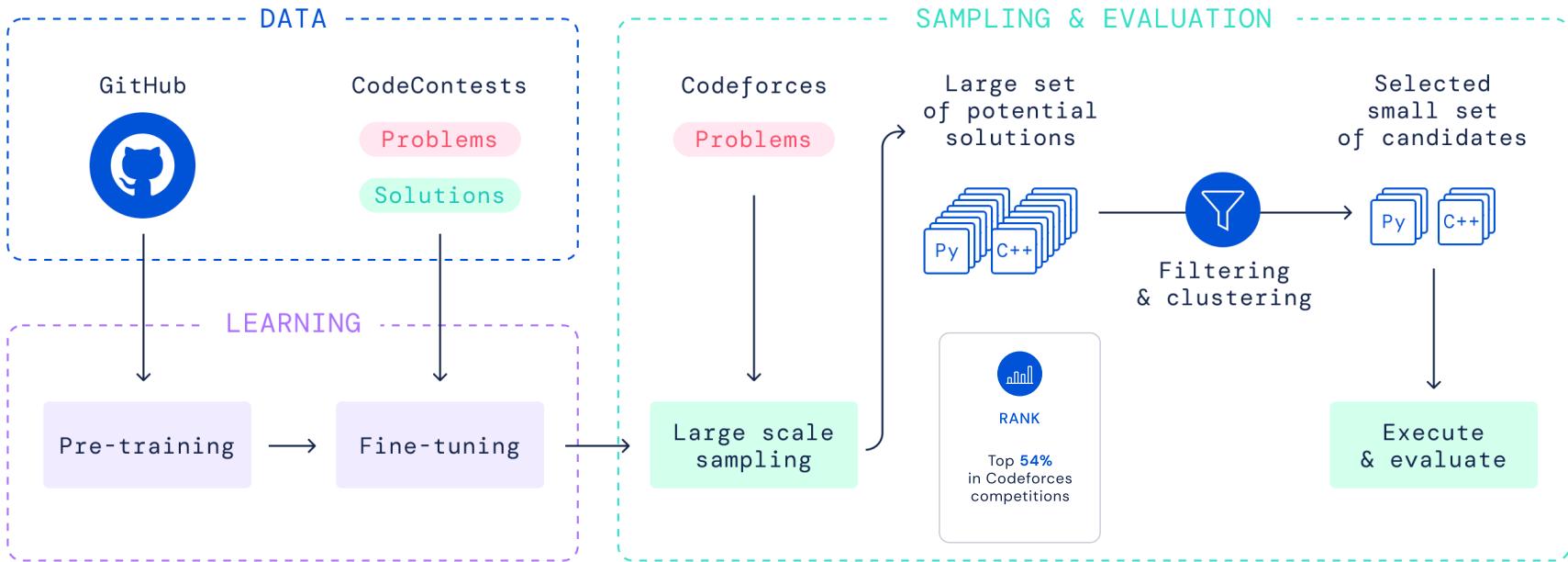
Elongated
Plasma

Degrave, J. et al. Magnetic control of tokamak plasmas through deep reinforcement learning. *Nature* 602, 414–419 (2022).



Programming

AlphaCode



Solving competitive programming problems is a really hard thing to do, requiring both good coding skills and problem solving creativity in humans. I was very impressed that AlphaCode could make progress in this area, and excited to see how the model uses its statement understanding to produce code and guide its random exploration to create solutions."

PETR MITRICHEV

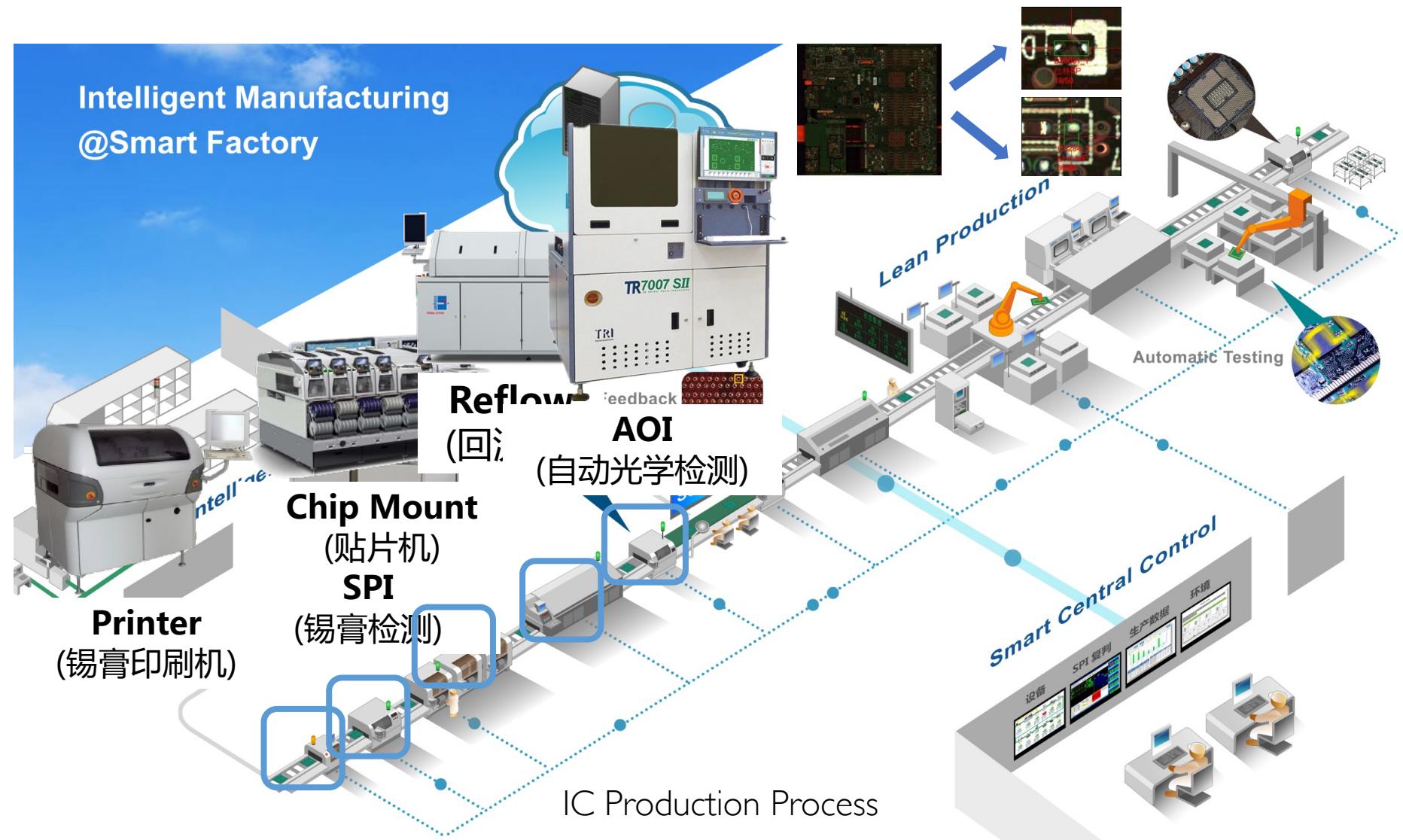
SOFTWARE ENGINEER, GOOGLE & WORLD-CLASS COMPETITIVE PROGRAMMER

Li Y. et al. Competitive programming with AlphaCode. *Nature*. 2022.



Manufacturing

Intelligent Manufacturing
@Smart Factory



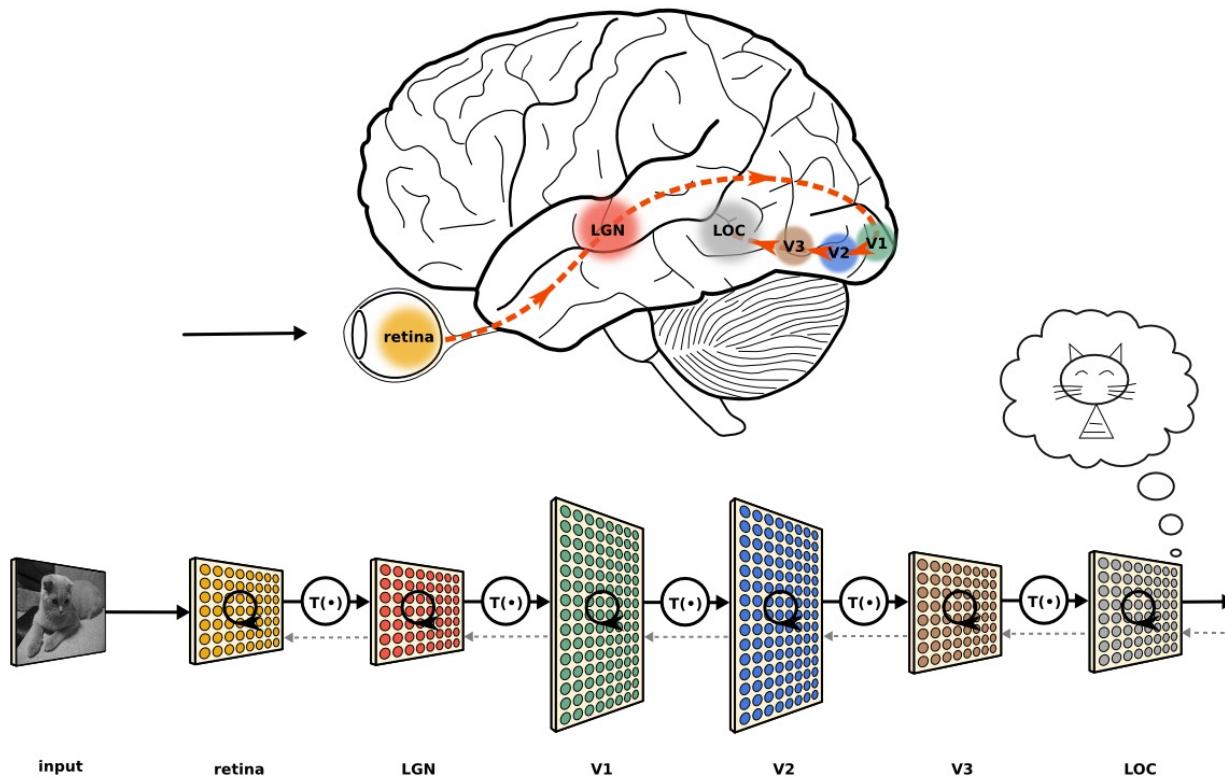
Outline

- Deep Learning
- Why Deep Learning



Why Deep Learning?

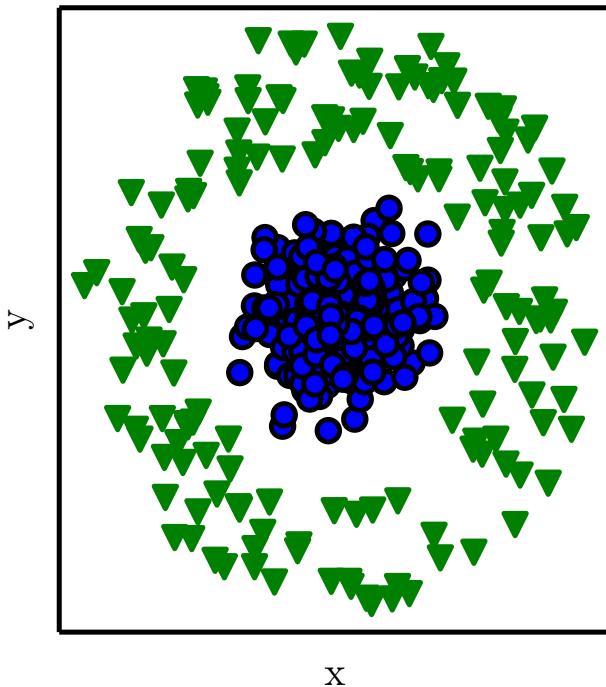
- Deep learning is algorithms that **model high-level abstractions** in data using architectures consisting of **multiple nonlinear transformations**.



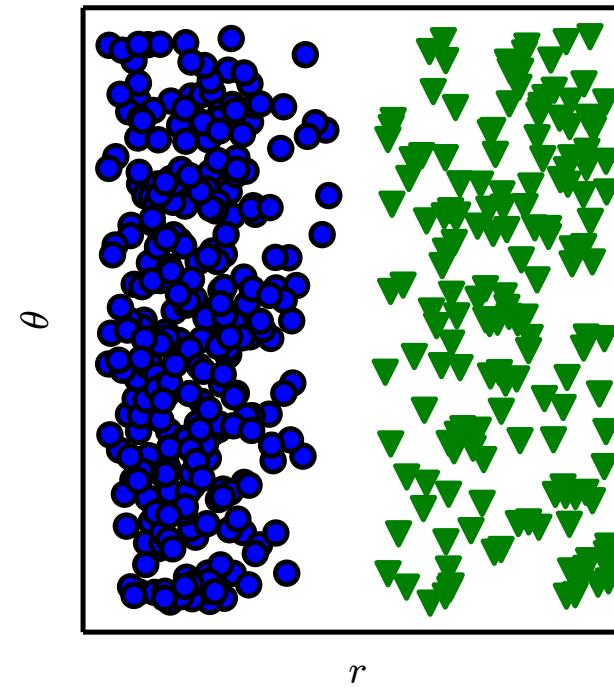
Features Really Matter

How many ways to turn linearly inseparable case into a separable one?

Cartesian coordinates



Polar coordinates



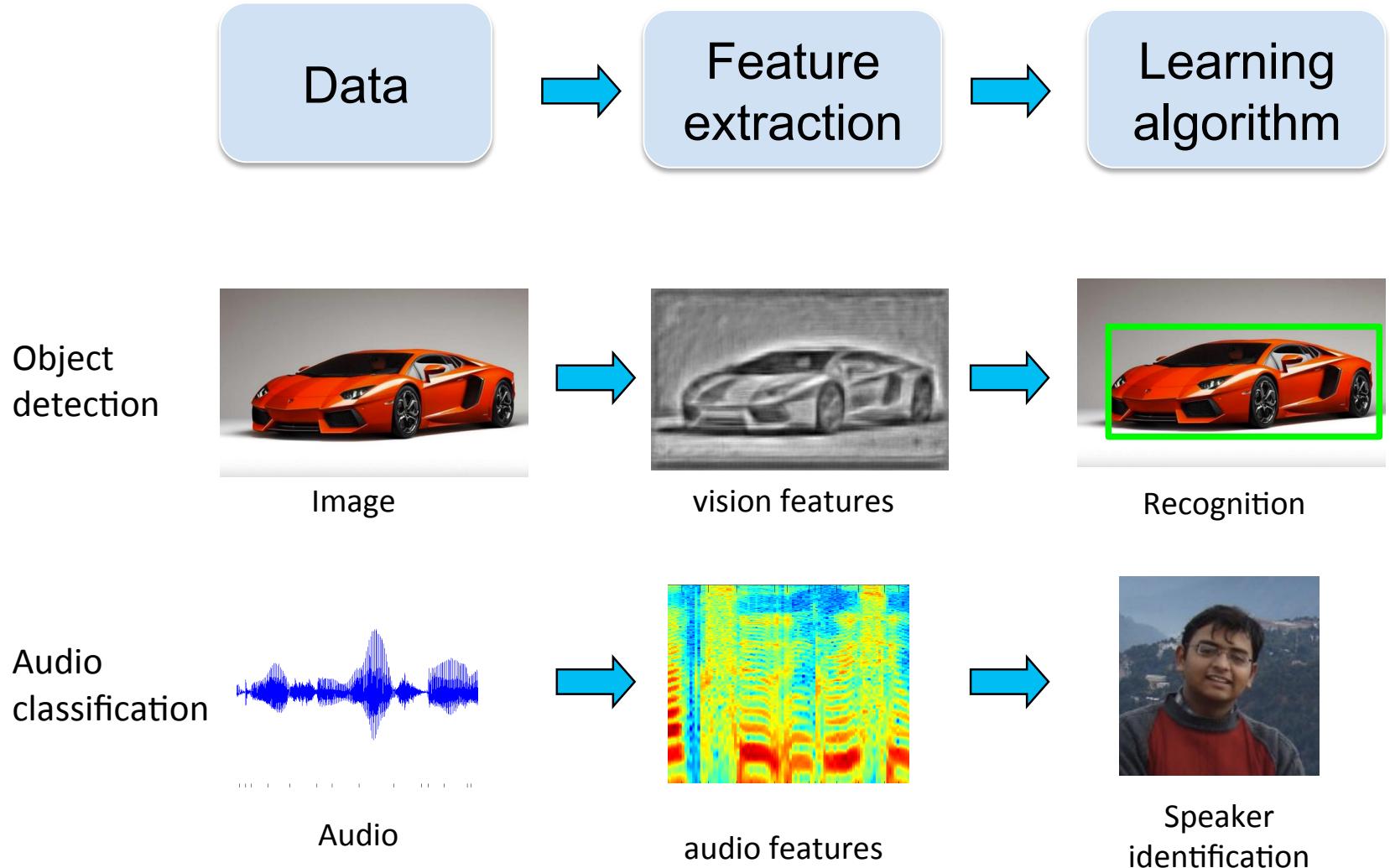
$$x = r\cos(\theta)$$
$$y = r\sin(\theta)$$

How about:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Jitendra Malik, et al. R-CNN: Regions with Convolutional Neural Network Features. CVPR 2014

Engineered Features



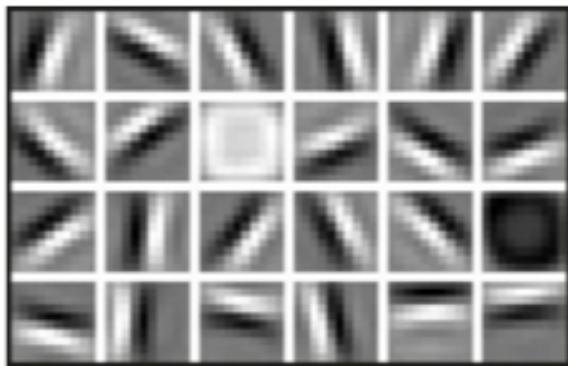
Learned Features

Hand engineered features are time consuming, brittle and not scalable.

(有多少智能，就有多少人工)

Can we learn the underlying features directly from data?

Low Level Features



Lines & Edges

Mid Level Features



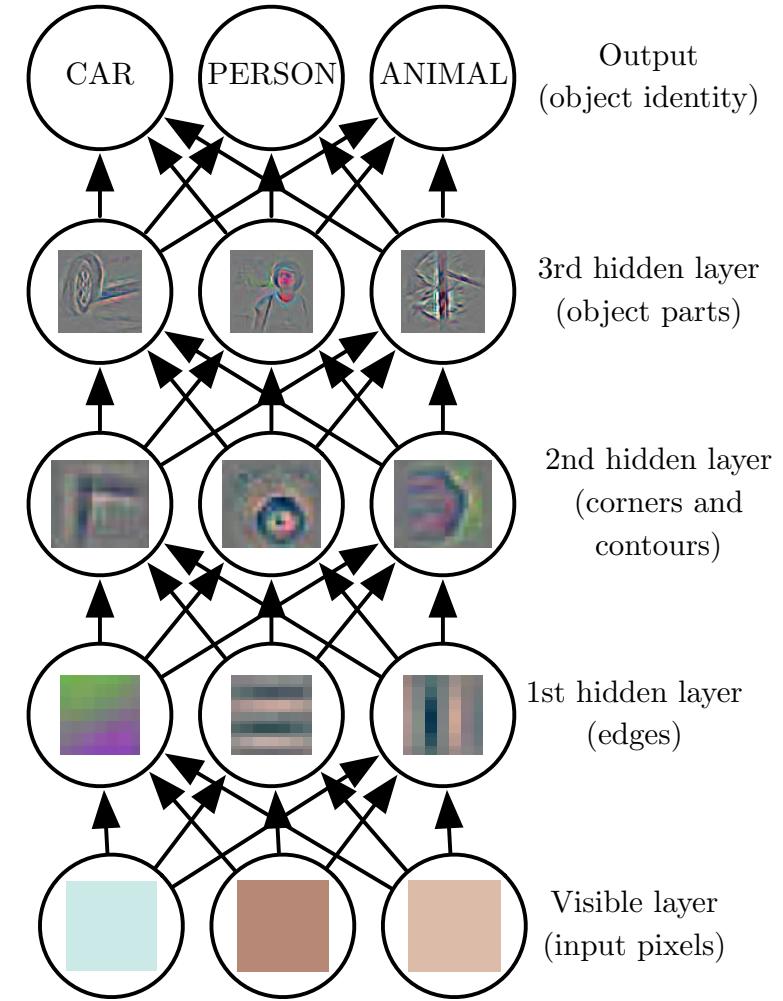
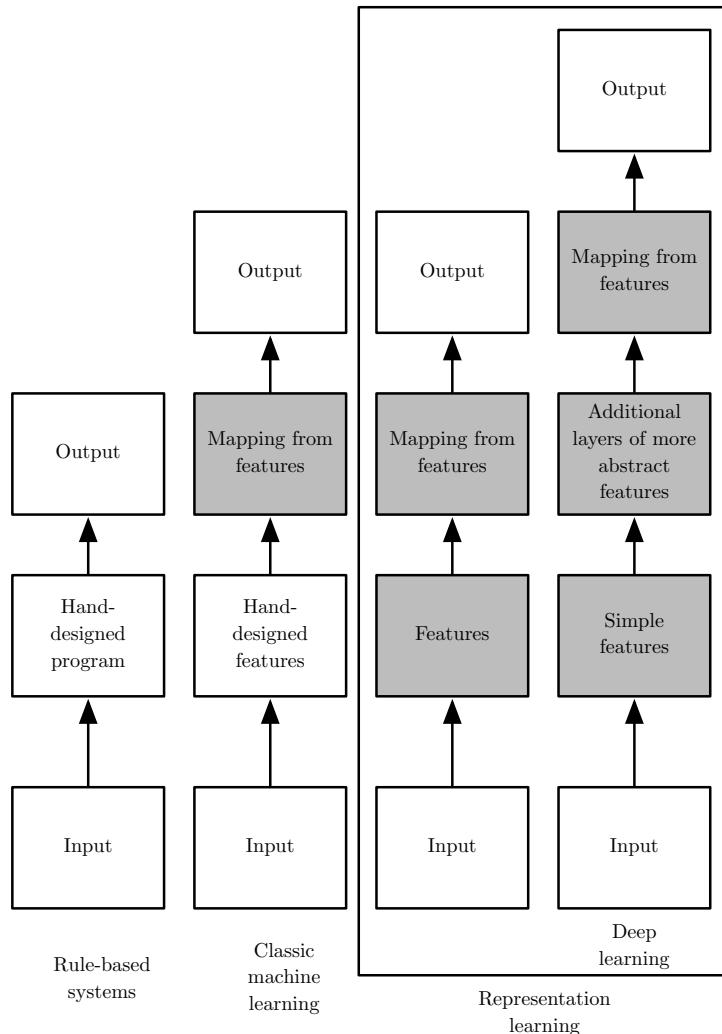
Eyes & Nose & Ears

High Level Features



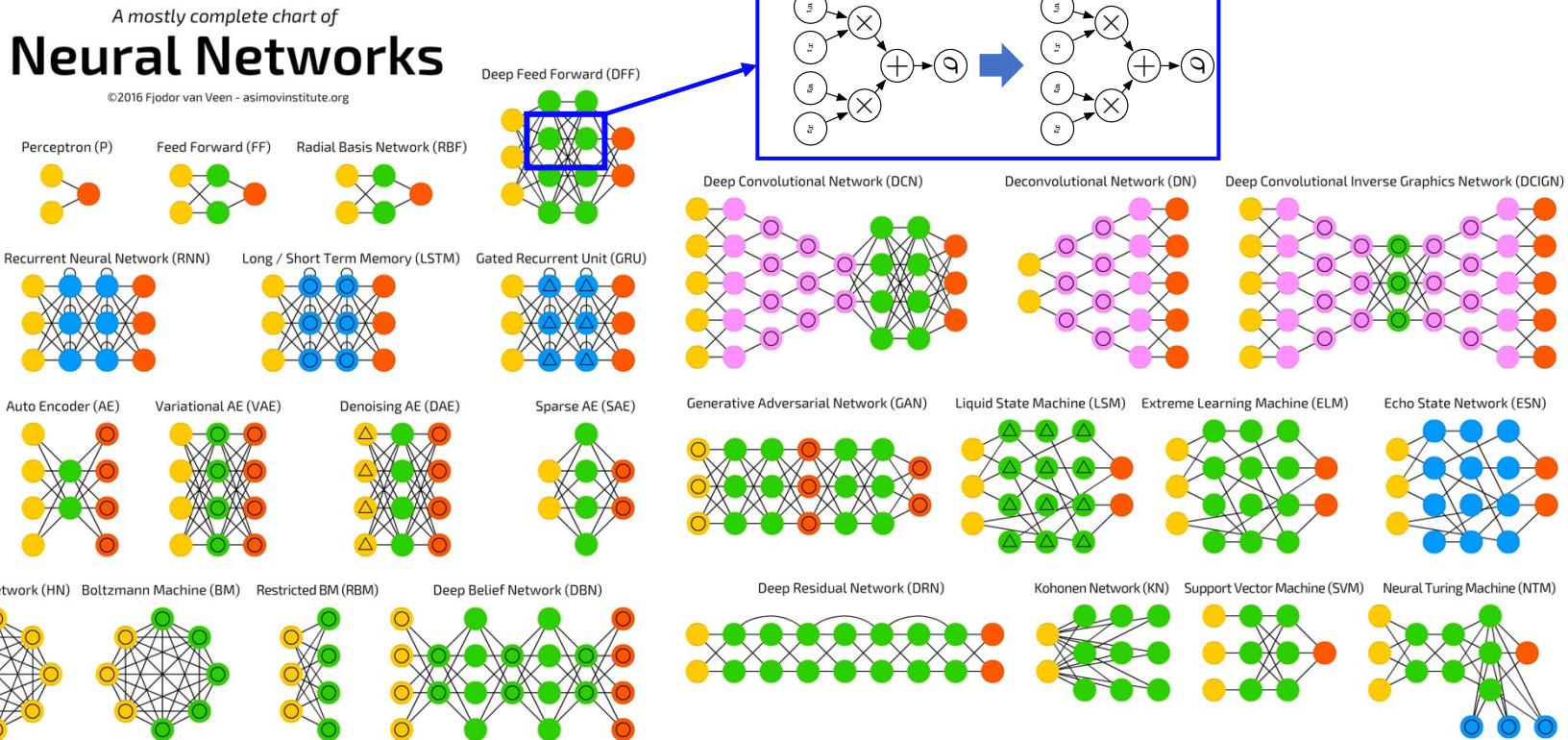
Facial Structure

Feature Learning with Abstraction



Neural Networks

From basic units to layers/modules to complex network architectures

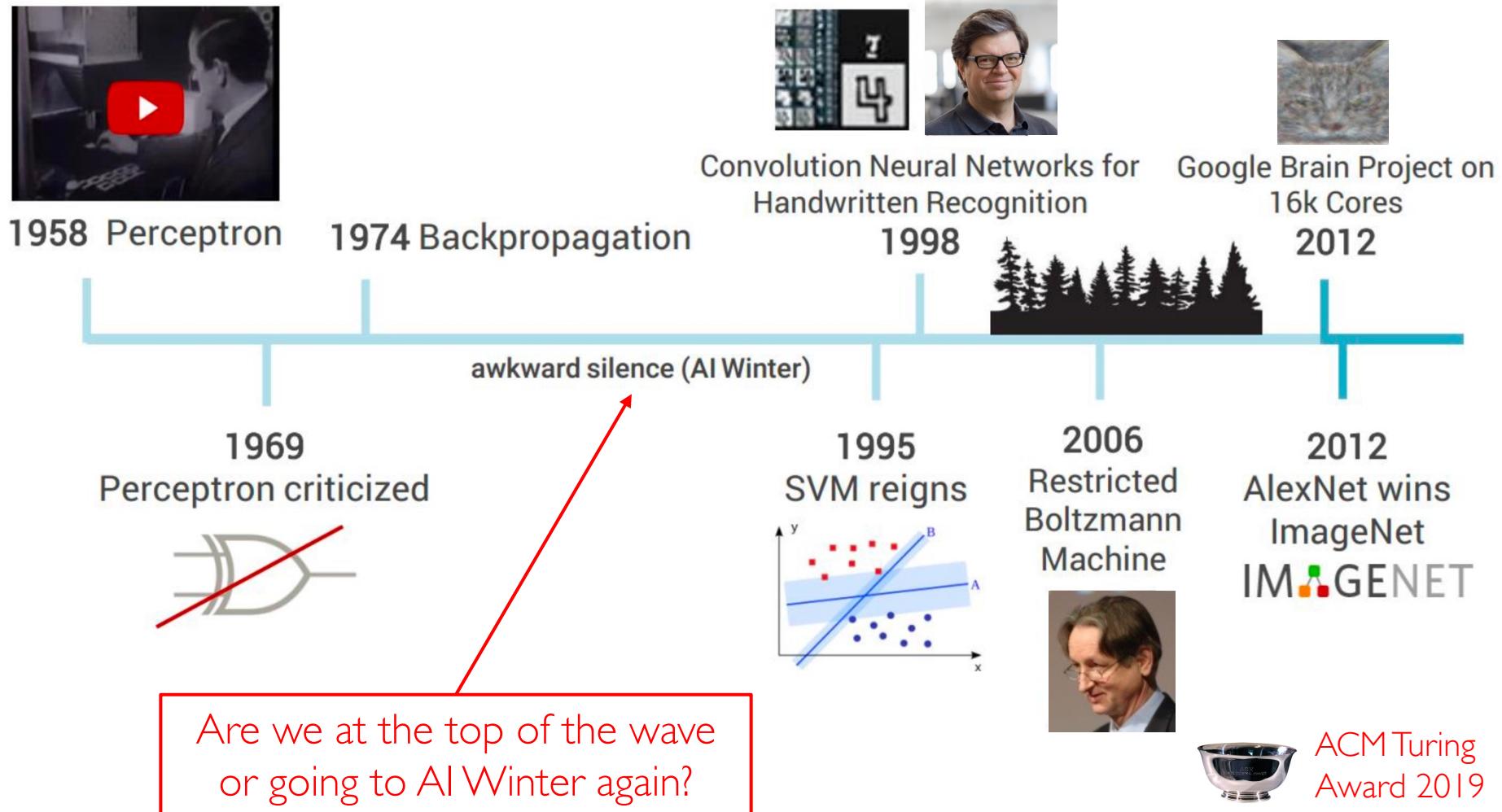


The Most Complete List of Best AI Cheat Sheets

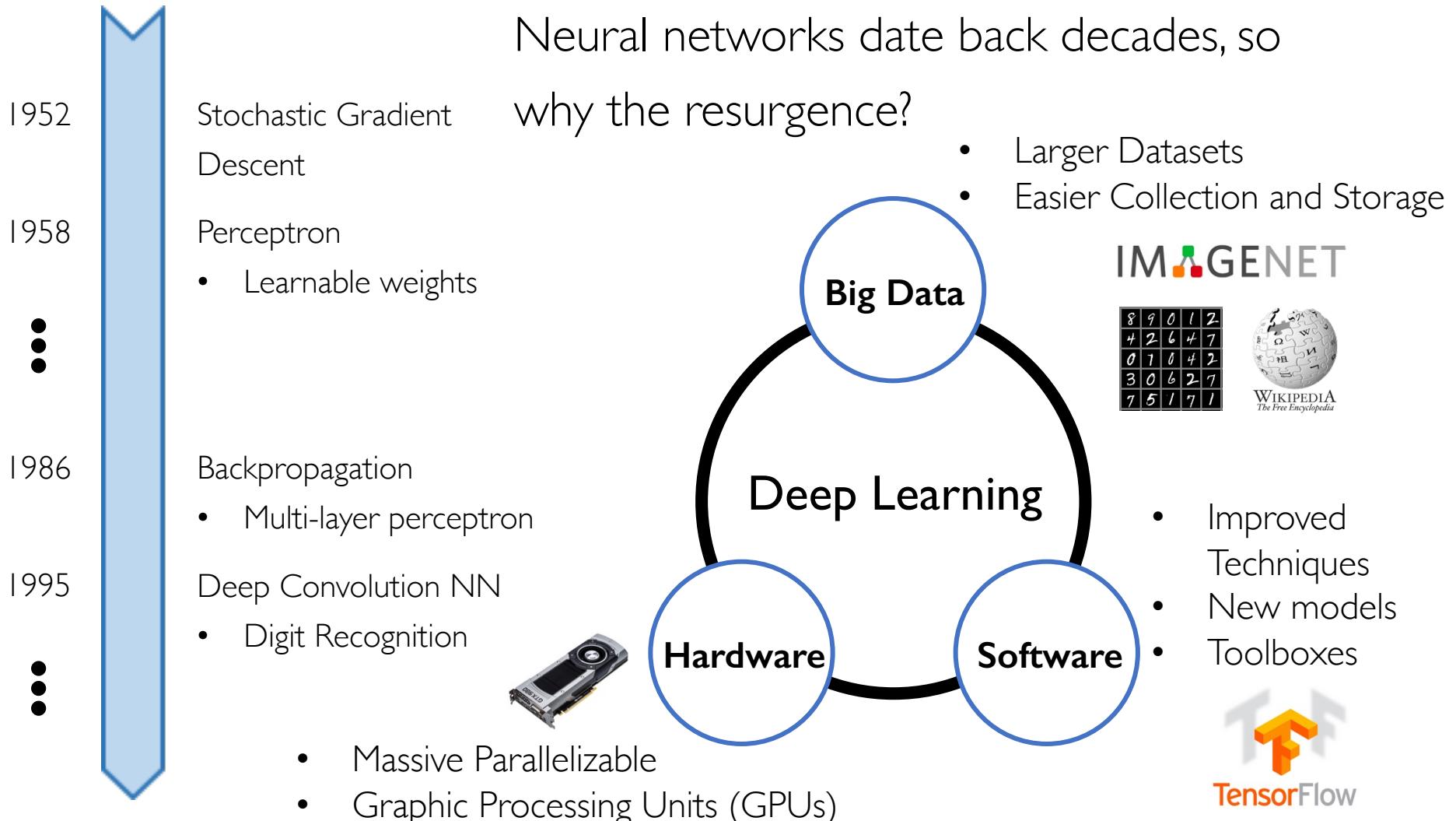
<https://becominghuman.ai/cheat-sheets-for-ai-neural-networks-machine-learning-deep-learning-big-data-678c51b4b463>



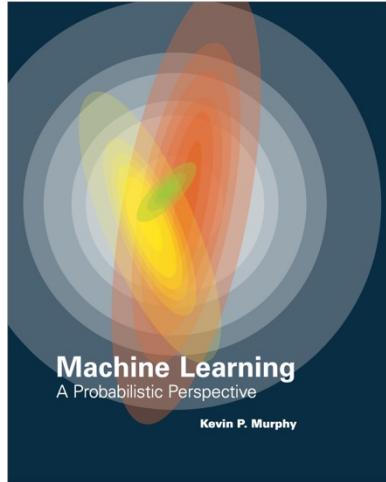
Brief History of Deep Learning



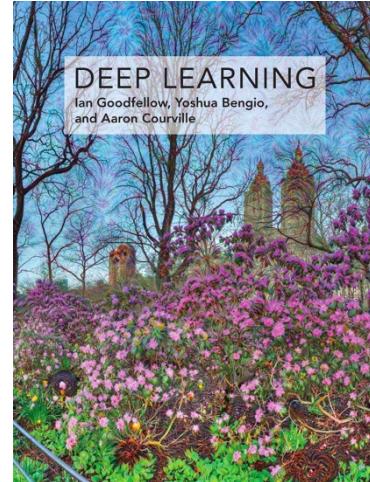
Why Now?



Reference Books

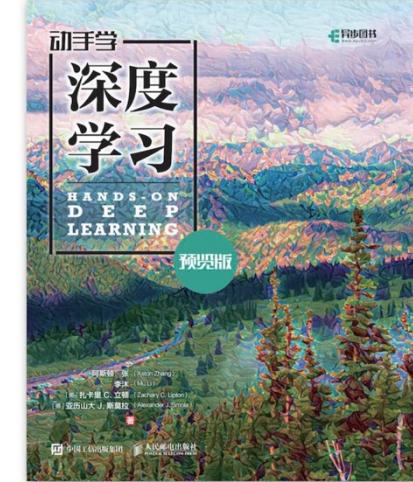


2012
Machine Learning



2016
Deep Learning
(Free E-book)

www.deeplearningbook.org/



2018
Dive Into Deep Learning
(Free E-book)

<https://zh.d2l.ai/>



Reading Materials

- Top Conferences
 - Theory: COLT
 - Methodology: ICML, NIPS, ICLR
 - Applications: CVPR, ICCV, ACL, KDD, SIGIR, WWW
- Top Journals
 - Methodology: JMLR, MLJ
 - Applications: TPAMI, AIJ, TKDE, TIP...



Resources



<http://pytorch.org/>



<https://keras.io>



<https://www.tensorflow.org>

Software



<http://www.image-net.org>



CANADIAN
INSTITUTE
FOR
ADVANCED
RESEARCH

<https://www.cs.toronto.edu/~kriz/cifar.html>



<http://cocodataset.org>

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

MNIST

<http://yann.lecun.com/exdb/mnist/>

Data

Awesome things: <https://github.com/ChristosChristofidis/awesome-deep-learning>

Get Hands Dirty!

To better understand theory, models, and algorithms.

