

# Deep Learning

Lecture 0: Introduction

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# Why learning?



What do you see?



Sheepdog or mop?



Chihuahua or muffin?

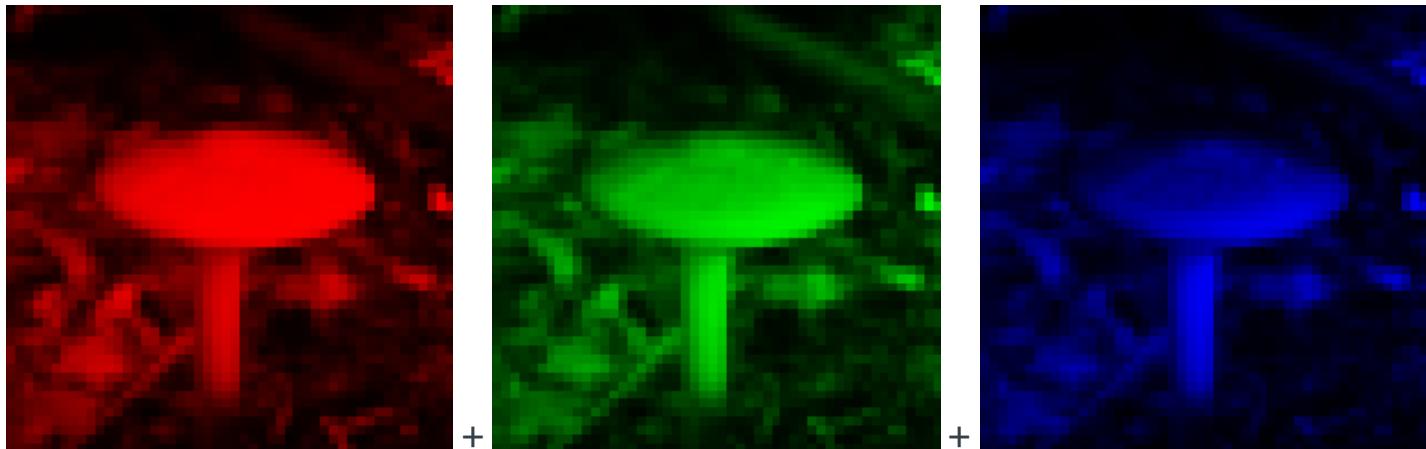
The (human) brain is so good at interpreting visual information that the **gap** between raw data and its semantic interpretation is difficult to assess intuitively:



This is a mushroom.



This is a mushroom.



This is a mushroom.

```
array([[[0.03921569, 0.03529412, 0.02352941, 1.        ],
       [0.2509804 , 0.1882353 , 0.20392157, 1.        ],
       [0.4117647 , 0.34117648, 0.37254903, 1.        ],
       ...,
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       [0.18039216, 0.18039216, 0.14117648, 1.        ]],

      [[0.1254902 , 0.11372549, 0.09411765, 1.        ],
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       [0.21176471, 0.2        , 0.20392157, 1.        ],
       ...,
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       [0.16470589, 0.20784314, 0.11764706, 1.        ]],

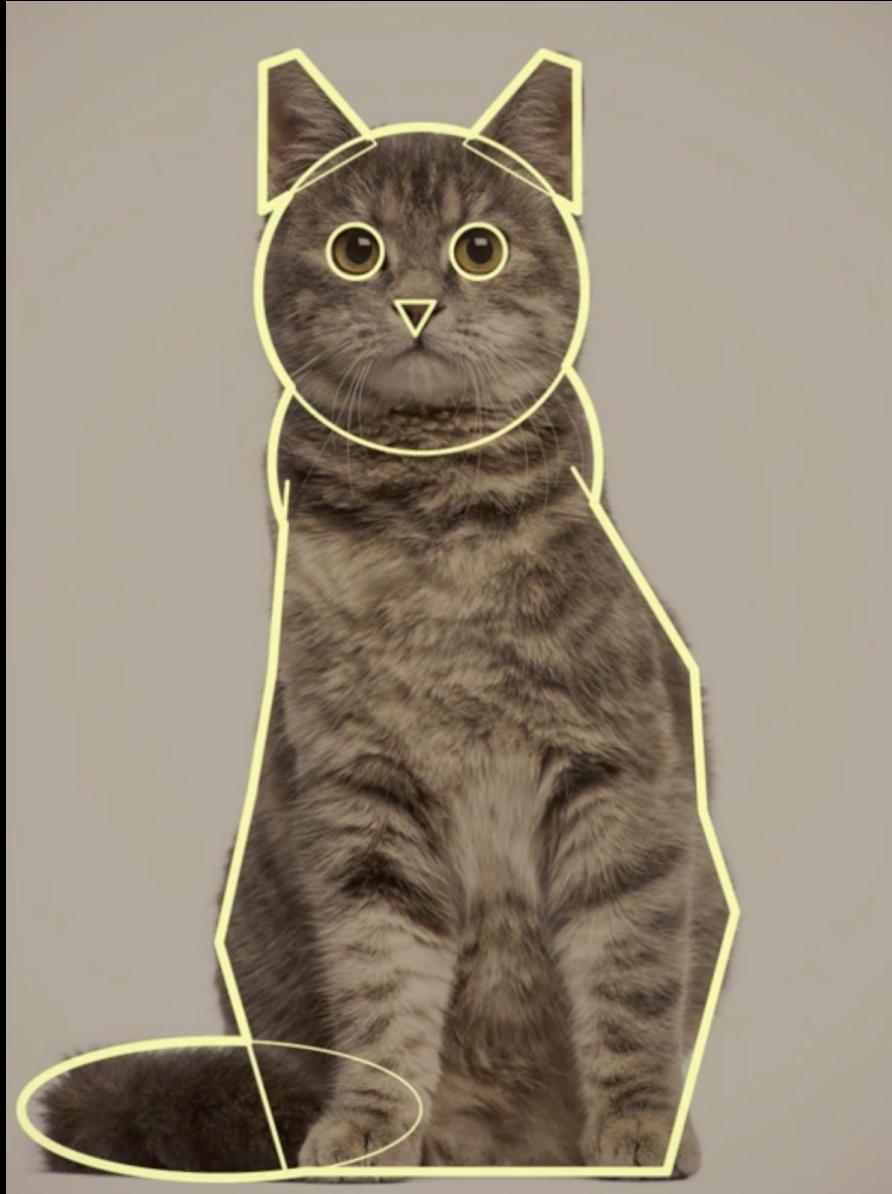
      [[0.14117648, 0.12941177, 0.10980392, 1.        ],
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       [0.10980392, 0.15686275, 0.08627451, 1.        ],
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      ...]
```

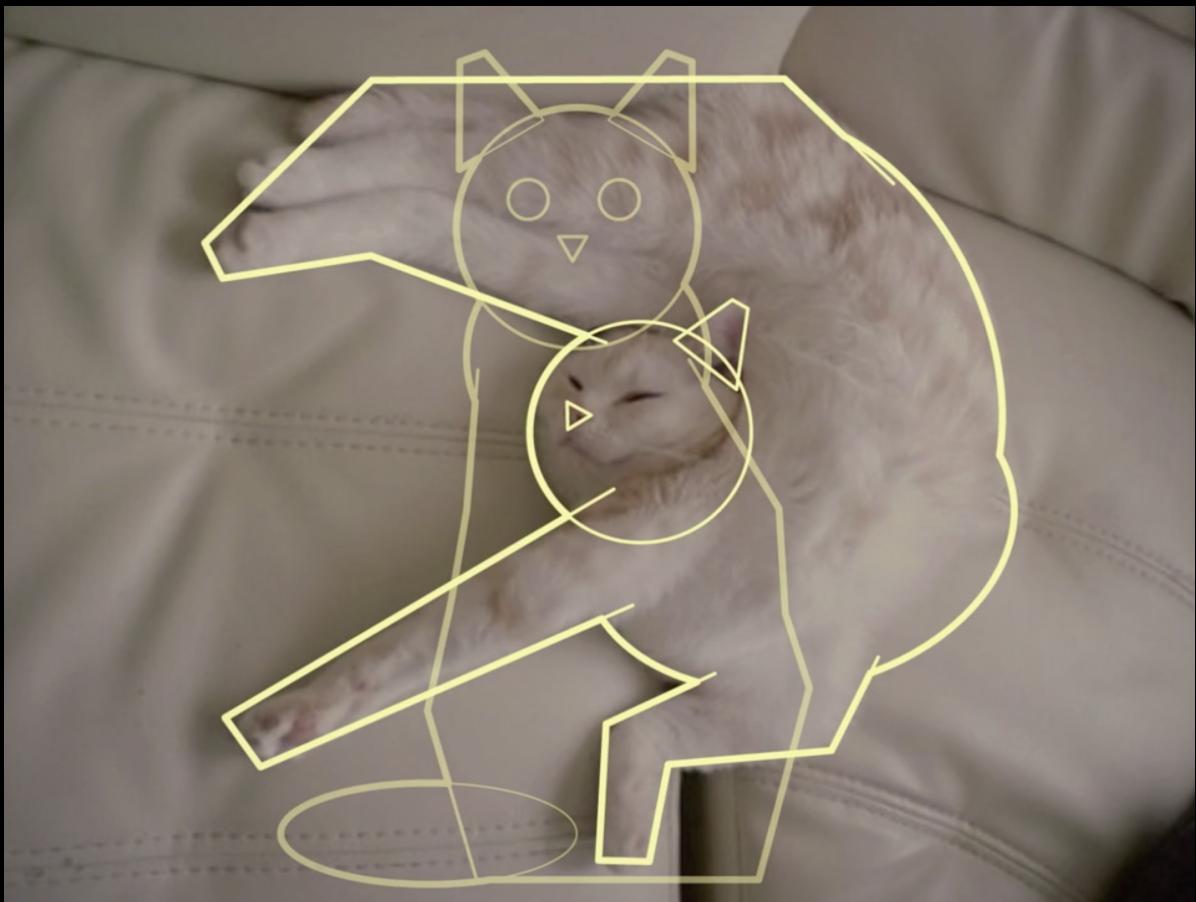
This is a mushroom.

Writing a computer program that sees?









Extracting semantic information requires models of **high complexity**, which cannot be designed by hand.

However, one can write a program that **learns** the task of extracting semantic information.



Techniques used in practice consist of:

- defining a parametric model with high capacity,
- optimizing its parameters, by "making it work" on the training data.

This is similar to **biological systems** for which the model (e.g., brain structure) is DNA-encoded, and parameters (e.g., synaptic weights) are tuned through experiences.

Deep learning encompasses software technologies to **scale-up** to billions of model parameters and as many training examples.

# **Applications and successes**



YOLOv3



Watch later



Share



Real-time object detection (Redmon and Farhadi, 2018)



ICNet for Real-Time Semantic Segmentation ...



Watch later



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Segmentation (Hengshuang et al, 2017)



Realtime Multi-Person 2D Human Pose Estim...



Watch later

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Pose estimation (Cao et al, 2017)



Google DeepMind's Deep Q-learning playing A...



Watch later



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Reinforcement learning (Mnih et al, 2014)



## AlphaStar Agent Visualisation



Watch later Share



Strategy games (Deepmind, 2016-2018)



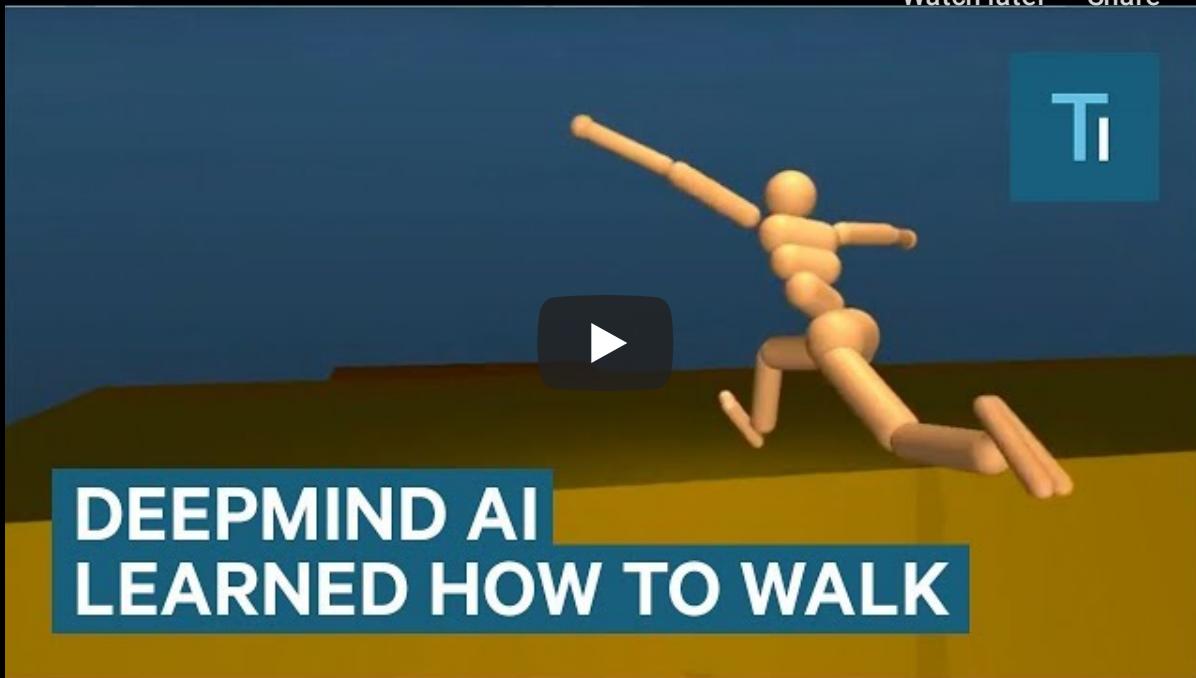
Google's DeepMind AI Just Taught Itself To W...



Watch later



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Learning to walk (2017)



NVIDIA Autonomous Car



Watch later



Share



Autonomous cars (NVIDIA, 2016)



Full Self-Driving



Watch later



Share



Autopilot (Tesla, 2019)



Tesla Autopilot Predicts Car Crash before it h...



Watch later



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... while preventing accidents.



Watch later



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So, that one change that particular break through increased  
recognition rates by approximately thirty percent, that's a big  
deal.  
That's the difference between going

Recognizability: 98%

Speech recognition, translation and synthesis (Microsoft, 2012)



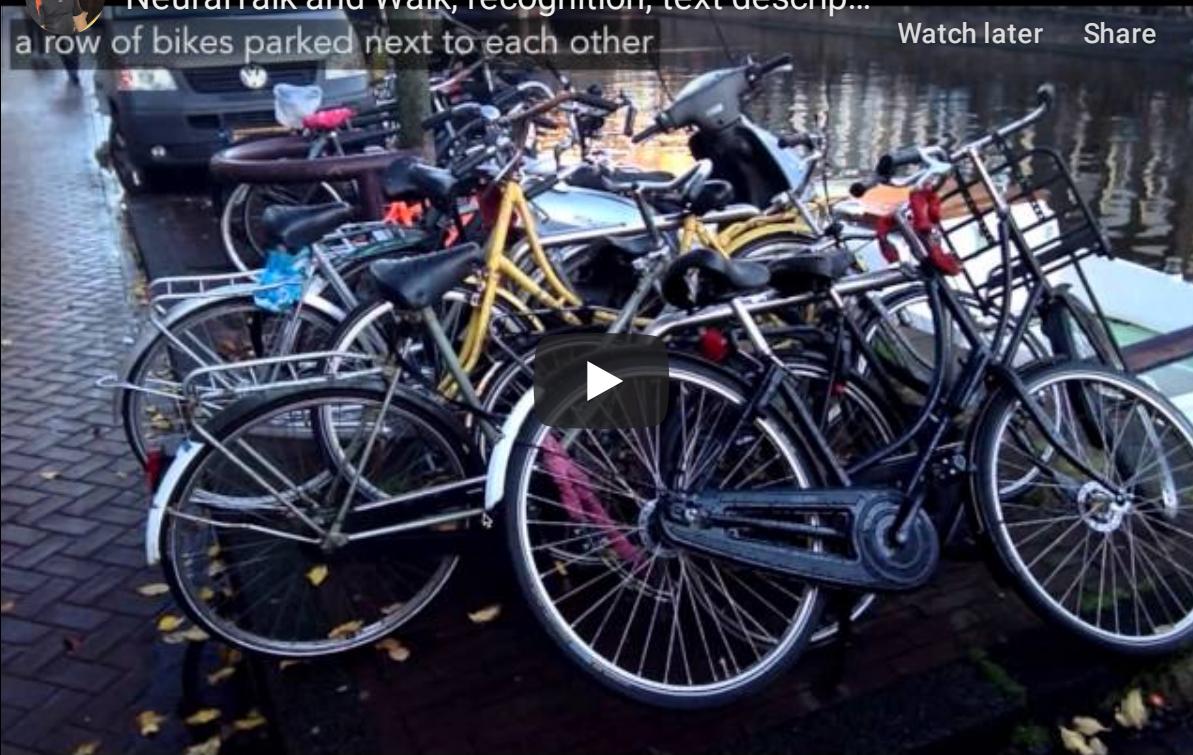
NeuralTalk and Walk, recognition, text descrip...

a row of bikes parked next to each other



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Auto-captioning (2015)



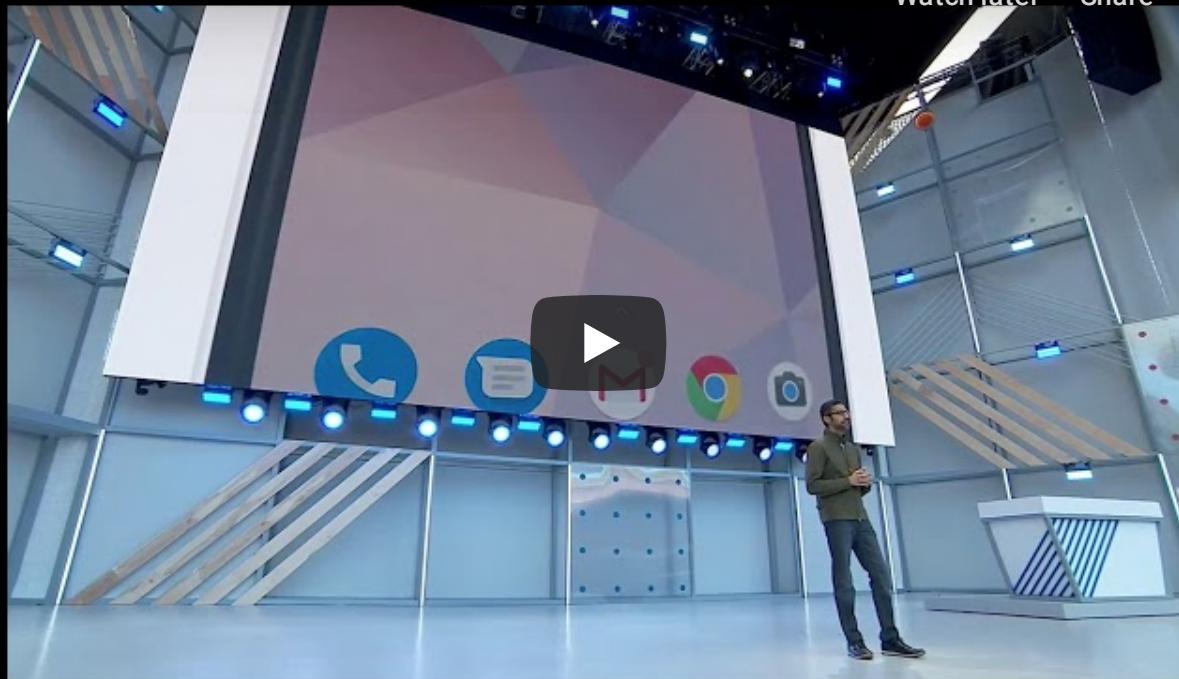
Google Assistant will soon be able to call rest...



Watch later



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Speech synthesis and question answering (Google, 2018)



Artistic style transfer for videos



Watch later



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Sintel movie, III



Artistic style transfer (Ruder et al, 2016)



# A Style-Based Generator Architecture for Gen...



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Image generation (Karras et al, 2018)



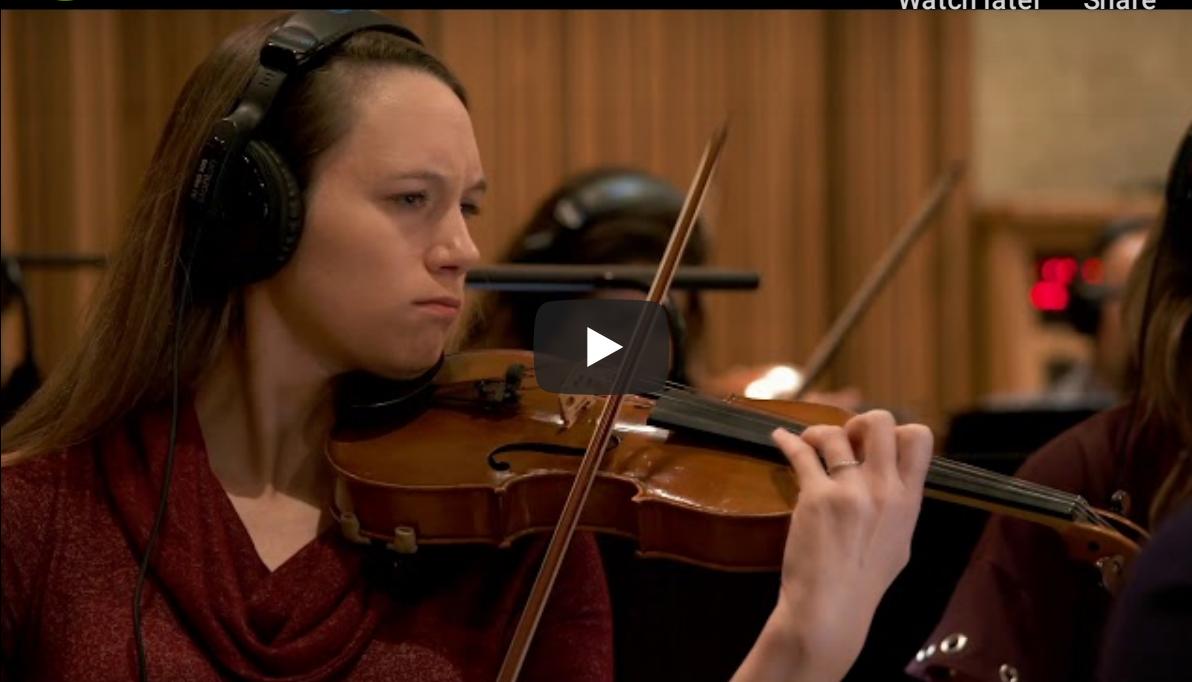
GTC Japan 2017 Part 9: AI Creates Original M...



Watch later



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Music composition (NVIDIA, 2017)



Behind the Scenes: Dali Lives



Watch later



Share



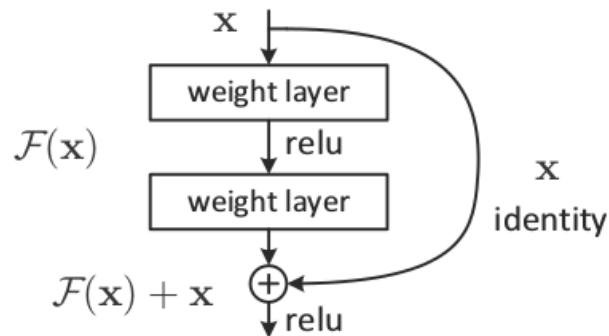
Dali Lives (2019)



*"ACM named **Yoshua Bengio**, **Geoffrey Hinton**, and **Yann LeCun** recipients of the **2018 ACM A.M. Turing Award** for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing."*

# **Why does it work now?**

## Algorithms (old and new)



More data



## Software



theano



## Faster compute engines



## Building on the shoulders of giants

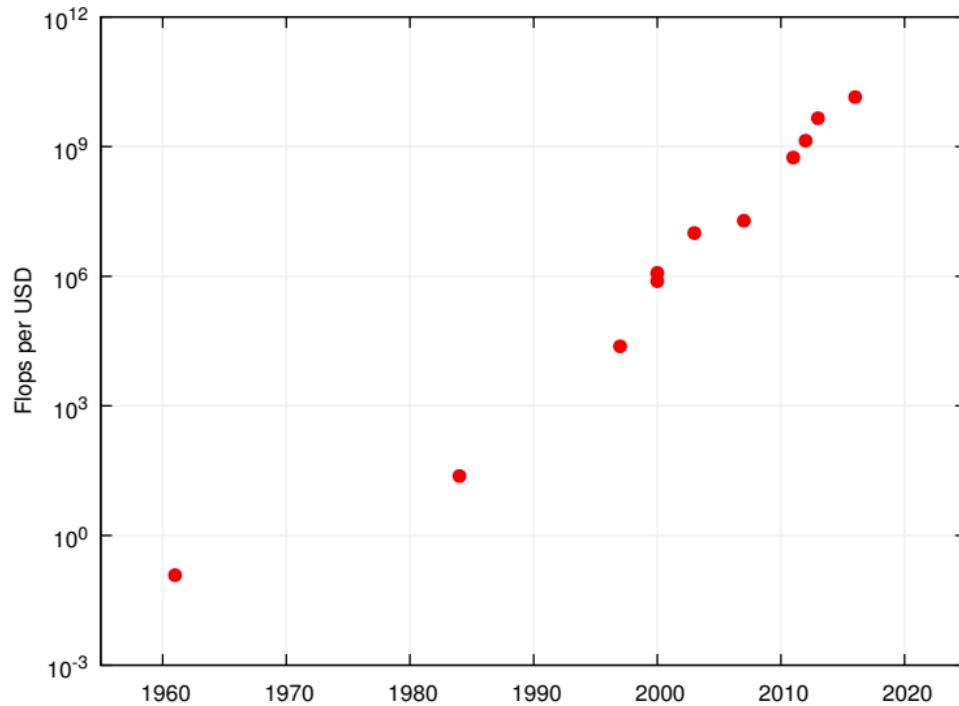
Five decades of research in machine learning provided

- a taxonomy of ML concepts (classification, generative models, clustering, kernels, linear embeddings, etc.),
- a sound statistical formalization (Bayesian estimation, PAC),
- a clear picture of fundamental issues (bias/variance dilemma, VC dimension, generalization bounds, etc.),
- a good understanding of optimization issues,
- efficient large-scale algorithms.

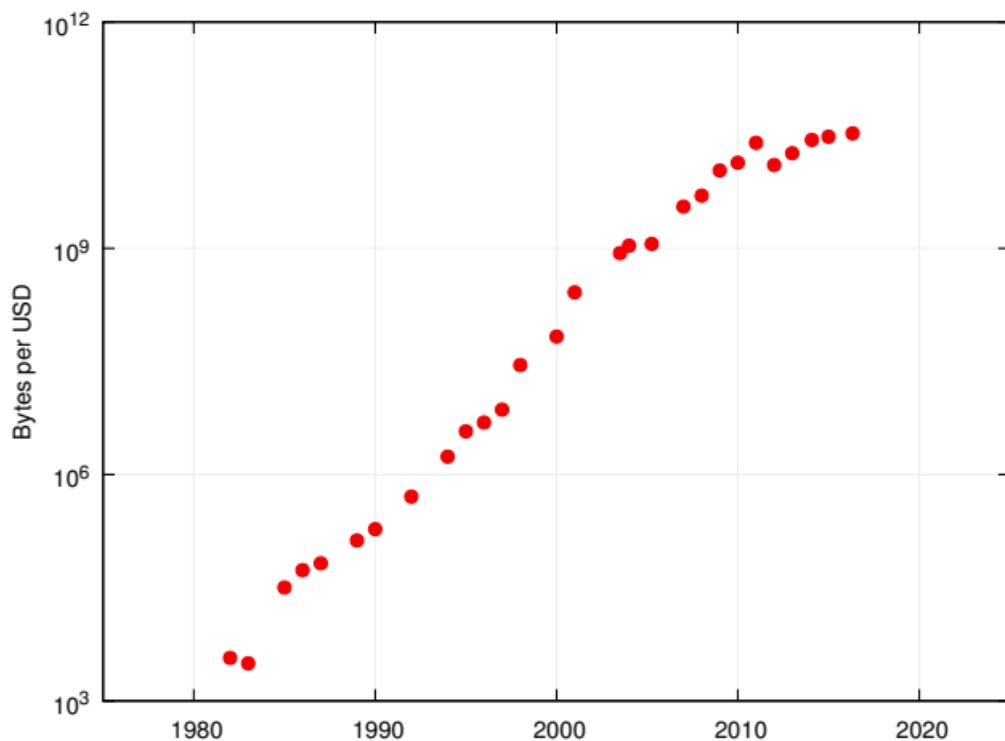
## Deep learning

From a practical perspective, deep learning

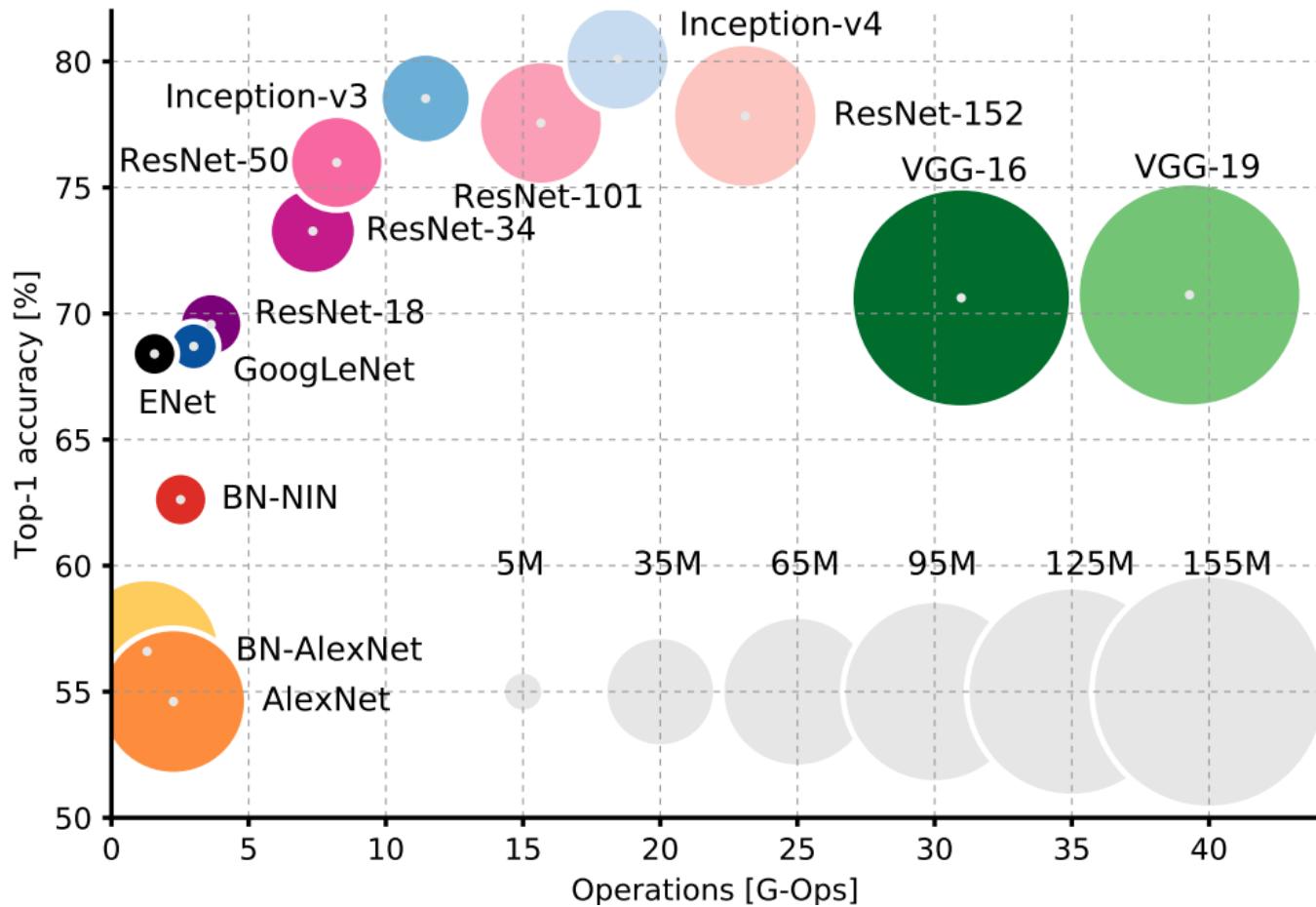
- lessens the need for a deep mathematical grasp,
- makes the design of large learning architectures a system/software development task,
- allows to leverage modern hardware (clusters of GPUs),
- does not plateau when using more data,
- makes large trained networks a commodity.



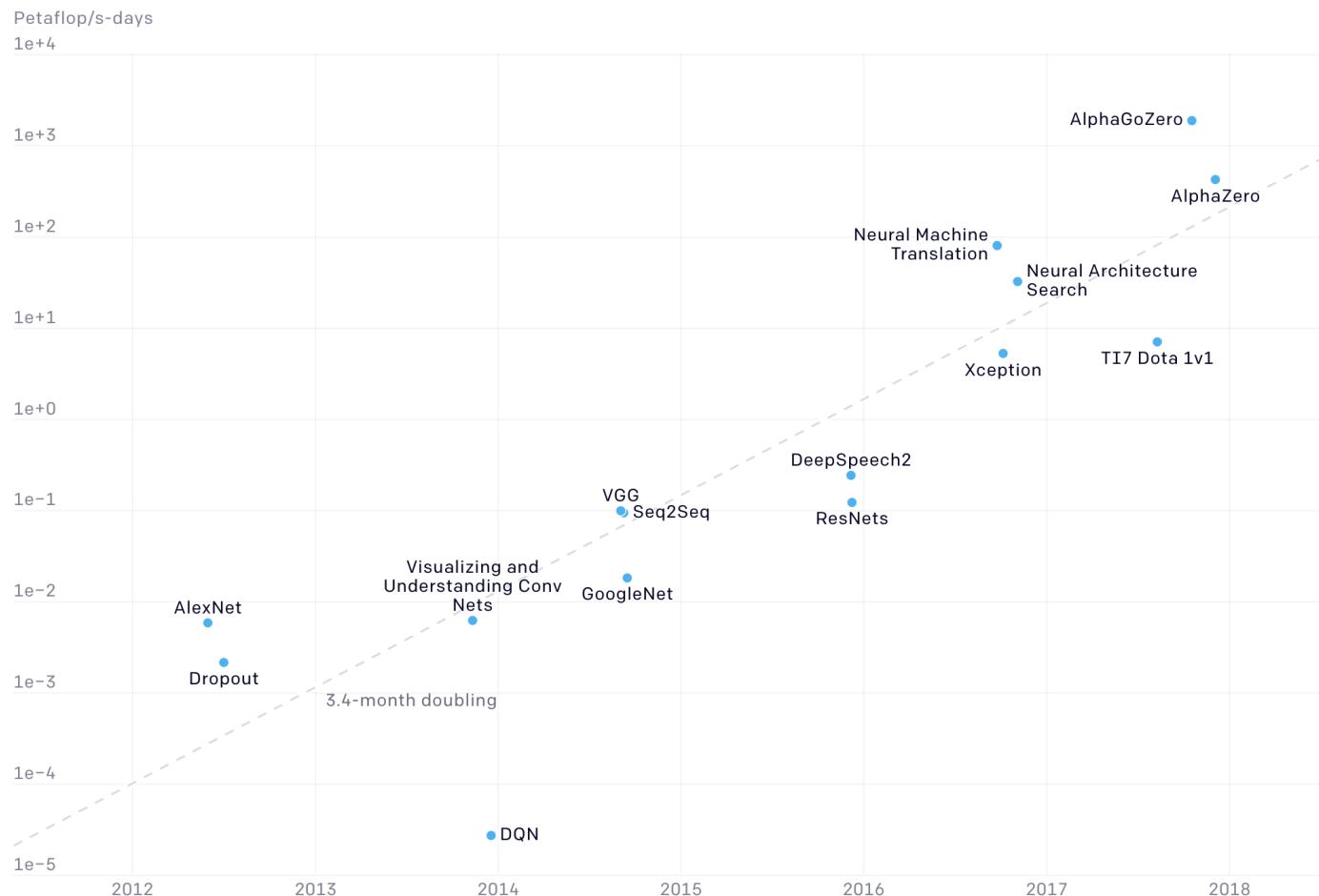
	TFlops ( $10^{12}$ )	Price	GFlops per \$
Intel i7-6700K	0.2	\$344	0.6
AMD Radeon R7 240	0.5	\$55	9.1
NVIDIA GTX 750 Ti	1.3	\$105	12.3
AMD RX 480	5.2	\$239	21.6
NVIDIA GTX 1080	8.9	\$699	12.7



The typical cost of a 4Tb hard disk is less than 100 USD (February 2020).



## AlexNet to AlphaGo Zero: A 300,000x Increase in Compute (Log Scale)



**1 petaflop/s-day**  
=  $10^{15}$  neural net operations per second for one day  
=  $10^{20}$  operations  
 $\approx 100$  GPUs for one day  
 $\approx 500\text{kWh}$

The end.

# References

- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *nature*, 521(7553), 436-444.