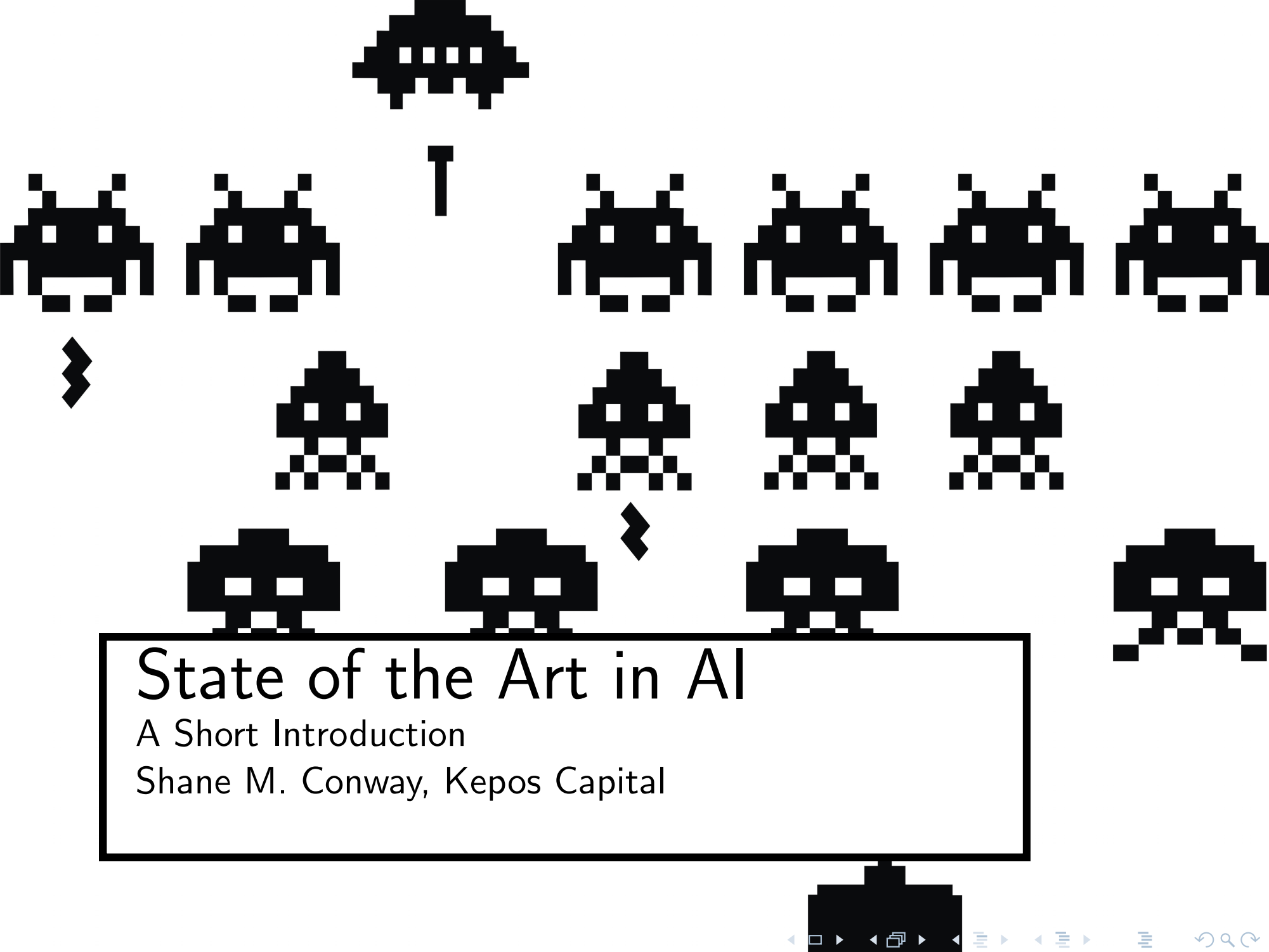

State of the Art in AI

A Short Introduction

Shane M. Conway, Kepos Capital

"I think we should be very careful about artificial intelligence. If I had to guess at what our biggest existential threat is, it's probably that. So we need to be very careful. I'm increasingly inclined to think that there should be some regulatory oversight, maybe at the national and international level, just to make sure that we don't do something very foolish." -Elon Musk

Outline

What is AI?

Cutting Edge Applications

Machine Learning

Deep Learning

Deep Reinforcement Learning

Outline

What is AI?

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Deep Learning

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Artificial Intelligence

Artificial Intelligence

What is it and why should we care?

The Associated Press
@AP

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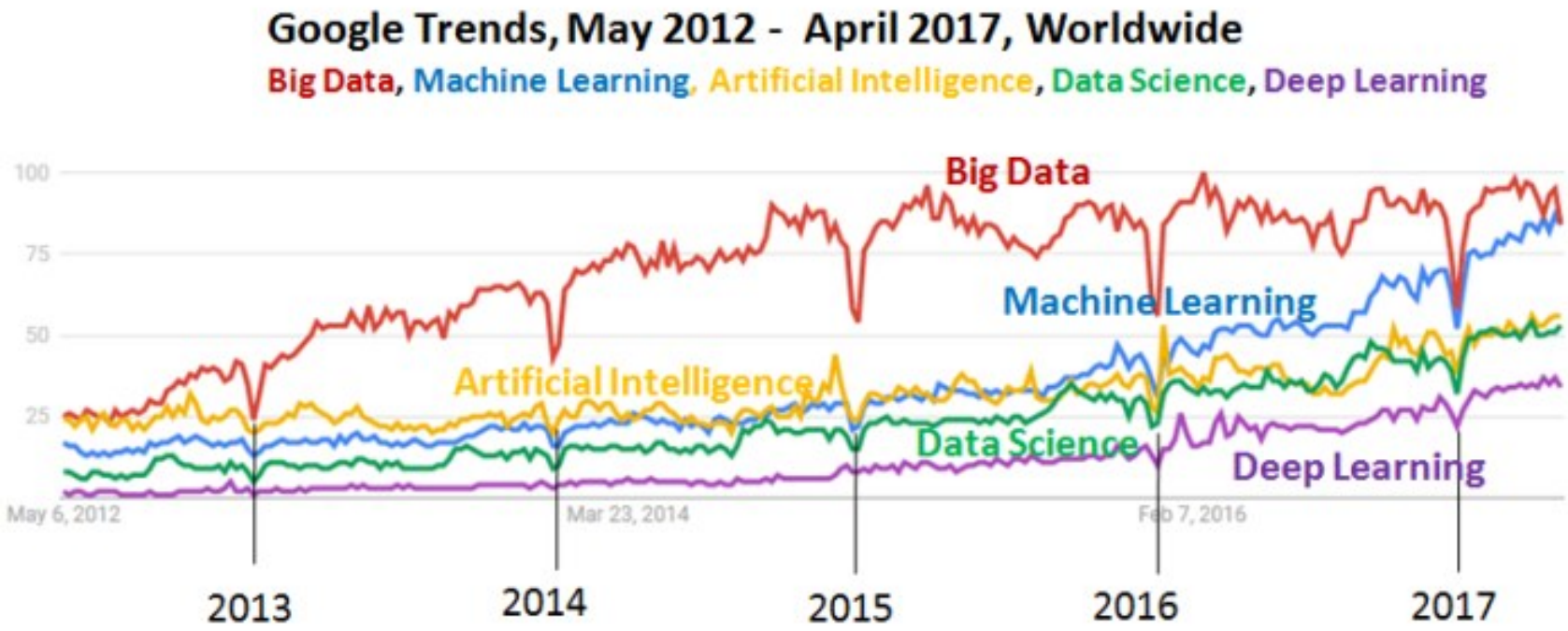
1:07 PM - 23 Apr 13

Twitter Crash

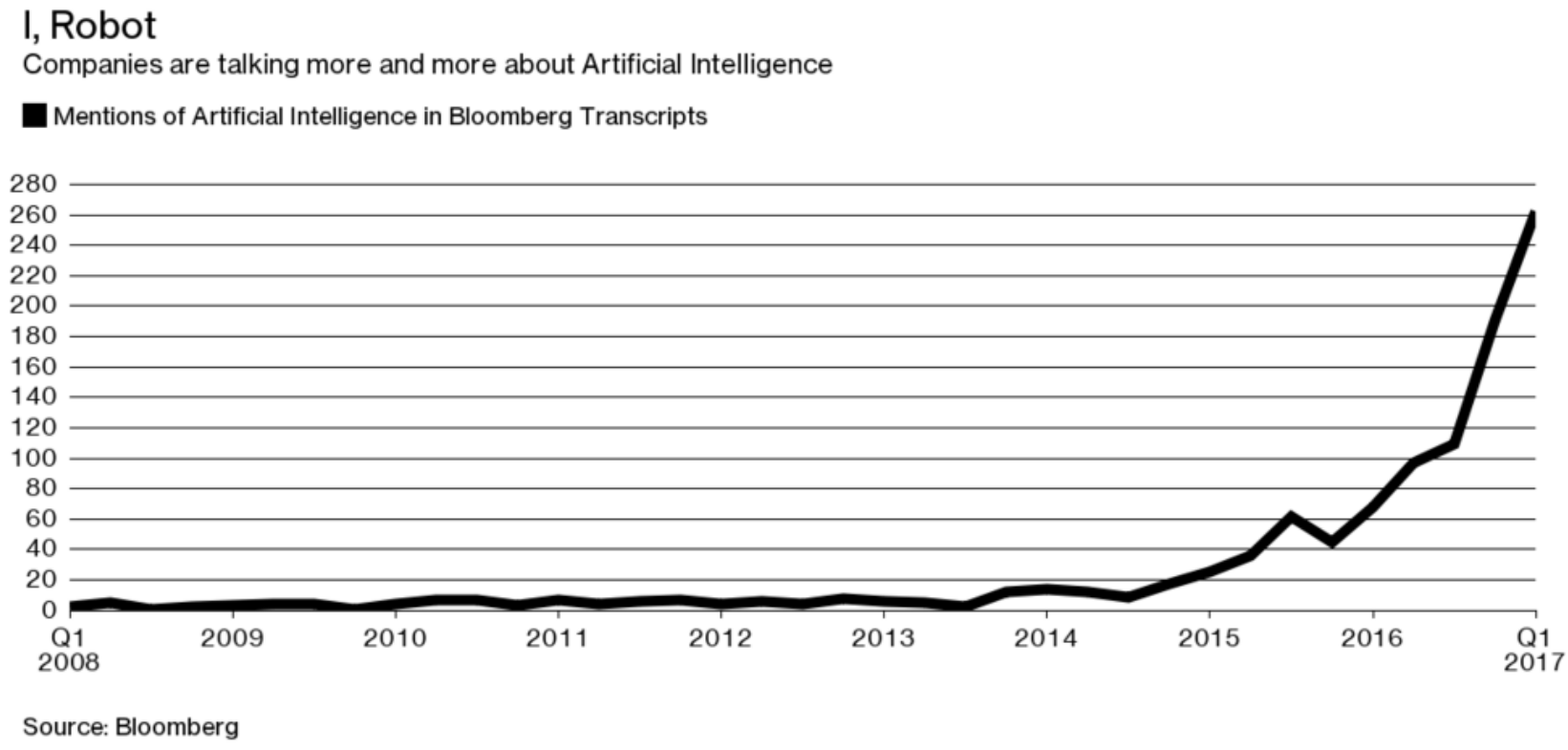
"A Fake AP Tweet Sinks the Dow for an Instant" Bloomberg (2013)

Trends



Source: Google Trends

Artificial Intelligence



"The Limits of Artificial Intelligence" Bloomberg (June 2017)

This isn't new...

MONIAC (Monetary National Income Analogue Computer) Bill Phillips (1949)

History of AI

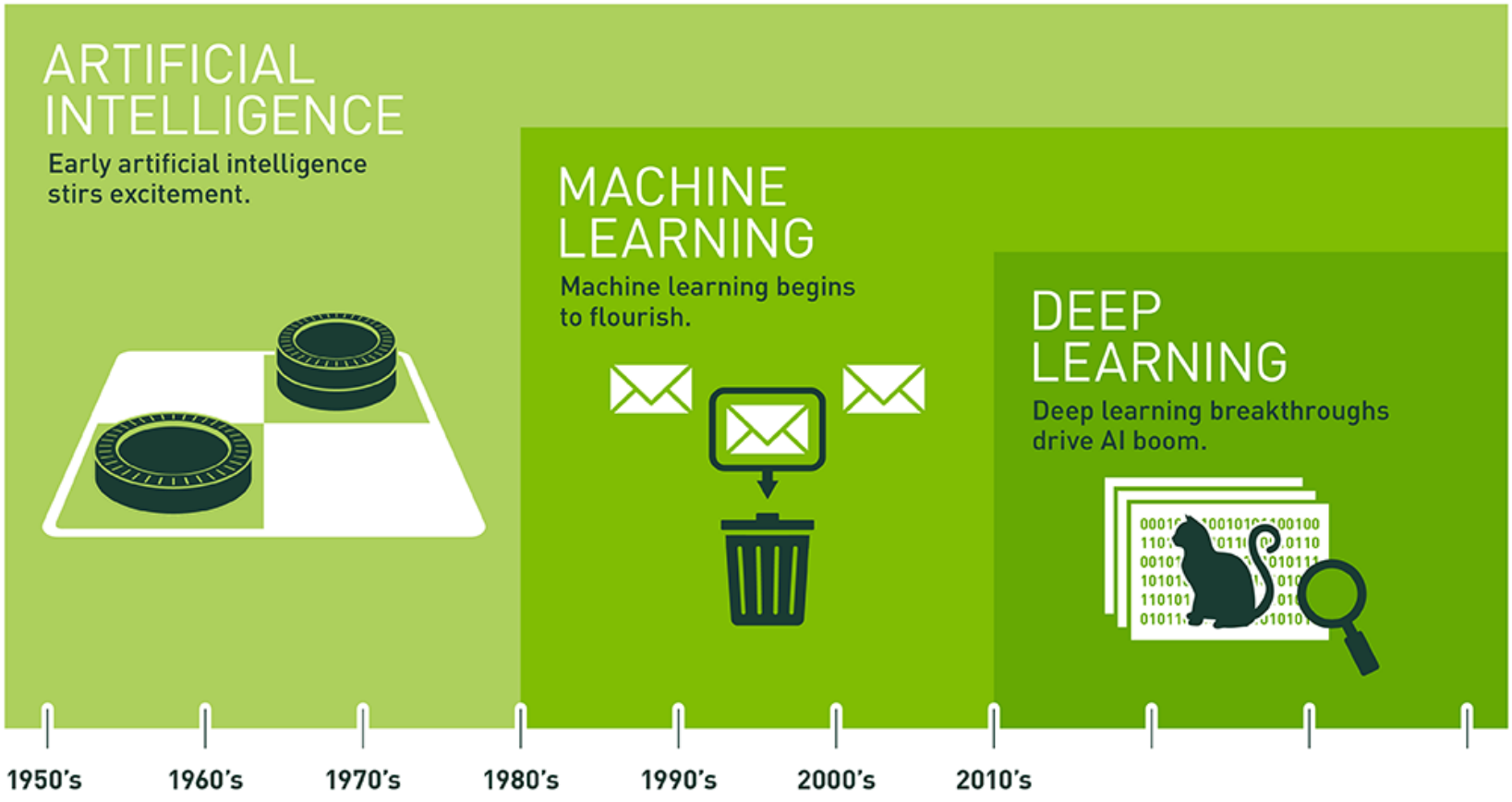


Image source: nvidia

Artificial Intelligence: Why now?

1. Compute (the obvious one: Moore's Law, GPUs, ASICs),
2. Data (in a nice form, not just out there somewhere on the internet - e.g. ImageNet),
3. Algorithms (research and ideas, e.g. backprop, CNN, LSTM), and
4. Infrastructure (software under you - Linux, TCP/IP, Git, ROS, PR2, AWS, AMT, TensorFlow, etc.).

Source: @karpathy

Artificial

AI is an *artificial* (as opposed to *natural*) science:

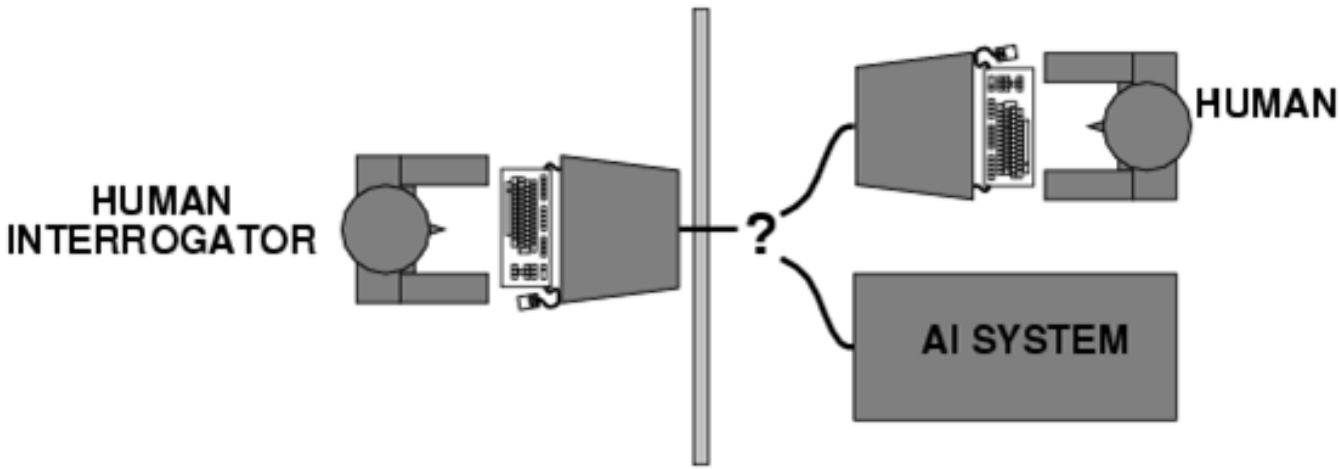
1. Artificial things are synthesized by human beings.
2. Artificial things may imitate appearances of natural things while lacking the reality of the latter.
3. Artificial things can be characterized in terms of functions, goals, adaptation.
4. Artificial things are often discussed in terms of imperatives as well as descriptives.

Source: Herbert A. Simon "The Sciences of the Artificial" (1968)

Intelligence

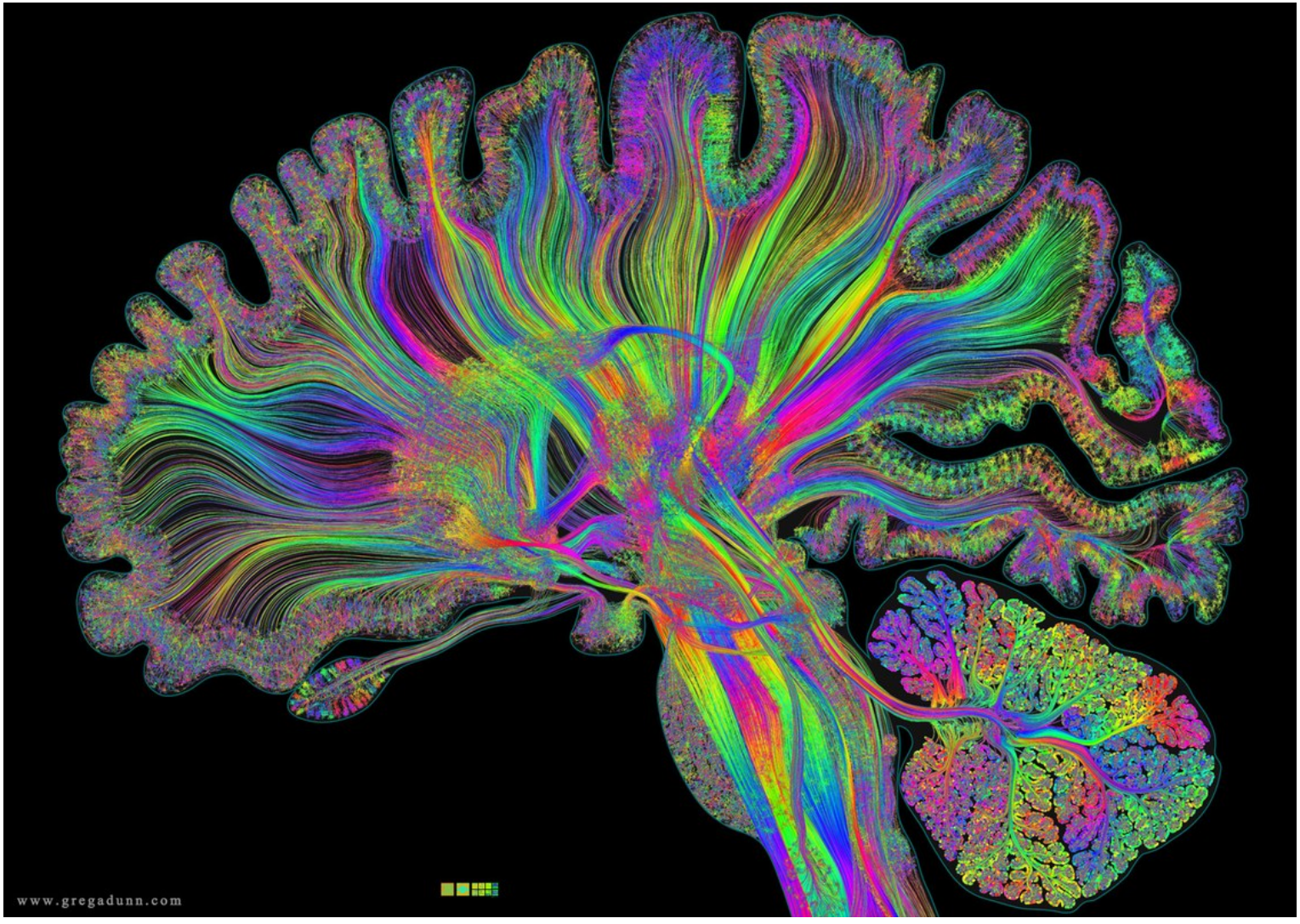
AI is a form of *intelligence*, in the same sense that human's have intelligence. Intelligence is hard to define, but "we know it when we see it".

Turing formulated the "Imitation Game" (or the turing test).



Source: Alan Turing "Computing machinery and intelligence" (1950)

Human Intelligence



Source: Greg Dunn "Self Reflected"

Human's vs Chimps

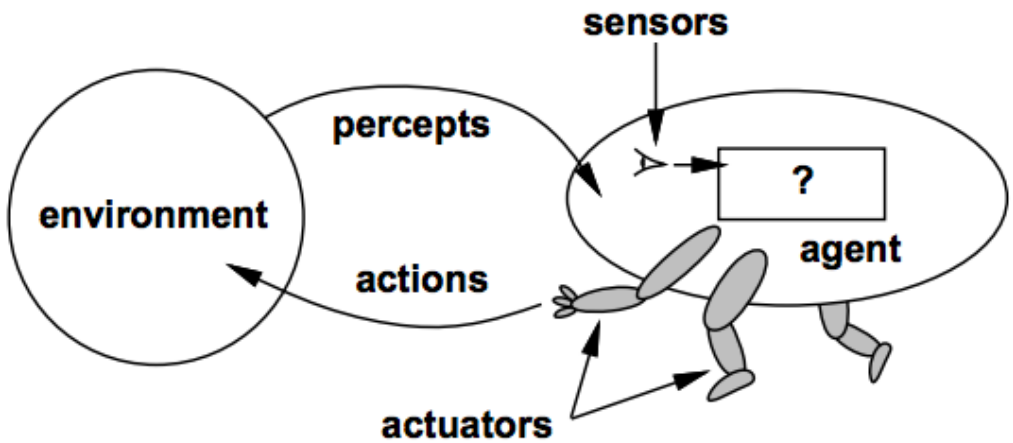
Human's are "social learners".

The big difference between baby humans and chimpanzees is not in mastering abstract ideas, like quantity or causality, but that we are "prolific, spontaneous and automatic imitators, even willing to copy seemingly unnecessary or purely stylistic steps". Under pressure to keep up with culture, we are built to imitate and fit in.

Source: Joseph Henrich "The Secret of Our Success" (2016)

Artificial Intelligence

- AI involves machines that can perform tasks that are characteristic of human intelligence. (John McCarthy 1956)
- ML is a subfield of computer science that "gives computers the ability to learn without being explicitly programmed". (Arthur Samuel, 1959)



Goal: Construct a single universal agent that learns to act optimally in any environment.

Outline

What is AI?

Cutting Edge Applications

Machine Learning

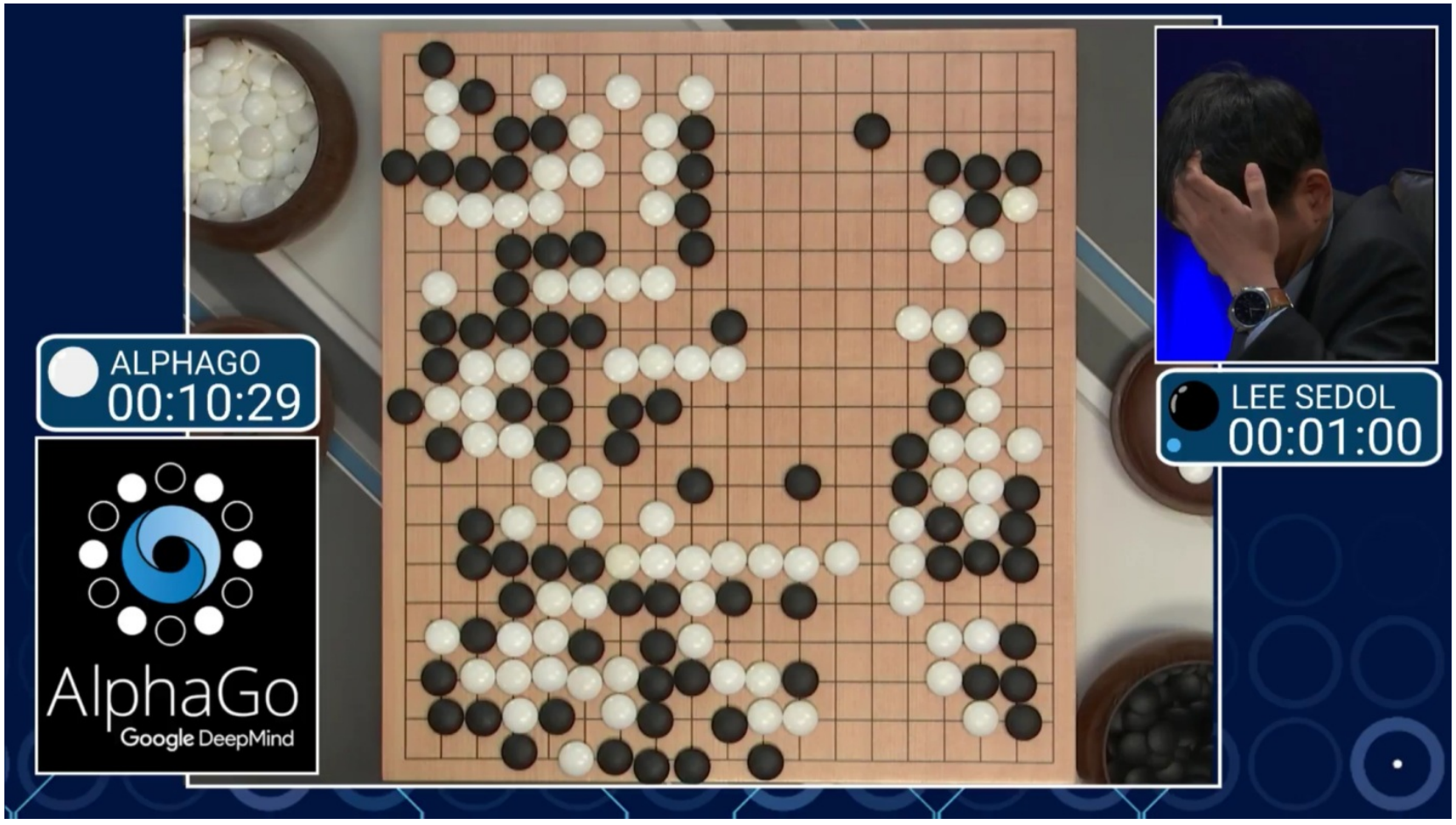
Deep Learning

Deep Reinforcement Learning

The State of the Art (SOTA)

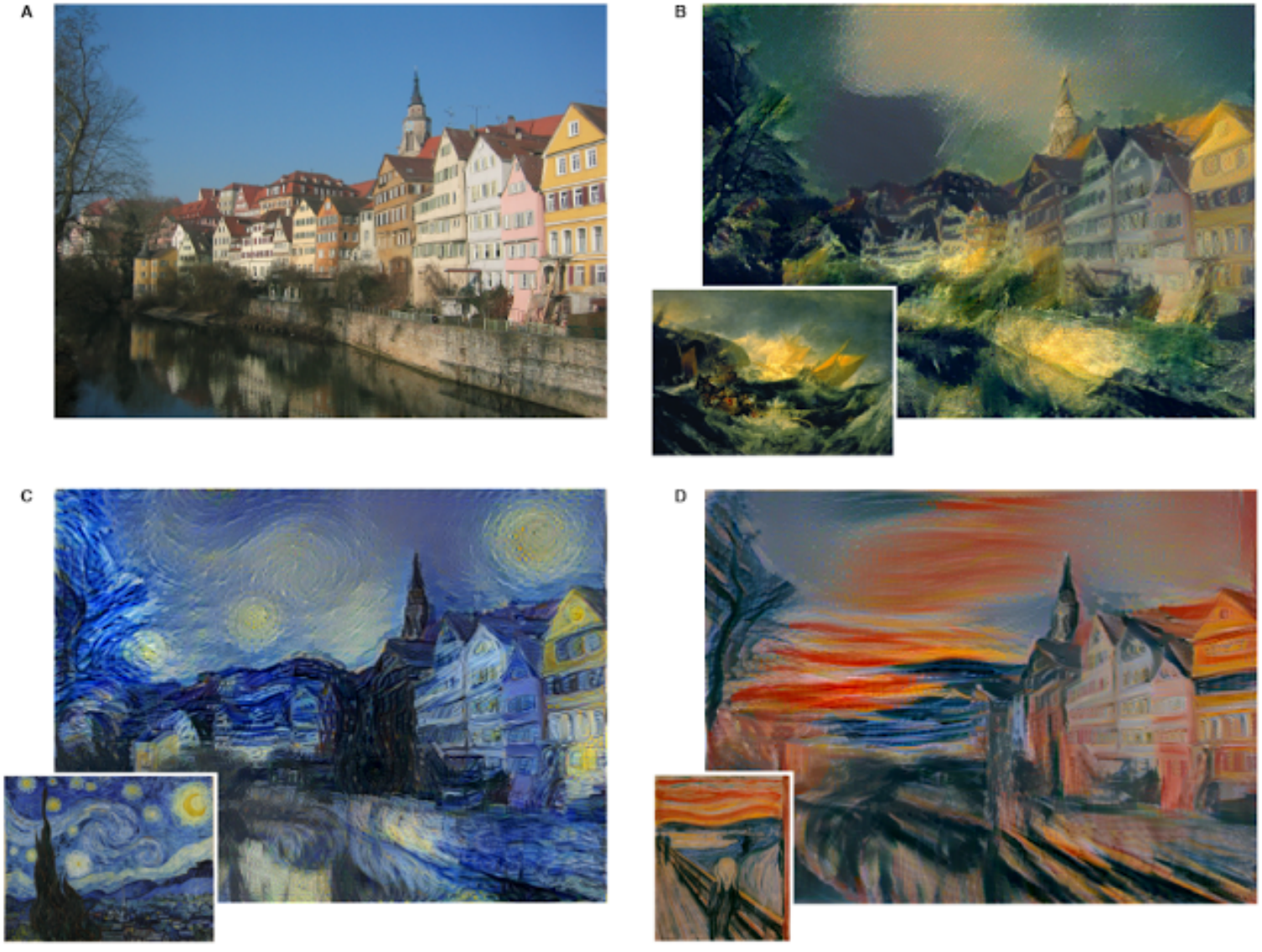
Mastering Atari

AlphaGo



The number of potential legal board positions in go is greater than the number of atoms in the universe.

Artwork



Source: L. Gatys e. al âĂIJA Neural Algorithm of Artistic StyleâĂİ (2015).

Writing Code

Intelligent Machines

AI Software Learns to Make AI Software

Google and others think software that learns to learn could take over some work done by AI experts.

by Tom Simonite January 18, 2017

Progress in artificial intelligence causes some people to worry that software will take jobs such as driving trucks away from humans. Now leading researchers are finding that they can make software that can learn to do one of the trickiest parts of their own jobs—the task of designing machine-learning software.

"AI Software Learns to Make AI Software" MIT Technology Review (Jan 2017)

Other Examples

There are many other examples of recent successes:

- Self driving cars
- Speech (e.g. WaveNet)
- Machine translation
- Natural language
- Image, video classification
- Journalism, poetry
- Robotics

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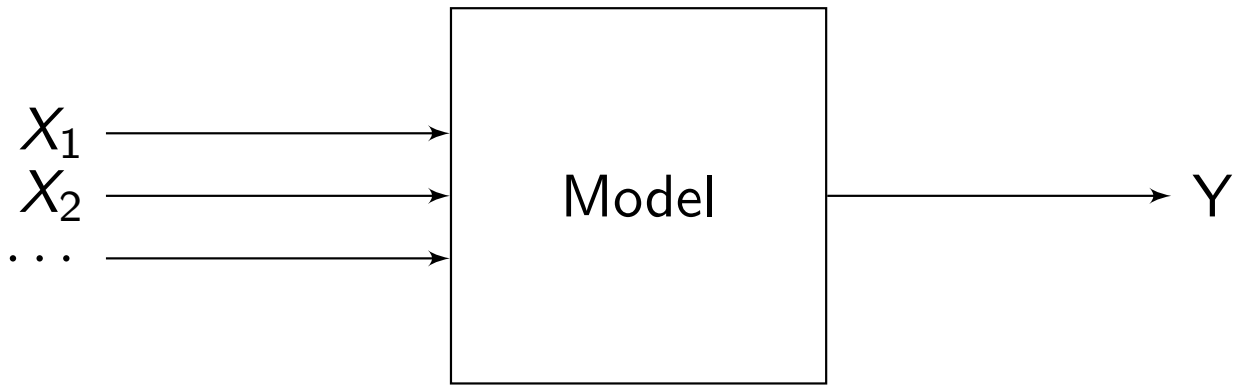
Machine Learning

Data in...predictions out.


X_1
X_2
...
Model
Y

Machine Learning

Machine learning includes several different kinds of *models*:

- Supervised learning: learn a function by fitting labeled targets and input features.
- Unsupervised learning: learn a function by fitting to input features (without labeled targets).
- Reinforcement learning: learn a policy based on receiving rewards for taking actions in states.

Models

There are a wide variety of models that serve different purposes, such as:

- Linear regression
- Logistic regression
- Neural networks
- Support vector machines
- Random forests
- Gradient Boosted Machines

Machine Learning Pipeline

Machine learning in practice is more than *models*; it includes a set of tools to make predictions robust.

- Feature engineering
- Regularization
- Feature selection
- Hyperparameter tuning
- Model selection
- Ensembling

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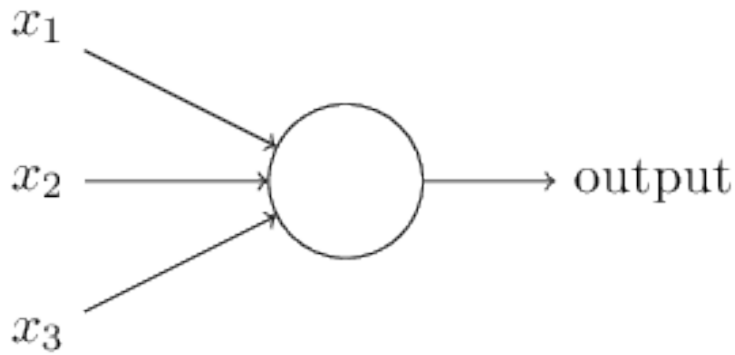
Deep Learning

Generalizing from what we see.

Neural Networks

Artificial neural networks (ANN) are learning models that were directly inspired by the structure of biological neural networks.



$$\text{output} = \begin{cases} 0 & \text{if } \sum_j w_j x_j \leq \text{ threshold} \\ 1 & \text{if } \sum_j w_j x_j > \text{ threshold} \end{cases} \tag{1}$$

Multi-layer Neural Networks

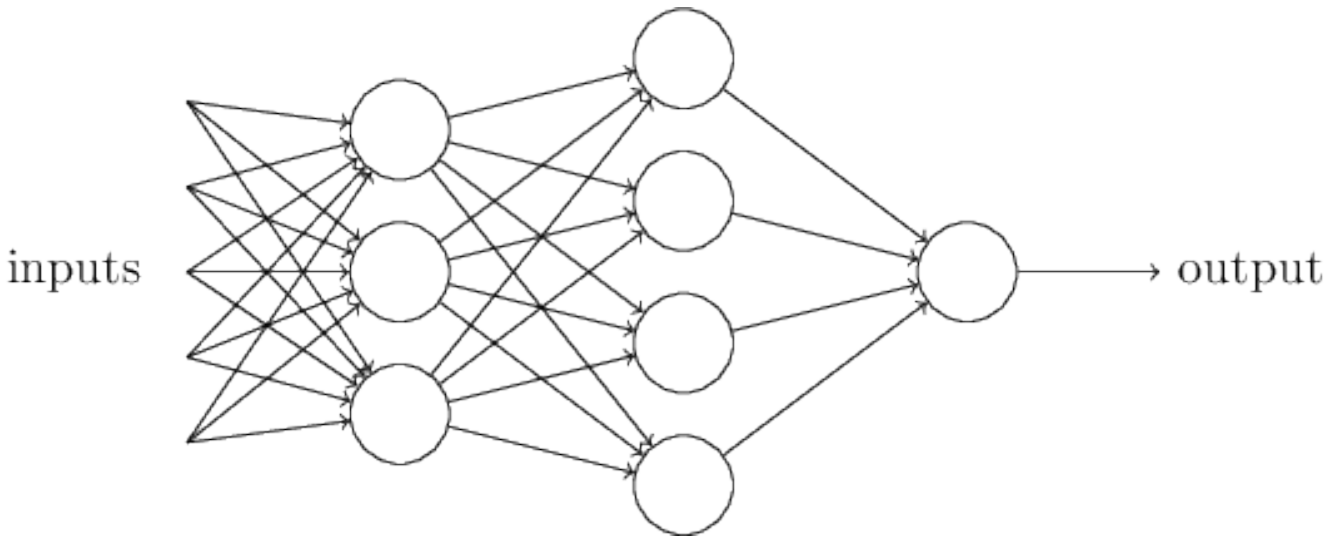


Figure: Multiple layers can be connected together.

Multi-layer neural networks can fit complex functions:

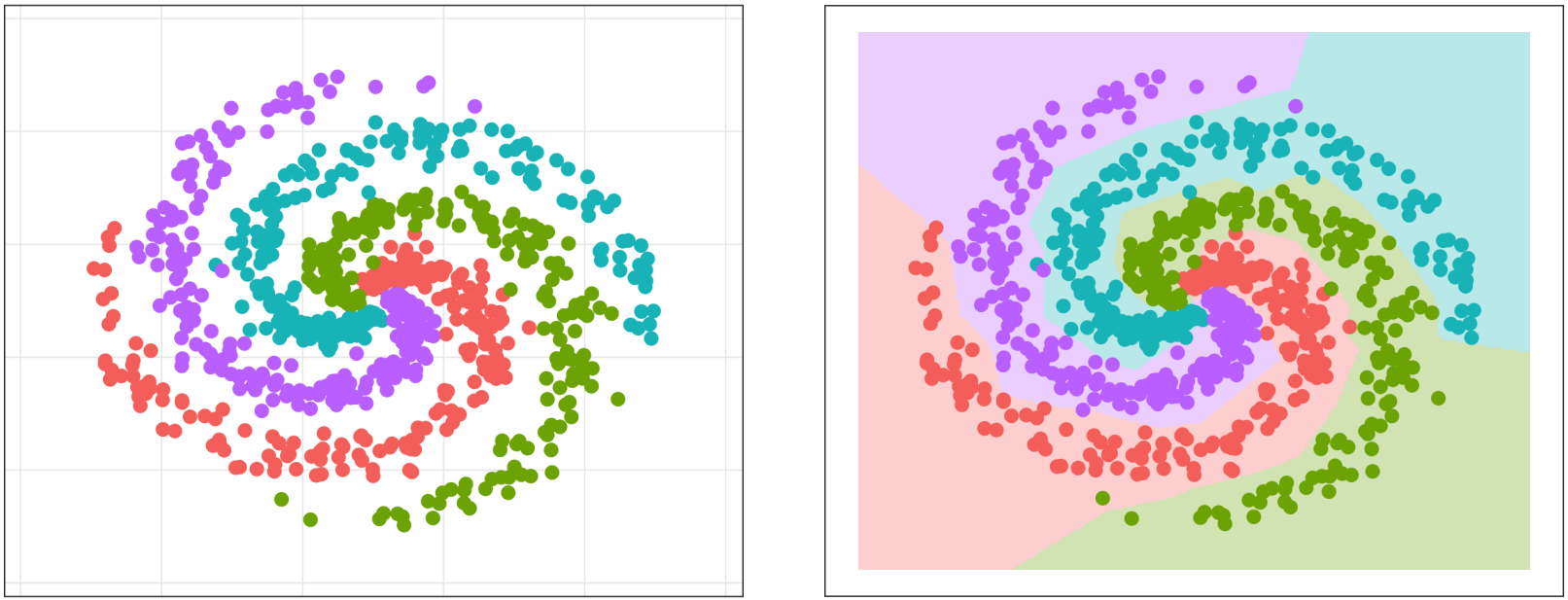
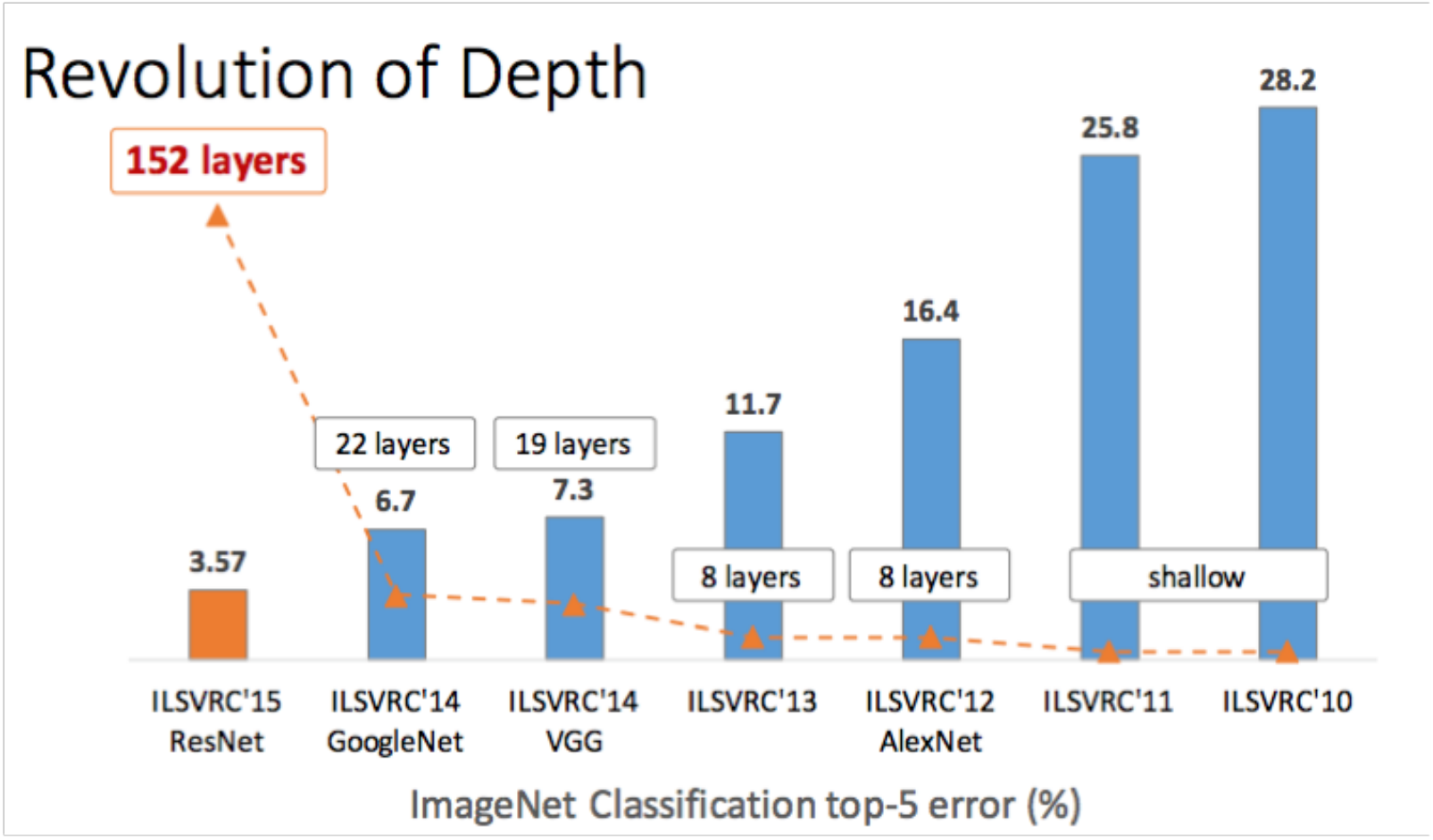


Figure: Spiral dataset with 4 different classes. The shaded region represents the neural network's predictions.

Deep Learning

Deep Learning employs multiple levels (hierarchy) of representations.



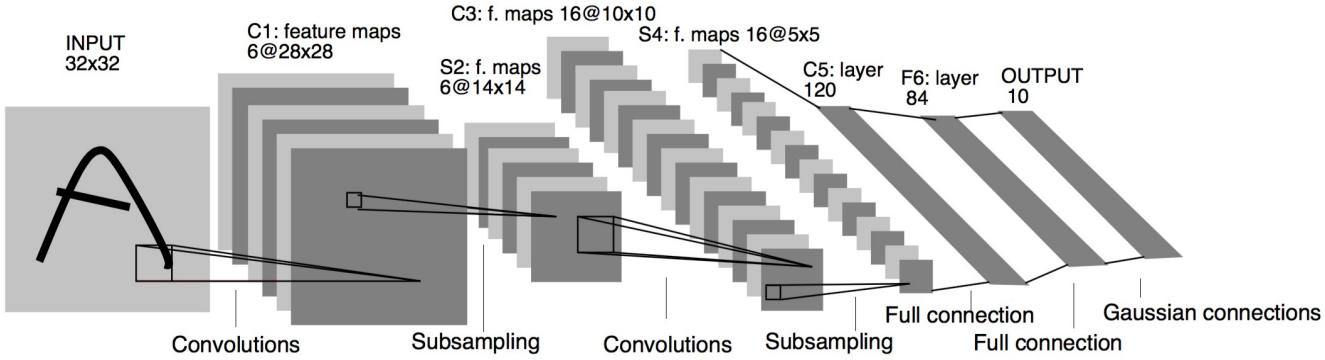


Figure: LeNET (1998), Yann LeCun et. al.

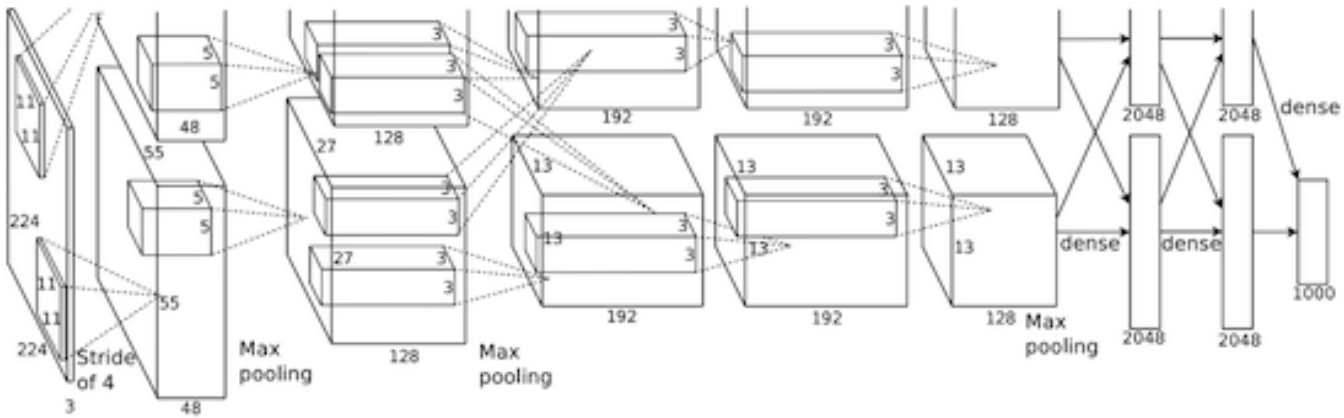
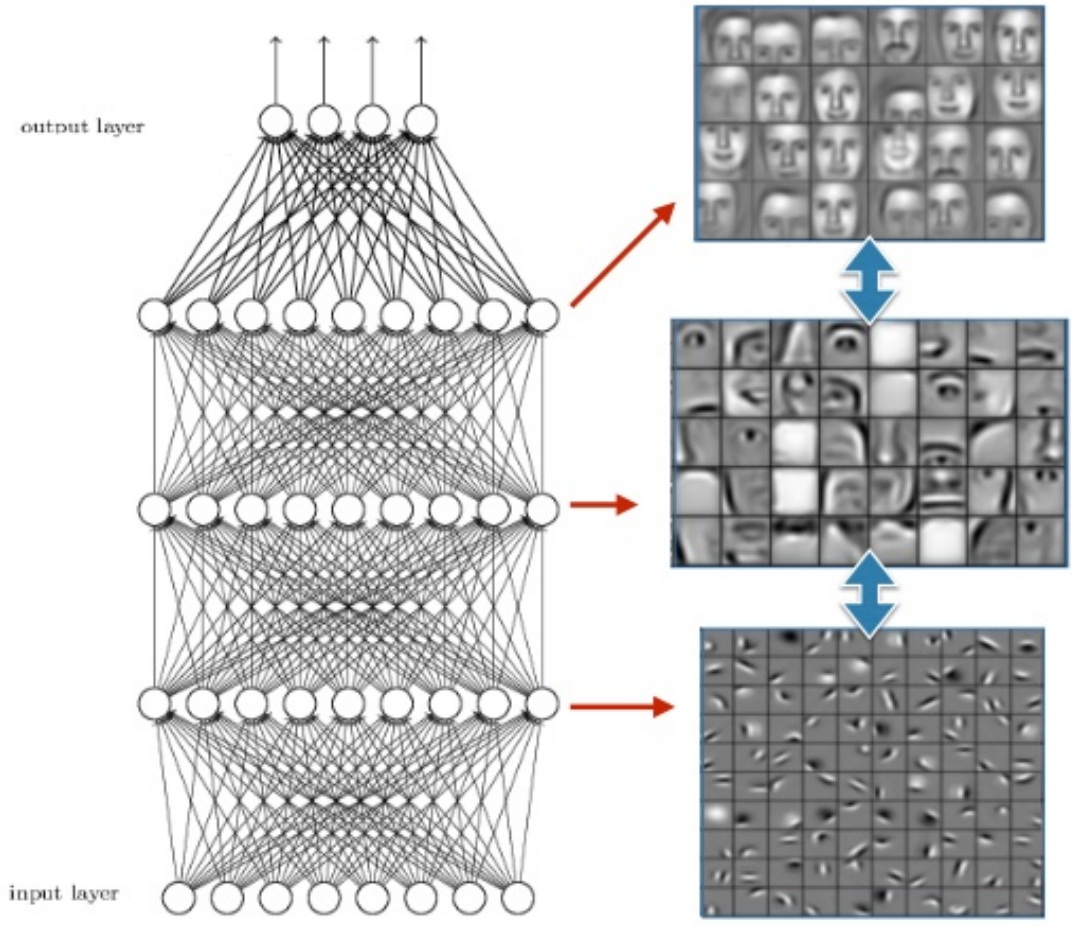


Figure: AlexNET (2012), Alex Krizhevsky, Ilya Sutskever and Geoff Hinton

Source: *Andrej Karpathy*

Hierarchical levels of abstraction



Outline

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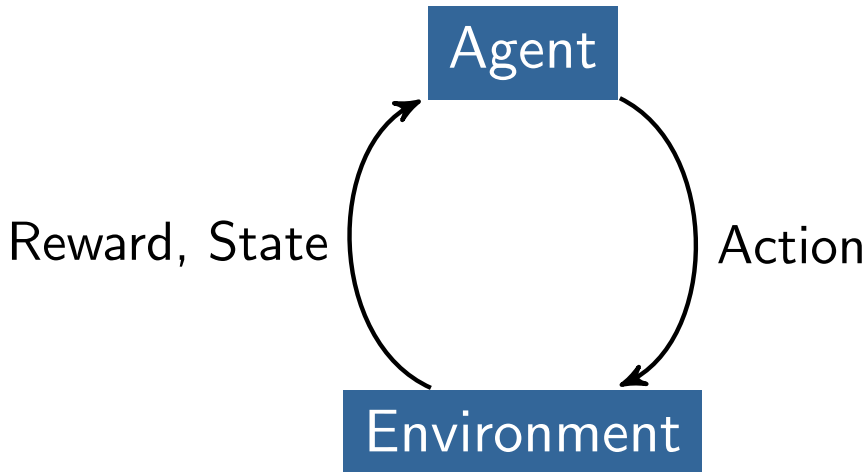
Deep Reinforcement Learning

Learning how to act on our model of the world.

Reinforcement Learning

In a single agent version, we consider two major components: the *agent* and the *environment*.



The agent takes actions, and receives updates in the form of state/reward pairs.

Policy

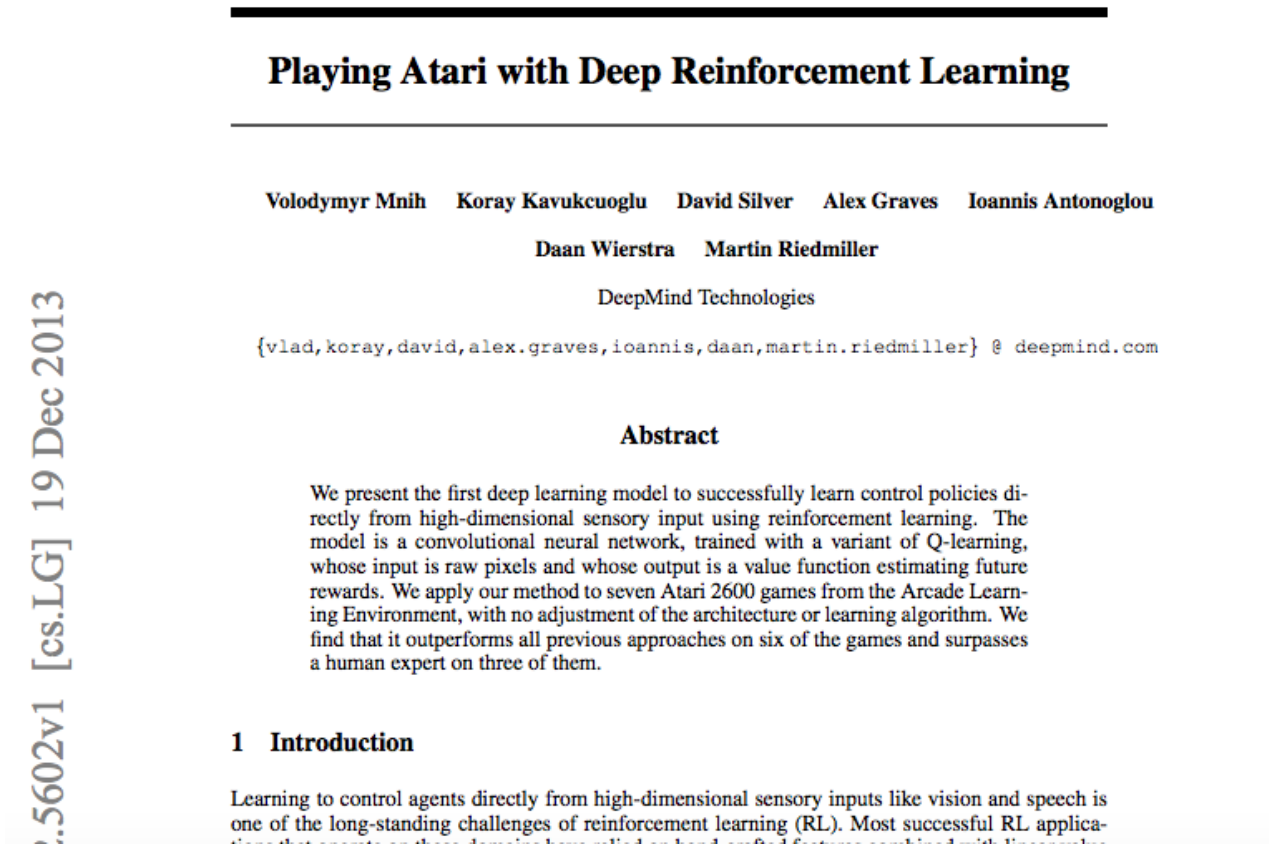
The objective is to find a policy π that maps actions to states, and will maximize the rewards over time:

$$\pi(s) \rightarrow a$$

The policy can be a table or a model (in DeepRL, the model will be a deep neural network).

DQN

DeepMind introduced Deep Q-Networks (DQN) for generally solving Atari games from pixels.



Playing Atari with Deep Reinforcement Learning

Volodymyr Mnih **Koray Kavukcuoglu** **David Silver** **Alex Graves** **Ioannis Antonoglou**

Daan Wierstra **Martin Riedmiller**

DeepMind Technologies

{vlad,koray,david,alex.graves,ioannis,daan,martin.riedmiller} @ deepmind.com

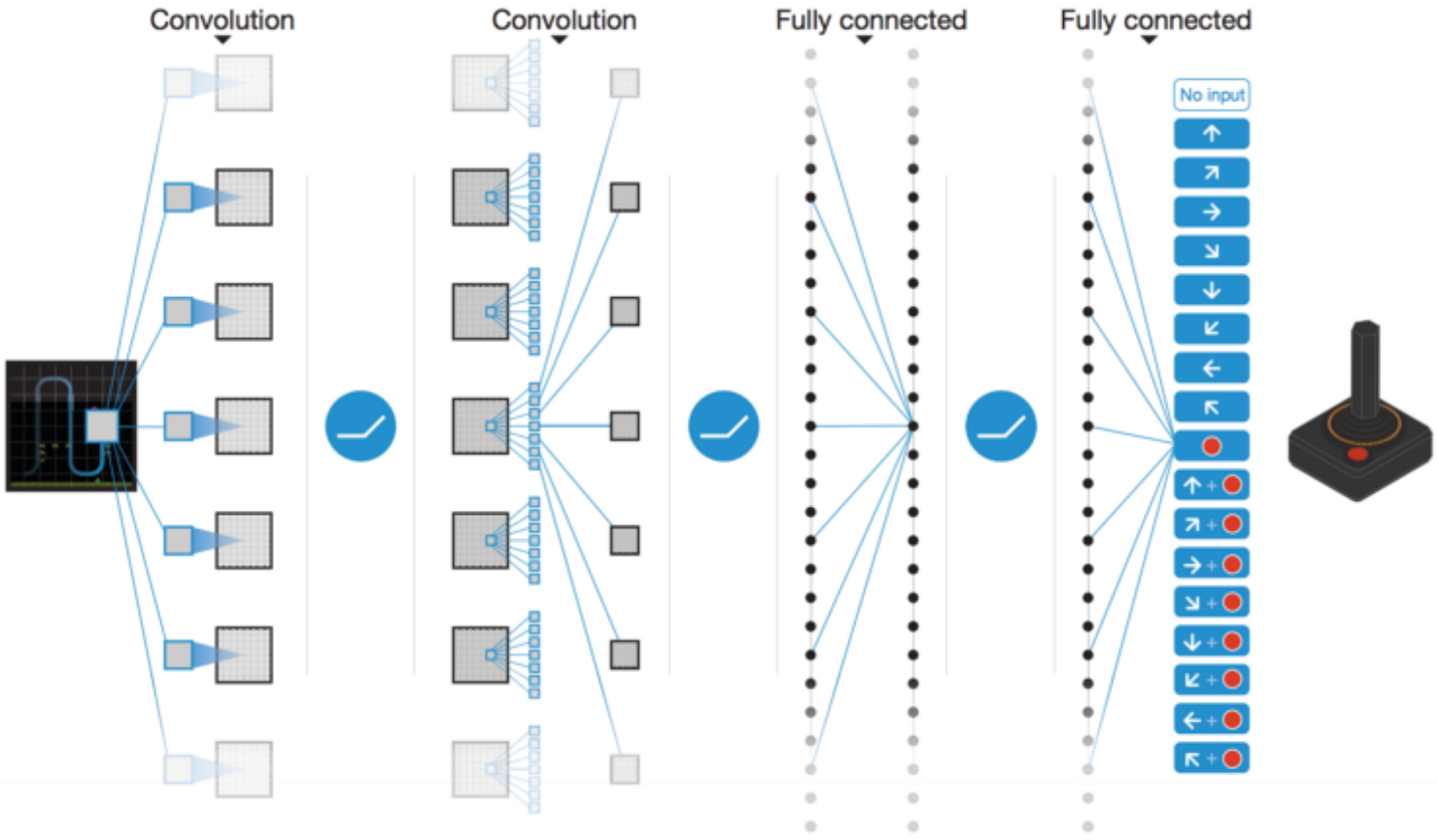
Abstract

We present the first deep learning model to successfully learn control policies directly from high-dimensional sensory input using reinforcement learning. The model is a convolutional neural network, trained with a variant of Q-learning, whose input is raw pixels and whose output is a value function estimating future rewards. We apply our method to seven Atari 2600 games from the Arcade Learning Environment, with no adjustment of the architecture or learning algorithm. We find that it outperforms all previous approaches on six of the games and surpasses a human expert on three of them.

1 Introduction

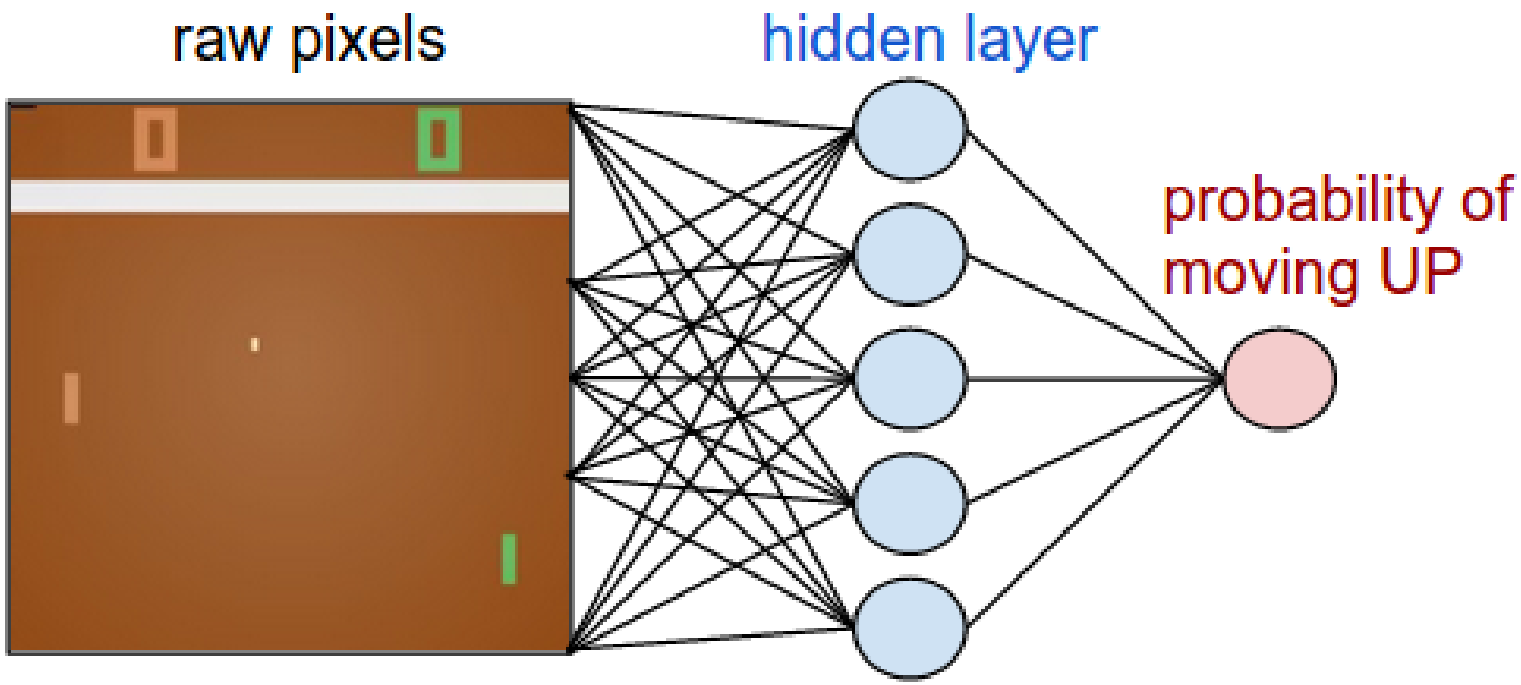
Learning to control agents directly from high-dimensional sensory inputs like vision and speech is one of the long-standing challenges of reinforcement learning (RL). Most successful RL applica-

DQN Network



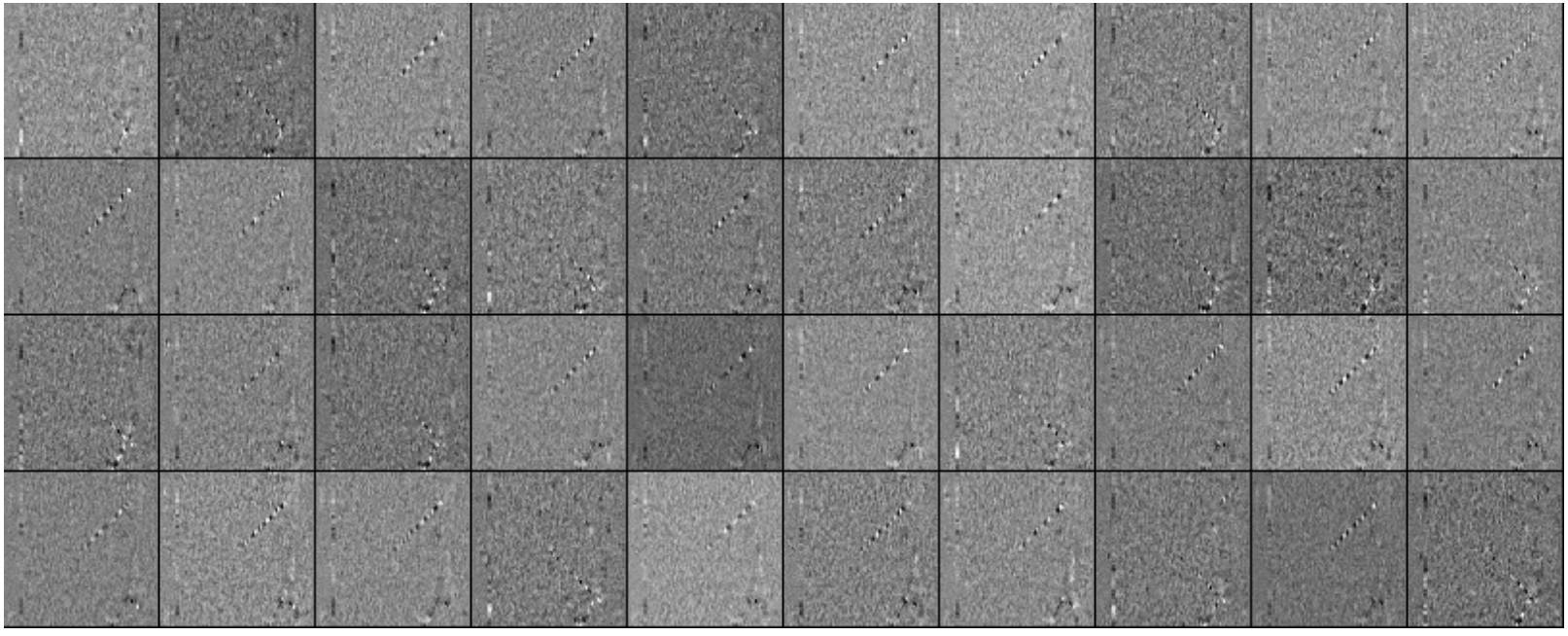
Source code from DeepMind

Policy network



Source: @karpathy

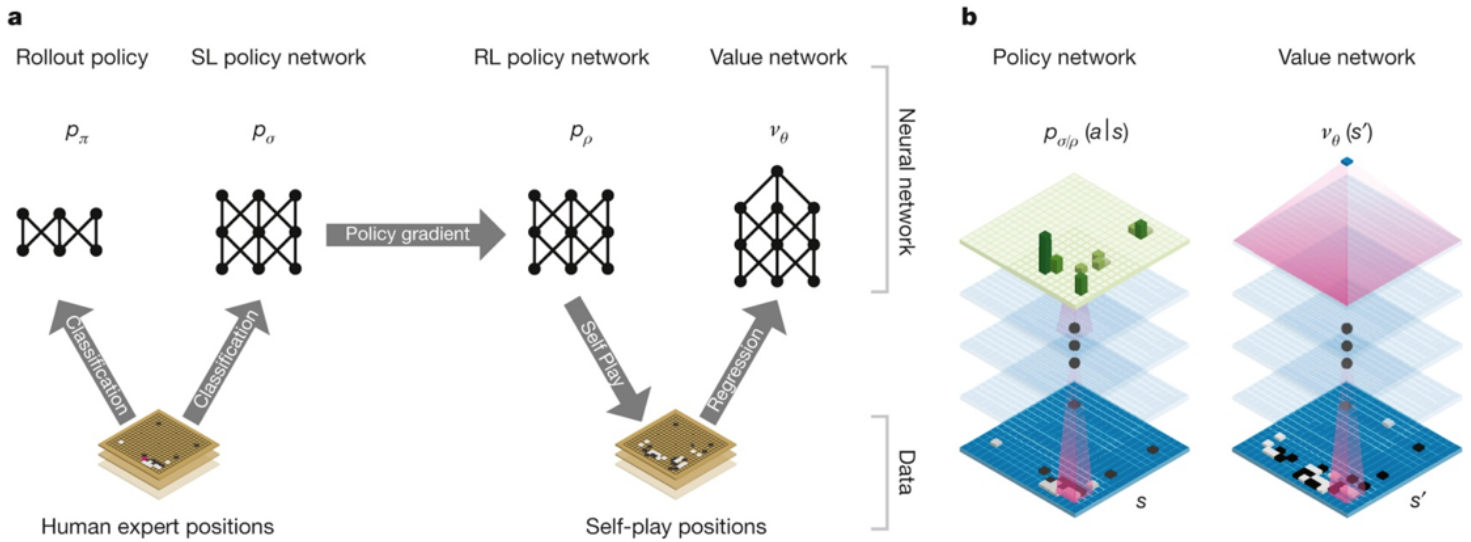
Network Weights



Source: @karpathy

AlphaGo

AlphaGo combined supervised learning and reinforcement learning, and made massive improvement through self-play.



Thank you!