

MACHINE LEARNING FOR ARCHITECTS

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TA:
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University of Florida
College of Design Construction and Planning

MACHINE LEARNING FOR ARCHITECTS

Application of Artificial Intelligence in Architecture

Semester: Fall 2024

Location: ARCH 231F

Meeting Times: TU 10:40 - 13:40 PM

Instructors: Dr. Karla Saldana Ochoa (ksaldanaochoa@ufl.edu) &

TA: Mobina Noorani (s.noorani@ufl.edu)

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Students will apply state-of-the-art AI and Machine Learning (ML) algorithms in different architectural design processes. They will emphasize AI as a paradigm for critical thinking and idea development, avoiding using AI only for optimization. This course will focus on experimentation and application, fulfilling university requirements to be categorized as "Use & Apply AI."



Karla Saldana Ochoa
SCHOOL OF ARCHITECTURE

-	DISCIPLINES	APPLICATIONS IN DCP	CLASSES	ASSIGNMENTS
Week 01	AI/ML	-	Introduction to AI and Machine Learning,	-
Week 02 -03	Data Collection & Visualization & Coding	-	Collecting image data and urban imagery for visualization; Coding exercise	A1 for 15 points
Week 03 -04				
Week 05 -06	Computer Vision	Image analysis	Computer vision and CNNs: overview and theory	A2 for 15 points
Week 07	Self organizing Maps	Data Exploration		
Week 08	Generative Models	Generative design	GANs and Diffusion models: overview and theory	A3 for 15 points
Week 09			AI forensics	
Week 10	Special topics	AI toolkits	Existing AI in architecture	A4 for 15 points
Week 11			application lecture	
Week 12	Project Definition	-	-	
Week 13-16	-	-	Final Project and Presentations	Final project for 40 points

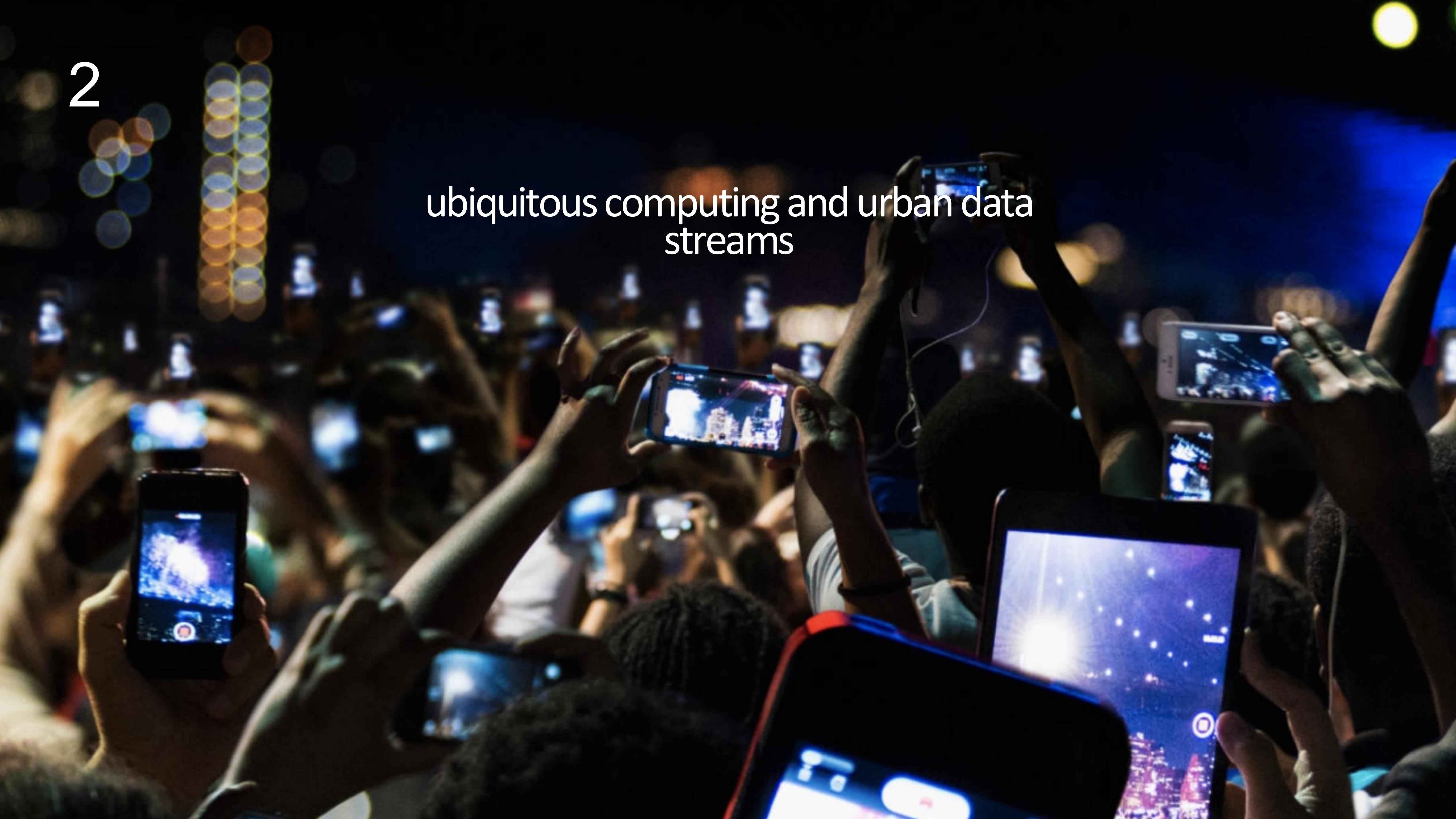
1

an urban planet

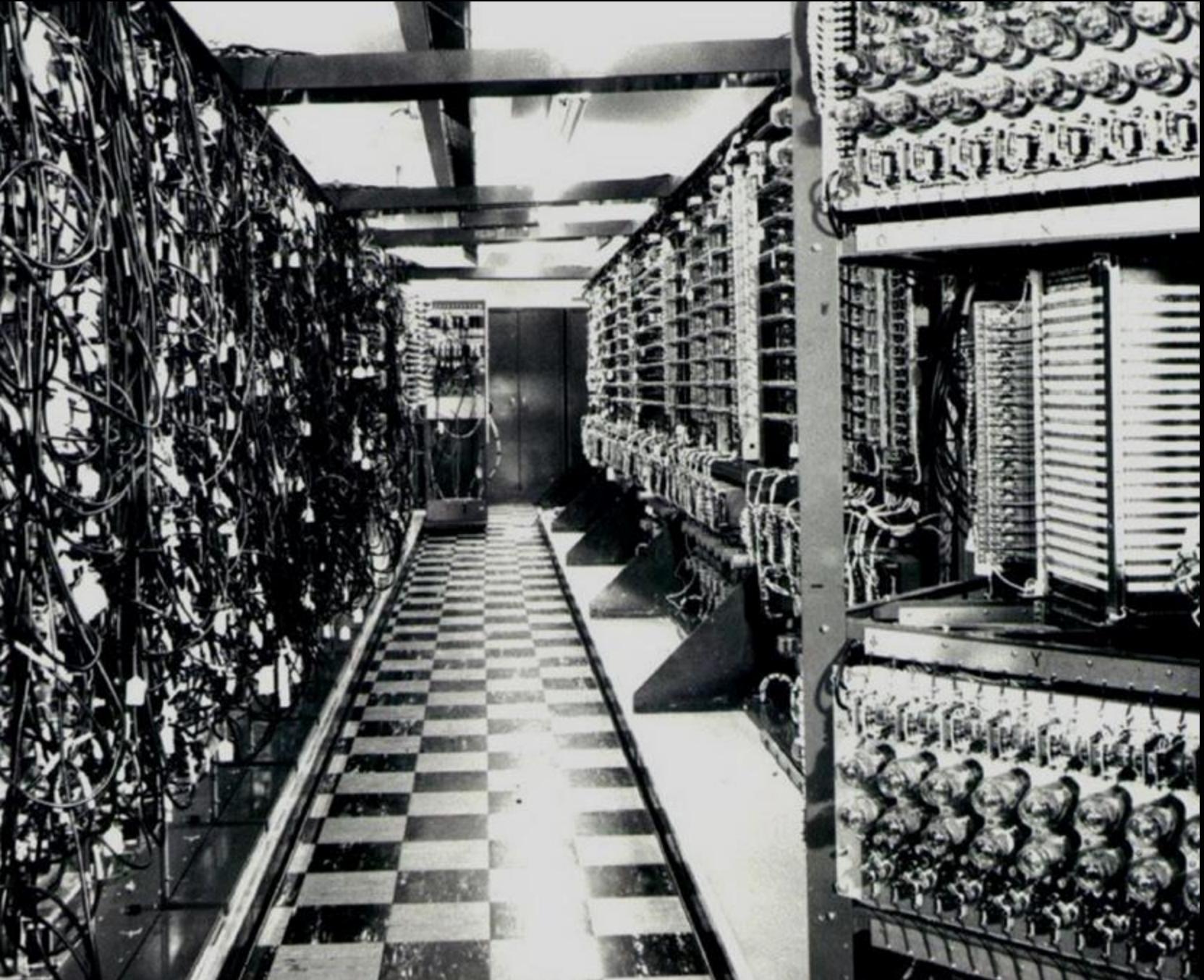
A dense network of light blue and yellowish-green lines and dots against a dark blue background. The lines represent connections between numerous small, glowing circular nodes. These nodes are concentrated in several large, irregular clusters, particularly on the left and right sides, while the center is more sparsely populated. The overall effect is one of a complex, interconnected system, possibly representing a global network or a specific urban area's connectivity patterns.

2

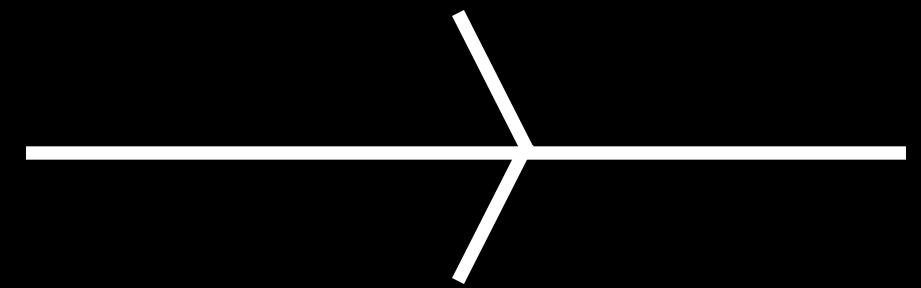
ubiquitous computing and urban data streams



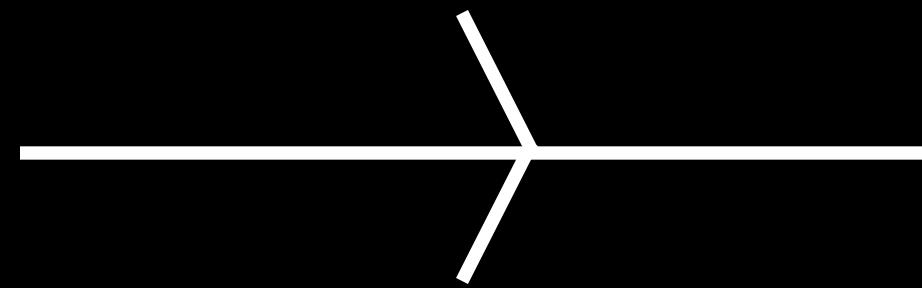
3



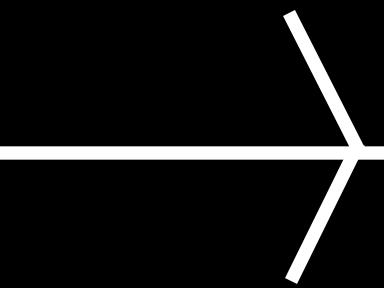
1943
one computer
MANY PEOPLE



1970
one computer
ONE PERSON



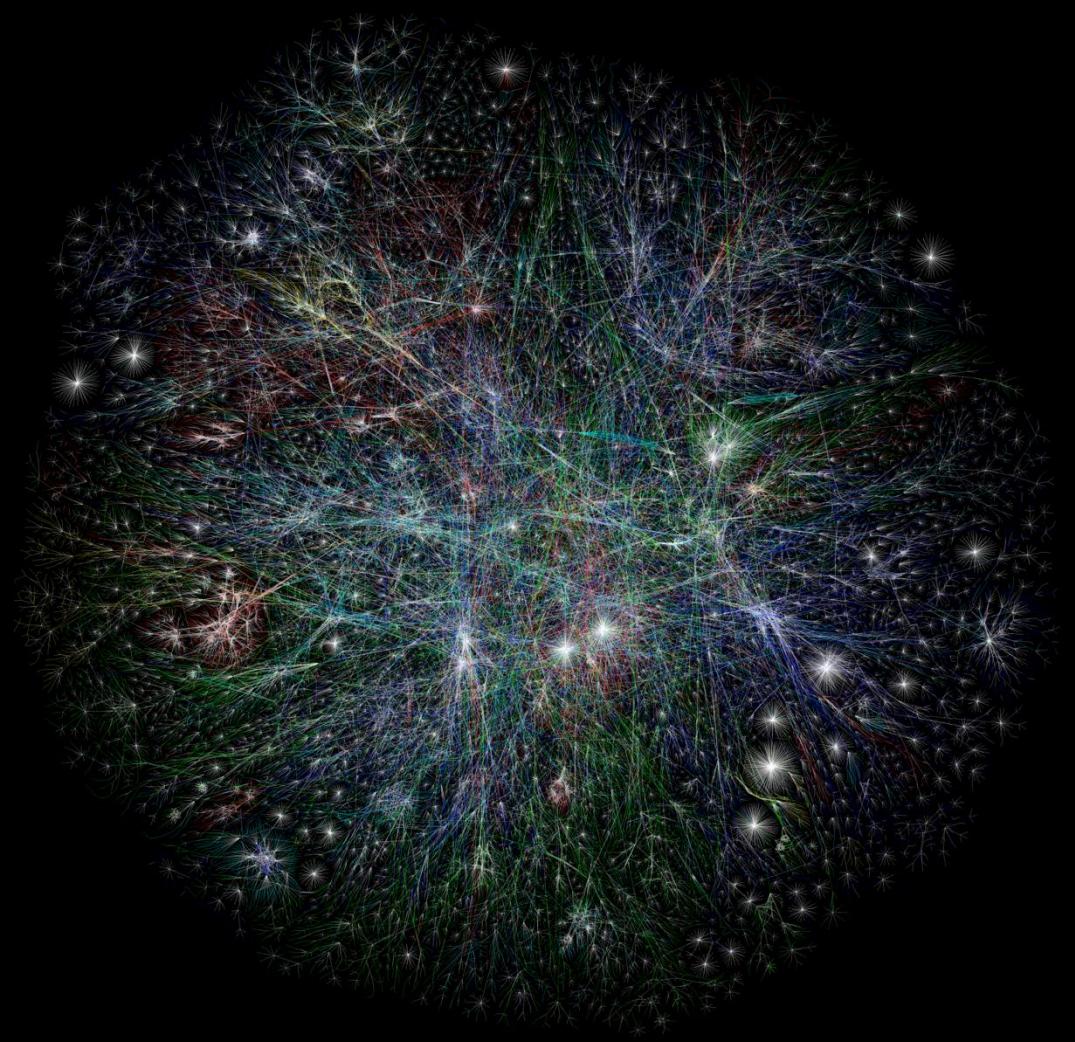
2024
many computers
ONE PERSON



THE GLOBAL NETWORK



1970



2024

?

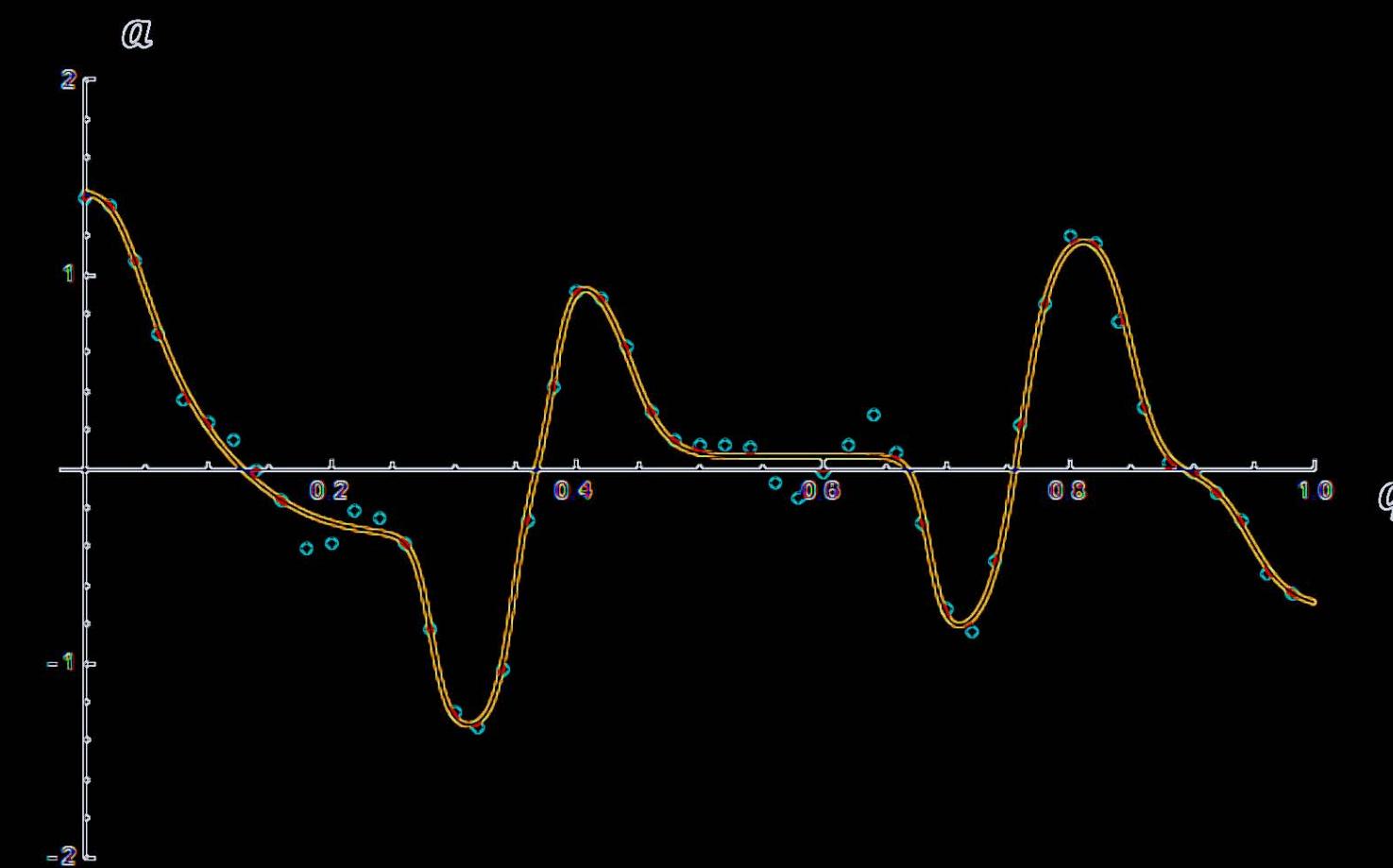
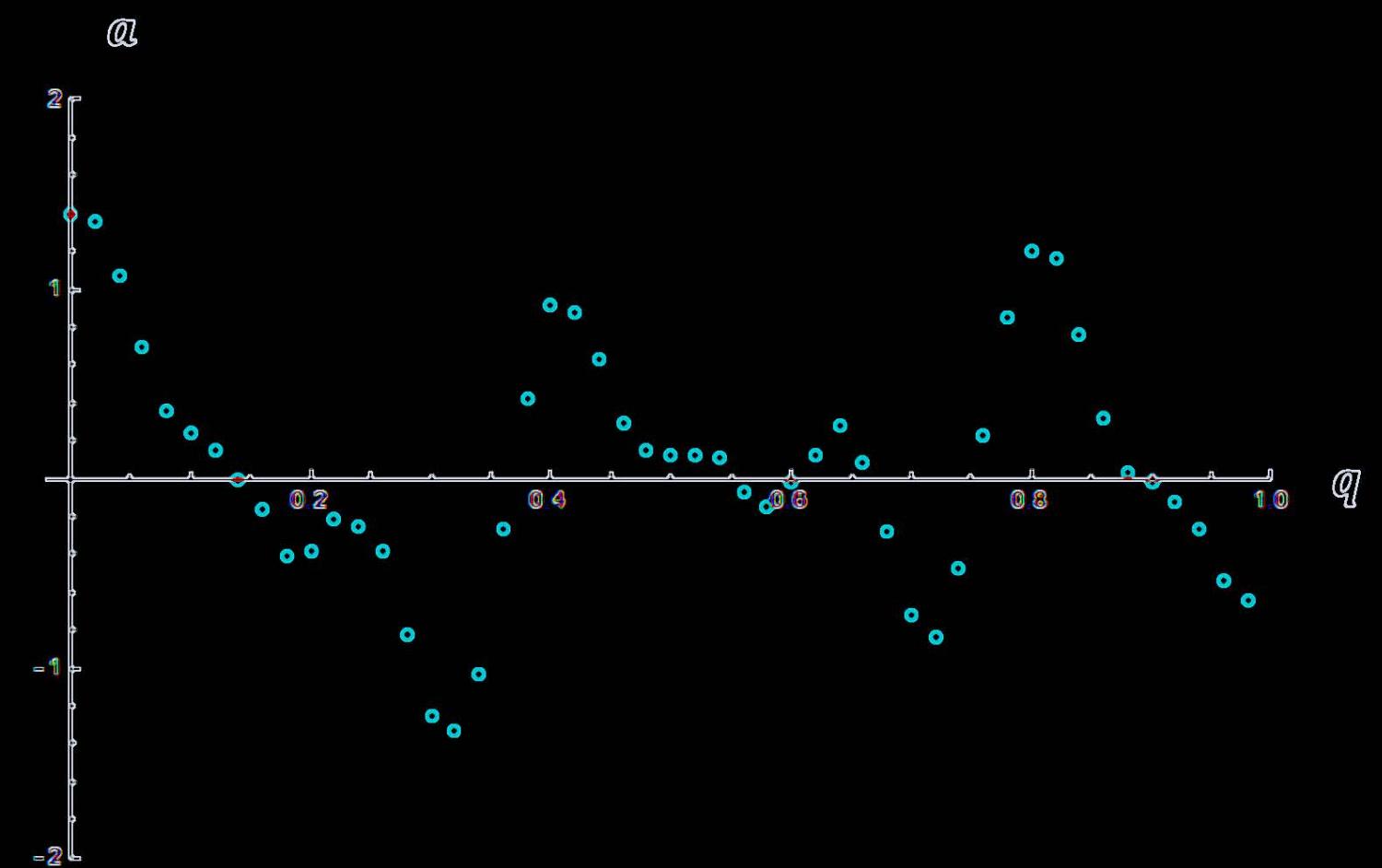
2050

"TURING TEST"

"It is played with three actors, a human (A), a human (B), and an interrogator (C). The object of the game for the interrogator is to determine which of the other two is the A and which is the B"

"What will happen when a machine takes the part of A in this game?"

INTERPOLATION



$$a = f(q)$$

Oracle

Let us suppose we are supplied with some unspecified means of solving number-theoretic problems; a kind of oracle as it were. . . . this oracle . . . cannot be a machine. With the help of the oracle we could form a new kind of machine (call them o-machines), having as one of its fundamental processes that of solving a given number-theoretic problem."

Alan Turing

Towards Symbolic Manipulation

⋮
rule system

⋮
Decision tree

Logic Based

Towards Neuro-Simulation

⋮
artificial neural network

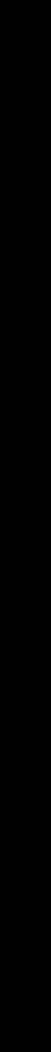
⋮
Explainable

⋮
neuro science

⋮
Mathematical Abstraction

⋮
Alpha go

Probabilistic Based



Towards Symbolic Manipulation

Expert
Systems

Computer
Vision

Natural Language
Processing

Robotics

Machine
Learning

Parametric
generators

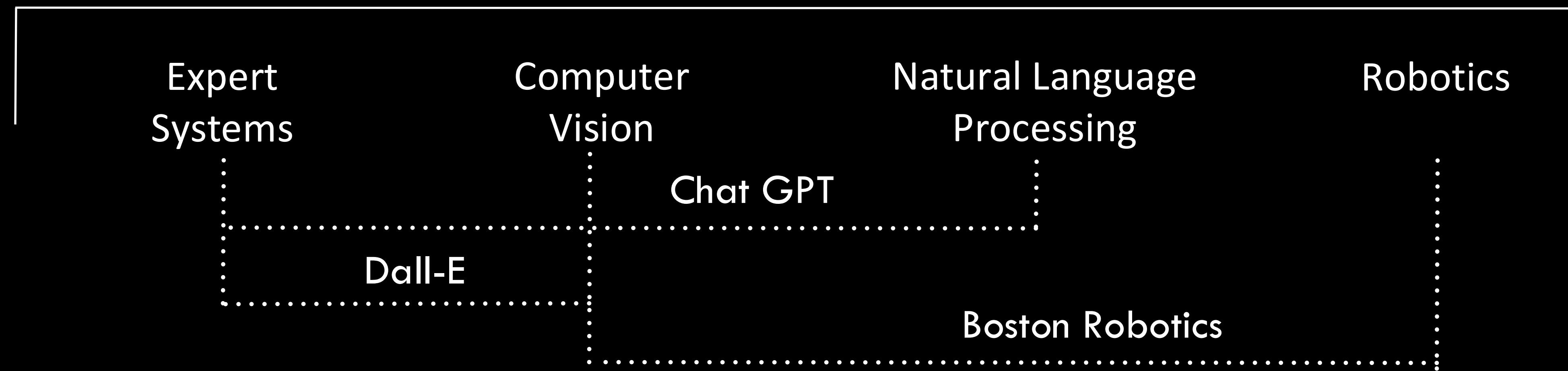
Edge
detection

Bag of
words

Rule-based
movement

Logistic
regression

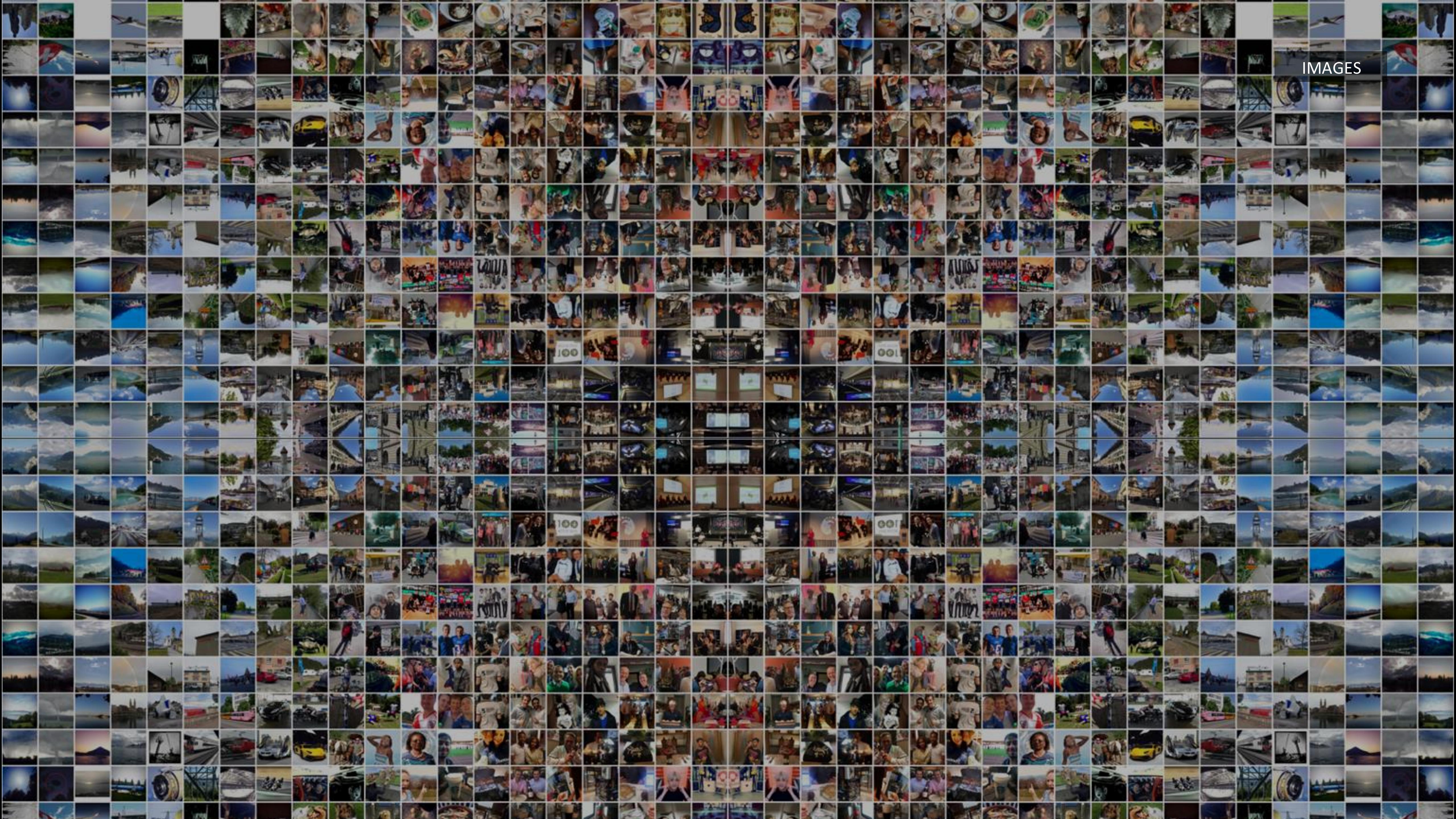
MACHINE LEARNING



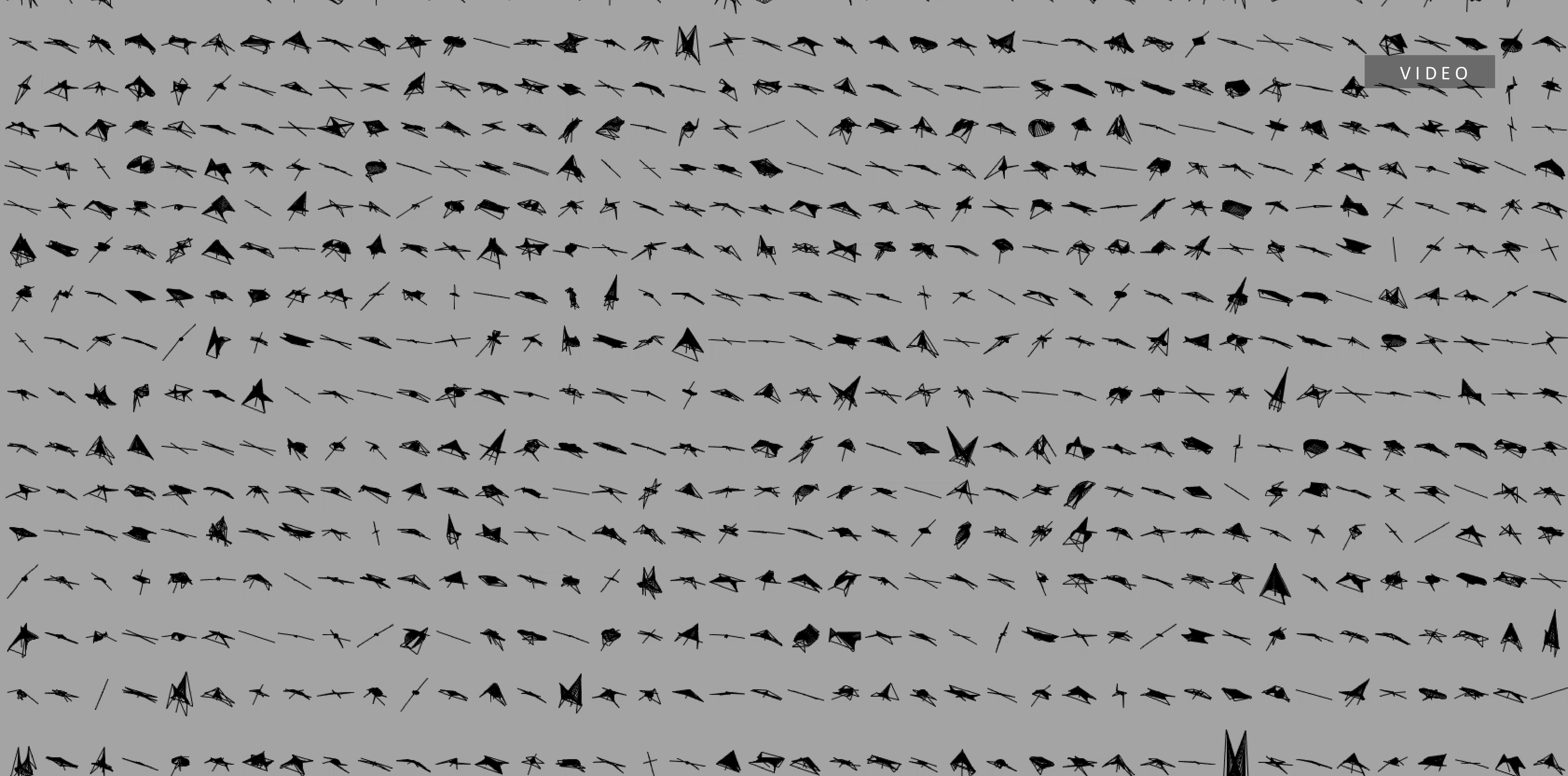
2024

TEXT

IMAGES



VIDEO

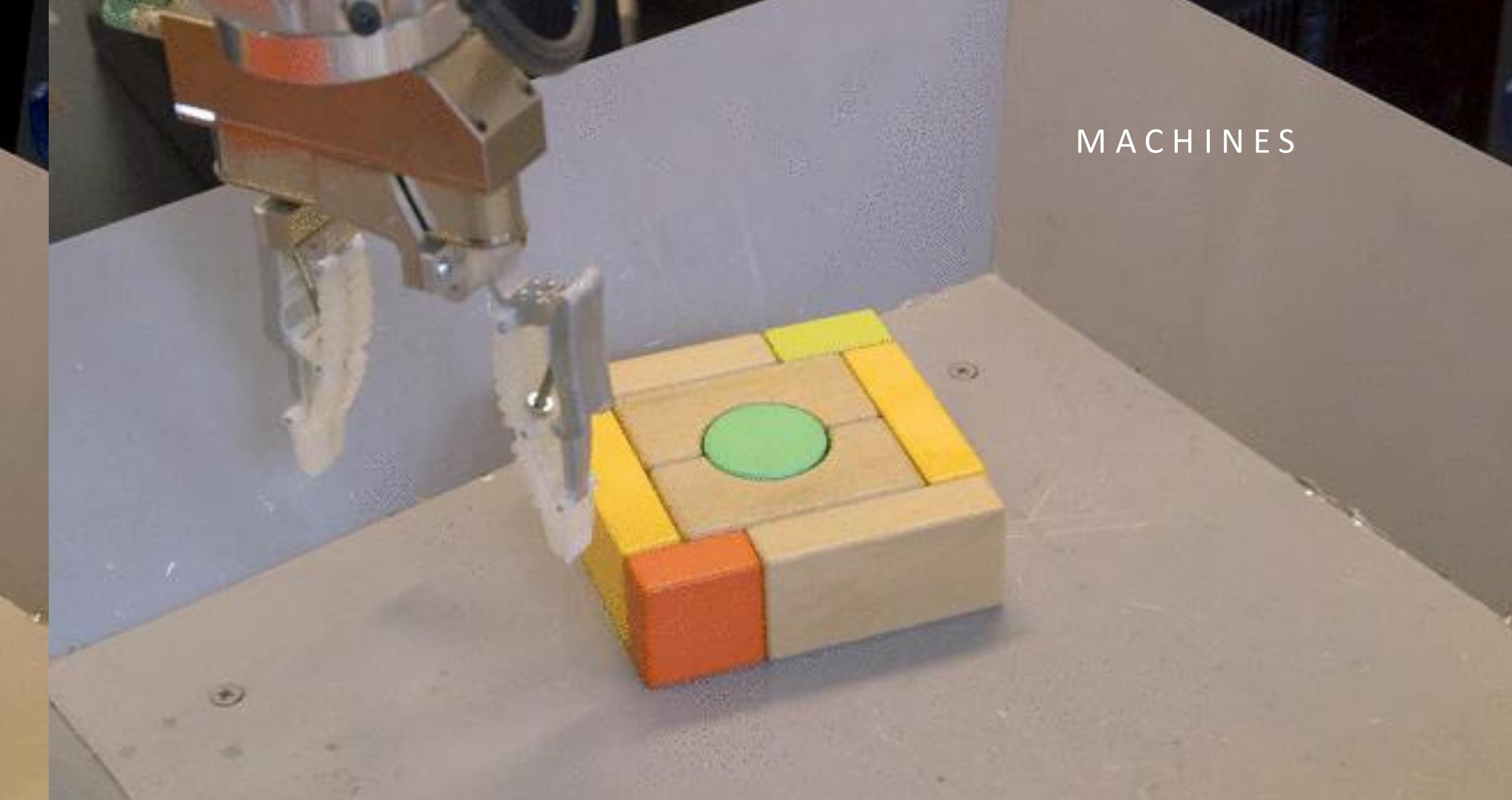
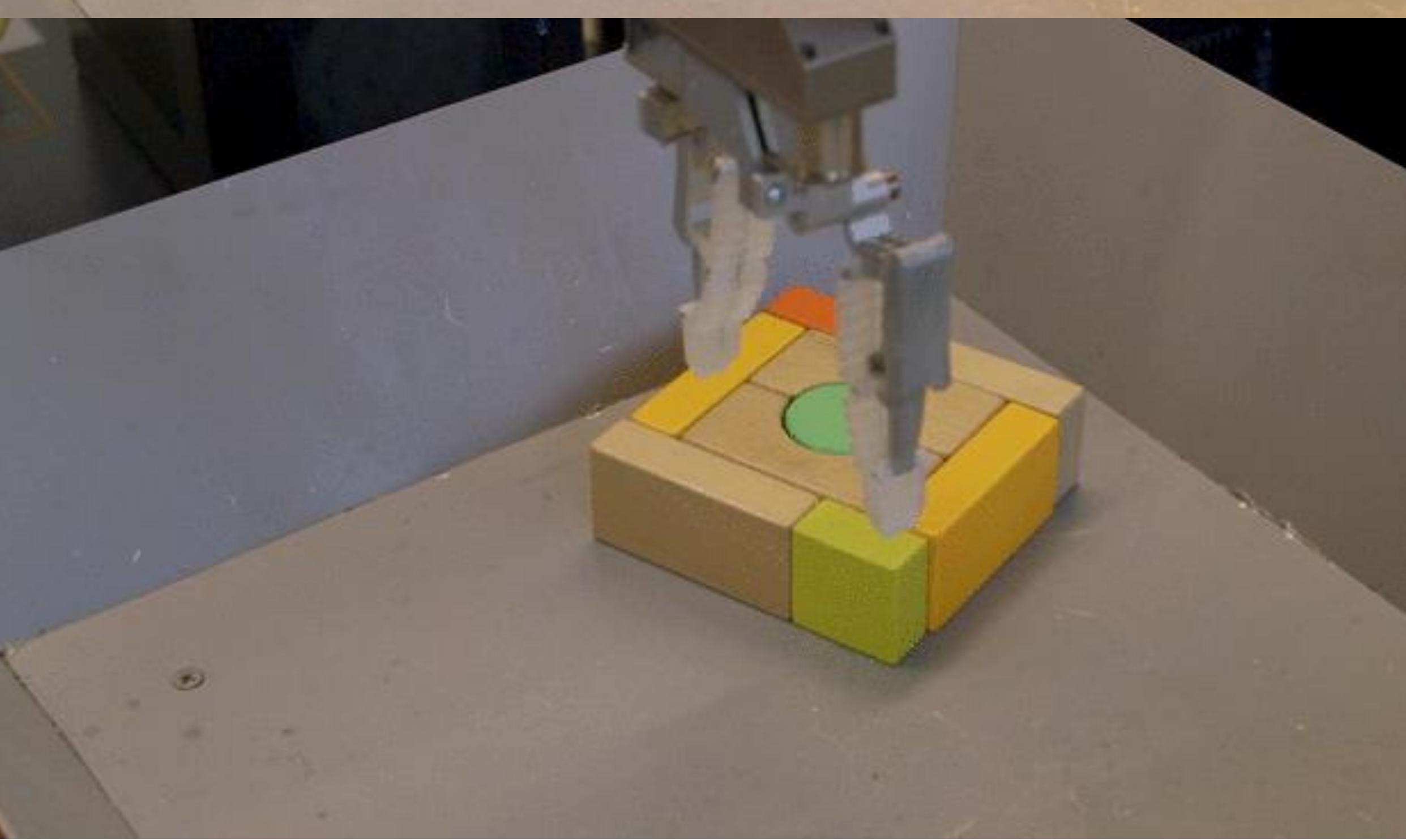


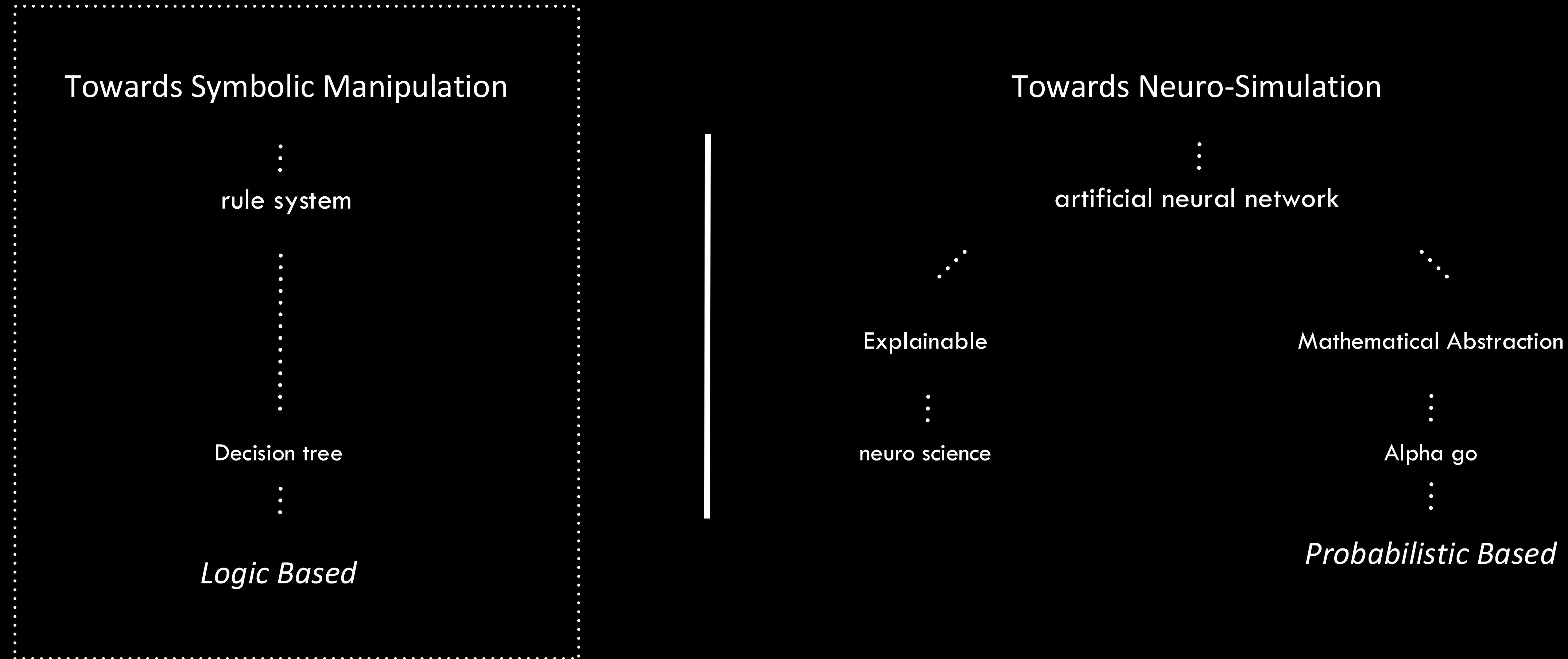
LOCATIONS



NUMBERS, 0.0069919

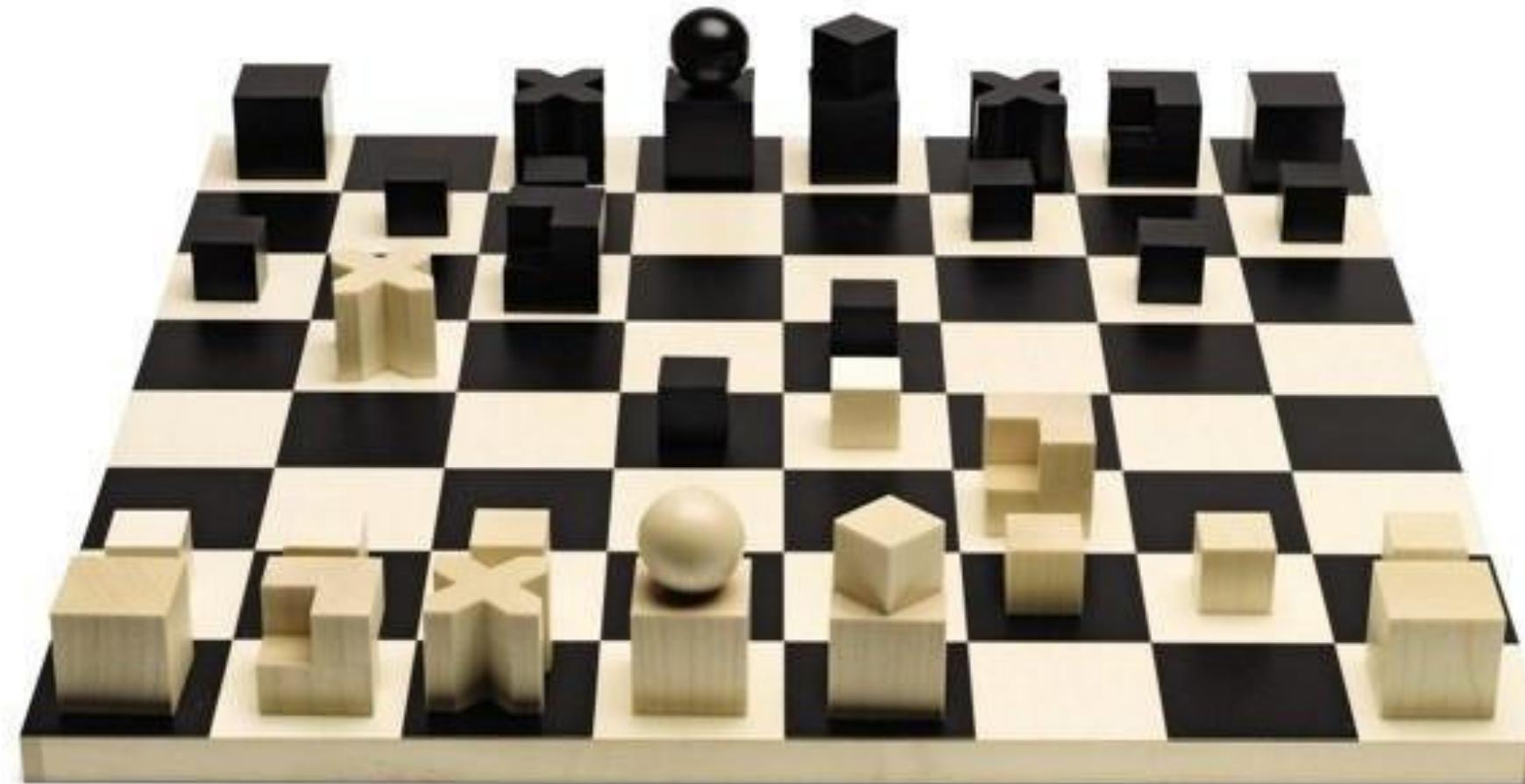
MACHINES





Logic Based

https://en.wikipedia.org/wiki/Deep_Blue_versus_Garry_Kasparov



Deep Blue

Brutal search for all possible moves

10^{50}

Logic Based

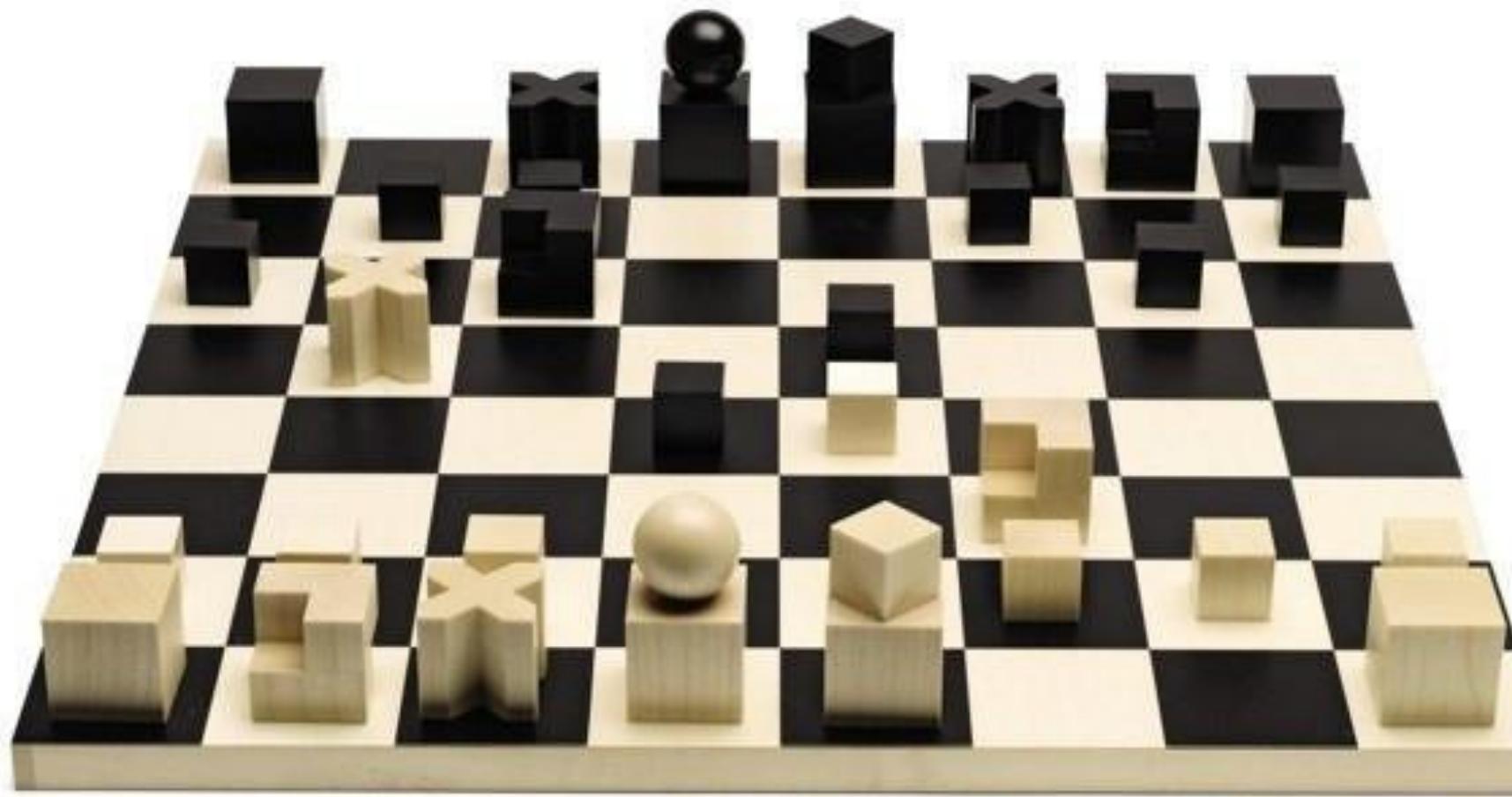


Game AI

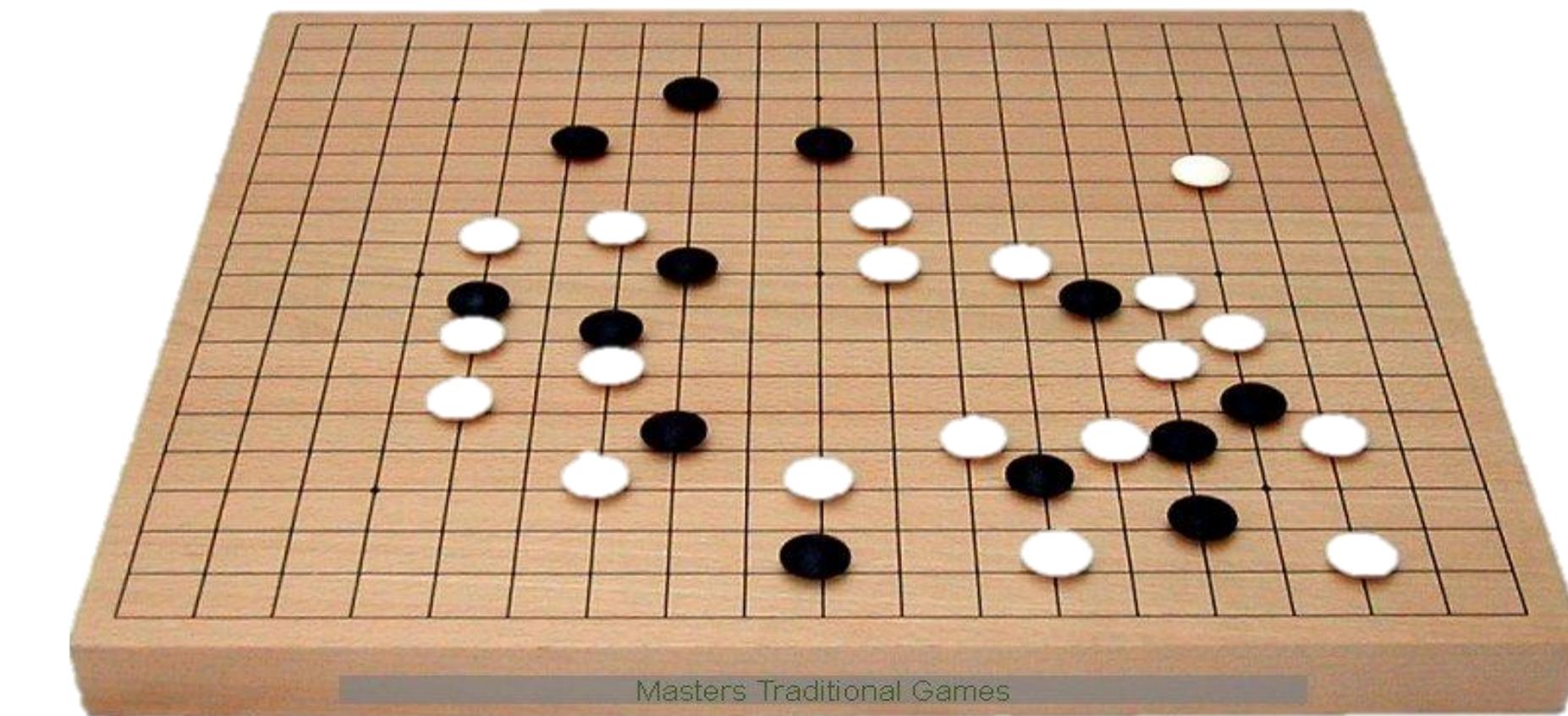
Predefined State-Action rules

Logic Based

Explosion of the search space

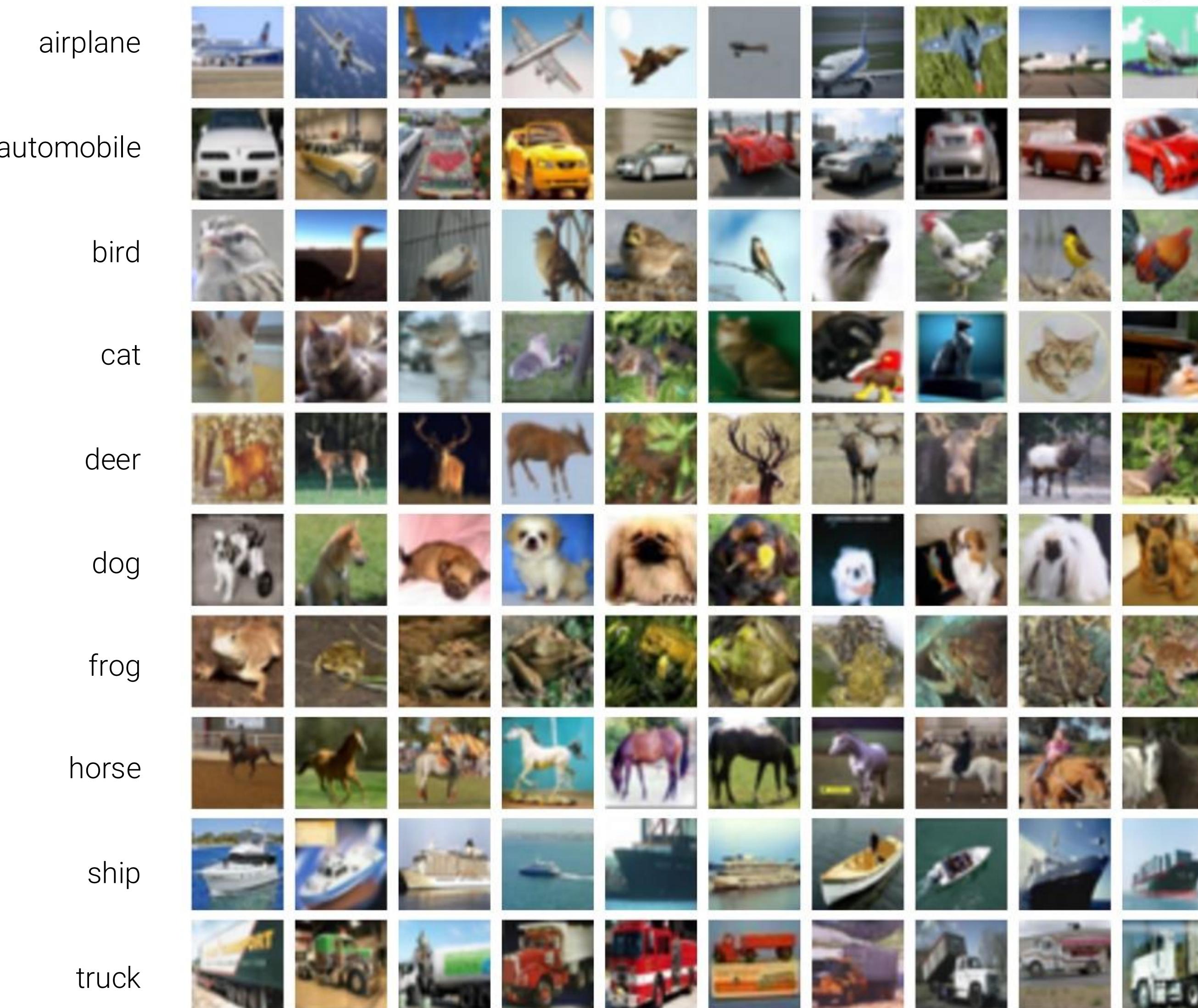


10^{50}



2×10^{170}

Allis, Louis Victor (1994), Searching for solutions in Games and Artificial Intelligence, Maastricht: Proefschrift Rijksuniversiteit Limburg, ISBN 90-9007488-0



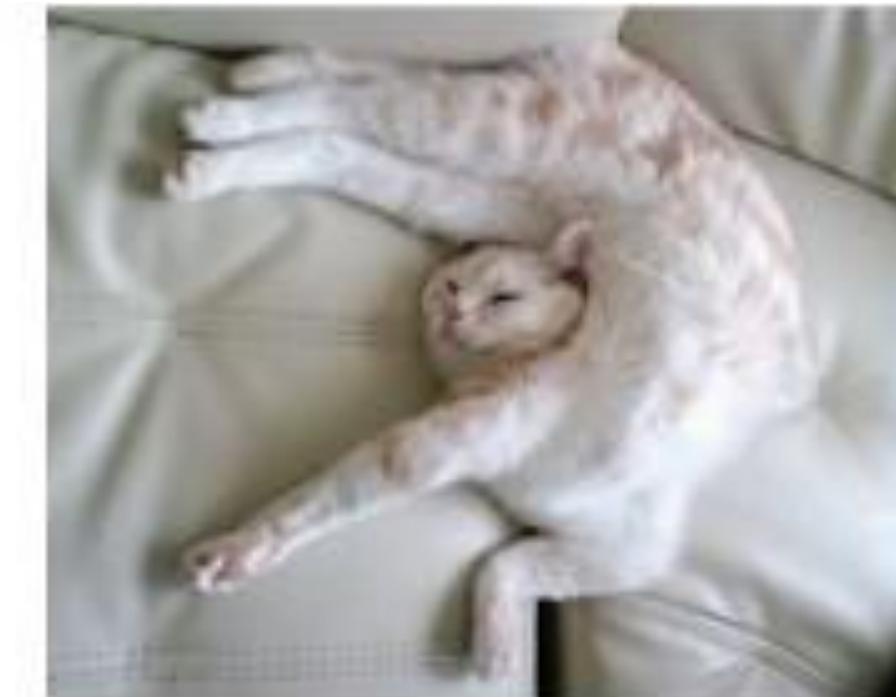
viewpoint variation



scale variation



deformation



occlusion



illumination condition

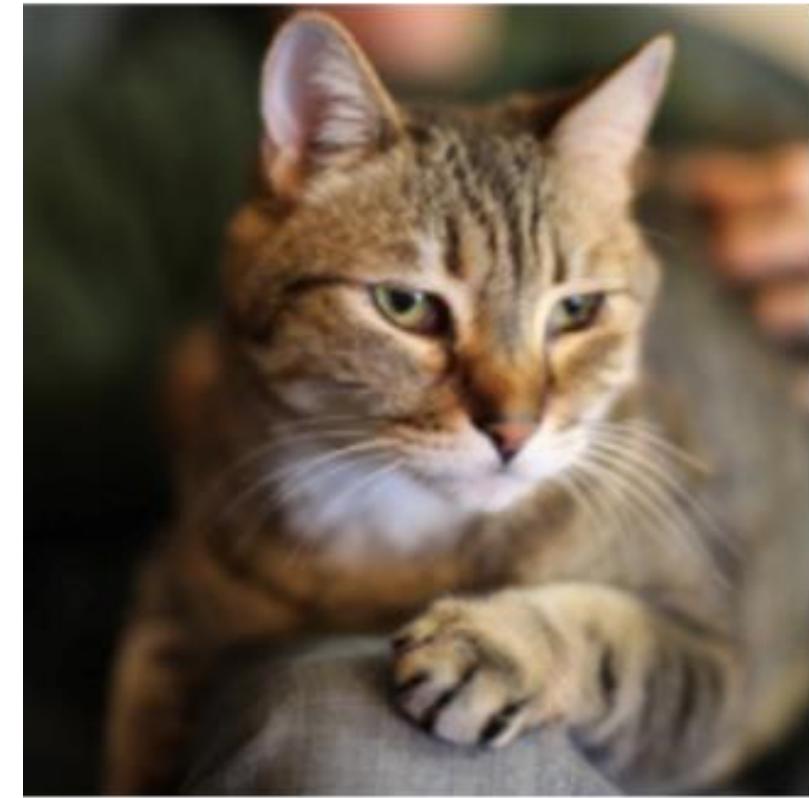


background clutter



intra-class variation





~~Explicit Rules~~



Inexplicit Correlations



Cat: Yes
Dog: No

Towards Symbolic Manipulation

rule system

Decision tree

Logic Based

Towards Neuro-Simulation

artificial neural network

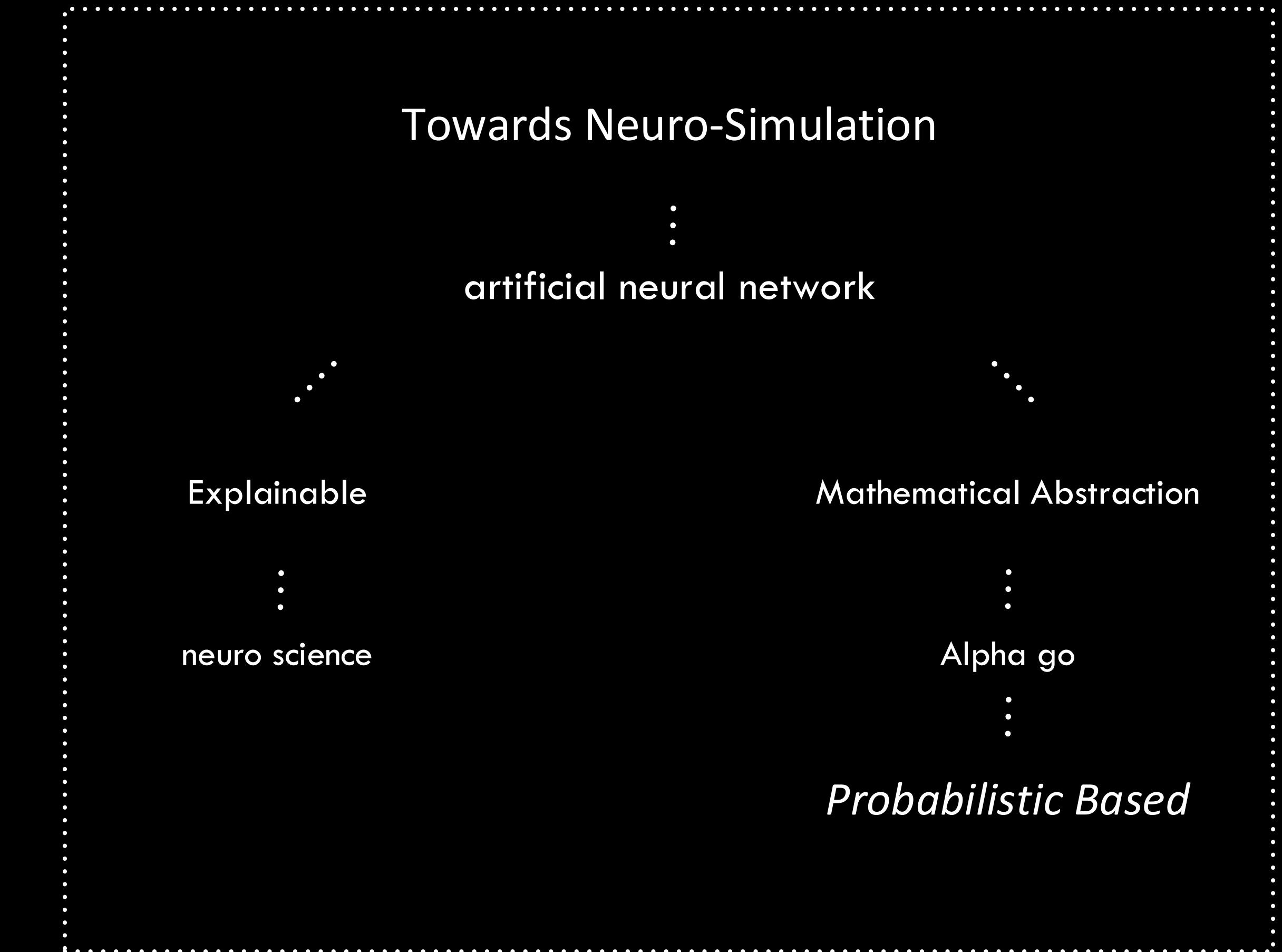
Explainable

neuro science

Mathematical Abstraction

Alpha go

Probabilistic Based



Towards Symbolic Manipulation

⋮
rule system

⋮
Decision tree

⋮
Logic Based

Towards Neuro-Simulation

⋮
artificial neural network

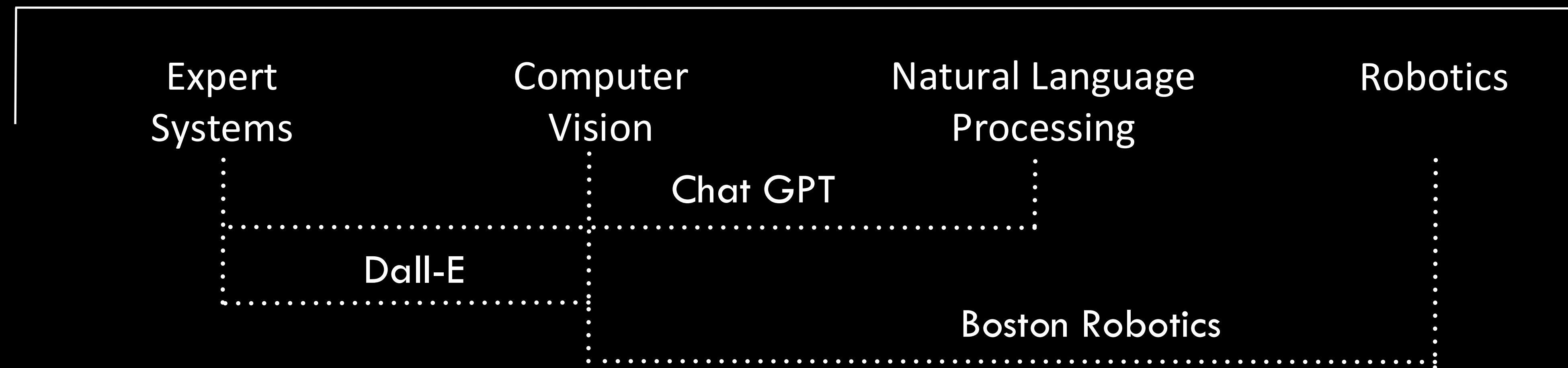
⋮
Explainable
⋮
neuro science

⋮
Mathematical Abstraction

⋮
Alpha go

⋮
Probabilistic Based

MACHINE LEARNING



2023

SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

REINFORCEMENT LEARNING

SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

REINFORCEMENT LEARNING

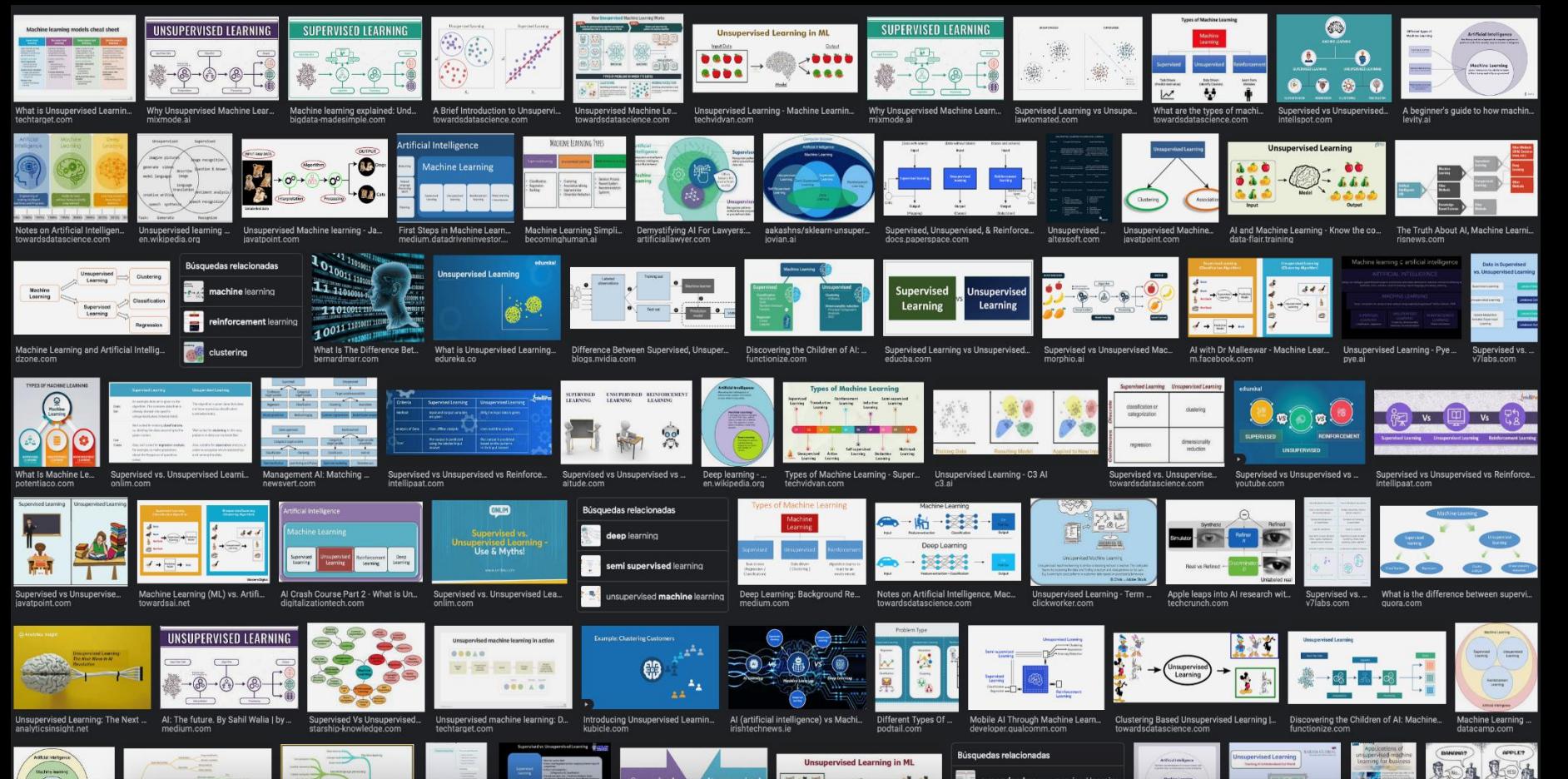


SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

REINFORCEMENT LEARNING



SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

REINFORCEMENT LEARNING

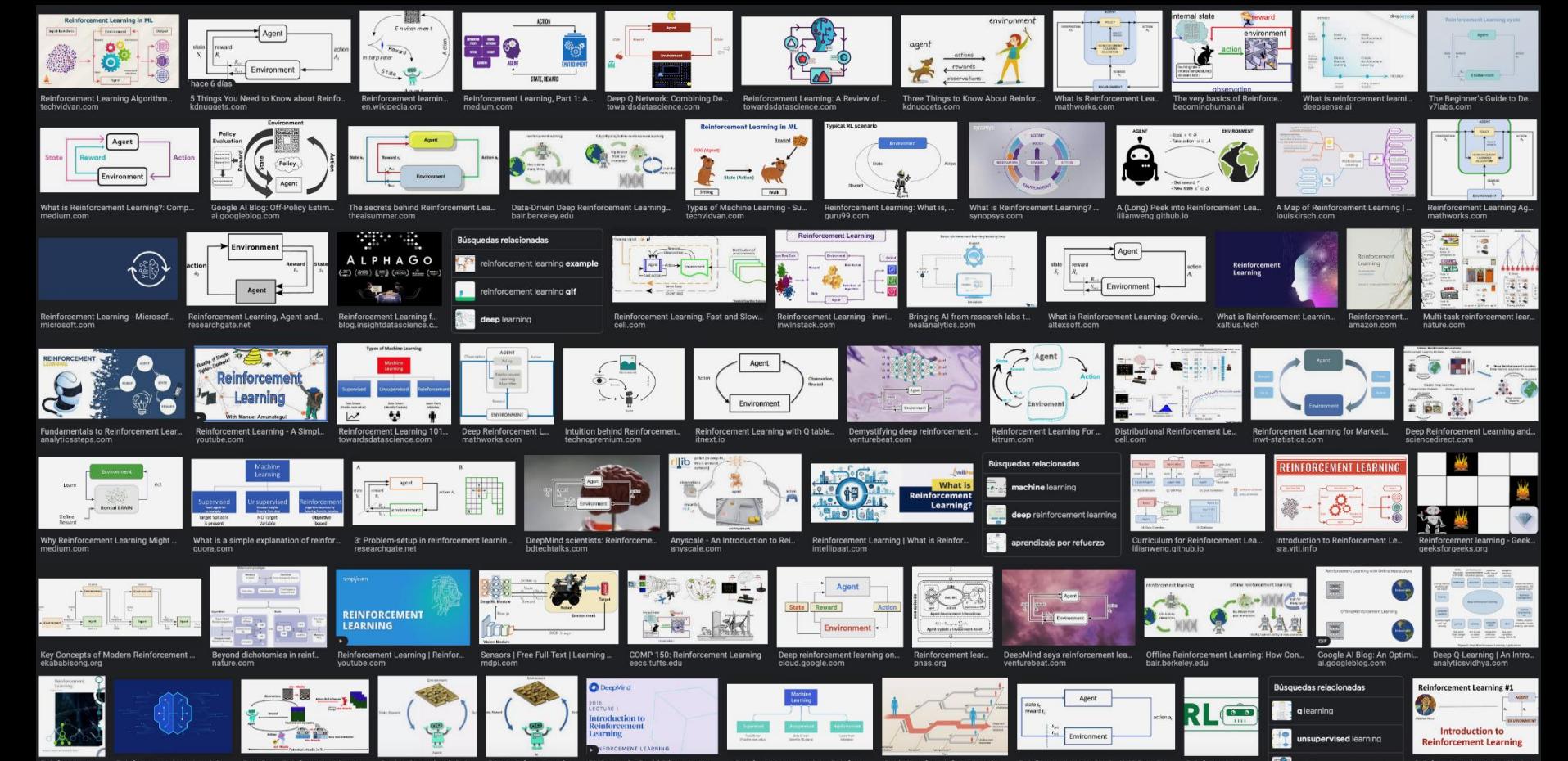


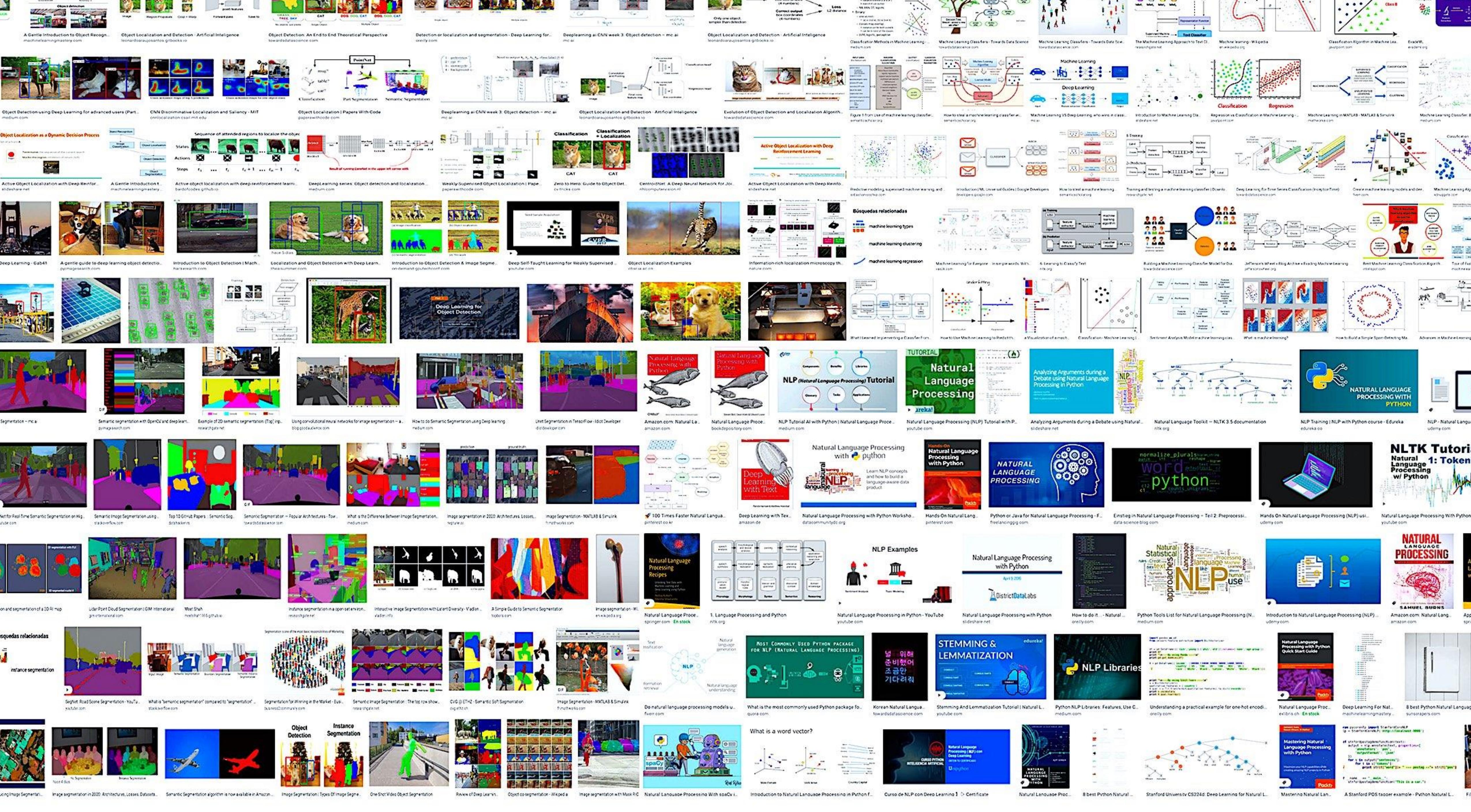
SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

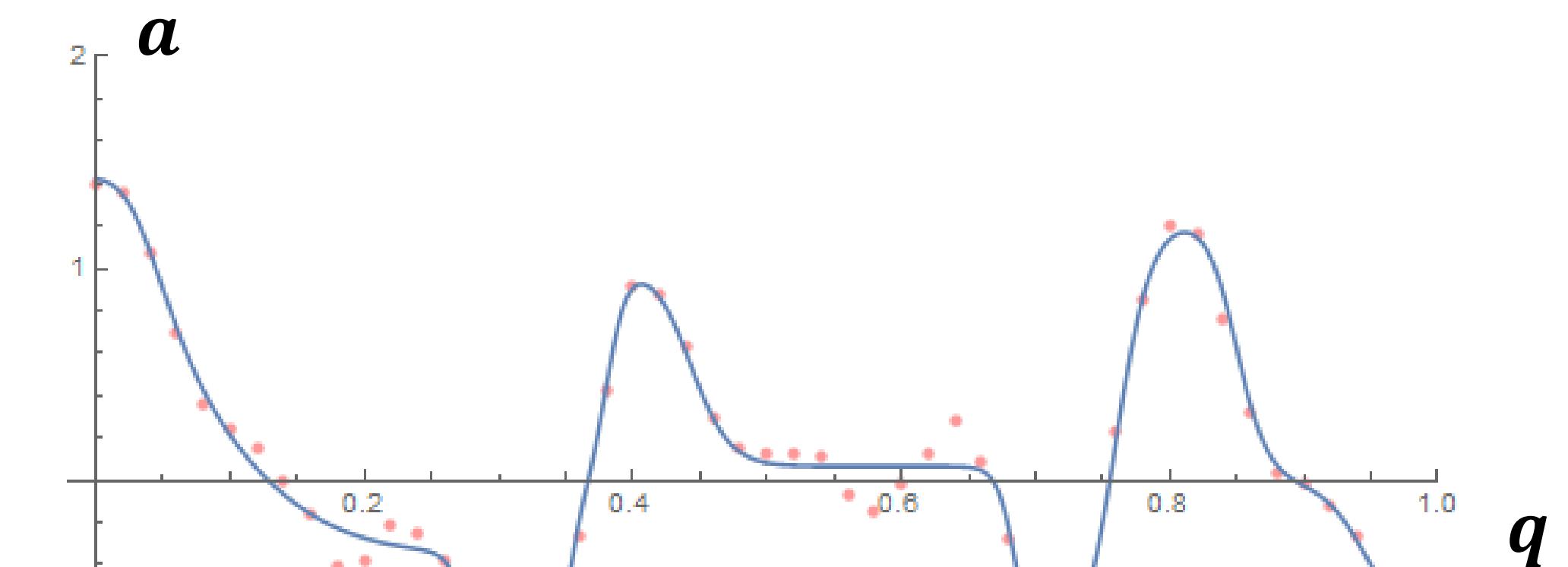
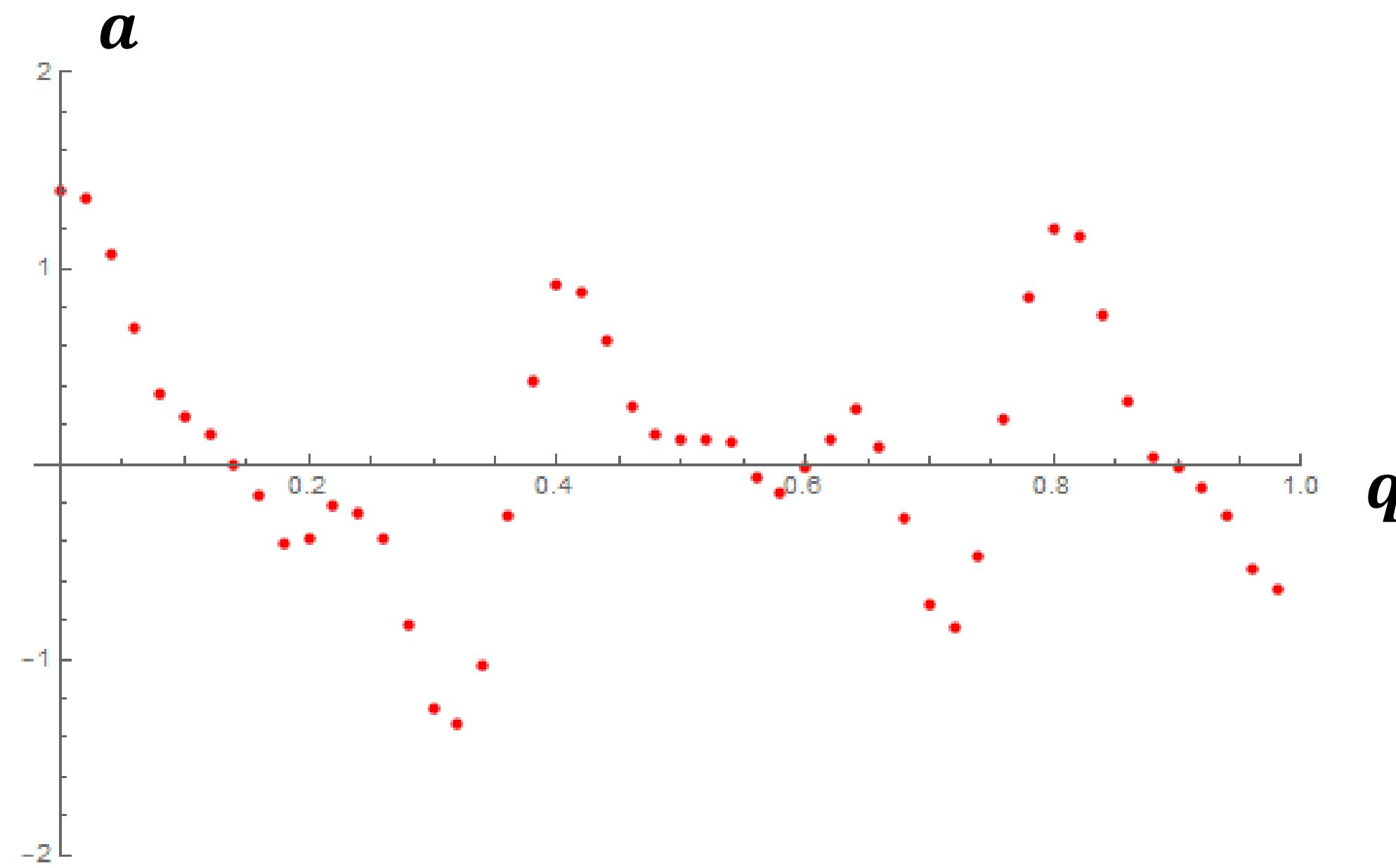
REINFORCEMENT LEARNING





Why it works?

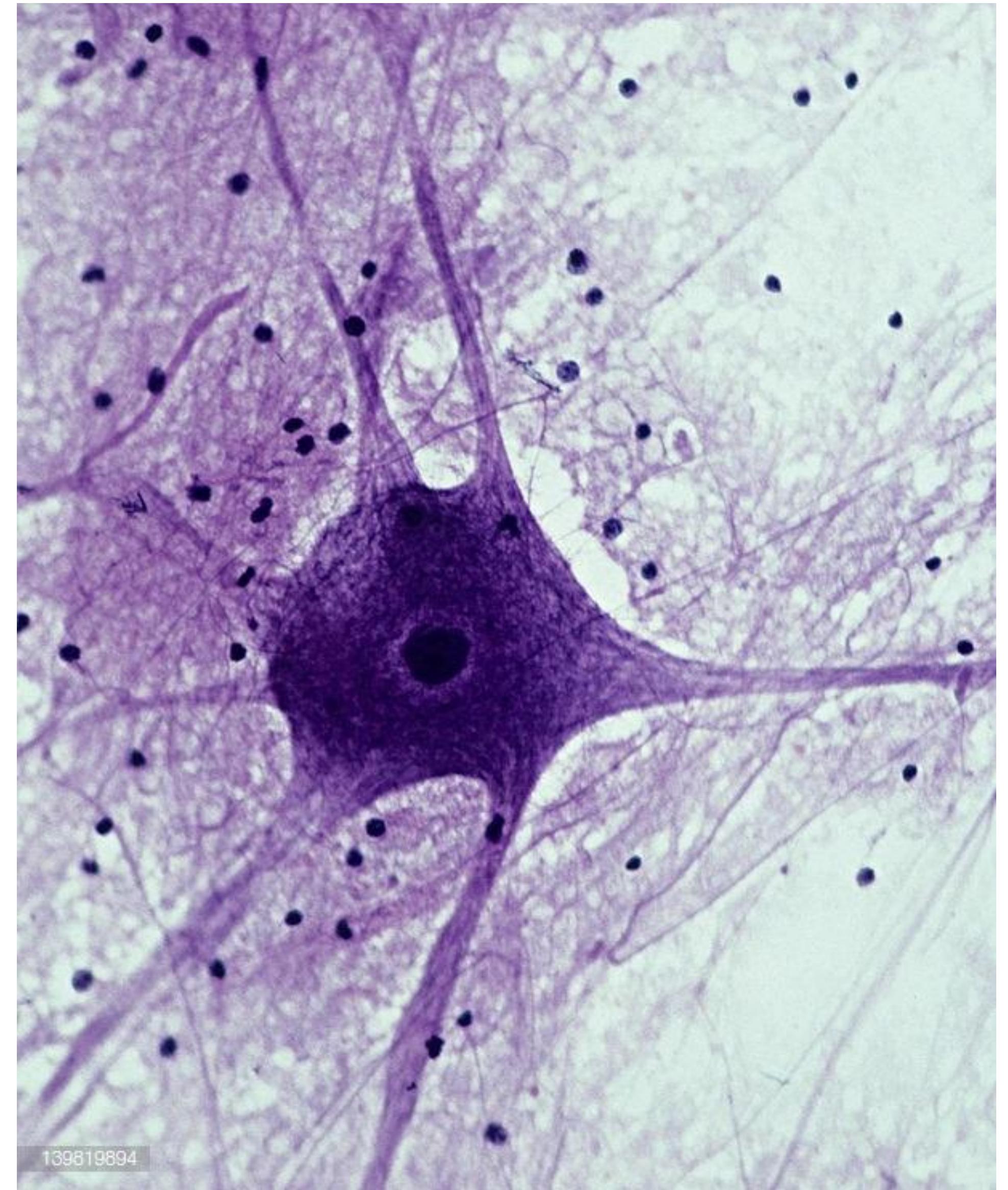
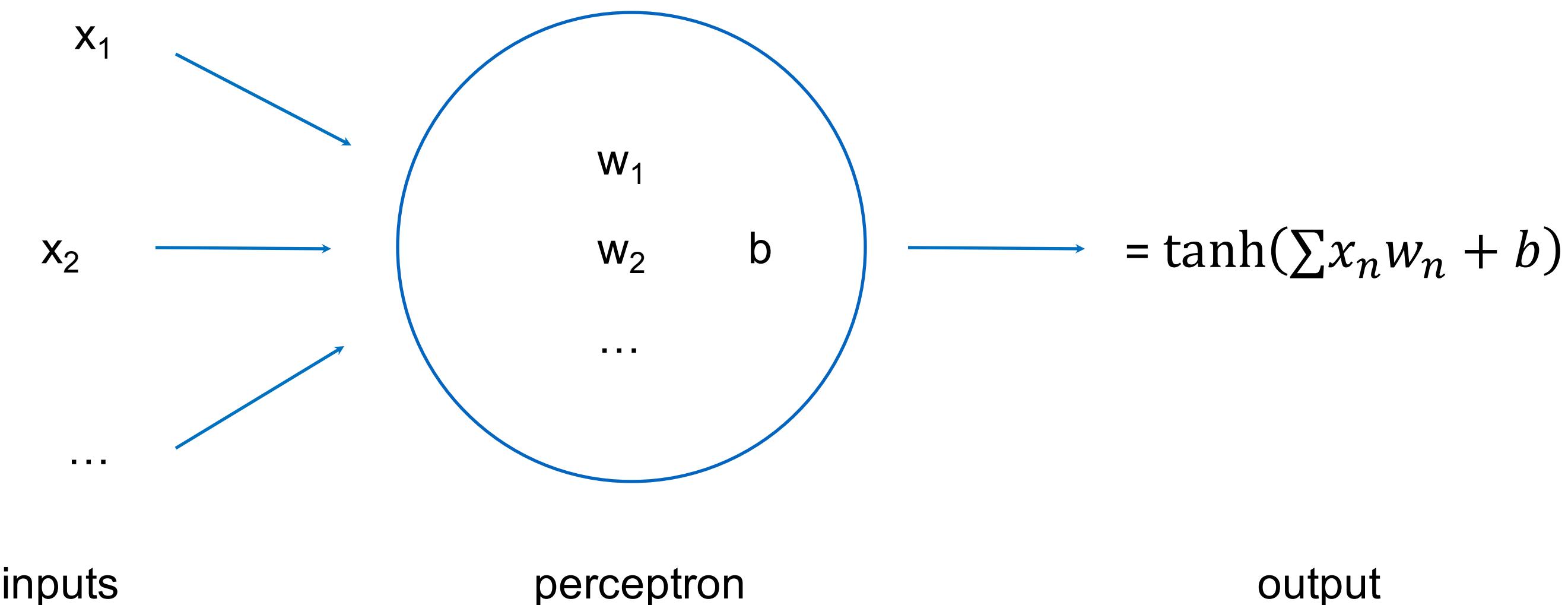
A function approximator, it finds the correlation between the **input** and the **expected output**



$$a = f(q)$$

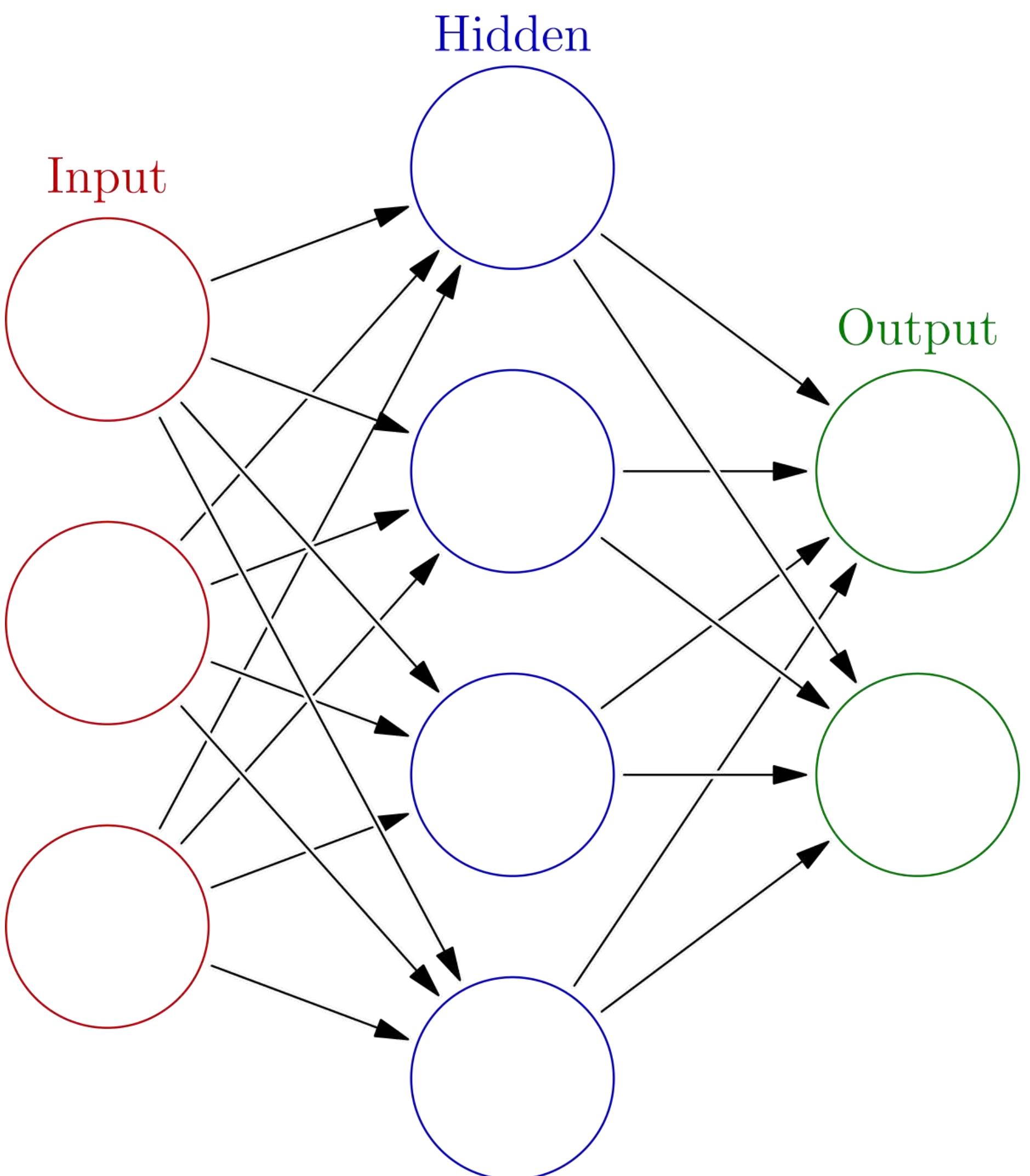
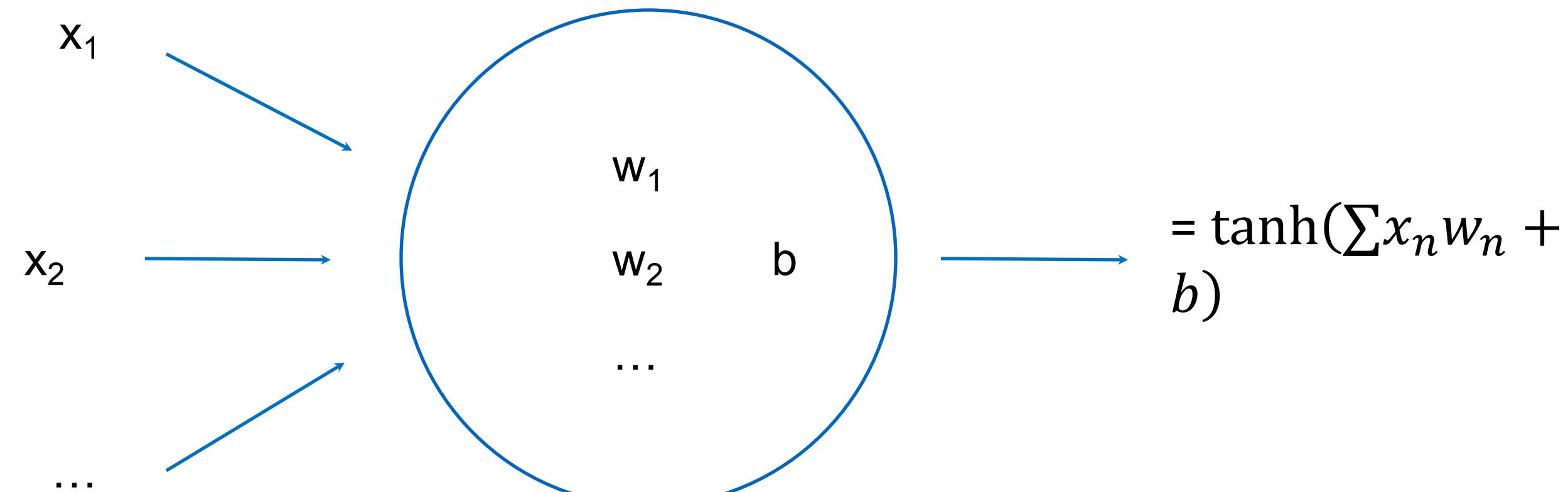
Perceptron?

A bio-inspired mathematic model

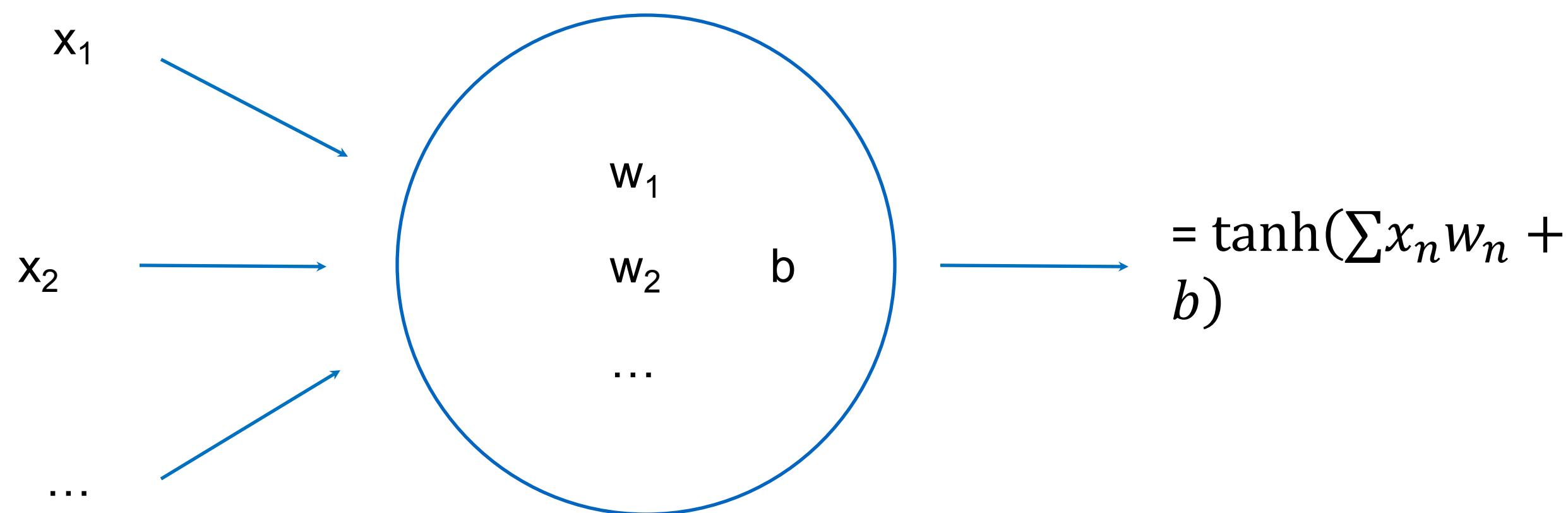


Neural network

Stack of connected Perceptrons

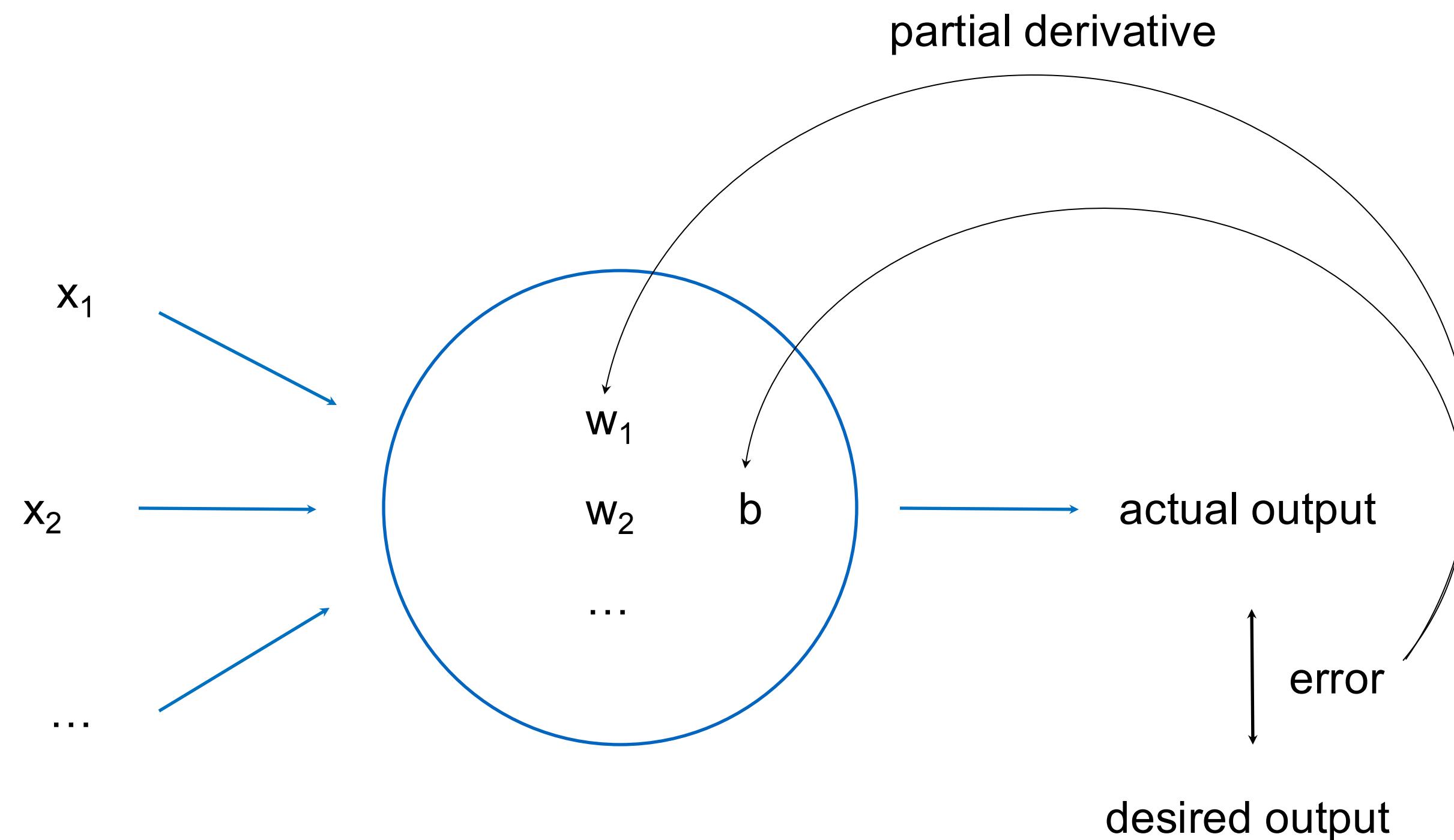


Learning?



The goal of the learning is to find proper values of w and b so that we get expected outputs from inputs

Backpropagation



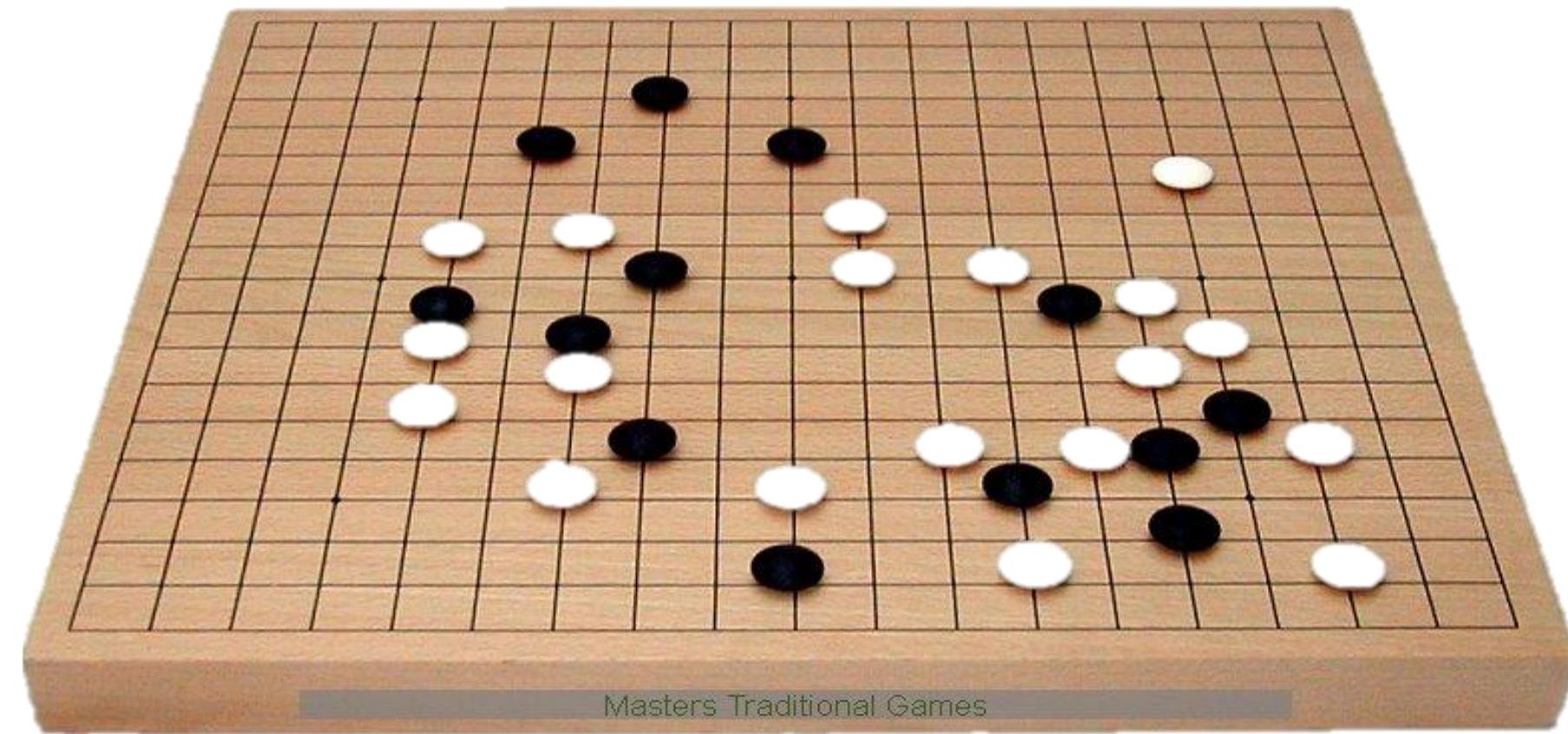
The idea of Backpropagation is that, since we know the error between the actual and desired outputs, and the network is differentiable, we can measure how much contribution each w and b has to the error using partial derivative, and adjust them accordingly.

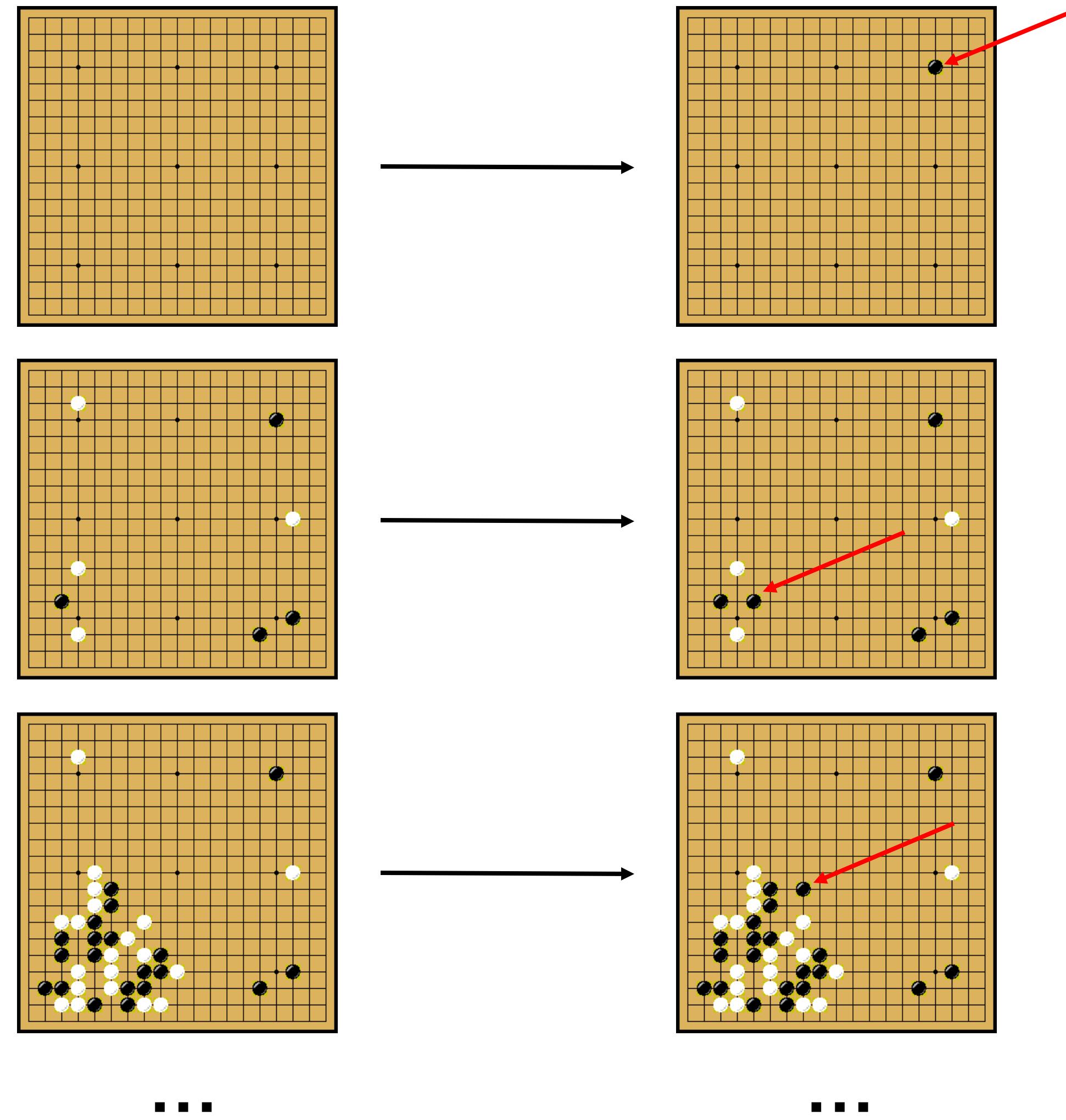
Deep Learning?

Machine learning on a model with many
layers, called Deep

Alpha Go

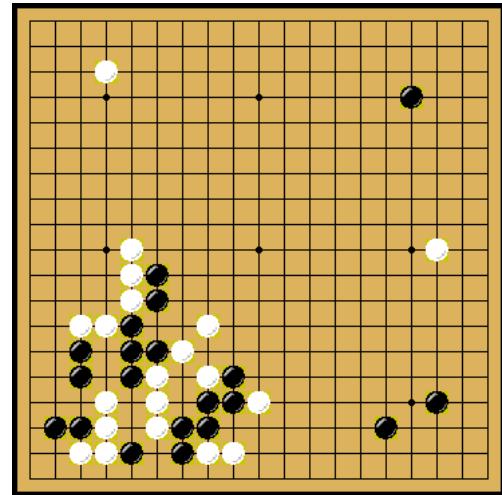
<https://deepmind.com/research/case-studies/alphago-the-story-so-far>



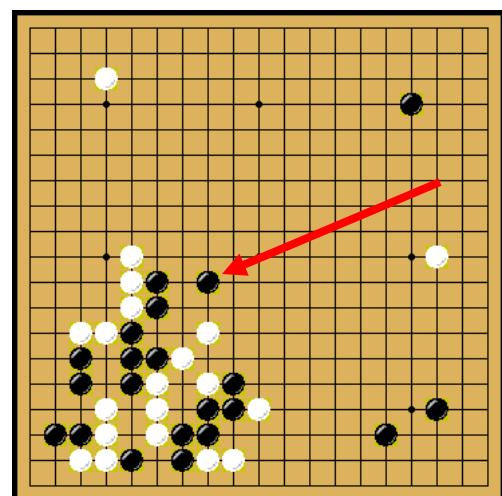


Alpha Go learns the correlation between **state/input** (left) and **decision/output** (right) by observing millions rounds of games by human players.

training data

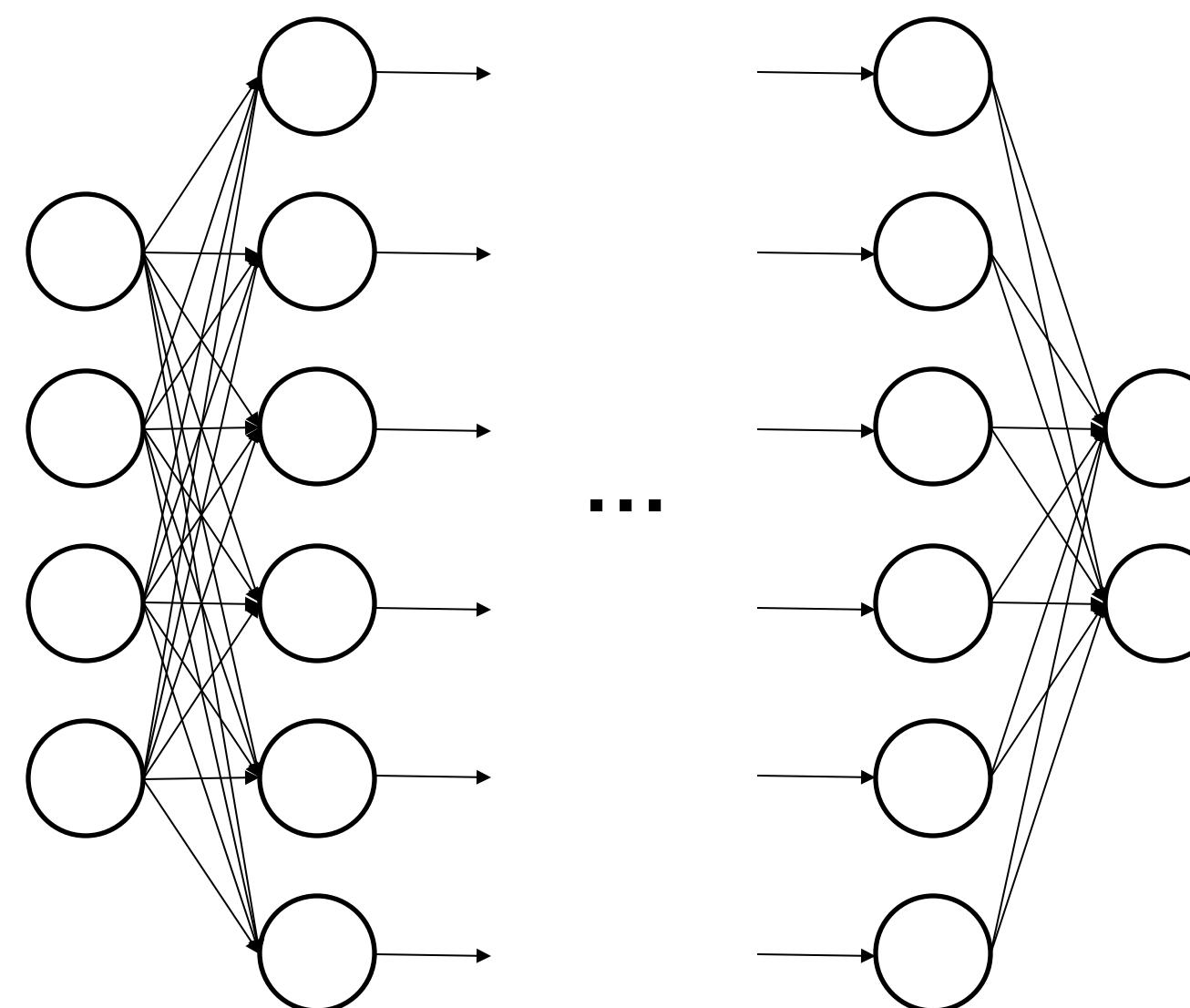


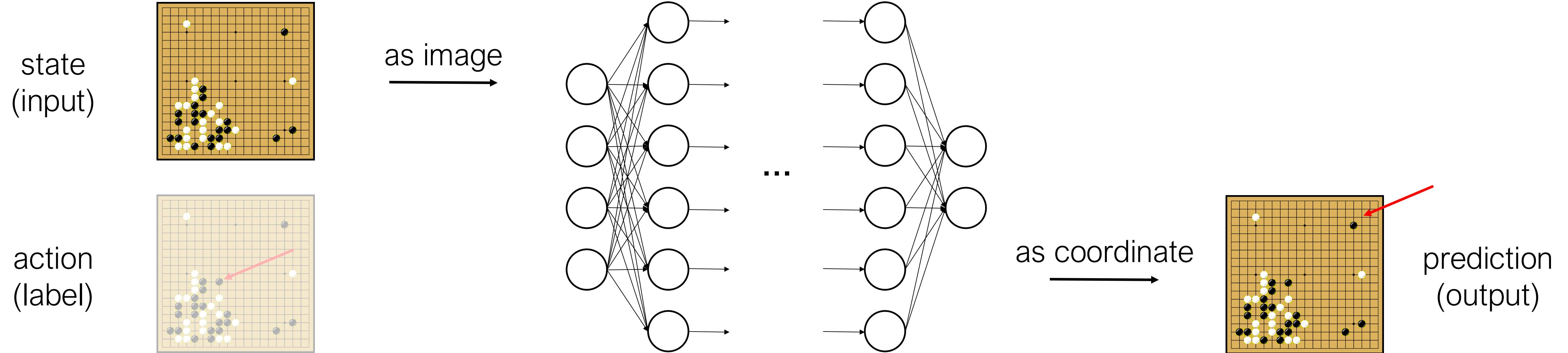
state
(input)



action
(label)

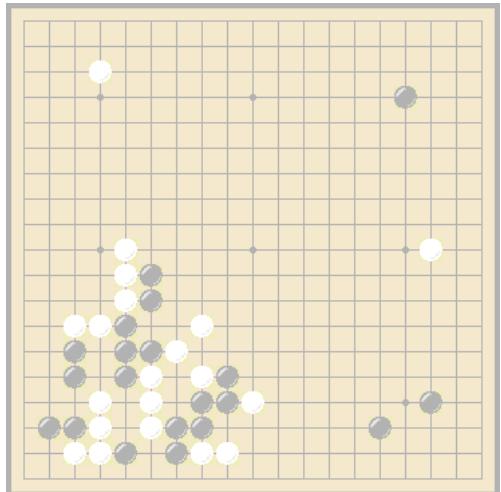
mathematical mode



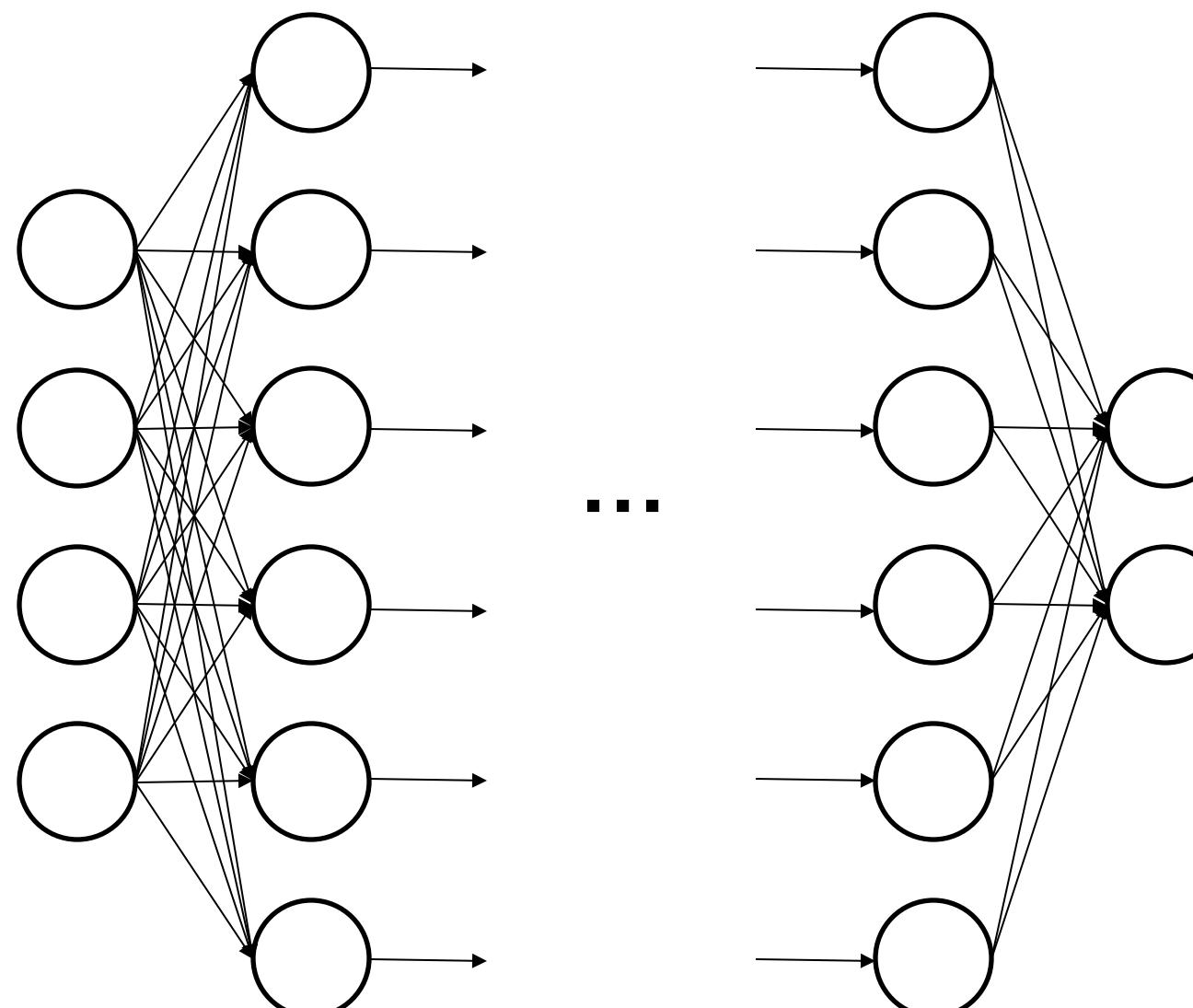
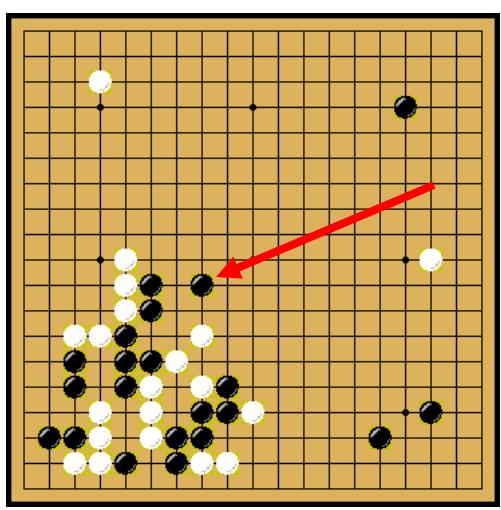


As we will show you in todays experiments, both images and coordinates are all numbers, the neural network is the projection from one numerical space (images) to the other (coordinates)

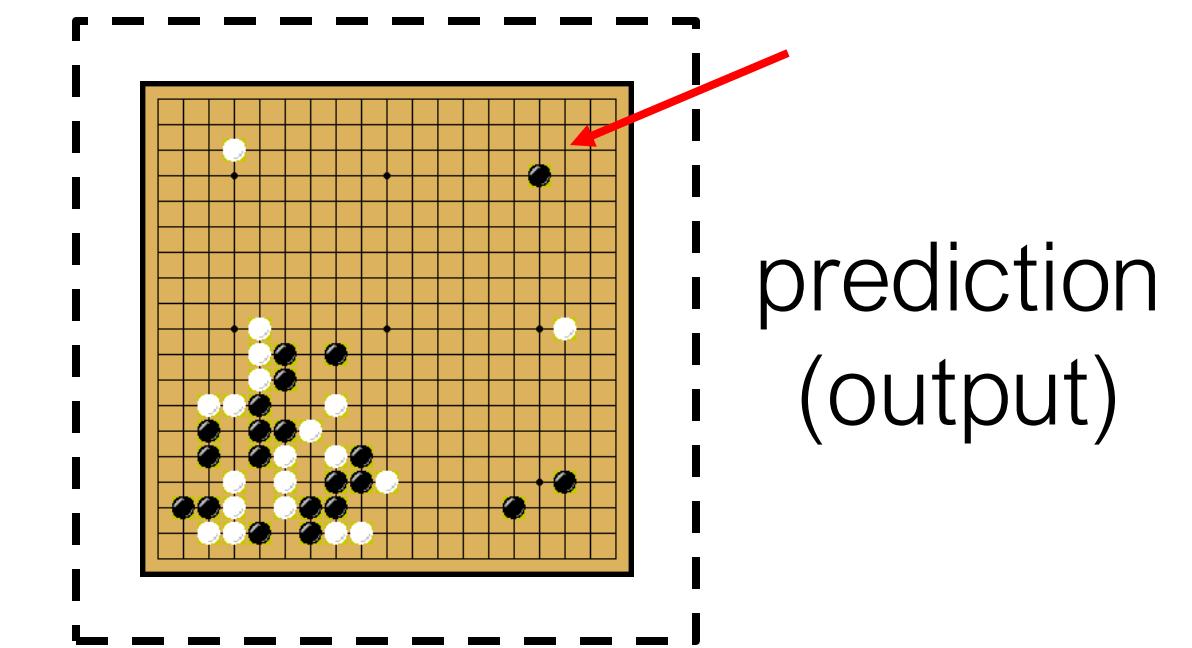
state
(input)

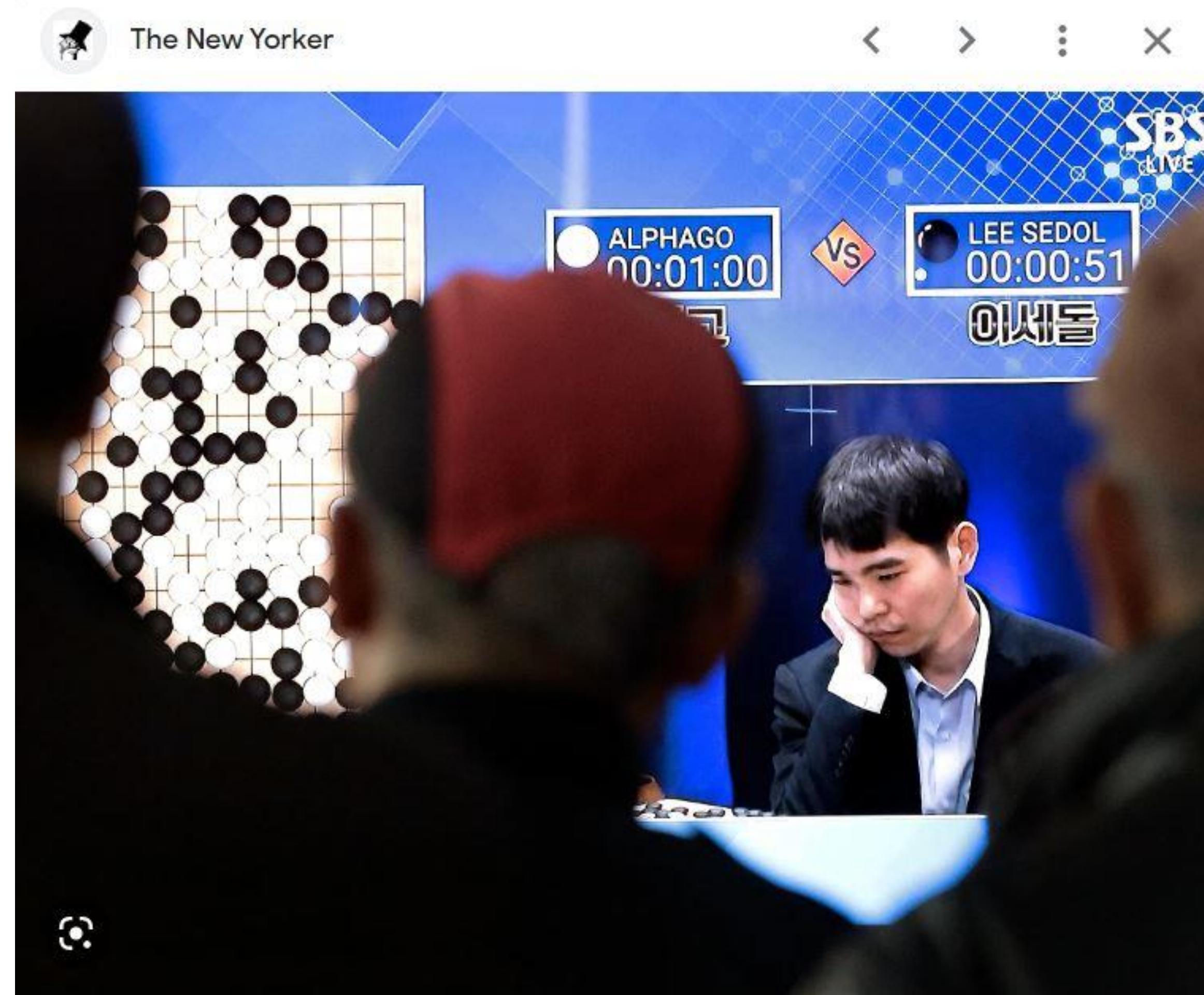


action
(label)



how error the prediction is



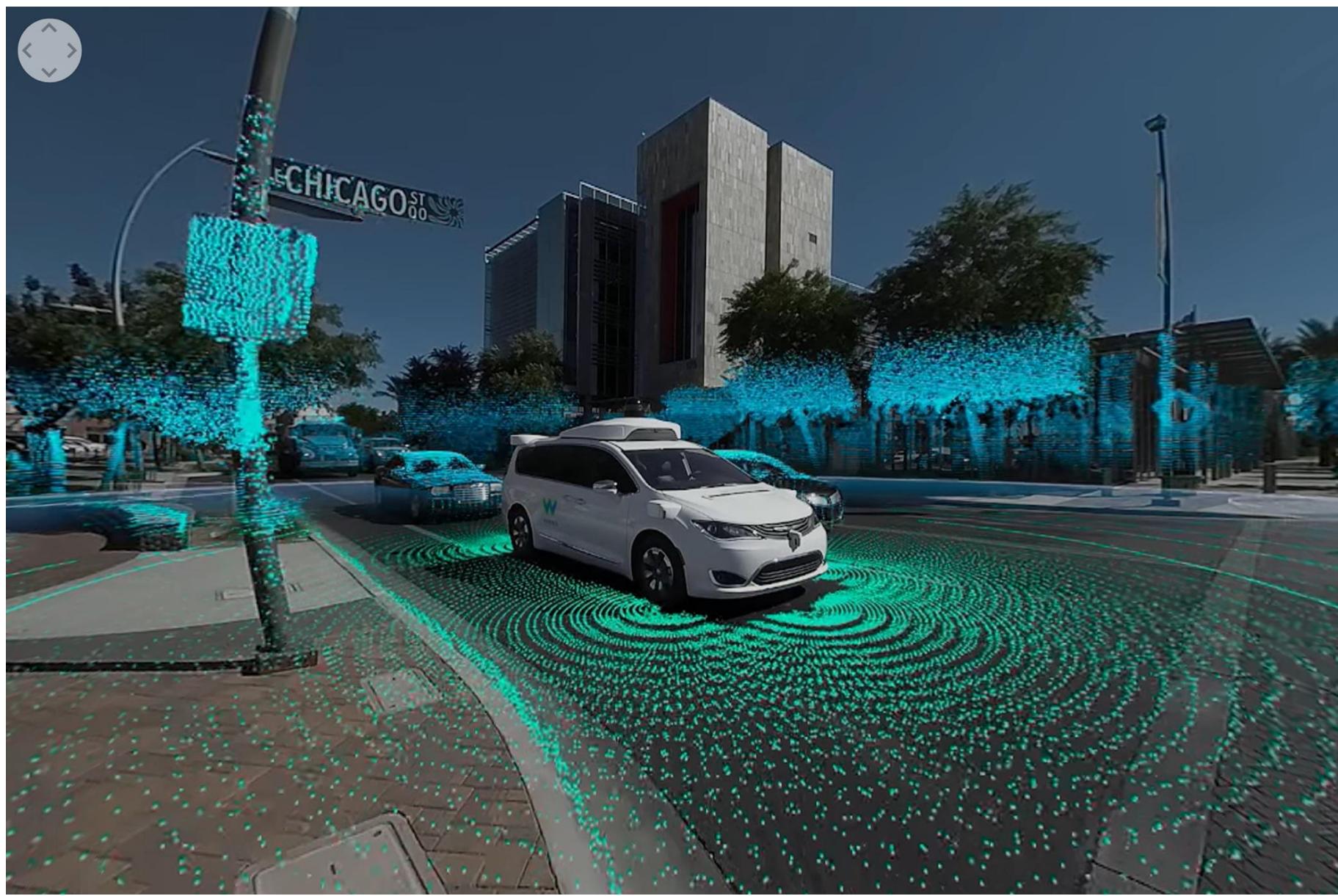


How the Artificial Intelligence Program AlphaZero Mastered
Its Games | The New Yorker

[Visit](#)

Applications of Probabilistic Approach

The model observes millions of labeled data provided by human and learns the correlation within them, and then is able to predict new cases.

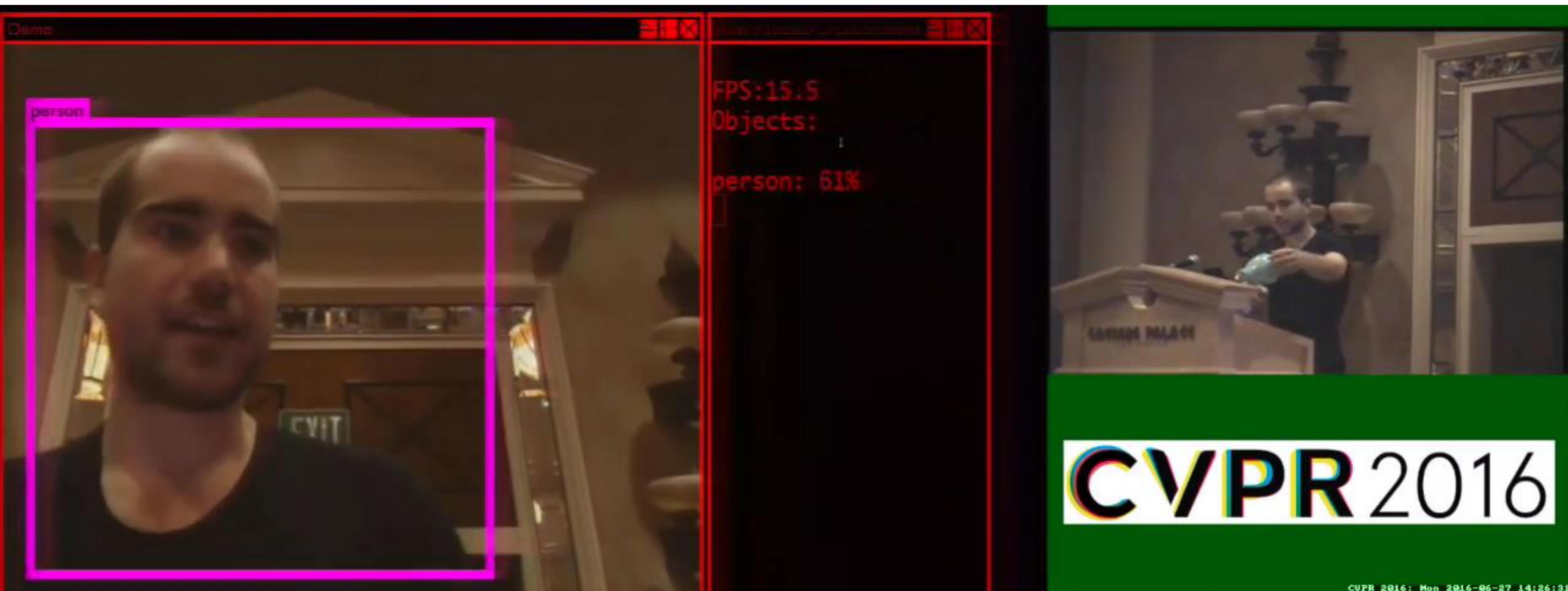


Self-Driving Car

Equipped with multiple sensors, the self-driving car can “see” its surroundings, just like Alpha Go can “see” the go board.



By observing how humans drive for millions of times, the self-driving car learns the correlation between the environment it sees and the actions it should take.



<https://www.youtube.com/watch?v=NM6lrxy0bxs>



<https://www.youtube.com/watch?v=ZJMtDRbqH40>

Hugging Face

Models Datasets Spaces Docs Solutions Pricing Log In Sign Up

Spaces: openai/point-e like 327 Running on A10G

App Files and versions Community 17

Point-E demo: text to 3D

Generated 3D Point Clouds with [Point-E](#). This demo uses a small, worse quality text-to-3D model to produce 3D point clouds directly from text descriptions. Check out the [notebook](#).

prompt

tropical tree

Clear Submit

output



A 3D point cloud visualization of a tropical tree, generated by the Point-E model from the input text "tropical tree". The tree has a dense canopy of green points and a trunk made of brown points.

DALL·E History Collections ... K

Edit the detailed description

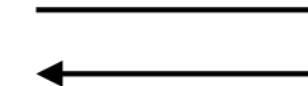
an image of a wooden modern building in the alps

Surprise me Upload → Recent Clear

Generate

The screenshot shows the DALL-E interface. At the top, there's a navigation bar with icons for user profile, DALL·E, History, Collections, and a user 'K'. Below the navigation is a text input field containing the prompt: 'an image of a wooden modern building in the alps'. To the right of the input are three buttons: 'Surprise me', 'Upload' with an arrow icon, and a large 'Generate' button. Below the input field are four generated images of a wooden modern building with a steep roof and large windows, set against a backdrop of mountains. To the right of the generated images is a vertical sidebar titled 'Recent' which displays a grid of thumbnail images related to architecture and buildings.

Turing, Alan (1950). "Computing Machinery and Intelligence," Mind, 59, 434-460 (reprinted in Feigenbaum and Feldman, 1963, and in Anderson, 1964).

Question  **Answer**

"The question and answer method seems to be suitable for introducing almost any one of the fields of human endeavor that we wish to include"

Oracle

Let us suppose we are supplied with some unspecied means of solving number-theoretic problems; a kind of oracle as it were.

. . . this oracle . . . cannot be a machine.

With the help of the oracle we could form a new kind of machine (call them o-machines), having as one of its fundamental processes that of solving a given number-theoretic problem."

Alan Turing

The jointing of Intelligent Human and Machine Intelligence

What is role of Artificial Intelligence in design and the built environment?

Would it take over?
Would it make our job much more interesting?
How?