

Introduction

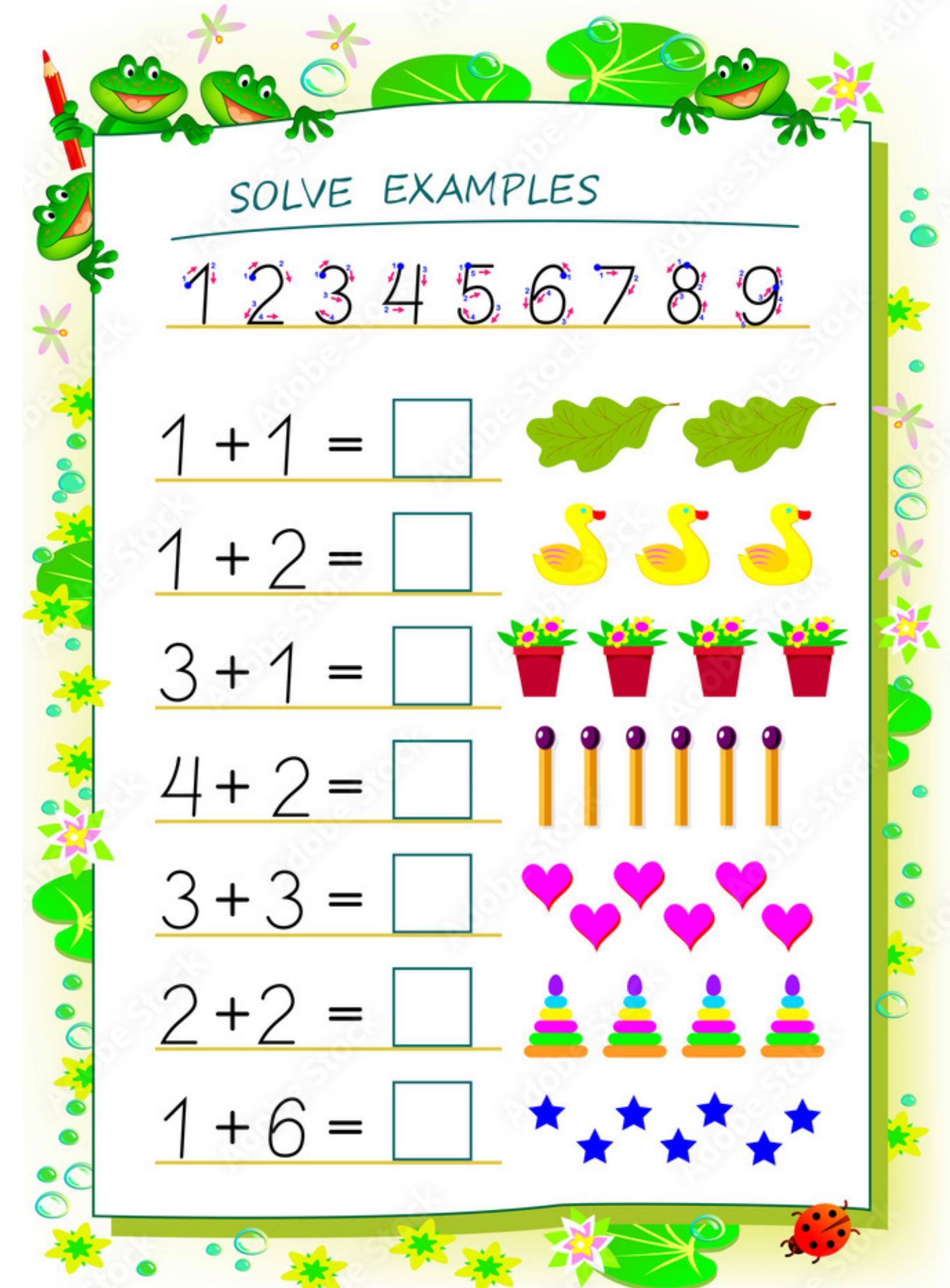
EECE454 Intro. to Machine Learning Systems

Fall 2024

What is machine learning?

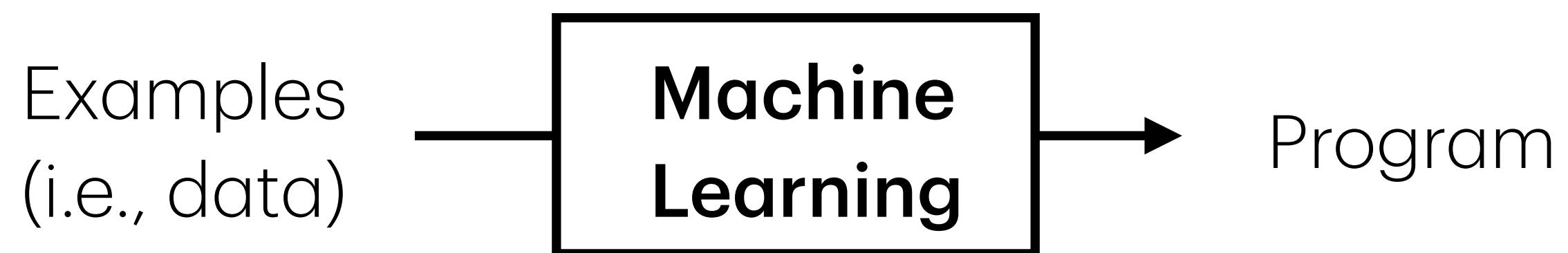
Human Learning

- How do human learn?
 - Given some **examples**, human can **find a pattern**.



Human Learning

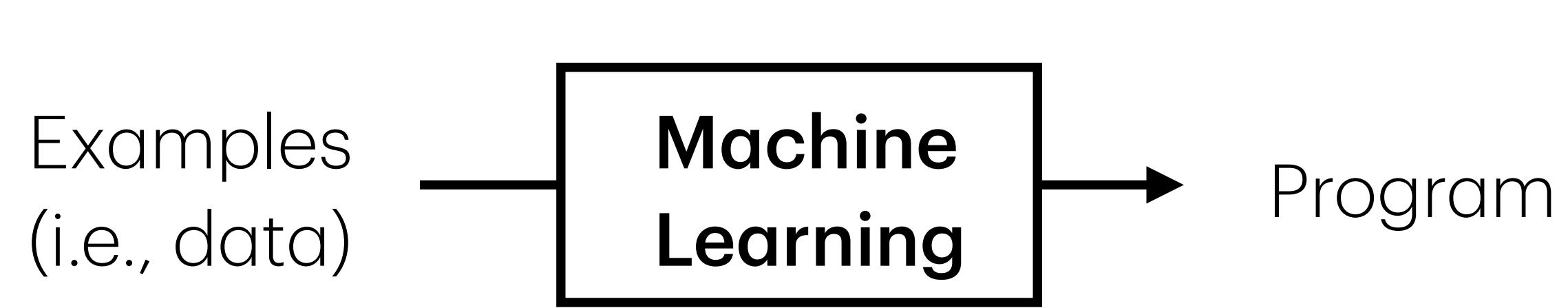
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- **Machine Learning.** Given some examples, a machine automatically:
 - discovers some pattern from the examples
 - builds some program that utilizes such discovered pattern.



Human Learning

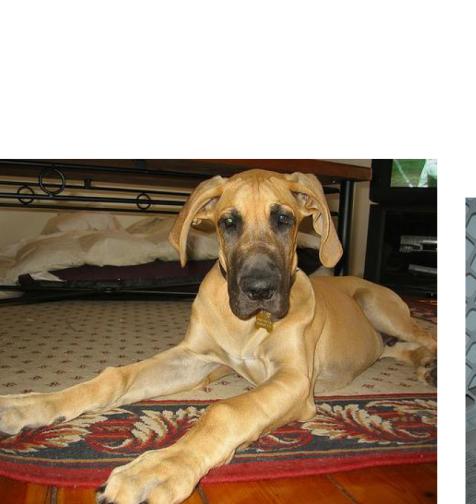
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What do we mean?



Example tasks

- Create a program that, given **an image of a dog**, returns the **name of the dog specie**
 - Human will need a lot of (image, species) pairs



(a)
(b)|
(c)



Example tasks

- Create a program that, given **a Netflix user** and **a movie**, returns the **expected user rating**
 - Human will need a lot of (user, movie, rating) triplets



Disney·PIXAR
INSIDE OUT 2



Example tasks

- Create a program that, given **a text input**, returns a **human-like response** (or better)
 - What data do we need?

The screenshot shows a dark-themed chat interface. On the left, a red button labeled 'M' contains the text 'Tell me how ChatGPT works.' On the right, a green icon representing the AI model is followed by a detailed response: 'ChatGPT is a large language model that uses deep learning techniques to generate human-like text. It is based on the GPT (Generative Pre-trained Transformer) architecture, which uses a transformer neural network to process and generate text. The model is pre-trained on a massive dataset of text, such as books, articles, and websites, so it can understand the patterns and structure of natural language. When given a prompt or a starting point, the model uses this pre-trained knowledge to generate text that continues the given input in a coherent and natural way.' Below the response are two small icons: a thumbs up and a thumbs down.

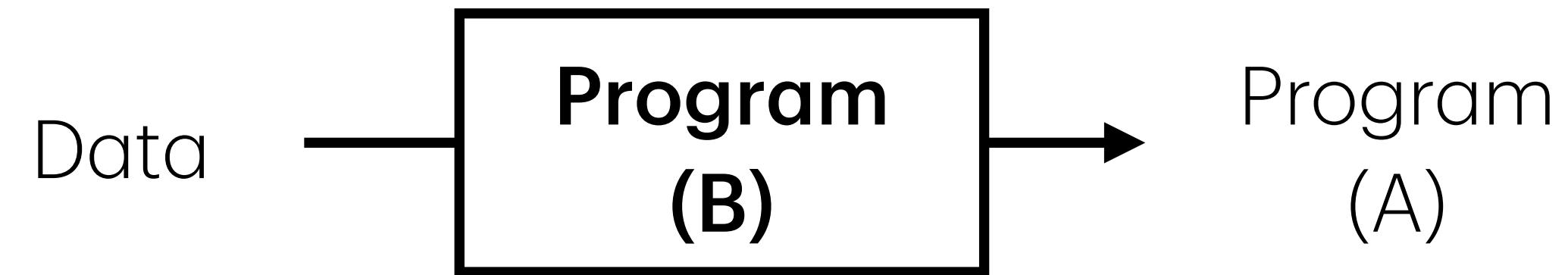
M Tell me how ChatGPT works.

 ChatGPT is a large language model that uses deep learning techniques to generate human-like text. It is based on the GPT (Generative Pre-trained Transformer) architecture, which uses a transformer neural network to process and generate text. The model is pre-trained on a massive dataset of text, such as books, articles, and websites, so it can understand the patterns and structure of natural language. When given a prompt or a starting point, the model uses this pre-trained knowledge to generate text that continues the given input in a coherent and natural way. thumb up thumb down

Terminologies

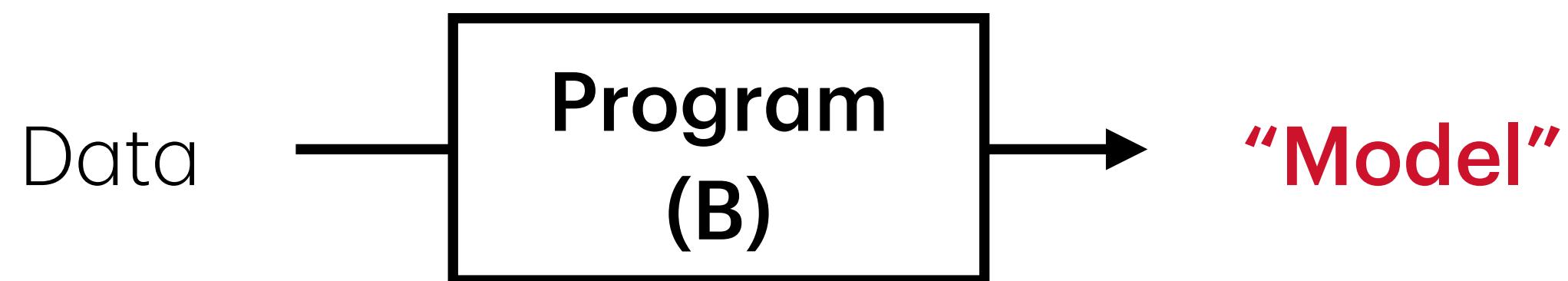
Terminologies

- Notice that there are **two programs in action**
 - (A) The program that utilizes the pattern
 - (B) The program that discovers patterns from data to build (A)



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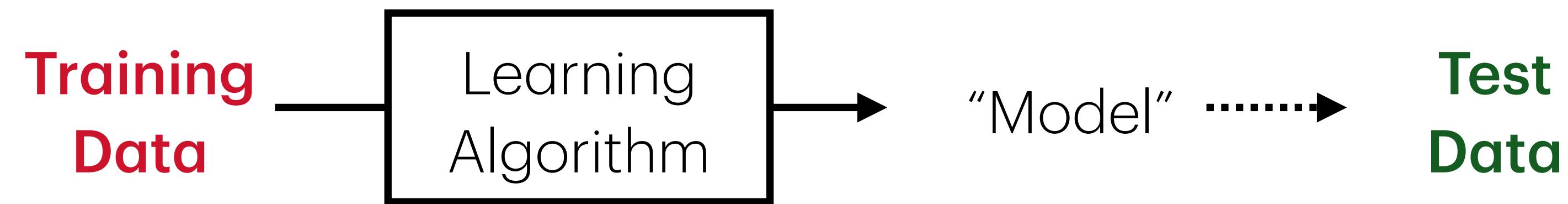
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- The program (A) is called **“model”** (or “predictor” or “hypothesis”) and what (A) does is called **“prediction”** (or “inference”)
- The program (B) is called **“learning algorithm”** and what (B) does is called **“training”**

Terminologies

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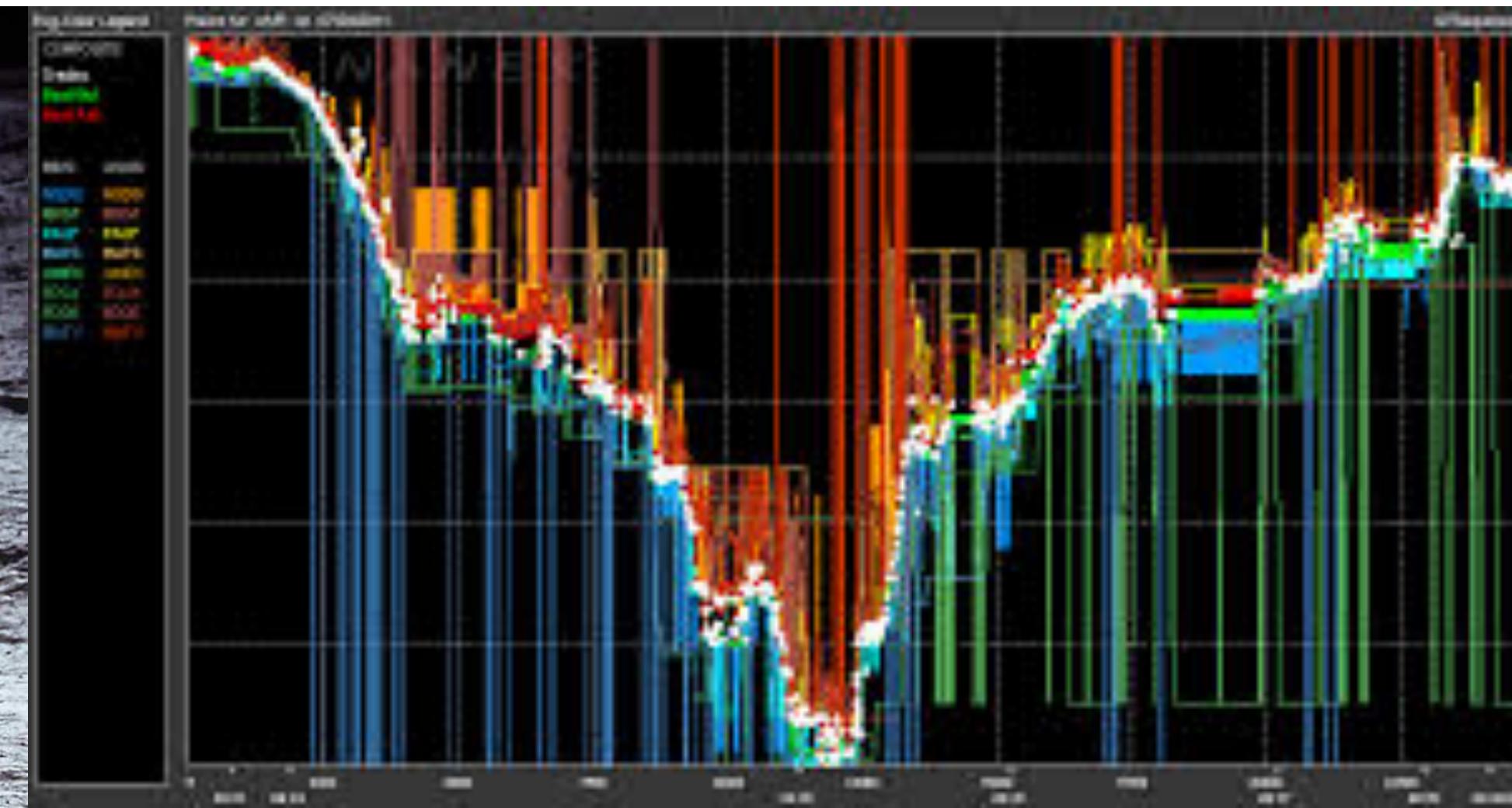
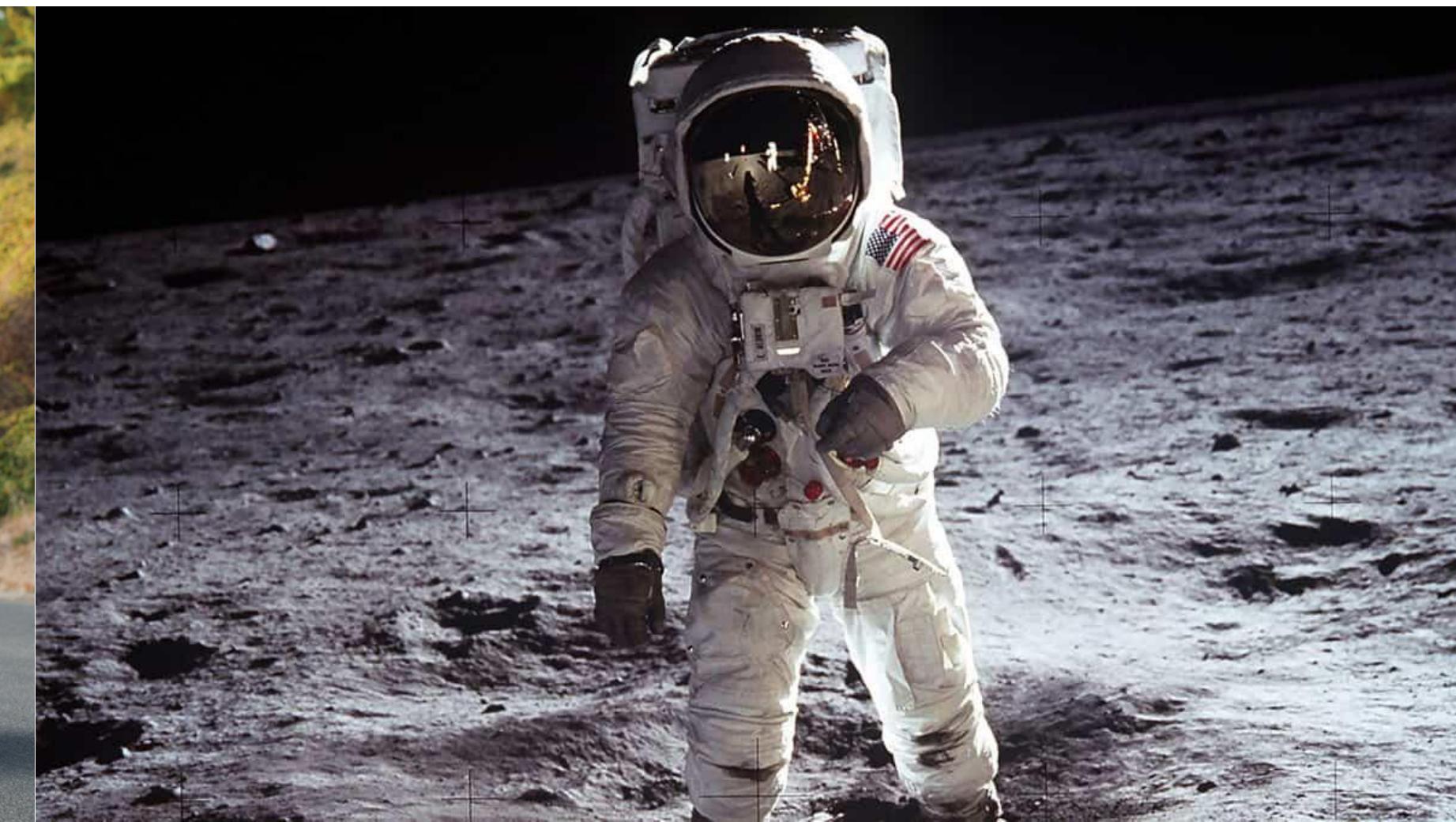
- The learning algorithm sees the **training data**, whereas the model will be used on a new, incoming data, called the **test data**.

(otherwise, we call it “data mining”)

Why “machine” learning?

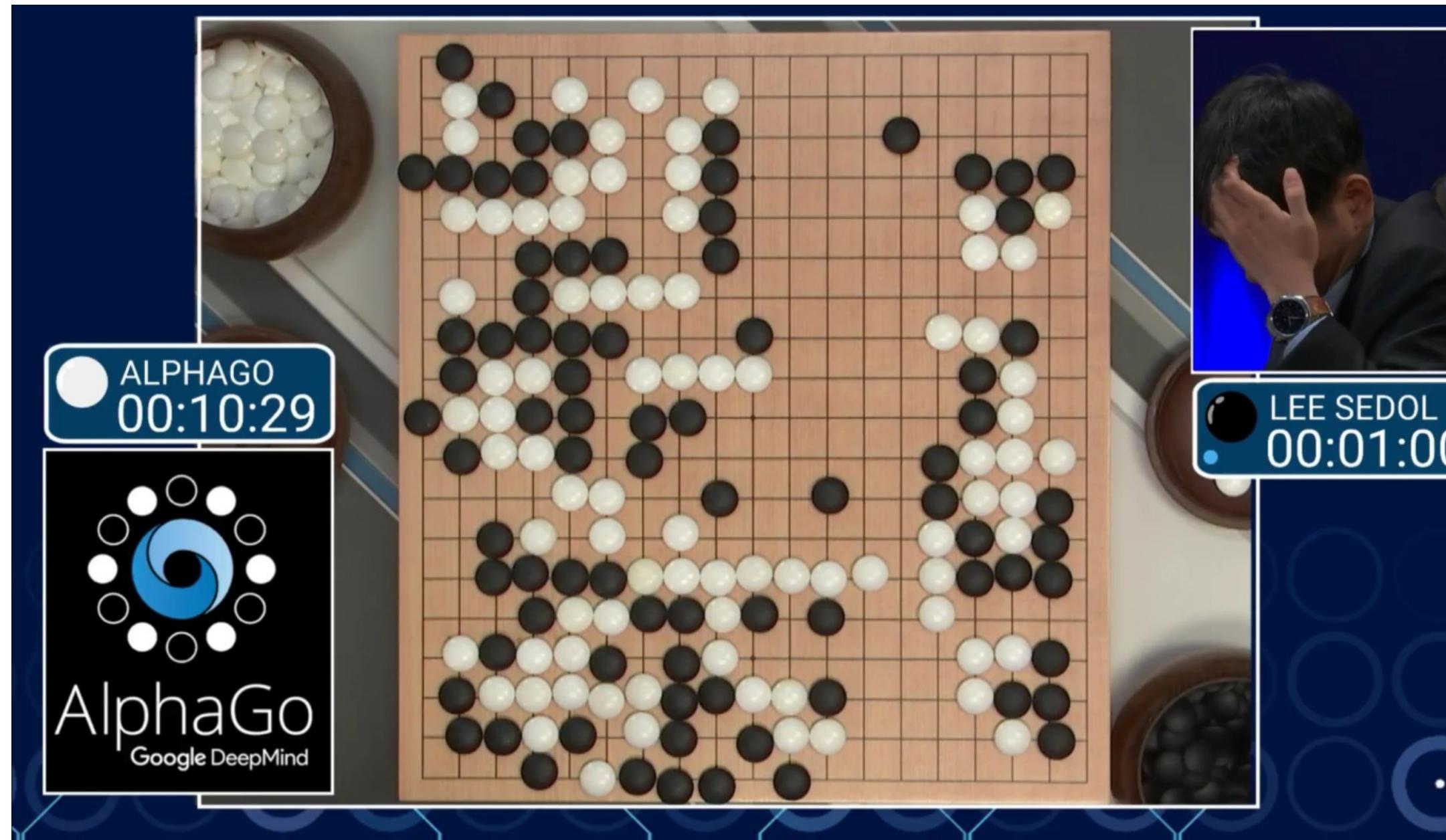
Why machines?

- We want machines to **use the patterns (prediction)**, because...
 - Human attention is limited (e.g., self-driving cars)
 - Human are vulnerable (e.g., space mission)
 - Human are slow (e.g., high-frequency trading)
 - Human are expensive (e.g., chatbots)



Why machines?

- We want machines to **find the patterns (training)**, because...
 - Human are dumb (e.g., AlphaGo)
 - Dataset is too big to handle (e.g., machine translation)
 - Difficult to write a code that uses human knowledge (e.g., dog classification)



What do “we” do for ML?

So what does human do?

- **ML algorithm researchers** develops the learning algorithm that
 - can train a model that solves a new task
 - requires very small computational cost
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 - inspire new algorithms

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 - requires very small computational cost
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 - give performance guarantees on ML algorithms and models
 - inspire new algorithms
- **ML system researchers** develop efficient systems for running ML algorithms and models

How do ML algorithms work?

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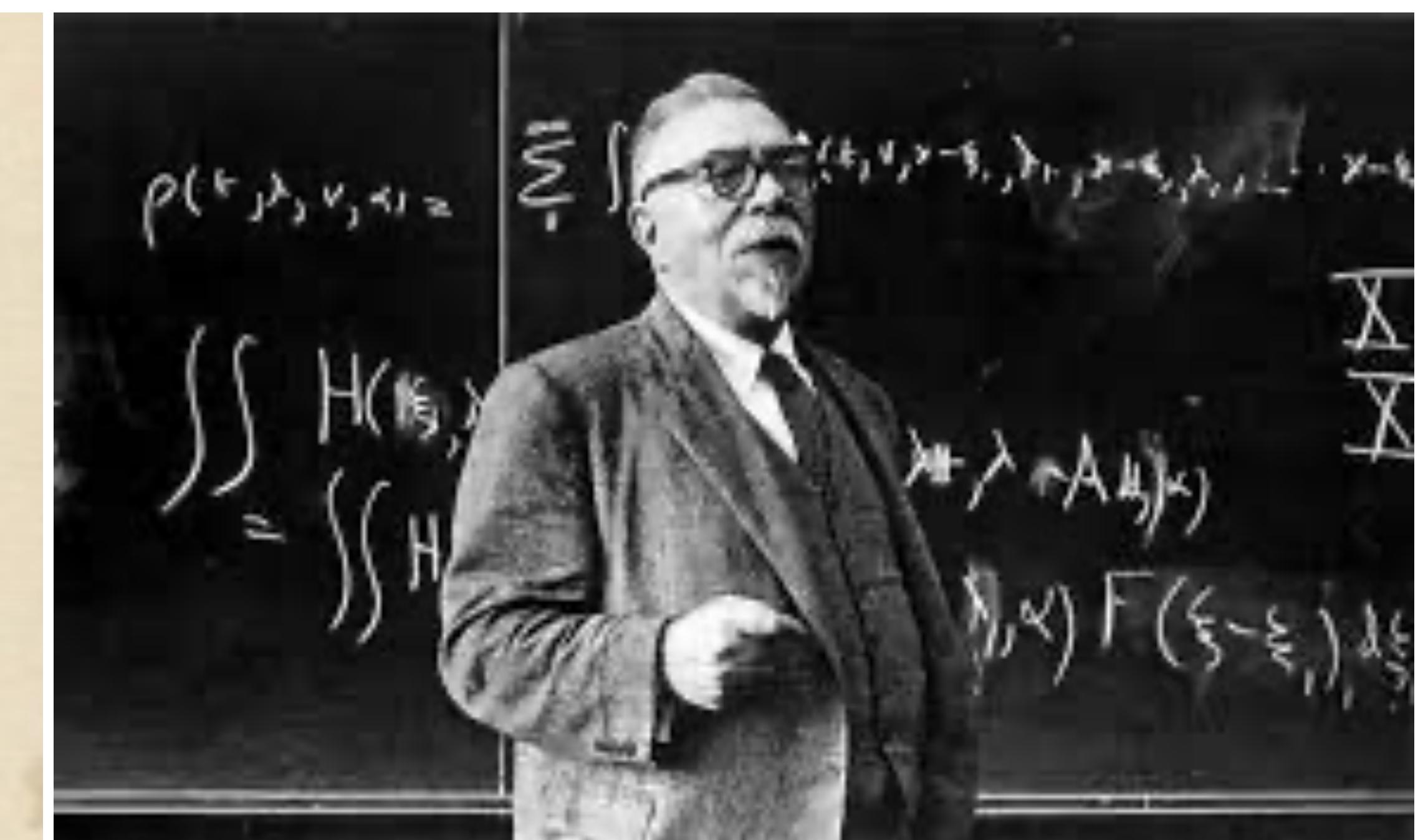
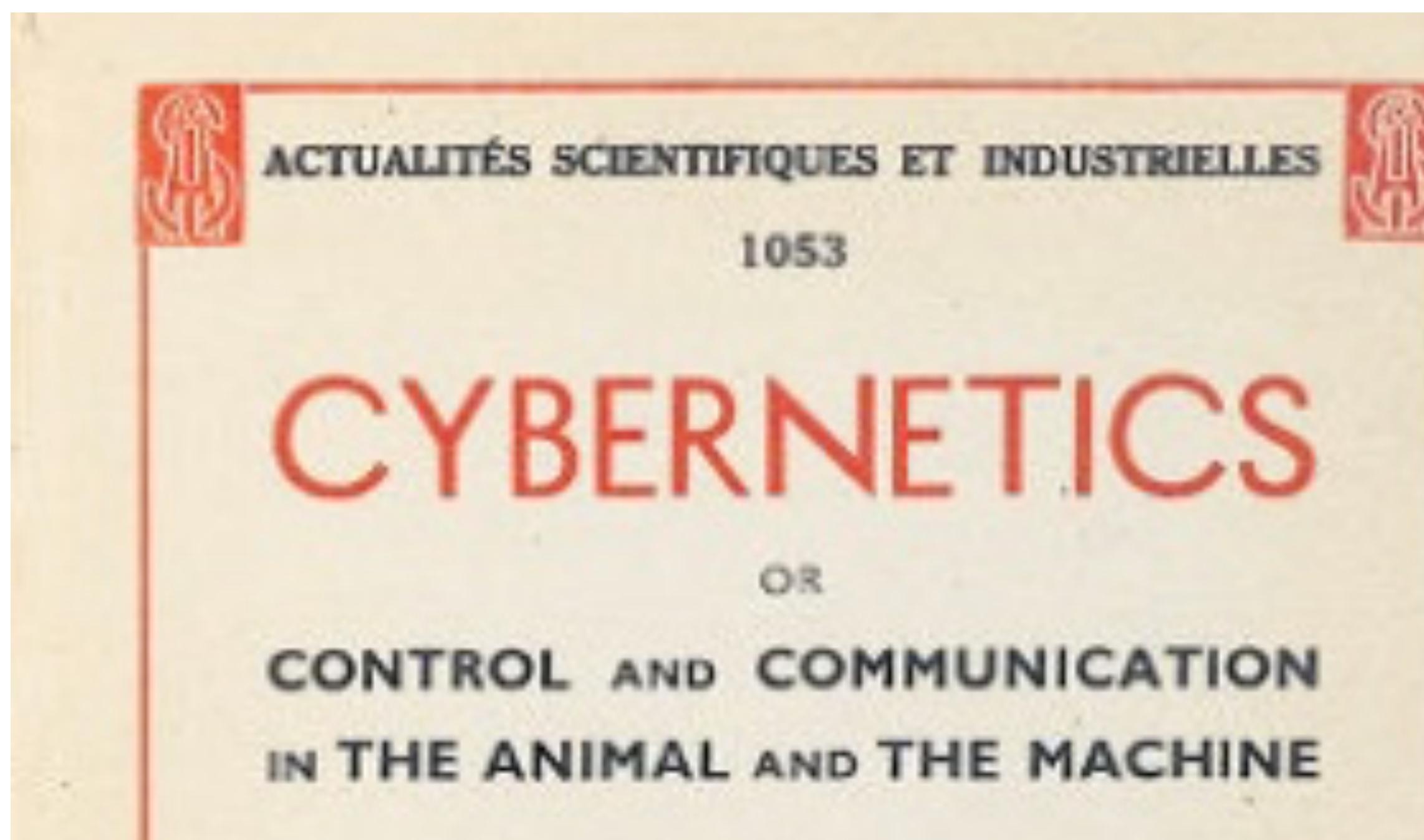
- Very difficult to give a simple answer
 - There are so many ML algorithms
 - They all work quite differently from each other
 - Some work well for this, some work well for that

How do ML algorithms work?

- Very difficult to give a simple answer
 - There are so many ML algorithms
 - They all work quite differently from each other
 - Some work well for this, some work well for that
- **Today.** Very briefly discuss two **unifying perspectives**.
 - “Cybernetics” paradigm
 - “Statistical Learning” paradigm
- There are competing paradigms, of course, e.g., Bayesian ML.

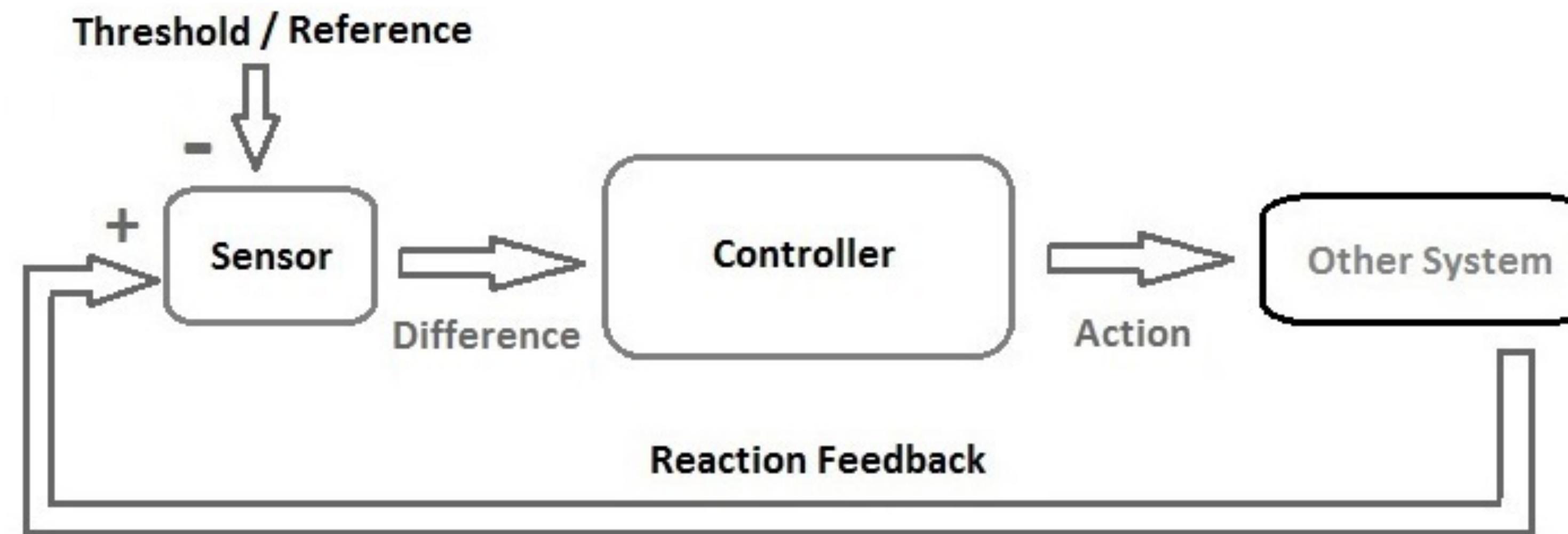
Cybernetics (1947)

- **Cybernetics.** The origin of “artificial intelligence”
 - Coined by a control theorist Norbert Wiener



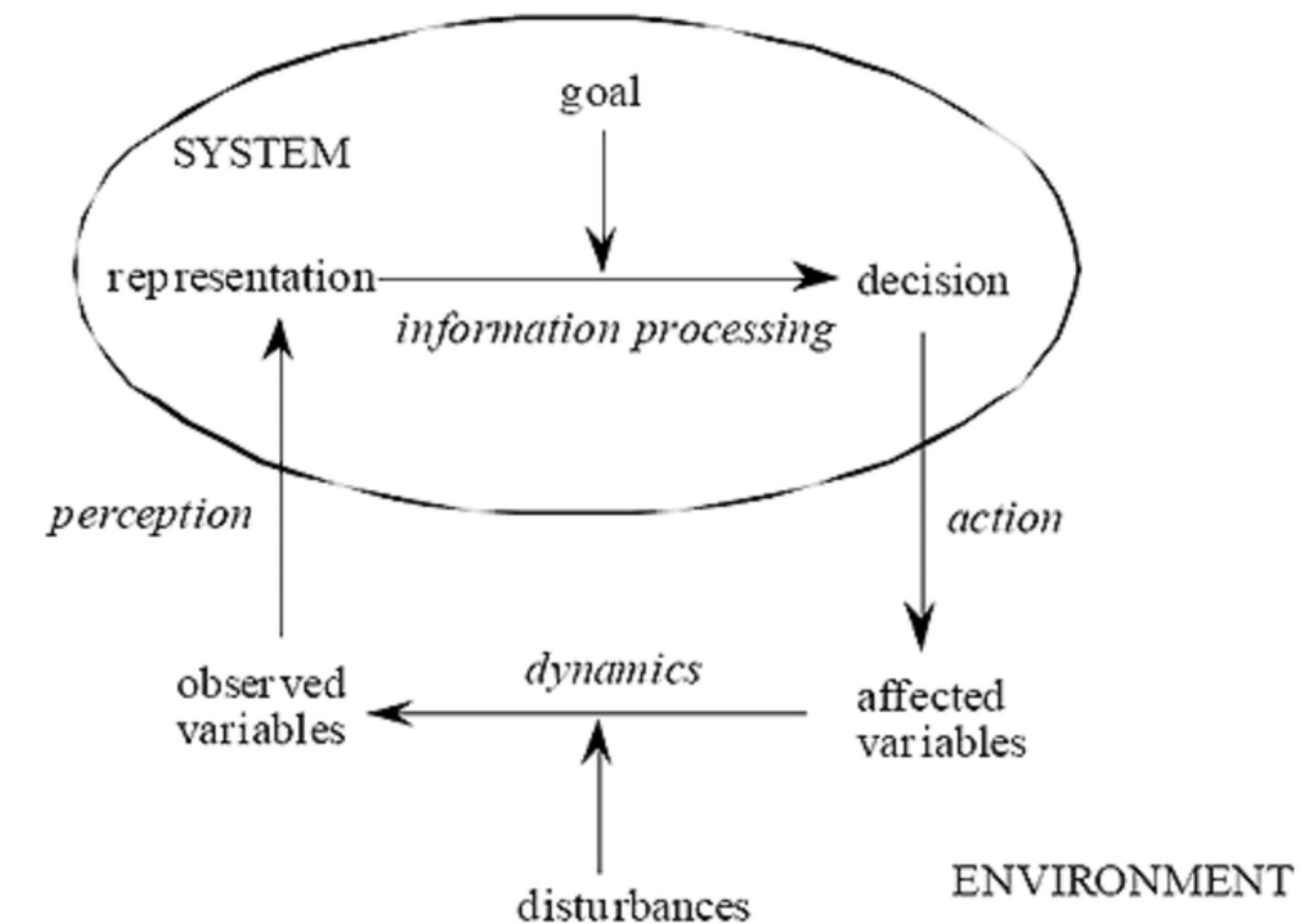
Cybernetics (1947)

- **Cybernetics.** The origin of “artificial intelligence”
 - Coined by a control theorist Norbert Wiener
- Wiener viewed intelligence as a **“circular causal process, via feedback loop”**
 - thus called “κυβερνήτης” (steering)
 - proposed a holistic study of communication, control, and feedback mechanisms.



Cybernetics (1947)

- Cybernetics provided all core concepts.
 - We have some **model** with **changeable internal states** (i.e., model parameters)
 - We find the **right internal state** (i.e., optimize) by repeating
 - Test the current program on training data
 - Get the feedback
 - Modify the state accordingly
 - Exactly what modern ML or RL does!



Statistical Learning (1968)

- **Statistical Learning.** Followed the cybernetics rush in Soviet union (Lyapunov, Kolmogorov, ...)
 - Core ideas developed by Vladimir Vapnik and Alexey Chervonenkis

NEWS

Prestigious AI Series Wraps up with Lecture by the Father of Machine Learning

POSTED:
MAY 14, 2018



Vladimir Vapnik, a professor at Columbia University's Center for Computational Learning System and Professor Anna Choromanska

Statistical Learning (1968)

- Statistical Learning. Followed the cybernetics rush in Soviet union (Lyapunov, Kolmogorov, ...)
 - Core ideas developed by Vladimir Vapnik and Alexey Chervonenkis
- An ML algorithm is defined by:
 - a **hypothesis space** (i.e., a bag of models)
 - a **loss function**
 - measures how bad a model is, when evaluated on a single example
 - a **search algorithm** to find the minimum loss model in this space
 - can be done by optimizing the internal parameters (can be NP-hard!)



What does this course do?

This course teaches ...

- This course consists of two parts:
 - Part 1. Introduce classic ML frameworks
 - Part 2. Familiarize you with basics of deep learning (+ hands-on experience)

This course teaches ...

- This course consists of two parts:
 - Part 1. Introduce classic ML frameworks
 - Part 2. Familiarize you with basics of deep learning (+ hands-on experience)
- **Why learn classic frameworks?**
 - Outperforms DL in many tasks (e.g., tabular, time-series)
 - Have inspired or directly employed in many DL algorithms (e.g., VQ-VAE)
 - Neat to analyze; gives you strong understanding and intuition.

This course teaches ...

- By the end of this course, I expect you to
 - be able to apply existing ML algorithms on real-world tasks
 - design your own ML frameworks and algorithms
 - conduct basic analysis on your algorithm and model

Administrivia

Team

- **Instructor.** Jaeho Lee 이재호
 - Assistant Professor @ POSTECH EE (2022.03 ~)
Research Scientist @ Google (2023.09 ~)
 - jaeho.lee@postech.ac.kr
 - Responsible for: Coursework-related, Anything else.
- **TA.** Minjae Park 박민재
 - Ph.D. track @ POSTECH EE (2024.03 ~)
 - mjae.park@postech.ac.kr
 - Responsible for: Assignments, Grading, Attendance

Location & Hours

- **Class.** Engineering Building #3, Classroom 115
 - 9:30AM – 11:00AM
- **Office hours.** Engineering Building #2, Office 323
 - 04:00PM – 05:00PM (+ by appointment)
- **Web.** <https://jaeho-lee.github.io> ← for lecture notes
PLMS ← for assignment submissions

Grading

- Attendance: 10%
- Assignments: 30%
- Mid-Term: 30%
- Final Project: 30%
 - Graduate students will be graded separately
 - QE sit-ins will be judged based on how UGs do.

Prerequisites

- Not 100% required, but I assume you know:

- Calculus
- Basic linear algebra
- Basic probability & statistics
- Signals & Systems
- Programming & Python

Textbook

- **Main**

- “Mathematics for Machine Learning” by Deisenroth, Faisal, and Ong
 - <https://mml-book.github.io>
- “Understanding Deep Learning” by Simon Prince
 - <https://udlbook.github.io/udlbook/>

Textbook

- **Further Readings**

- “Patterns, Predictions, and Actions” by Hardt and Recht
 - <https://mlstory.org>
- “Dive into Deep Learning” by Zhang, Lipton, Li, and Smola
 - <https://d2l.ai>
 - Very recommended for programming exercises

Honor Codes

- **Simple principle: Cheating = F**
 - Sharing solutions —> not okay
 - Copying solutions —> not okay
 - Discussion —> do this with me or TA?
 - ChatGPT —> please don't

Coming next

- We do some recap:
 - Linear Algebra
 - Probability and Optimization

Cheers