ELTE | FACULTY OF INFORMATICS

# Introduction to Machine Learning

Computer Science BSc

Compulsory Electible Course

ELTE, Faculty of Informatics

ELTE | IK

DEPARTMENT OF ARTIFICIAL INTELLIGENCE

# Logistics

# Classes

- Wednesday, 16:00-16:45 (**45 mins!**)
- North Building, Lecture Hall, -1.75

# Lecturers

**János Botzheim**
**Research interests:**
Computational Intelligence;
Cognitive Robotics;
**e-mail:** botzheim@inf.elte.hu
**Room:** 7.91B (north building)

**László Gulyás**
Associate professor
**Research interests:**
distributed AI; multi - agent systems; agent - based modelling; evolution;
**e-mail:** lgulyas@inf.elte.hu
**Room:** 7.96 (north building)

**Balázs Nagy**
Assistant professor
**Research interests:**
Ethorobotics, Deep Learning, Sensor fusion, Mechatronics
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**Room:** 7.100 (north building)

Email contacts:

- Any of us
- **Only with subjects starting with [Intro2ML]**

# Requirements

## Assignments

- 1 End-of-Semester Test
  - **Compulsory**
  - Written
  - In person
  - 100 points
- 2 **optional** homework projects
  - Applying existing AI tools
  - Documenting it
  - 10 points each

## Grading

| Points | Grade |
|---|---|
| 0-39 | 1 |
| 40-54 | 2 |
| 55-69 | 3 |
| 70-84 | 4 |
| 85-120 | 5 |

# Course Plan

1. Intro and Brief History (*Gulyás*)
2. AI as Optimisation (*Gulyás*)
3. ChatGPT & Ethics (*Nagy*)
4. Supervised Learning (*Botzheim*)
5. Unsupervised Learning (*Botzheim*)
6. Reinforcement Learning (*Nagy*)
7. Evolutionary Algorithms (*Botzheim*)
8. Bioinspired Collective Algorithms (*Gulyás*)
9. Swarm Intelligence (*Botzheim*)
10. Neural Networks (*Botzheim*)
11. Ethorobotics (*Nagy*)
12. Multi-Agent Simulations & Learning (*Gulyás*)
13. Applications (*Nagy*)

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# Brief History of AI

**Introduction to Machine Learning**
Computer Science BSc Course, ELTE Faculty of Informatics

László Gulyás

Associate Professor
Department of Artificial Intelligence
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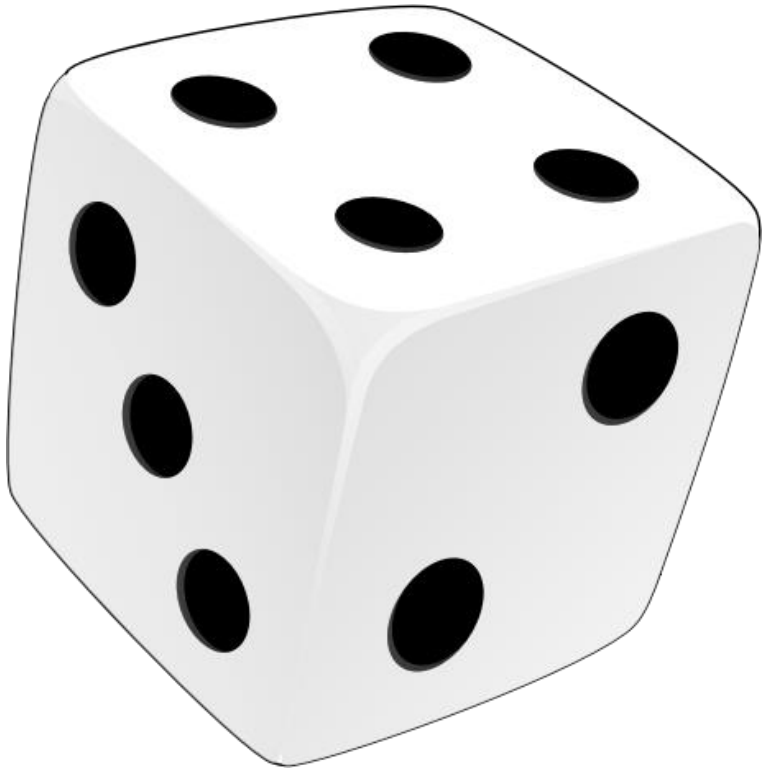
# AI = Machine Learning?

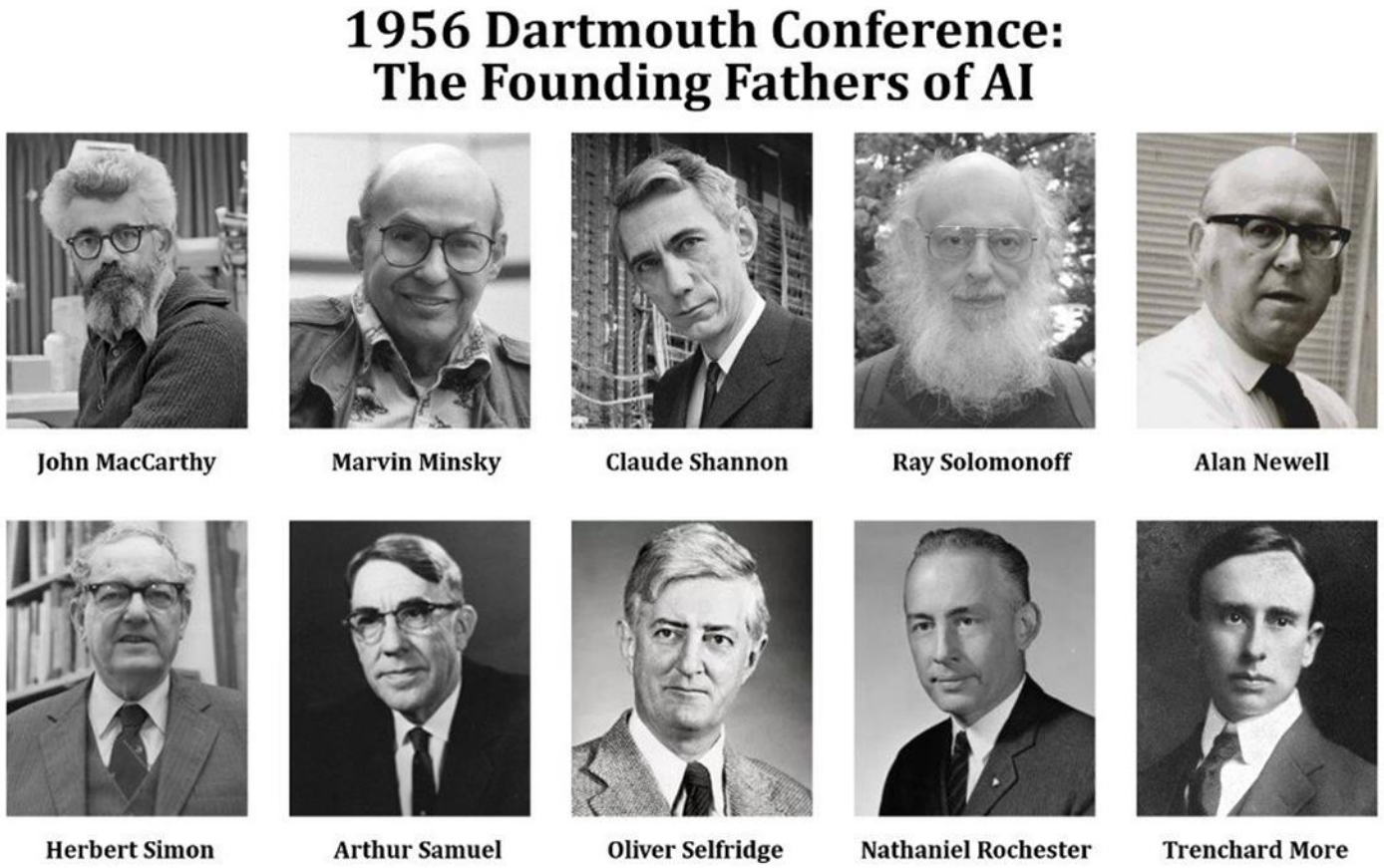
- Machine Learning originates in Artificial Intelligence
  - But AI has many other tools and methods
- Current AI is dominated by (deep) machine learning
- Machine Learning is used outside of AI proper as well
  - Data Science
  - Autonomous Systems
  - Etc.

# What is AI?

# Since when?

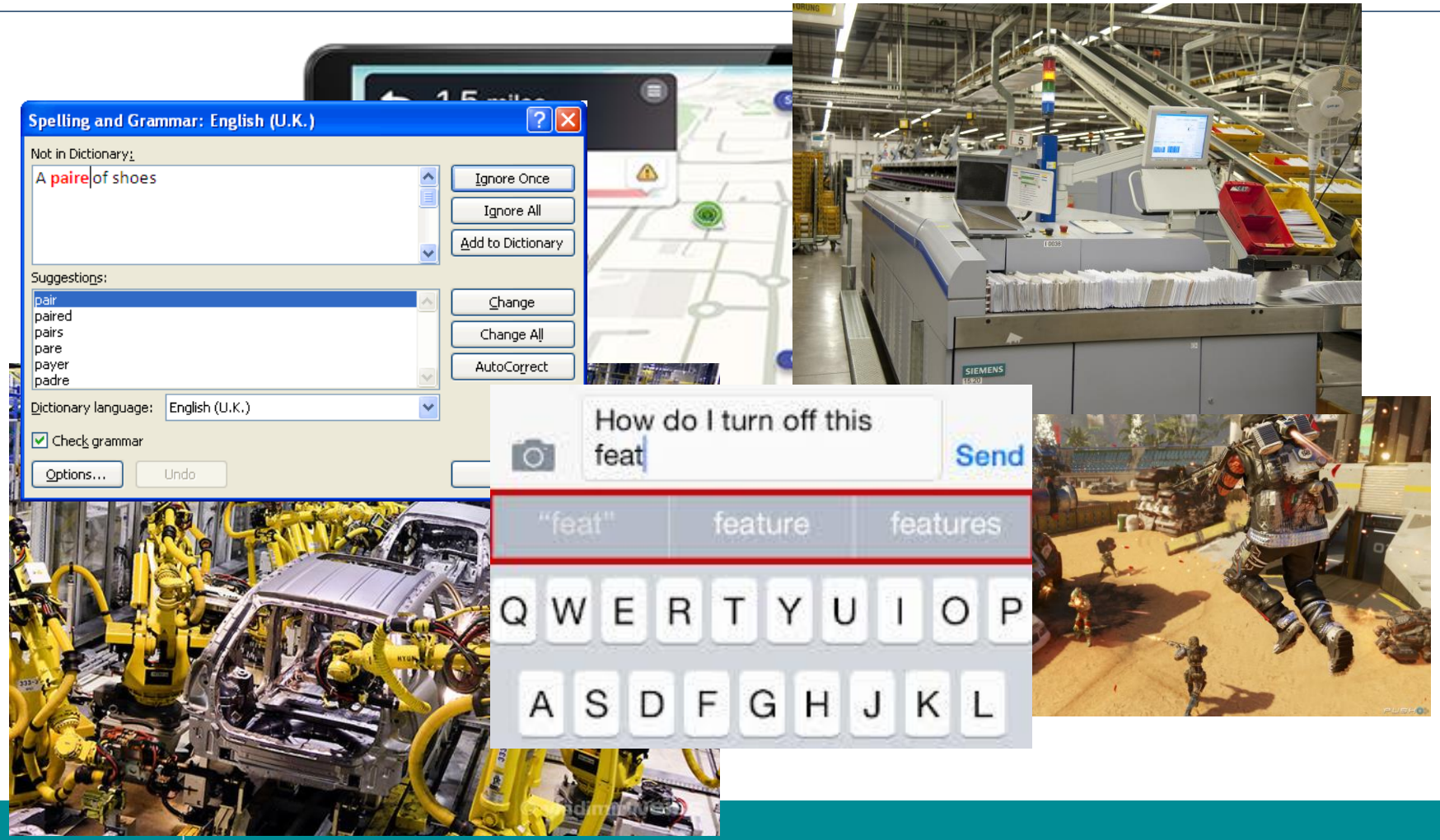


# The Founding Fathers



# Old Research Programme
## Any Success before 2000?

# ‚Old' Results of AI



# So, what is AI after all?

# A Moving Target

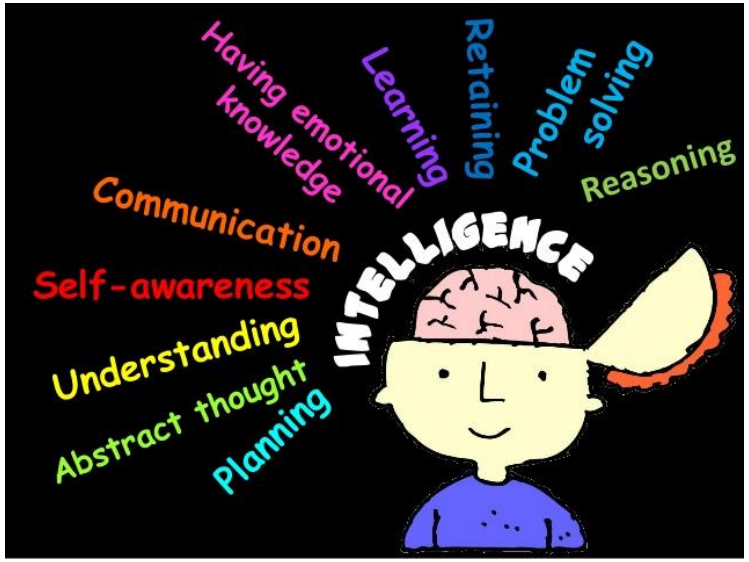
# What is Intelligence, BTW?

- Difficulty of defining
  - We only have a single example – humans
  - Cf. Animal cognition

# What is the *goal* of AI?

One could think of many possibilities:

- Problem solving?
- Helping humans?
- Creation of a synthetic brain?
- Creation of synthetic mind/cognition?
- Creation of a (artificial) human?



# Digitalisation ~ Mechanisation (21th Century)

**Machines + Digitalisation = „AI”**

# AI is not a miracle

- It is a machine
  - Created by humans – to be *better at something* (than humans)
  - Better as in faster, cheaper, more precise, etc.
  - Cf. Sewing machine

# Digitalisation ~ Mechanisation (21th Century)

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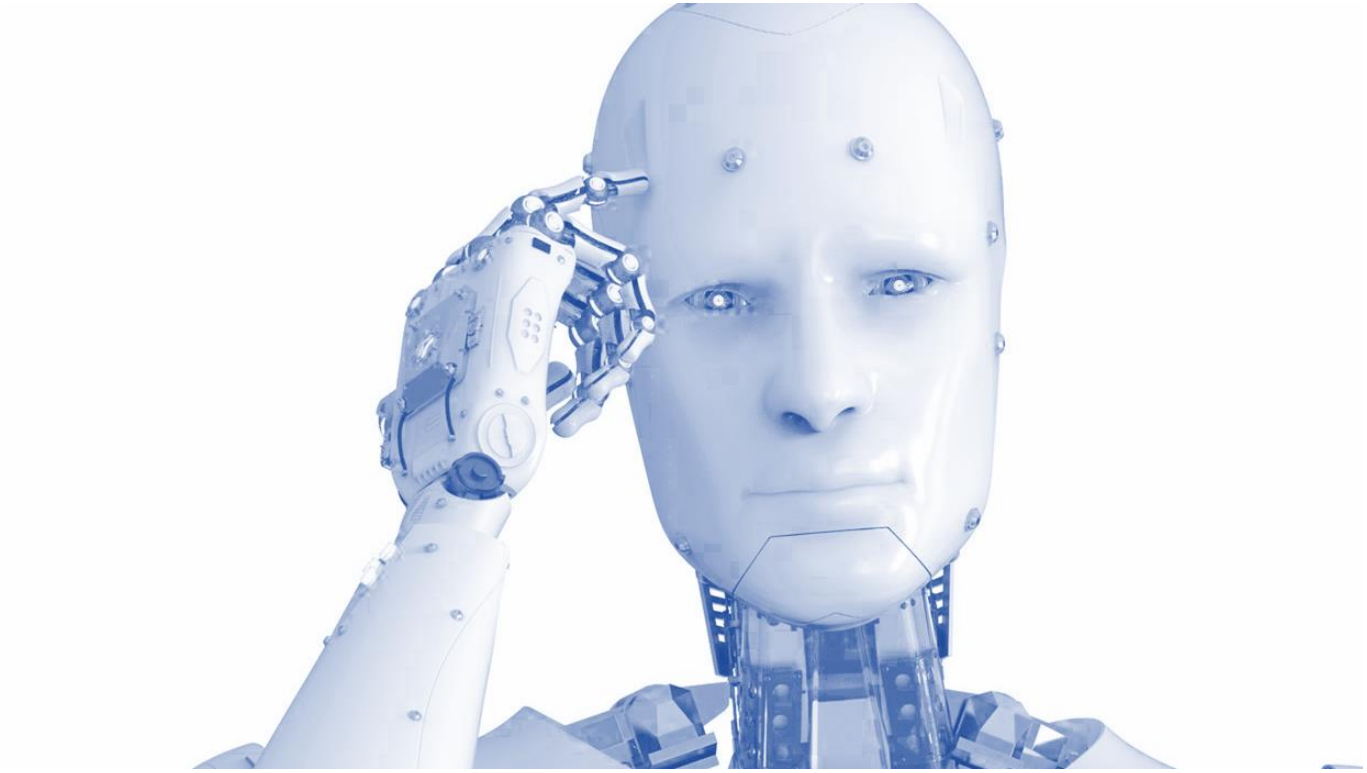

# Digitalisation ~ Mechanisation (21th Century)

## Machines + Digitalisation = „AI”

# What is AI? – A Kind of Conclusion

AI is tomorrow's computing

Today's computing is yesterday's AI

- In our phones,
- In the cloud,
- In IoT networks, etc.

# Important Distinctions

- Narrow AI
  - Can match (or surpass) human performance
  - In a given (narrow) domain
    - At a specific task
- Artificial General Intelligence (AGI)
  - Can (learn to) match (or surpass) human performance
  - In *any* intellectual task that humans (or animals) can perfoms

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- Other (theoretical) concepts
  - Syngularity
    - Runaway, i.e., uncontrollable technology
  - Superintelligence
    - Qualitatively surpasses human intelligence
    - Humans cannot even understand it
  - Conscious machines
    - What is cognition?
    - Theory of mind

# Tests for AGI, Pt 1

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

- **Turing Test** (Turing)
  - A machine and a human both converse unseen with a second human
  - The second human must evaluate which of the two is the machine
  - The test is passed if the evaluator is fooled a significant fraction of the time
  - **Note:**
    - Turing does not prescribe what should qualify as intelligence, only that knowing that it is a machine should disqualify it.
  - The AI Eugene Goostman achieved Turing's estimate of convincing 30% of judges that it was human in 2014
- **Robot College Student Test** (Goertzel)
  - A machine enrolls in a university, taking and passing the same classes that humans would, and obtaining a degree
  - Some LLMs can now pass university degree-level exams without even attending the classes
- **Employment Test** (Nilsson)
  - A machine performs an economically important job at least as well as humans in the same job
  - AIs are now replacing humans in many roles as varied as fast food, and marketing
  - Is this narrow AI?

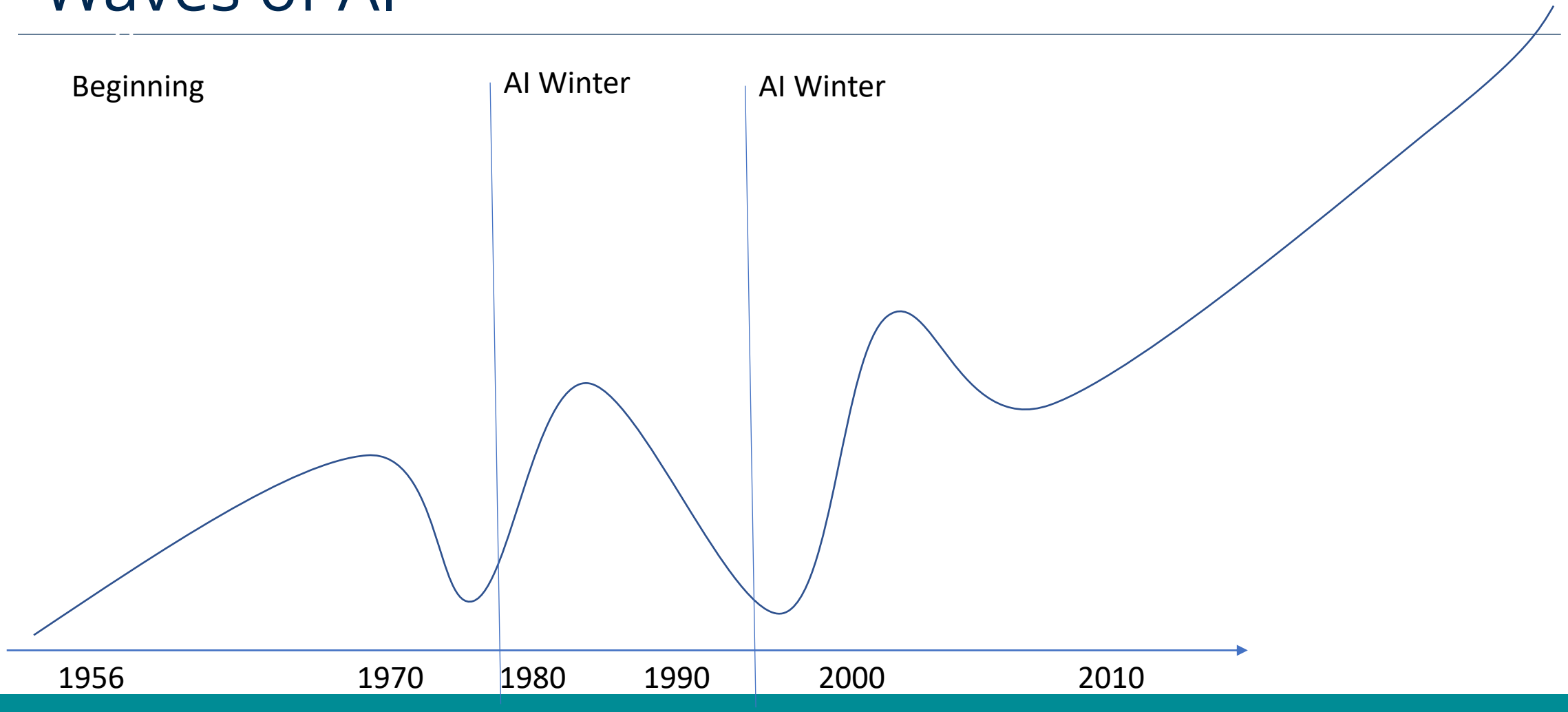
# Tests for AGI, Pt 2

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

- **Ikea Test** (Marcus)
  - Also known as the Flat Pack Furniture Test
  - An AI views the parts and instructions of an Ikea flat-pack product, then controls a robot to assemble the furniture correctly
- **Coffee Test** (Wozniak)
  - A machine enters an average home and figures out how to make coffee:
    - Finds the coffee machine,
    - Finds the coffee,
    - Adds water,
    - Finds a mug, and
    - Brews the coffee by pushing the proper buttons
  - This has not yet been completed

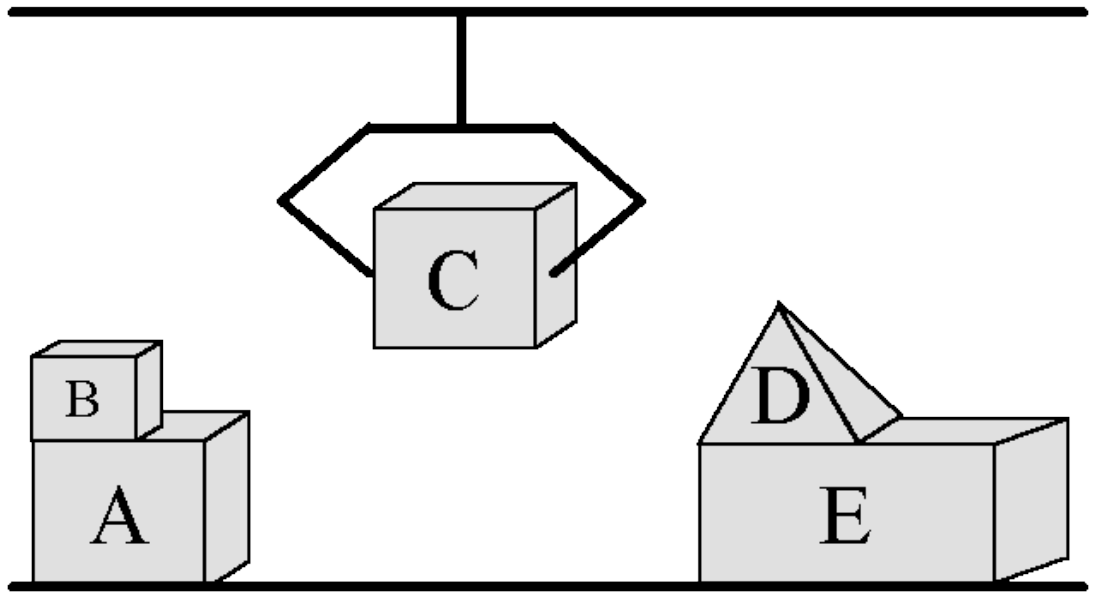
# Brief History of AI

# Waves of AI

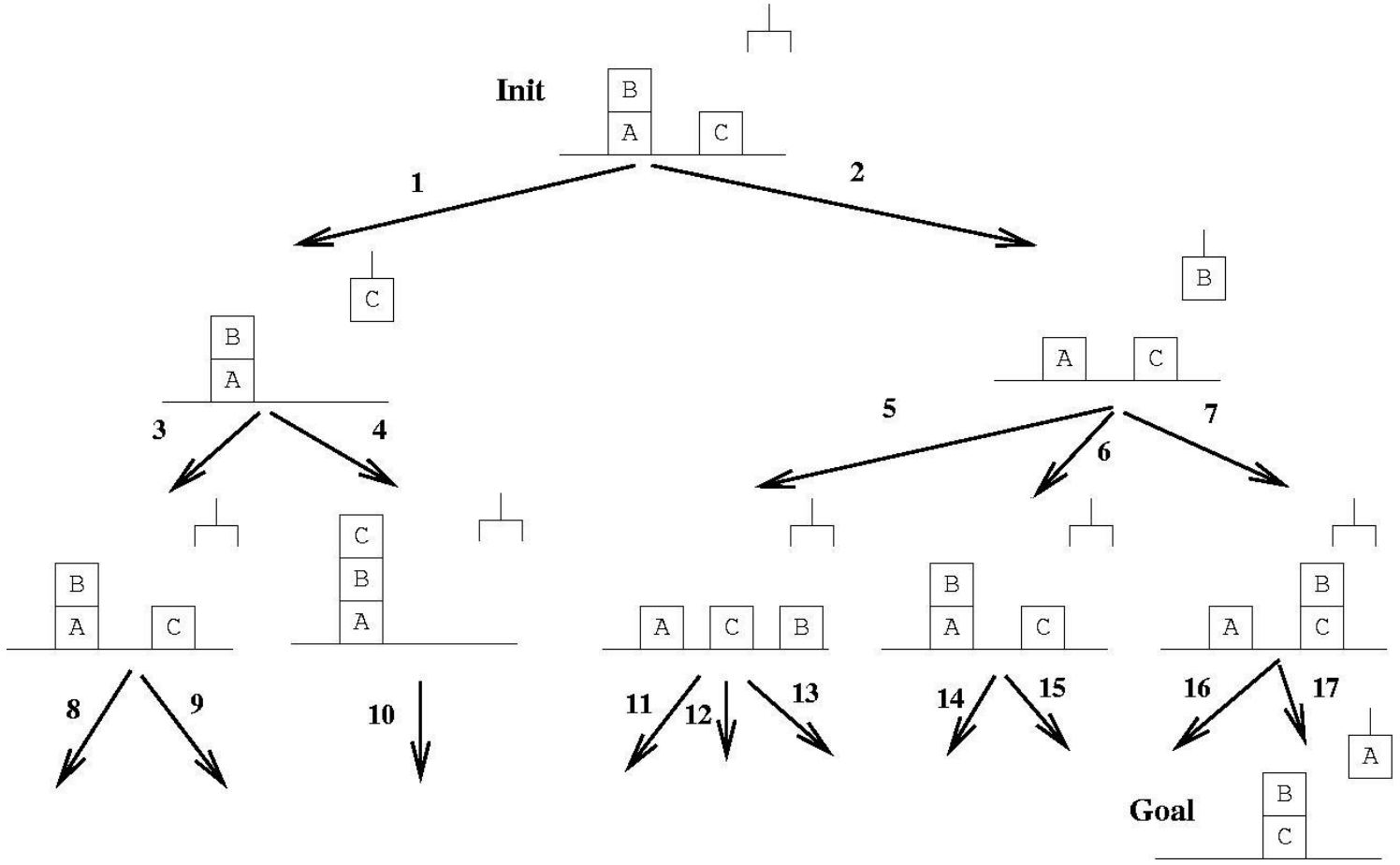


# First Wave

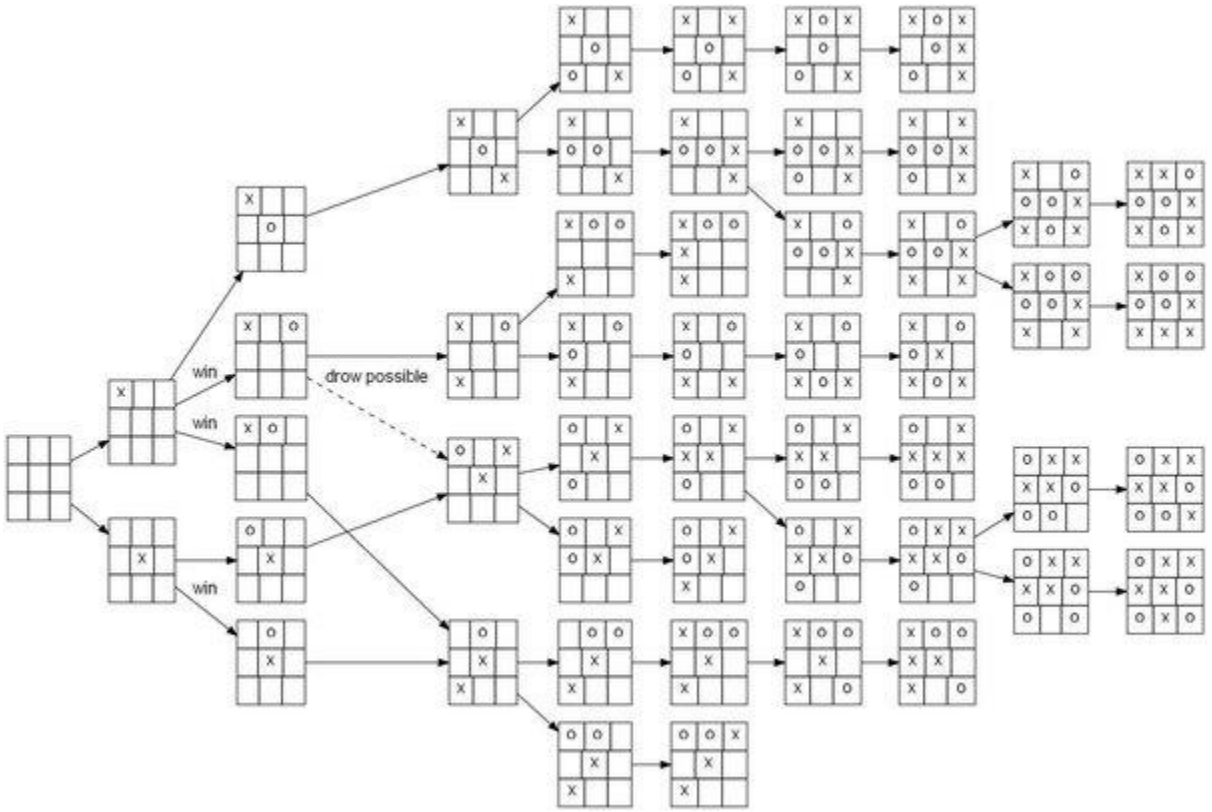
- ‚Frontal Attack'
  - ‚A little bit of everything'
  - Optimism
- General Problem Solving
- Path planning
  - Heuristics
- Automated theorem proving (resolution)
- Classic approaches to games
  - Minimax, Alpha-Beta cut
- Seeds of Machine Learning



# General Problem Solving



# General Problem Solving -- Games



# The Problem of Chess

Number of potential games: ~$\mathbf{10^{120}}$

# The Problem of Chess

Number of potential games: ~$\mathbf{10^{120}}$

Number of atoms in the known universe (estimate): ~$\mathbf{10^{80}}$

# One Size Does NOT Fit All
# (Brute force is not enough)

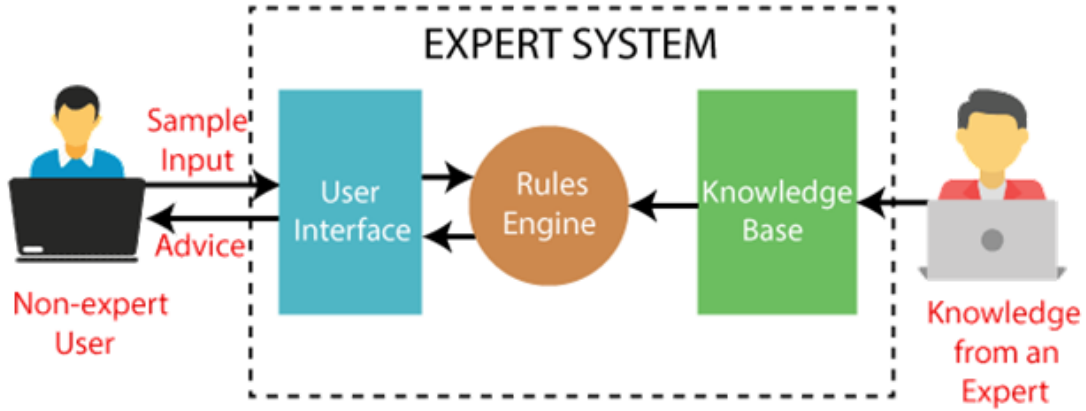
# Other Problems

- World is rich
  - Hard to translate to the abstract language of the GPS
- E.g., ‚Cube World' is rather artificial
  - Yet, it is daunting to specify what is possible and what is not
- GPS is rigid and slow
  - World is dynamic and changing fast

# Yet, some results are still widely used today

# Second Wave

- Expert Systems
  - Solve complex problems by reasoning
  - Through bodies of knowledge
  - Represented mainly as *if–then* rules
  - Rather than through procedural code
- Main components
  - Inference Engine
  - Knowledge Base (≠ Database!)
- Special topics
  - Knowledge representation
  - Logic programming (to describe rules)
- First commercial successes of AI



# Mini-Wave of 1990s – Autonomous, Situated Intelligence

**Agents**

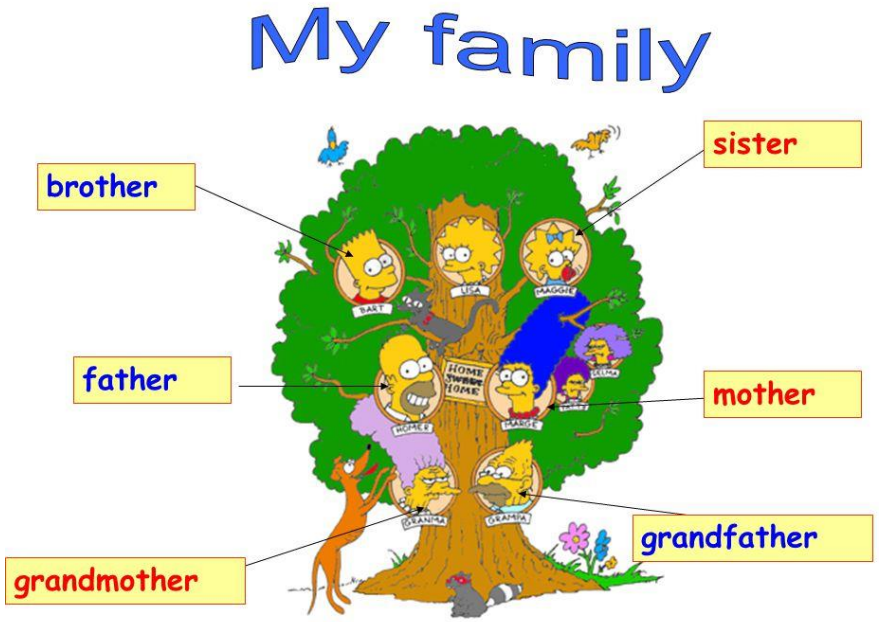
- World is rich and dynamic
  - Make it the default assumption
- Forget abstract environments
  - Always picture the machine in an environment (situated)
- Let machines react to their environment
  - In addition to seeking their (autonomous) goals

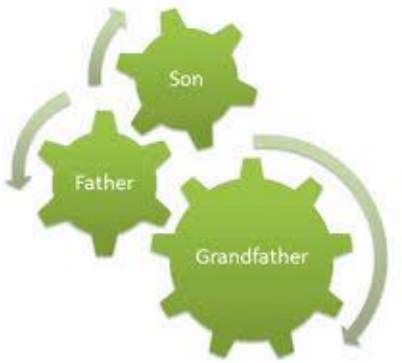
**Multi-Agent Systems**

- You are never alone
  - The age of the Internet
- There is always someone around
  - A human
  - Another AI agent
  - On the Network (LAN, WAN, etc.)
  - On the computer (multi-tasking operating systems)

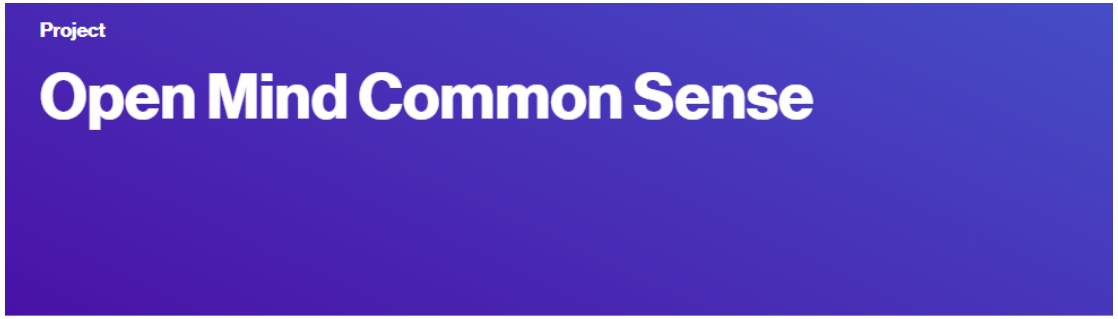
# State of the Art at The Turn of Millenia

## Lack of common knowledge

# A Project by Minsky at MIT (cf. Founding Fathers)




The biggest problem facing artificial intelligence today is how to teach computers enough about the everyday world so that they can reason about it like we do—so that they can develop "common sense." We think this problem may be solved by harnessing the knowledge of people on the Internet, and we have built a Web site to make it easy and fun for people to work together to give computers the millions of little pieces of ordinary knowledge that constitute "common sense." Teaching computers how to describe and reason about the world will give us exactly the technology we need to take the Internet to the next level, from a giant repository of Web pages to a new state where it can think about all the knowledge it contains; in essence, to make it a living entity.

# It is 20+ years old now…

- Is this the reason of the new AI wave?

# It is 20+ years old now…

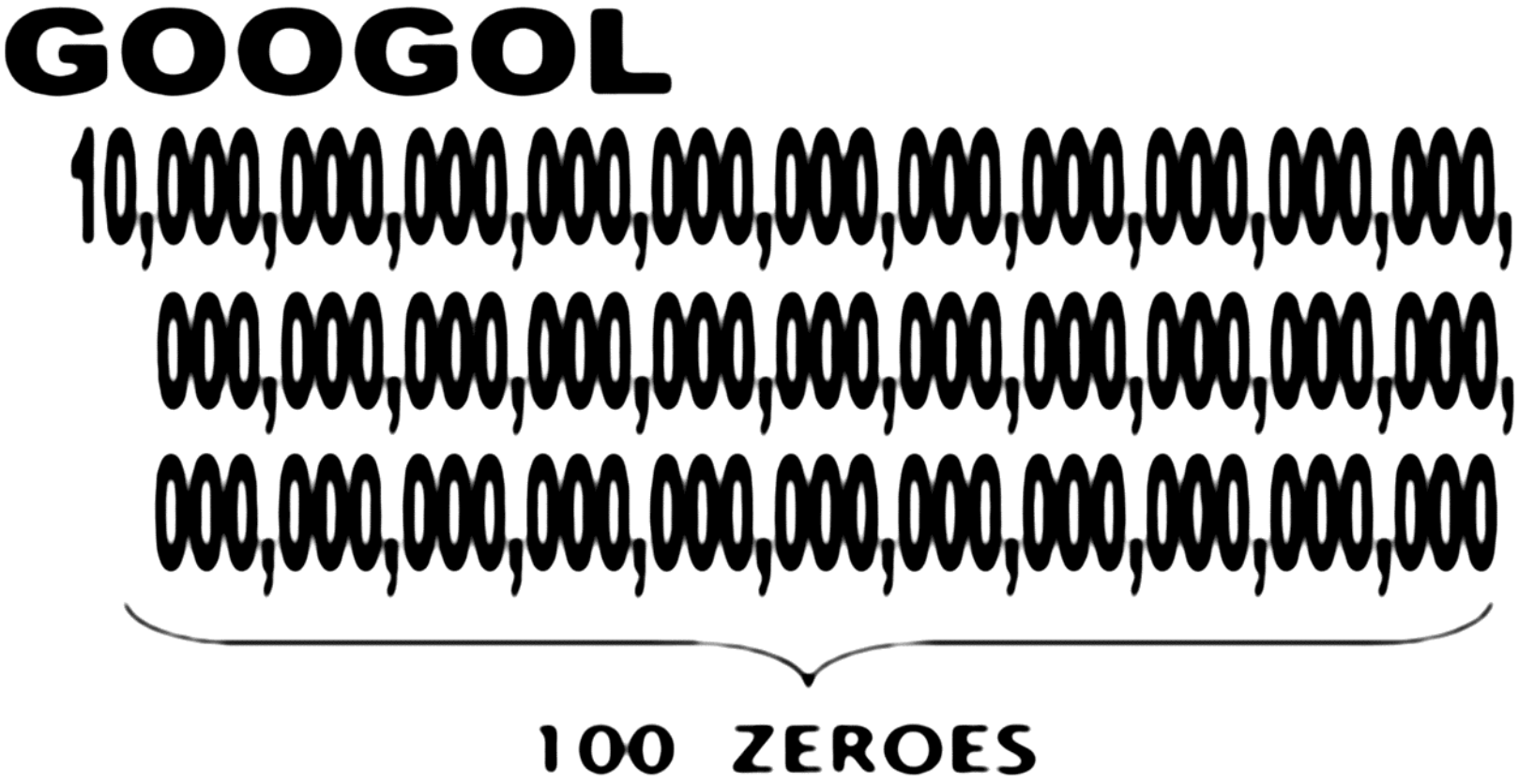
- Is this the reason of the new AI wave?

**NO**

# Internet (and smart phones)

- What is the origin of Google's name?

# The origin of Google's name



# The Era of Data Economy (Big Data)
## Google (Apple, Facebook, Amazon, …)

Why collecting data for decades?

- If you can get access to ‚all' information at once
- About the ‚whole of humanity'

Example:

- Google's speech recognition was introduced first to recognise search keywords
  - Trained on internet search logs since 1998

# Additional Facilitators of the new AI wave

- Advent and proliferation of GPUs
- Invention of ‚deep learning'
  - Especially in the context of graphics → Convolutional Neural Networks

# Fate of the Current Wave?

- A significant difference:
  - This is the first wave to be (mostly) financed by private capital
- For better or worse
  - Too big to fail?
    - Cf. Famous last words
  - Or colder AI winter than ever?
  - Or better marketing?
    - Recognition of achievements

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# Thank you!


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