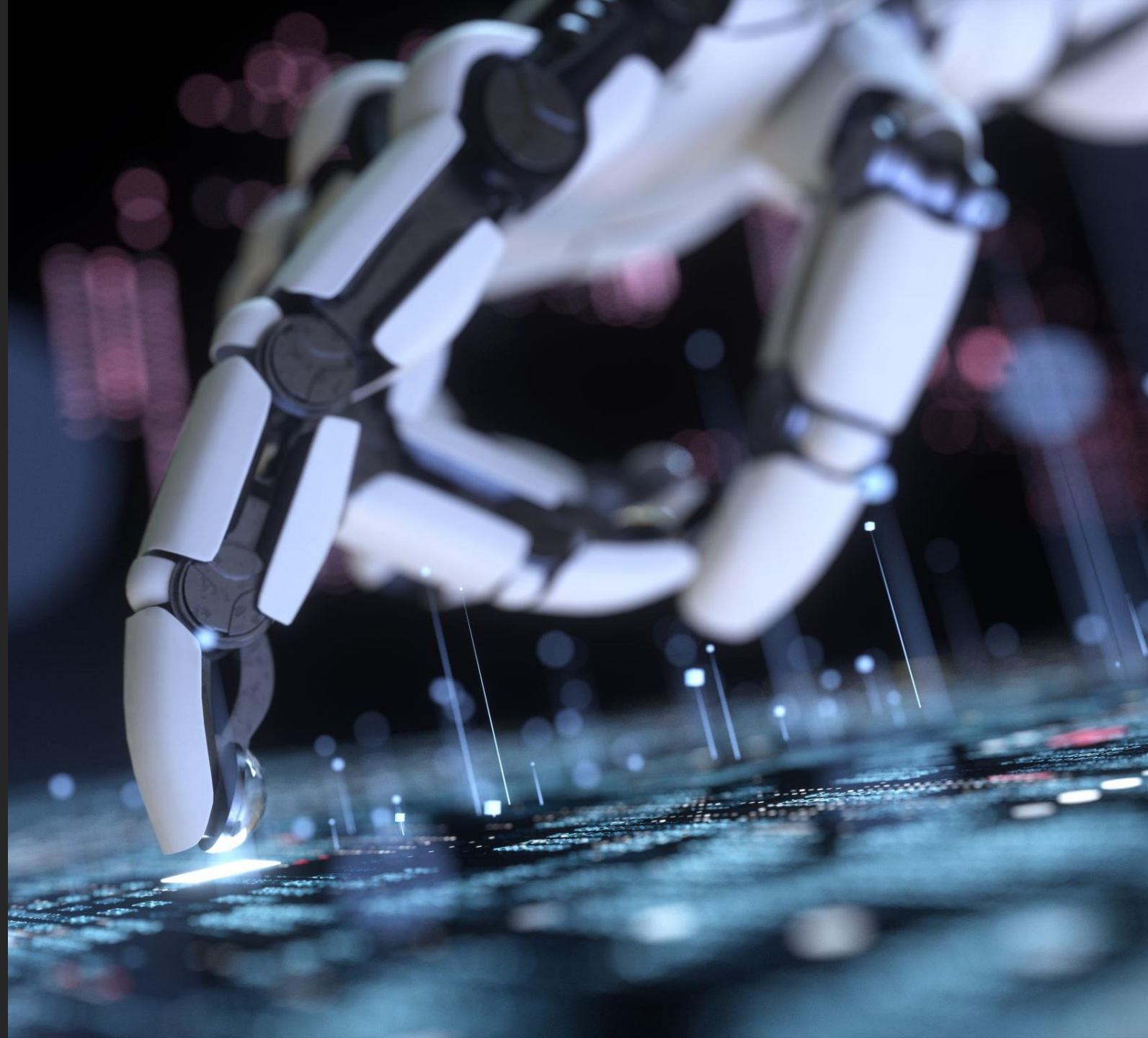
AI UNDER THE HOOD: TRANSFORMING BUSINESS, INDUSTRY, AND SOCIETY

STEFAAN HASPESLAGH



WHO AM I?

ACADEMIC

KU LEUVEN kulak

PRACTITIONER

hogeschool vives

TECH ENTHOUSIAST

THE TRANSFORMATIVE POWER OF ARTIFICIAL INTELLIGENCE

- Artificial Intelligence (AI) is a versatile tool that is rapidly reshaping various domains, from healthcare and finance to transportation and education. With advancements in machine learning, deep learning, and natural language processing, the development of AI-powered solutions is accelerating at an unprecedented pace, leading to widespread adoption and transformative impact across numerous industries.

WHY AI IN THE FIRST PLACE?

INTELLECTUAL AND PHILOSOPHICAL CURIOSITY

Understanding Human Thought:

Investigate how intelligence works.

Explore the essence of reasoning, learning, and problem-solving.

The Nature of Consciousness:

Can machines be conscious or self-aware?

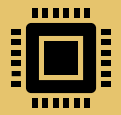
How close can artificial systems get to replicating human-like thinking?

Key Questions:

What does it mean to think?

Can intelligence exist beyond biological systems?

TECHNOLOGICAL OPTIMISM



Breakthroughs in Computing:

The rise of programmable computers (like the ENIAC).

Inspiration from the Turing Machine and logical operations.

Belief in Rapid Progress:

Early successes in simple AI systems led to optimism about achieving AGI quickly.

Assumption: Computational power would eventually rival the human brain.

Dream of creating machines that could independently think and solve complex problems.

PRACTICAL DRIVERS

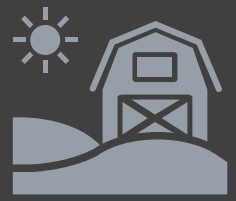
Solving Human Limitations

Automate repetitive, time-consuming tasks.

Tackle problems too complex or large-scale for humans.

Enhancing Productivity:

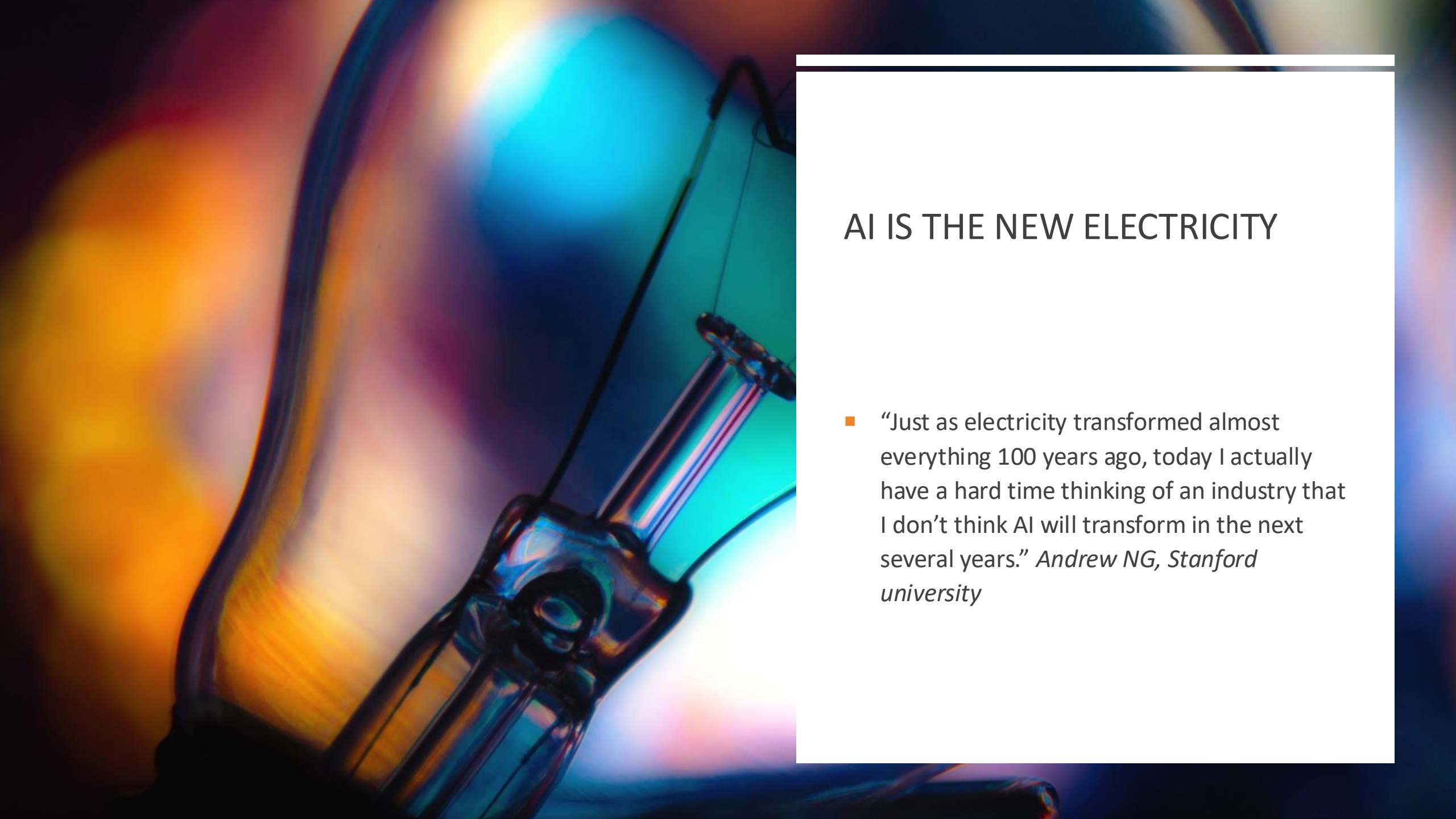
Use machines to complement human labour and improve efficiency.



Addressing Societal Challenges

Revolutionise fields like healthcare, education, transportation, and agriculture.

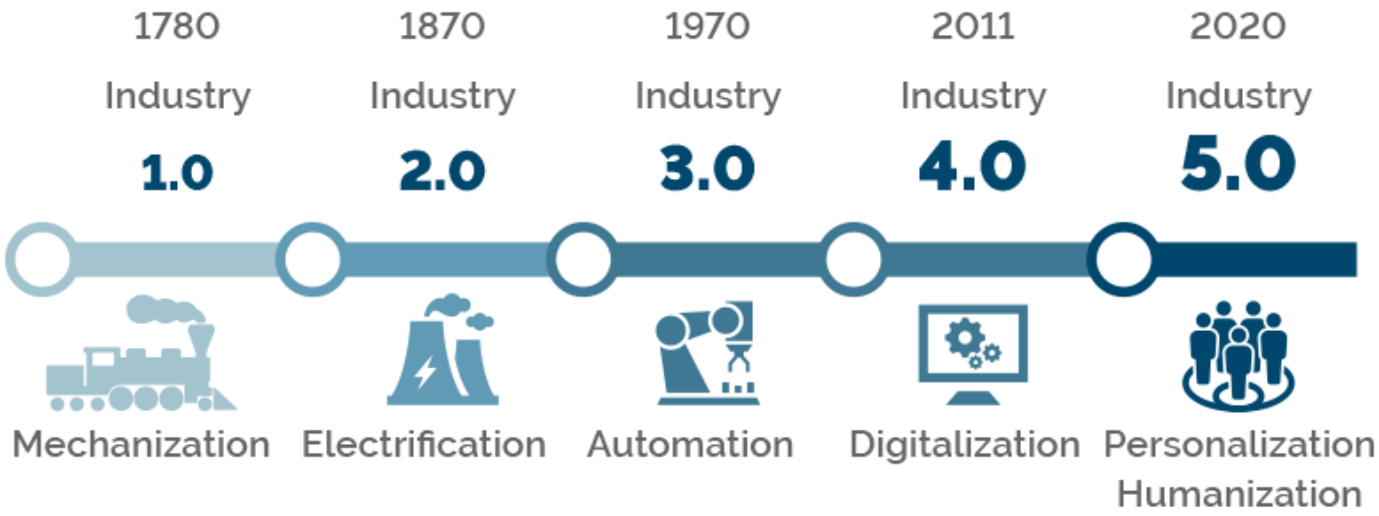
NEED FOR AI

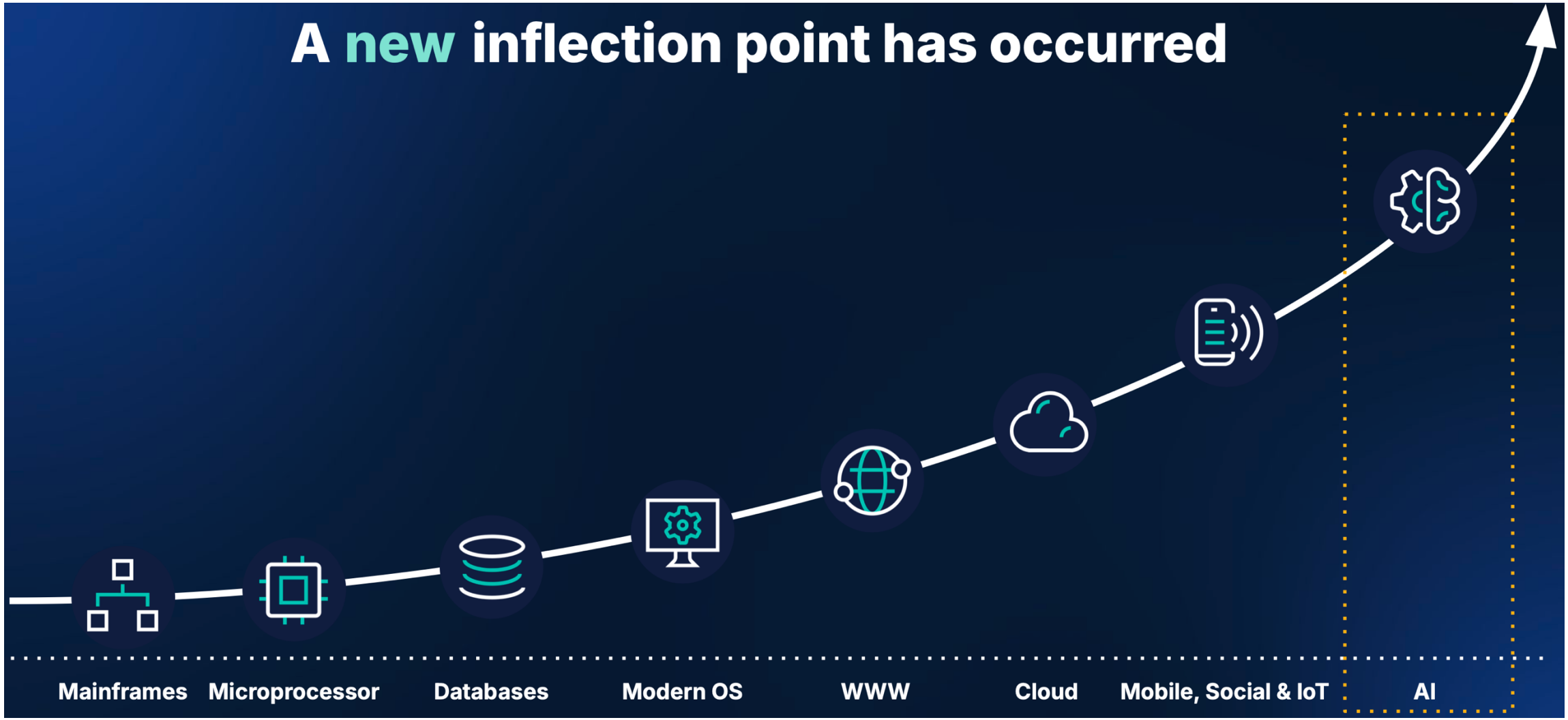


AI IS THE NEW ELECTRICITY

- “Just as electricity transformed almost everything 100 years ago, today I actually have a hard time thinking of an industry that I don’t think AI will transform in the next several years.” *Andrew NG, Stanford university*

FIFTH INDUSTRIAL REVOLUTION




A new inflection point has occurred
Mainframes
Microprocessor
Databases
Modern OS
WWW
Cloud
Mobile, Social & IoT
AI

THE EVOLVING CHALLENGES OF THE MODERN WORKPLACE

Increasing Complexity

As jobs become more specialized, the tasks required to perform them become increasingly complex, requiring more training and expertise.

Efficiency in a Fast-Paced World

Repetitive tasks and the demand for quick, accurate decisions can overwhelm workers, especially in fields like finance, healthcare, and logistics. High-volume operations such as customer support and manufacturing need scalable, continuous solutions to maintain efficiency and consistency.

Skill Bottlenecks

Certain intellectual tasks, such as data analysis, software development, and strategic planning, require highly specialised skills that are in high demand but limited supply, creating bottlenecks in the job market.

DRIVERS FOR AI IMPLEMENTATION (EXPECTATIONS)

Improve productivity and/or efficiency

To reduce operational cost

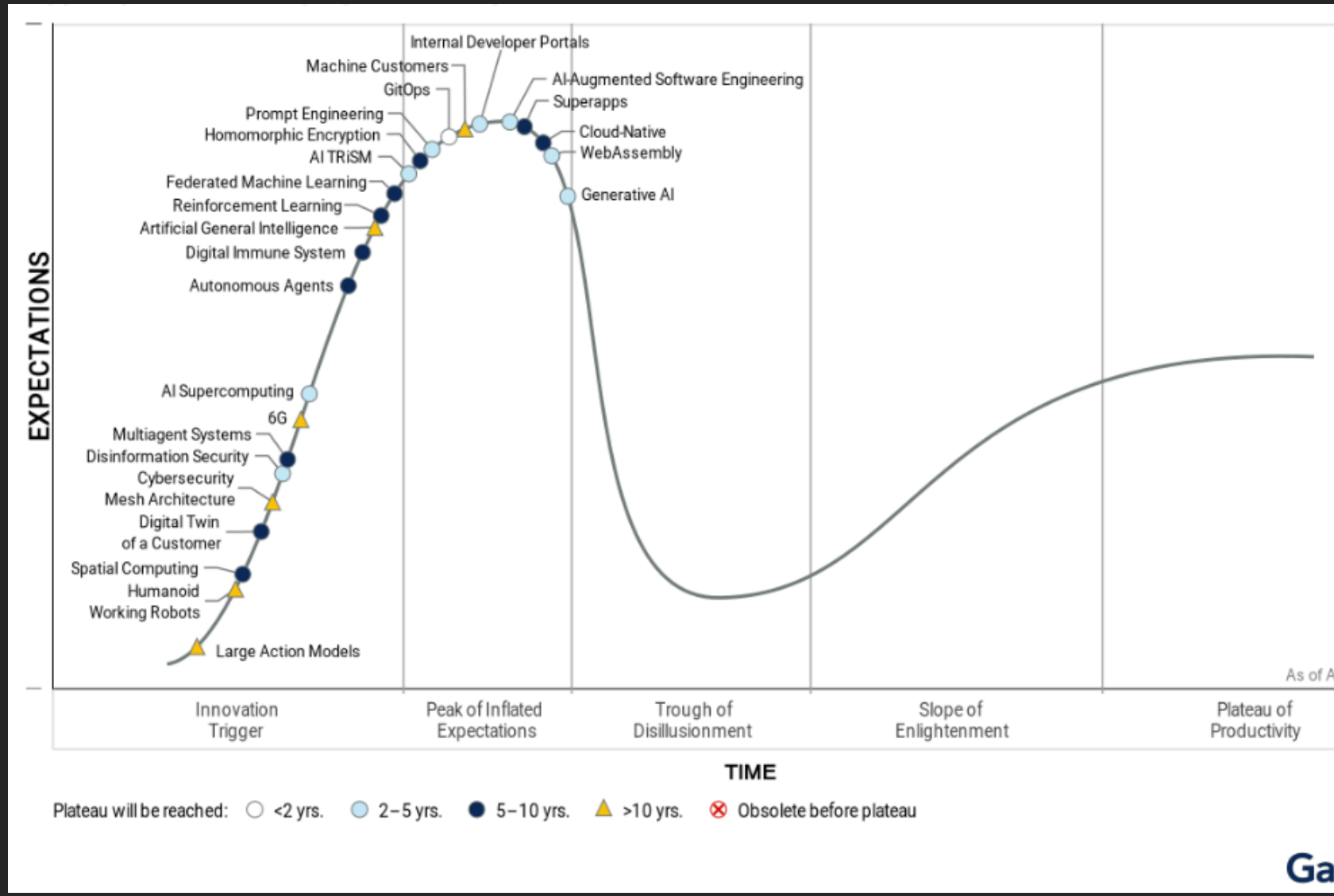
Improve customer experience

Gain insights from large volumes of data sets to improve or inform decision-making processes

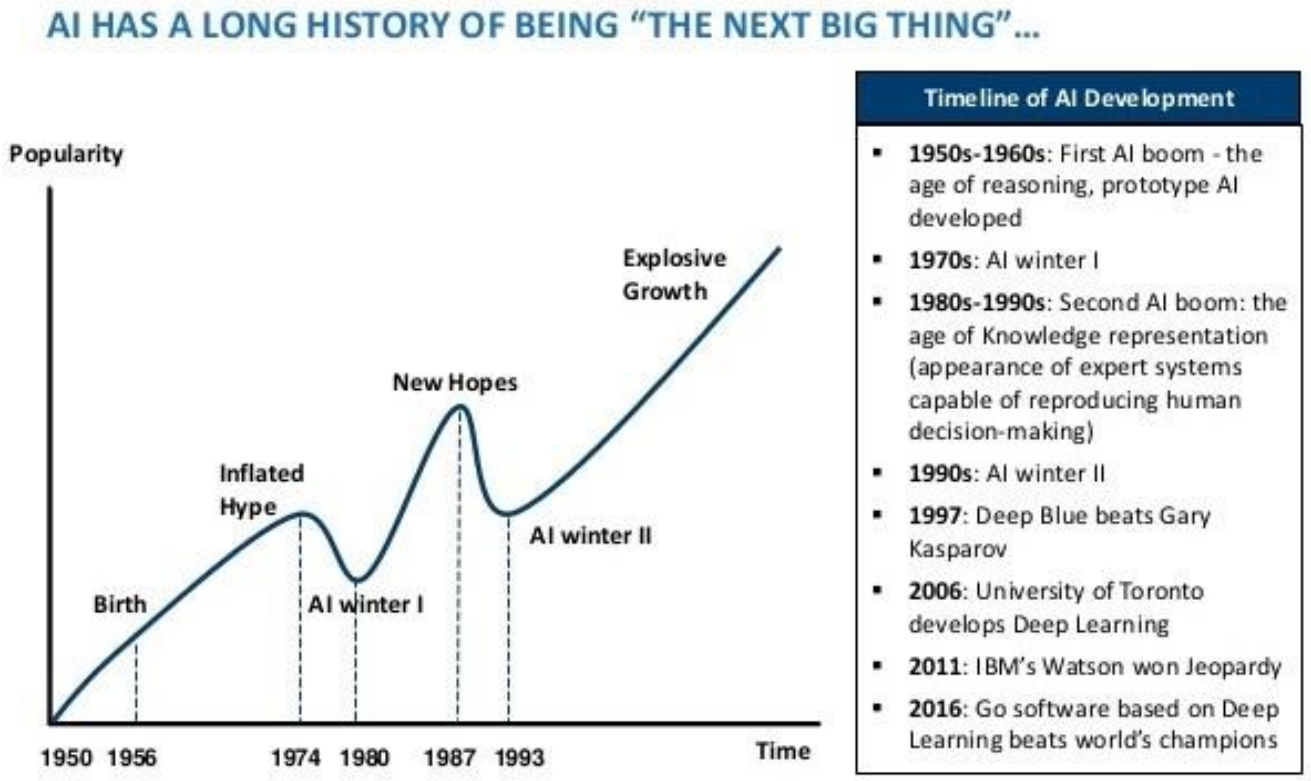
UST AI in the Enterprise Survey, 2024

WHAT IS AI?

AI – GARTNER HYPE CYCLE

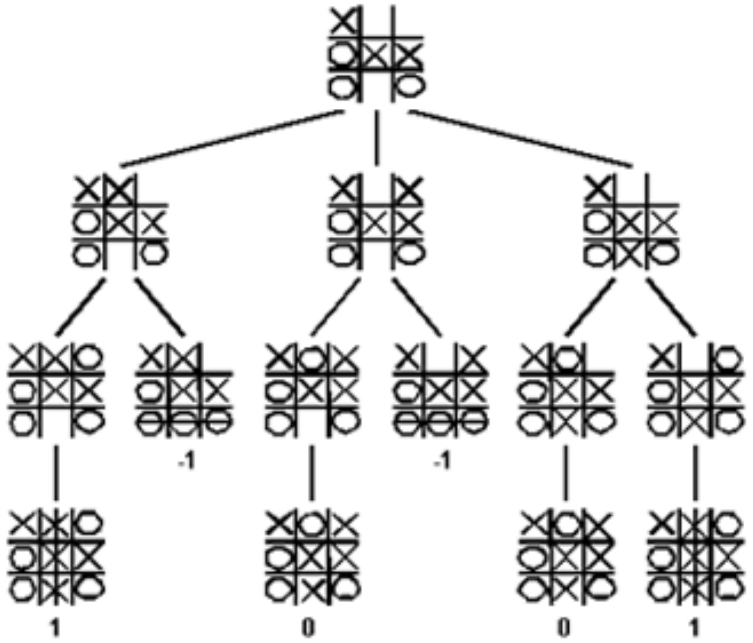


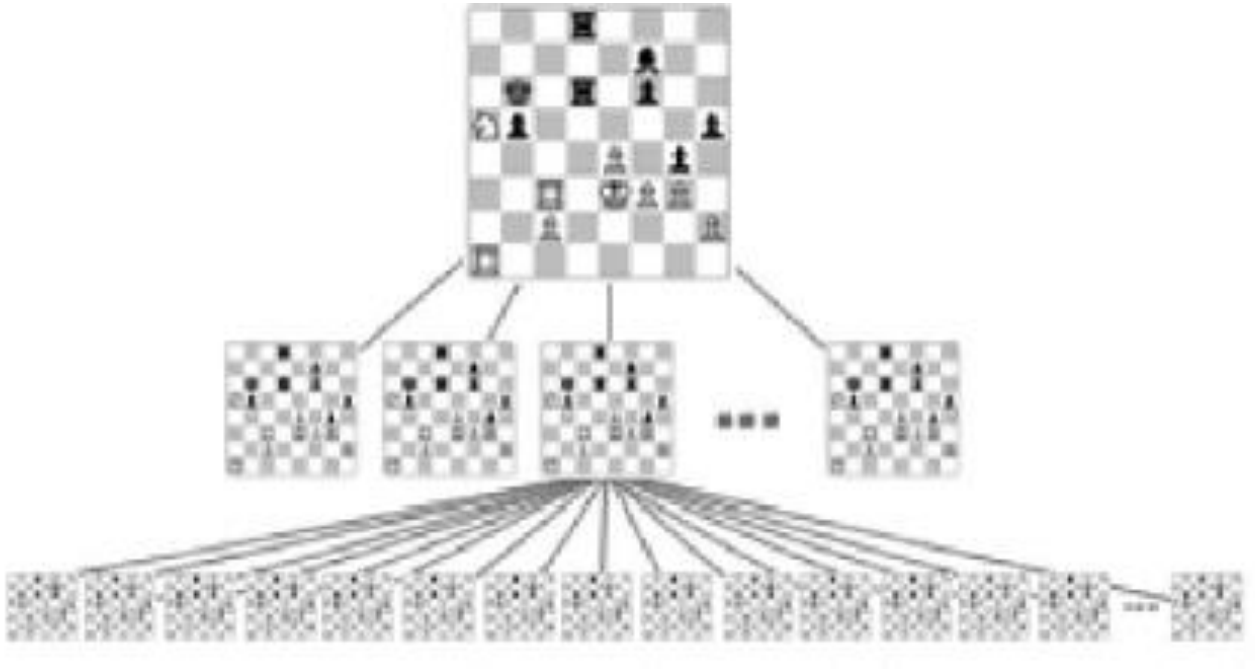
AI – WINTERS AND SUMMERS



AI –LATEST (ML) SUMMER

SEARCH TREES





SEARCH TREES

- Complexity games
- Parallellisation!

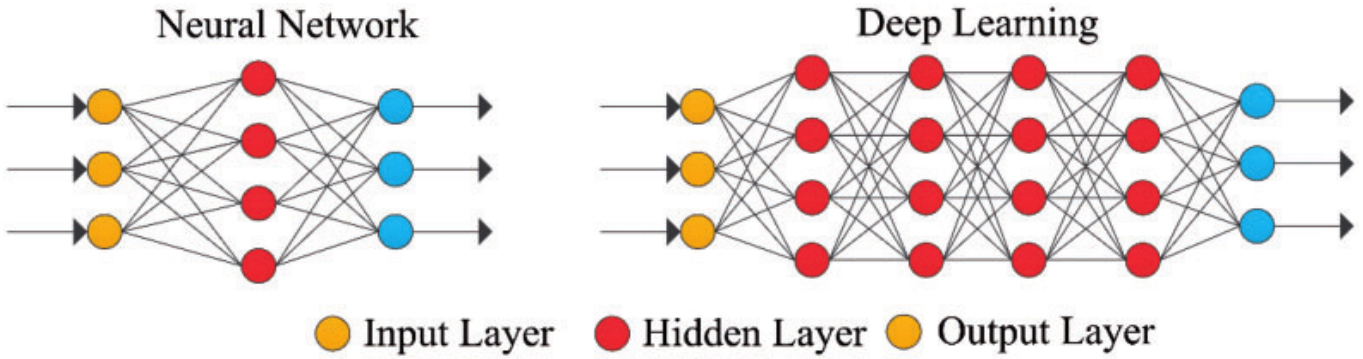
	Avg. branching factor	Search tree size
Tic-tac-toe	4	9!
Chess	35	~ 10^{120}

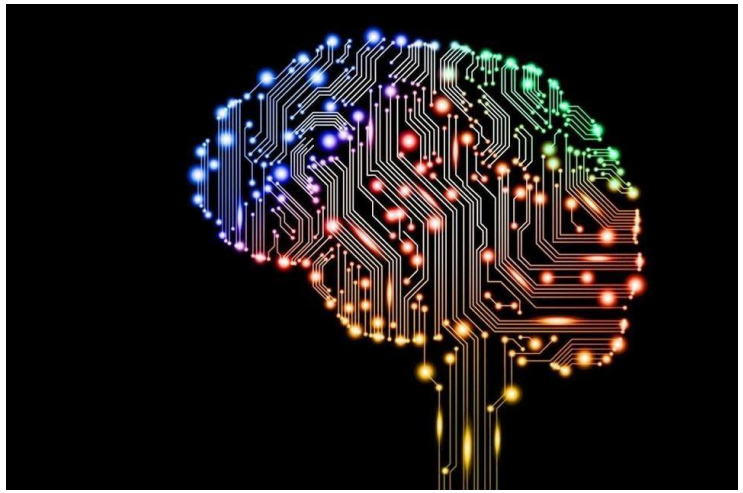
10 YEARS LATER: WATSON

Requires knowledge!

DEEP LEARNING & GO

19X19 – B.F. 250 - 10^{360}

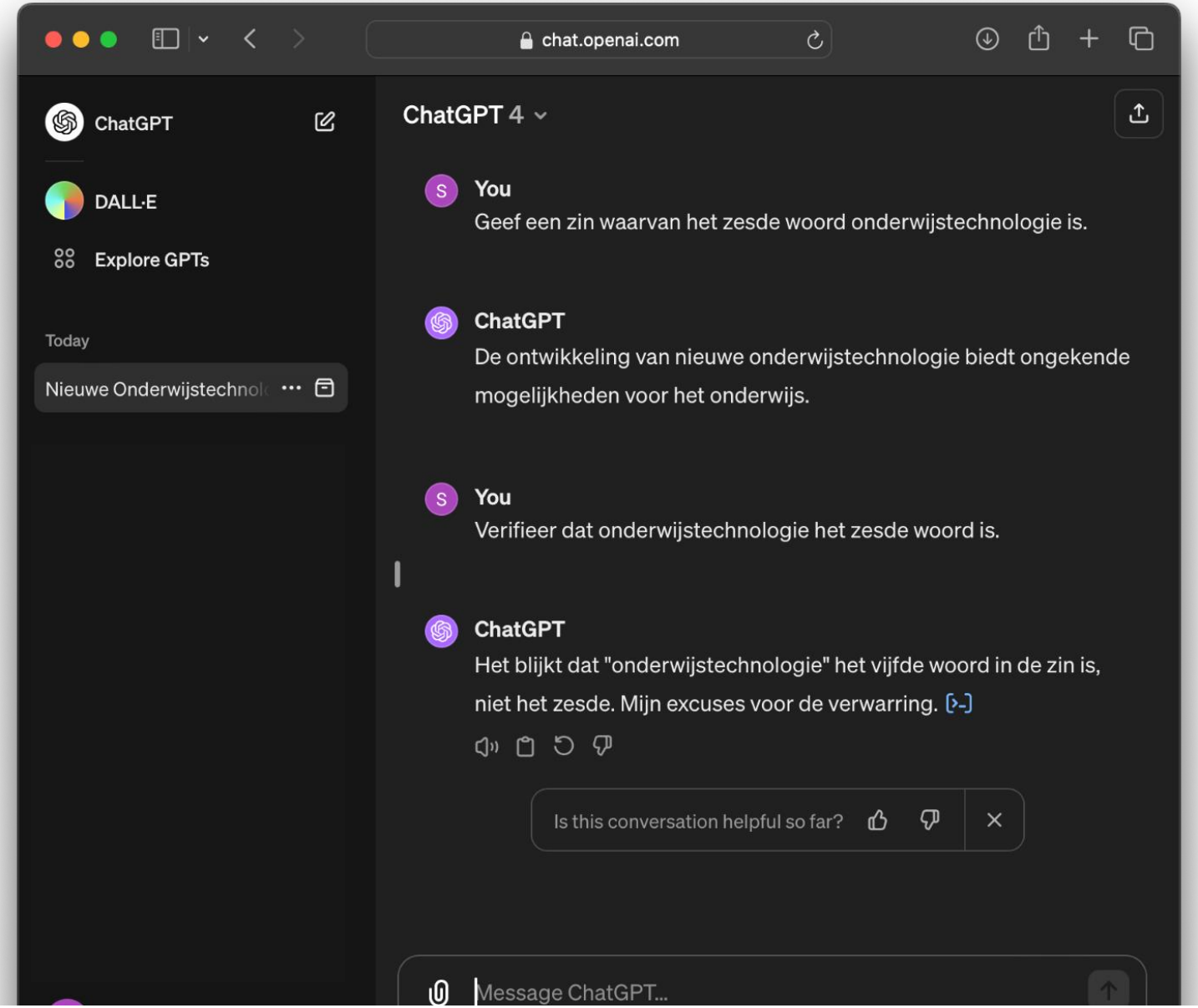


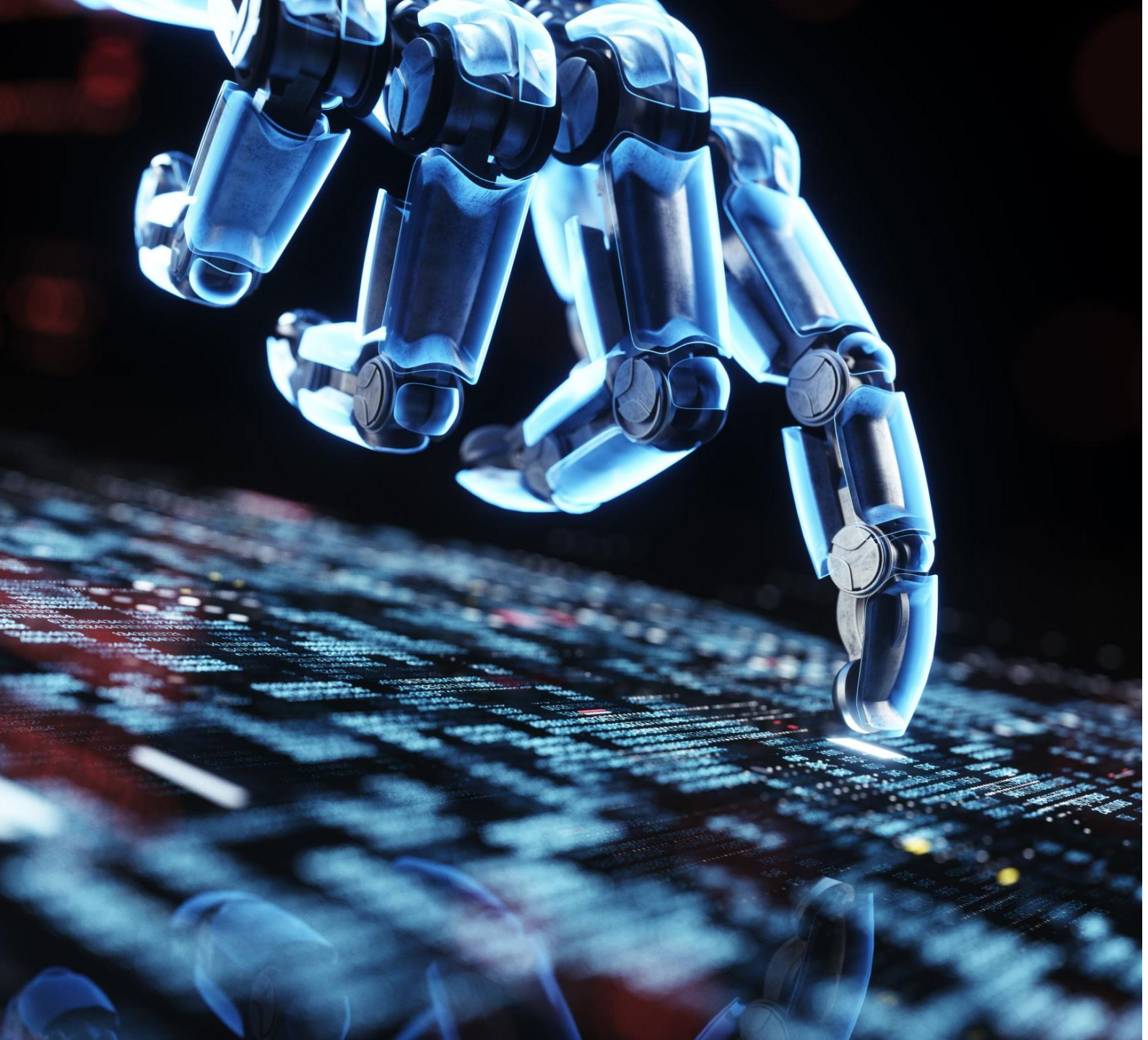


GOOGLE DEEP MIND: 2016

CHATGPT – 2022 & 2023

Deep learning based → Language model – does NOT know anything! → Predicts the probability that the next word is X given some previous words





ABOUT INTELLIGENCE…

- Most used definition of artificial intelligence:
  - If a task performed by humans requires intelligence, and the software/device is able to perform this task, then the software/device is an artifical intelligence system.
- When should we consider a program intelligent?

DOES NUMERIC COMPUTATION REQUIRE INTELLIGENCE?

For humans?

Calculation: 3921,56 x 73,13 = ?

For computers?

When do we consider a program “intelligent”?

And when will computers ‘overrule’ us?

TO SITUATE THE QUESTION: TWO AIMS

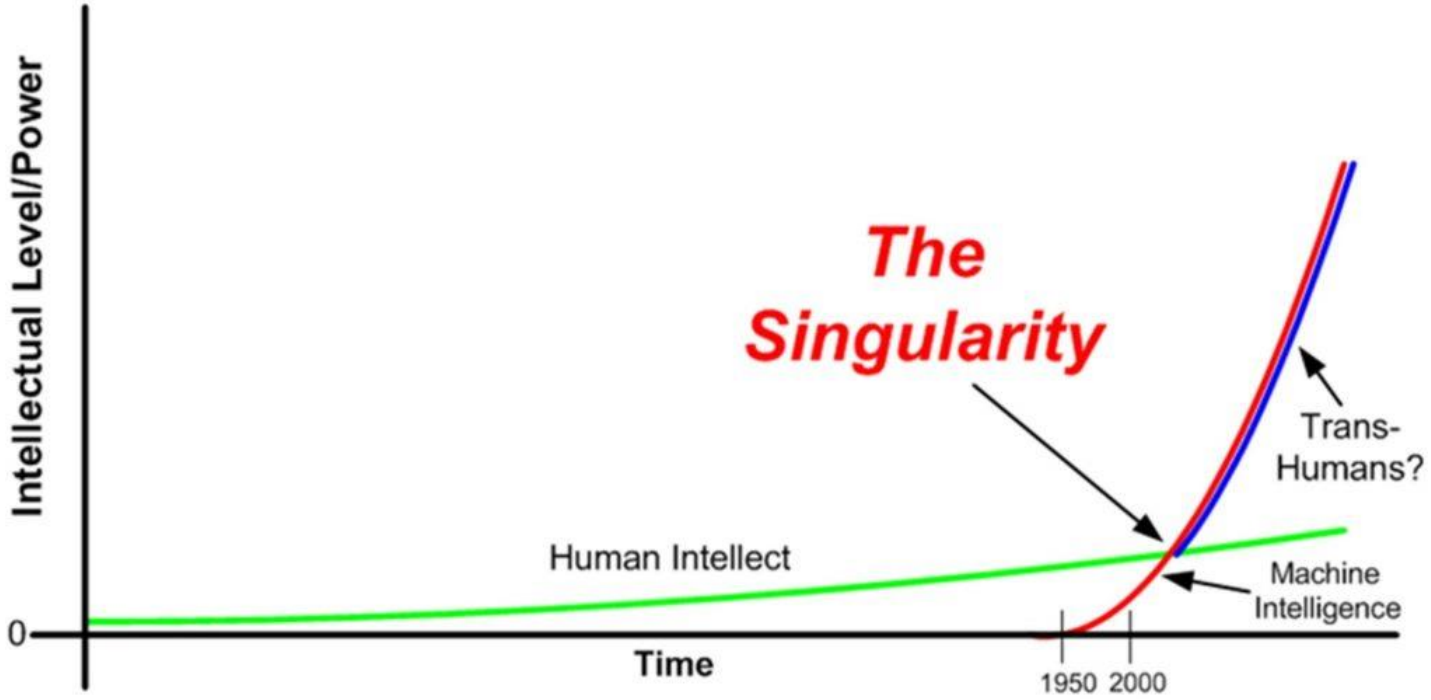
Short term aim:

- on specific tasks that seem to require intelligence
- develop systems that achieve a “level of intelligence” similar/comparable/better? than that of humans
- achieved for very many tasks already: deep blue, data mining, computer vision, …

Long term aim:

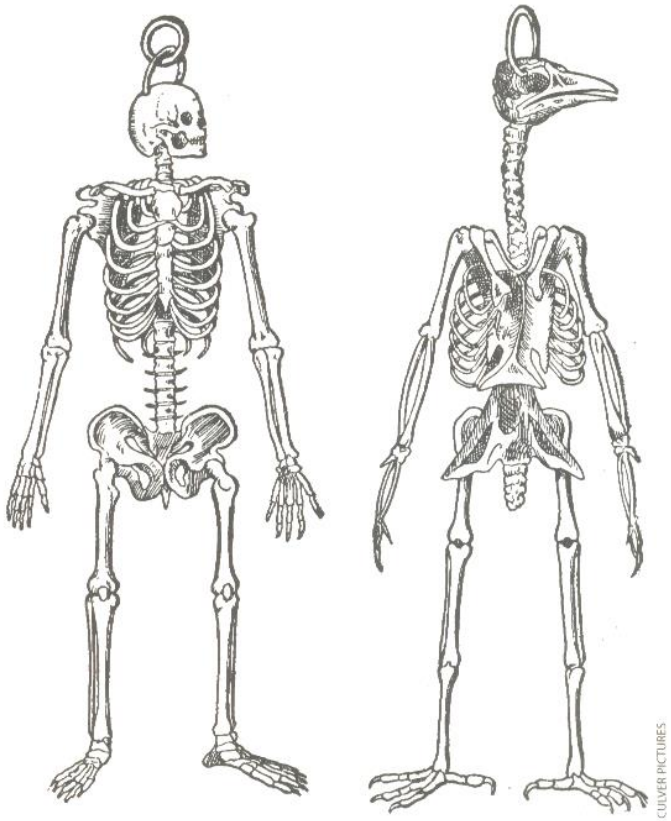
- develop systems that achieve a level of “intelligence” similar/comparable/better? than that of humans
- not achievable in the next 20 to 30 years

LONG TERM: POINT OF SINGULARITY

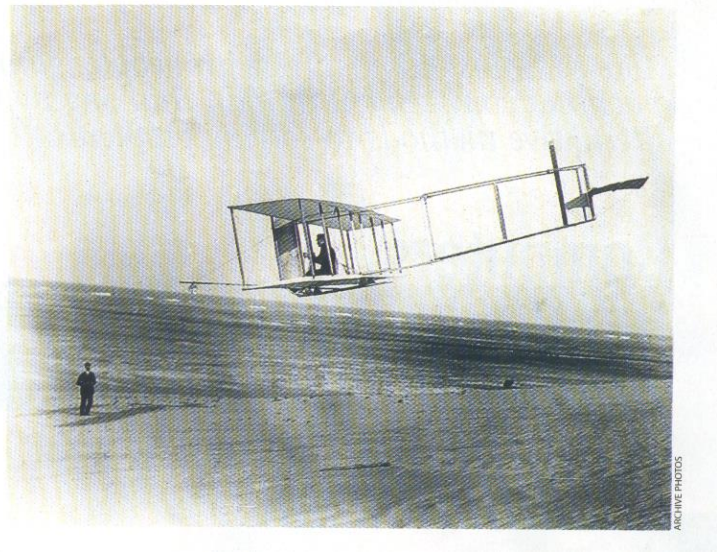


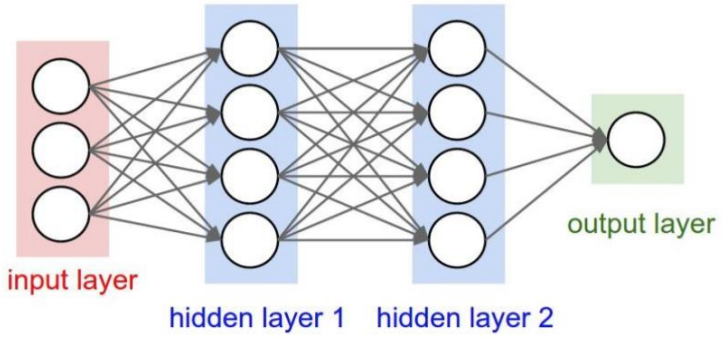
SHORT TERM: REPRODUCTION VERSUS SIMULATION

- We are not to SIMULATING human intelligence
- We are REPRODUCING the effect of intelligence

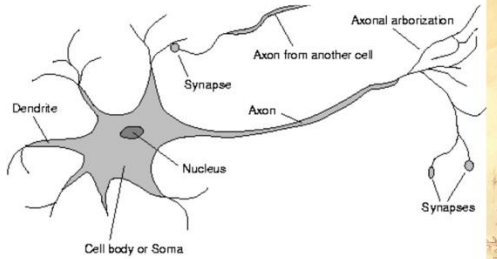


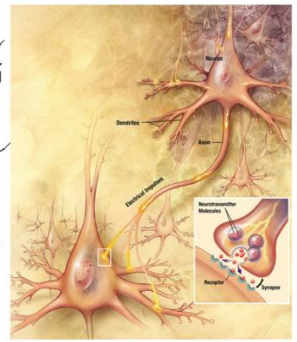
COMPARISON OF SKELETONS of a human and a bird—here taken from a 16th-century manuscript by French naturalist Pierre Belon—examined similarites in anatomy in an attempt to understand how birds can fly.

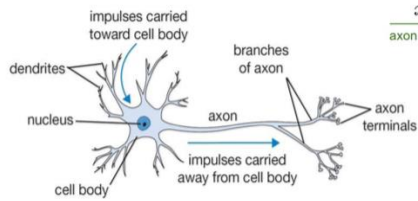


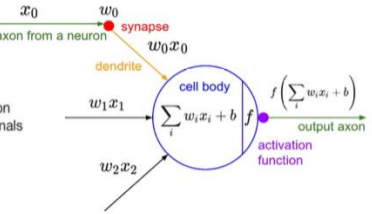


Biology of a Neuron









WILL AI OVERRULE US?

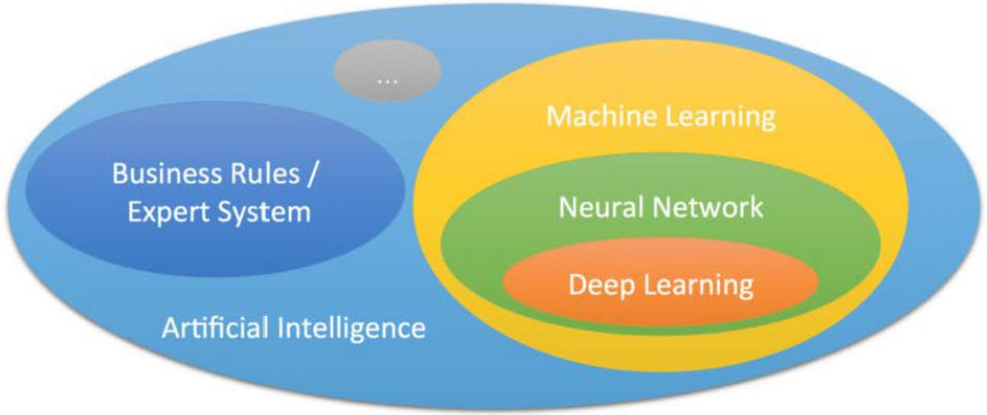
IS MORE OR LESS THE QUESTION: WILL DEEP LEARNING OVERRULE US?

A BETTER DEFINITION

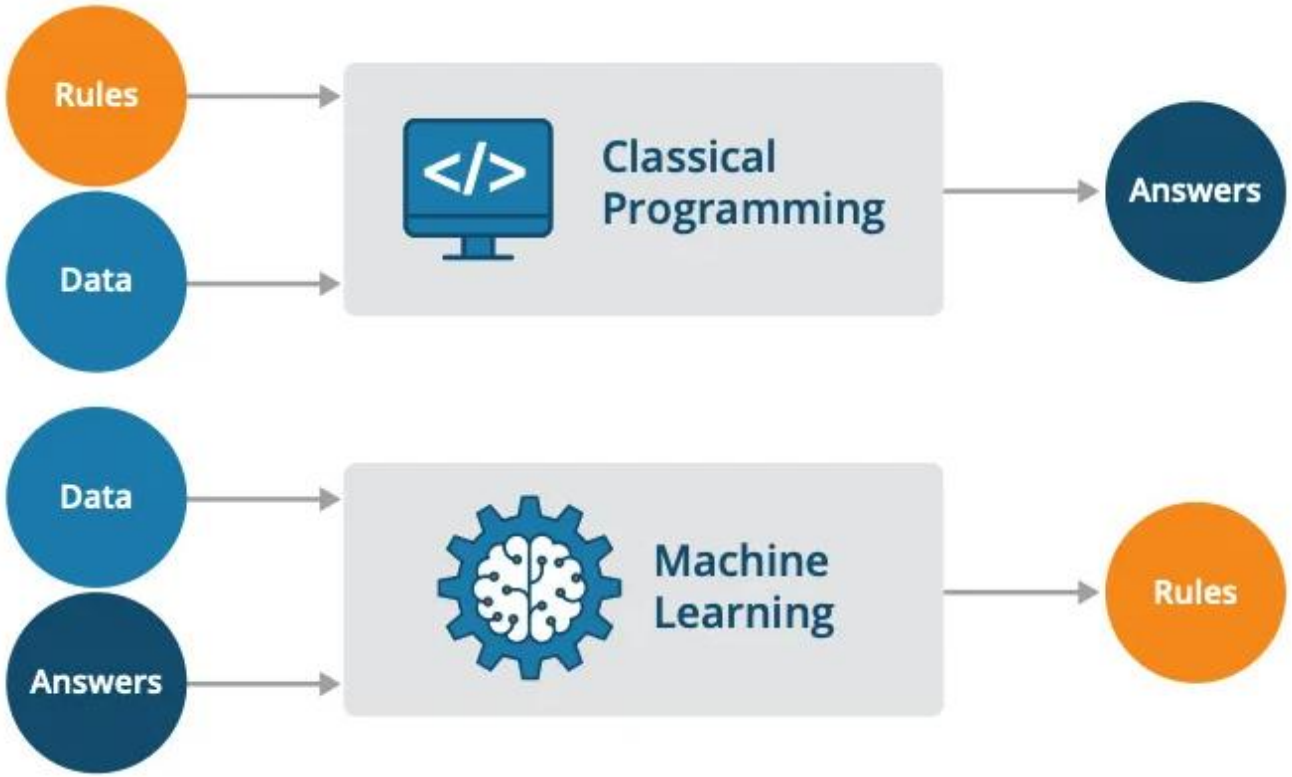
- Artificial Intelligence is the study of how to make computers do things at which, at the moment, people are better.

- Long lasting definition:
  - Computations?
  - Chess?
  - Entering a (unknown) room/city, making an inventory of items, planning and taking actions
    - Field of autonomous robots/vehicles

AI – ML - DL



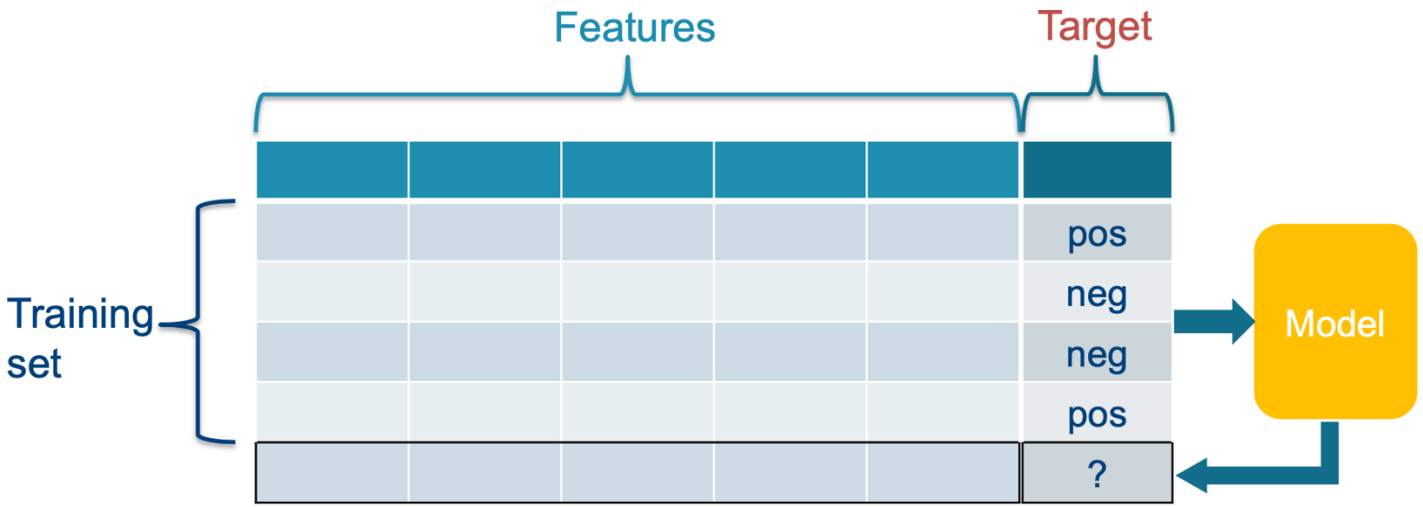
- **Artificial Intelligence** (AI):
  - "The set of all tasks in which a computer can make decisions."
- **Machine Learning** (ML):
  - "The set of all tasks in which a computer can make decisions *based on data*."
- **Deep Learning** (DL):
  - "The field of machine learning that uses certain objects called *neural networks*."



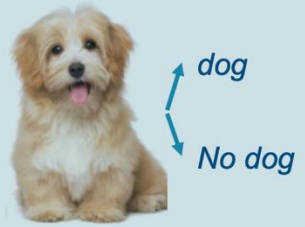
ML VERSUS TRADITIONAL PROGRAMMING

ML: SUPERVISED LEARNING

- Task: learn a model to predict a property (target) for new data instances, based om training set of data instances for which the property is observed



ML: SUPERVISED LEARNING TASKS



Classification
(binary / multi-class)

Regression

Time-to-event prediction

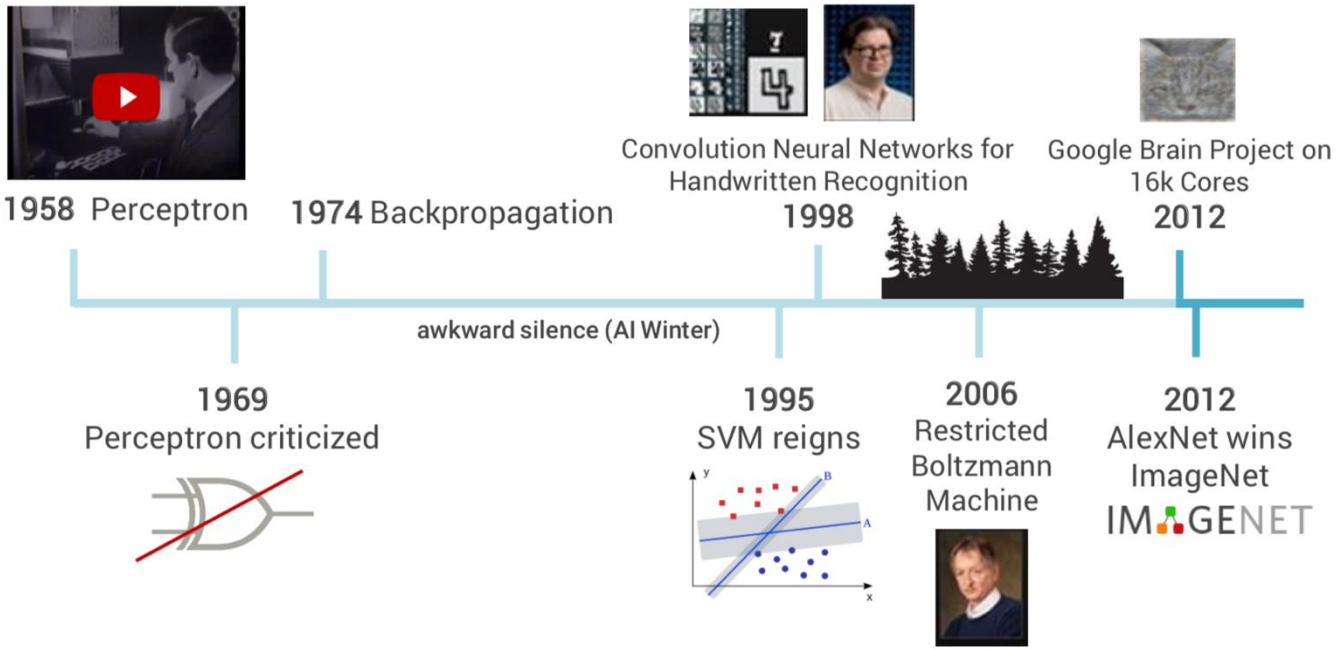
Learning to rank

Link (interaction)
prediction

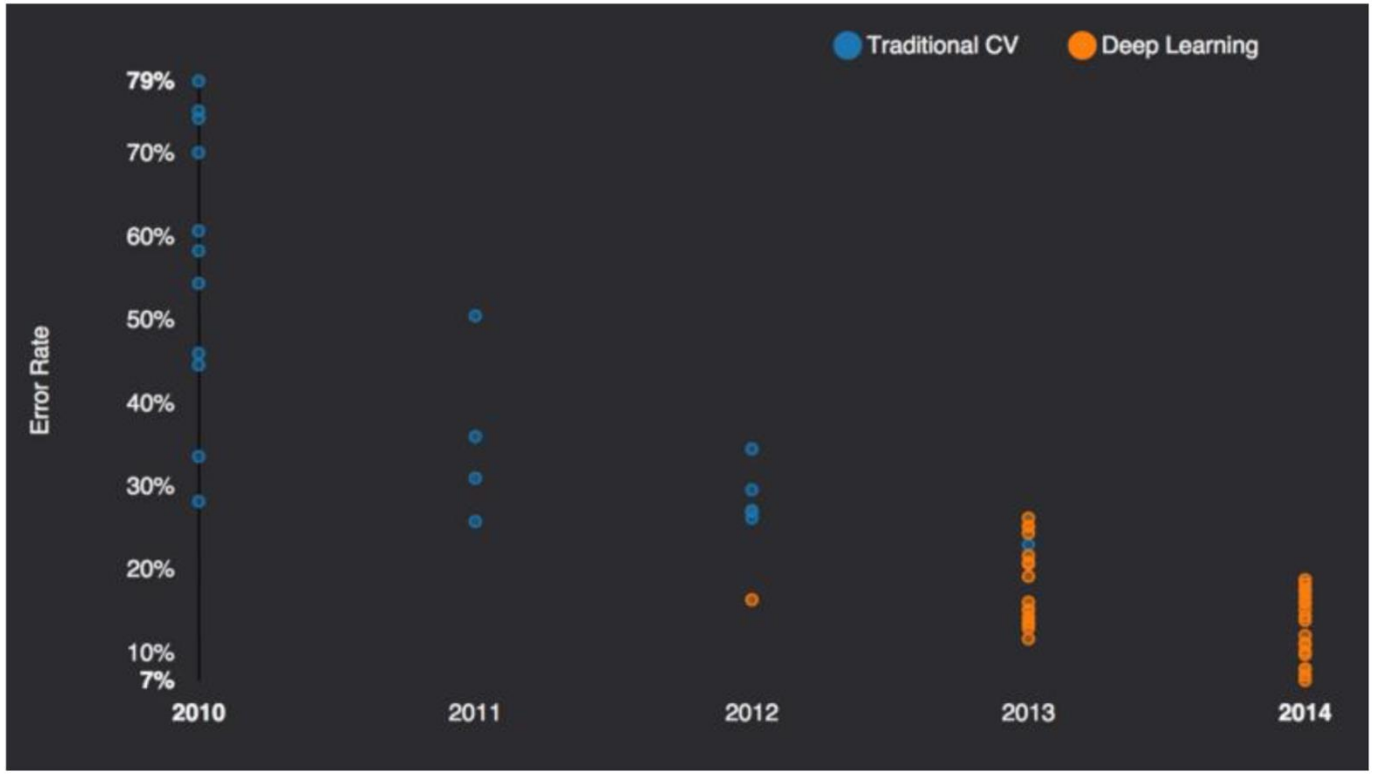
Multi-output prediction

DEEP LEARNING

DEEP LEARNING: BRIEF HISTORY

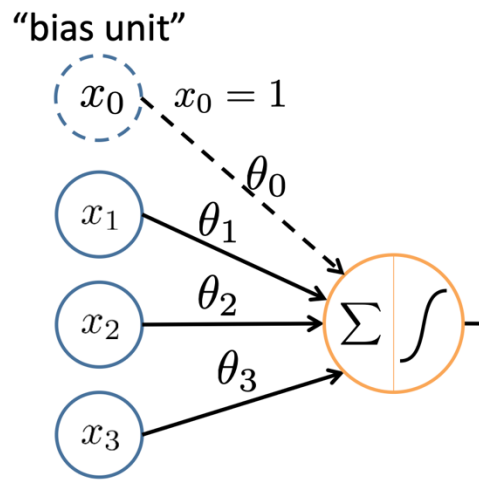


DEEP LEARNING: BRIEF HISTORY



ImageNet: The “computer vision World Cup”

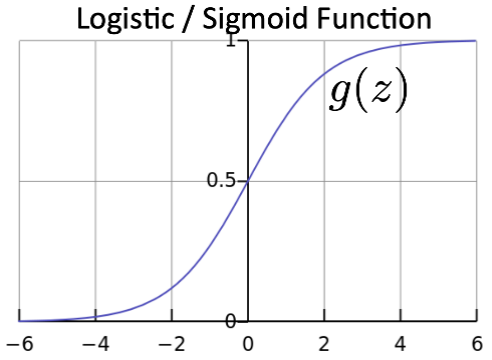
DEEP LEARNING: A NEURON

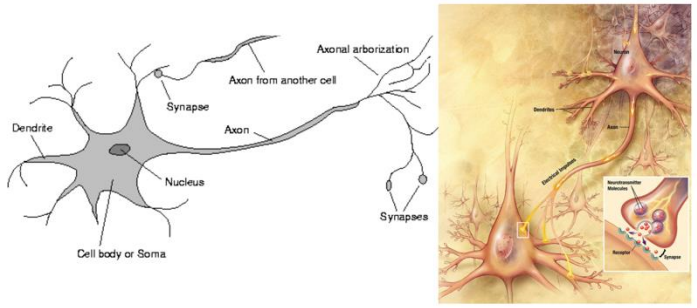


$$\mathbf{x} = \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix} \qquad \boldsymbol{\theta} = \begin{bmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \\ \theta_3 \end{bmatrix}$$

$$h_{\boldsymbol{\theta}}(\mathbf{x}) = g\left(\boldsymbol{\theta}^{\mathsf{T}}\mathbf{x}\right) = \frac{1}{1 + e^{-\boldsymbol{\theta}^{\mathsf{T}}\mathbf{x}}}$$

Sigmoid (logistic) activation function: $g(z) = \dfrac{1}{1 + e^{-z}}$



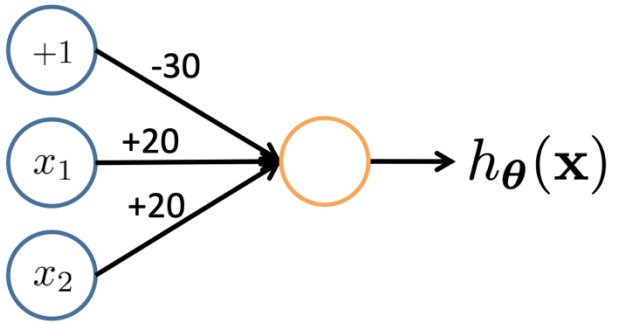


A SIMPLE NEURAL NETWORK

Simple example: AND

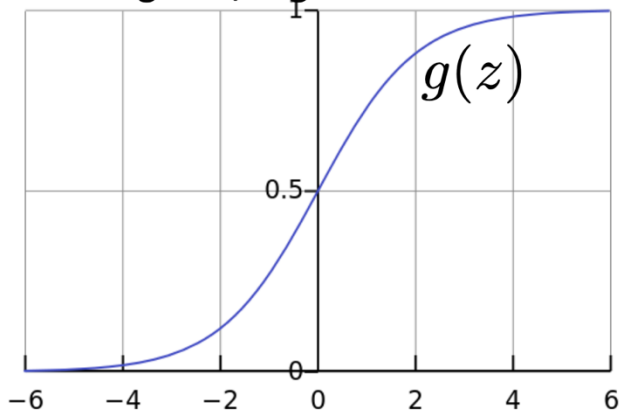
$x_1, x_2 \in \{0, 1\}$

$y = x_1 \text{ AND } x_2$



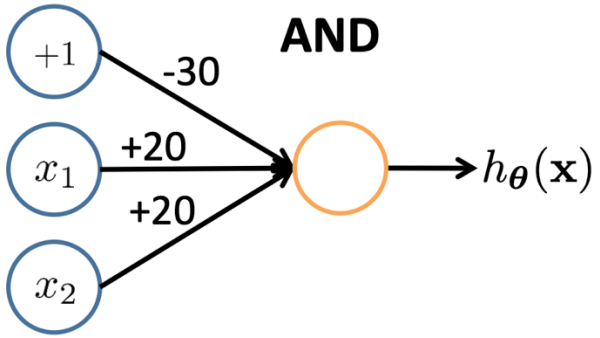
$$h_\Theta(\mathbf{x}) = g(-30 + 20x_1 + 20x_2)$$

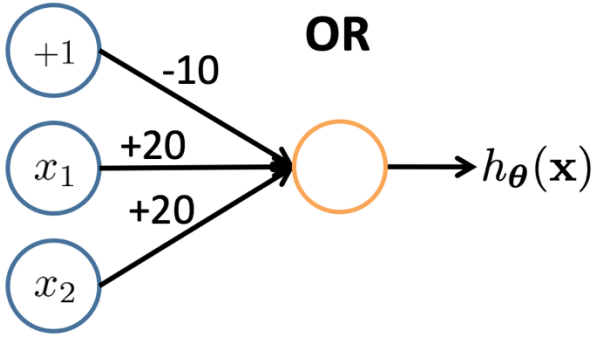
Logistic / Sigmoid Function

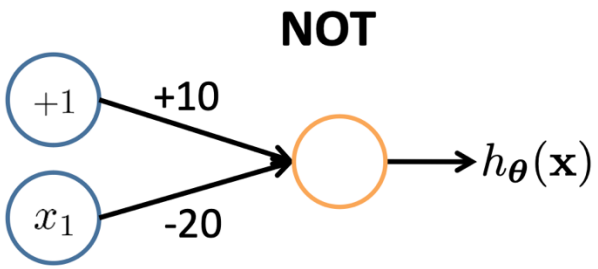


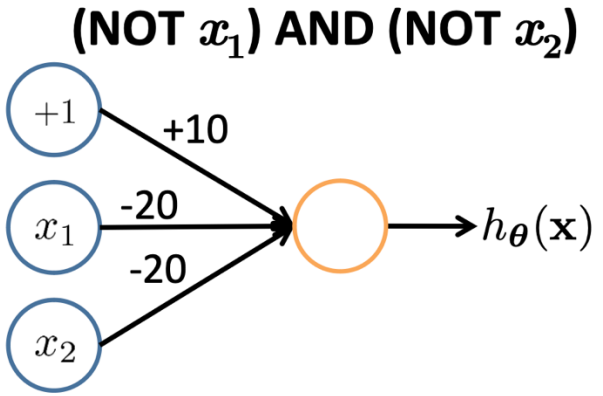
x_1	x_2	$h_\Theta(\mathbf{x})$
0	0	$g(-30) \approx 0$
0	1	$g(-10) \approx 0$
1	0	$g(-10) \approx 0$
1	1	$g(10) \approx 1$

MORE SIMPLE NEURAL NETWORKS

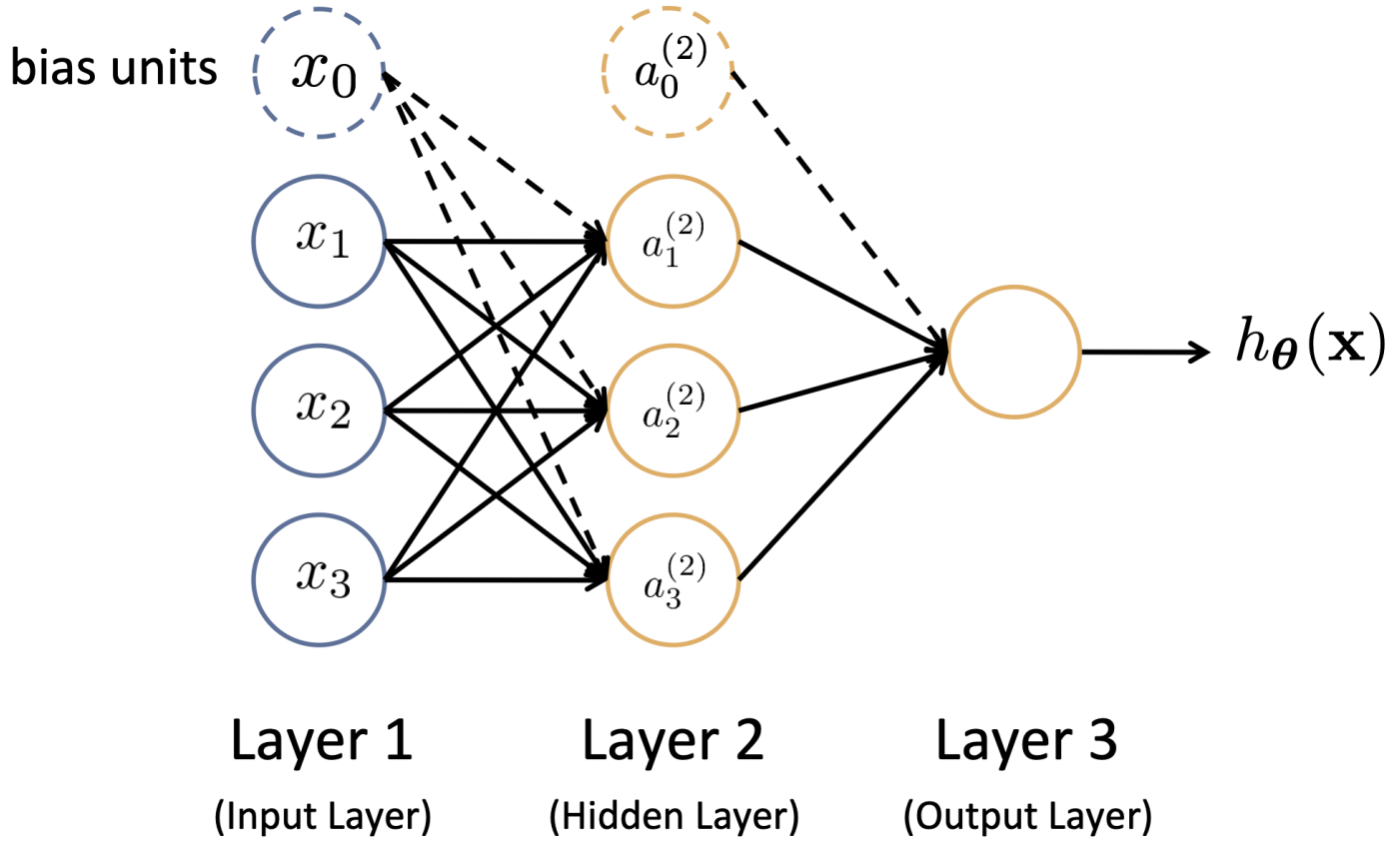




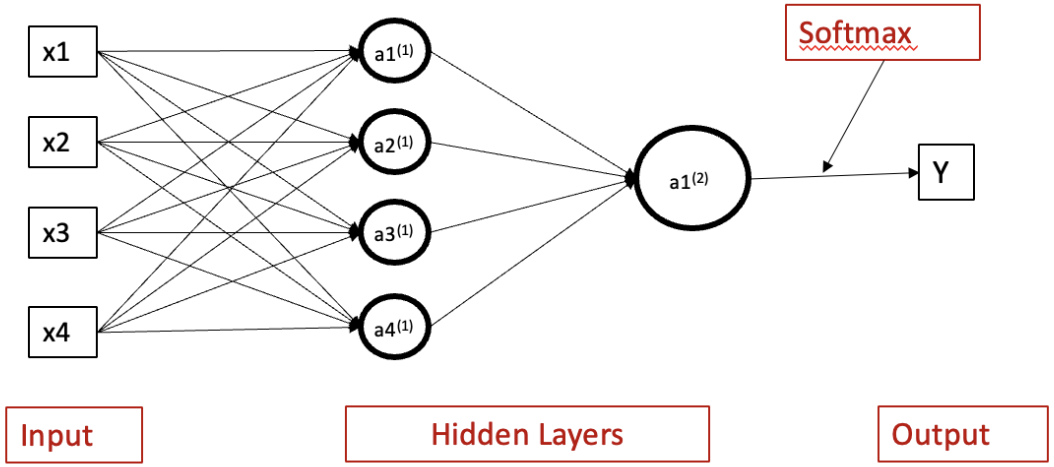




DEEP LEARNING: NEURAL NETWORK



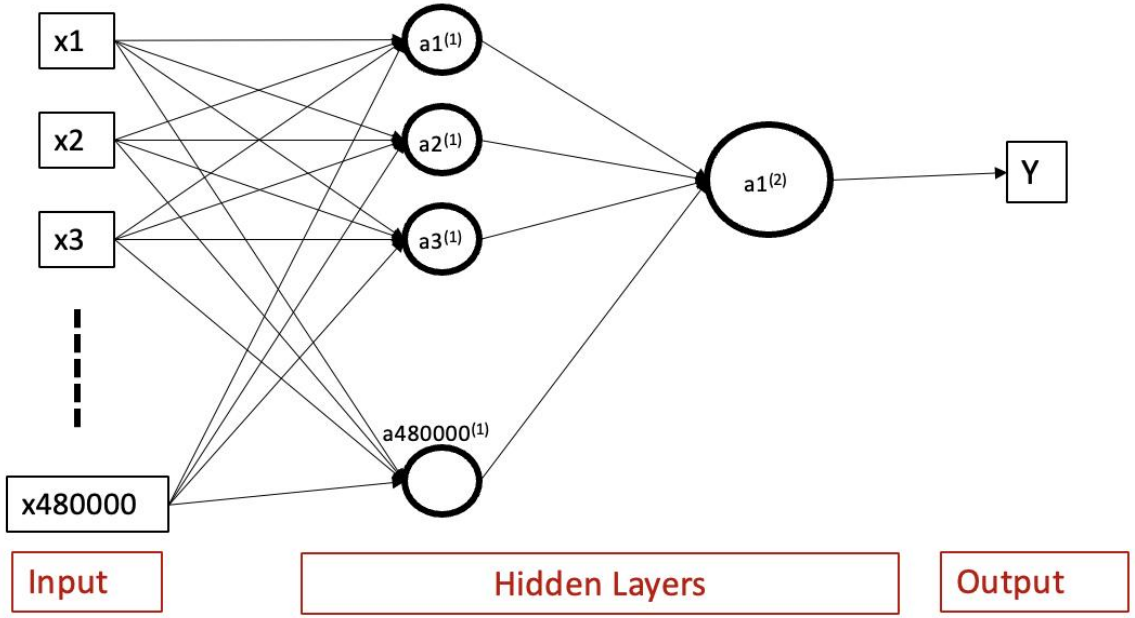
NUMBER OF PARAMETERS



$$4*4 + 4 = 20$$

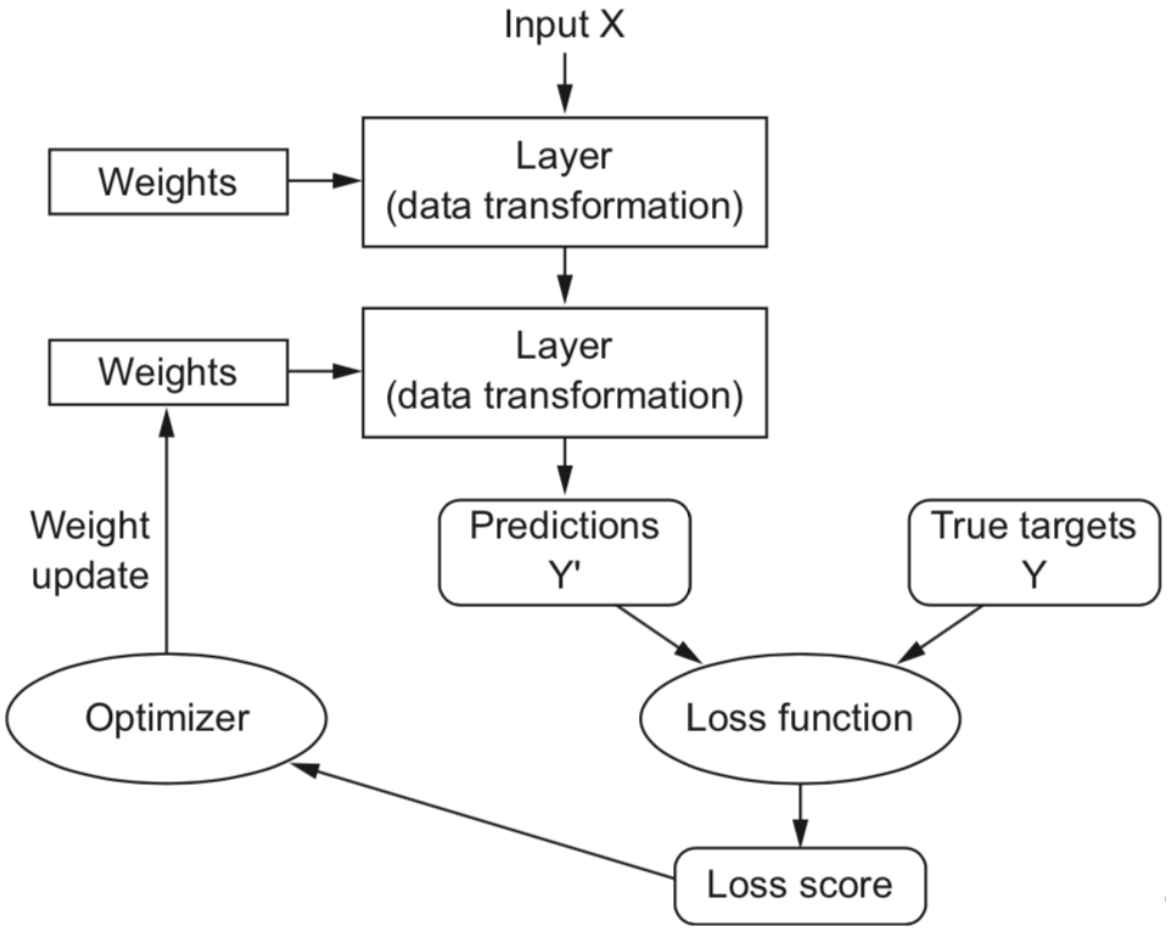
IF THE INPUT IS AN IMAGE?

400 X 400 X 3



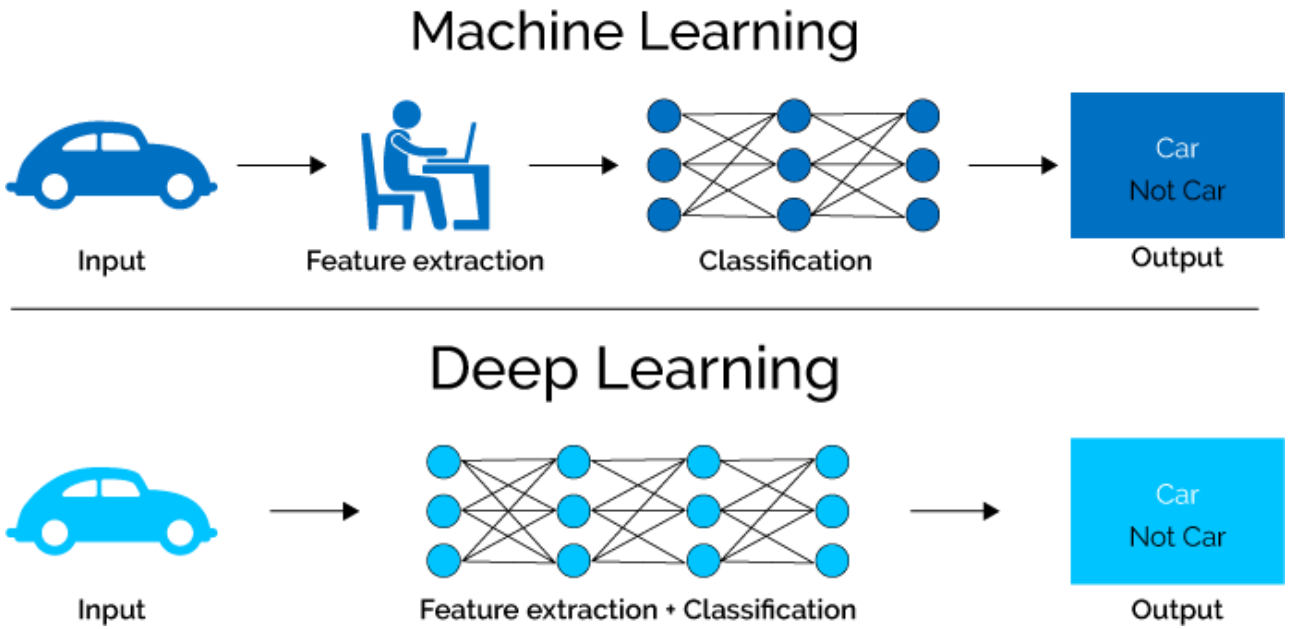
Number of Parameters
480000*480000 + 480000 = **approximately 230 Billion !!!**
480000*1000 + 1000 = approximately **480 million !!!**

DEEP NEURAL NETWORK: LEARNING!



DEEP LEARNING

- Subfield of ML for learning representations of data.
- Exceptional effective at learning patterns.
- Utilizes learning algorithms that derive meaning out of data by using a hierarchy of multiple layers that mimic the neural networks of our brain.
- If you provide the system tons of information, it begins to understand it and respond in useful ways.



GENERATIVE AI

GENERATIVE AI (R)EVOLUTION

DISRUPTIVE!

SINCE 2021-2022

A NEW HYPE?

GENERATIVE AI

NLP

or

Natural language processing

GPT

- Technology behind tool ChatGPT
- Based on Large Language model (LLM)
  - = deep neural network
- Is a language model!
  - does NOT know anything!
- Predicts the probability that the next or missing word is X given some previous and/or following words

Next-token-prediction

The model is given a sequence of words with the goal of predicting the next word.

Example:
Hannah is a ____

Hannah is a *sister*
Hannah is a *friend*
Hannah is a *marketer*
Hannah is a *comedian*

Masked-language-modeling

The model is given a sequence of words with the goal of predicting a 'masked' word in the middle.

Example
Jacob [mask] reading

Jacob *fears* reading
Jacob *loves* reading
Jacob *enjoys* reading
Jacob *hates* reading

GPT - ARCHITECTURE

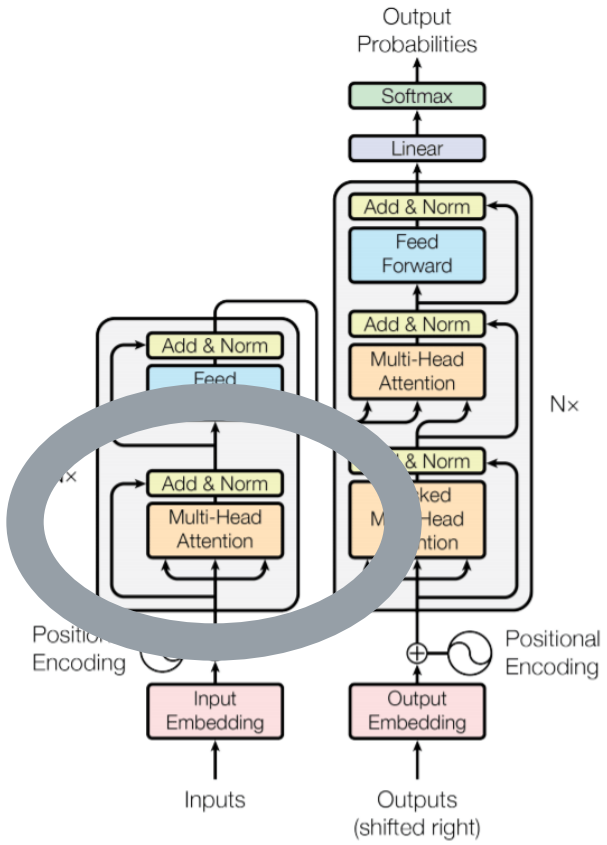
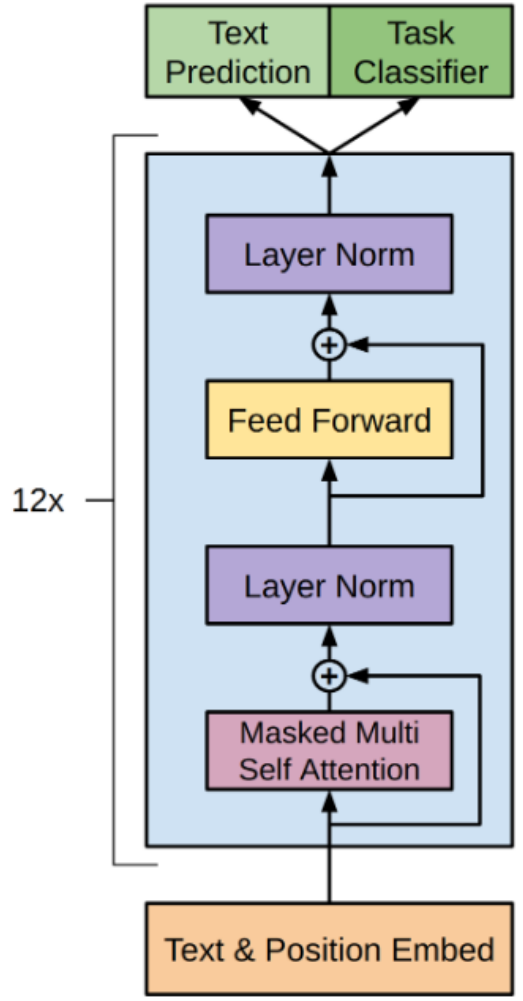
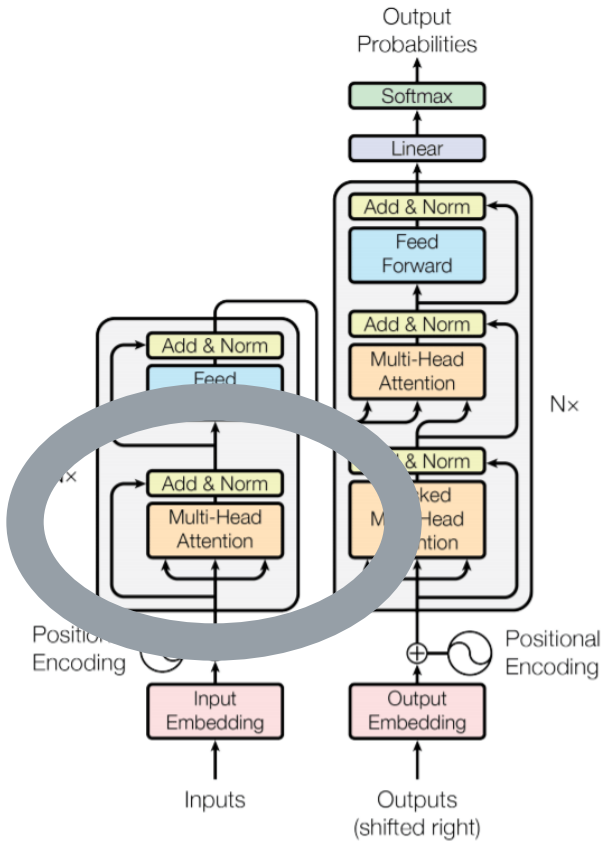


Figure 1: The Transformer - model architecture.



GPT - ARCHITECTURE



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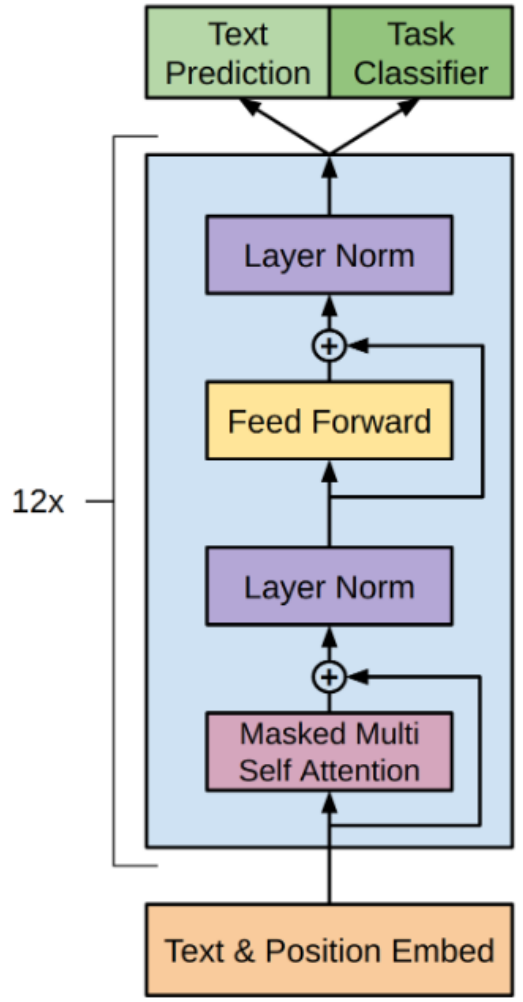
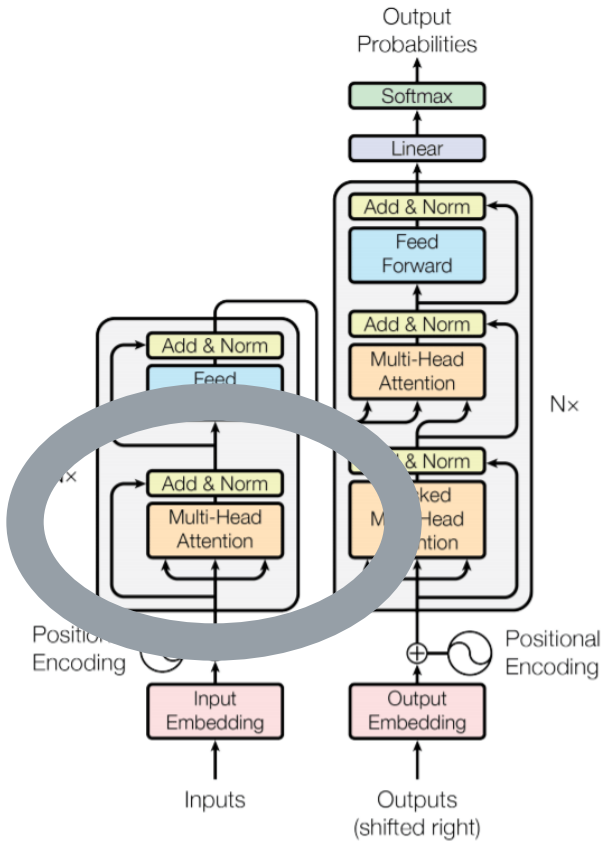


summary

GPT - ARCHITECTURE



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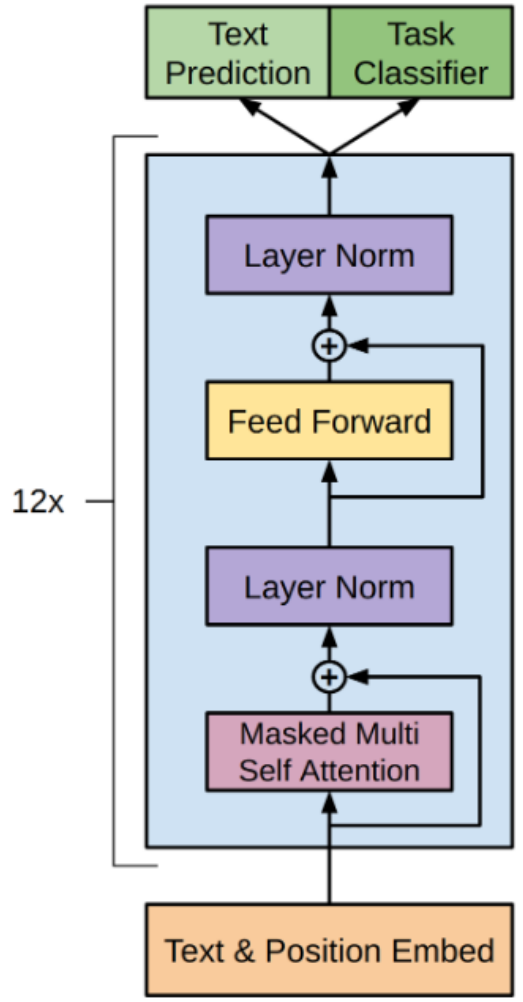
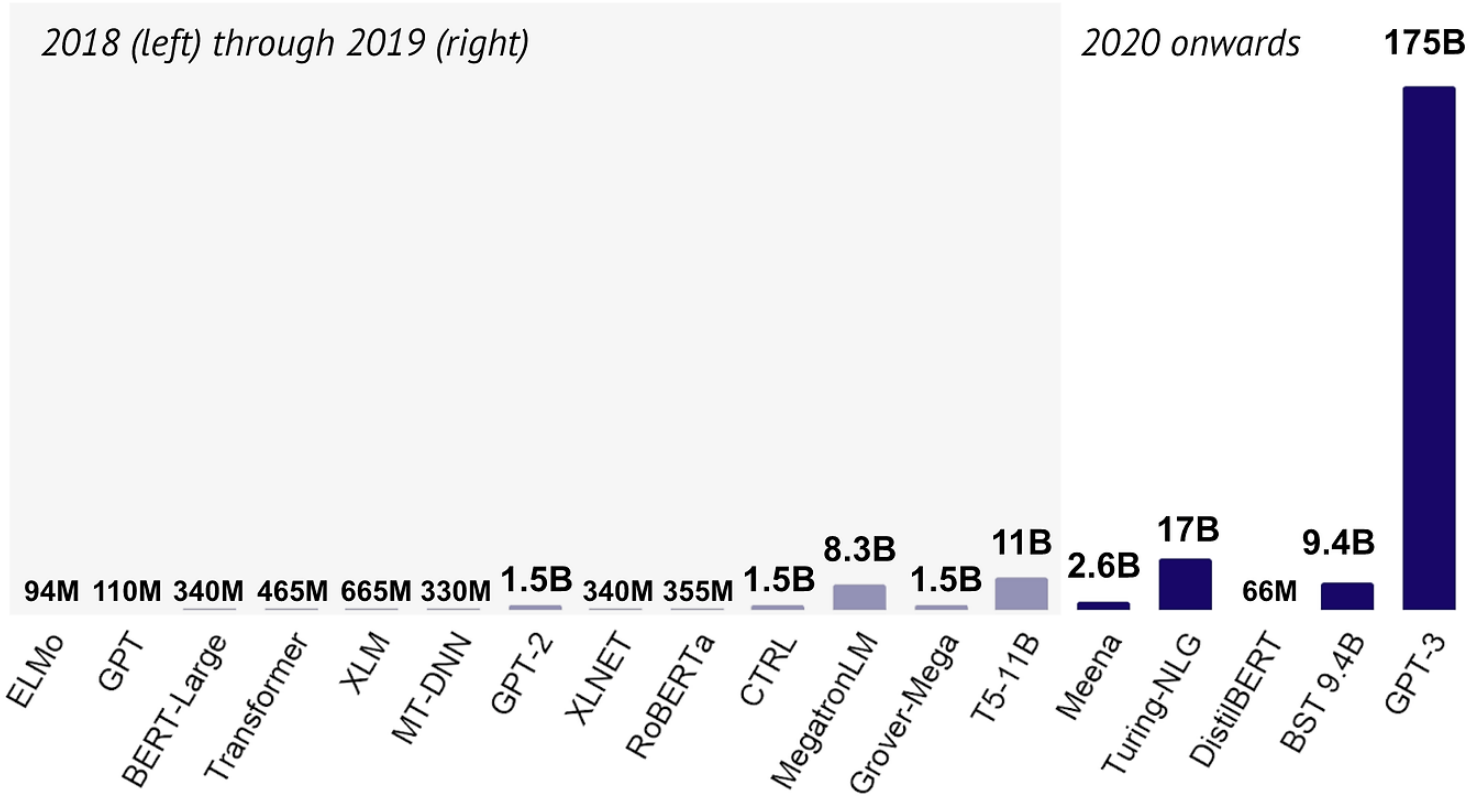


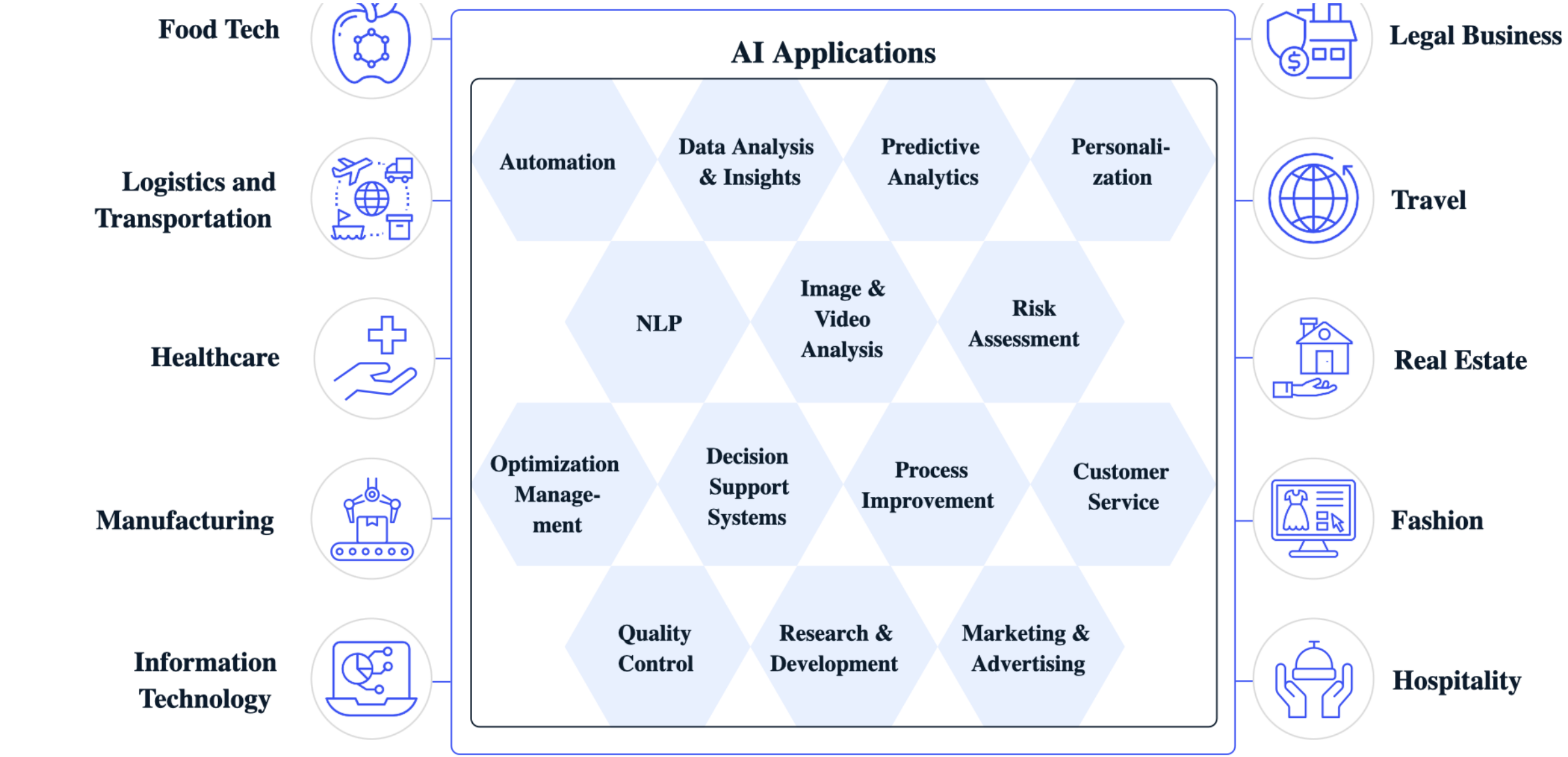
summary

GPT 3(.5) & GPT-4

- Latest improvements: more parameters!
- GPT-4: ~1.8 trillion parameters (over 10x more than GPT-3)



AI APPLICATIONS


Food Tech
Logistics and Transportation
Healthcare
Manufacturing
Information Technology
AI Applications
Automation
Data Analysis & Insights
Predictive Analytics
Personali-zation
NLP
Image & Video Analysis
Risk Assessment
Optimization Manage-ment
Decision Support Systems
Process Improvement
Customer Service
Quality Control
Research & Development
Marketing & Advertising
Legal Business
Travel
Real Estate
Fashion
Hospitality

AI IN HEALTH

PERSONALISED HEALTHCARE

ORGANISATION OF HEALTH

LOGISTICS IN HEALTH

AI IN HEALTH: KIDNEYAID

Acute Kidney failure (AKI):

- Sudden loss of kidney function, leading to the buildup of toxins, fluid imbalances, and disrupted waste removal
- Can cause life-threatening complications such as heart issues, infections, and long-term kidney damage.

Augmented Renal Clearance:

- a condition of excessive kidney filtration

Key Points:

- Critically ill (ICU) patients often face kidney complications like AKI and ARC.
- These complications lead to increased risk of mortality and long-term health issues.
- Predicting and managing kidney function early can save lives.

AI IN HEALTH: KIDNEYAID – NEED AND GOALS

- During ICU stay:
  - Need 1: Acute kidney injury (AKI) occurs in up to 57% of critically ill patients and increases mortality and morbidity.
    - Goal: Predicts the risk of AKI within the first week of ICU admission to enable early intervention and prevention.
  - Need 2: Augmented renal clearance (ARC), a condition of excessive kidney filtration, can lead to underdosing of medications like antibiotics, causing treatment failure.
    - Goal: Forecasts creatinine clearance daily to guide optimal drug dosing.
- Recovery and Long-Term Risk Models
  - Need 3: AKI survivors, especially those with severe cases (AKI stage 3), face high risks of mortality, chronic kidney disease (CKD), and dialysis dependency.
    - Goal: predict likelihood of kidney function recovery at discharge and risk of CKD and mortality at 3–6 months post-AKI.

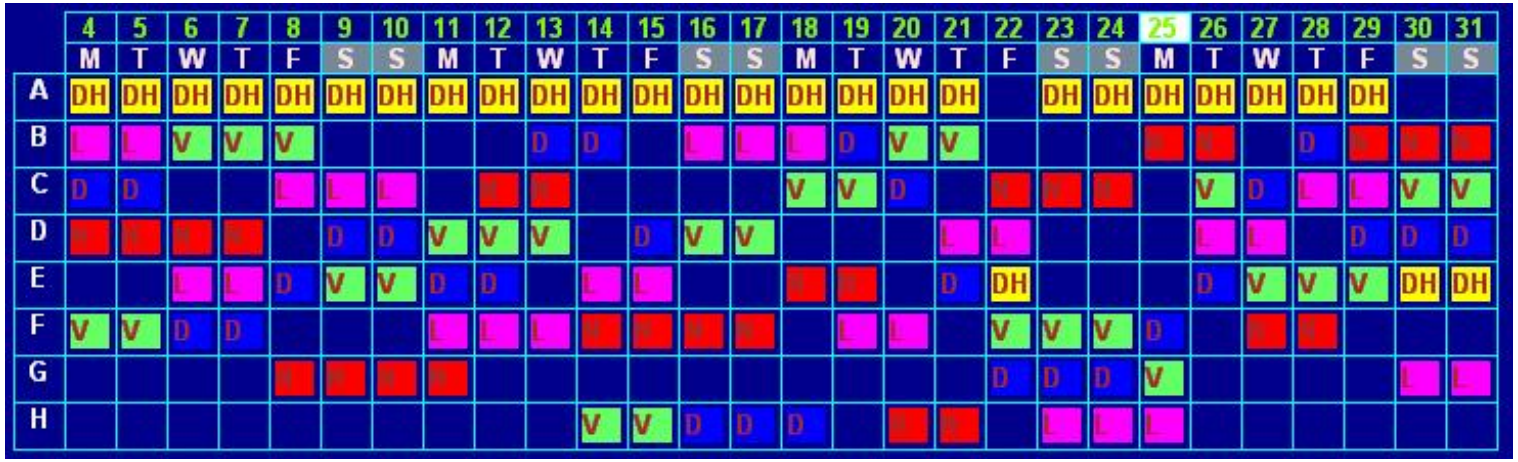
AI IN HEALTH: KIDNEYAID – PLAN

- Current situation:
  - KU Leuven, in cooperation with UZ Leuven and Z Groeninge have developed models that can meet the goals.
- What to do?
  - Create a tool or platform combining all the models
    - Integrate the models with current IT-systems in the hospitals
  - Test the tool in real hospitals, by clinicians
    - Further validation in clinical trials
    - Validate and refine the predictions
  - Work towards getting official certification (CE marking) for the tool → MDR!:
    - Allowing it to be used in hospitals worldwide
    - Collaborate with healthcare companies to make the tool widely available

TRL	1	2	3	4	5	6	7	8	9
Activity	Discovery & Research				Innovation			Commercialisation	
Description	basic principles observed	application formulated	experimental proof of concept	lab validation	(system or component) validation in relevant environment	demonstrator in relevant environment	system prototype demonstrated in operational environment	system complete and qualified (test & demo) in operational environment	actual system proven in operational environment

AI IN HEALTH: EMPLOYEE ROSTERING

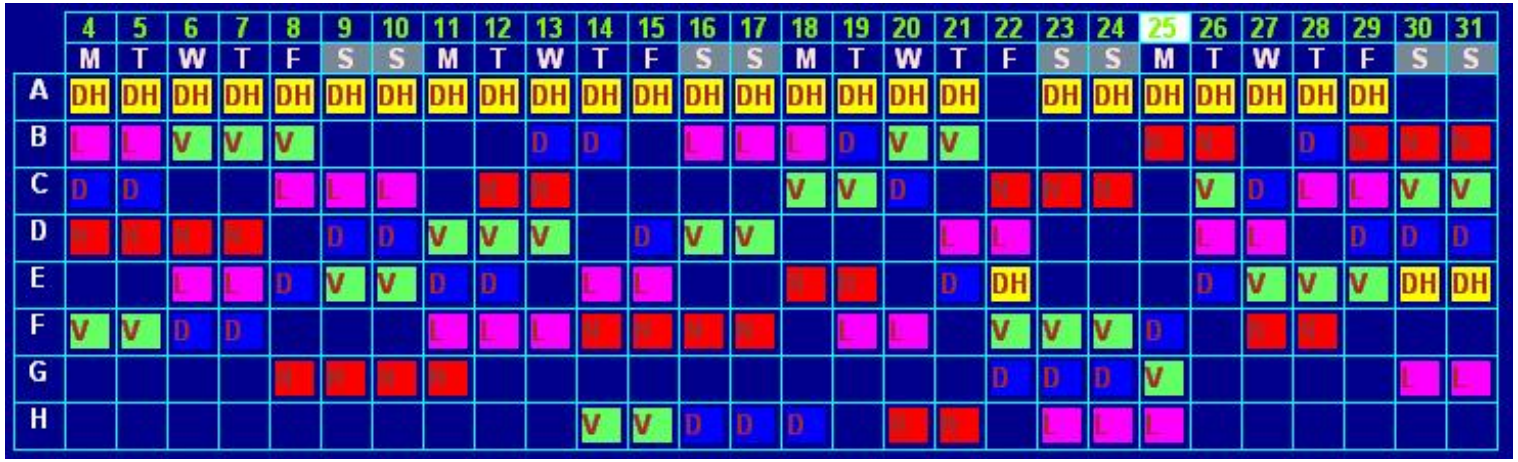
- Problem:
  - assignments of shifts to employees with a certain qualification
  - considering a large number of constraints and preferences



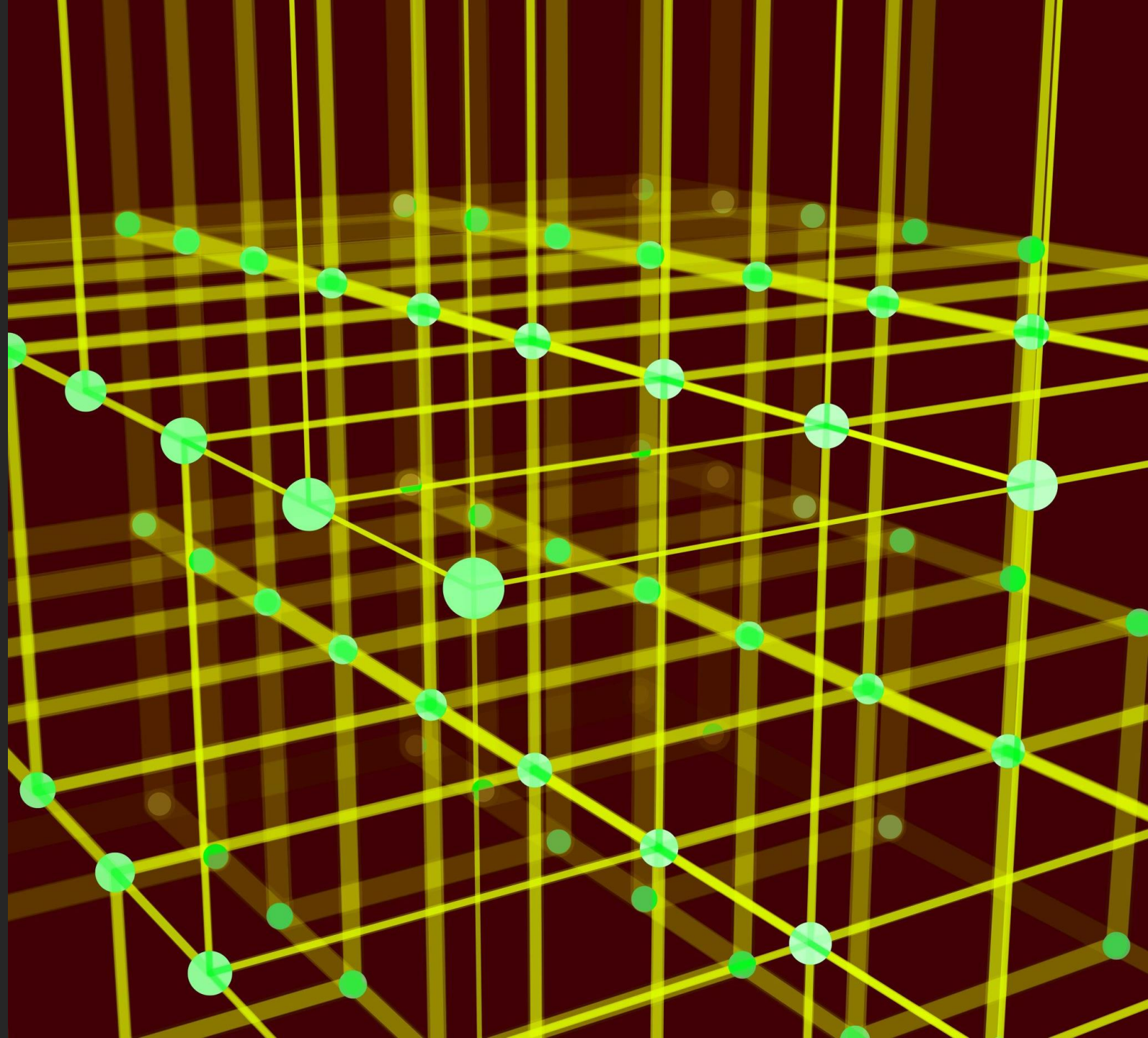
AI IN HEALTH: EMPLOYEE ROSTERING

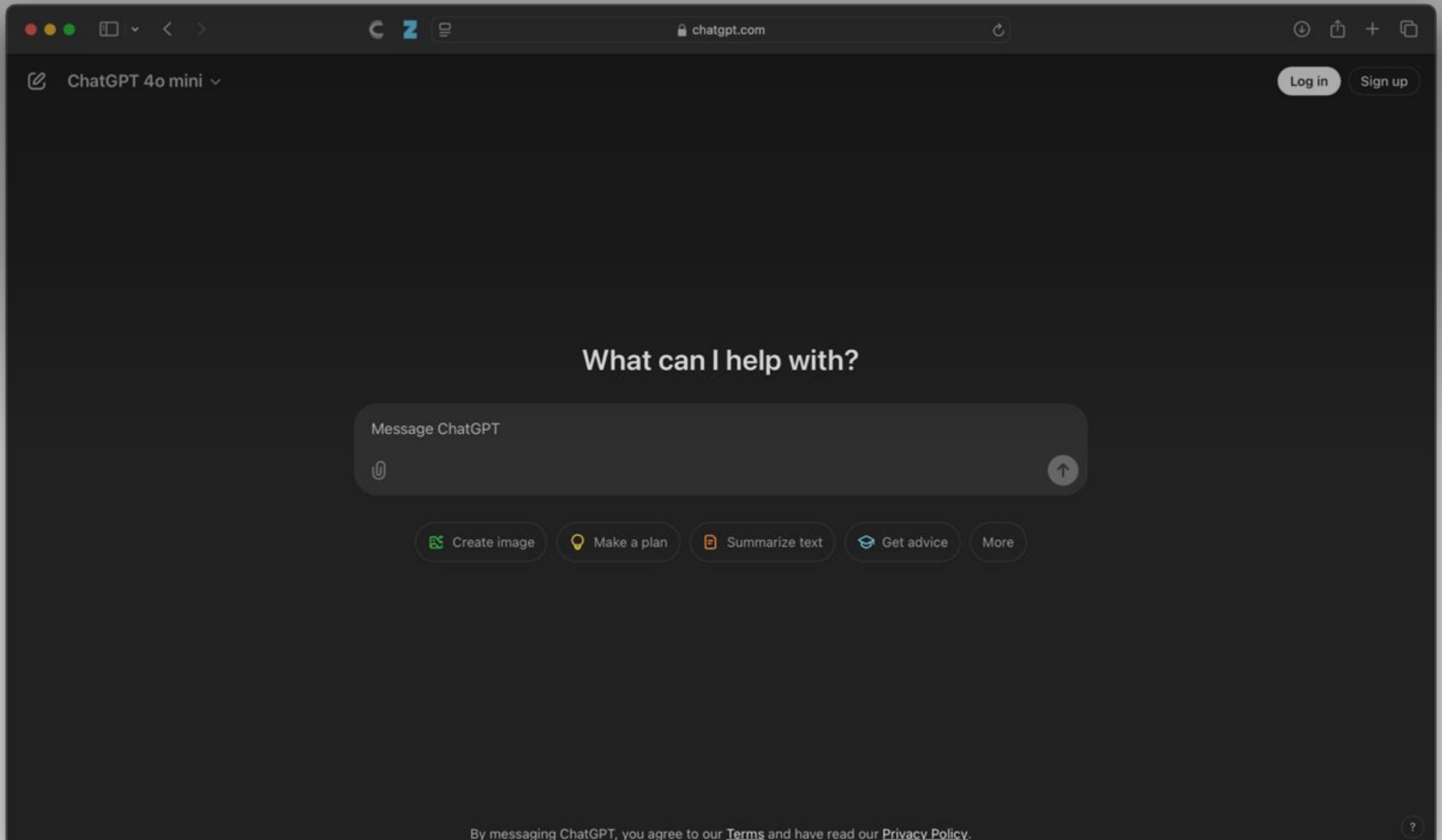
- Small example:
  - 4 shifts to schedule
  - 10 possible employees
  - 7 days

- Number of variations on 1 day = 5040
  - For 1 week: number of possible rosters = 5040^7 = 8,26e25
  - For 1 month: number of possible rosters = 5040^{30} = 1,18e111



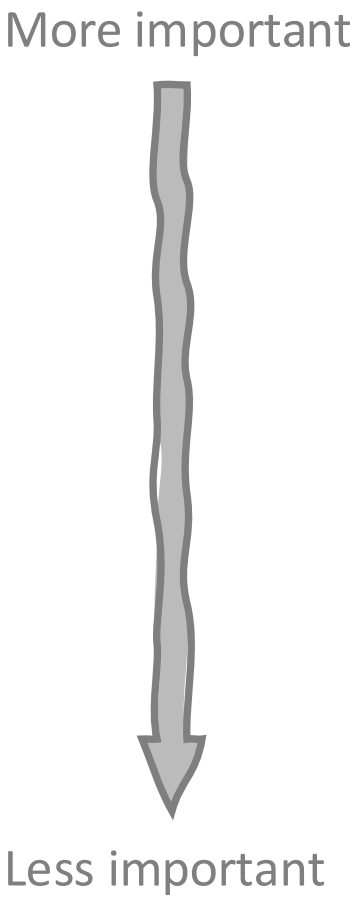
GEN AI - EXAMPLE



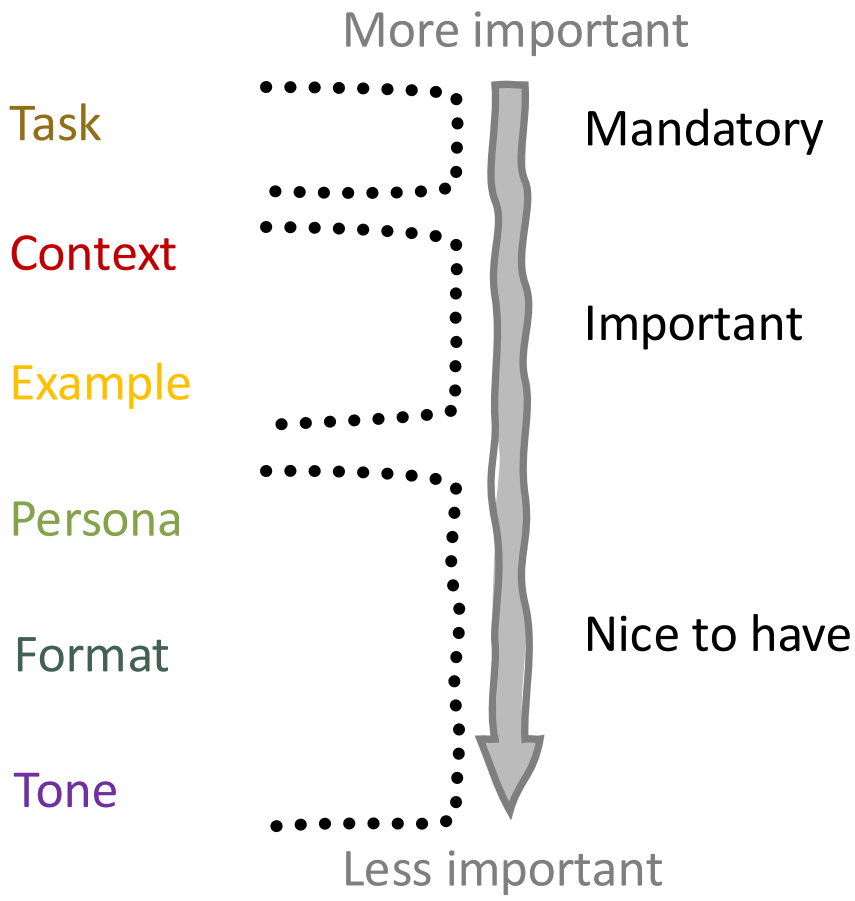

chatgpt.com
ChatGPT 4o mini
Log in
Sign up
What can I help with?
Message ChatGPT
Create image
Make a plan
Summarize text
Get advice
More
By messaging ChatGPT, you agree to our Terms and have read our Privacy Policy.

HOW TO PROMPT?

- NEW SKILL!



HOW TO PROMPT?



HOW TO PROMPT?

Task

Context

Example

Persona

Format

Tone

Provide a task:

- ❑ Generate
- ❑ Give
- ❑ Write
- ❑ Analyze
- ❑ Create
- ❑ …

Create a step plan?

HOW TO PROMPT?

Task

Context

Example

Persona

Format

Tone

Limit the endless possibilities:

- ❑ User background
- ❑ Purpose
- ❑ Limitations
- ❑ ….

I'm teaching about how-to-prompt for people with average AI knowledge to improve their prompting. Create a step plan?

HOW TO PROMPT?

Task

Context

Example

Persona

Format

Tone

Give an example:

- ❑ Reasoning process
- ❑ I accomplished X with the help of Y that resulted in Z
- ❑ STAR answer method (Situ, Task, Action, Results)
- ❑ Company format
- ❑ Style from pictures
- ❑ ….

I'm teaching about how-to-prompt for people with average AI knowledge to improve their prompting skills . Create a step plan by using the STAR method.

HOW TO PROMPT?

Task

Context

Example

Persona

Format

Tone

I'm teaching about how-to-prompt for people with average AI knowledge to improve their prompting skills . Create a step plan by using the STAR method. Answer as if you were a professor.

Who you want the AI to be:

- ❑ Which style of answer?
- ❑ Level of difficulty
- ❑ Which background (healthcare?)
- ❑ ….

HOW TO PROMPT?

Task

Context

Example

Persona

Format

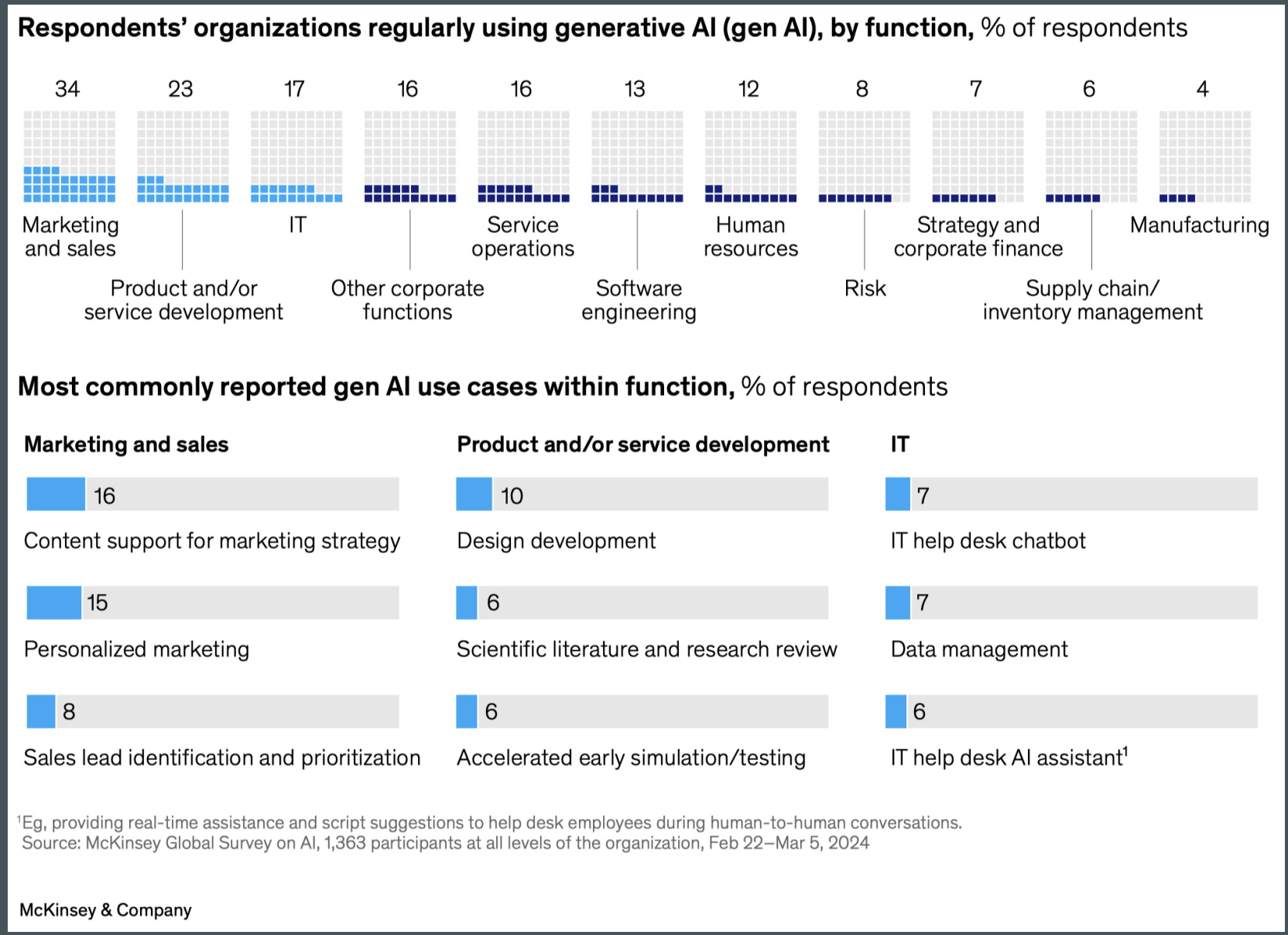
Tone

I'm teaching about how-to-prompt for people with average AI knowledge to improve their prompting skills . Create a step plan by using the STAR method. Answer as if you were a crazy enthusiastic professor. Output it with the help from examples in short bulletpoints.

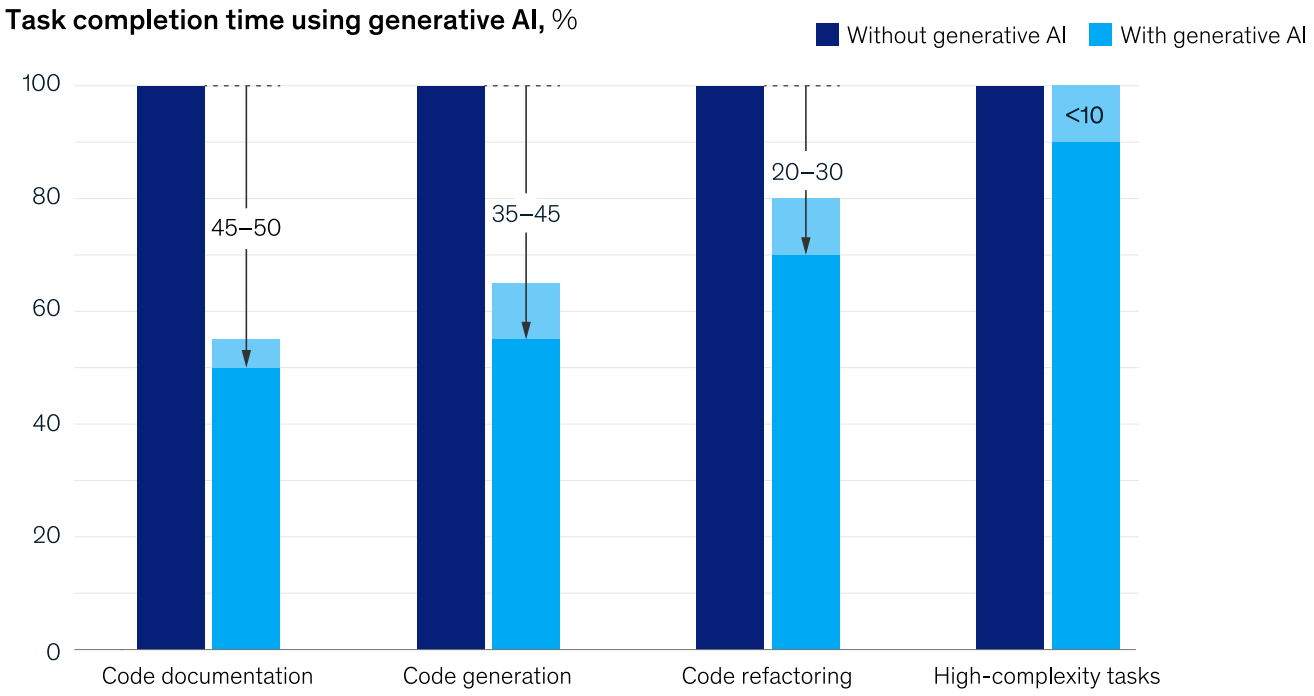
How does it need to sound:

- ❑ Formal / Casual tone of voice
- ❑ Pessimistic or Enthusiasm
- ❑ ….

GENERATIVE AI USE CASES



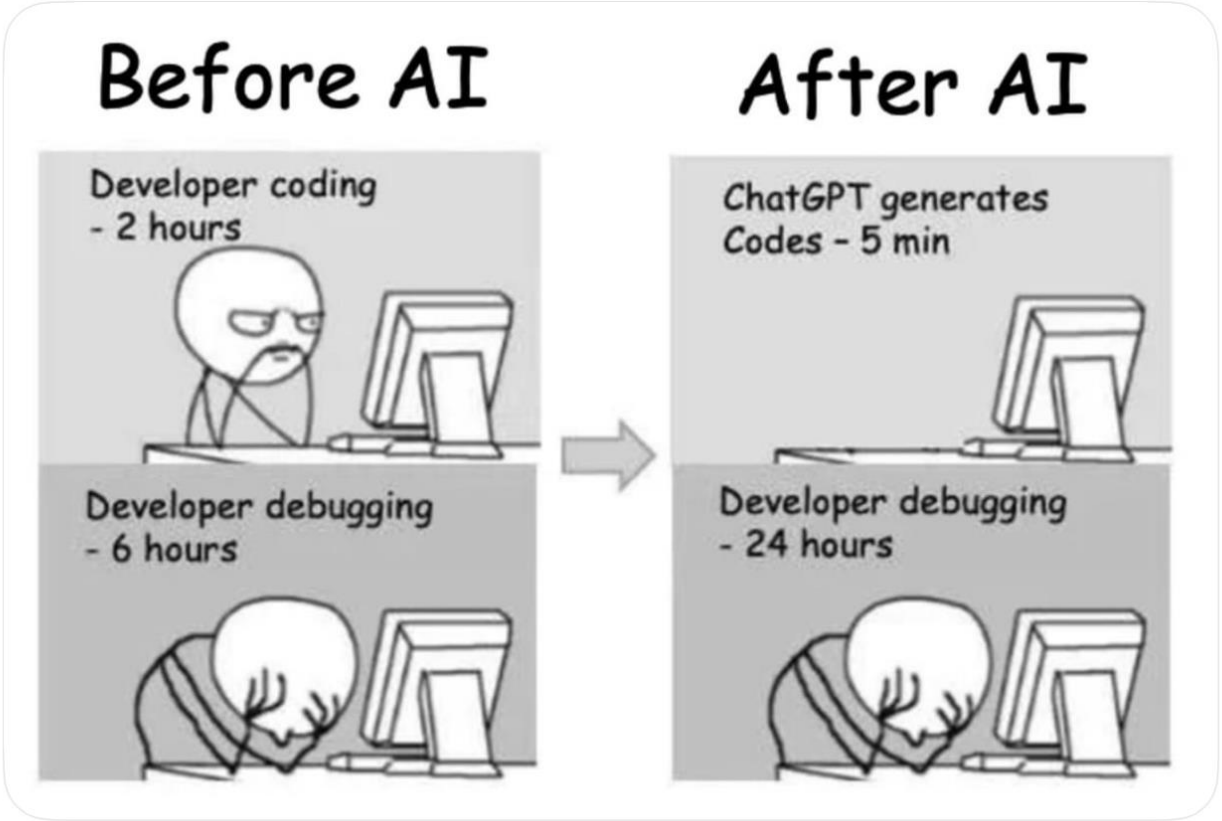
Generative AI can increase developer speed, but less so for complex tasks.



McKinsey & Company

IMPACT OF GEN AI ON JOBS

PROGRAMMING, E.G. COPILOT



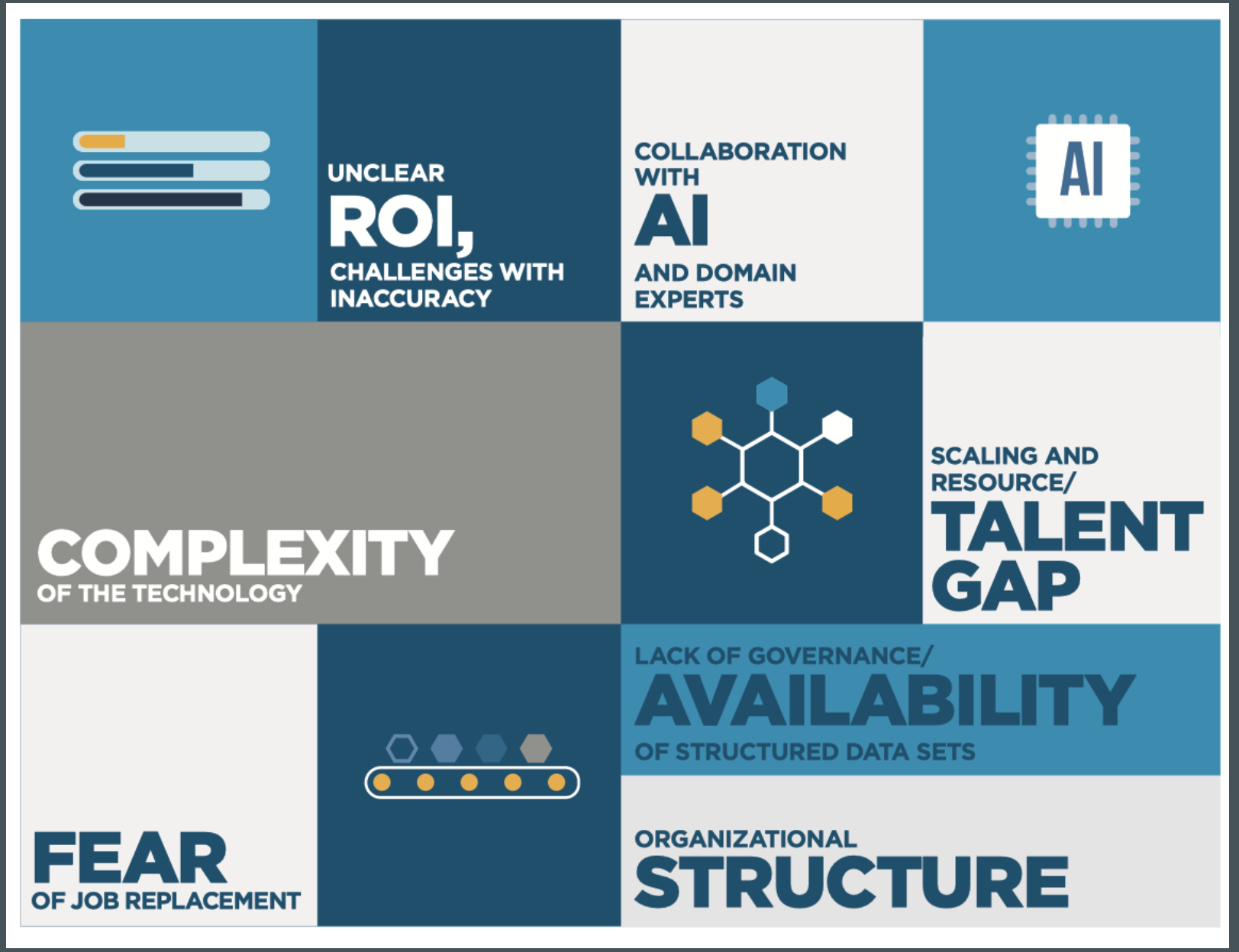
IMPACT OF GEN AI ON JOBS

PROGRAMMING, E.G. COPILOT

"AI WON'T REPLACE HUMANS — BUT HUMANS WITH AI WILL REPLACE HUMANS WITHOUT AI"

PROF. KARIM LAKHANI, HARVARD BUSINESS SCHOOL

BARRIERS FOR AI IMPLEMENTATION



SUCCESSFUL ADOPTION OF AI

80% OF THE PROJECTS FAIL

PROBLEM IS NOT THE TECHNOLOGY

PROBLEM IS THE STARTING POINT

WHAT CAN GO WRONG?

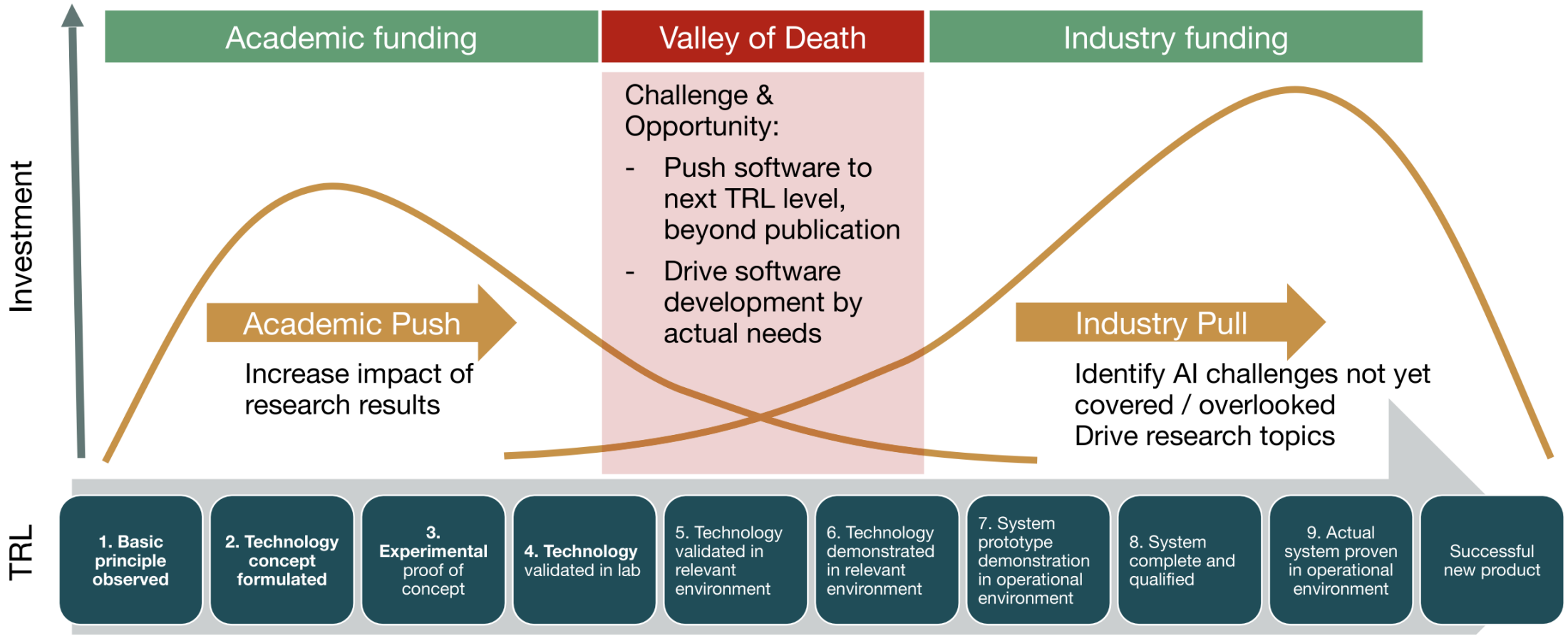
- Insufficient data
- Inferior data quality and governance
- Issues with data
- Unrealistic expectations
- ROI too low
- Resistance by humans

ROI

RESISTANCE BY HUMANS

WAYMO

INNOVATION GAP



HOUSE OF AI @ FLAX - VIVES

- experience centre on AI
- low-barrier, collective and broad dissemination


THE END