# Tehisintellekt: sissejuhatus

- Orientatsioon
- Tehisintellekti tüübid ja valdkonnad
- Hübriidsüsteemid
- Robotid
- Filosoofia ja prognoosid
- Keelemudelite rakendamise hetkeseis

# Orientatsioon

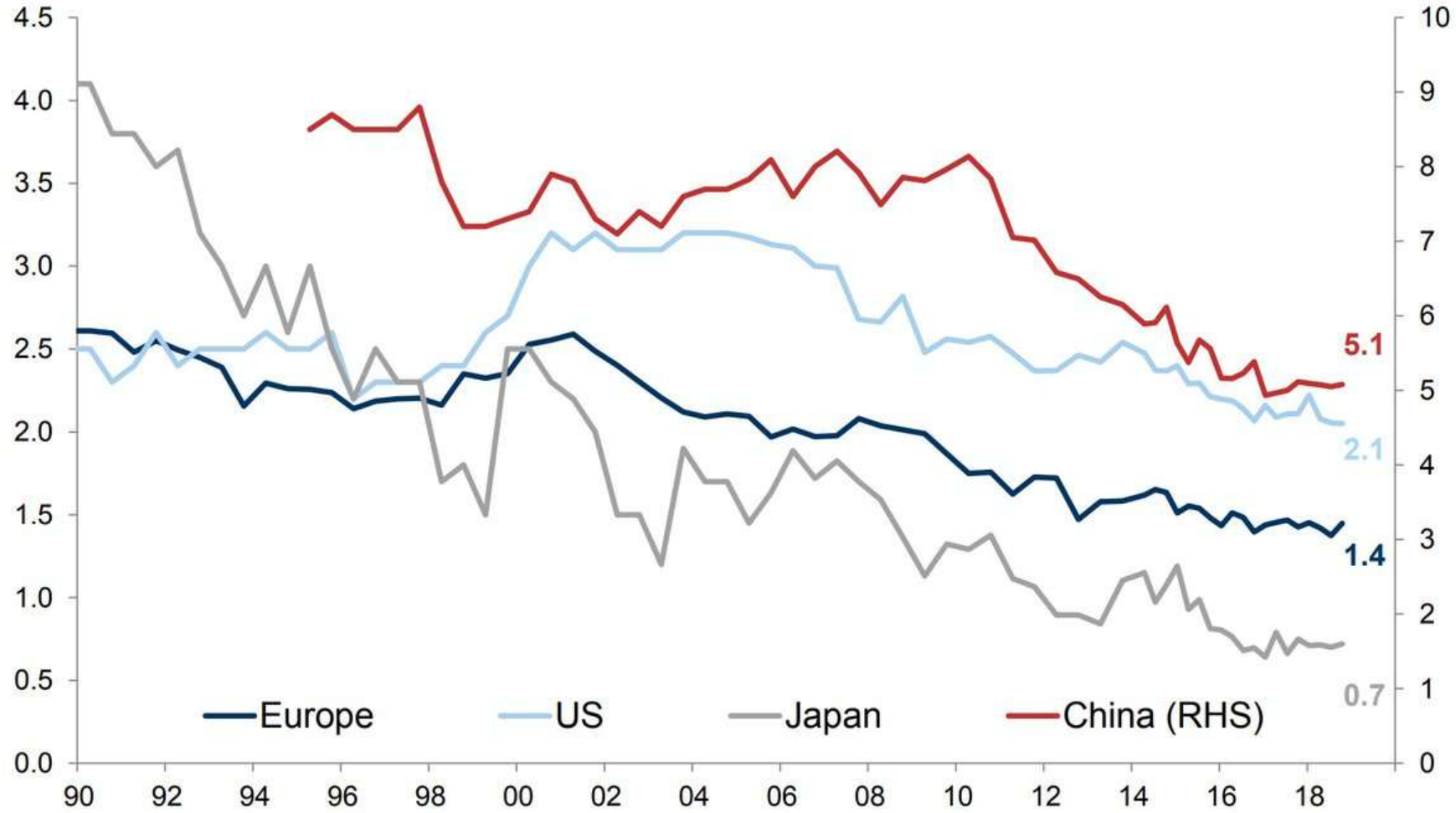
*Marc Andreessen:*

Software Is Eating the World

*Paradoks:*

IT ei ole sel sajandil globaalmajandust oluliselt efektiivistanud: vastupidi, GDP kasvutempo on pikaajalises langustrendis.

**Exhibit 8: Long-term real global GDP growth forecast is at a historical low**
Long-term (6-10y) GDP growth from Consensus Economics




Source: Consensus Economics, Goldman Sachs Global Investment Research

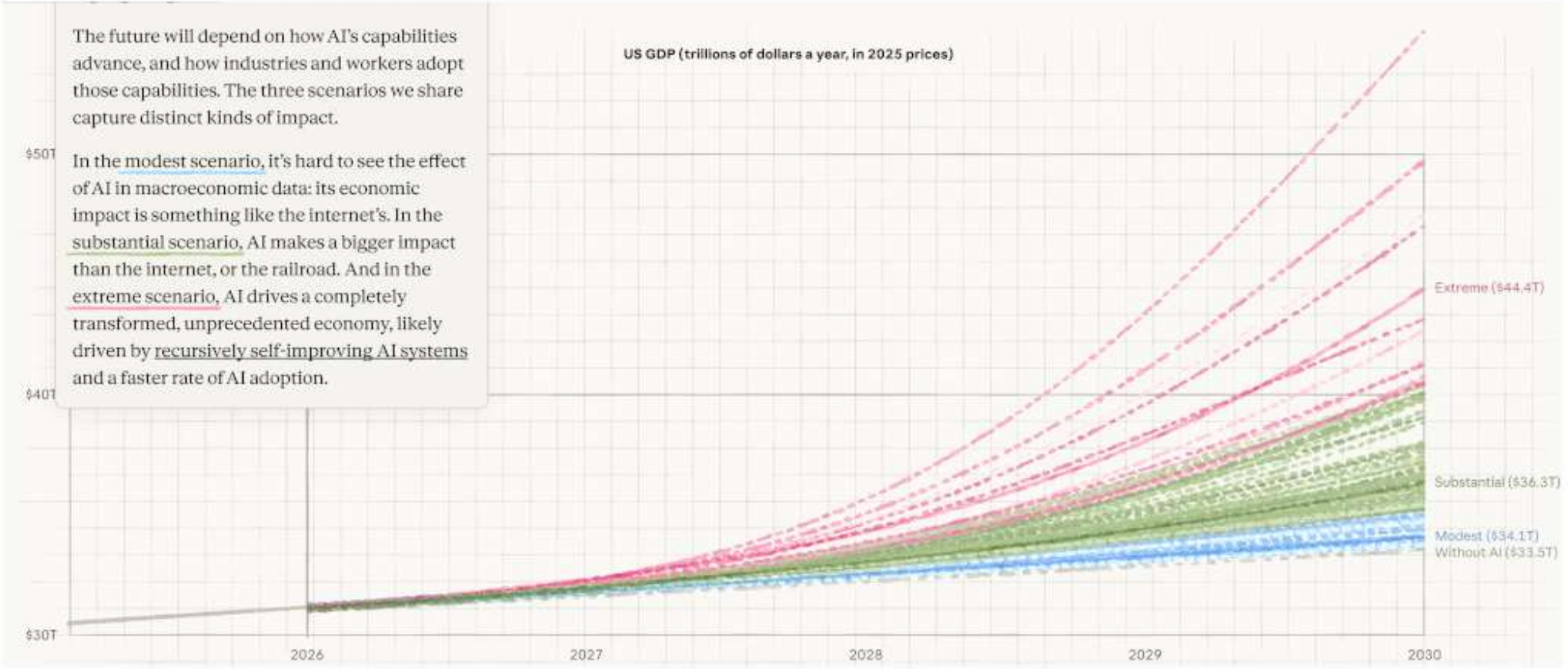
*IT globaalne probleem ja lootus*

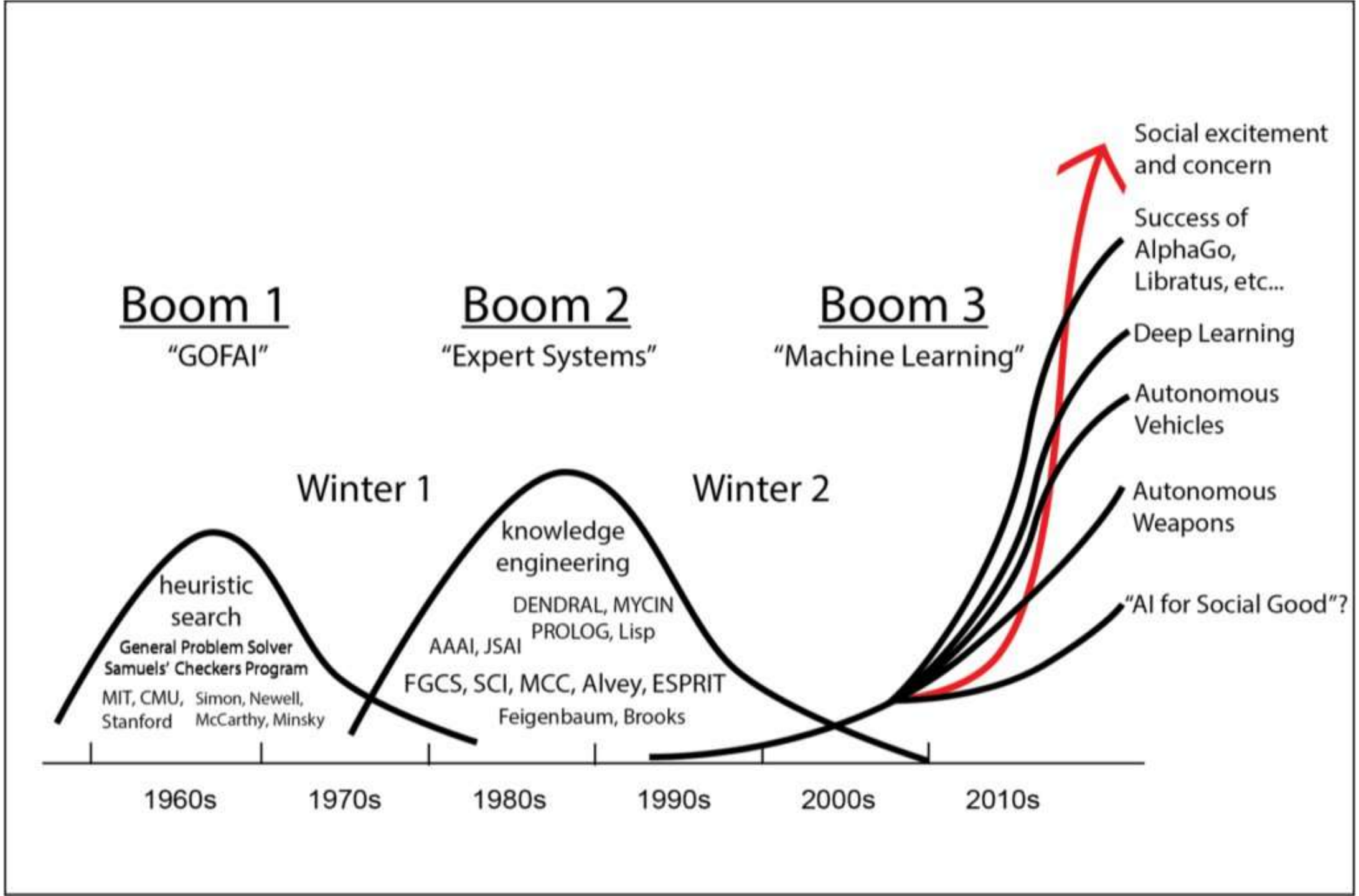
Tööprotsesside automatiseerimine on siiani olnud väga raske:  tarkvara ehitamine on olnud aeglane ja kallis.

Praegu aitavad tehismõistuse tehnoloogiad mh palju efektiivsemalt ehitada automatiseerimis-tarkvara.

Oleme protsessis, kus tava-tarkvara ehitamise asemel saab üha enam töid automatiseerida otse LLMdele antavate ülesannete + taustainfo abil.

# Anthropic: optimistlikud ennustused 2026 september




Boom 1
"GOFAI"
Boom 2
"Expert Systems"
Boom 3
"Machine Learning"
Winter 1
Winter 2
heuristic search
General Problem Solver
Samuels' Checkers Program
MIT, CMU, Stanford
Simon, Newell, McCarthy, Minsky
knowledge engineering
DENDRAL, MYCIN
PROLOG, Lisp
AAAI, JSAI
FGCS, SCI, MCC, Alvey, ESPRIT
Feigenbaum, Brooks
Social excitement and concern
Success of AlphaGo, Libratus, etc...
Deep Learning
Autonomous Vehicles
Autonomous Weapons
"AI for Social Good"?
1960s
1970s
1980s
1990s
2000s
2010s

# Tehisintellekti tüübid ja valdkonnad

*Kolm suuremat A.I. meetodite valdkonda:*

- Simulatsioonid

  tegevuse tulemuste ja valdkondliku reaalsuse kiire prognoosimine a la FPS, digitaalsed kaksikud

- Otsing (sümbol-A.I.)

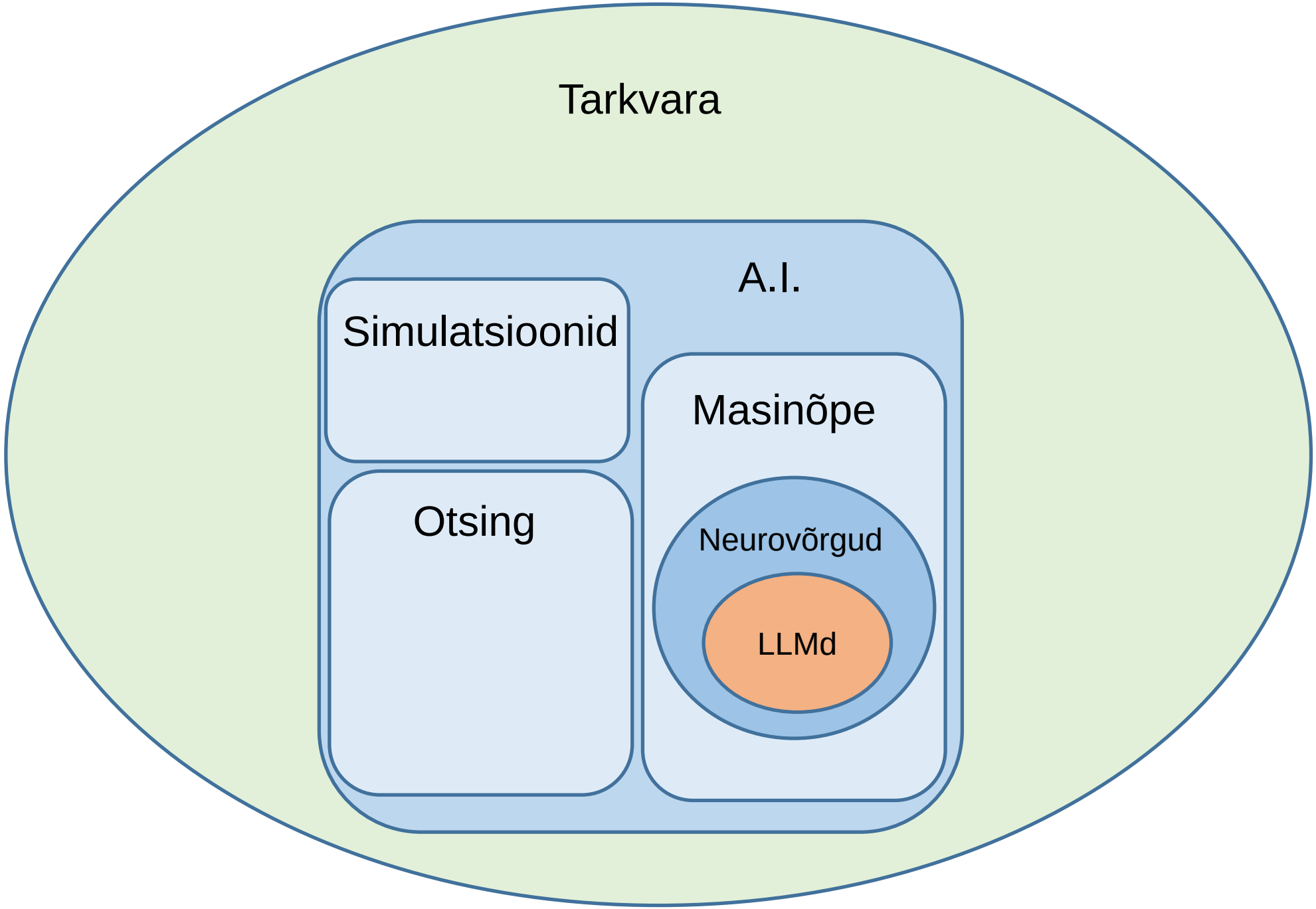
  paljude variantide seast a la malemäng, matemaatikatõestus,

  teekonna optimeerimine, planeerimine jne.

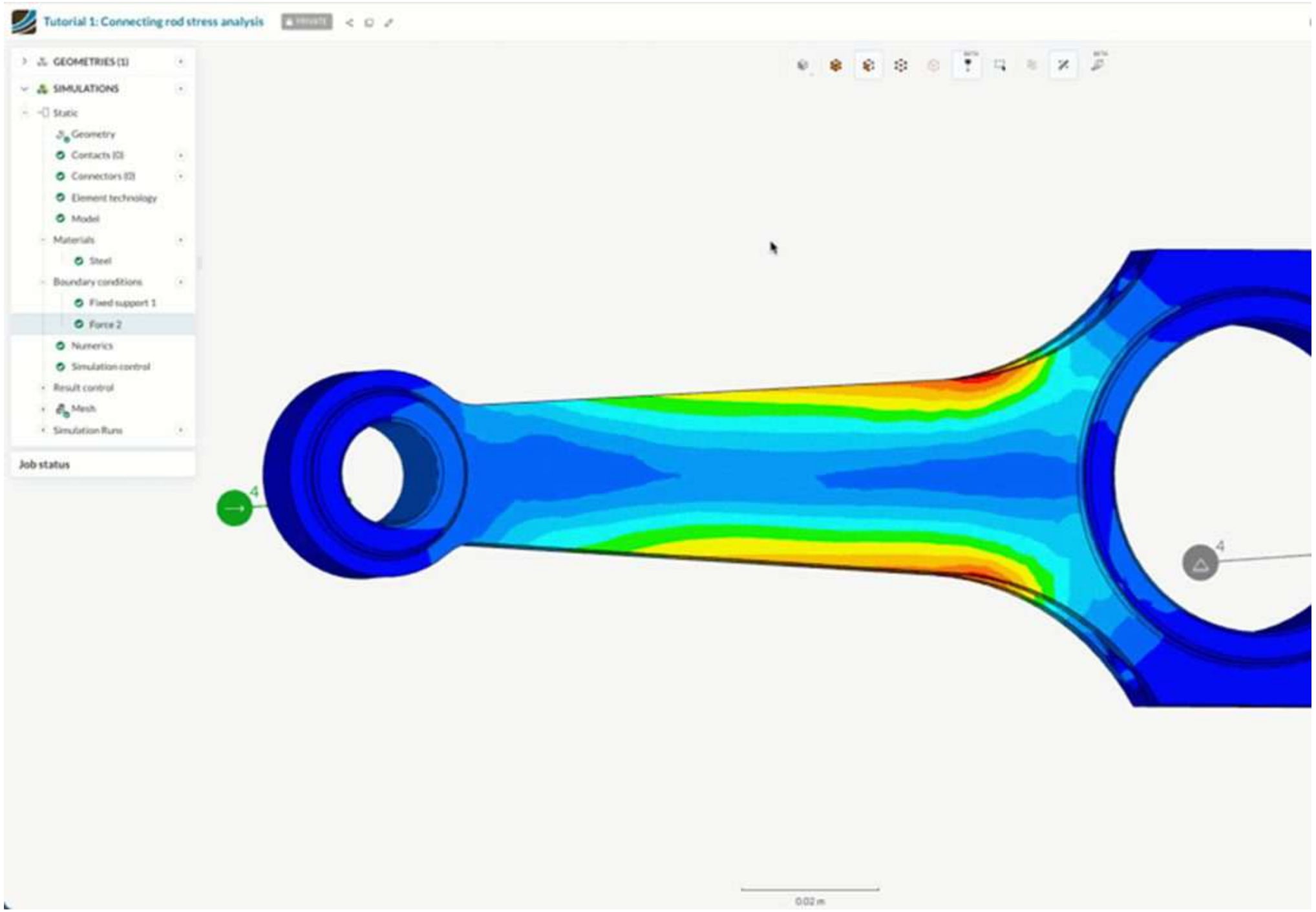
- Masinõpe (“neuro”-A.I.)

  näidetelt üldistamine, a la objektide äratundmine pildilt, deepfake,

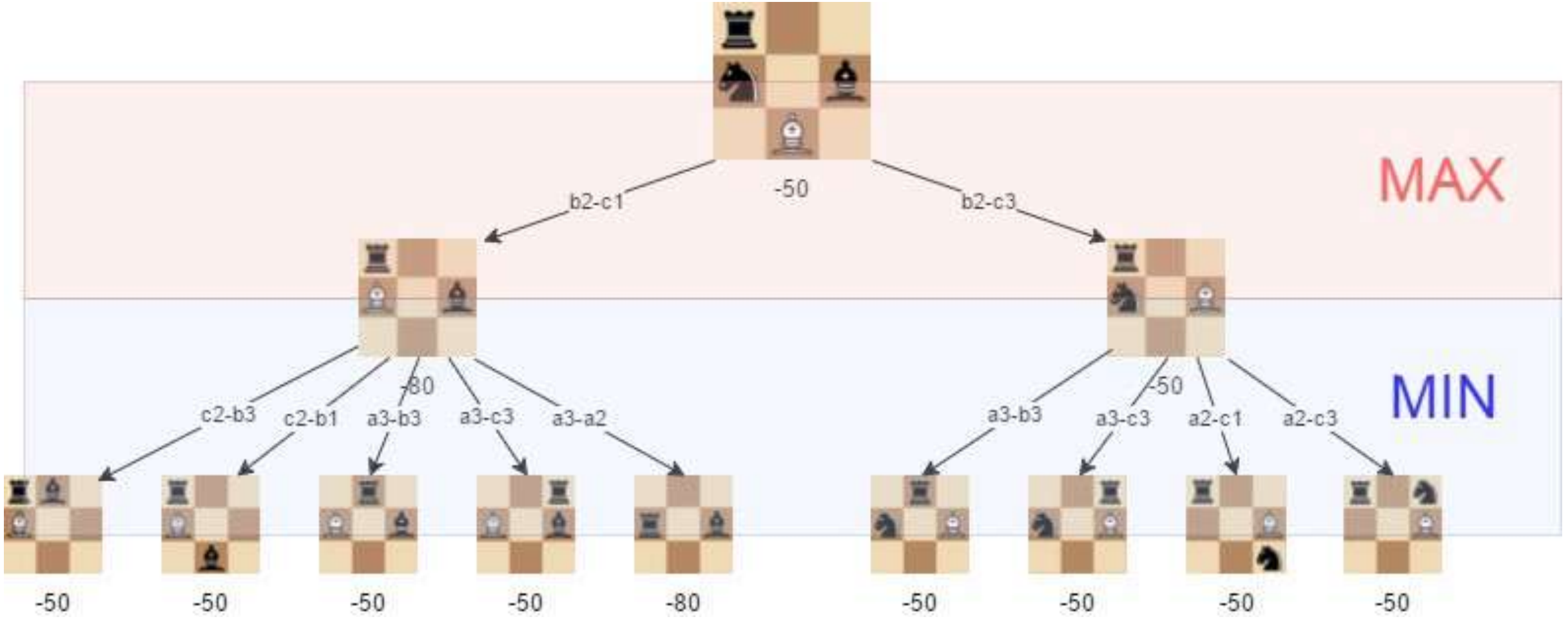
  aegridadelt ennustamine, suured keelemudelid (LLM) GPT, LLaMA, Claude jne.

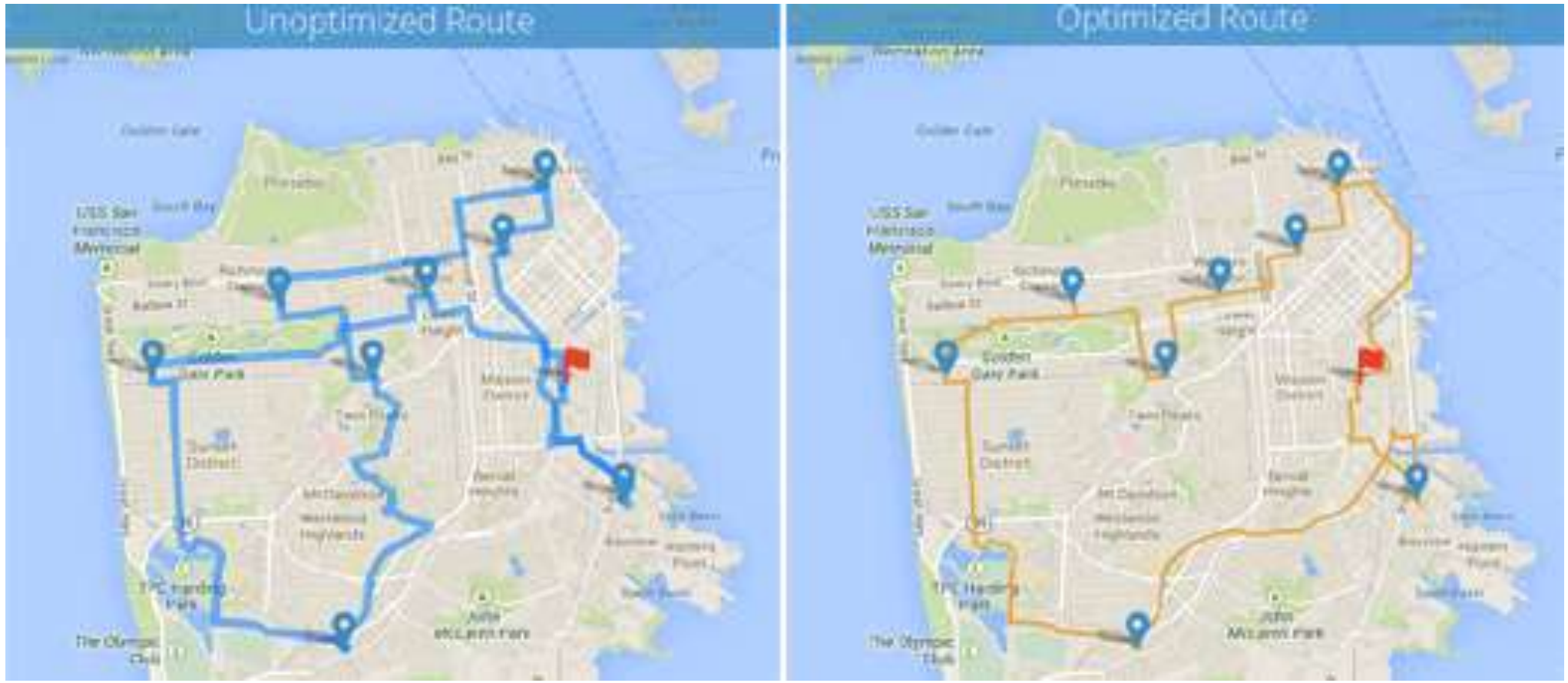

Tarkvara
A.I.
Simulatsioonid
Masinõpe
Otsing
Neurovõrgud
LLMd

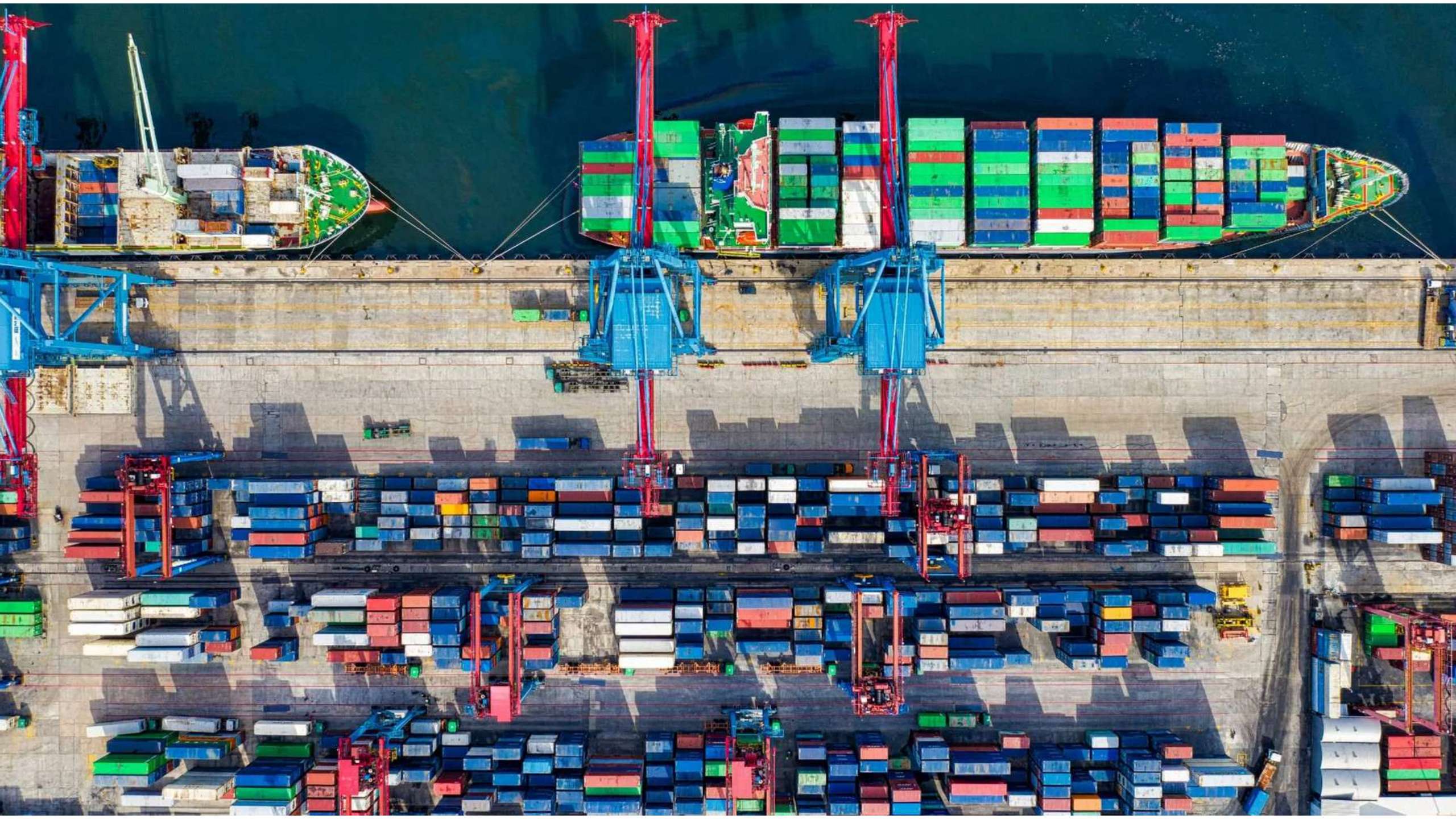

CAPTURE THE FLAG!
22:37
GEORGE JOINED THE GAME
73%
73%


Tutorial 1: Connecting rod stress analysis
GEOMETRIES (1)
SIMULATIONS
Static
Geometry
Contacts (0)
Connectors (0)
Element technology
Model
Materials
Steel
Boundary conditions
Fixed support 1
Force 2
Numerics
Simulation control
Result control
Mesh
Simulation Runs
Job status
4
4
0.02 m

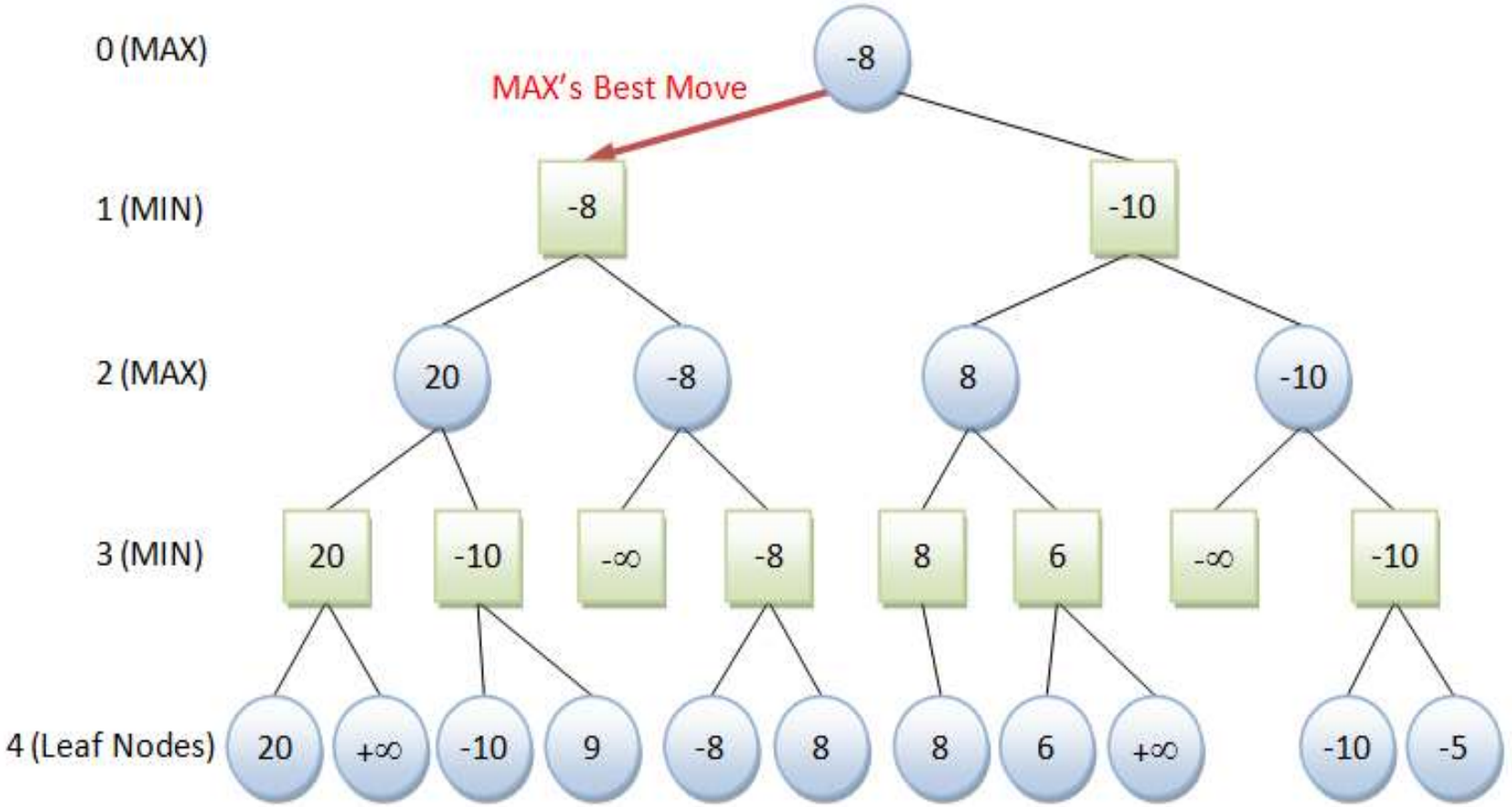
# *Otsing variantide hargnevast puust*



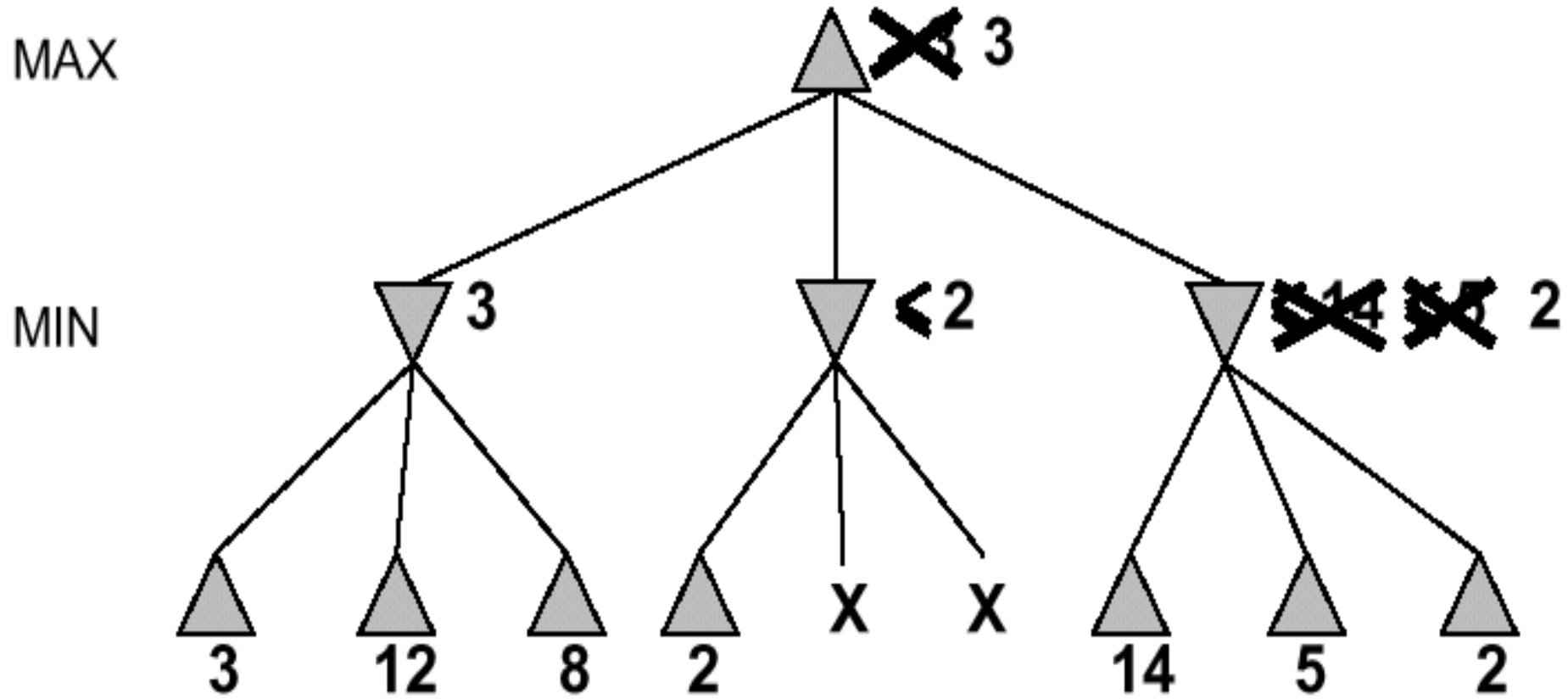

Unoptimized Route
Optimized Route



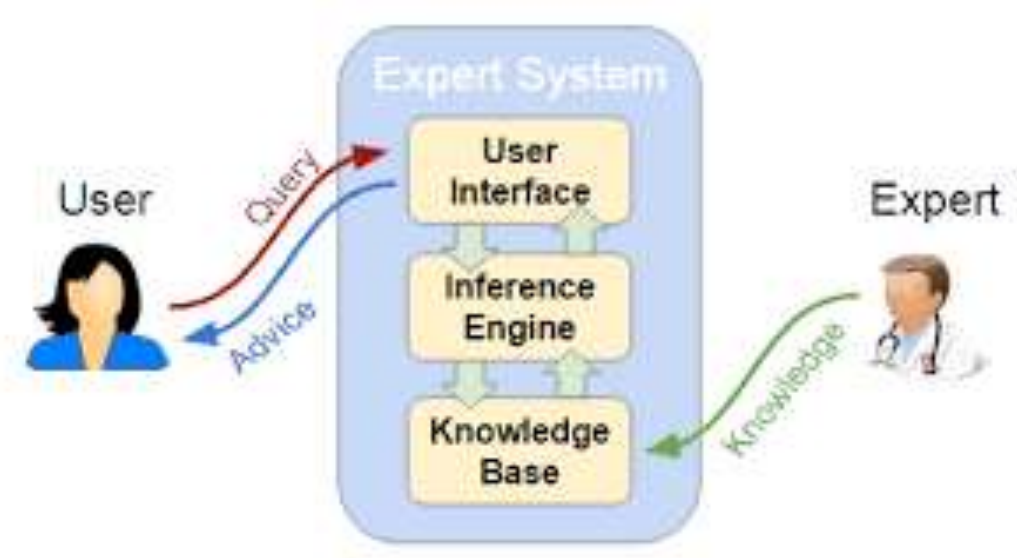
# Otsing mängupuust: minimax algoritm



# Üks esimesi universaalseid otsinguoptimeerimise meetodeid: alpha-beta



*Rule-based systems, including expert systems*



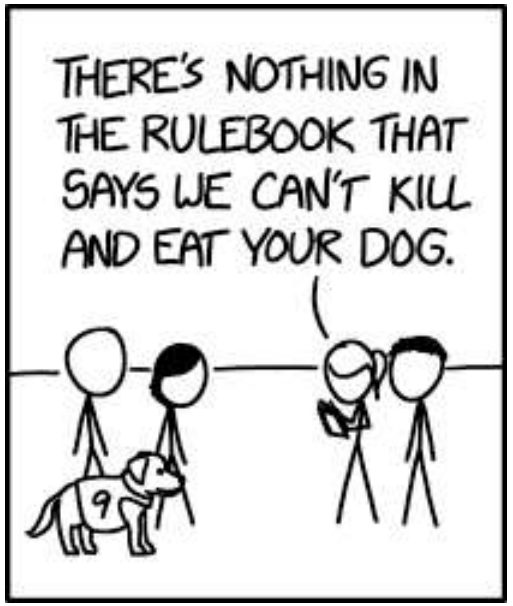

Given

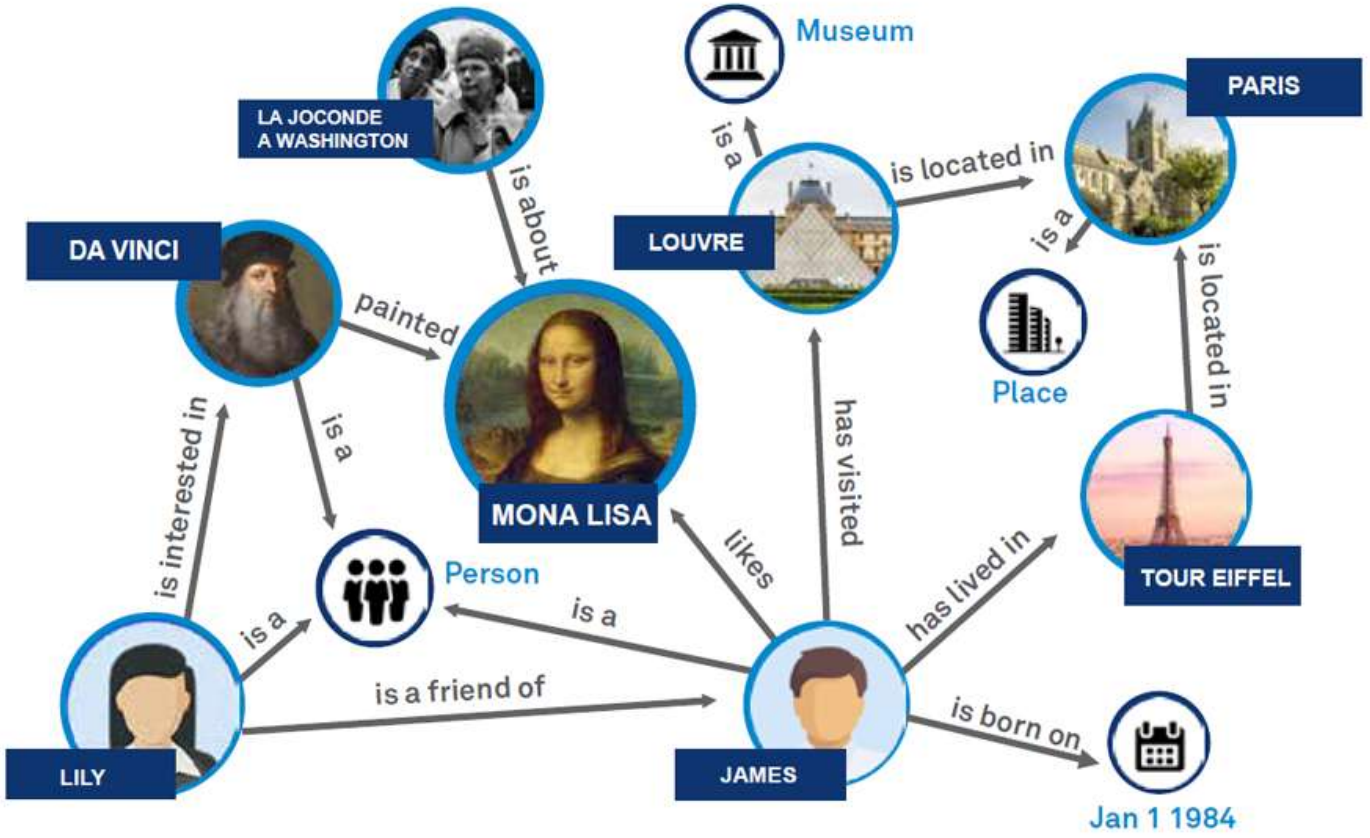
father(john,pete)  John is a father of Pete
father(pete,mark)  Pete is a father of Mark
father(X,Y) & father(Y,Z) => grandfather(X,Z)
father(X,Y) & mother(Y,Z) => grandfather(X,Z)
If X is a father of Y and Y is a father/mother of Z, then X is a grandfather of Z
grandfather(X,Y) => grandson(Y,X)
If X is a grandfather of Y then Y is a grandson of X

Exists X : grandson(X,john) ?  Find a grandson of John

*Knowledge graphs*

A drastically simplified form of rule-based / expert systems



# Solve a predicate logic reasoning task: help

```
% a simple example: using two facts and two rules, find a grandson of john

father(john,pete).
father(pete,mark).
(father(X,Y)  & father(Y,Z)) => grandfather(X,Z).
grandfather(X,Y) => grandson(Y,X).

grandson(X,john) => $ans(X).
```

Prove | simple examples | complex examples | or Browse | Advanced | Clear result | Clear input | ?

# Result:

```
result: proof found

answer: $ans(mark).
proof:
 1: [in] -father(X,Y) | -father(Z,X) | grandfather(Z,Y).
 2: [in] father(pete,mark).
 3: [mp, 1, 2] -father(X,pete) | grandfather(X,mark).
 4: [in] father(john,pete).
 5: [mp, 3, 4] grandfather(john,mark).
 6: [in] -grandfather(X,Y) | grandson(Y,X).
 7: [mp, 5, 6] grandson(mark,john).
 8: [in] -grandson(X,john) | $ans(X).
 9: [mp, 7, 8] $ans(mark).
```

## *Masinõpe*

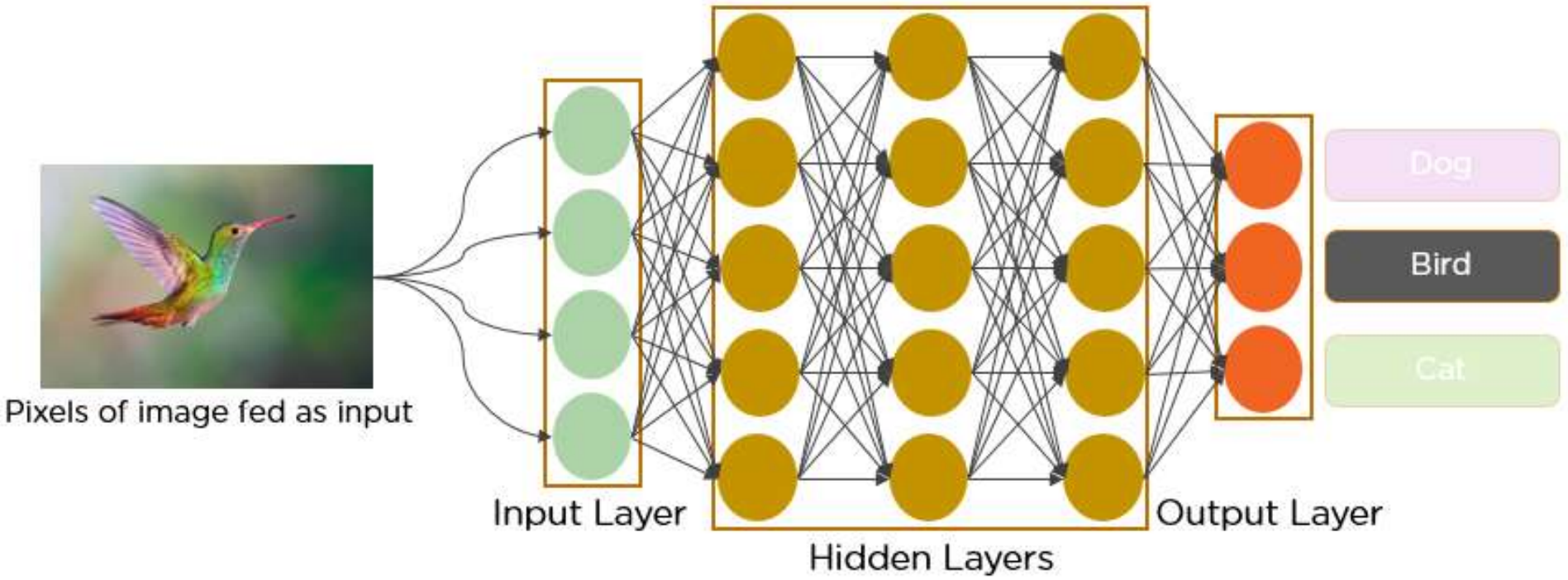
- Lihtsustatult öeldes: “äärmuslikult vinge statistika”.
- Kõige tuntum meetodite klass on närvivõrgud, mis omakorda jagunevad paljudeks alamtüüpideks.
- Kasutusel ka suur hulk mitte-närvivõrkude-põhiseid masinõppe algoritme: vektormasinad, lähimad naabrid, juhustemetsad, …

*Machine learning: what is the point?*

"cat" "dog"

Writing a program to recognize whether an image is of a cat or a dog
is theoretically possible, but extremely complicated: not realistic in practice.

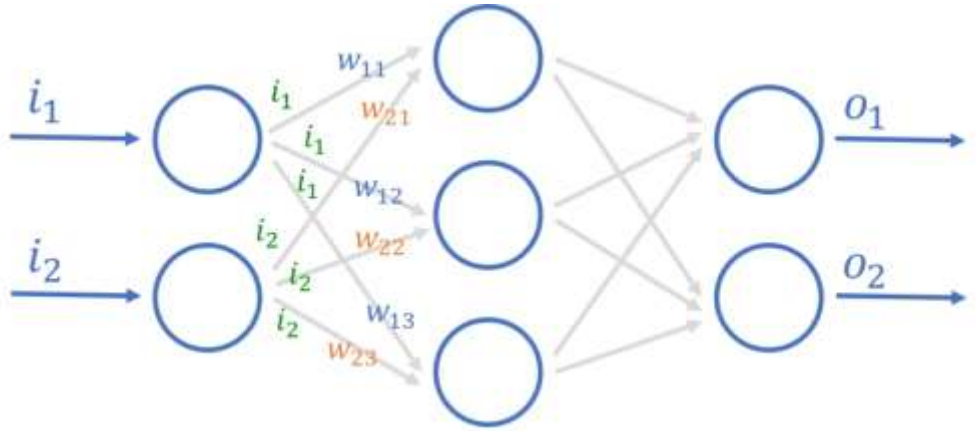
*Deep neural networks* ehk sügavad närvivõrgud



# Matrices and calculations

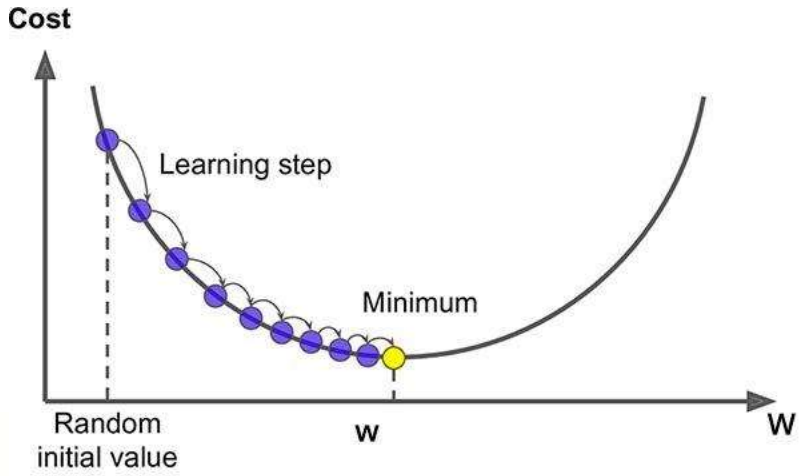
Connections are simply numbers (weights) you can store in a large table (matrix).

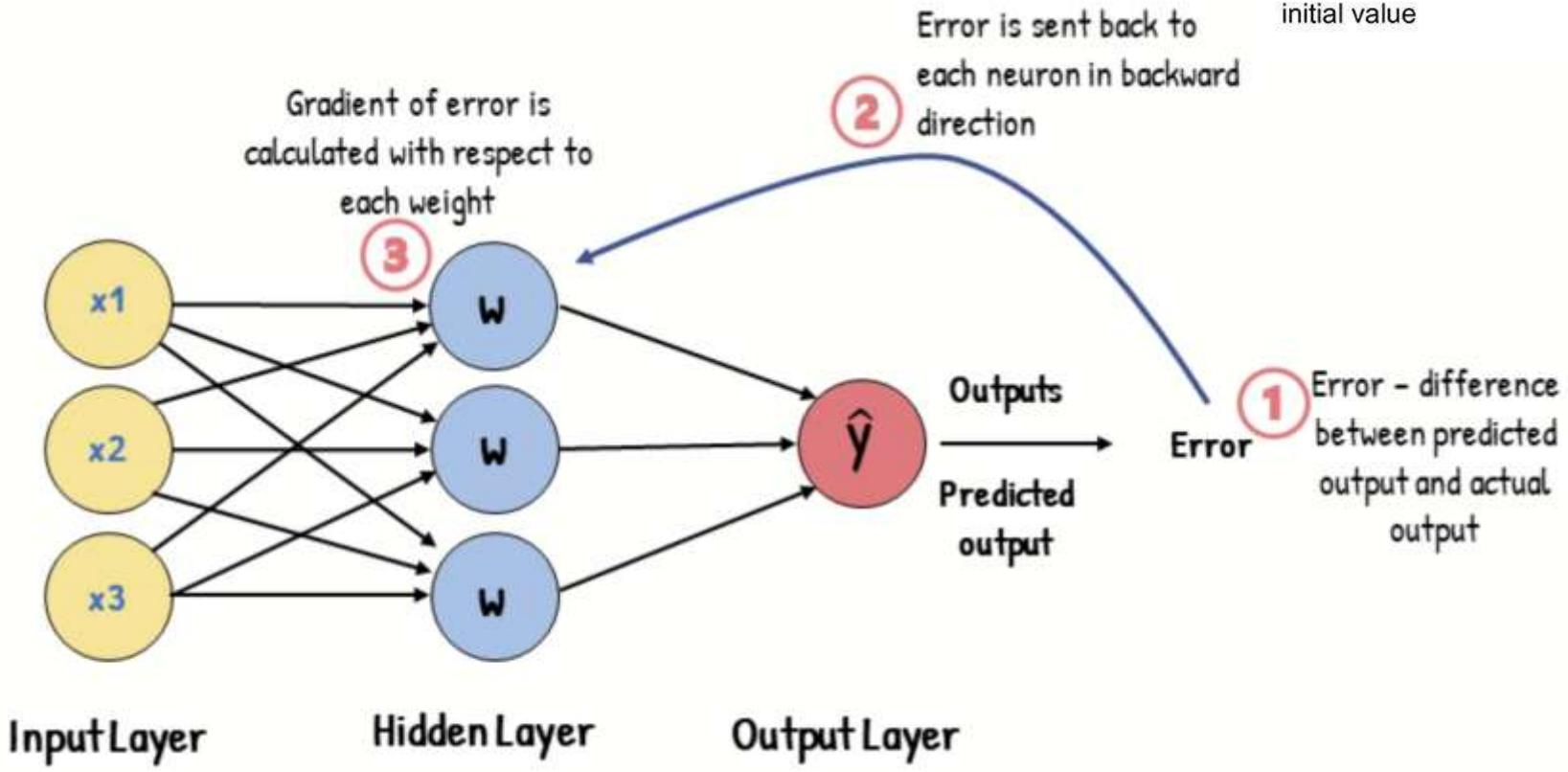
Calculating values for nodes can be done in several ways. One simple approach is to first multiply weights with inputs, sum all of them together and then normalize, using some popular simple function for this.



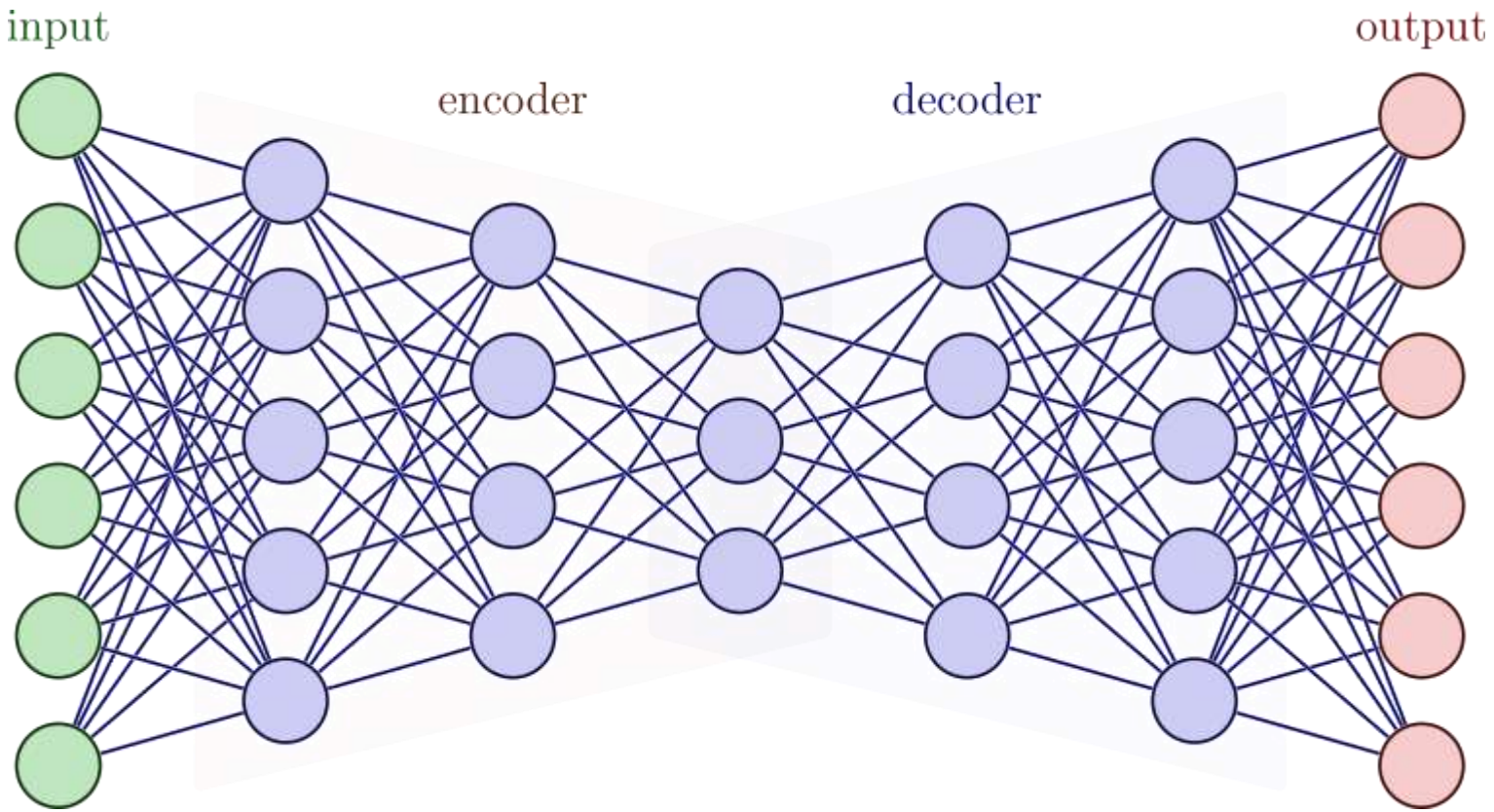

$$\begin{bmatrix} w_{11} & w_{21} \\ w_{12} & w_{22} \\ w_{13} & w_{23} \end{bmatrix} \cdot \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} (w_{11} \times i_1) + (w_{21} \times i_2) \\ (w_{12} \times i_1) + (w_{22} \times i_2) \\ (w_{13} \times i_1) + (w_{23} \times i_2) \end{bmatrix}$$

# Learning by backpropagation and gradient descent

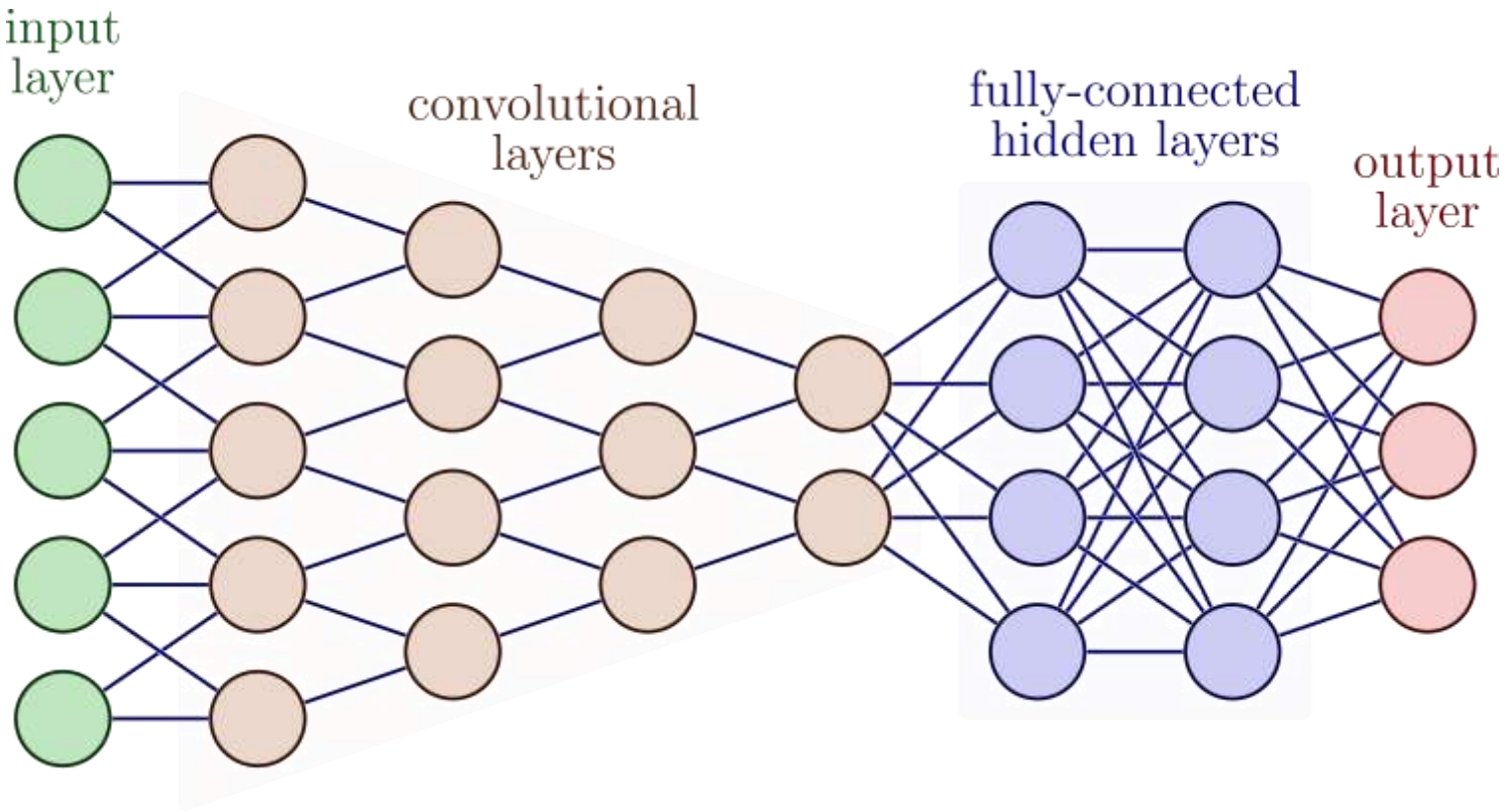


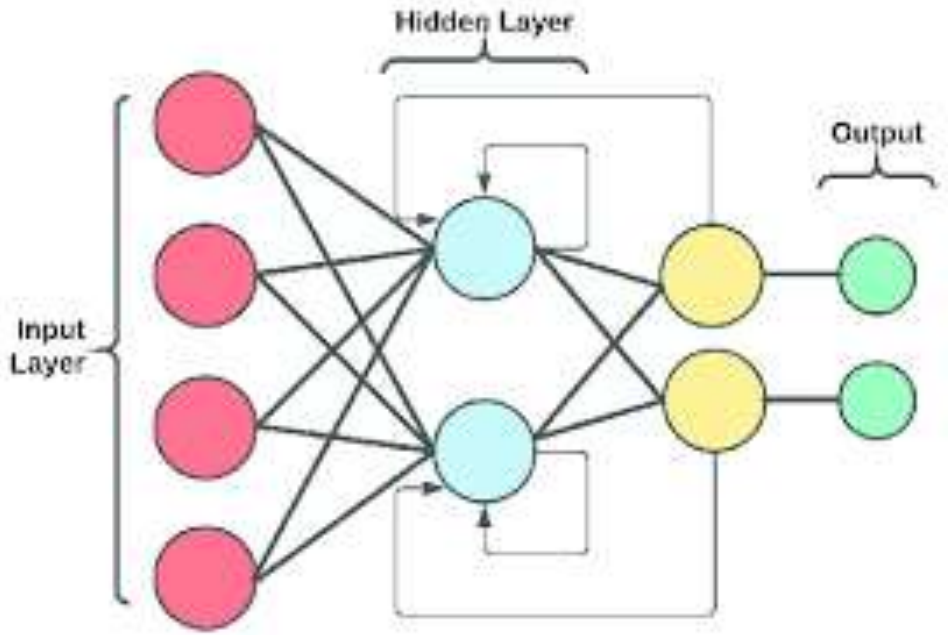
# Autoencoder neural network (denoising, compression, generation)

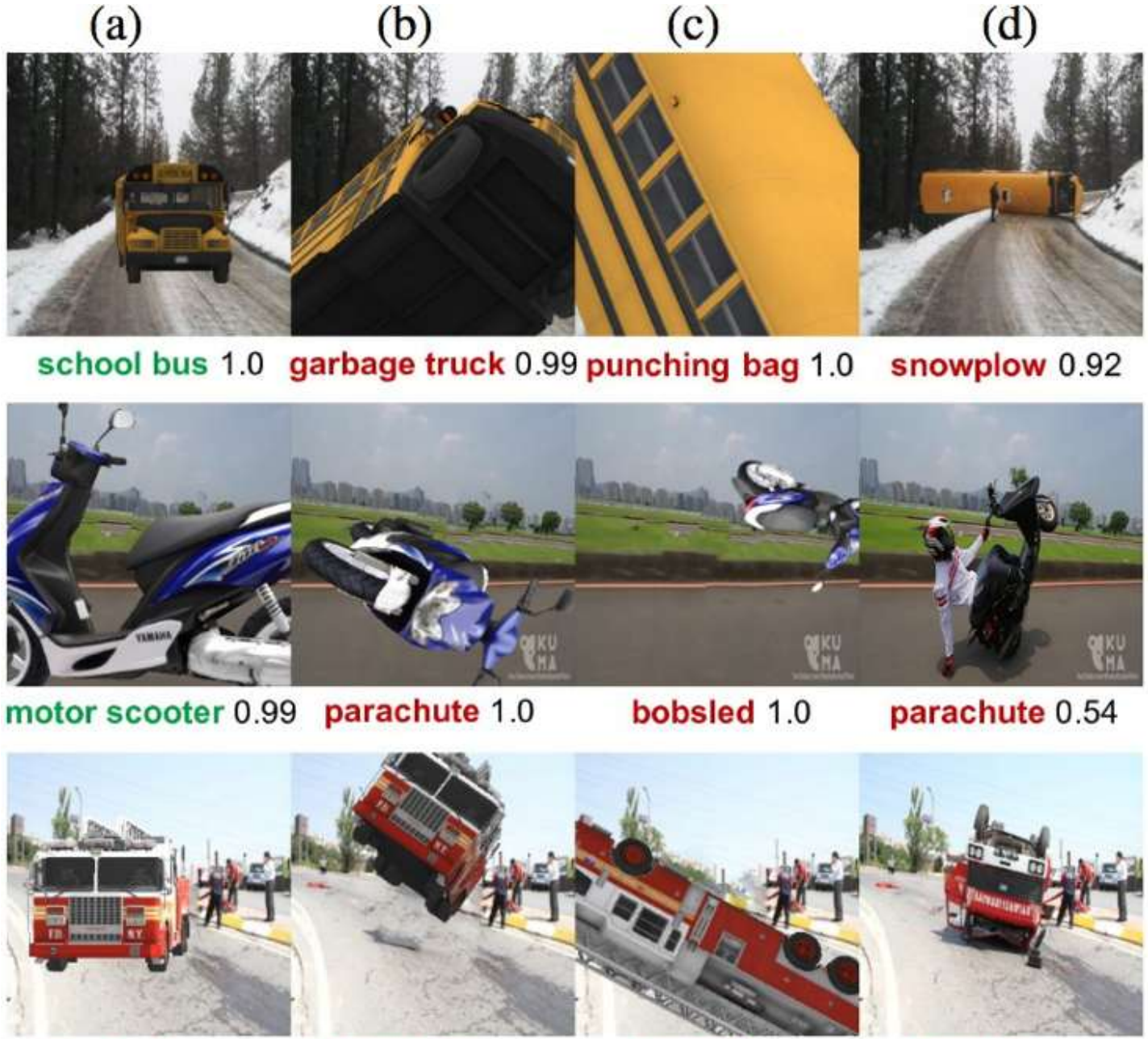


# Convolutional neural network (image recognition)



# Recurrent neural network (time series, etc)




(a)
(b)
(c)
(d)
school bus 1.0
garbage truck 0.99
punching bag 1.0
snowplow 0.92
motor scooter 0.99
parachute 1.0
bobsled 1.0
parachute 0.54
fire truck 0.99
school bus 0.98
fireboat 0.98
bobsled 0.79

*Mida suured keelemudelid (LLM) teevad?*

*Ennustavad samm-sammult teksti jätkumist:*

- Jaan istus autosse ja …
- Jaan istus autosse ja hakkas …
- Jaan istus autosse ja hakkas sõitma …
- Jaan istus autosse ja hakkas sõitma kodu …

*Kuidas LLM ennustab? Lihtsustatult:*

- Kogub statistikat suure tekstihulga pealt: mismoodi seal on laused jätkunud, näiteks

Mihkel istus mootorrattale ja … *(hakkas, mõtles, …)*

- Kui näeb lauset, mille kohta statistikat ei ole, kasutab statistikat varasemate sarnaste lausete kohta:

Jaan istus autosse ja …

LLM hallucinations: confidently generating wrong answers.

Why?

- LLMs learn an approximate, highly compressed picture of the world knowledge.
- LLMs are always hallucinating: just that mostly these correspond to reality
- LLM learning optimizes for confident tone of voice and pleasing answers
- … etc …

## *LLMi põhiprobleemid 2025 (chatbot age)*

- Hallutsineerib ehk leiutab “fakte”, mis ei ole üldse tõesed.
- Vaikimisi omab ainult üldteadmisi.
- Ei ole mälu: uusi asju raske juurde õpetada.
- “Must kast” ehk ei anna tegelikke seletusi, kuidas vastused saadi.
- Ei sisalda otsialgoritme ja enamasti ei suuda teha pikemaid järeldusahelaid.
- Ei ole lihtsat viisi siduda andmebaasidega, inseneriarvutustega jne.
- Vastuste kvaliteet langeb kiirelt, kui sisendtekst on pikk.
- Ei ole selget viisi tema suunamiseks või mingit sorti vastuste keelamiseks.
- …

*LLMi põhiprobleemid 2026 (agentic age) :*

*oranzhid probleemid püsivad, rohelised oluliselt paranenud, mustad kergelt paranenud*

- Hallutsineerib ehk leiutab “fakte”, mis ei ole üldse tõesed.
- Vaikimisi omab ainult üldteadmisi.
- Ei ole mälu: uusi asju raske juurde õpetada.
- “Must kast” ehk ei anna tegelikke seletusi, kuidas vastused saadi.
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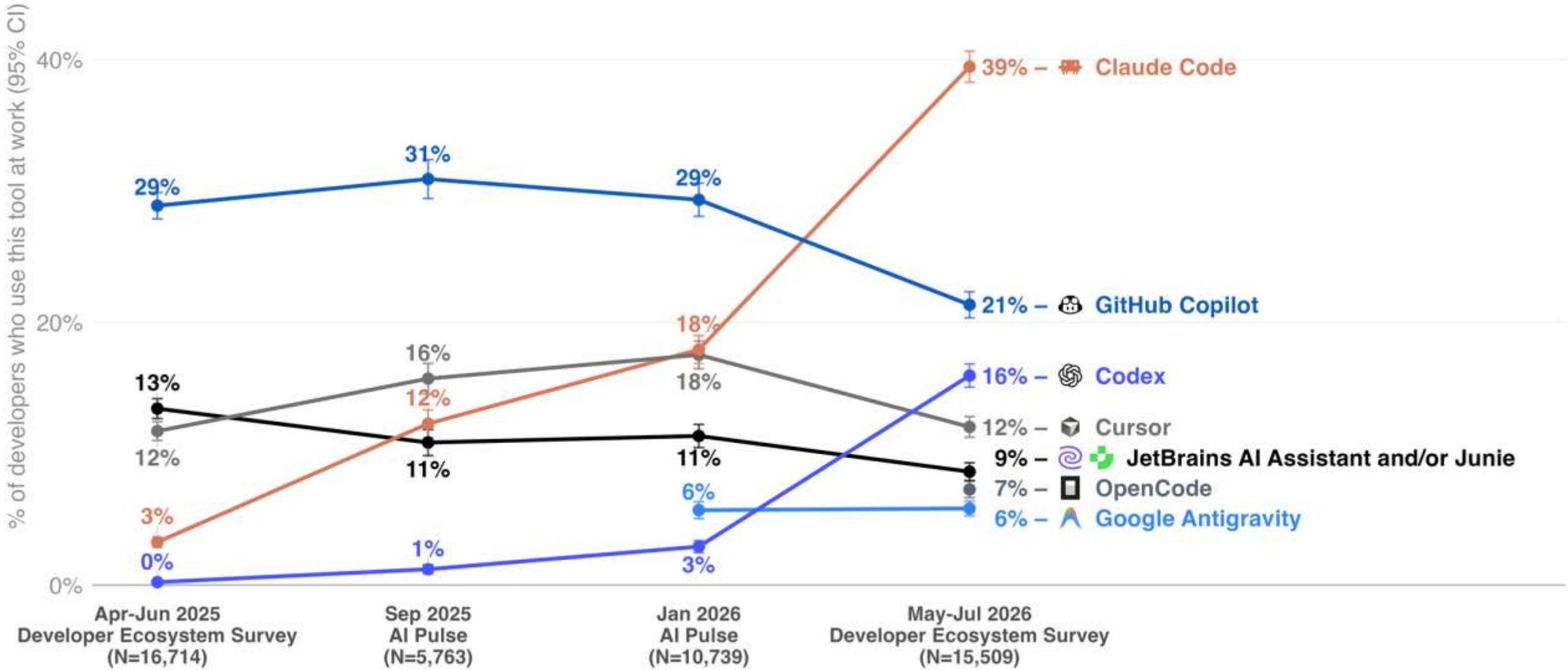
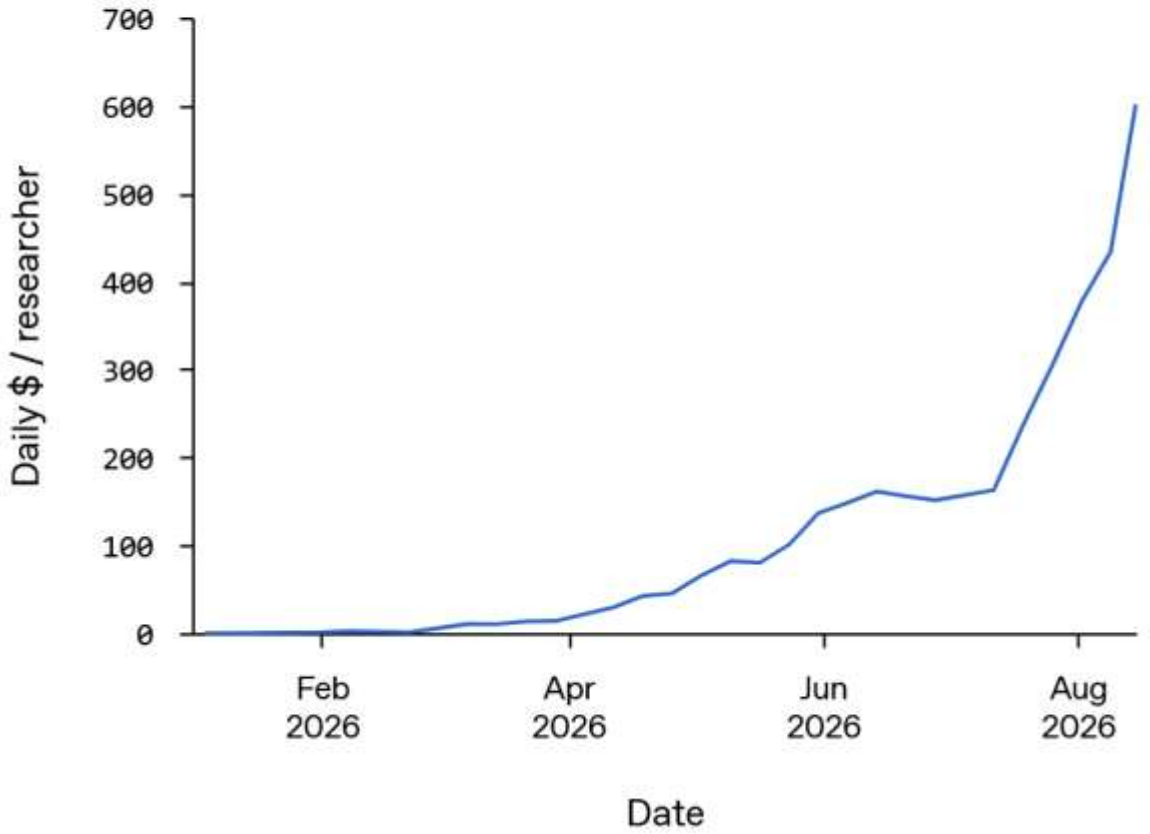
- Ei ole selget viisi tema suunamiseks või mingit sorti vastuste keelamiseks.
- …

## Use at work

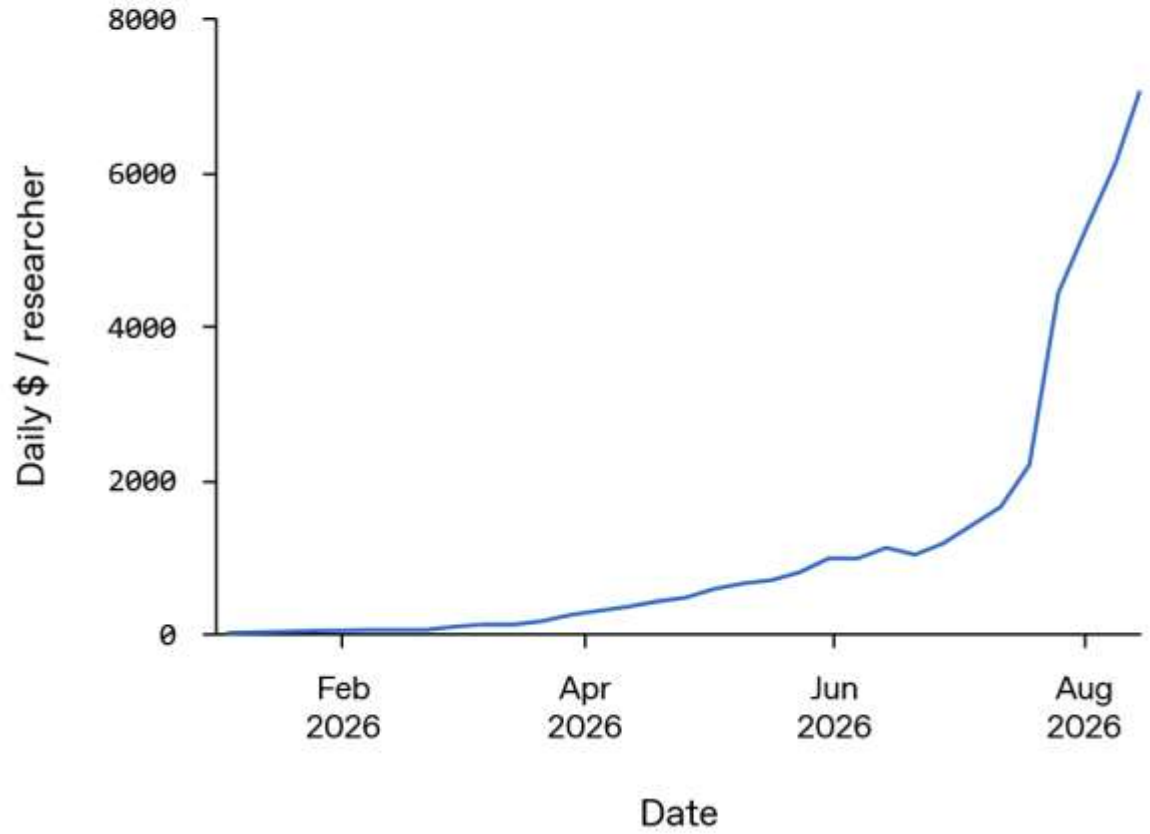
Which of these AI tools do you use for your coding and other development-related tasks at work?
*(Multiple answers were possible; only a subset of tools is shown)*



## Usage of internal coding agents is increasing significantly—Median researcher




## Usage of internal coding agents is increasing significantly—90th percentile researcher



# Neurosümboolsed ehk hübriidsüsteemid

| | Common AI Techniques | | | | | |
|---|---|---|---|---|---|---|
| **Use Case Families** | **Generative Models** | **Non-Generative ML** | **Optimisation** | **Simulation** | **Rules** | **Graphs** |
| Forecasting | Low | High | Low | High | Medium | Low |
| Planning | Low | Low | High | Medium | Medium | High |
| Decision Intelligence | Low | Medium | High | High | High | Medium |
| Autonomous System | Low | Medium | High | Medium | Medium | Low |
| Segmentation | Medium | High | Low | Low | High | High |
| Recommender | Medium | High | Medium | Low | Medium | High |
| Perception | Medium | High | Low | Low | Low | Low |
| Intelligent Automation | Medium | High | Low | Low | High | Medium |
| Anomaly Detection | Medium | High | Low | Medium | Medium | High |
| Content Generation | High | Low | Low | High | Low | Low |
| Chatbots | High | High | Low | Low | Medium | High |
| Knowledge Discovery | High | Medium | Low | Low | Medium | High |

*Research area of neurosymbolic A.I. aka hybrid A.I.*

Find ways to combine M.L. with symbolic components to be able to solve different really hard tasks.

Some approaches:

- Use M.L. to heuristically guide proof search for symbolic reasoning
- Build LLMs capable of autoformalization and then use symbolic reasoning
- Let LLMs learn on symbolic knowledge in addition to free text
- Build new architectures for M.L. capable of learning external software tool use
- Build new architectures for M.L. capable of performing search / planning
- Build symbolic rules already into a neural switch level of M.L. systems

# Explainable A.I. ehk selgitatav tehismõistus

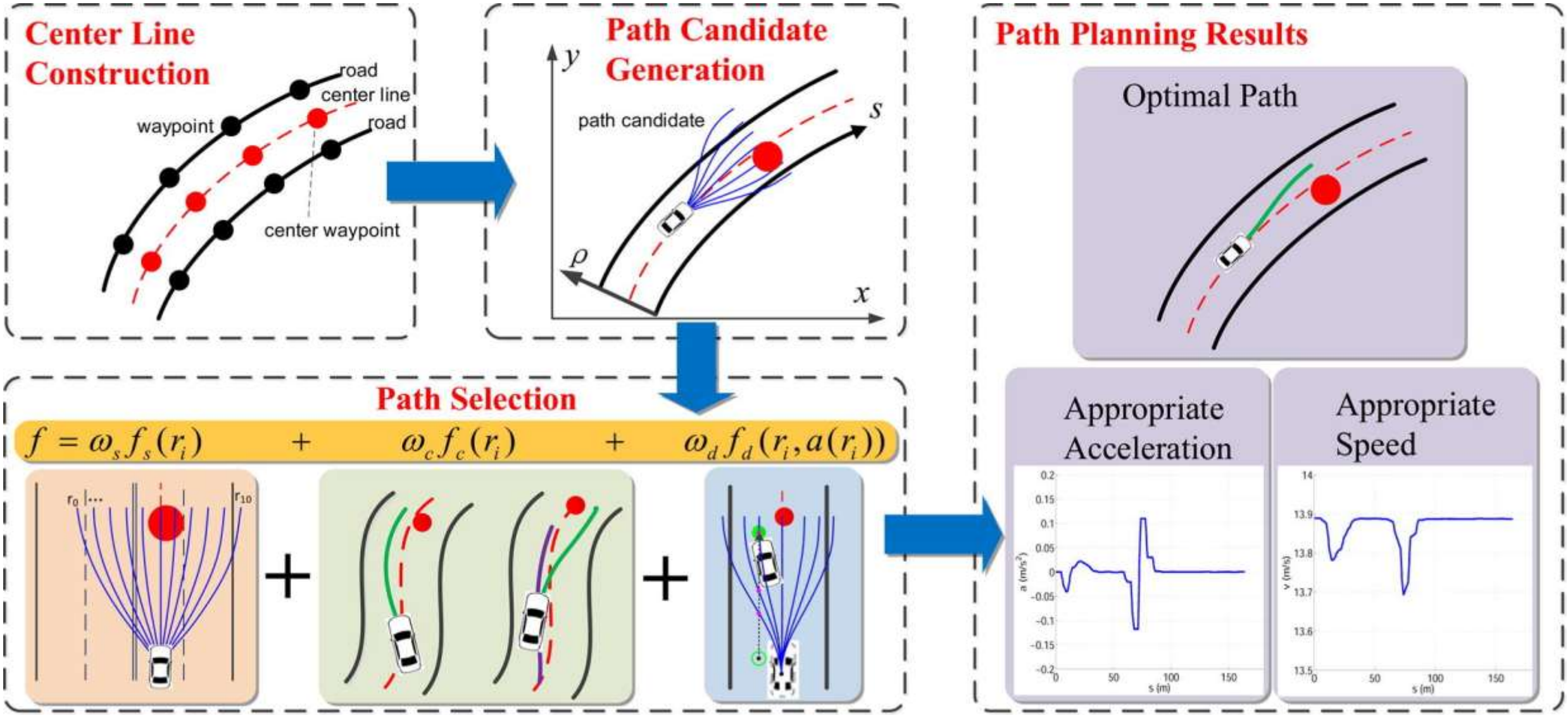
Masinõppe süsteemide tehtud otsuste taga on suur hägune võrgustik seoseid, mitte inim-arusaadavad reeglid.

Otsuste põhjendamiseks oleks lisaks hägusele võrgustikule vaja ehitada mõistetavad reeglid, mille abil otsust põhjendada.

*Hetkel* puhtalt akadeemiline uurimistöö, praktilisi süsteeme ei osata teha.

*Hübriidsüsteemi näide: isesõitvad autod*

Pildil: 2005,
Stanfordi Stanley võidab DARPA Grand Challenge II


Center Line Construction
road
center line
road
waypoint
center waypoint
Path Candidate Generation
y
path candidate
s
ρ
x
Path Planning Results
Optimal Path
Path Selection
$f = \omega_s f_s(r_i) + \omega_c f_c(r_i) + \omega_d f_d(r_i, a(r_i))$
r0
r10
Appropriate Acceleration
Appropriate Speed
a (m/s²)
v (m/s)
s (m)


WHEN
CHILDREN
ARE PRESENT
Rotini
May stop quickly
23810T3
cruise
Rotini

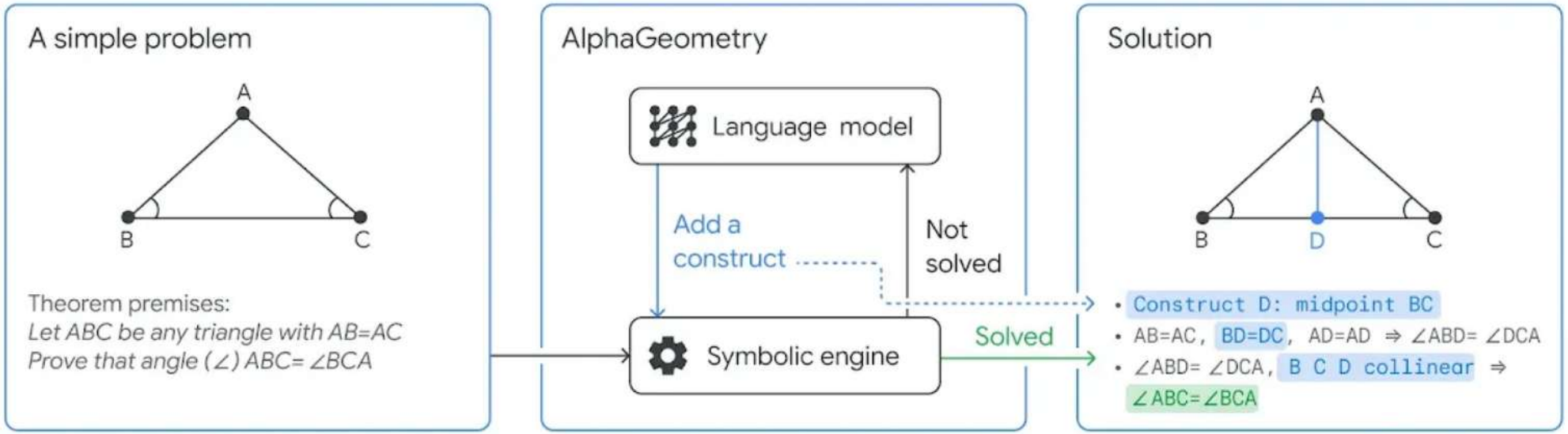
# AlphaGo ja AlphaZero: hübriidsüsteemid

DeepMind / Google projekt masinõppeks Go ja male jaoks.

Iseenda vastu mängides õpib seisumustrite järgi seisu headust kiirelt ja hästi hindama.

Hea seisuhindamine on kombineeritud Monte-Carlo otsinguga: vaatab juhusliku valikuga läbi hulga võimalikke käikude jadasid mängu lõpuni välja.

*Google DeepMind AlphaGeometry: autoformalization + symbolic reasoning engine*

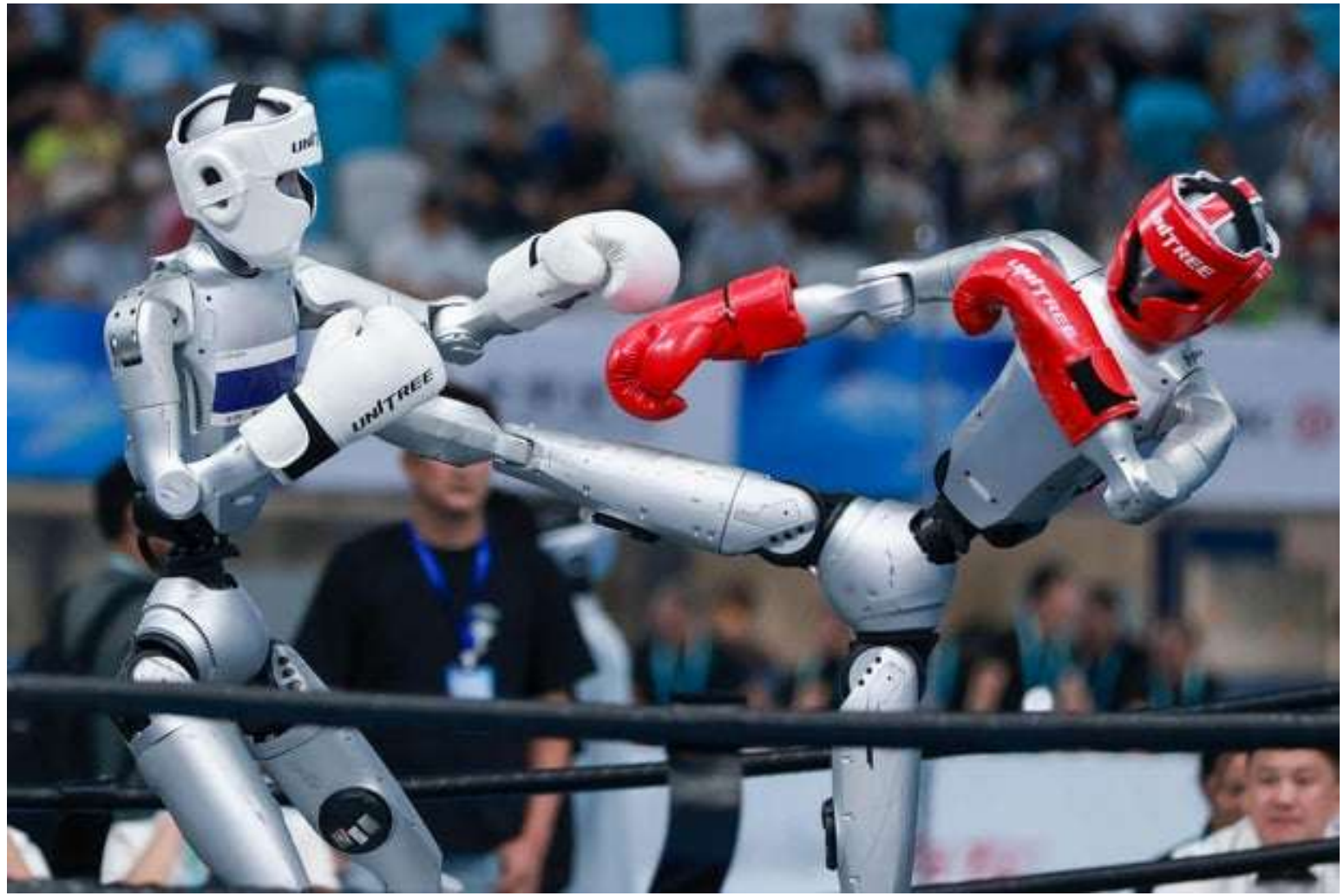



Solves complex geometry problems at a level approaching a high-school Olympiad gold-medalist

# Robotid

# *Robots: a very hard area!*

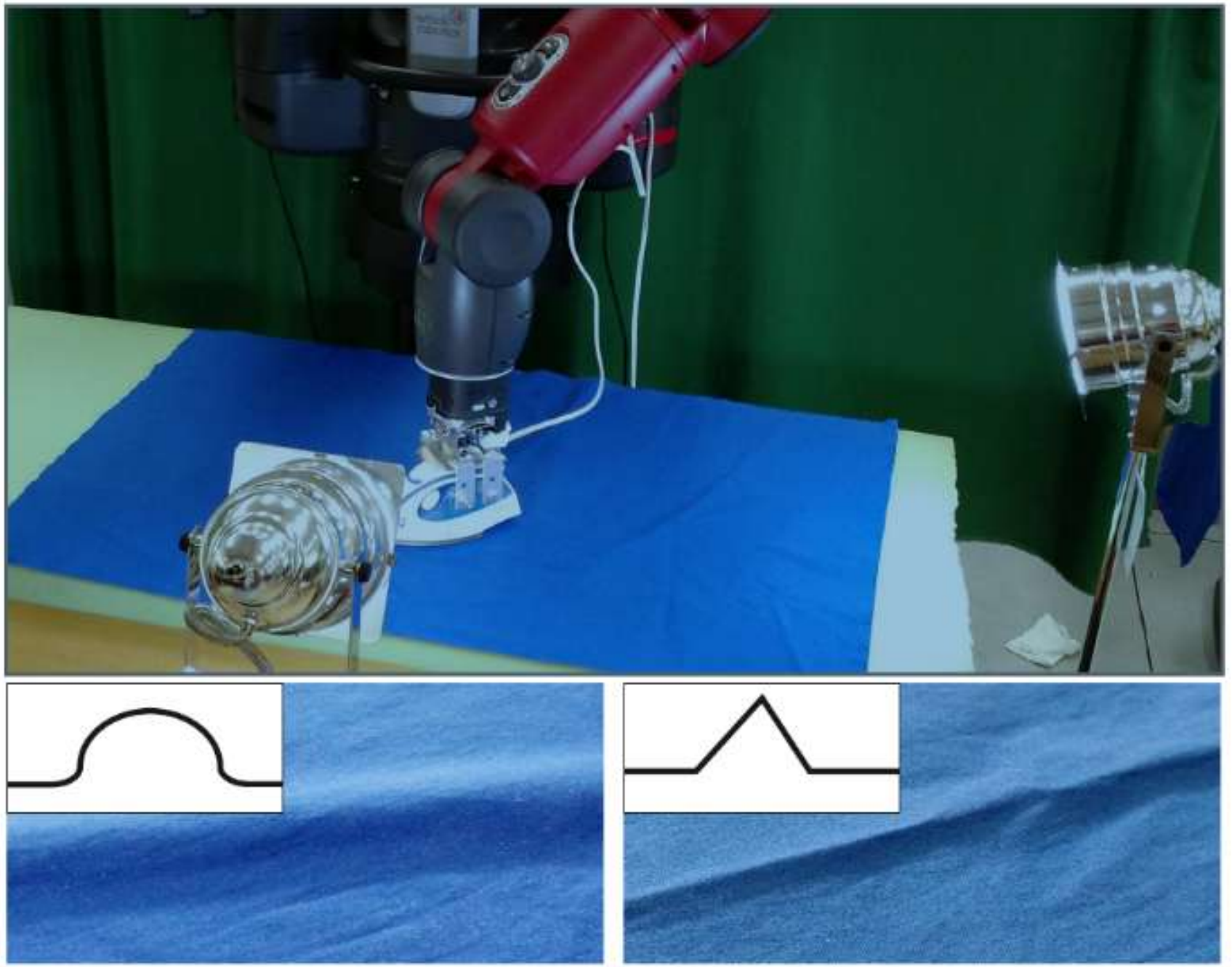
# *Most robots contain fairly little A.I.*


UNITREE
UNITREE
UNITREE

# Industrial robots are mostly hand-coded, with A.I. relegated to detection etc

*Example:*

No real success in developing robots able to iron ordinary clothes.



*Example:*

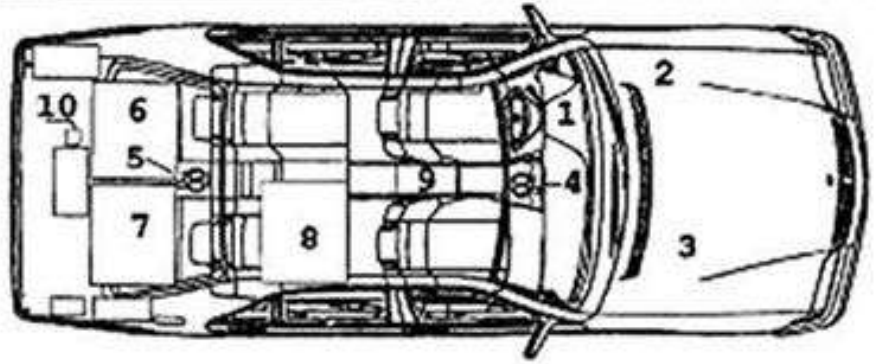
Bringing dirty dishes from the table to the dishwasher does not seem realistic in visible future.



cheddar
TikTok
@cheddar


@sarahstacks_
TikTok
@espn
6.127 Second Cycle
Second Fastest Time in US

1980- ja 1990-d:
Isesõitev auto
Saksamaal:
tuhanded
kilomeetrid
kiirteel


1 Torque motor for steering
2 brake system
3 electric throttle control
4 front platform } for 2 CCD
5 rear platform } cameras
6, 8 Transputer system, image processing
7 processors for gaze & locomotion control
8 user interface
9 linear accelerometers
10 angular rate sensors

https://en.wikipedia.org/wiki/History_of_self-driving_cars

2005: Stanfordi Stanley võidab DARPA Grand Challenge II

# Darpa urban challenge 2007

96 km linnas, aeg 4:10

Tesla

„Traffic-Aware Cruise Control **cannot detect all objects and may not brake/decelerate for stationary vehicles**, especially in situations when you are driving over 50 mph (80 km/h) and a vehicle you are following moves out of your driving path and a stationary vehicle or object is in front of you instead.”

Volvo

„In other words, **your Volvo won't brake to avoid hitting a stopped car that suddenly appears up ahead“**.

# Filosoofia
# ja prognoosid

*Tugev ehk „päris“ AI, mida meil ei ole (???)*

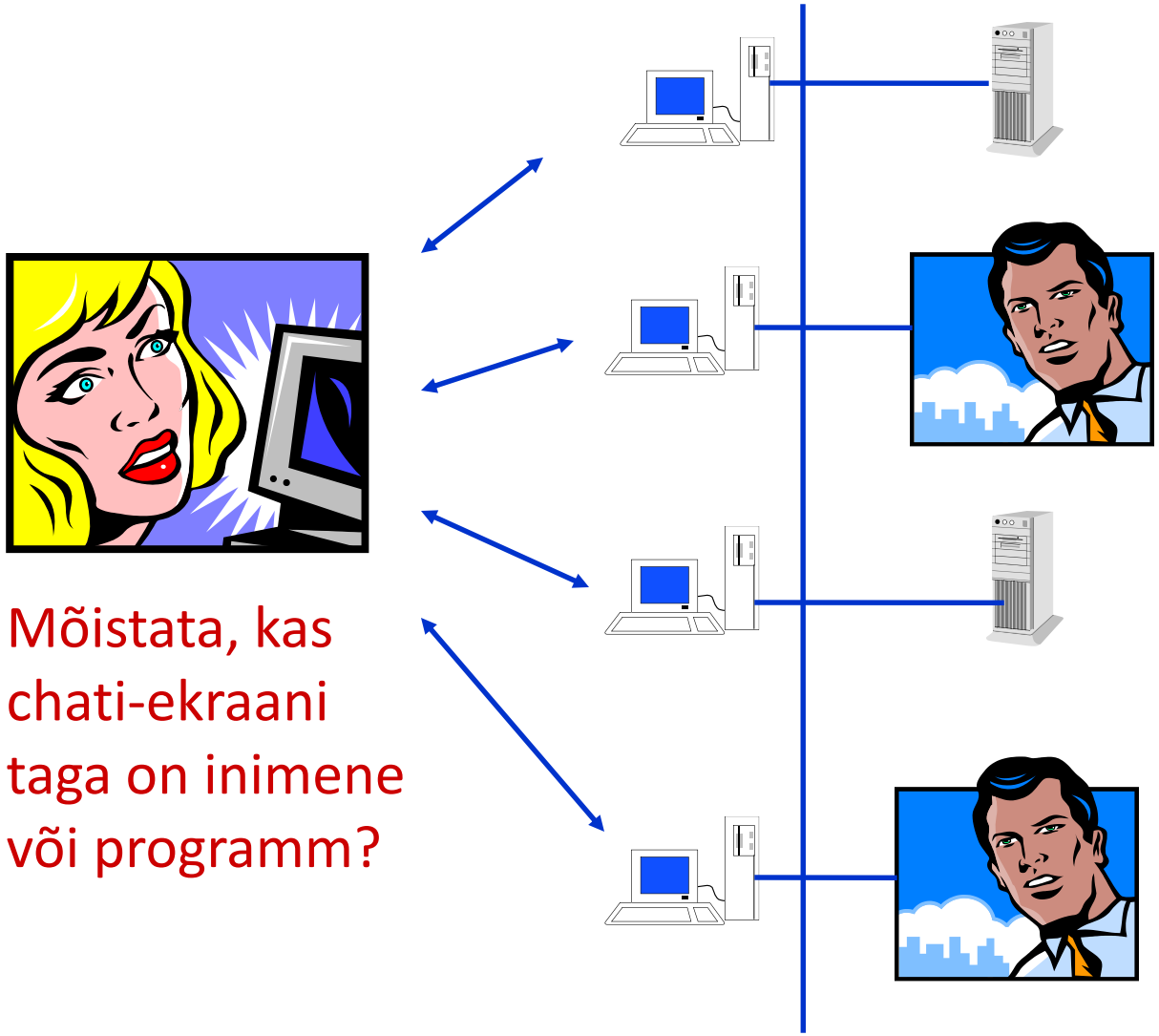
*(ehk AGI: artificial general intelligence):*

Masin on intellektilt inimmõistusele lähedane või ületab seda, suudab täita tüüpilisi inimülesandeid, kasutada laia spektrit taustateadmisi ja omab mingil määral eneseteadvust.

*Nõrk AI ehk see, mis tegelikult on:*

Tarkvara kasutamine spetsiifiliste probleemide või mõtlemisülesannete lahendamiseks, mis ei vaja laia spektrit inimvõimeid.

# **Turingi test**: filosoofiline idee/ettepanek 50-datest



Mõistata, kas chati-ekraani taga on inimene või programm?

Turing:
Kui katsetajad ei suuda ära arvata (st ära-arvamise sagedus on 50% ja 50% eksitakse), siis on jutlev masin **päriselt** intelligentne.

# IF ANYONE BUILDS IT, EVERYONE DIES

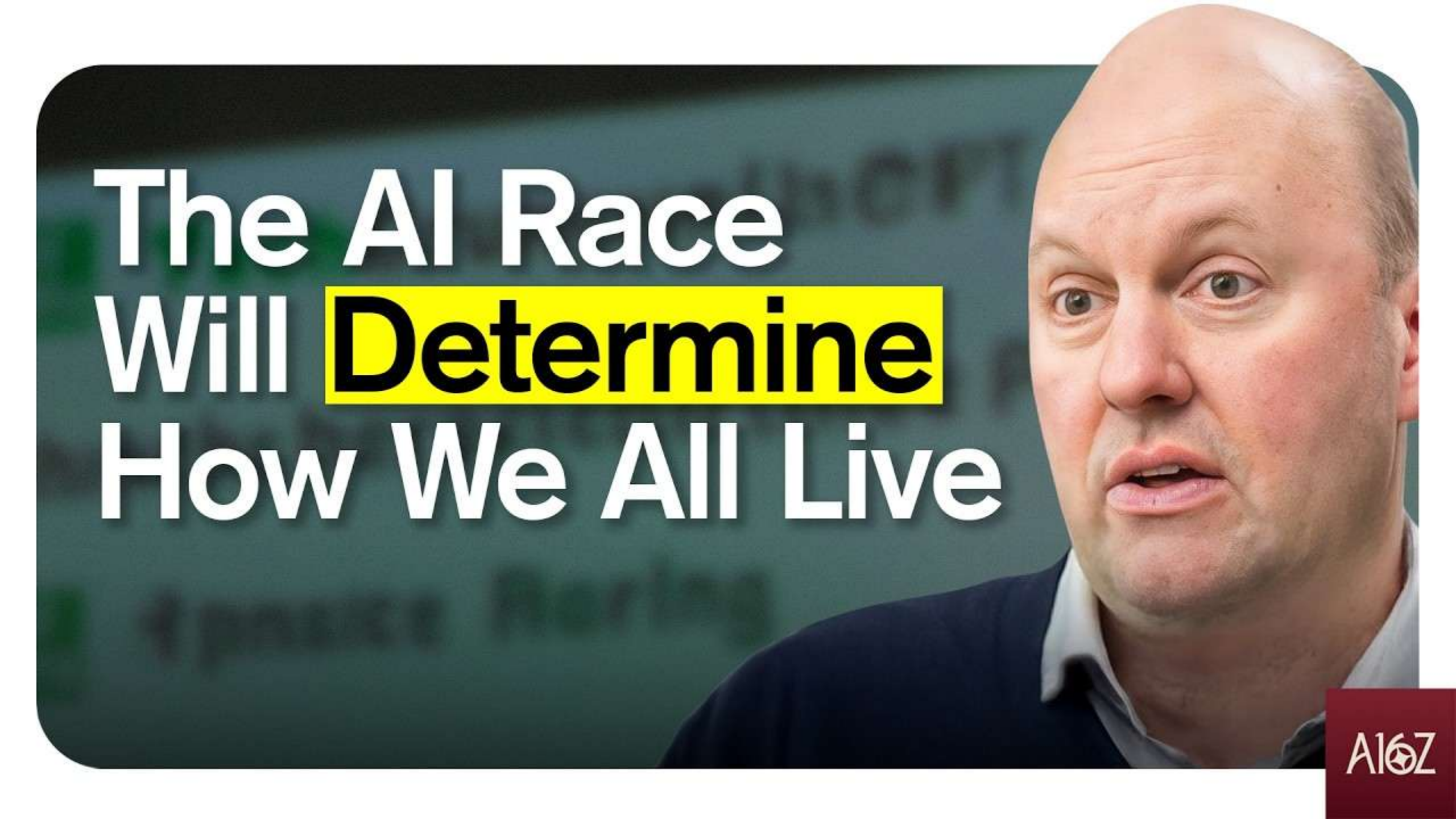
## WHY SUPERHUMAN AI WOULD KILL US ALL

ELIEZER YUDKOWSKY & NATE SOARES

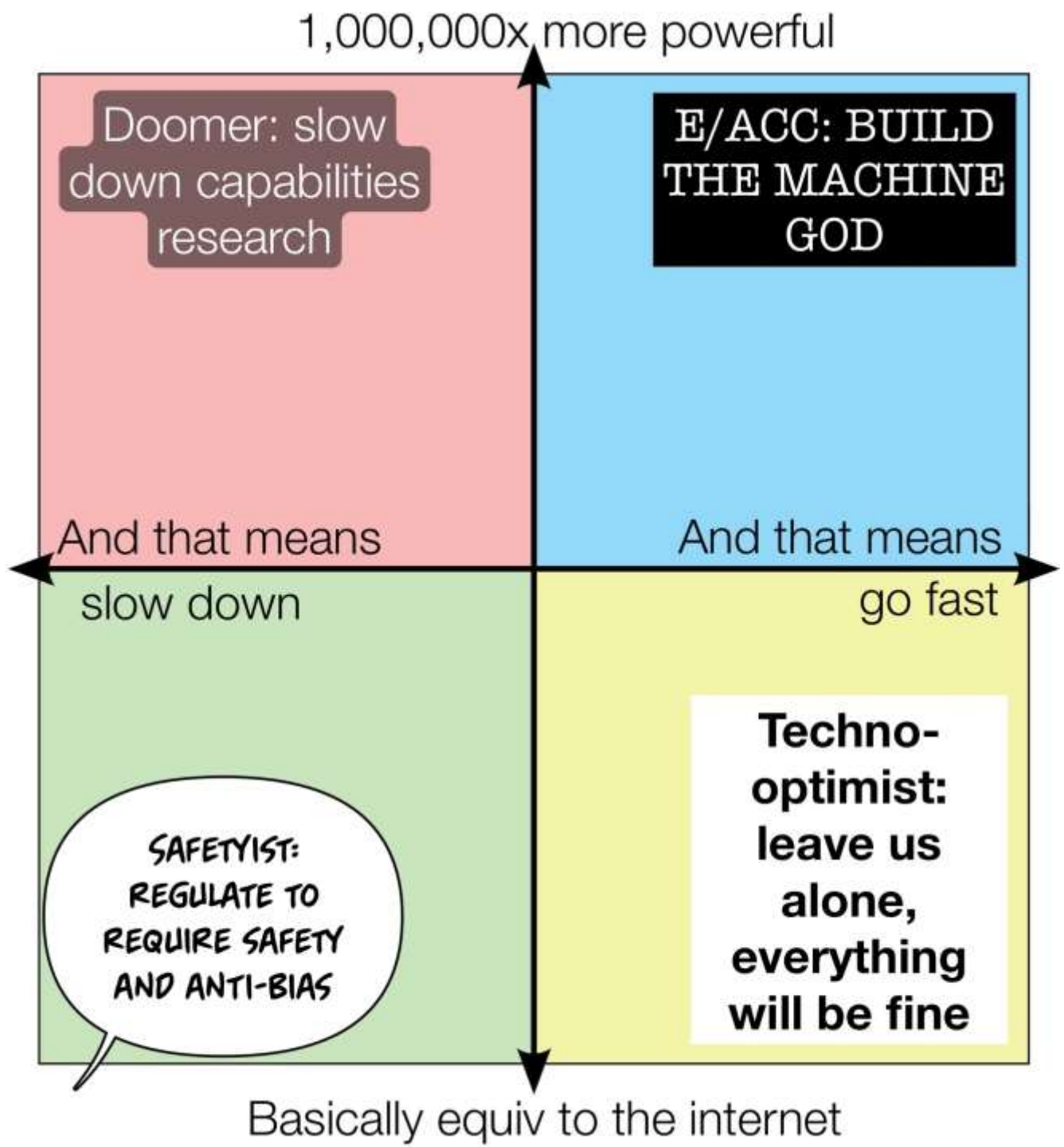
# WHY AI WILL SAVE THE WORLD

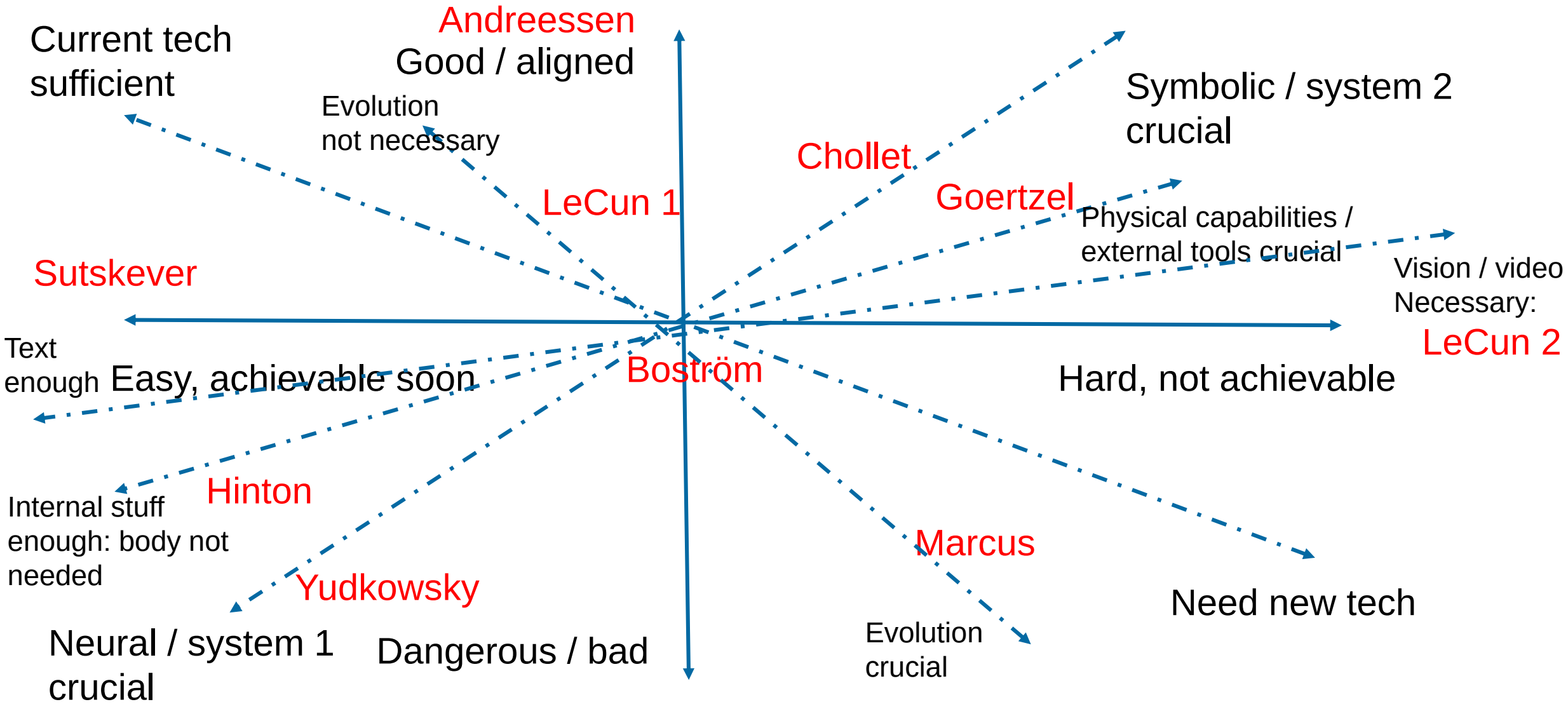
MARC ANDREESSEN

# The AI Race Will Determine How We All Live



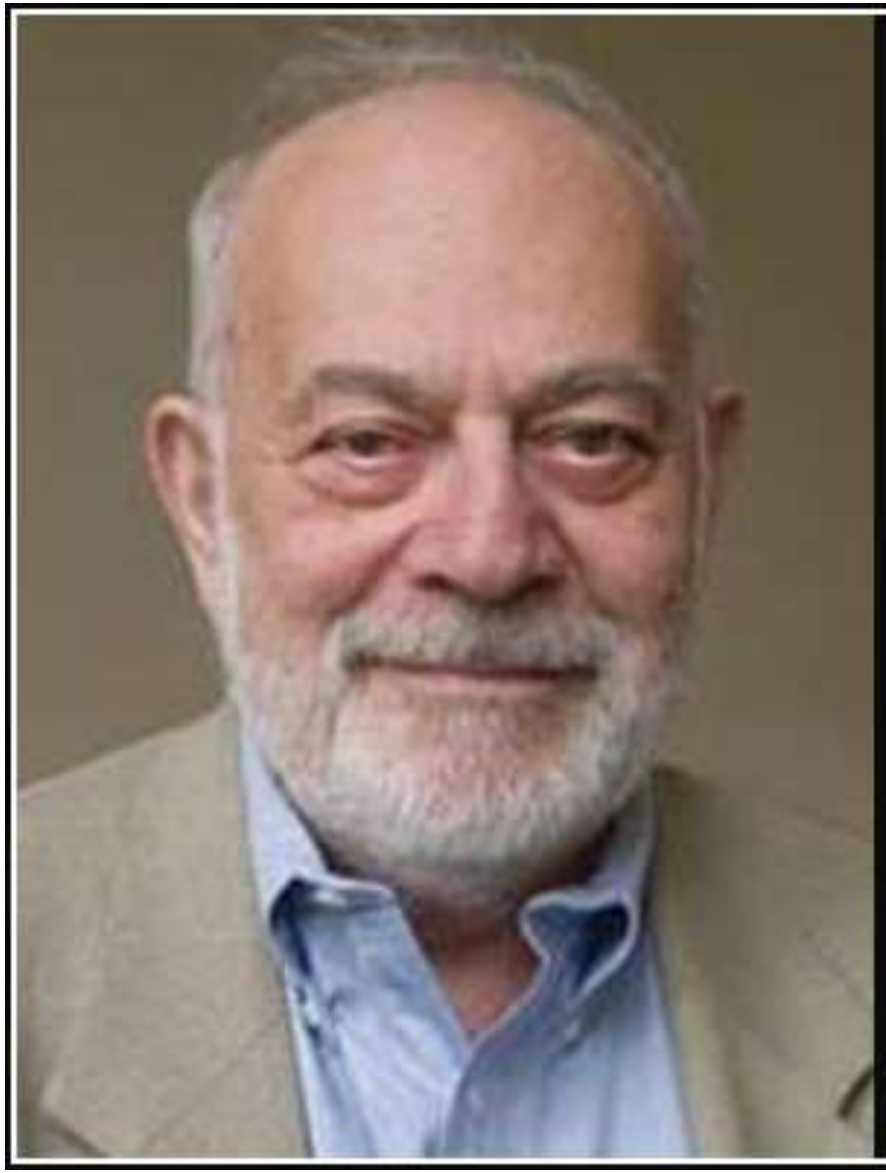
A16Z


1,000,000x more powerful
Doomer: slow down capabilities research
E/ACC: BUILD THE MACHINE GOD
And that means
slow down
And that means
go fast
SAFETYIST: REGULATE TO REQUIRE SAFETY AND ANTI-BIAS
Techno-optimist: leave us alone, everything will be fine
Basically equiv to the internet


Current tech sufficient
Andreessen
Good / aligned
Evolution not necessary
LeCun 1
Chollet
Symbolic / system 2 crucial
Goertzel
Physical capabilities / external tools crucial
Vision / video
Necessary:
LeCun 2
Sutskever
Text enough
Easy, achievable soon
Boström
Hard, not achievable
Internal stuff enough: body not needed
Hinton
Yudkowsky
Marcus
Need new tech
Neural / system 1 crucial
Dangerous / bad
Evolution crucial

# ON BULLSHIT

*Harry G. Frankfurt*



The bullshitter is neither on the side of the true or the side of the false. His eye is not on the facts at all. He does not reject the authority of the truth, as the liar does, and oppose himself to it. He pays no attention to it at all. By virtue of this, bullshit is a greater enemy of the truth than lies are.

— Harry Frankfurt —

AZ QUOTES

## *European Union A.I. Act: 12 July 2024*

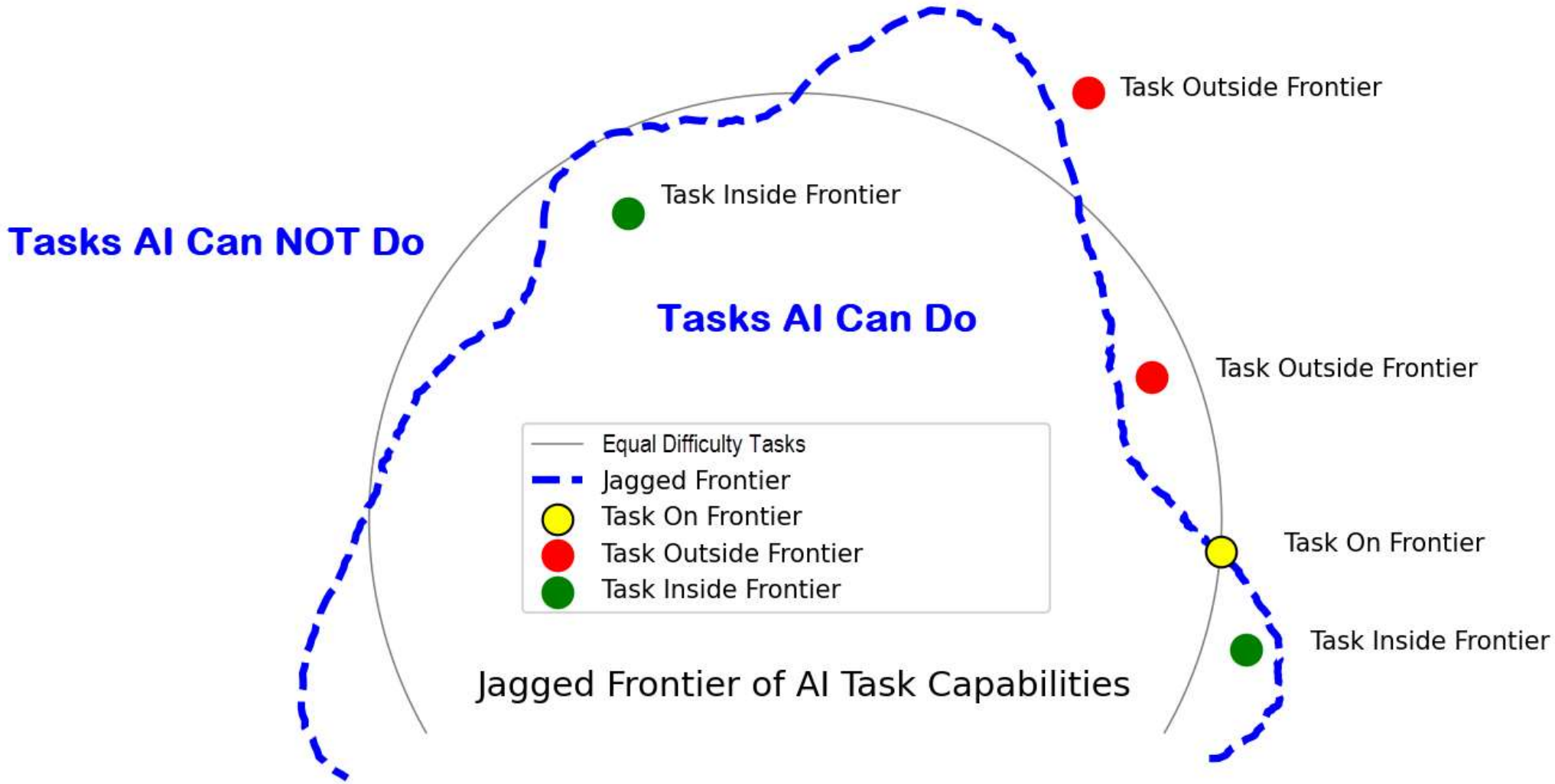
The Act assigns applications of AI to several risk categories.

Applications and systems that create an unacceptable risk are banned (manipulative / deceptive, exploiting vulnerabilities, inferring emotions in organisations, unrestricted collection of facial databases, social scoring of the type used in China, etc).

High-risk applications (profiling individuals, remote biometric identification systems, CV-scanning tool that ranks job applicants, determining access, admission or assignment to educational and vocational training institutions, applying the law to disputes, etc) are subject to specific legal requirements

Limited risk AI systems are subject to lighter transparency obligations: developers and deployers must ensure that end-users are aware that they are interacting with AI (chatbots and deepfakes).

Minimal risk is unregulated (including AI applications like AI enabled video games and spam filters).


Task Outside Frontier
Task Inside Frontier
Tasks AI Can NOT Do
Tasks AI Can Do
Task Outside Frontier
Equal Difficulty Tasks
Jagged Frontier
Task On Frontier
Task Outside Frontier
Task Inside Frontier
Task On Frontier
Task Inside Frontier
Jagged Frontier of AI Task Capabilities

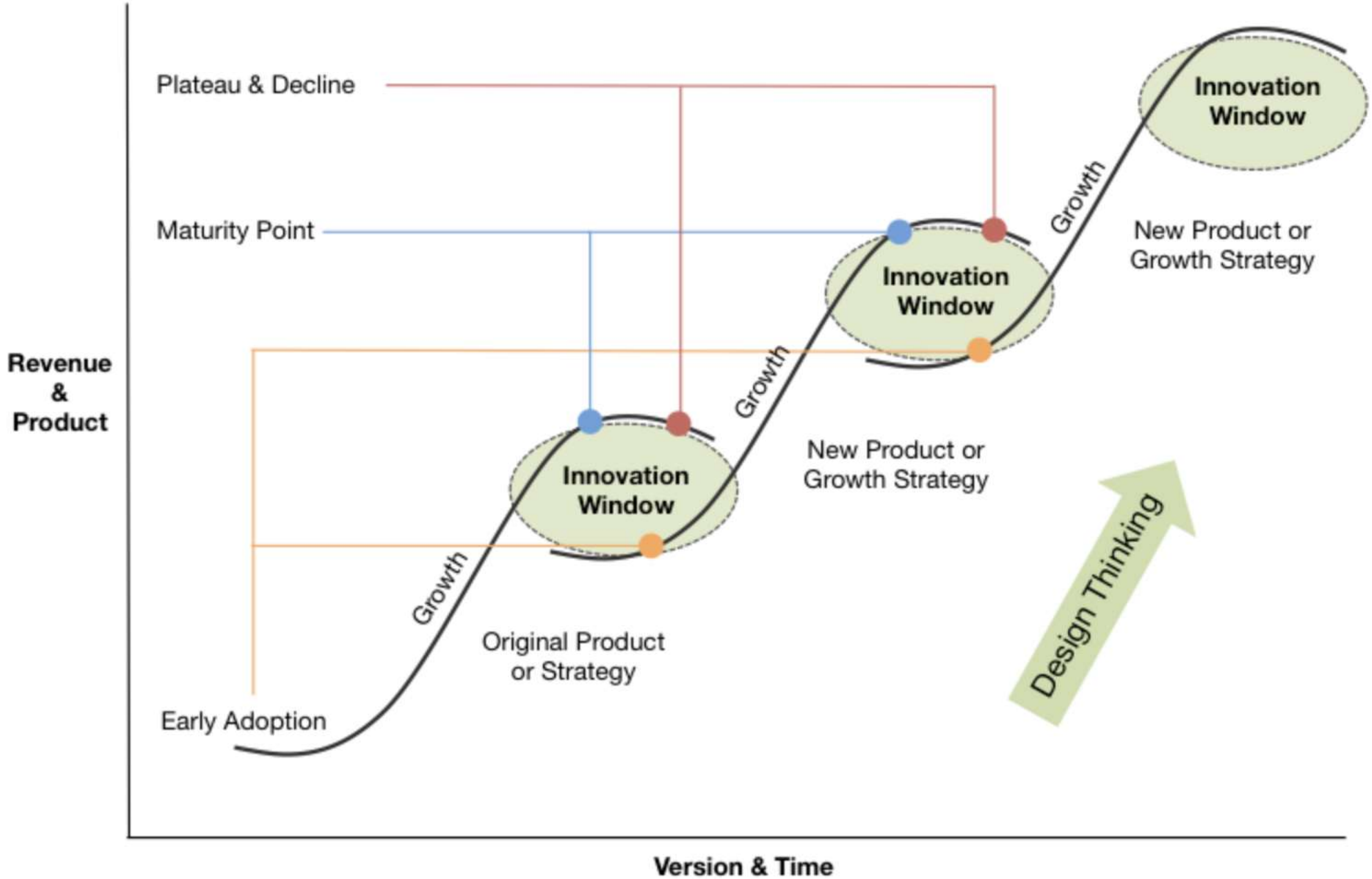
*Moravec'i paradoks:*

Inimeste jaoks rasked ülesanded on masina jaoks tihtipeale lihtsad.

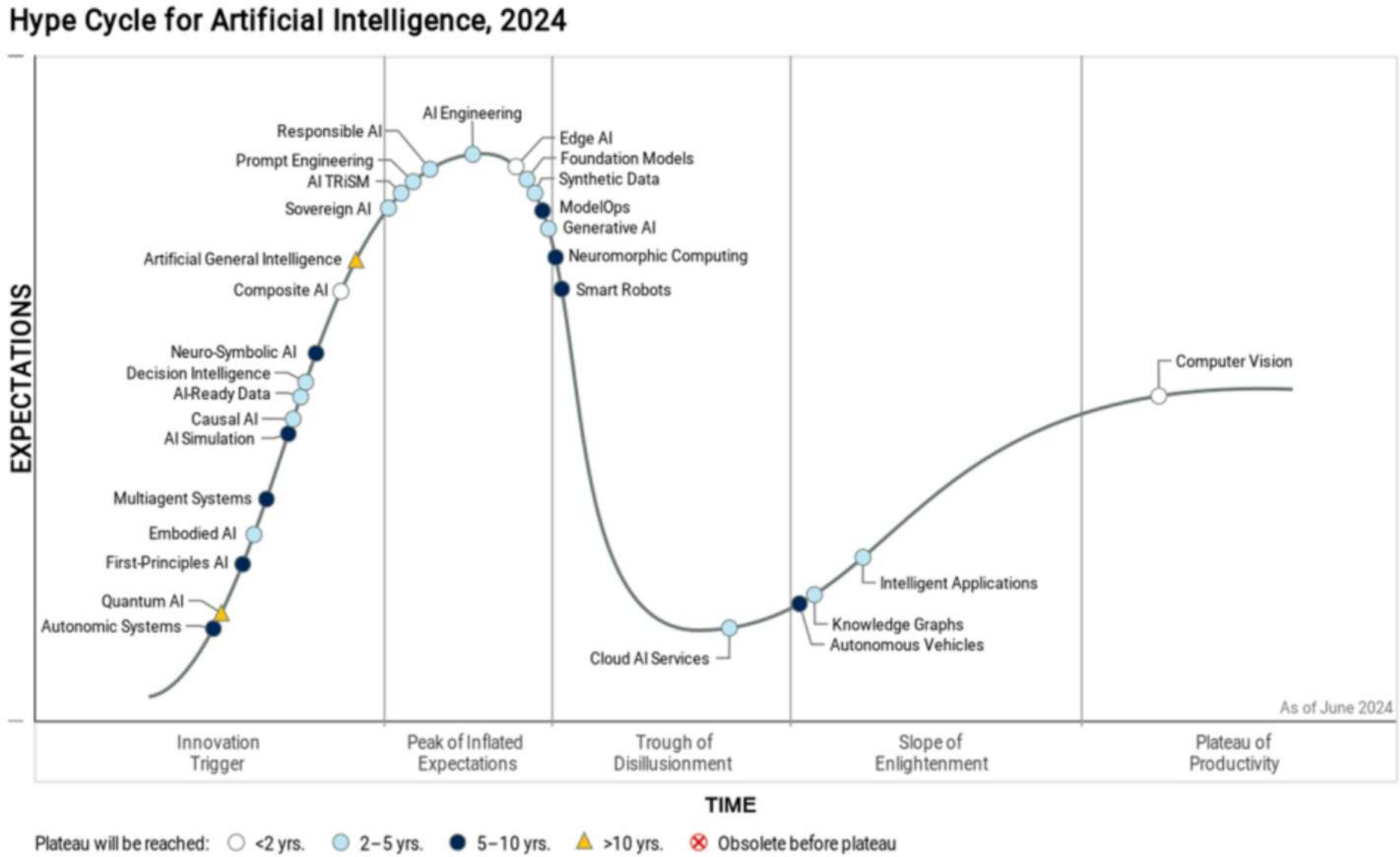
Inimeste jaoks lihtsad ülesanded on masina jaoks tihtipeale äärmiselt keerulised.

*Amara printsiip:*

Meil on kalduvus lähiperspektiivis tehnoloogia mõju üle hinnata ja pikemas perspektiivis alahinnata.

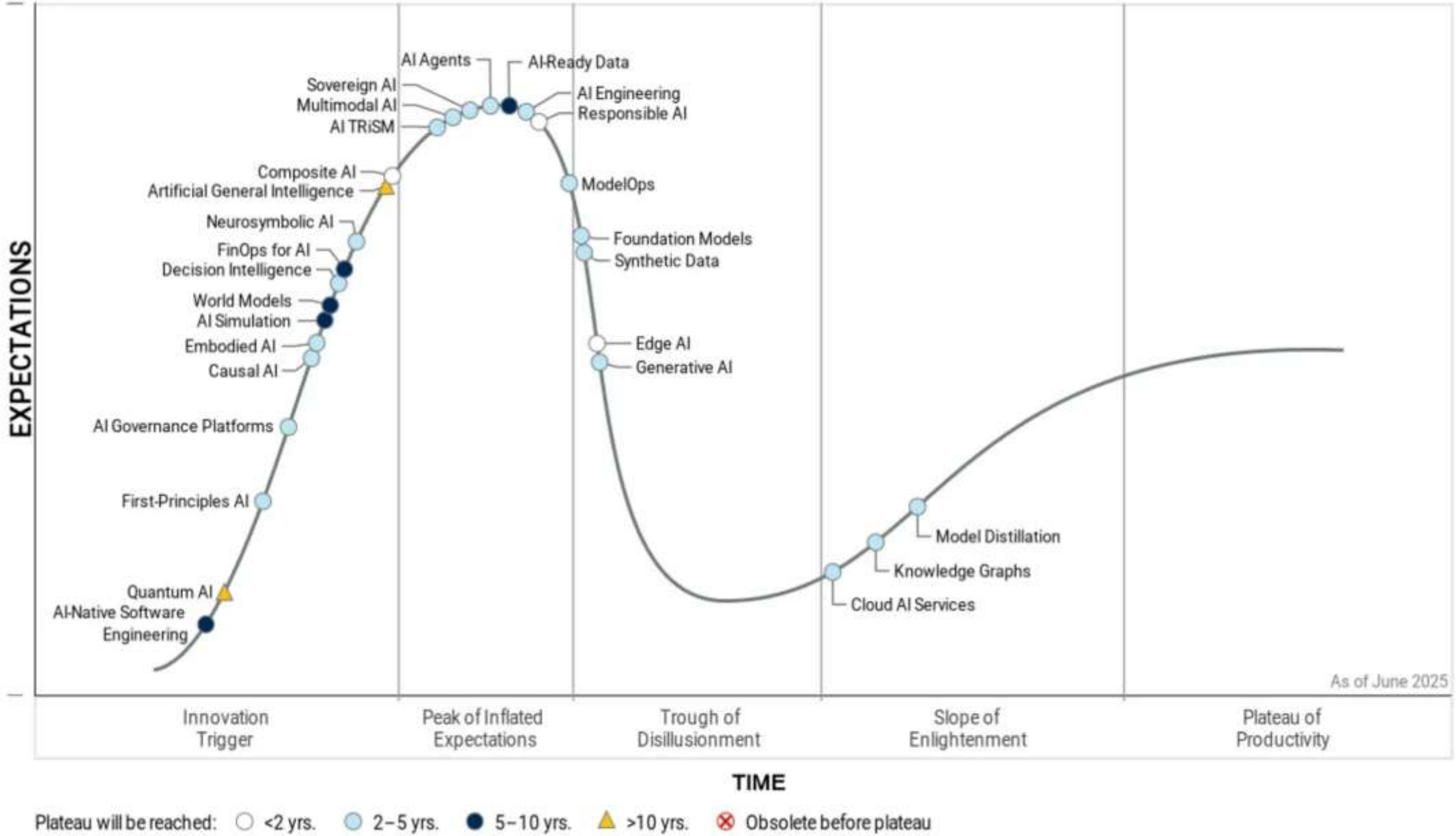

Plateau & Decline
Maturity Point
Revenue & Product
Early Adoption
Growth
Original Product or Strategy
Innovation Window
Growth
New Product or Growth Strategy
Innovation Window
Growth
New Product or Growth Strategy
Innovation Window
Design Thinking
Version & Time

# Figure 1: Hype Cycle for Artificial Intelligence, 2024




Gartner

# Hype Cycle for Artificial Intelligence, 2025




Gartner

# Hype Cycle for Agentic AI




Gartner

*Erinevad suunad, eesmärgid, tehnoloogiad:*

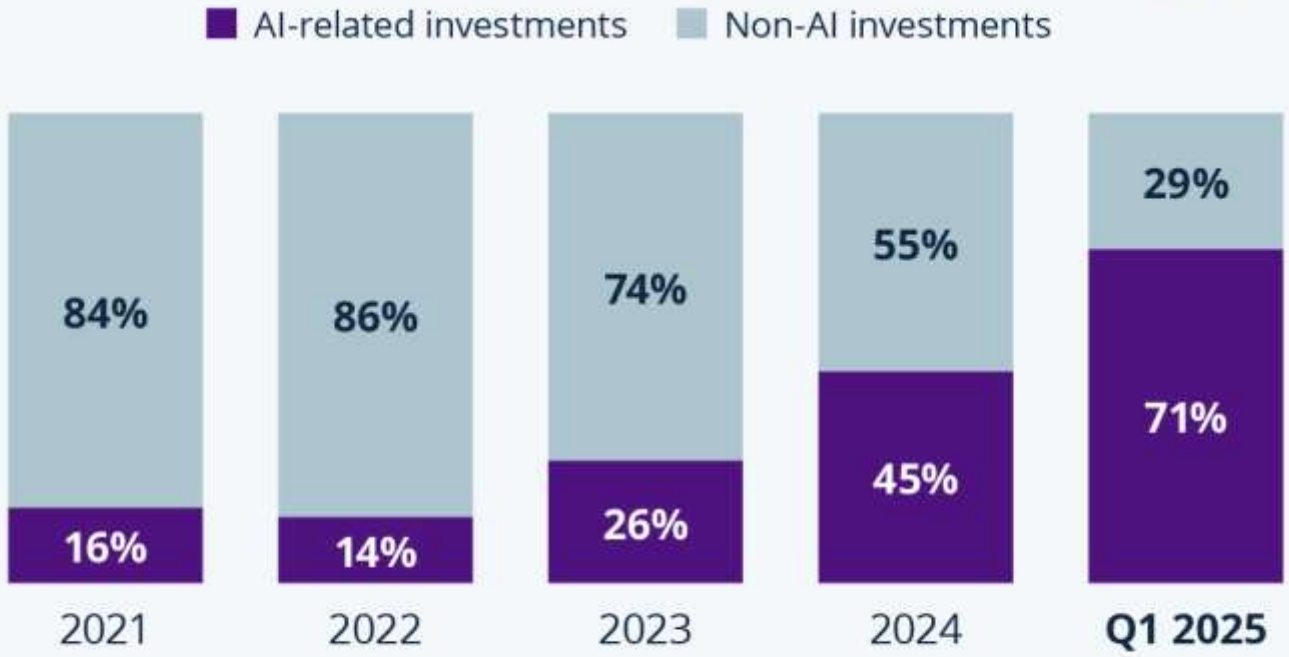
- Tsentraliseerimine
- Automatiseerimine
- Tehisintellekt

} Vastastikune mõju ja võimendus

# Keelemudelite äri ja kasutuse hinnangud 2025-2026

# AI Sucks Up a Growing Chunk of VC Funding in the U.S.

Share of equity investments into U.S. VC-backed companies that are (not) AI-related*


* Sources of cash investments include VC firms, corporate investors, other private equity firms and individuals.

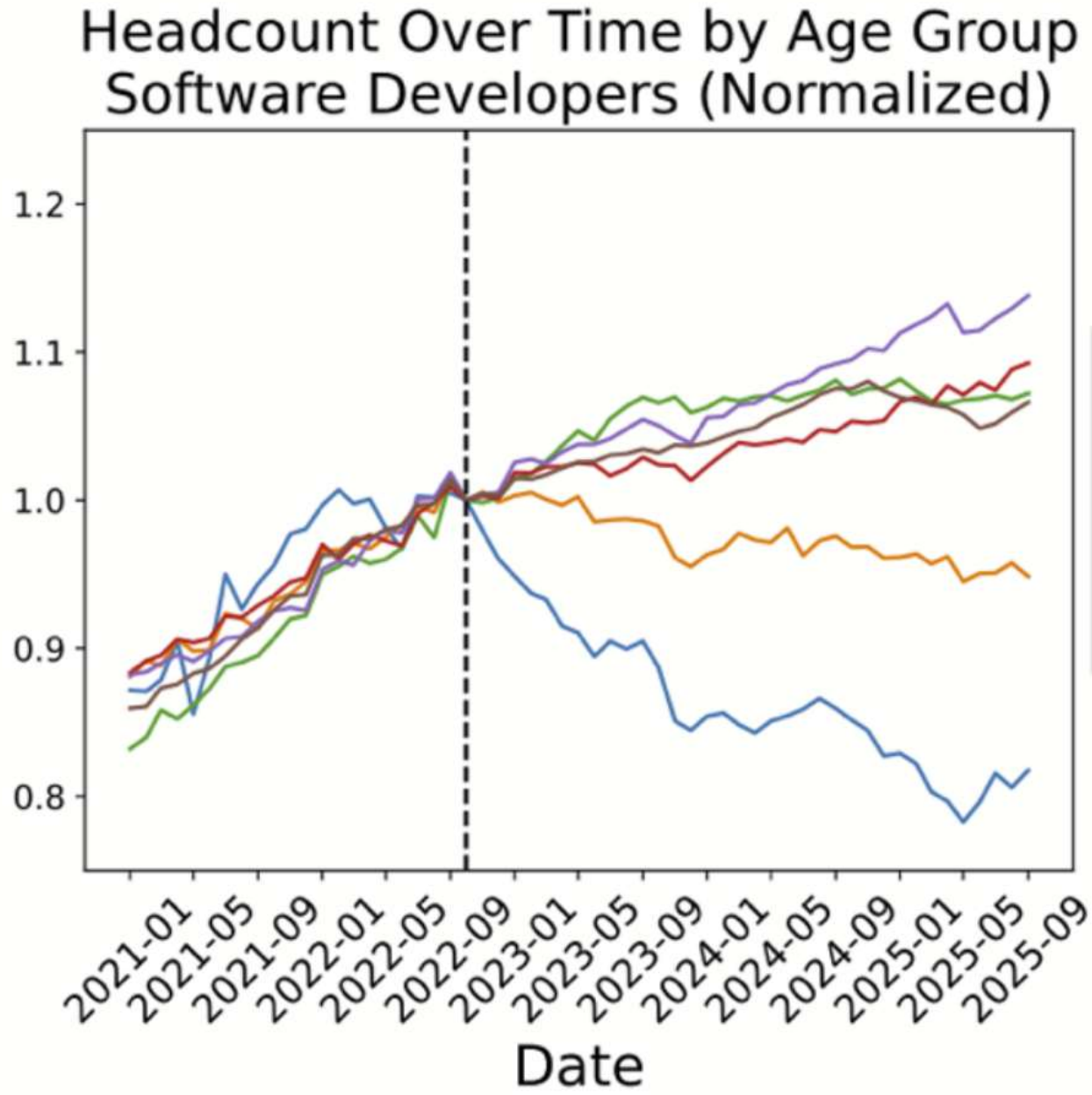
Source: Crunchbase via EY

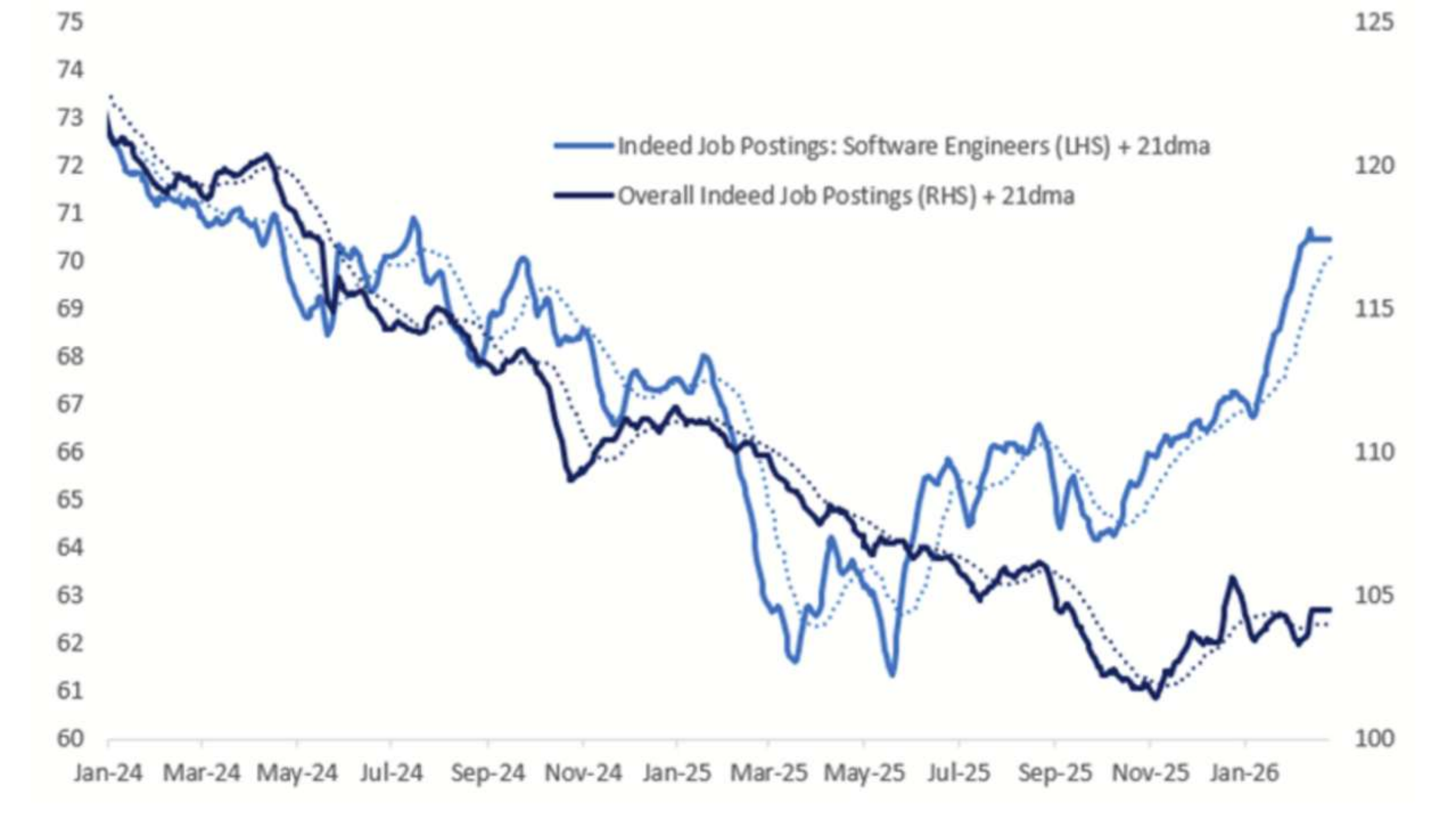
Humlum & Vestergaard, May 2025

*“Large Language Models, Small Labor Market Effects”*

*We examine the labor market effects of AI chatbots using two large-scale adoption surveys (late 2023 and 2024) covering 11 exposed occupations (25,000 workers, 7,000 workplaces), linked to matched employer-employee data in Denmark.*

*AI chatbots have had no significant impact on earnings or recorded hours in any occupation, with confidence intervals ruling out effects larger than 1%. Modest productivity gains (average time savings of 3%), combined with weak wage pass-through, help explain these limited labor market effects.*

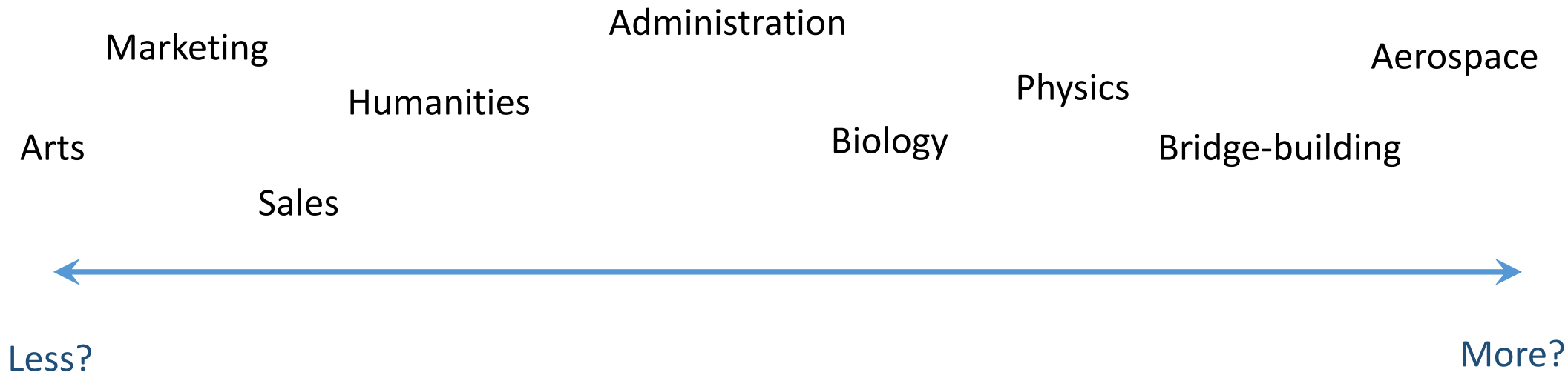

Headcount Over Time by Age Group
Software Developers (Normalized)
1.2
1.1
1.0
0.9
0.8
2021-01
2021-05
2021-09
2022-01
2022-05
2022-09
2023-01
2023-05
2023-09
2024-01
2024-05
2024-09
2025-01
2025-05
2025-09
Date


Indeed Job Postings: Software Engineers (LHS) + 21dma
Overall Indeed Job Postings (RHS) + 21dma
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
125
120
115
110
105
100
Jan-24
Mar-24
May-24
Jul-24
Sep-24
Nov-24
Jan-25
Mar-25
May-25
Jul-25
Sep-25
Nov-25
Jan-26

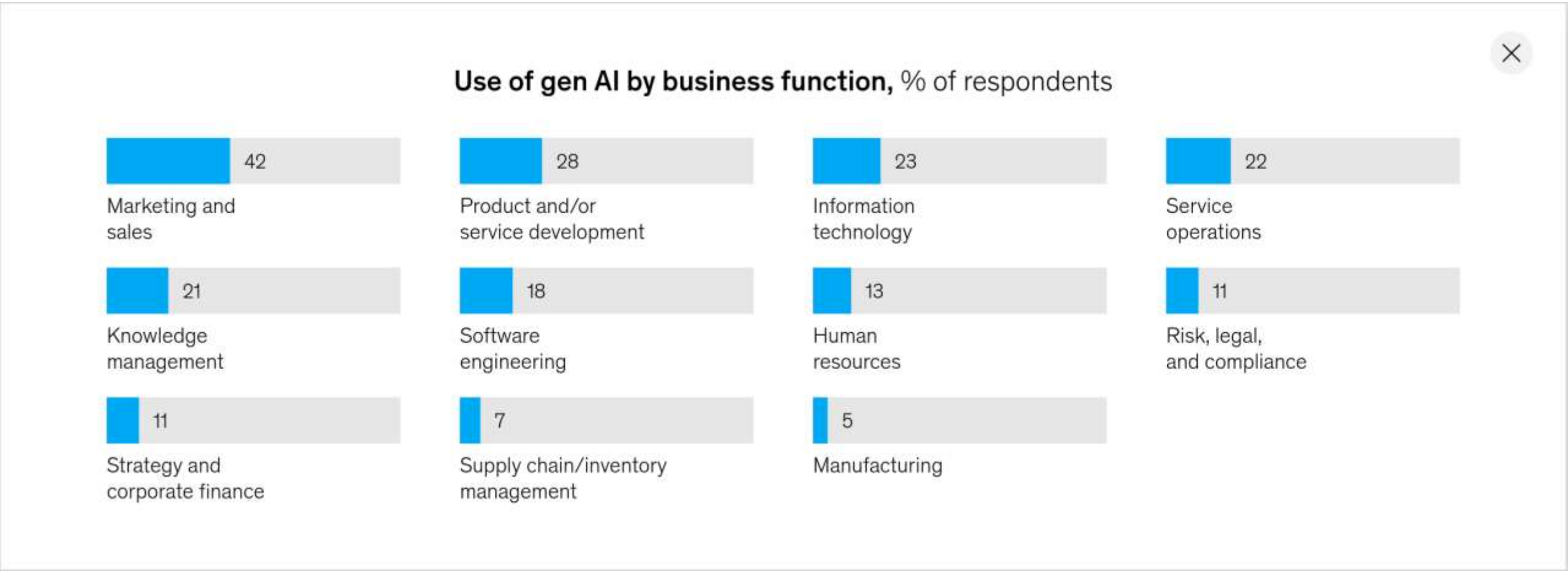
MIT study: The GenAI Divide: State of AI in Business 2025

- Only 5% of organizations are seeing transformative returns. The vast majority—95%—report zero impact on profit and loss statements from formal AI investments.
- The core barrier to scaling is not infrastructure, regulation, or talent. It is learning. Most GenAI systems do not retain feedback, adapt to context, or improve over time.
- At the same time, employees in over 90% of companies regularly use personal AI tools for work.

Where does truth matter?



# McKinsey report, March 2025



# Oletused

- A.I. areneb ennustamatutes suundades, ennustamatu kiirusega.
- Pea kõik “tava-tööd” jäävad nähtavas tulevikus alles.
- Vajalikest A.I. / IT oskustest on väga puudu.
- A.I. võimestab tarkvara arendajaid.
- Nõudlus tarkvara arenduse vastu kasvab.
- Õpetamise struktuuri variatiivsust tasub suurendada.

  Näiteks: käivitame integreeritud erialasid lisaks hüperspetsialiseeritutele.