

Complementarity: A Radically Hopeful Vision for Humans, Artificial Intelligence, and Robots

Ken Goldberg, UC Berkeley



Complementarity: A Radically Hopeful Vision for Humans, Artificial Intelligence, and Robots

(Ken) Goldberg@Berkeley.edu

1. Complementarity



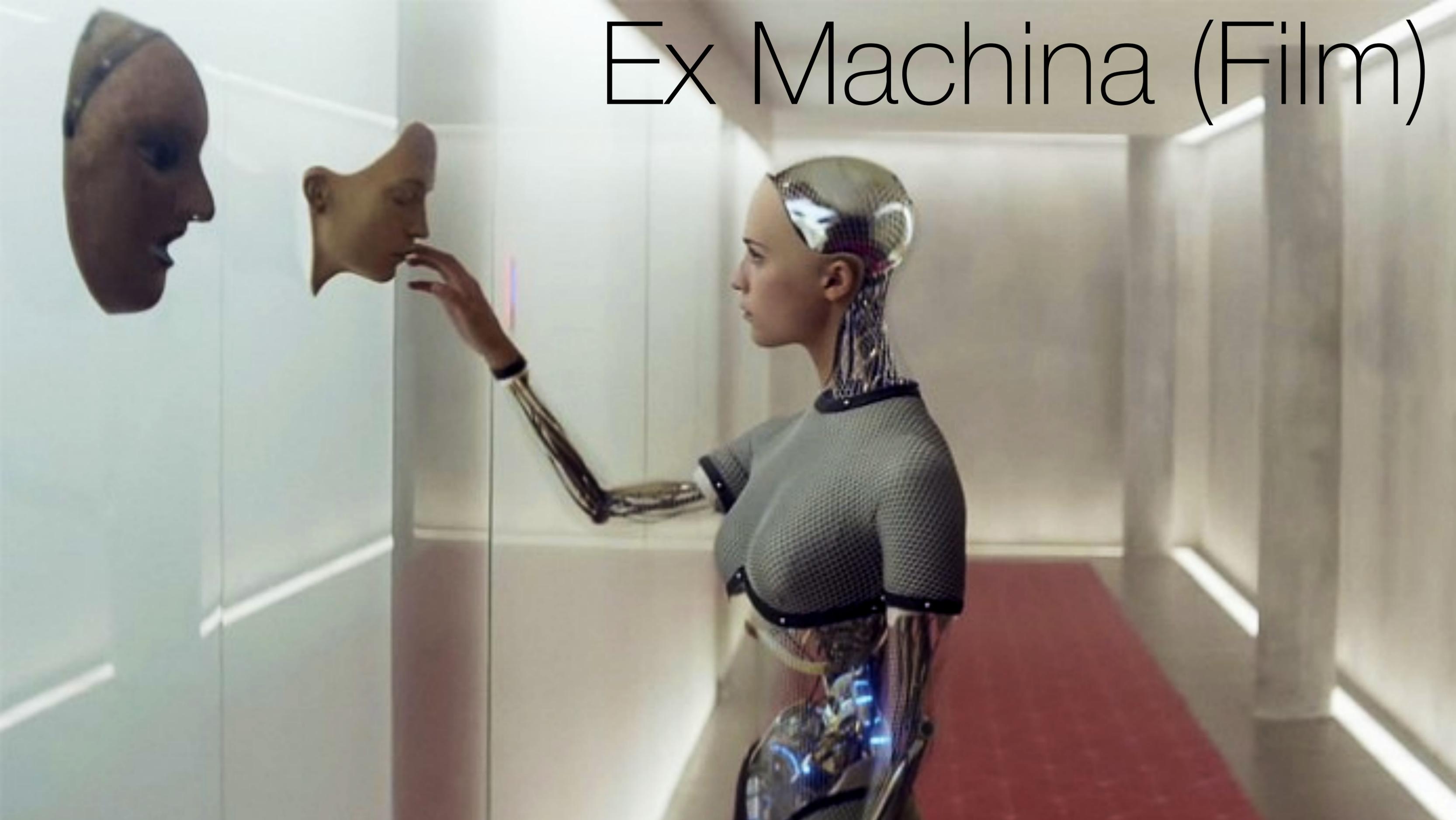
2. Inclusive Intelligence



3. AI School Movement



Ex Machina (Film)

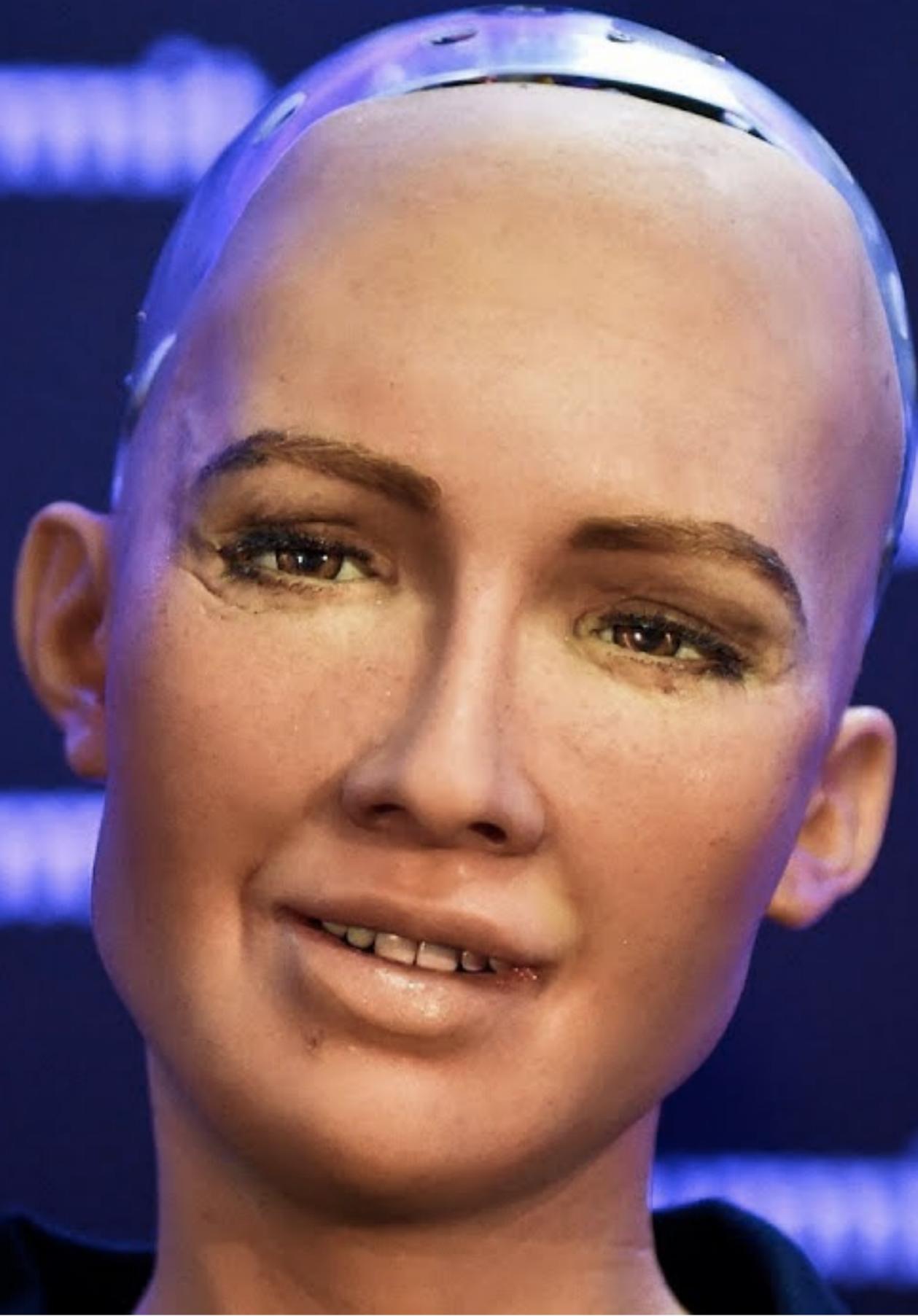




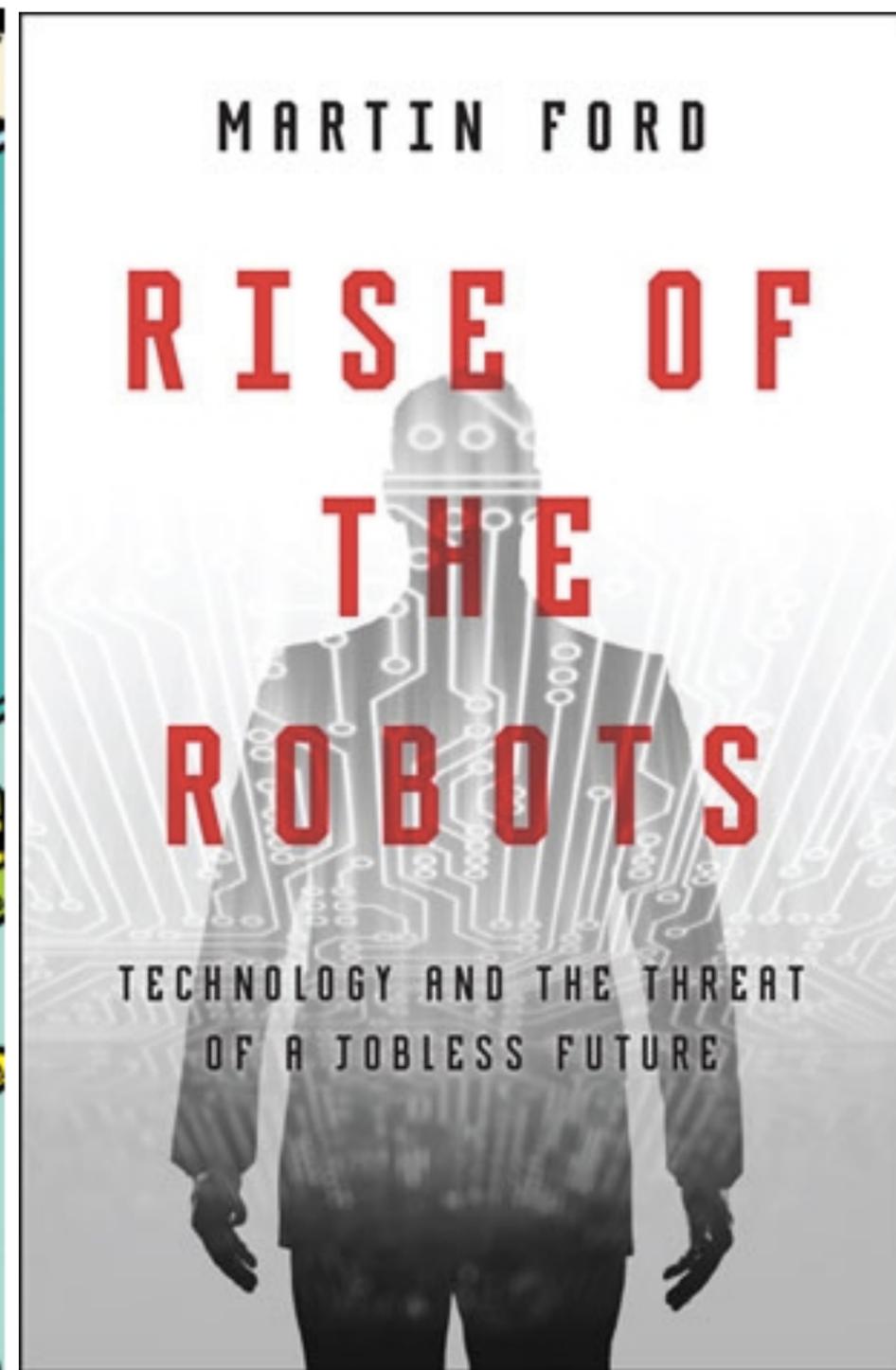
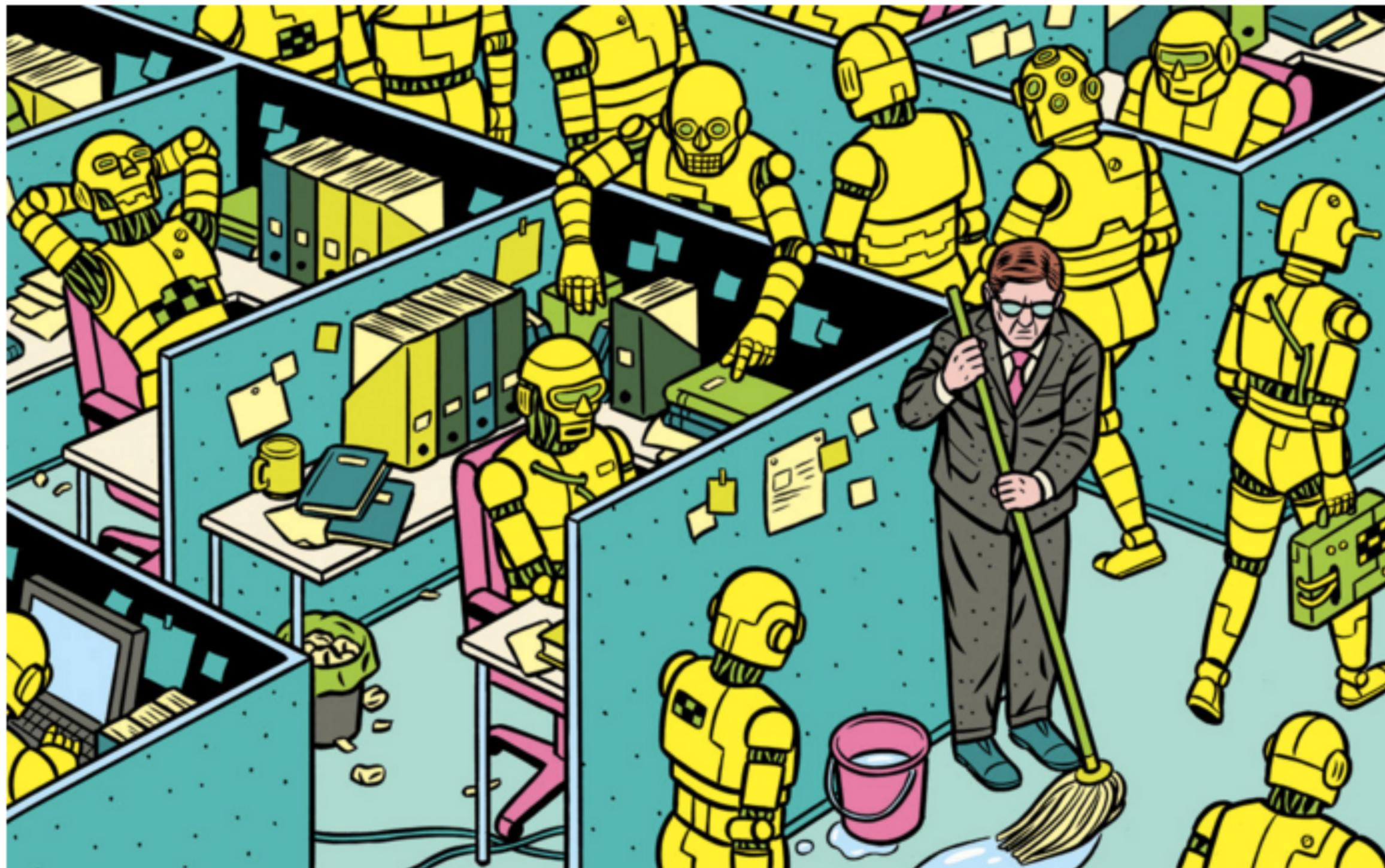
“Humans” (TV)



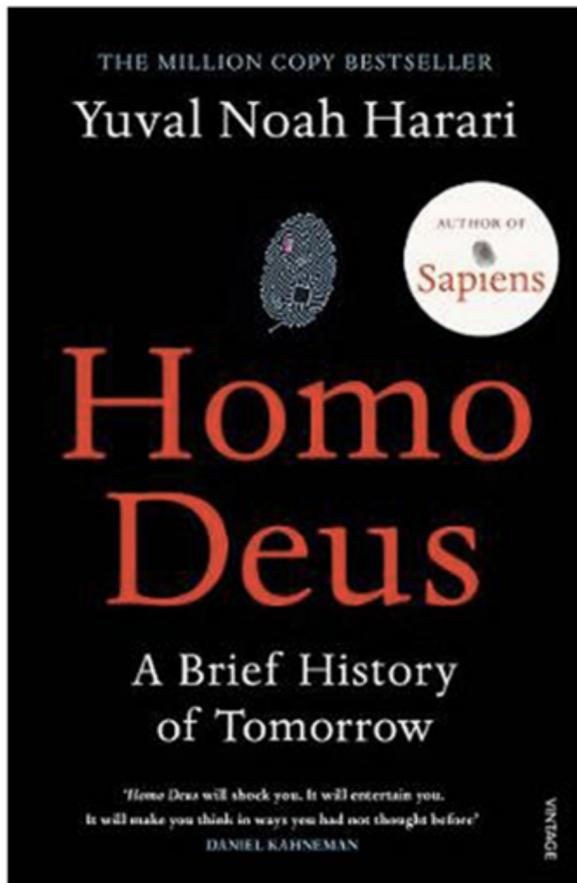
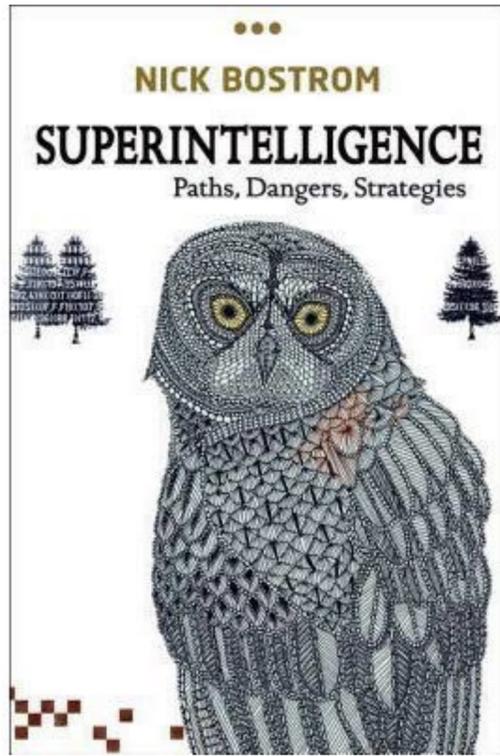
**SOPHIA
THE ROBOT
FULL
INTERVIEW**



The New York Times



Artificial Intelligence Concerns



Bill Gates



Stephen Hawking



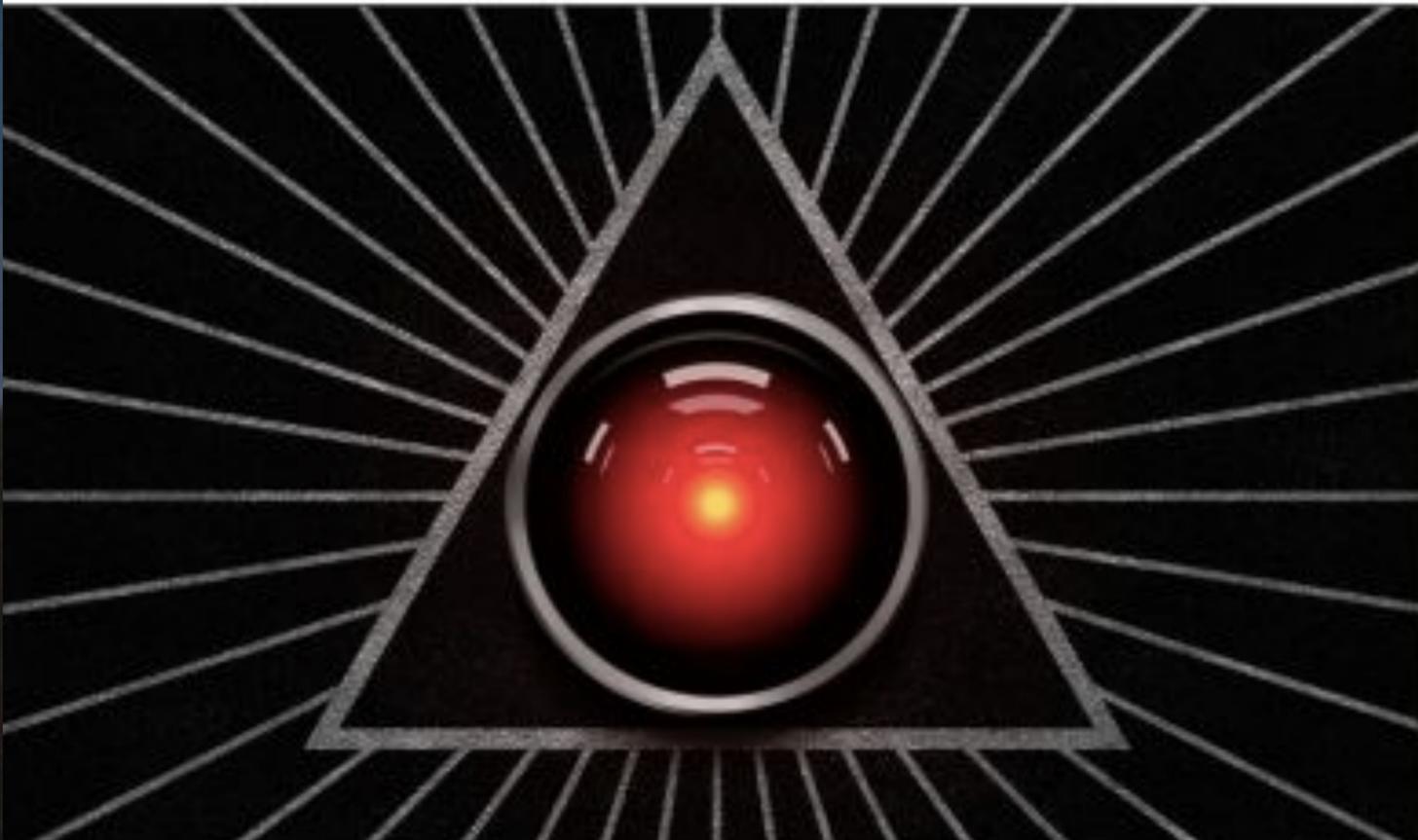
Elon Musk



The Atlantic

SUBSCRIBE

Popular Latest Sections Magazine More



Edmon de Haro

How the Enlightenment Ends

Philosophically, intellectually—in every way—human society is unprepared for the rise of artificial intelligence.

HENRY A. KISSINGER

JUNE 2018 ISSUE | TECHNOLOGY

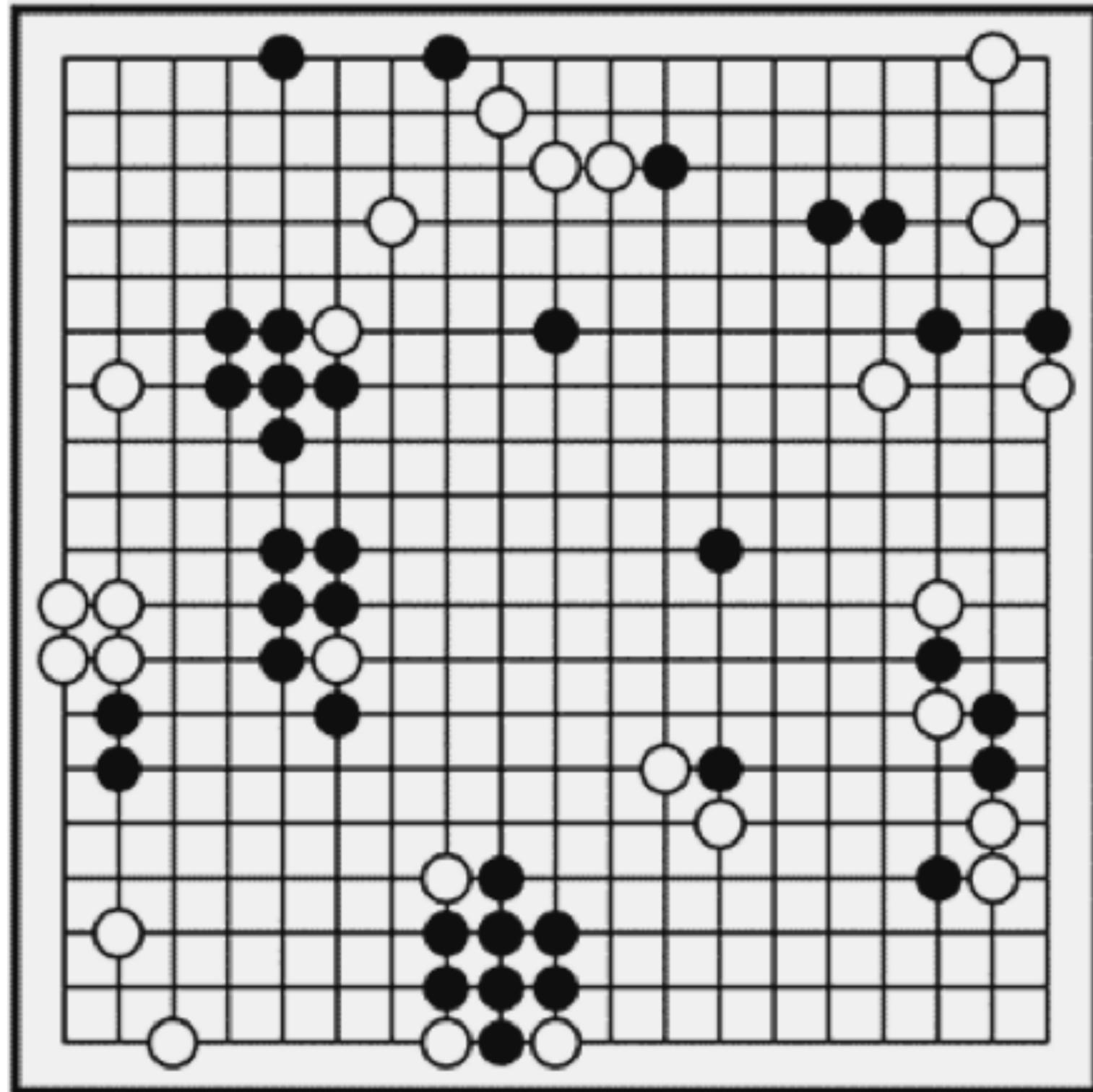
The image shows the top portion of a web page from The Atlantic. At the top left is the logo "The Atlantic". To the right is a "SUBSCRIBE" button and a search icon. Below this is a navigation bar with five icons: an upward-pointing arrow labeled "Popular", a clock labeled "Latest", a hamburger menu labeled "Sections", an open book labeled "Magazine", and a plus sign labeled "More". The main content area features a large, stylized Illuminati symbol (an eye inside a triangle with radiating lines) on a dark background. Below the symbol, the author's name "Edmon de Haro" is visible in small text. The main headline is "How the Enlightenment Ends" in a large, bold font. Below the headline is a sub-headline: "Philosophically, intellectually—in every way—human society is unprepared for the rise of artificial intelligence." At the bottom of the article preview, the author's name "HENRY A. KISSINGER" is displayed in red. Below that, it says "JUNE 2018 ISSUE" followed by a vertical line and a red button with the word "TECHNOLOGY" in white.



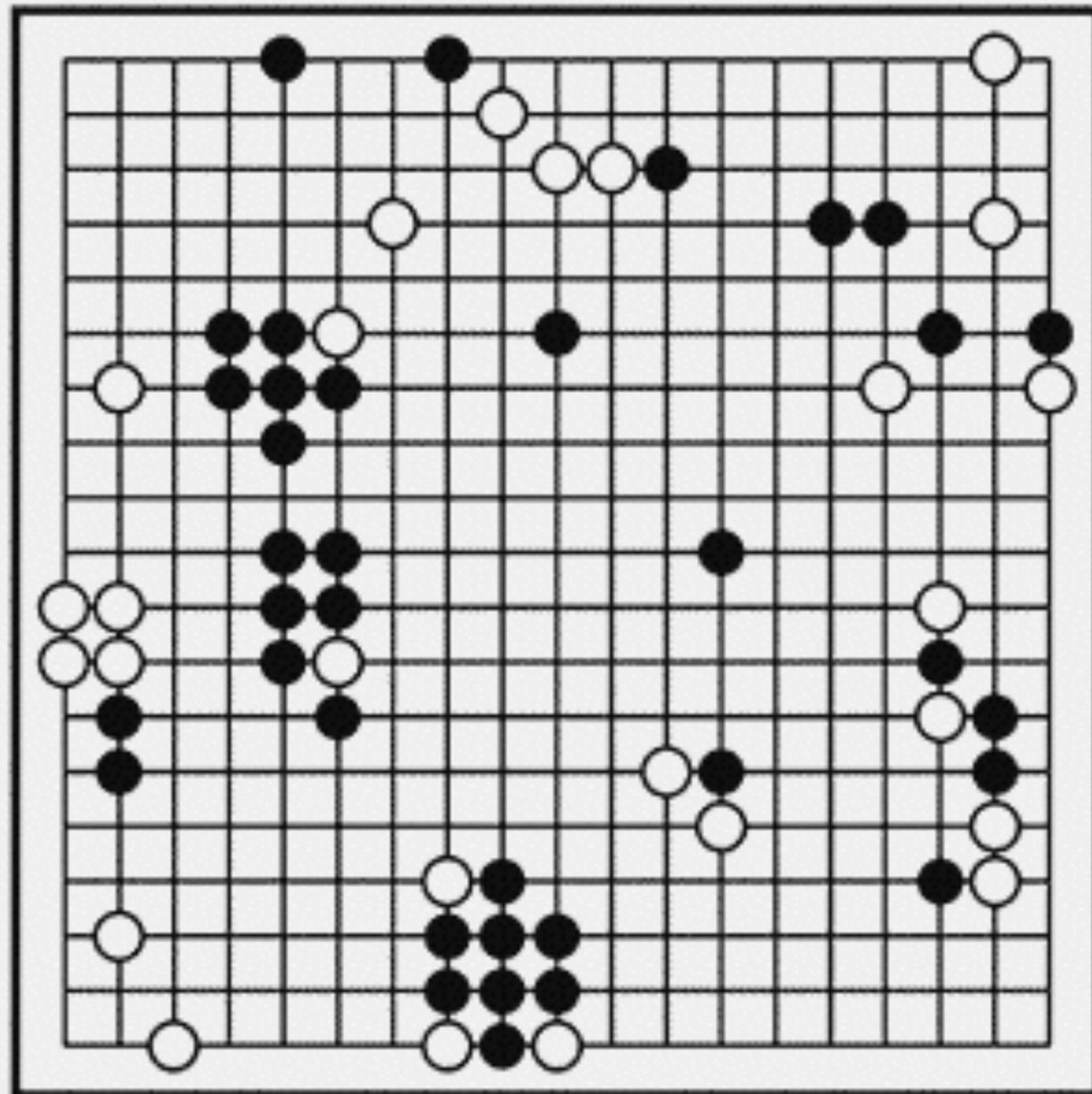
Google DeepMind Challenge Match

8 - 15 March 2016



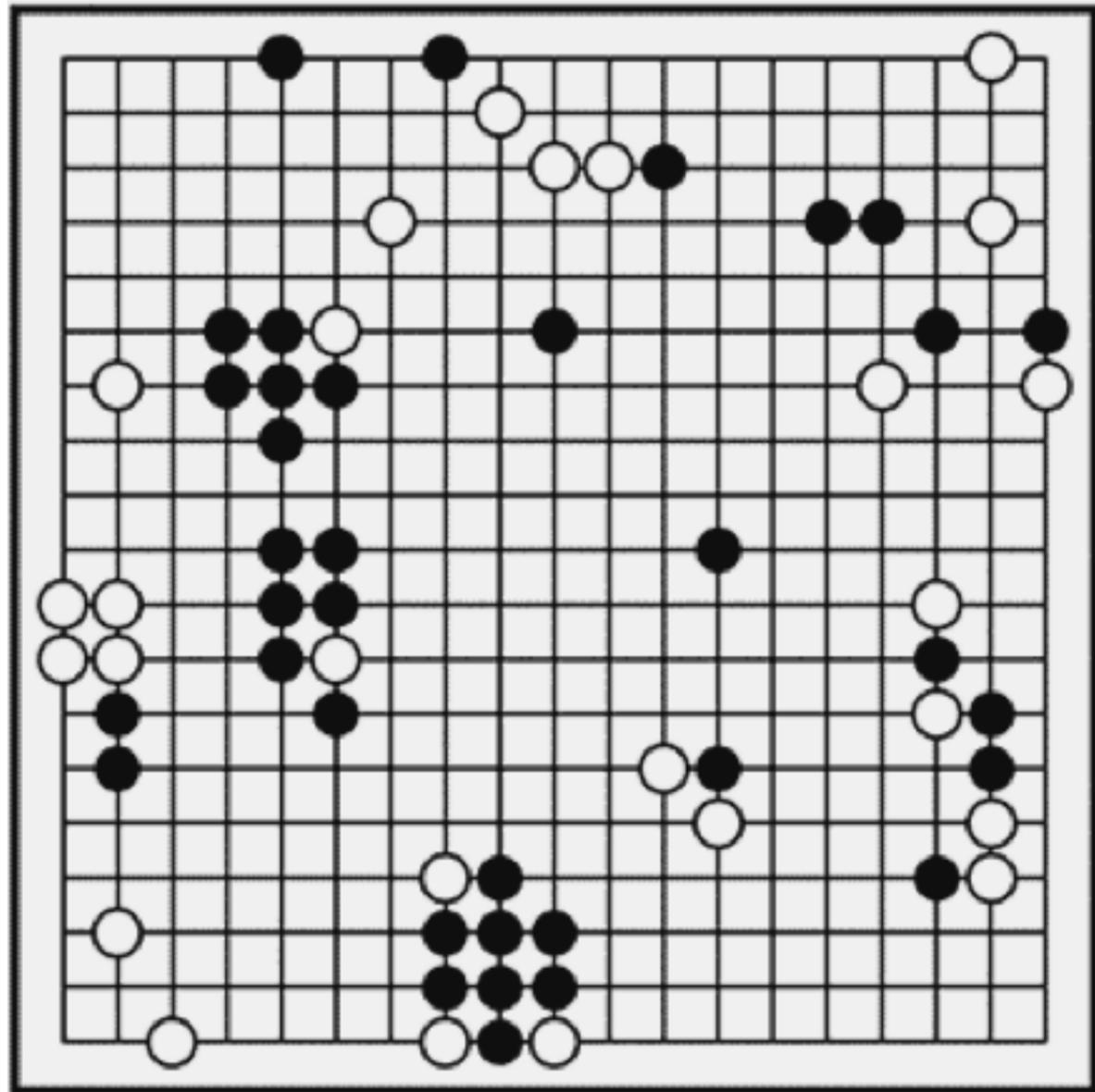


Fully Observed State:
19x19,
Trinary,
Static.





Game



Reality



WE
WANT
JOBS

It's not
just
about
Wall
Street.
It's about
Congress

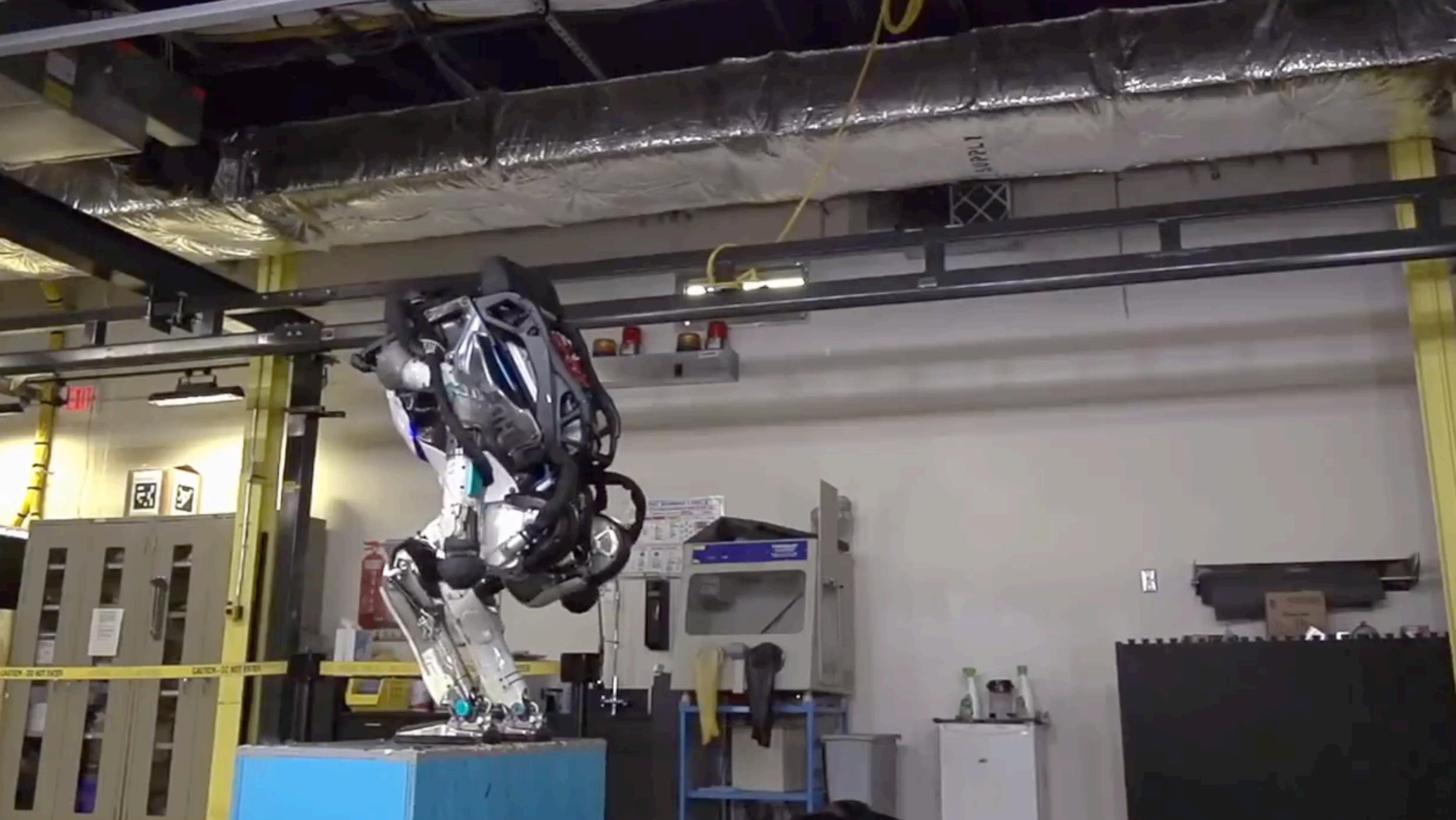
JOBS
YES





Automation Anxiety





SUPPLY

CAUTION - DO NOT ENTER

CAUTION - DO NOT ENTER



Elon Musk ✓

@elonmusk

Following



Replying to [@timkhiggins](#)

Yes, excessive automation at Tesla was a mistake. To be precise, my mistake. Humans are underrated.

3:54 PM - 13 Apr 2018





70

Sand Hill Rd
1.6 mi

2825 Sand Hill Rd

2.2 mi 2 min 12:21 PM

68°

CUSTOM







USC MOVING

8Y14500

FC

EMERGENCY

The World's Finest
Emergency Services in the Area
New York City, NY & Surrounding Areas
1-800-555-1234

ONE WAY

China intends for self-driving cars to propel smart megacity

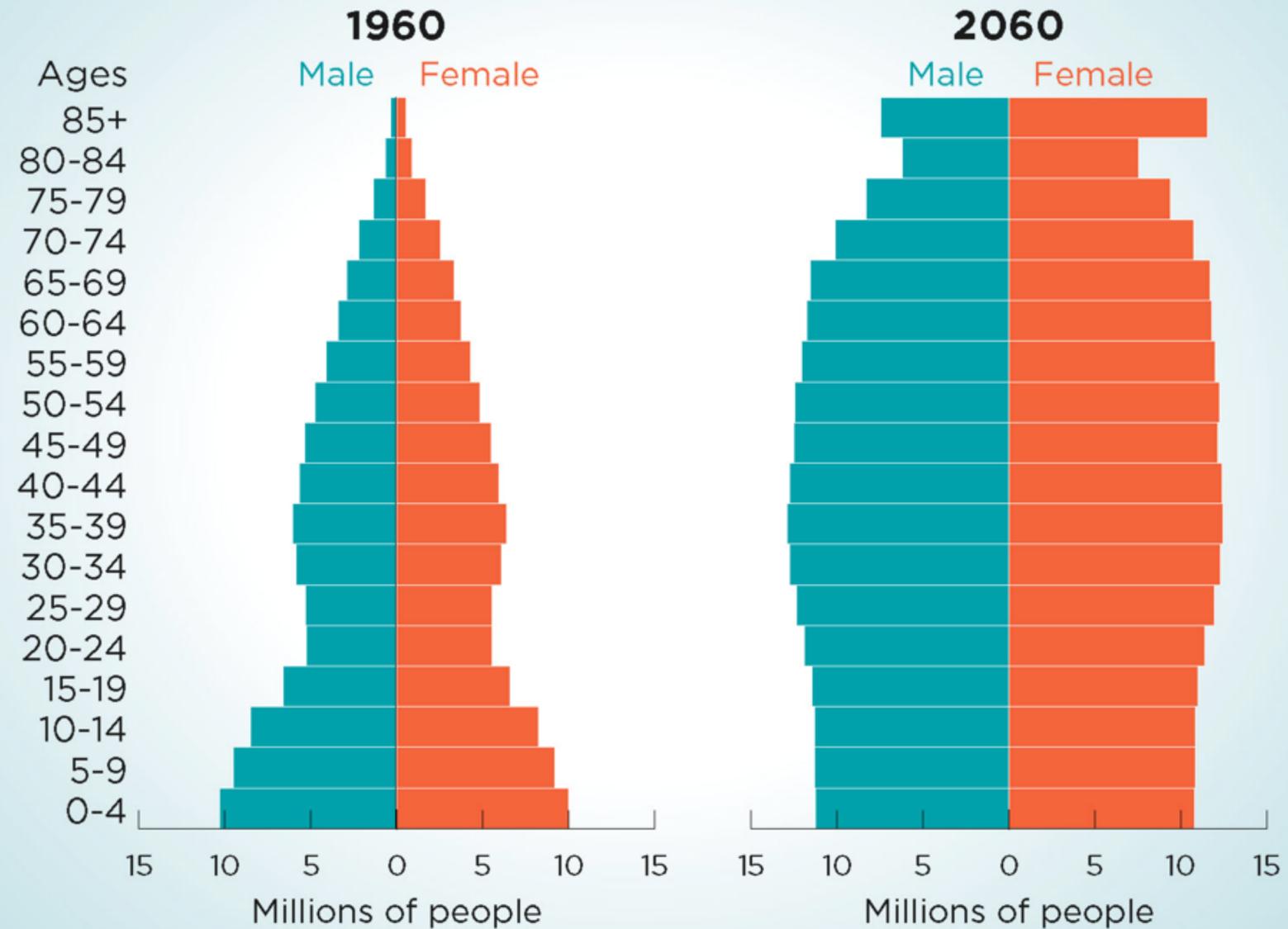
President Xi's Xiongan project challenges US tech dominance and free market innovation

SHUNSUKE TABETA, Nikkei staff writer
MAY 20, 2018 12:46 JST



From Pyramid to Pillar: A Century of Change

Population of the United States



419

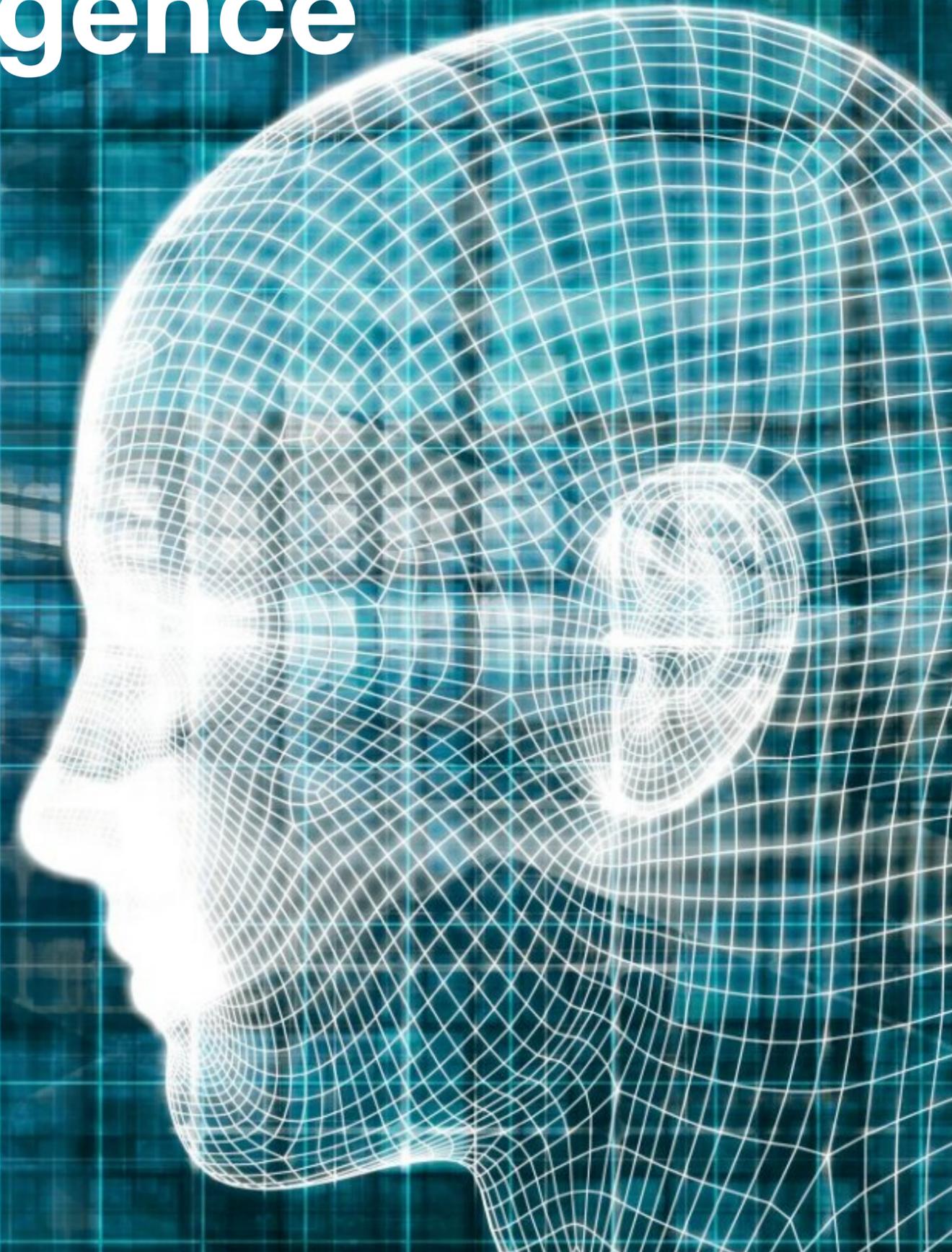
**NOW
HIRING**



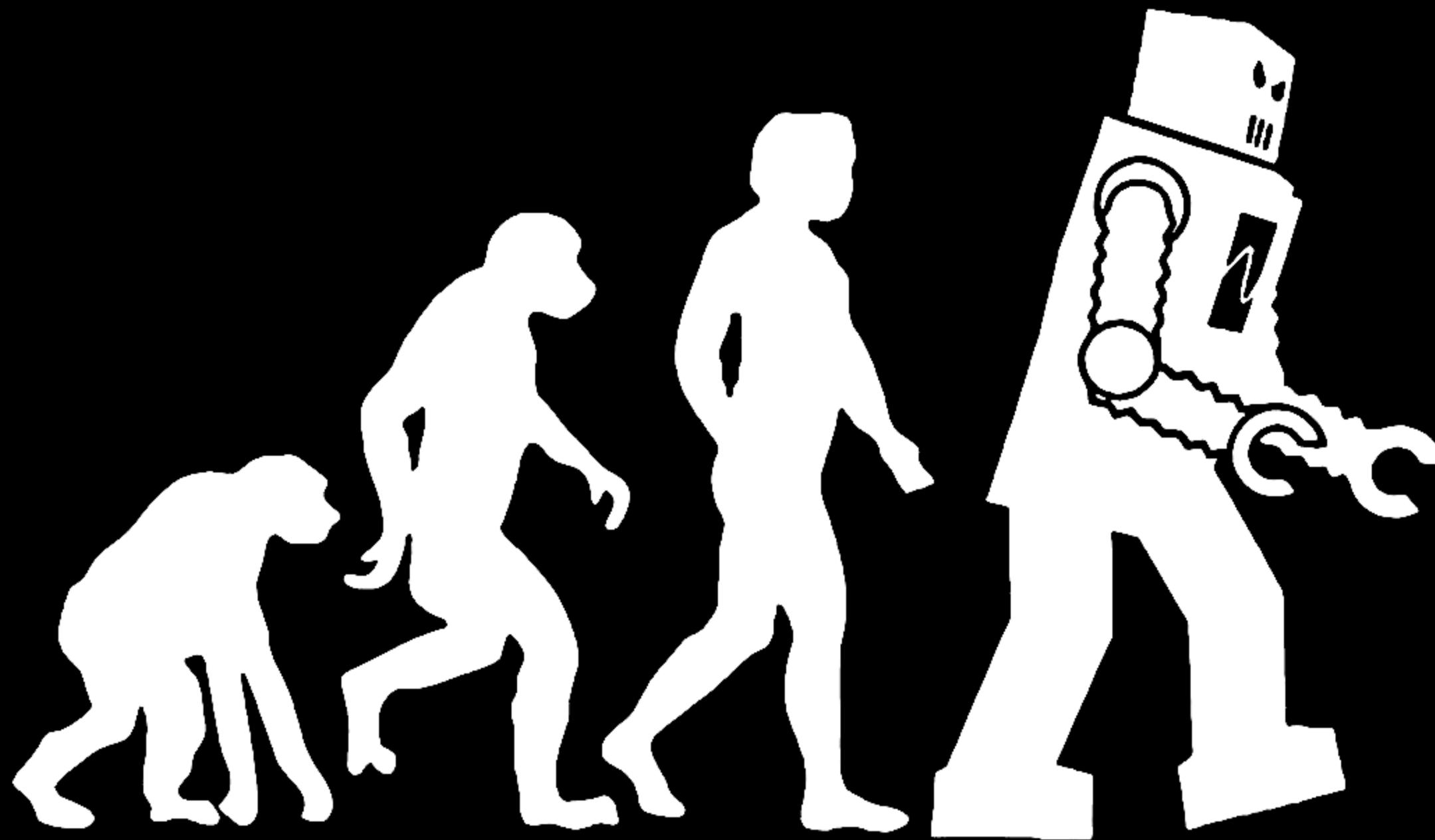
NOW



Artificial Intelligence



SINGULARITY ?



A. ARTIFICIAL

I. INTELLIGENCE

+

I. INTELLIGENCE

A. AMPLIFICATION

COMPLEMENTARY SKILLS

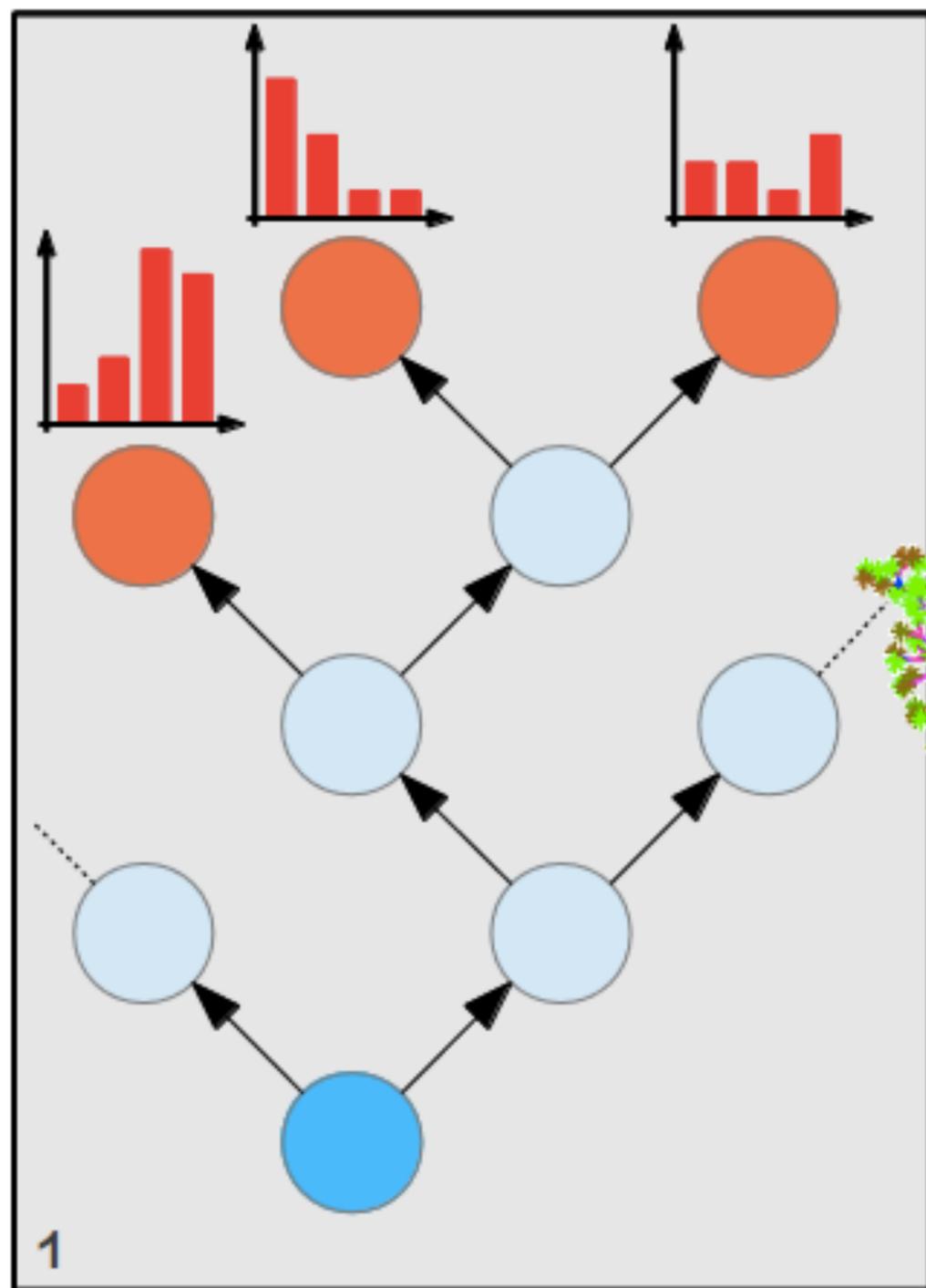




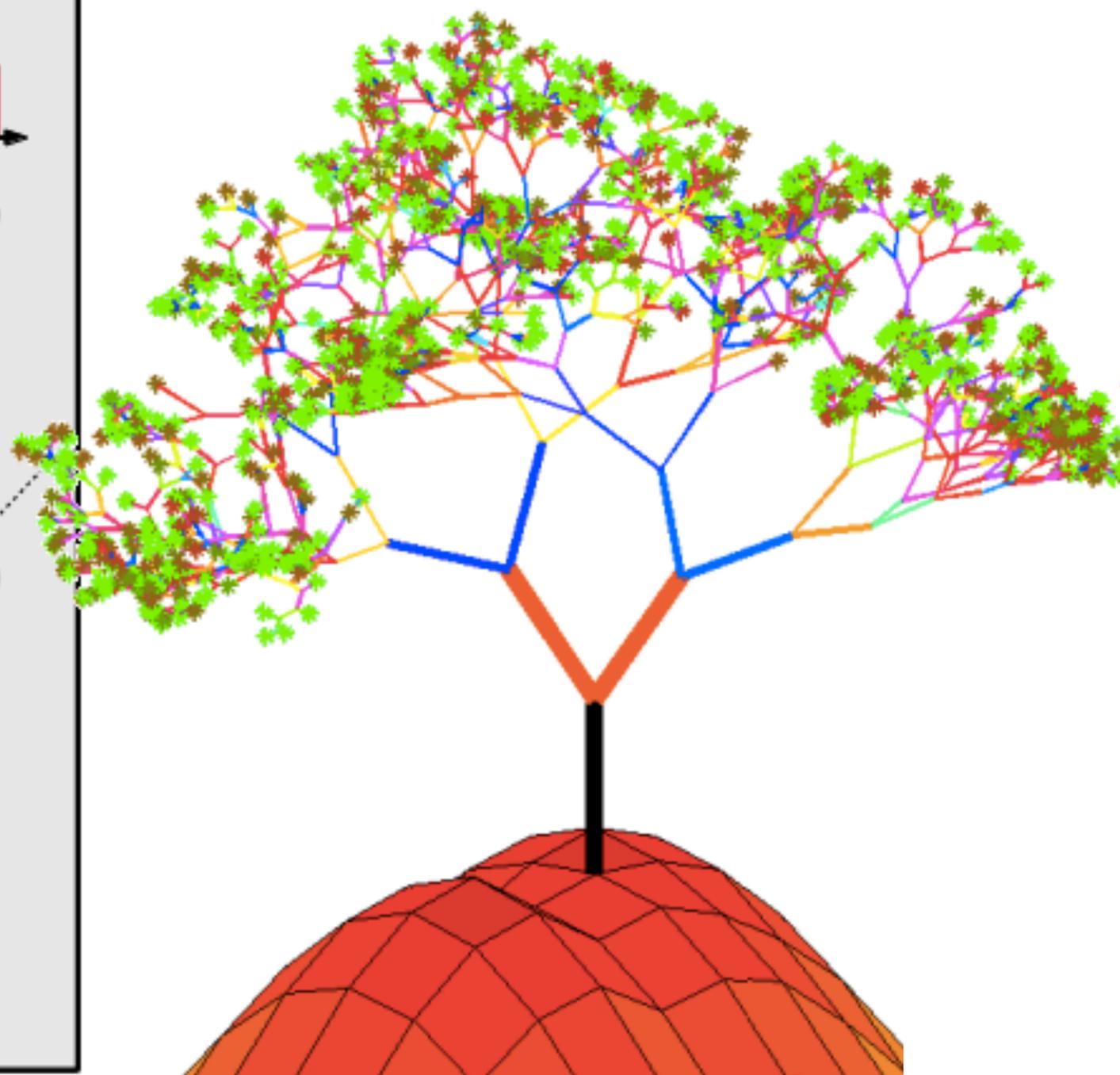
Calculations
Precision
Objectivity

Understanding
Empathy
Dexterity

Decision Tree



8,0.78985

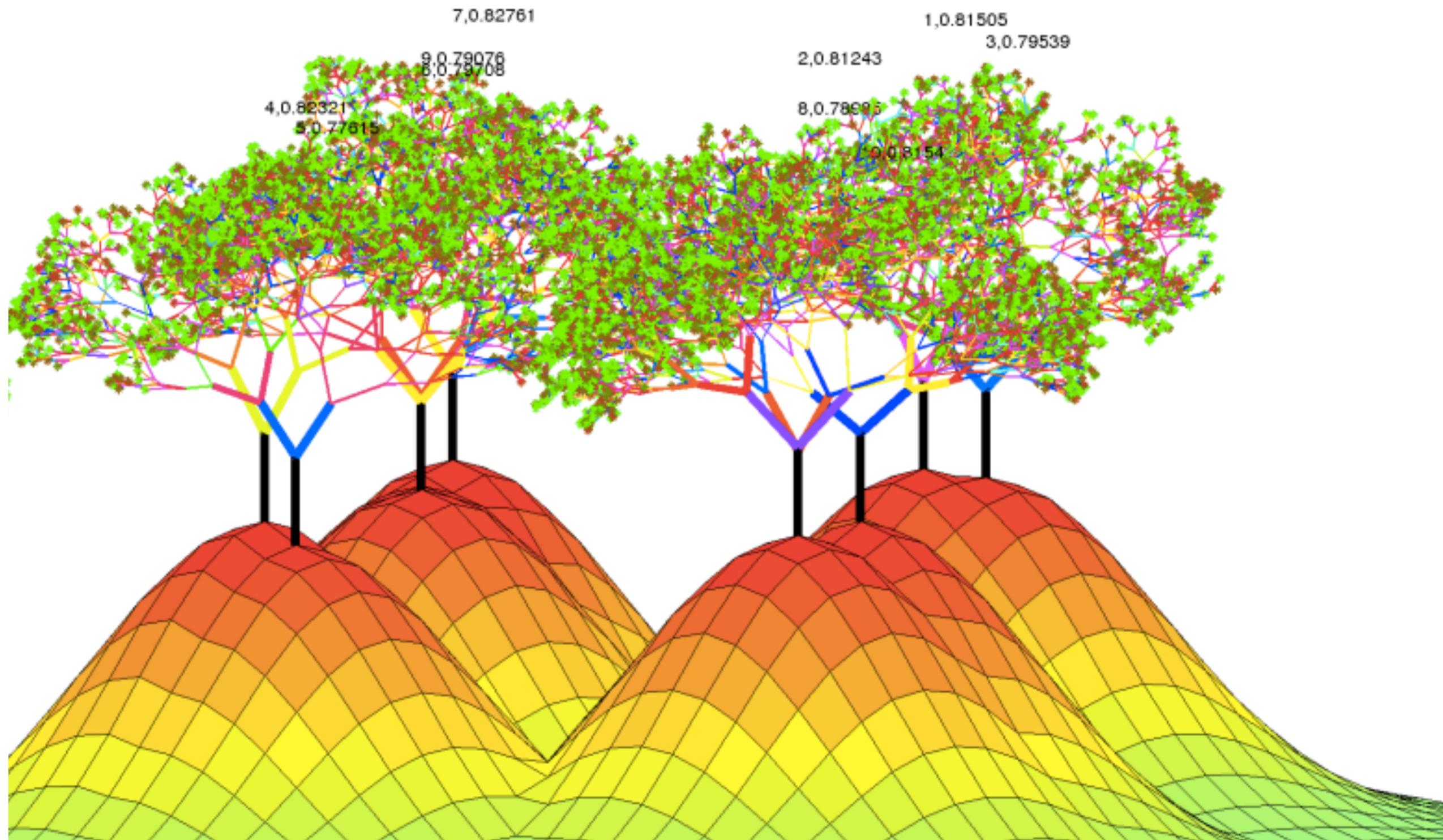


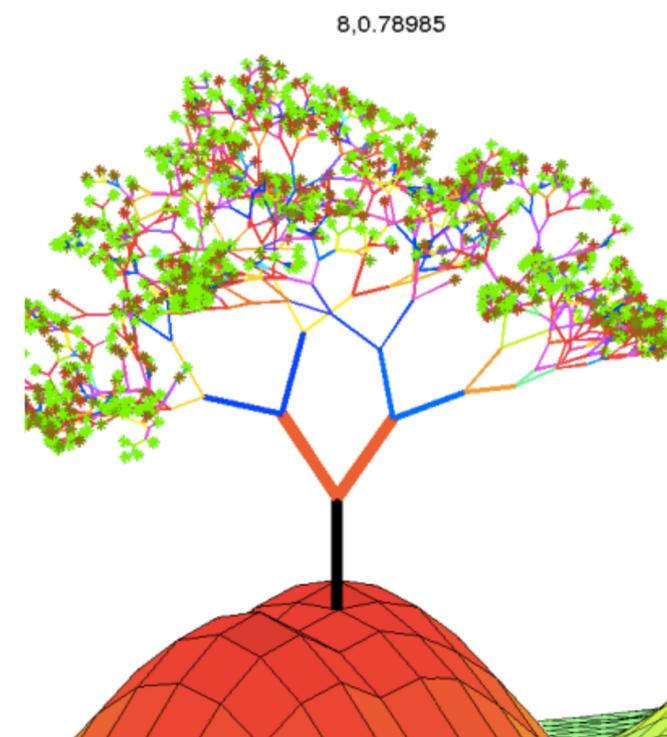
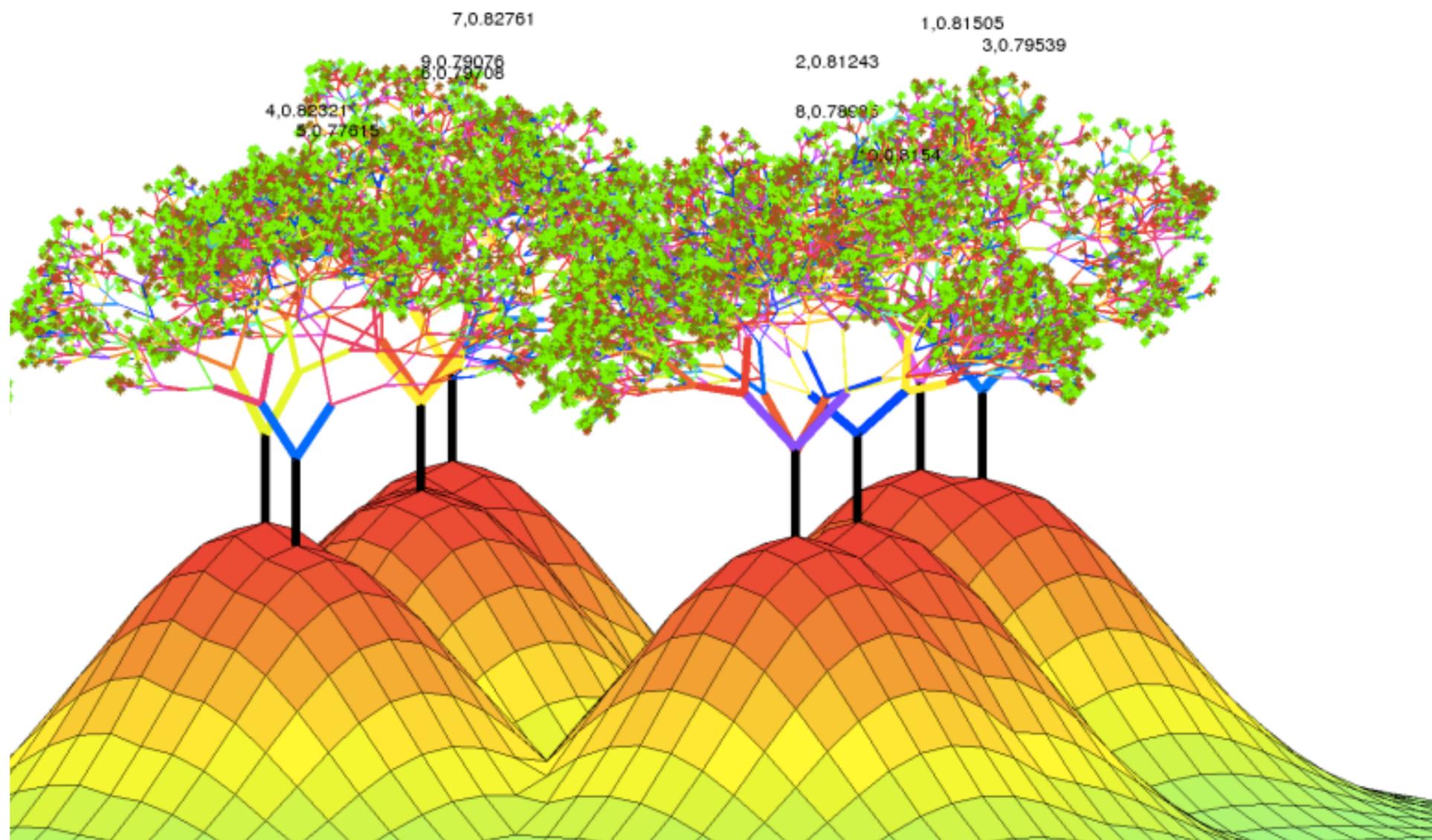
In 2001 at UC Berkeley...



Leo Breiman and Adele Cutler

“Random Forest”





Theorem 2.3. *An upper bound for the generalization error is given by*

$$PE^* \leq \bar{\rho}(1 - s^2)/s^2.$$

Copyrighted Material
"Deeply explores the power of information technology to enable truly new forms of human organization. Highly recommended." — JIMMY WALES, WIKIPEDIA FOUNDER

Superminds



THE SURPRISING POWER OF PEOPLE
AND COMPUTERS THINKING TOGETHER

THOMAS W. MALONE

Copyrighted Material

“Collective IQ”



VICIPÆDIA

ΒΙΚΙΠΑΙΔΕΙΑ

ウィキペディア

ויקיפדיה

WIKIPÉDIA

維基百科

วิกิพีเดีย

ويكيبيديا

위키백과

VICIPÉID

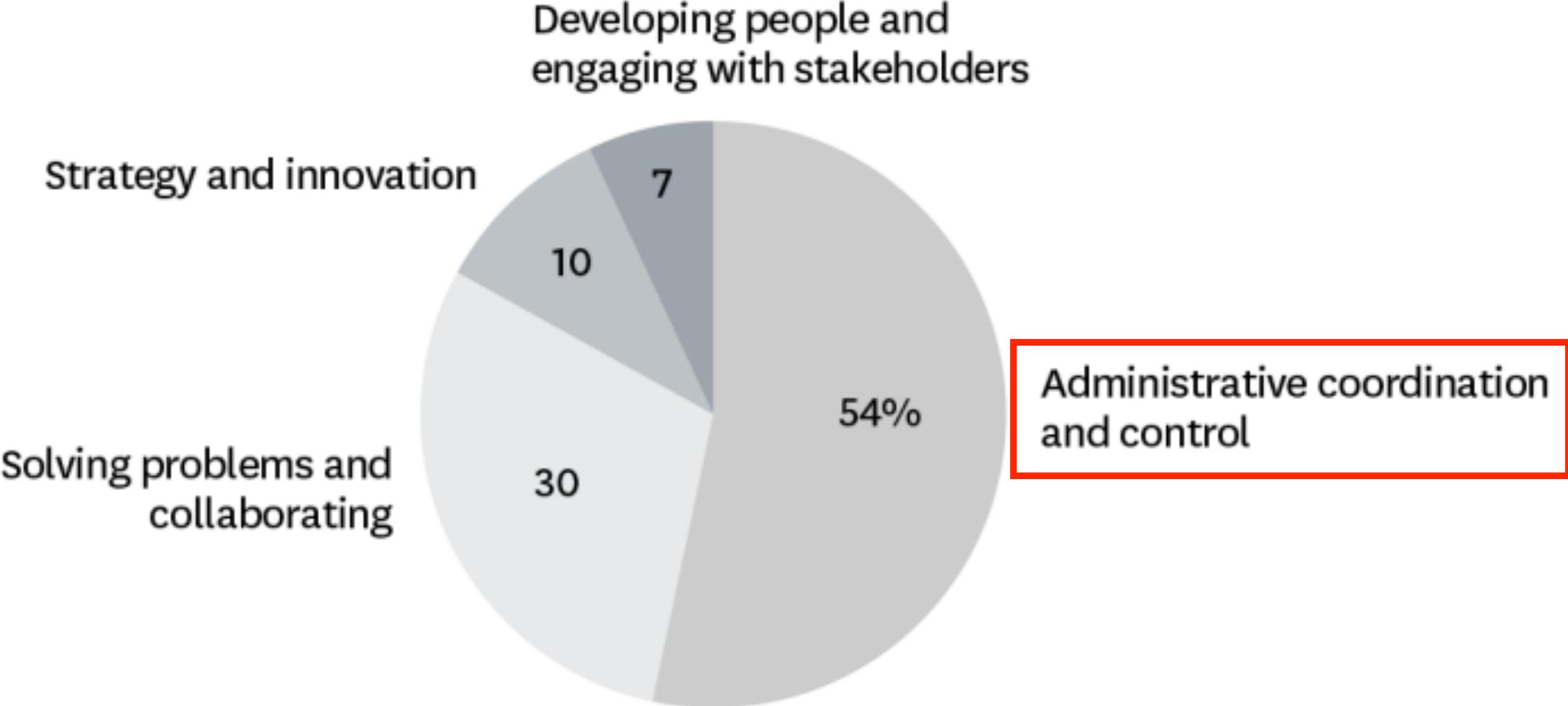
विकिपीडिया

WIKIPEDIA
The Free Encyclopedia

How Managers Spend Their Time

The bulk of it is spent on administrative tasks.

PERCENTAGE OF TIME RESPONDENTS SPEND ON CATEGORIES OF WORK



SOURCE ACCENTURE SURVEY OF 1,770 FRONTLINE, MID-LEVEL, AND EXECUTIVE-LEVEL MANAGERS FROM 14 COUNTRIES

The Skills Managers Say They Will Need to Succeed

PERCENTAGE OF RESPONDENTS WHO SELECTED THE GIVEN SKILL AMONG THEIR TOP THREE



SOURCE ACCENTURE SURVEY OF 1,770 FRONTLINE, MID-LEVEL, AND EXECUTIVE-LEVEL MANAGERS FROM 14 COUNTRIES

© HBR.ORG



Complementarity: A Radically Hopeful Vision for Humans, Artificial Intelligence, and Robots

(Ken) Goldberg@Berkeley.edu

1. Complementarity



2. Inclusive Intelligence



3. AI School Movement



AI today is **exclusionary** in four ways:

1. **Arcane:** many AI techniques and results require advanced math and statistical knowledge at graduate-school levels.
2. **Inaccessible:** requiring access to substantial datasets and computation.
3. **Centralizing:** only a small number of companies and universities have the funding and expertise to advance AI.
4. **Polarizing:** increasing social disparities in knowledge, income, and privilege.

Inclusive Intelligence

AI that is:

- 1) Inclusive of diverse populations including those most vulnerable;
- 2) Inclusive of the spectrum of human and artificial intelligences and the ways they can constructively interact, enhance, and complement each other.

THE WALL STREET JOURNAL

Nadal Takes a Record 10th Title at Roland Garros

Uber Faces Deeper Turmoil

OPINION

The Robot-Human Alliance

Humanity is on the cusp of a new era. The integration of artificial intelligence and robotics into our daily lives is no longer a distant future. It is here, and it is changing the way we think, work, and live. As we embrace this technology, we must also consider the implications for our society and our future.

Call it Multiplicity
diverse perspectives

A Metropolis Rises Again

AI will allow us to do what it is that we are uniquely meant to do: to focus on high-level thinking, strategy and paving the way for innovation.

—Tony Blair, Executive Chair of the Institute for Global Change and Former UK Prime Minister

bit.ly/Cognitive-Diversity-Tata-Study

Motivation and Executive Summary

The new role of the human being is not to produce; it is to create.

—Reinaldo Pamponet, Founder, Itsnoon

This study began in the summer of 2016 with a series of discussions between Vinod Kumar, CEO of Tata Communications, and Ken Goldberg, professor of engineering at the University of California, Berkeley, about how perceived and potential innovations in artificial intelligence and cloud communications will affect business practices, jobs and worker morale.

Although 5G networking is on a clear road map, the evolution and impact of AI is less certain, due in part to widespread claims of an impending “Singularity” when AI and robots might surpass humans and “steal” a substantial fraction of jobs.

Goldberg’s critique of the Singularity as distracting and counterproductive motivated him to propose an alternative concept, “Multiplicity,” where groups of machines and humans collaborate to innovate and solve problems. Machine learning theory has established the importance of statistical diversity in algorithms, parameters and data sets.

In *The Diversity Bonus*, Scott E. Page highlights the importance of cognitive diversity—differences in how humans perceive, interpret, reason and solve—in human groups. The more diverse the participants, he argues, the more opportunities to discover insights and novel approaches. Accordingly, the goal of this study is to explore inclusive and constructive future roles for AI that could have a positive impact on work and morale, under the hypothesis:

AI has the potential to enhance collective intelligence and intellectual diversity, allowing human workers to do more diverse thinking, become more efficient, and undertake more creative, fulfilling labour.

Tata Communications, operating at the forefront of a pivotal moment in the evolution of society—the so-called “Fourth Industrial Revolution”—helps customers make sense of and navigate the vast potential offered by emerging and disruptive technologies such as the internet of things (IoT), artificial intelligence (AI), big data, mobility and cloud computing. It is also uniquely positioned to help its customers embrace these new opportunities starting to make their presence felt including edge computing, 5G, blockchain and more—enabling its customers’ digital future, now.

The study, conducted by Tata Communications and Prof. Goldberg,¹ began with a literature survey and was influenced

¹ Produced in conjunction with Gershoni Creative (San Francisco, California).

Cognitive Diversity: AI & The Future of Work

AI

<http://bit.ly/AI-Diversity-Study>

TATA COMMUNICATIONS

The Economist

SEPTEMBER 15TH-21ST 2018

Chaguan: a new column on China

Africa's looming debt crisis

How to fix America's Supreme Court

The world's most expensive pet fish

Our 175th anniversary edition

Bartleby | Artificial stimulant

Fears of the impact of new technology may be overdone

ASPECTRE is haunting workers—the rise of artificial intelligence (AI). The fear is that smart computer programs will eliminate millions of jobs, condemning a generation to minimum-wage drudgery or enforced idleness. Never mind the robots, fear the software.

There is no need to be so gloomy, say Ken Goldberg of the University of California, Berkeley, and Vinod Kumar, the chief executive of Tata Communications, a unit of India's biggest business house (which stands to profit from the spread of AI). They have produced a report* that is much more optimistic about the outlook for ordinary employees. In many cases, it says, job satisfaction will be enhanced by the elimination of mundane tasks, giving people time to be more creative.

Their views are backed up by a survey of 120 senior executives, conducted for the report, which found that more of them (77%) thought that AI would create new roles than believed it would replace existing positions (57%; respondents could choose both options). Extra skills may be needed to cope with the new technology and more than half of the bosses are already taking steps to train their workforces.

Previous technology shifts have not had as negative effects on employment as was first feared. The authors note some well-known examples. Bar-code scanners did not eliminate the role of cashiers in America; jobs in the retail industry grew at an annual rate of more than 2% between 1980 and 2013. The arrival of automated teller machines (ATMs) spared bank employees the job of doling out cash and freed them to offer financial advice to customers.

Some jobs could be made a lot easier by AI. One example is lorry-driving. Some fear that truck drivers will be re-



placed by autonomous vehicles. But manoeuvring a lorry around busy streets is far harder than driving down the motorway. So the driver could switch into automatic mode (and get some rest) when outside the big cities, and take over the wheel once again when nearing the destination. The obvious analogy is with jetliners, where the pilots handle take-off and landing but turn on the computer to cruise at 35,000 feet. Using AI may prevent tired drivers from causing accidents.

Turning to office life, AI can help with complex and fiddly tasks like managing supply chains, allocating desk space and keeping records of meetings. All this can free up time for people to work on more important strategic decisions. The authors also think that AI could help collaboration within companies. One obvious example is the elimination of language barriers. Multinational companies may have employees who lack a common language; AI can handle translation in real time so that dialogue is easier.

And the report argues that AI can produce better decision-making by offering a contrarian opinion so that teams can avoid

the danger of groupthink. A program could analyse e-mails and meeting transcripts and issue alerts when potentially false assumptions are being made (rather like the boy in the Hans Christian Andersen tale who notices that the Emperor has no clothes). Or it can warn a team when it is getting distracted from the task in hand.

When a firm is starting a new project, AI can also suggest experts from other parts of the organisation who could contribute. In recruitment, managers could set criteria for "cognitive diversity" (seeking people with different academic and cultural backgrounds) when conducting a job search and allow AI to suggest candidates. This could eliminate remaining hiring biases in favour of white males.

Helen Poitevin of Gartner, a research company, says that some firms are using AI to suggest training possibilities to existing workers, based on the career paths of similar staff, as an aid to their career development. And programs are also being used to analyse individual employees' feedback so that managers can be aware of specific areas where a lot of people are unhappy. If they react in the right way, this should make workers' lives better.

All of which is a useful corrective to some of the more alarming predictions about the potential effects of AI. But as ever, it needs to be remembered that programs are only as good as the data they are given. If those who input the data have biases, they may show up in the suggestions that it generates. As Ms Poitevin says, AI can help improve diversity in the workforce "if we want it to". The best employers should be able to turn AI into a positive for workers.

* "Cognitive Diversity: AI and the Future of Work"

Economist.com/blogs/bartleby





"AI is not about replacing the human with a robot. It's about taking the robot out of the human."

- Diego Kuonen

1910: 10% of Americans Finish High School



1911: The “High School Movement”



1950: **80%** of Americans Finish High School



2020: An “AI School Movement”



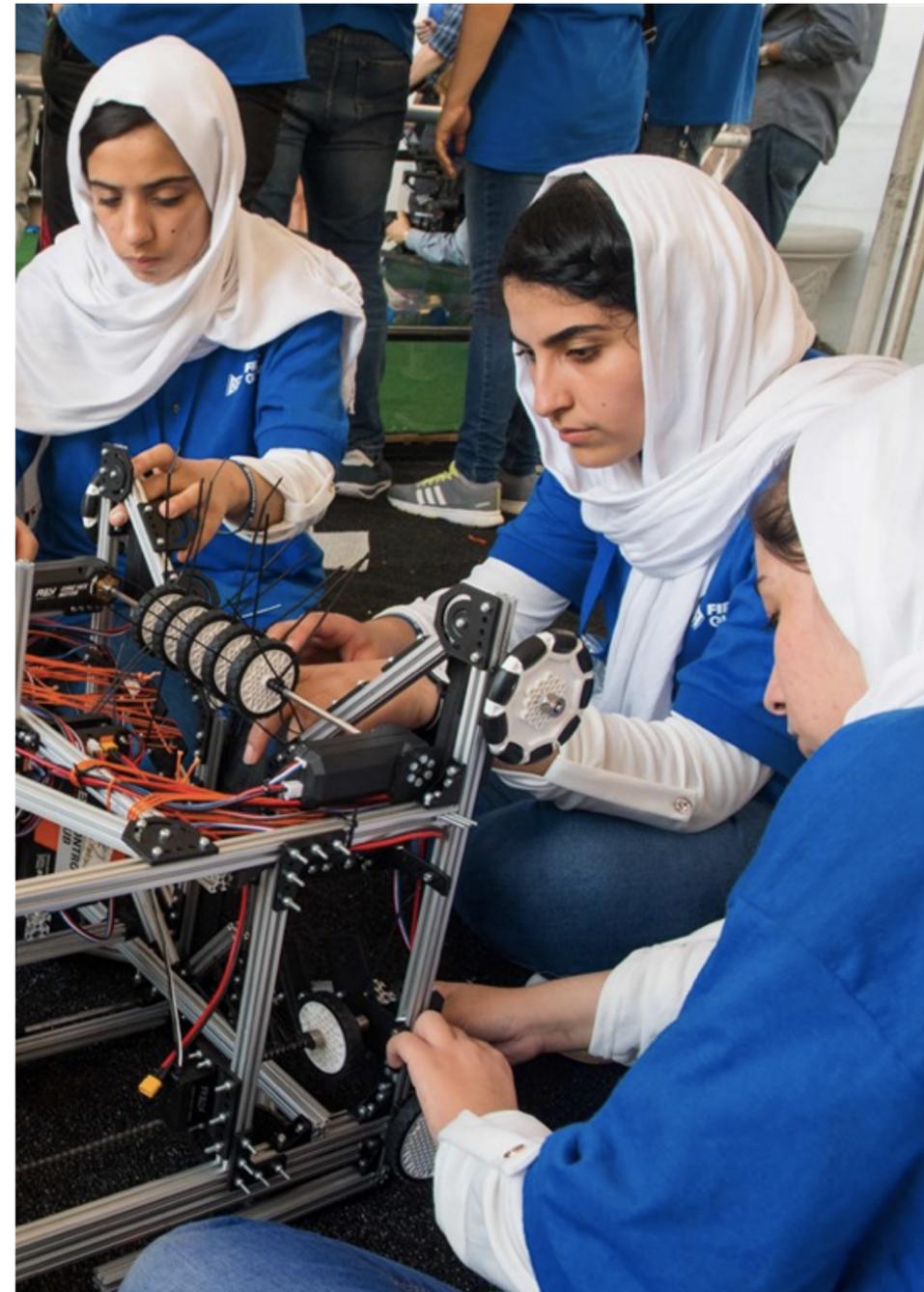
Conformity

Uniformity
Consistency
Obedience
Rigidity



Creativity

Diversity
Variety
Collaboration
Innovation



Complementarity: A Radically Hopeful Vision for Humans, Artificial Intelligence, and Robots

(Ken) Goldberg@Berkeley.edu

1. Complementarity



2. Inclusive Intelligence



3. AI School Movement



Complementarity: A Radically Hopeful Vision for Humans, Artificial Intelligence, and Robots

goldberg@Berkeley.edu



