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)
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
Fully Observed State: 19x19, Trinary, Static.
Game

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

1960
Ages
85+
80-84
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4

2060

Source: National Population Projections, 2017
www.census.gov/programs-surveys/pepproj.html
Artificial Intelligence
SINGULARITY ?
A. ARTIFICIAL INTELLIGENCE
+ I. INTELLIGENCE
I. INTELLIGENCE
A. AMPLIFICATION
COMPLEMENTARITY
COMPLEMENTARY SKILLS
Decision Tree
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

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

- Developing people and engaging with stakeholders: 54%
- Solving problems and collaborating: 30%
- Strategy and innovation: 10%
- Administrative coordination and control: 7%

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

<table>
<thead>
<tr>
<th>Skill</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital and technology</td>
<td>42%</td>
</tr>
<tr>
<td>Creative thinking and experimentation</td>
<td>33%</td>
</tr>
<tr>
<td>Data analysis and interpretation</td>
<td>31%</td>
</tr>
<tr>
<td>Strategy development</td>
<td>30%</td>
</tr>
<tr>
<td>Planning and administration</td>
<td>23%</td>
</tr>
<tr>
<td>Social networking</td>
<td>21%</td>
</tr>
<tr>
<td>People development and coaching</td>
<td>21%</td>
</tr>
<tr>
<td>Collaboration</td>
<td>20%</td>
</tr>
<tr>
<td>Quality management and standards</td>
<td>20%</td>
</tr>
<tr>
<td>Sharper skills within my current domain of expertise</td>
<td>20%</td>
</tr>
<tr>
<td>Performance management and reporting</td>
<td>17%</td>
</tr>
</tbody>
</table>

**Source:** Accenture survey of 1,770 frontline, mid-level, and executive-level managers from 14 countries
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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”
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 Robot-Human Alliance

A Metropolis Rises Again
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, began with a literature survey and was influenced by a diverse range of experts and thought leaders.

bit.ly/Cognitive-Diversity-Tata-Study
Cognitive Diversity: AI & The Future of Work


A SPECTRE 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, says Ken Goldberg of the University of California, Berkeley, and Wood Rummler, a chief executive of Lens 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 100 senior executives, conducted for the report, which found that more than 80% thought AI would create new roles rather than replace existing positions (85% 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 workforce.

Professionals in technology shifts have not had as many positive experiences as was first feared. The authors note some well-known examples. Bar-code scanners did not eliminate the role of cashiers in American jobs in the retail industry: they grew at an annual rate of more than 10% between 1970 and 2017. The arrival of automated teller machines (ATMs) did not amount to unemployment for bank employees, and the job of doing out cash and sending it to other branches was removed.

Some jobs could be made a lot easier by AI. One example is letter-writing. Some fear that track drivers will be replaced by autonomous vehicles. But manufacturing a luxury around busy streets is far harder than driving down the motorway. So the driver could switch into automatic mode (and get some rest) when entering the big cities, and take over when once again ready to reach the destination. The obvious analogy is with jeeps, where the pilot handles take-off and landing but hands over on the computer to cruise at 50,000 feet. Using AI may prevent tired drivers from causing accidents.

Turning to office life, AI can help with complex and hilly 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 dialogues is easier.

And the report argues that AI can produce better decision-making by offering a counterintuitive opinion so that teams can avoid the danger of groupthink. A program could analyse e-mails and meeting transcripts and raise alerts when potentially false assumptions are being made (either 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" (looking for 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 Pollitt of Gartner, a research company, says that some firms are using AI to support training programmes to upskill 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 even so, it needs to be remembered that programs are only as good as the data they are given. Those who input the data have biases, may show up their suggestions that it generates. As Ms Pollitt says, AI can help improve diversity in the workforce if we want it to. The best employers should be able to turn it into a positive for workers.
"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
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