HUMAN PLUS MACHINE

BY MARINA GORBIS

In the next ten years, smart machines will enter virtually every domain of our lives, including assisting doctors during surgery, fighting on battlefields, building things in factories, and assisting in classrooms, nursing homes, and offices. As machines augment and replace humans in various tasks, their largest impact may be less obvious: their presence among us will change how we see ourselves, forcing us to confront the fundamental question of what we humans are uniquely good at. What is our competitive advantage, and where is our place alongside these machines?

It's not so long ago that economists heatedly debated issues of global division of labor. It made sense that people, organizations, and countries would specialize in what they did best. Now we need to figure out a new division of labor, between humans and machines.

While machines will replace humans in some tasks, they'll also amplify us, enabling us to do things we never dreamed of doing before. We'll enter into a partnership with them that will build on our respective strengths, resulting in a new level of human-machine collaboration and codependence. To see how we get there, let's focus first on areas where we humans seem not to fare so well when compared to machines, and then on what we're uniquely good at.

TASKS BETTER SUITED TO MACHINES

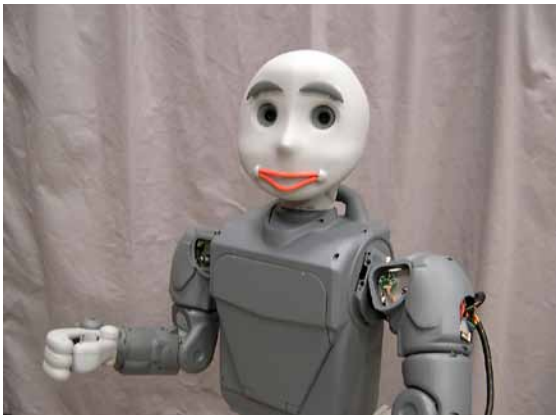
Here are some tasks we aren't particularly good at and will be ceding to machines.

Repetitive, mechanistic tasks

There are many tasks in which humans essentially imitate machines, such as hammering nails on an assembly line or answering the same support question over and over again. We get tired and bored, and we start making mistakes. We've come to accept machines performing these kinds of activities, but they'll also increasingly take over rote, repetitive white-collar tasks, such as language instruction and phone sales, as we develop more sophisticated operating systems.

Accordingly to MIT economist David Autor, we've been on this path for several decades. He concluded in a recent study that the U.S. workforce is becoming more polarized over time, with opportunities expanding in high- and low-skill occupations but declining in mid-skill jobs, both white-collar and blue-collar. He cites the automation of routine work as a key contributor to this polarization[1].

We'll continue to outsource to machines any task that can be routinized and programmed. Already, thousands of robots are assisting with language instruction in Korean schools; an assistive robot prototyped by the University of Southern California works with autistic children; and the MIT-Manus robotic system helps with stroke rehabilitation.



Bandit-II is a socially-assistive robot, built at the University of Southern California.

Source: plasticpals.com

The Trauma Pod system, prototyped at SRI International, enables remote diagnosis and treatment of soldiers wounded in combat.

Source: sri.com

Tasks that are too dangerous or simply impossible

Robots recently played a key role in helping to contain the BP oil spill in the Gulf of Mexico. Humans just aren't able to operate and interact with objects at such extreme depths. BP used remotely operated vehicles (ROVs) to conduct underwater observations and repair work. ROVs are operated by human controllers in a command center who see what the ROV is seeing (along with data from other sensors) and control it with a joystick.

Similarly, we're now using drones for warfare, raising questions about the ethics of remote warfare. As we're working on substituting humans with machines in direct combat, we're also prototyping systems to help care for humans in the battlefield. Trauma Pod, a system developed by a consortium of organizations led by SRI International, would make it possible to retrieve wounded soldiers from the battlefield, diagnose them remotely, and even perform lifesaving procedures en route to a hospital. Inside the prototype theater is a team of robots, led by a robotic surgeon that's remotely controlled by a human surgeon.

We'll increasingly enlist machines in dangerous or remote operations, such as firefighting, removal of hazardous waste, and deep-water exploration. We're already sending machines to explore other planets. What additional new domains will we be able to explore? What impossible things will become possible?

Tasks requiring too much rationality or data analysis

For centuries, economists have built models based on the assumption that humans behave as rational economic actors. But thanks to advances in neuroscience and behavioral economics, we've come to realize that humans aren't good at thinking through probabilities and risks and making rational economic choices based on those probabilities. While we don't want to use pure rationality when making moral or ethical decisions, more rationality would be helpful in situations such as when making financial decisions.

We're already relying on software to help us make complex decisions, including modeling climate change scenarios, impacts of financial market interventions, and optimal oil-drilling locations. But what happens when *every* decision, large or small, incorporates decision support from our machine helpers? This is beginning to happen already, as we routinely check Amazon ratings before buying a product or scan Yelp reviews before deciding where to eat. Imagine a future in which every decision we make incorporates rational analysis of risks and probabilities. We'll outsource some decisions to machines completely, while also assimilating computational rationality into our own decision processes.

Tasks too large or small

Since time immemorial, our tools have extended our abilities to manipulate our environment, and to do things individuals can't do alone (such as lift large stones). With the new generation of smart machines, we'll achieve even more grandiose feats, and with less human intervention. Already, the Japanese robotics company FANUC is operating a factory where robots are building other robots at a rate of about 50 per 24-hour shift and can run unsupervised for 30 days at a time—with no lights, air conditioning, or heat required.

Humans are also not suited to manipulate things on a very small scale. Here again, machines will be recruited to do things that previously couldn't be done. Today, nanorobots in pill form can diagnose cancer or deliver highly targeted chemotherapy. The da Vinci Surgical System from Intuitive Surgical can perform laparoscopies, prostate surgery, and other surgeries with a level of accuracy that's difficult for human surgeons to achieve alone. Machines will enable us to reach hidden places in the body and assemble objects molecule by molecule in new manufacturing facilities.

WHAT HUMANS BRING TO THE TABLE

What we're uniquely good at is everything that's not programmable: tasks that require abstract thinking rather than computation, and situation-specific responses rather than codified ones. Here are a few specific areas in which we fare well and have a comparative advantage in our interactions with machines.

Thinking

In 1997, IBM's Deep Blue supercomputer defeated grandmaster Garry Kasparov in the game of chess. Many took this as a sign of the machine's superior "thinking" abilities; however, as Kasparov points out in an essay in the *New York Review of Books*, many artificial intelligence specialists were dismayed because "instead of a computer that thought and played chess like a human, with human creativity and intuition, they got one that played like a machine, systematically evaluating 200 million possible moves on the chess board per second and winning with brute number-crunching force … It was an impressive achievement, of course, and a *human* achievement by the members of the IBM team, but Deep Blue was only intelligent the way your programmable alarm clock is intelligent."[2]

As Igor Aleksander, a British AI and neural networks pioneer, explained in his book *How to Build a Mind*, "In the Kasparov defeat they recognized that here was a great triumph for programmers, but not one that may compete with the human intelligence that helps us to lead our

Intuitive Surgical's da Vinci Surgical System allows surgery to be performed remotely, using robotic manipulators.

Source: intuitivesurgical.com

MIT's Mind Machine project is an interdisciplinary brain trust formed to "create intelligent machines."

Source: MIT

lives."[3] A computer may be able to beat a human in the game of chess with the force of its computational abilities, but ask it whether it wants to play pool and it won't be able to tell whether you're talking about swimming, financial portfolios, or billiards.

Thinking and computation are different processes, and machines are not good at thinking. Jaron Lanier, author of *You Are Not a Gadget*, points out, "We don't know how information is represented in the brain. We don't know how reason is accomplished by neurons. … if we ask what thinking is, so that we can then ask how to foster it, we encounter an astonishing and terrifying answer: We don't know."[4]

This is why MIT recently launched a five-year, $5 million project called the Mind Machine Project, a collaboration of professors, researchers, students, and post-docs working together to rethink traditional AI approaches. The project is "revisiting fundamental assumptions"[5] in all areas of AI, including the nature of the mind and memory and how intelligence can be manifested in physical form. But for the foreseeable future, thinking is something unique to humans.

Social and emotional intelligence

Humans' social and emotional intelligence has been honed through millennia of living in groups. We're social animals: we need each other for survival, happiness, and a sense of identity; we read cues in each other's body language and facial expressions; we're tuned into each other and our social and emotional environments. Tachi Yamada, president of the Gates Foundation's Global Health Program, talks about this kind of intelligence in the *New York Times*, explaining what he looks for when he interviews job applicants: "Intelligence is often more displayed in … complex abstract thinking, and there's nothing more complex and abstract than human relationships. And if they can work their way through a human relationship problem intelligently, my guess is that they're very smart people."[6]

Although we're seeing early prototypes of "social" and "emotional" robots in research labs today, the range of social skills and emotions they display is very limited. We're also learning that, being the social creatures we are, we're developing attachments to these machines and imbuing them with human characteristics, becoming concerned if they appear to "feel sad" or be injured. Feeling is as complicated as thinking, if not more so, and just as the machines we're building aren't thinking machines, the emotional and social robots we're building aren't feeling machines—at least not yet.

Creativity, intuition, and improvisation

In his study of employment patterns over the past several decades,

David Autor states that the increasing use of computers to perform routine tasks raises the relative demand for nonroutine tasks, in which workers hold a comparative advantage. He roughly subdivides these nonroutine tasks into two categories: abstract and manual. Abstract tasks require problem solving, intuition, and persuasion; workers who are most adept in these tasks typically have high levels of education and analytical capability. Manual tasks require "situational adaptability, visual and language recognition, and in-person interactions"[7]; workers engaged in these tasks include janitors and cleaners, home health aides, construction laborers, security personnel, and motor vehicle operators.

Whether at the high or low end of education and pay scales, the comparative advantage of humans is in doing things spontaneously, responding to unique circumstances of the moment, and making decisions accordingly.

WORKING TOGETHER

When thinking about smart machines or robots entering many domains of our lives, several dystopian visions come to mind: robots taking over the world, jobs disappearing, and machines running amok and reproducing themselves. But a look at what's being developed today, and the potential of these new powerful machines, yields an optimistic view of the future.

We're on the cusp of a major transformation in our relationships with our tools, analogous to the transformation humanity went through during the agrarian revolution. As agricultural production became mechanized, many farming jobs disappeared and farming families moved to cities, where they became responsible for building bridges and skyscrapers, producing things in factories, and creating new kinds of services.

Despite generations of new technologies, we're now working more rather than less. Adult male peasants in the 13th century in the United Kingdom worked an average of 1,600 hours a year; a manufacturing worker in the United Kingdom in 1990 worked 1,850 hours; an investment banker in New York today works close to 5,000 hours. There hasn't yet been a technology that has resulted in our working less. This is because machines don't just replace what we do, they change the nature of what we do: by extending our capabilities, they set new expectations for what's possible and create new performance standards and needs. Before we created dishwashers, we didn't expect our glasses to be spotlessly clean, nor did we think dustless floors were necessary until we introduced vacuum cleaners into every home. Our tools change us.

"Machines don't just replace what we do, they change the nature of what we do … our tools change us."

We'll come to understand ourselves at a new level as we build machines that can do different human tasks. We'll enter into a new kind of partnership with these machines—one that will shine light on the unique comparative advantages of humans: thinking, creativity, spontaneity, adaptability, and improvisation.

Whereas in the 1990s Gary Kasparov battled the mighty IBM supercomputer, today anyone can buy a $50 program that will crush most grandmasters. But here's a twist: in 2005, Playchess.com hosted a "freestyle" chess tournament online, in which anyone could compete in teams with other players or computers. Several groups of grandmasters working with multiple computers at the same time entered the competition. As Kasparov describes it:

> The surprise came at the conclusion of the event. The winner was revealed to be not a grandmaster with a state-of-the-art PC but a pair of amateur American chess players using three computers at the same time. Their skill at manipulating and "coaching" their computers to look very deeply into positions effectively counteracted the superior chess understanding of their grandmaster opponents and the greater computational power of other participants. Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process.[8]

Amateurs armed with good strategies and harnessing the computational power of machines turned out to be the winning combination! That's the best metaphor for the evolving new machine-human partnership: with smart machines as our partners, we can operate at the level of grandmasters, not just in chess but in most domains of our lives, from science and medicine to game playing and commerce. The combination of humans partnering with machines and using superior strategies opens up new worlds for exploration.

NOTES

1 Autor, D., "The Polarization of Job Opportunities in the U.S. Labor Market: Implications for Employment and Earnings," April 2010, The Center for American Progress and The Hamilton Project, http://www.brookings.edu/~/media/Files/rc/papers/2010/04_jobs_autor/04_jobs_autor.pdf.

2 Kasparov, G., "The Chess Master and the Computer," *New York Review of Books*, February 11, 2010.

3 Aleksander, I., *How to Build a Mind: Toward Machines with Imagination*, Columbia University Press, 2001.

4 Lanier, J., *You Are Not a Gadget: A Manifesto*, Knopf, 2010.

5 "Building intelligent machines," MIT Mind Machine Project Web site, http://mmp.mit.edu/.

6 Bryant, A., "Talk to Me. I'll Turn Off My Phone," interview with Tachi Yamada, *New York Times*, February 27, 2010.

7 Autor, *op. cit.*

8 Kasparov, *op. cit.*

INSTITUTE FOR THE FUTURE

Technology Horizons Program
124 University Ave., 2nd Floor
Palo Alto, CA 94301
t 650.854.6322
f 650.854.7850
www.iftf.org