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Machines VS Humans

Should technology replace the humans with labor?

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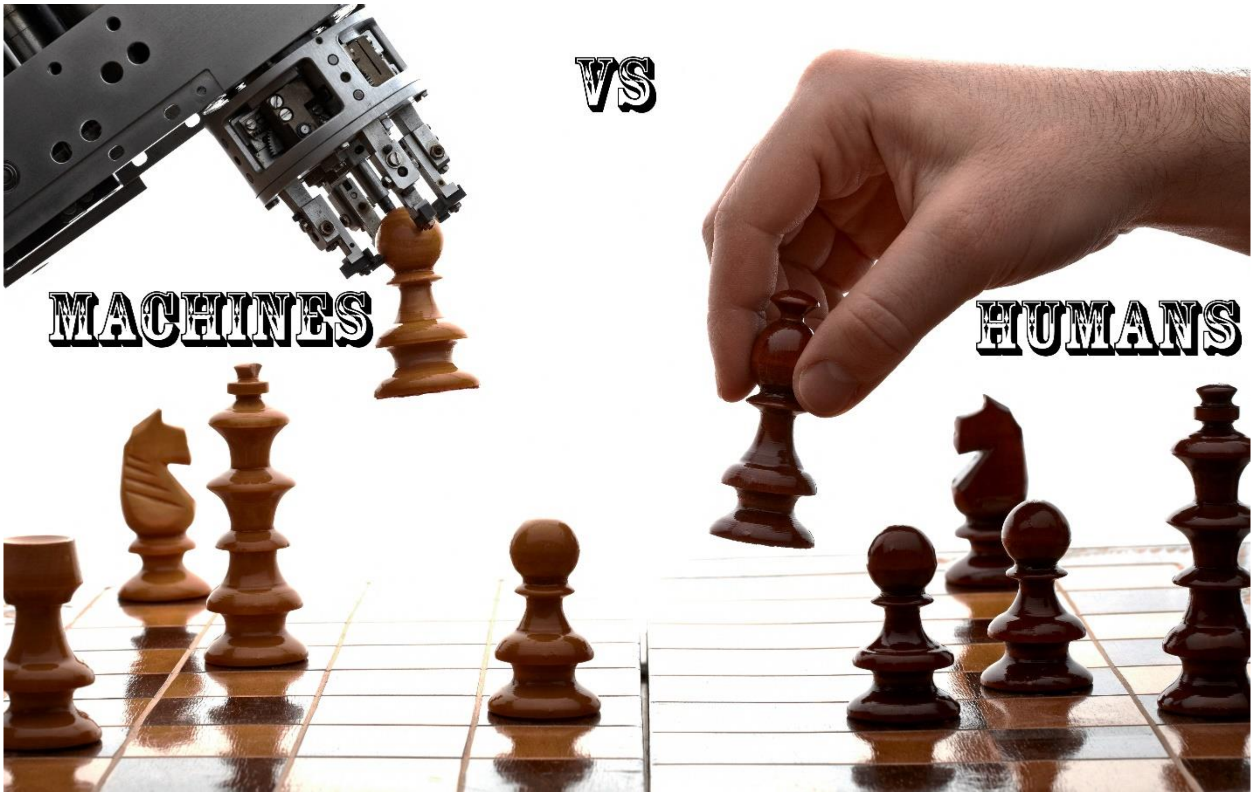

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Introduction:

We’re clearly heading into an age of brilliant technology. Computers are already impressively good at guiding driverless cars and beating humans at chess. As Erik Brynjolfsson and Andrew McAfee of the Massachusetts Institute of Technology point out in their book “The Second Machine Age,” computers are increasingly going to be able to perform important parts of even mostly cognitive jobs, like picking stocks, diagnosing diseases and granting parole.

As this happens, certain mental skills will become less valuable because computers will take over. Having a great memory will probably be less valuable. Being able to be a straight-A student will be less valuable — gathering masses of information and regurgitating it back on tests. So will being able to do any mental activity that involves following a set of rules.

The age of brilliant machines seems to reward a few traits. First, it rewards enthusiasm. The amount of information in front of us is practically infinite; so is that amount of data that can be collected with new tools. The people who seem to do best possess a voracious explanatory drive, an almost obsessive need to follow their curiosity. Maybe they started with obsessive gaming sessions, or marathon all-night study sessions, but they are driven to perform extended bouts of concentration, diving into and trying to make sense of these bottomless information oceans.

In his book, “Smarter than You Think,” Clive Thompson describes the work of Deb Roy, who wired his house with equipment so he and his team could monitor and record every word he and his wife uttered while his son was learning to speak. That is total commitment and total immersion in an attempt to understand the language learning process.[1]

Second, the era seems to reward people with extended time horizons and strategic discipline. When Garry Kasparov was teaming with a computer to play freestyle chess (in which a human and machine join up to play against another human and machine), he reported that his machine partner possessed greater “tactical acuity,” but he possessed greater “strategic guidance.”

That doesn’t seem too surprising. A computer can calculate a zillion options, move by move, but a human can provide an overall sense of direction and a conceptual frame. In a world of online distractions, the person who can maintain a long obedience toward a single goal, and who can filter out what is irrelevant to that goal, will obviously have enormous worth.

But can we completely replace humans with machines?

What are the positives and negatives of replacing humans with machines?

And finally should we replace humans with machines?

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[1] “Smarter than You Think,” Clive Thompson, 2013.

Chapter 1:

The evolution of machines throughout history

Date	Invention or discovery
10 million years ago.	Humans make the first tools from stone, wood, antlers, and bones.
1–2 million years ago	Humans discover fire.
25,000–50,000 BCE	Humans first wear clothes.
10,000 BCE	Earliest boats are constructed.
8000– 9000 BCE	Beginnings of human settlements and agriculture.
6000– 7000 BCE	Hand-made bricks first used for construction in the Middle East.
4000 BCE	Iron used for the first time in decorative ornaments.
3500 BCE	Humans invent the wheel.
0– 1500 BCE	Ancient societies invent some of the first machines for moving water and agriculture.
1000 BCE	Iron Age begins: iron is widely used for making tools and weapons in many parts of the world.
150– 100 BCE	First gear-driven, precision clockwork machine (the Antikythera mechanism) is developed.
50 BCE	Roman engineer Vitruvius perfects the modern, vertical water wheel.
62 CE	Hero of Alexandria, a Greek scientist, pioneers steam power.
27 BCE–395 CE	Romans develop the first, basic concrete called pozzolana.
600 CE	Windmills are invented in the Middle East.
700– 900 CE	Chinese invent gunpowder and fireworks.
1000 CE	Chinese develop eyeglasses by fixing lenses to frames that fit onto people's faces.
1450	Johannes Gutenberg pioneers the modern printing press, using rearrange able metal letters called movable type.
1470s	The first parachute is sketched on paper by an unknown inventor.
1530s	Gerardus Mercator helps to revolutionize navigation with better mapmaking.
1590	A Dutch spectacle maker named Zacharias Janssen makes the first compound microscope.

1600	Galileo Galilei designs a basic thermometer.
16th century	Antoni van Leeuwenhoek and Robert Hooke independently develop microscopes.
1600	William Gilbert publishes his great book De Magnete describing how Earth behaves like a giant magnet. It's the beginning of the scientific study of magnetism.
1609	Galileo Galilei builds a practical telescope and makes new astronomical discoveries.
1643	Galileo's pupil Evangelista Torricelli builds the first mercury barometer for measuring air pressure.
1650s	Christiaan Huygens develops the pendulum clock (using Galileo's earlier discovery that a swinging pendulum can be used to keep time).
1687	Isaac Newton formulates his three laws of motion.
1700s	Bartolomeo Cristofori invents the piano.
1701	English farmer Jethro Tull begins the mechanization of agriculture by inventing the horse-drawn seed drill.
1703	Gottfried Leibniz pioneers the binary number system now used in virtually all computers.
1712	Thomas Newcomen builds the first practical (but stationary) steam engine.
1700s	Christiaan Huygens conceives the internal combustion engine, but never actually builds one.
1737	William Champion develops a commercially viable process for extracting zinc on a large scale.
1757	John Campbell invents the sextant, an improved navigational device that enables sailors to measure latitude.
1730s–1770s	John Harrison develops reliable chronometers (seafaring clocks) that allow sailors to measure longitude accurately for the first time.
1751	Axel Cronstedt isolates nickel.
1756	Axel Cronstedt notices steam when he boils a rock—and discovers zeolites.
1769	Wolfgang von Kempelen develops a mechanical speaking machine: the world's first speech synthesizer.
1770s	Abraham Darby III builds a pioneering iron bridge at a place now called Ironbridge in England.
1780	Josiah Wedgwood (or Thomas Massey) invents the pyrometer.
1783	French Brothers Joseph-Michel Montgolfier and Jacques-Étienne Montgolfier make the first practical hot-air balloon.
1800	Italian Alessandro Volta makes the first battery (known as a Voltaic pile).
1801	Joseph-Marie Jacquard invents the automated cloth-weaving loom. The punched cards it uses to store patterns help to inspire programmable computers.
1803	Henry and Sealy Fourdrinier develop the papermaking machine.
1806	Humphry Davy develops electrolysis into an important chemical technique and uses it to identify a number of new elements.

1807	Humphry Davy develops the electric arc lamp.
1814	George Stephenson builds the first practical steam locomotive.
1816	Robert Stirling invents the efficient Stirling engine.
1820s–1830s	Michael Faraday builds primitive electric generators and motors.
1827	Joseph Niepce makes the first modern photograph.
1830s	William Sturgeon develops the first practical electric motor.
1830s	Louis Daguerre invents a practical method of taking pin-sharp photographs called Daguerreotypes.
1830s	William Henry Fox Talbot develops a way of making and printing photographs using reverse images called negatives.
1830s–1840s	Charles Wheatstone and William Cooke, in England, and Samuel Morse, in the United States, develop the electric telegraph (a forerunner of the telephone).
1836	Englishman Francis Petit-Smith and Swedish-American John Ericsson independently develop propellers with blades for ships.
1839	Charles Goodyear finally perfects a durable form of rubber (vulcanized rubber) after many years of unsuccessful experimenting.
1840s	Scottish physicist James Prescott Joule outlines the theory of the conservation of energy.
1840s	Scotsman Alexander Bain invents a primitive fax machine based on chemical technology.
1849	James Francis invents a water turbine now used in many of the world's hydropower plants.
1850s	Henry Bessemer pioneers a new method of making steel in large quantities.
1850s	Louis Pasteur develops pasteurization: a way of preserving food by heating it to kill off bacteria.
1850s	Italian Giovanni Caselli develops a mechanical fax machine called the pantelegraph.
1860s	Frenchman Étienne Lenoir and German Nikolaus Otto pioneer the internal combustion engine.
1860s	James Clerk Maxwell figures out that radio waves must exist and sets out basic laws of electromagnetism.
1860s	Fire extinguishers are invented.
1861	Elisha Graves Otis invents the elevator with built-in safety brake.
1867	Joseph Monier invents reinforced concrete.
1868	Christopher Latham Sholes invents the modern typewriter and QWERTY keyboard.
1876	Alexander Graham Bell patents the telephone, though the true ownership of the invention remains controversial even today.
1870s	Thomas Edison develops the phonograph, the first practical method of recording and playing back sound on metal foil.
1870s	Lester Pelton invents a useful new kind of water turbine known as a Pelton

	wheel.
1877	Thomas Edison invents his sound-recording machine or phonograph—a forerunner of the record player and CD player.
1877	Edward Very invents the flare gun (Very pistol) for sending distress flares at sea.
1880	Thomas Edison patents the modern incandescent electric lamp.
1880	Pierre and Paul-Jacques Curie discover the piezoelectric effect.
1880s	Thomas Edison opens the world's first power plants.
1880s	Charles Chamberland invents the autoclave (steam sterilizing machine).
1880s	Charles and Julia Hall and Paul Heroult independently develop an affordable way of making aluminum.
1880s	Carrie Everson invents new ways of mining silver, gold, and copper.
1881	Jacques d'Arsonval suggests heat energy could be extracted from the oceans.
1883	Charles Eastman invents plastic photographic film.
1884	Charles Parsons develops the steam turbine.
1885	Karl Benz builds a gasoline-engined car.
1886	Josephine Cochran invents the dishwasher.
1888	Friedrich Reinitzer discovers liquid crystals.
1888	Nikola Tesla patents the alternating current (AC) electric induction motor and, in opposition to Thomas Edison, becomes a staunch advocate of AC power.
1899	Everett F. Morse invents the optical pyrometer for measuring temperatures at a safe distance.
1890s	French brothers Joseph and Louis Lumiere invent movie projectors and open the first movie theater.
1890s	German engineer Rudolf Diesel develops his diesel engine—a more efficient internal combustion engine without a sparking plug.
1895	German physicist Wilhelm Röntgen discovers X rays.
1895	American Ogden Bolton, Jr. invents the electric bicycle.
1901	Guglielmo Marconi sends radio-wave signals across the Atlantic Ocean from England to Canada
1901	The first electric vacuum cleaner is developed.
1903	Brothers Wilbur and Orville Wright build the first engine-powered airplane.
1905	Albert Einstein explains the photoelectric effect.
1905	Samuel J. Bens invents the chainsaw.
1906	Willis Carrier pioneers the air conditioner.
1906	Mikhail Tswett discovers chromatography.
1907	Leo Baekeland develops Bakelite, the first popular synthetic plastic.
1907	Alva Fisher invents the electric clothes washer.
1906-8	Frederick Gardner Cottrell develops the electrostatic smoke precipitator (smokestack pollution scrubber).
1908	American industrialist and engineer Henry Ford launches the Ford Model T, the world's first truly affordable car.
1909	German chemists Fritz Haber and Zygmunt Klemensiewicz develop the glass

	electrode, enabling very precise measurements of acidity.
1912	American chemist Gilbert Lewis describes the basic chemistry that leads to practical, lithium-ion rechargeable batteries (though they don't appear in a practical, commercial form until the 1990s).
1912	Hans Geiger develops the Geiger counter, a detector for radioactivity.
1919	Francis Aston pioneers the mass spectrometer and uses it to discover many isotopes.
1920s	John Logie Baird develops mechanical television.
1920s	Philo T. Farnsworth invents modern electronic television.
1920s	Robert H. Goddard develops the principle of the modern, liquid-fueled space rocket.
1920s	German engineer Gustav Tauschek and American Paul Handel independently develop primitive optical character recognition (OCR) scanning systems.
1920s	Albert W. Hull invents the magnetron, a device that can generate microwaves from electricity.
1921	Karel Capek and his brother coin the word "robot" in a play about artificial humans.
1921	John Larson develops the polygraph ("lie detector") machine.
1928	Thomas Midgley, Jr. invents coolant chemicals for air conditioners and refrigerators.
1928	The electric refrigerator is invented.
1930s	Peter Goldmark pioneers color television.
1930s	Laszlo and Georg Biro pioneer the modern ballpoint pen.
1930s	Maria Telkes creates the first solar-powered house.
1930s	Wallace Carothers develops neoprene (synthetic rubber used in wetsuits) and nylon, the first popular synthetic clothing material.
1930s	Robert Watson Watt oversees the development of radar.
1930s	Arnold Beckman develops the electronic pH meter.
1931	Harold E. Edgerton invents the xenon flash lamp for high-speed photography.
1932	Arne Olander discovers the shape memory effect in a gold-cadmium alloy.
1936	W.B. Elwood invents the magnetic reed switch.
1938	Chester Carlson invents the principle of photocopying (xerography).
1938	Roy Plunkett accidentally invents a nonstick plastic coating called Teflon.
1939	Igor Sikorsky builds the first truly practical helicopter.
1940s	English physicists John Randall and Harry Boot develop a compact magnetron for use in airplane radar navigation systems.
1942	Enrico Fermi builds the first nuclear chain reactor at the University of Chicago.
1945	US government scientist Vannevar Bush proposes a kind of desk-sized memory store called Memex, which has some of the features later incorporated into electronic books and the World Wide Web (WWW).
1947	John Bardeen, Walter Brattain, and William Shockley invent the transistor,

	which allows electronic equipment to make much smaller and leads to the modern computer revolution.
1949	Bernard Silver and N. Joseph Woodland patent barcodes—striped patterns that are initially developed for marking products in grocery stores.
1950s	Charles Townes and Arthur Schawlow invent the maser (microwave laser). Gordon Gould coins the word "laser" and builds the first optical laser in 1958.
1950s	Stanford Ovshinksy develops various technologies that make renewable energy more practical, including practical solar cells and improved rechargeable batteries.
1950s	European bus companies experiment with using flywheels as regenerative brakes
1950s	Percy Spencer accidentally discovers how to cook with microwaves, inadvertently inventing the microwave oven.
1954	Indian physicist Narinder Kapany pioneers fiber optics.
1956	First commercial nuclear power is produced at Calder Hall, Cumbria, England.
1957	Soviet Union (Russia and her allies) launch the Sputnik space satellite.
1957	Lawrence Curtiss, Basil Hirschowitz, and Wilbur Peters build the first fiber-optic gastroscope.
1958	Jack Kilby and Robert Noyce, working independently, develop the integrated circuit.
1959	IBM and General Motors develop Design Augmented by Computers-1 (DAC-1), the first computer-aided design (CAD) system.
1960s	Joseph-Armand Bombardier perfects his Ski-Doo® snowmobile.
1960	Theodore Maiman invents the ruby laser.
1962	William Armistead and S. Donald Stookey of Corning Glass Works invent light-sensitive (photochromic) glass.
1963	Ivan Sutherland develops Sketchpad, one of the first computer-aided design programs.
1964	IBM helps to pioneer e-commerce with an airline ticket reservation system called SABRE.
1965	Frank Pantridge develops the portable defibrillator for treating cardiac arrest patients.
1966	Stephanie Kwolek patents a super-strong plastic called Kevlar.
1967	Japanese company Noritake invents the vacuum fluorescent display (VFD).
1968	Alfred Y. Cho and John R. Arthur, Jr invent a precise way of making single crystals called molecular beam epitaxy (MBE).
1969	World's first solar power station opened in France.
1969	Long before computers become portable, Alan Kay imagines building an electronic book, which he nicknames the Dynabook.
1969	Willard S. Boyle and George E. Smith invent the CCD (charge-coupled device): the light-sensitive chip used in digital cameras, webcams, and other modern optical equipment.
1969	Astronauts walk on the Moon.

1960s	Douglas Engelbart develops the computer mouse.
1960s	James Russell invents compact discs.
1971	Electronic ink is pioneered by Nick Sheridon at Xerox PARC.
1971	Ted Hoff builds the first single-chip computer or microprocessor.
1973	Martin Cooper develops the first handheld cellphone (mobile phone).
1973	Robert Metcalfe figures out a simple way of linking computers together that he names Ethernet. Most computers hooked up to the Internet now use it.
1974	First grocery-store purchase of an item coded with a barcode.
1975	Whitfield Diffie and Martin Hellman invent public-key cryptography.
1975	Pico Electronics develops X-10 home automation system.
1976	Steve Wozniak and Steve Jobs launch the Apple I: one of the world's first personal home computers
1970s–1980s	James Dyson invents the bagless, cyclonic vacuum cleaner.
1970s-1980s	Scientists including Charles Bennett, Paul Benioff, Richard Feynman, and David Deutsch sketch out how quantum computers might work.
1980s	Japanese electrical pioneer Akio Morita develops the Sony Walkman, the first truly portable player for recorded music.
1981	Stung by Apple's success, IBM releases its own affordable personal computer (PC).
1981	The Space Shuttle makes its maiden voyage.
1981	Patricia Bath develops laser eye surgery for removing cataracts.
1981– 1982	Alexei Ekimov and Louis E. Brus (independently) discover quantum dots.
1983	Compact discs (CDs) are launched as a new way to store music by the Sony and Philips corporations.
1987	Larry Hornbeck, working at Texas Instruments, develops DLP® projection—now used in many projection TV systems.
1989	Tim Berners-Lee invents the World Wide Web.
1990	German watchmaking company Junghans introduces the MEGA 1, believed to be the world's first radio-controlled wristwatch.
1991	Linus Torvalds creates the first version of Linux, a collaboratively written computer operating system.
1994	American-born mathematician John Daugman perfects the mathematics that make iris scanning systems possible.
1994	Israeli computer scientists Alon Cohen and Lior Haramaty invent VoIP for sending telephone calls over the Internet.
1995	Broadcast.com becomes one of the world's first online radio stations.
1995	Pierre Omidyar launches the eBay auction website.
1996	WRAL-HD broadcasts the first high-definition television (HDTV) signal in the United States.
1997	Electronics companies agree to make Wi-Fi a worldwide standard for wireless

	Internet.
2001	Apple revolutionizes music listening by unveiling its iPod MP3 music player.
2001	Richard Palmer develops energy-absorbing D3O plastic.
2001	The Wikipedia online encyclopedia is founded by Larry Sanger and Jimmy Wales.
2001	Bram Cohen develops Bit Torrent file-sharing.
2001	Scott White, Nancy Sottos, and colleagues develop self-healing materials.
2002	IRobot Corporation releases the first version of its Roomba® vacuum cleaning robot.
2004	Electronic voting plays a major part in a controversial US Presidential Election.
2004	Andre Geim and Konstantin Novoselov discover graphene.
2005	A pioneering low-cost laptop for developing countries called OLPC is announced by MIT computing pioneer Nicholas Negroponte.
2007	Amazon.com launches its Kindle electronic book (e-book) reader.
2007	Apple introduces a touchscreen cellphone called the iPhone.
2010	Apple releases its touchscreen tablet computer, the iPad.
2010	3D TV starts to become more widely available.
2013	Elon Musk announces "hyperloop"—a giant, pneumatic tube transport system.
2015	Supercomputers (the world's fastest computers) are now 30 times less powerful than human brains.

Table 1: Timeline of the evolution of machines.

Chapter 2:
Machines defeating humans

At least since the followers of Ned Ludd smashed mechanized looms in 1811, workers have worried about automation destroying jobs. Economists have reassured them that new jobs would be created even as old ones were eliminated. For over 200 years, the economists were right. Despite massive automation of millions of jobs, more Americans had jobs at the end of each decade up through the end of the 20th century. However, this empirical fact conceals a dirty secret. There is no economic law that says that everyone, or even most people, automatically benefit from technological progress.

People with little economics training intuitively grasp this point. They understand that some human workers may lose out in the race against the machine. Ironically, the best-educated economists are often the most resistant to this idea, as the standard models of economic growth implicitly assume that economic growth benefits all residents of a country. However, just as Nobel Prize-winning economist Paul Samuelson showed that outsourcing and offshoring do not necessarily increase the welfare of all workers, it is also true that technological progress is not a rising tide that automatically raises all incomes. Even as overall wealth increases, there can be, and usually will be, winners and losers. And the losers are not necessarily some small segment of the labor force like buggy whip manufacturers. In principle, they can be a majority or even 90% or more of the population.

If wages can freely adjust, then the losers keep their jobs in exchange for accepting ever-lower compensation as technology continues to improve. But there's a limit to this adjustment. Shortly after the Luddites began smashing the machinery that they thought threatened their jobs, the economist David Ricardo, who initially thought that advances in technology would benefit all, developed an abstract model that showed the possibility of technological unemployment. The basic idea was that at some point, the equilibrium wages for workers might fall below the level needed for subsistence. A rational human would see no point in taking a job at a wage that low, so the worker would go unemployed and the work would be done by a machine instead.

Of course, this was only an abstract model. But in his book "A Farewell to Alms", economist Gregory Clark gives an eerie real-world example of this phenomenon in action: There was a type of employee at the beginning of the Industrial Revolution whose job and livelihood largely vanished in the early twentieth century. This was the horse. The population of working horses actually peaked in England long after the Industrial Revolution, in 1901, when 3.25 million were at work[2]. Though they had been replaced by rail for long-distance haulage and by steam engines for driving machinery, they still plowed fields, hauled wagons and carriages short

[2] A farewell to alms, G. Clark, Princeton University Press, 2007.

distances, pulled boats on the canals, toiled in the pits, and carried armies into battle. But the arrival of the internal combustion engine in the late nineteenth century rapidly displaced these workers, so that by 1924 there were fewer than two million. There was always a wage at which all these horses could have remained employed. But that wage was so low that it did not pay for their feed".

As technology continues to advance in the second half of the chessboard, taking on jobs and tasks that used to belong only to human workers, one can imagine a time in the future when more and more jobs are more cheaply done by machines than humans. And indeed, the wages of unskilled workers have trended downward for over 30 years.

We also now understand that technological unemployment can occur even when wages are still well above subsistence if there are downward rigidities that prevent them from falling as quickly as advances in technology reduce the costs of automation. Minimum wage laws, unemployment insurance, health benefits, prevailing wage laws, and long-term contracts--not to mention custom and psychology--make it difficult to rapidly reduce wages. Furthermore, employers will often find wage cuts damaging to morale. As the efficiency wage literature notes, such cuts can be depressing to employees and cause companies to lose their best people.

But complete wage flexibility would be no panacea, either. Ever-falling wages for significant shares of the workforce is not exactly an appealing solution to the threat of technological employment. A side from the damage it does to the living standards of the affected workers, lower pay only postpones the day of reckoning. Moore's Law is not a one-time blip but an accelerating exponential trend.

The threat of technological unemployment is real. To understand this threat, we'll define three overlapping sets of winners and losers that technical change creates: (1) high-skilled vs. low-skilled workers, (2) superstars vs. everyone else, and (3) capital vs. labor. Each set has well-documented facts and compelling links to digital technology. What's more, these sets are not mutually exclusive. In fact, the winners in one set are more likely to be winners in the other two sets as well, which concentrates the consequences.

In each case, economic theory is clear. Even when technological progress increases productivity and overall wealth, it can also affect the division of rewards, potentially making some people worse off than they were before the innovation. In a growing economy, the gains to the winners may be larger than the losses of those who are hurt, but this is a small consolation to those who come out on the short end of the bargain.

Ultimately, the effects of technology are an empirical question--one that is best settled by looking at the data. For all three sets of winners and losers, the news is troubling. Let's look at each in turn.

1. High-Skilled vs. Low-Skilled Workers

We'll start with skill-biased technical change, which is perhaps the most carefully studied of the three phenomena. This is technical change that increases the relative demand for high-skill labor while reducing or eliminating the demand for low-skill labor. A lot of factory automation falls into this category, as routine drudgery is turned over to machines while more complex programming, management, and marketing decisions remain the purview of humans.

A recent paper[3] by economists Daron Acemoglu and David Autor highlights the growing divergence in earnings between the most-educated and least-educated workers. Over the past 40 years, weekly wages for those with a high school degree have fallen and wages for those with a high school degree and some college have stagnated. On the other hand, college-educated workers have seen significant gains, with the biggest gains going to those who have completed graduate training.

What's more, this increase in the relative price of educated labor--their wages--comes during a period where the supply of educated workers has also increased. The combination of higher pay in the face of growing supply points unmistakably to an increase in the relative demand for skilled labor. Because those with the least education typically already had the lowest wages, this change has increased overall income inequality

It's clear that wage divergence accelerated in the digital era. As documented in careful studies by David Autor, Lawrence Katz, and Alan Krueger[4], as well as Frank Levy and Richard Murnane[5] and many others, the increase in the relative demand for skilled labor is closely correlated with advances in technology, particularly digital technologies. Hence, the moniker "skill-biased technical change," or SBTC. There are two distinct components to recent SBTC. Technologies like robotics, numerically controlled machines, computerized inventory control, and automatic transcription have been substituting for routine tasks, displacing those workers. Meanwhile other technologies like data visualization, analytics, high-speed communications, and rapid prototyping have augmented the contributions of more abstract and data-driven reasoning, increasing the value of those jobs.

Skill-biased technical change has also been important in the past. For most of the 19th century, about 25% of all agriculture labor threshed grain. That job was automated in the 1860s. The 20th century was marked by an accelerating mechanization not only of agriculture but also of factory work. Echoing the first Nobel Prize winner in economics, Jan Tinbergen, Harvard economists Claudia Goldin and Larry Katz described the resulting SBTC as a "race between education and technology." Ever-greater investments in education, dramatically increasing the average educational level of the American workforce, helped prevent inequality from soaring as technology automated more and more unskilled work. While education is certainly not

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[3] http://econ-www.mit.edu/files/5571
[4] http://econ-www.mit.edu/files/563
[5] http://press.princeton.edu/titles/7704.html

synonymous with skill, it is one of the most easily measurable correlates of skill, so this pattern suggests that demand for upskilling has increased faster than its supply.

Studies by this book's co-author Erik Brynjolfsson along with Timothy Bresnahan, Lorin Hitt, [6]and Shinku Yang found that a key aspect of SBTC was not just the skills of those working with computers, but more importantly the broader changes in work organization that were made possible by information technology. The most productive firms reinvented and reorganized decision rights, incentives systems, information flows, hiring systems, and other aspects of organizational capital to get the most from the technology. This, in turn, required radically different and, generally, higher skill levels in the workforce. It was not so much that those directly working with computers had to be more skilled, but rather that whole production processes, and even industries, were reengineered to exploit powerful new information technologies. What's more, each dollar of computer hardware was often the catalyst for more than $10 of investment in complementary organizational capital. The intangible organizational assets are typically much harder to change, but they are also much more important to the success of the organization.

As the 21st century unfolds, automation is affecting broader swaths of work. Even the low wages earned by factory workers in China have not insulated them from being undercut by new machinery and the complementary organizational and institutional changes. For instance, Terry Gou, the founder and chairman of the electronics manufacturer Foxconn, announced this year a plan to purchase 1 million robots over the next three years to replace much of his workforce. The robots will take over routine jobs like spraying paint, welding, and basic assembly. Foxconn currently has 10,000 robots, with 300,000 expected to be in place by next year.

2. Superstars vs. Everyone Else

The second division is between superstars and everyone else. Many industries are winner-take-all or winner-take-most competitions, in which a few individuals get the lion's share of the rewards. Think of pop music, professional athletics, and the market for CEOs. Digital technologies increase the size and scope of these markets. These technologies replicate not only information goods but increasingly business processes as well. As a result, the talents, insights, or decisions of a single person can now dominate a national or even global market. Meanwhile good, but not great, local competitors are increasingly crowded out of their markets. The superstars in each field can now earn much larger rewards than they did in earlier decades.

The effects are evident at the top of the income distribution. The top 10% of the wage distribution has done much better than the rest of the labor force, but even within this group there has been growing inequality. Income has grown faster for the top 1% than the rest of the top decile. In turn, the top 0.1% and top 0.01% have seen their income grow even faster. This is not run-of-the-mill skill-biased technical change but rather reflects the unique rewards of

[6] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=166994

superstardom. Sherwin Rosen, himself a superstar economist, laid out the economics of superstars in a seminal 1981 article. In many markets, consumers are willing to pay a premium for the very best. If technology exists for a single seller to cheaply replicate his or her services, then the top-quality provider can capture most--or all--of the market. The next-best provider might be almost as good yet get only a tiny fraction of the revenue.

Technology can convert an ordinary market into one that is characterized by superstars. Before the era of recorded music, the very best singer might have filled a large concert hall but at most would only be able to reach thousands of listeners over the course of a year. Each city might have its own local stars, with a few top performers touring nationally, but even the best singer in the nation could reach only a relatively small fraction of the potential listening audience. Once music could be recorded and distributed at a very low marginal cost, however, a small number of top performers could capture the majority of revenues in every market, from classical music's Yo-Yo Ma to pop's Lady Gaga.

Economists Robert Frank and Philip Cook[7] documented how winner-take-all markets have proliferated as technology transformed not only recorded music but also software, drama, sports, and every other industry that can be transmitted as digital bits. This trend has accelerated as more of the economy is based on software, either implicitly or explicitly. As discussed in the 2008 Harvard Business Review article, [8]digital technologies make it possible to replicate not only bits but also processes. For instance, companies like CVS have embedded processes like prescription drug ordering into their enterprise information systems. Each time CVS makes an improvement[9], it is propagated across 4,000 stores nationwide, amplifying its value. As a result, the reach and impact of an executive decision, like how to organize a process, is correspondingly larger.

In fact, the ratio of CEO pay to average worker pay has increased from 70 in 1990 to 300 in 2005, and much of this growth is linked to the greater use of IT, according to recent research that Erik did with his student Heekyung Kim[10]. They found that increases in the compensation of other top executives followed a similar, if less extreme, pattern. Aided by digital technologies, entrepreneurs, CEOs, entertainment stars, and financial executives have been able to leverage their talents across global markets and capture reward that would have been unimaginable in earlier times.

To be sure, technology is not the only factor that affects incomes. Political factors, globalization, changes in asset prices, and, in the case of CEOs and financial executives, corporate governance also plays a role. In particular, the financial services sector has grown dramatically as a share of GDP and even more as a share of profits and compensation, especially at the top of the income distribution. While efficient finance is essential to a modern

[7] http://www.amazon.com/Winner-Take-All-Society-Robert-H-Frank/dp/0028740343
[8] http://hbr.org/2008/07/investing-in-the-it-that-makes-a-competitive-difference/ar/1
[9] http://hbr.org/product/pharmacy-service-improvement-at-cvs-a/an/606015-PDF-ENG
[10]http://digital.mit.edu/erik/ITandOrg.html

economy, it appears that a significant share of returns to large human and technological investments in the past decade, such as those in sophisticated computerized program trading, were from rent redistribution rather than genuine wealth creation. Other countries, with different institutions and also slower adoption of IT, have seen less extreme changes in inequality. But the overall changes in the United States have been substantial. According to economist Emmanuel Saez, the top 1% of U.S. households got 65% of all the growth in the economy since 2002. In fact, Saez reports[11] that the top 0.01% of households in the United States--that is, the 14,588 families with income above $11,477,000--saw their share of national income double from 3% to 6% between 1995 and 2007.

3. Capital vs. Labor

The third division is between capital and labor. Most types of production require both machinery and human labor. According to bargaining theory, the wealth they generate is divided according to relative bargaining power, which in turn typically reflects the contribution of each input. If the technology decreases the relative importance of human labor in a particular production process, the owners of capital equipment will be able to capture a bigger share of income from the goods and services produced. To be sure, capital owners are also humans--so it's not like the wealth disappears from society--but capital owners are typically a very different and smaller group than the ones doing most of the labor, so the distribution of income will be affected.

In particular, if technology replaces labor, you might expect that the shares of income earned by equipment owners would rise relative to laborers--the classic bargaining battle between capital and labor. This has been happening increasingly in recent years. As noted by Kathleen Madigan[12], since the recession ended, real spending on equipment and software has soared by 26% while payrolls have remained essentially flat.

Furthermore, there is growing evidence that capital has captured a growing share of GDP in recent years. As shown in Figure 3.6, corporate profits have easily surpassed their pre-recession levels.

According to the recently updated data from the U.S. Commerce Department, recent corporate profits accounted for 23.8% of total domestic corporate income, a record high share that is more than 1 full percentage point above the previous record. Similarly, corporate profits as a share of GDP are at 50-year highs. Meanwhile, compensation to labor in all forms, including wages and benefits, is at a 50-year low. Capital is getting a bigger share of the pie, relative to labor.

The recession exacerbated this trend, but it's part of long-term change in the economy. As noted by economists Susan Fleck, John Glaser, and Shawn Sprague[13], the trend line for labor's share

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[11] http://elsa.berkeley.edu/~saez/saez-UStopincomes-2006prel.pdf
[12] http://blogs.wsj.com/economics/2011/09/28/its-man-vs-machine-and-man-is-losing/
[13] http://www.bls.gov/opub/mlr/2011/01/art3full.pdf

of GDP was essentially flat between 1974 and 1983 but has been falling since then. When one thinks about the workers in places like Foxconn's factory being replaced by labor-saving robots, it's easy to imagine a technology-driven story for why the relative shares of income might be changing.

It's important to note that the "labor" share in the Bureau of Labor Statistics' data includes wages paid to CEOs, finance professionals, professional athletes, and other "superstars" discussed above. In this sense, the declining labor share understates how badly the median worker has fared. It may also understate the division of income between capital and labor, insofar as CEOs and other top executives may have bargaining power to capture some of the "capital's share" that would otherwise accrue to owners of common stock

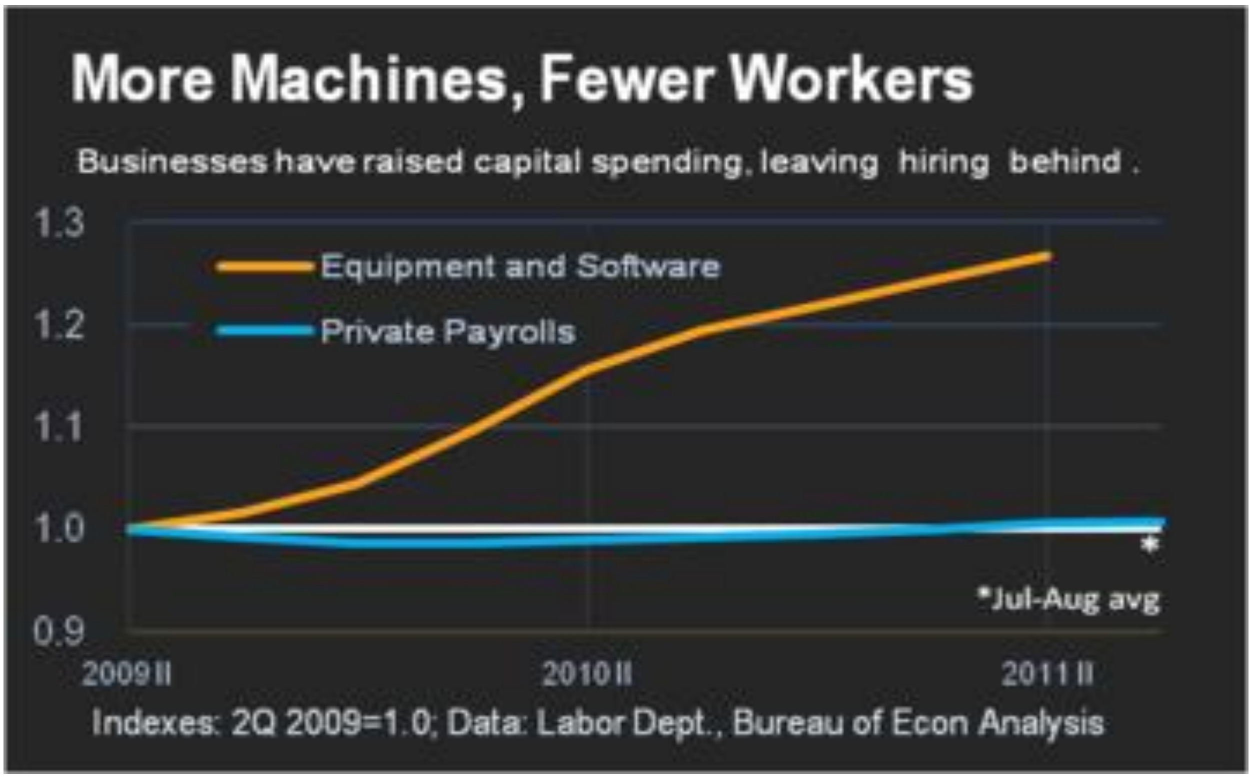

Figure (1): Increasing in the number of machines 2009-2011.

In a few decades, twenty or thirty years — or sooner – robots and their associated technology will be as ubiquitous as mobile phones are today, at least that is the prediction of Bill Gates; and we would be hard-pressed to find a roboticist, automation expert or economist who could present a strong case against this. The Robotics Revolution promises a host of benefits that are compelling (especially in health care) and imaginative, but it may also come at a significant price.

The Pareto Principle of Prediction

We find ourselves faced with an intractable paradox: On the one hand technology advances increase productivity and wellbeing, and on the other hand it often reinforces inequalities.

A new study[14] due to be published in the forthcoming *Oxford Handbook of Skills and Training* by Stuart Elliot visiting analyst at the Organization for Economic Co-operation and Development (OECD), who incidentally is on leave from the Board on Testing and Assessment of the National Research Council, **indicates that technology could replace 'workers for 80 percent of current jobs.'**

In his study Elliot relies on advances in speech, reasoning capabilities and movement capabilities to illustrate how robots and technology can replace jobs. I am in agreement with the general thoughts of the study, although I believe speech recognition is now far more advanced than Elliot states. This element alone will lead to a reduction in many jobs, such as translation over the next five years.

Elliot is not the first to claim that robotics and technology will have such a profound impact on employment or inequality. Michael Hammer, a former MIT professor and prime mover in the restructuring of the workplace in the 1990's estimated that up to 80 percent of those engaged in middle management tasks were susceptible to elimination due to automation.

In the book *Average is Over* [15]Professor Tyler Cowen also predicts a hollowed-out labor market, devoid of middle-skill, middle-wage jobs, where 80% or more of our citizens will be unable to prosper. They will become a permanent underclass, unable to improve their lot.

This 'underclass' may be happening sooner than Cowen predicted. While there are 'short term' adjustments in the employment numbers, the majority are in the low-paying sectors, 73% of 'new' jobs are in the bottom of the wage pyramid and temporary employment positions rather than permanent.

The US Bureau of Labor Statistics estimates [16]that among the most rapidly growing occupational categories over the next ten years will be "healthcare support occupations[17]" (nursing aides, orderlies, and attendants) and "food preparation and serving workers" – overwhelmingly low-wage jobs.

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[14] http://www.issues.org/30.3/Stuart.html

[15] http://www.amazon.com/Average-Over-Powering-America-Stagnation/dp/0525953736/ref=sr_1_1?s=books&ie=UTF8&qid=1397640882&sr=1-1&keywords=average+is+over

[16] http://www.bls.gov/news.release/pdf/ecopro.pdf

[17] http://www.project-syndicate.org/commentary/adair-turner-explains-how-a-fresh-wave-of-automation-is-transforming-employment-and-much-else

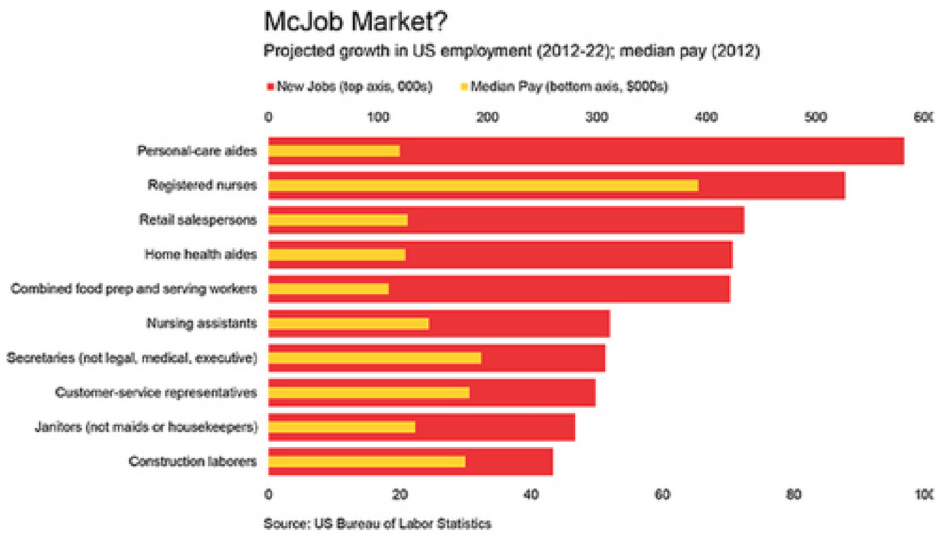

Figure (2): Projected growth in the US employment.

As recent as last month the FT reported that[18]: "New technologies are transforming the structure of the US economy but creating only modest numbers of jobs, according to the biggest official survey of businesses, conducted only once every five years."

In the book Race Against The Machine[19] the authors state: "Digital technologies change rapidly, but organizations and skills aren't keeping pace. As a result, millions of people are being left behind. Their incomes and jobs are being destroyed, leaving them worse off."

Speaking at the World Economic Forum in Davos[20] earlier this year, Google's Eric Schmidt warned[21] that the problem of new technologies substantially changing and replacing jobs will be "the defining one" for the next two or three decades.

Thinking machines

Increasingly, machines are providing not only the brawn but the brains, too, and that raises the question of where humans fit into this picture. Earlier this year, Jörg Asmussen State Secretary in the German Ministry of Labor and Social Affairs emphasized this trend when he said[22]:

"Digitization, or the "second machine age" (as in the title of the best seller by Erik Brynjolfsson and Andrew McAffee), has only just begun. It is in the process of relieving and ultimately replacing first our physical and then our intellectual labor. This trend will be a threat to

18 http://www.ft.com/cms/s/0/f8a95502-b502-11e3-af92-00144feabdc0.html#ixzz2z2SoMMcy
19 http://www.amazon.com/Race-Against-Machine-Accelerating-Productivity/dp/0984725113/ref=sr_1_1?s=books&ie=UTF8&qid=1397641254&sr=1-1&keywords=Race+Against+The+Machine
20 http://robotenomics.com/2014/01/24/google-chairman-warns-jobs-are-being-automated-out/
21 http://www.bbc.co.uk/news/business-25872006
22 http://www.bmas.de/SharedDocs/Downloads/EN/speech_asmussen-2014226.pdf?__blob=publicationFile

brainworkers such as accountants and stock-market traders. And check-out clerks at supermarkets will also soon be a thing of the past."

Echoing this, Randall Parker, Professor of Economics at East Carolina University, recently wrote[23]:

"Robots and other automated equipment have increased factory automation so much that factories are a dwindling source of all jobs. The next big target for automation has been and continues to be office work."

In the US manufacturing sector there was a solid increase in sales of 8 percent between 2007 and 2012 but with significant falling employment, the industry shed 2.1m jobs and its payroll dropped $20 billion.

Approximately one out of 25 workers in Japan is a robot, this is in part due to a growing elderly population and declining birthrates, which mean a shrinking workforce, but it is also a fact that global business seeks to drive productivity, efficiency, and effectiveness to new heights with robotics.

This time is different, or maybe not

In his seminal book, *The Enlightened Economy*[24], Joel Mokyr argued that: "in Britain the high quality of workmanship available to support innovation, local and imported, helped create the Industrial Revolution." Dig a little further and Mokyr refers to: "the top 3 to 5 percent of the labor force in terms of skills: engineers, mechanics, millwrights, chemists, clock and instrument makers, skilled carpenters and metal workers, wheelwrights, and similar workmen."

It was a small minority of the working population that had the skills to help advance the Industrial Revolution, others had to learn new skills to adapt to the technology changes. This time is no different. Just as each revolution sets a higher potential level of productivity each revolution requires a new set of skills to overcome the resistance of the old paradigm, which is deeply embedded in the minds and the practices.

Despite the job losses in the US manufacturing sector factories are increasingly employing more skilled engineers to tend complex equipment and at higher wages, Annual payroll per employee[25] in the manufacturing sector rose from $45,818 in 2007 to $52,686 in 2012.

[23] http://www.futurepundit.com/archives/002025.html#002025

[24] http://www.amazon.com/The-Enlightened-Economy-Economic-1700-1850/dp/0300189516

[25] http://www.ft.com/intl/cms/s/0/f8a95502-b502-11e3-af92-00144feabdc0.html#axzz2z2iRFfV1

It’s time to act

Robotic hardware, Artificial Intelligence, automated software and connected networks are only going to get more powerful and capable in the future, and have even bigger impact on jobs, skills and the economy.

The message for all of us can be summed up in a quote from Abraham Lincoln’s second address to Congress.

“As our case is new, so we must think anew, and act anew.”

In his paper Elliot raises a very good question: “Even if alternative jobs are available, how will the displaced workers acquire the necessary skills for the new tasks?” This should be a wakeup call. All of us must give serious consideration to our future and learn the skills that will give us the best chance of working WITH the machines. I’ll repeat Lincoln’s statement, since that’s the big takeaway. “As our case is new, so we must think anew, and ACT anew.” These are exciting and challenging times…

Chapter 3:

Humans defeating machines

People and computers are coming together in all kinds of interesting ways these days. The right combination of human and digital smarts in chess[26] will beat the top grandmaster, the best chess supercomputer, and the top grandmaster *with* the best supercomputer. At least one VC firm is giving an algorithm a formal vote[27]on its investments. And robots (which I consider to be computers with a physical presence) are increasingly working side by side with people[28] on factory and warehouse floors.

In some cases, it’s clear what each party brings to the collaboration. Because humans still have greater manual dexterity they’re the ones picking parts out of bins in the newest Amazon warehouses, while Kiva robots bring the shelves[29]full of bins to the people quickly and reliably. The VC algorithm, if properly constructed, will systematically and objectively take into account[30]“prospective companies’ financing… intellectual property and previous funding rounds” in a way that might be hard for biased, pressed-for-time humans to replicate. And chess computers keep human players from some kinds of dumb moves — the ones whose negative future consequences should have been foreseen, but weren’t.

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[26] http://infinitychess.com/Web/Page/Public/Article/DefaultArticle.aspx?id=118
[27] http://www.businessinsider.com/vital-named-to-board-2014-5
[28] http://newsoffice.mit.edu/2012/robot-manufacturing-0612
[29]https://www.youtube.com/watch?v=6KRjuuEVEZs&feature=kp
[30] http://www.businessinsider.com/vital-named-to-board-2014-5

But alchemy between people and computers — combinations that are way better than either party could do on its own — remains mysterious. In particular, it's not clear to me (and many others) how people continue to add value as technology races ahead. Computers are clearly better at brute force computation and search, and their pattern matching abilities are improving by leaps and bounds these days. So what are we better at?

That's a surprisingly hard question to nail down. It appears that when the task is so wide open that searching through history or enumerating all the possibilities won't work, our abilities are superior. In domains as diverse as playing the Asian board game Go[31] and predicting how proteins will fold [32]the human brain is still the best tool available. In both of these cases, there are just too many possibilities for even a network of supercomputers to go through all of them.

So what do our brains do in such cases? How do they come up with better answers? As far as I can tell, we aren't sure. But we're clearly doing something that our best digital technologists have not yet been able to master. The same seems to be true, at least for now, in many domains that require taste, creativity, or an aesthetic or emotional response. Computers still can't write a good short story, or design a beautiful computer.

Will they learn to? As Erik Brynjolfsson wrote in The second machine age the mantra we learned from studying many examples of digital progress is "never say never." But I haven't seen these things yet, which gives me hope that people will have important roles to play in our societies and economies for some time to come.

According to "Dancing with Robots: Human skills for computerized work[33]," computers' strengths lie in speed and accuracy, while humans' strengths are all about flexibility. Computer programs are progressing from simple rules-based logic to pattern recognition, which uses more processing power and more data. Pattern recognition can deal with more complex tasks than rules-based logic, but it often works best as a complement to, not a substitute for, human labor. There are three types of work that humans do really well but computers cannot (yet):

1) Unstructured problem-solving: solving for problems in which the rules do not currently exist. Examples: a doctor diagnosing a disease, a lawyer writing a persuasive argument, a designer creating a new web application.

2) Acquiring and processing new information, deciding what is relevant in a flood of undefined phenomena. Examples: a scientist discovering the properties of a medicine, an underwater explorer, or a journalist reporting on a story.

3) Nonroutine physical work. Performing complex tasks in 3-D space, from cleaning to driving to cooking to giving manicures, which is thought of as relatively low-skilled work for

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[31] http://www.wired.com/2014/05/the-world-of-computer-go/

[32] http://www.scientificamerican.com/article/foldit-gamers-solve-riddle/

[33] http://content.thirdway.org/publications/714/Dancing-With-Robots.pdf

humans, but actually requires a combination of skill #1 and skill #2 that is still very difficult for computers to master.

When you separate out these three factors, it's easier to understand the complex ways that both technology and outsourcing are affecting the job market. David Autor at MIT calls it a "hollowing out" of the market. There's a whole set of "middle-skilled jobs" like cashing checks, approving mortgage applications, selling airline tickets, typing and formatting letters, and taking tolls, that are being partially or fully replaced by computer programs. Some of these jobs disappear, and others become more complex and interesting as the computer takes over the routine parts of the task. (Bank teller to financial advisor; travel agent to specialized vacation outfitter; secretary to executive assistant).

In other words, what's left for humans, after the robots have conquered everything, is low-skilled physical jobs and highly skilled, complex mental jobs. The scientists conclude by recommending that we reinvent our education system to prepare children for an "increased emphasis on conceptual understanding and problem-solving"—and to better collaborate with, take care of, and program the computers that are going to continue to be our sidekicks.

However, by considering only the cognitive requirements for jobs, Frank Levy and Richard J. Murmane, are leaving out a crucial point. The fourth thing that humans are much better at than computers is:

4) Being human: Expressing empathy, making people feel good, taking care of others, being artistic and creative for the sake of creativity, expressing emotions and vulnerability in a relatable way, making people laugh. The human touch is indispensable for most jobs, and in some cases, it is the entire job. In this one, humans win.

Chapter 4

Advantages and disadvantages of this trend

The issue of whether using of machine are bring many advantages to society is of great concern to many people. In my opinion, although using machines have many benefits, we cannot ignore its negative effects.

It is undoubted that machines can bring many benefits. For one thing, machines are more effective than human. Not like human, machines do not need rest, which means they can work as long as employers want and consistently produce high quality products without any mistakes. For another, using machines can save company's money. Because machines never ask for salary, over-time pay or pension, so employers do not need to spend money on employee's welfare. The company only needs some technicians to make sure machines are working on the right track or replace some part when machines are not working.

However, the disadvantages of machines that bring to us should not be neglected by people. To start with, because of extensive of using machines, many people losses their job. Especially in large population countries, high unemployment rate may cause crime and social instability. Apart from this, using of machines are also pose serious pollution and energy dissipation. For example, nowadays people prefer to use dish-washing machine to wash dishes and plates rather than hand washing. But they did not know that compared with hand washing dish-washing machine consume at least 2 times water and electricity to wash this tableware. As you can imagine, if thousands of families use dish-washing machines, how many water and how much electricity will be wasted!

Conclusions;

Even with the rapidly advancing technology, machines couldn't replace all of us. They lack in creativity needed in several jobs. Architects, dancers, song writers, actors, authors, photographers-- all of which are jobs that need creativity. Other jobs like nurses and psychiatrists need empathy and compassion. Machines do not have the capability to "feel" emotions.

Humans make decisions based on past experiences and values. We have the ability to correct and learn from our mistakes, whereas machines, whom seldom make mistakes, cannot learn from errors. Other factors, like judgment, intuition, and innovation, also aren't found in machines.

So let's say machines do replace humans; what happens then?

If the machines take away our jobs, the lower class citizens wouldn't earn any money. Without money, they can't buy anything, meaning that there would be no need to make anything if the people can't buy things.

Not only that, but once the economy fails, the rich would only get richer. The people who own the machines would eventually lose their money, but not before the lower classes would riot. That could led to the eradication of the human race, leaving the machines to run the planet. There is no denying the fact that the machines would eventually break down, but who would be there to fix them? Even if there was a machine which could repair other machines, what happens when that one breaks down? And when they run out of the repairing machines? There would be no point in letting machines replace us, even with the impressive advances in our technology.

So machines are invented to support humans not to replace them.

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