AI, Robotics, and the Future of Jobs

BY AARON SMITH AND JANNA ANDERSON

Key Findings

The vast majority of respondents to the 2014 Future of the Internet canvassing anticipate that robotics and artificial intelligence will permeate wide segments of daily life by 2025, with huge implications for a range of industries such as health care, transport and logistics, customer service, and home maintenance. But even as they are largely consistent in their predictions for the evolution of technology itself, they are deeply divided on how advances in AI and robotics will impact the economic and employment picture over the next decade.

We call this a canvassing because it is not a representative, randomized survey. Its findings emerge from an "opt in" invitation to experts who have been identified by researching those who are widely quoted as technology builders and analysts and those who have made insightful predictions to our previous queries about the future of the Internet. (For more details, please see the section "About this Report and Survey.")

Key themes: reasons to be hopeful

1. Advances in technology may displace certain types of work, but historically they have been a net creator of jobs.
2. We will adapt to these changes by inventing entirely new types of work, and by taking advantage of uniquely human capabilities.
3. Technology will free us from day-to-day drudgery, and allow us to define our relationship with "work" in a more positive and socially beneficial way.
4. Ultimately, we as a society control our own destiny through the choices we make.

Key themes: reasons to be concerned

1. Impacts from automation have thus far impacted mostly blue-collar employment; the coming wave of innovation threatens to upend white-collar work as well.
2. Certain highly-skilled workers will succeed wildly in this new environment—but far more may be displaced into lower paying service industry jobs at best, or permanent unemployment at worst.
3. Our educational system is not adequately preparing us for work of the future, and our political and economic institutions are poorly equipped to handle these hard choices.

Some 1,896 experts responded to the following question:

The economic impact of robotic advances and AI—Self-driving cars, intelligent digital agents that can act for you, and robots are advancing rapidly. Will networked, automated, artificial intelligence (AI) applications and robotic devices have displaced more jobs than they have created by 2025?

Half of these experts (48%) envision a future in which robots and digital agents have displaced significant numbers of both blue- and white-collar workers—with many expressing concern that this will lead to vast increases in income inequality, masses of people who are effectively unemployable, and breakdowns in the social order.

The other half of the experts who responded to this survey (52%) expect that technology will *not* displace more jobs than it creates by 2025. To be sure, this group anticipates that many jobs currently performed by humans will be substantially taken over by robots or digital agents by 2025. But they have faith that human ingenuity will create new jobs, industries, and ways to make a living, just as it has been doing since the dawn of the Industrial Revolution.

These two groups also share certain hopes and concerns about the impact of technology on employment. For instance, many are concerned that our existing social structures—and especially our educational institutions—are not adequately preparing people for the skills that will be needed in the job market of the future. Conversely, others have hope that the coming changes will be an opportunity to reassess our society's relationship to employment itself—by returning to a focus on small-scale or artisanal modes of

production, or by giving people more time to spend on leisure, self-improvement, or time with loved ones.

A number of themes ran through the responses to this question: those that are unique to either group, and those that were mentioned by members of both groups.

The view from those who expect AI and robotics to have a positive or neutral impact on jobs by 2025

JP Rangaswami, chief scientist for Salesforce.com, offered a number of reasons for his belief that automation will *not* be a net displacer of jobs in the next decade: "The effects will be different in different economies (which themselves may look different from today's political boundaries). Driven by revolutions in education and in technology, the very nature of work will have changed radically—but only in economies that have chosen to invest in education, technology, and related infrastructure. Some classes of jobs will be handed over to the 'immigrants' of AI and Robotics, but more will have been generated in creative and curating activities as demand for their services grows exponentially while barriers to entry continue to fall. For many classes of jobs, robots will continue to be poor labor substitutes."
Rangaswami's prediction incorporates a number of arguments made by those in this canvassing who took his side of this question.

Argument #1: Throughout history, technology has been a job creator—not a job destroyer

Vint Cerf, vice president and chief Internet evangelist for Google, said, "Historically, technology has created more jobs than it destroys and there is no reason to think otherwise in this case. Someone has to make and service all these advanced devices."
Jonathan Grudin, principal researcher for Microsoft, concurred: "Technology will continue to disrupt jobs, but more jobs seem likely to be created. When the world population was a few hundred million people there were hundreds of millions of jobs. Although there have always been unemployed people, when we reached a few billion people there were billions of jobs. There is no shortage of things that need to be done and that will not change."

Michael Kende, the economist for a major Internet-oriented nonprofit organization, wrote, "In general, every wave of automation and computerization has increased productivity without depressing employment, and there is no reason to think the same will not be true this time. In particular, the new wave is likely to increase our personal or professional productivity (e.g. self-driving car) but not necessarily directly displace a job (e.g. chauffeur). While robots may displace some manual jobs, the impact should not be different than previous waves of automation in factories and elsewhere. On the other hand, someone will have to code and build the new tools, which will also likely lead to a new wave of innovations and jobs."

Fred Baker, Internet pioneer, longtime leader in the IETF and Cisco Systems Fellow, responded, "My observation of advances in automation has been that they change jobs, but they don't reduce them. A car that can guide itself on a striped street has more difficulty with an unstriped street, for example, and any automated system can handle events that it is designed for, but not events (such as a child chasing a ball into a street) for which it is not designed. Yes, I expect a lot of change. I don't think the human race can retire en masse by 2025."

Argument #2: Advances in technology create new jobs and industries even as they displace some of the older ones

Ben Shneiderman, professor of computer science at the University of Maryland, wrote, "Robots and AI make compelling stories for journalists, but they are a false vision of the major economic changes. Journalists lost their jobs because of changes to advertising, professors are threatened by MOOCs, and store salespeople are losing jobs to Internet sales people. Improved user interfaces, electronic delivery (videos, music, etc.), and more self-reliant customers reduce job needs. At the same time someone is building new websites, managing corporate social media plans, creating new products, etc. Improved user interfaces, novel services, and fresh ideas will create more jobs."

Amy Webb, CEO of strategy firm Webbmedia Group, wrote, "There is a general concern that the robots are taking over. I disagree that our emerging technologies will permanently displace most of the workforce, though I'd argue that jobs will shift into other sectors. Now more than ever, an army of talented coders is needed to help our technology advance. But we will still need folks to do packaging, assembly, sales, and outreach. The collar of the future is a hoodie."

John Markoff, senior writer for the Science section of the New York Times, responded, "You didn't allow the answer that I feel strongly is accurate—too hard to predict. There will be a vast displacement of labor over the next decade. That is true. But, if we had gone back 15 years who would have thought that 'search engine optimization' would be a significant job category?"

Marjory Blumenthal, a science and technology policy analyst, wrote, "In a given context, automated devices like robots may displace more than they create. But they also generate new categories of work, giving rise to second- and third-order effects. Also, there is likely to be more human-robot collaboration—a change in the kind of work opportunities available. The wider impacts are the hardest to predict; they may not be strictly attributable to the uses of automation but they are related…what the middle of the 20th century shows us is how dramatic major economic changes are—like the 1970s OPEC-driven increases of the price of oil—and how those changes can dwarf the effects of technology."

Argument #3: There are certain jobs that only humans have the capacity to do

A number of respondents argued that many jobs require uniquely human characteristics such as empathy, creativity, judgment, or critical thinking—and that jobs of this nature will never succumb to widespread automation.

David Hughes, a retired U.S. Army Colonel who, from 1972, was a pioneer in individual to/from digital telecommunications, responded, "For all the automation and AI, I think the 'human hand' will have to be involved on a large scale. Just as aircraft have to have pilots and copilots, I don't think all 'self-driving' cars will be totally unmanned. The human's ability to detect unexpected circumstances, and take action overriding automatic driving will be needed as long and individually owned 'cars' are on the road."

Pamela Rutledge, PhD and director of the Media Psychology Research Center, responded, "There will be many things that machines can't do, such as services that require thinking, creativity, synthesizing, problem-solving, and innovating…Advances in AI and robotics allow people to cognitively offload repetitive tasks and invest their attention and energy in things where humans can make a difference. We already have cars that talk to us, a phone we can talk to, robots that lift the elderly out of bed, and apps that remind us to call Mom. An app can dial Mom's number and even send flowers, but an app can't do that most human of all things: emotionally connect with her."

Michael Glassman, associate professor at the Ohio State University, wrote, "I think AI will do a few more things, but people are going to be surprised how limited it is. There will be greater differentiation between what AI does and what humans do, but also much more realization that AI will not be able to engage the critical tasks that humans do."

Argument #4: The technology will not advance enough in the next decade to substantially impact the job market

Another group of experts feels that the impact on employment is likely to be minimal for the simple reason that 10 years is too short a timeframe for automation to move substantially beyond the factory floor. **David Clark**, a senior research scientist at MIT's Computer Science and Artificial Intelligence Laboratory, noted, "The larger trend to consider is the penetration of automation into service jobs. This trend will require new skills for the service industry, which may challenge some of the lower-tier workers, but in 12 years I do not think autonomous devices will be truly autonomous. I think they

will allow us to deliver a higher level of service with the same level of human involvement."

Jari Arkko, Internet expert for Ericsson and chair of the Internet Engineering Task Force, wrote, "There is no doubt that these technologies affect the types of jobs that need to be done. But there are only 12 years to 2025, some of these technologies will take a long time to deploy in significant scale… We've been living a relatively slow but certain progress in these fields from the 1960s."

Christopher Wilkinson, a retired European Union official, board member for EURid.eu, and Internet Society leader said, "The vast majority of the population will be untouched by these technologies for the foreseeable future. AI and robotics will be a niche, with a few leading applications such as banking, retailing, and transport. The risks of error and the imputation of liability remain major constraints to the application of these technologies to the ordinary landscape."

Argument #5: Our social, legal, and regulatory structures will minimize the impact on employment

A final group suspects that economic, political, and social concerns will prevent the widespread displacement of jobs. **Glenn Edens**, a director of research in networking, security, and distributed systems within the Computer Science Laboratory at PARC, a Xerox Company, wrote, "There are significant technical and policy issues yet to resolve, however there is a relentless march on the part of commercial interests (businesses) to increase productivity so if the technical advances are reliable and have a positive ROI then there is a risk that workers will be displaced. Ultimately we need a broad and large base of employed population, otherwise there will be no one to pay for all of this new world."

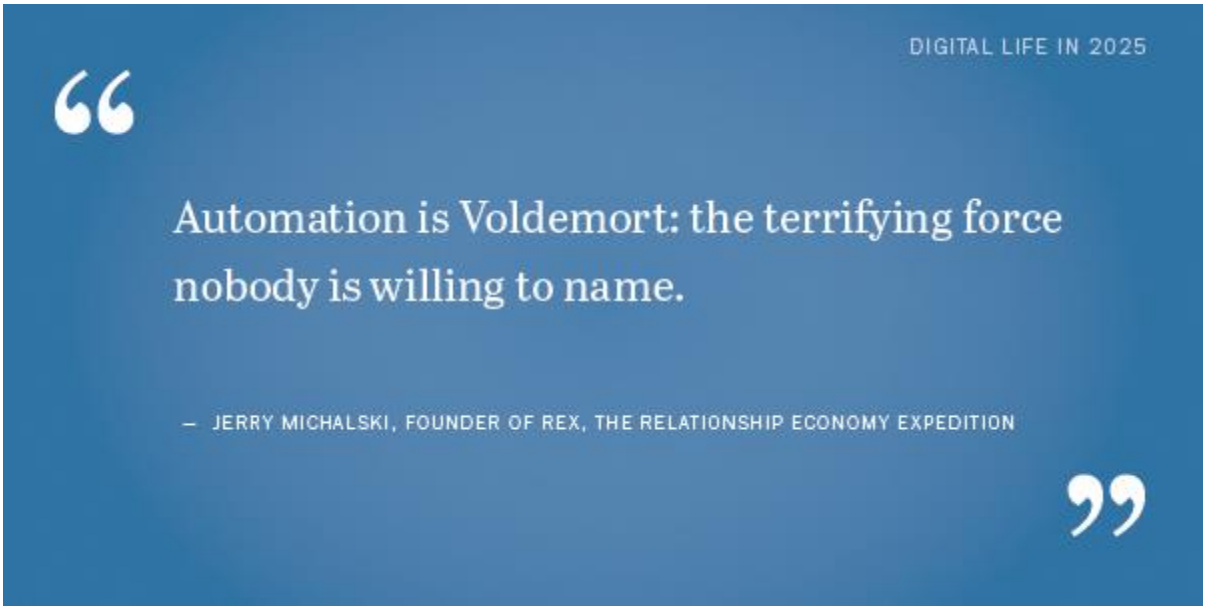
Andrew Rens, chief council at the Shuttleworth Foundation, wrote, "A fundamental insight of economics is that an entrepreneur will only supply goods or services if there is a demand, and those who demand the good can pay. Therefore any country that wants a competitive economy will ensure that most of its citizens are employed so that in turn they can pay for goods and services. If a country doesn't ensure employment driven demand it will become increasingly less competitive."

Geoff Livingston, author and president of Tenacity5 Media, wrote, "I see the movement towards AI and robotics as evolutionary, in large part because it is such a sociological leap.The technology may be ready, but we are not—at least, not yet."

The view from those who expect AI and robotics to displace more jobs than they create by 2025

An equally large group of experts takes a diametrically opposed view of technology's impact on employment. In their reading of history, job displacement as a result of technological advancement is clearly in evidence today, and can only be expected to get worse as automation comes to the white-collar world.

Argument #1: Displacement of workers from automation is already happening—and about to get much worse



Jerry Michalski, founder of REX, the Relationship Economy eXpedition, sees the logic of the slow and unrelenting movement in the direction of more automation: "Automation is Voldemort: the terrifying force nobody is willing to name. Oh sure, we talk about it now and then, but usually in passing. We hardly dwell on the fact that someone trying to pick a career path that is not likely to be automated will have a very hard time making that choice. X-ray technician? Outsourced already, and automation in progress. The race between automation and human work is won by automation, and as long as we need fiat currency to pay the rent/mortgage, humans will fall out of the system in droves as this shift takes place…The safe zones are services that require local human effort (gardening, painting, babysitting), distant human effort (editing, coaching, coordinating), and high-level thinking/relationship building. Everything else falls in the target-rich environment of automation."

Mike Roberts, Internet pioneer and Hall of Fame member and longtime leader with ICANN and the Internet Society, shares this view: "Electronic human avatars with substantial work capability are years, not decades away. The situation is exacerbated by total failure of the economics community to address to any serious degree sustainability issues that are destroying the modern 'consumerist' model and undermining the early 20th century notion of 'a fair day's pay for a fair day's work.' There is great pain down the road for everyone as new realities are addressed. The only question is how soon."

Robert Cannon, Internet law and policy expert, predicts, "Everything that can be automated will be automated. Non-skilled jobs lacking in 'human contribution' will be replaced by automation when the economics are favorable. At the hardware store, the

guy who used to cut keys has been replaced by a robot. In the law office, the clerks who used to prepare discovery have been replaced by software. IBM Watson is replacing researchers by reading every report ever written anywhere. This begs the question: What can the human contribute? The short answer is that if the job is one where that question cannot be answered positively, that job is not likely to exist."

Tom Standage, digital editor for *The Economist*, makes the point that the next wave of technology is likely to have a more profound impact than those that came before it: "Previous technological revolutions happened much more slowly, so people had longer to retrain, and [also] moved people from one kind of unskilled work to another. Robots and AI threaten to make even some kinds of skilled work obsolete (e.g., legal clerks). This will displace people into service roles, and the income gap between skilled workers whose jobs cannot be automated and everyone else will widen. This is a recipe for instability."

Mark Nall, a program manager for NASA, noted, "Unlike previous disruptions such as when farming machinery displaced farm workers but created factory jobs making the machines, robotics and AI are different. Due to their versatility and growing capabilities, not just a few economic sectors will be affected, but whole swaths will be. This is already being seen now in areas from robocalls to lights-out manufacturing. Economic efficiency will be the driver. The social consequence is that good-paying jobs will be increasingly scarce."

Argument #2: The consequences for income inequality will be profound

For those who expect AI and robotics to significantly displace human employment, these displacements seem certain to lead to an increase in income inequality, a continued hollowing out of the middle class, and even riots, social unrest, and/or the creation of a permanent, unemployable "underclass".

Justin Reich, a fellow at Harvard University's Berkman Center for Internet & Society, said, "Robots and AI will increasingly replace routine kinds of work—even the complex routines performed by artisans, factory workers, lawyers, and accountants. There will be a labor market in the service sector for non-routine tasks that can be performed interchangeably by just about anyone—and these will not pay a living wage—and there will be some new opportunities created for complex non-routine work, but the gains at this top of the labor market will not be offset by losses in the middle and gains of terrible jobs at the bottom. I'm not sure that jobs will disappear altogether, though

that seems possible, but the jobs that are left will be lower paying and less secure than those that exist now. The middle is moving to the bottom."

DIGITAL LIFE IN 2025

"The central question of 2025 will be: What are people for in a world that does not need their labor, and where only a minority are needed to guide the 'bot-based economy?

— STOWE BOYD,
LEAD RESEARCHER AT GIGAOM RESEARCH"

Stowe Boyd, lead researcher at GigaOM Research, said, "As just one aspect of the rise of robots and AI, widespread use of autonomous cars and trucks will be the immediate end of taxi drivers and truck drivers; truck driver is the number-one occupation for men in the U.S.. Just as importantly, autonomous cars will radically decrease car ownership, which will impact the automotive industry. Perhaps 70% of cars in urban areas would go away. Autonomous robots and systems could impact up to 50% of jobs, according to recent analysis by Frey and Osborne at Oxford, leaving only jobs that require the 'application of heuristics' or creativity…An increasing proportion of the world's population will be outside of the world of work—either living on the dole, or benefiting from the dramatically decreased costs of goods to eke out a subsistence lifestyle. The central question of 2025 will be: What are people for in a world that does not need their labor, and where only a minority are needed to guide the 'bot-based economy?"

Nilofer Merchant, author of a book on new forms of advantage, wrote, "Just today, the guy who drives the service car I take to go to the airport [said that he] does this job because his last blue-collar job disappeared from automation. Driverless cars displace him. Where does he go? What does he do for society? The gaps between the haves and have-nots will grow larger. I'm reminded of the line from Henry Ford, who understood he does no good to his business if his own people can't afford to buy the car."

Alex Howard, a writer and editor based in Washington, D.C., said, "I expect that automation and AI will have had a substantial impact on white-collar jobs, particularly back-office functions in clinics, in law firms, like medical secretaries, transcriptionists, or paralegals. Governments will have to collaborate effectively with technology companies and academic institutions to provide massive retraining efforts over the next decade to prevent massive social disruption from these changes."

Point of agreement: The educational system is doing a poor job of preparing the next generation of workers

A consistent theme among both groups is that our existing social institutions—especially the educational system—are not up to the challenge of preparing workers for the technology- and robotics-centric nature of employment in the future.

Howard Rheingold, a pioneering Internet sociologist and self-employed writer, consultant, and educator, noted, "The jobs that the robots will leave for humans will be those that require thought and knowledge. In other words, only the best-educated humans will compete with machines. And education systems in the U.S. and much of the rest of the world are still sitting students in rows and columns, teaching them to keep quiet and memorize what is told to them, preparing them for life in a 20th century factory."

Bryan Alexander, technology consultant, futurist, and senior fellow at the National Institute for Technology in Liberal Education, wrote, "The education system is not well positioned to transform itself to help shape graduates who can 'race against the machines.' Not in time, and not at scale. Autodidacts will do well, as they always have done, but the broad masses of people are being prepared for the wrong economy."

Point of agreement: The concept of "work" may change significantly in the coming decade

On a more hopeful note, a number of experts expressed a belief that the coming changes will allow us to renegotiate the existing social compact around work and employment.

Possibility #1: We will experience less drudgery and more leisure time

Hal Varian, chief economist for Google, envisions a future with fewer 'jobs' but a more equitable distribution of labor and leisure time. "If 'displace more jobs' means 'eliminate dull, repetitive, and unpleasant work,' the answer would be yes. How unhappy are you

that your dishwasher has replaced washing dishes by hand, your washing machine has displaced washing clothes by hand, or your vacuum cleaner has replaced hand cleaning? My guess is this 'job displacement' has been very welcome, as will the 'job displacement' that will occur over the next 10 years. The work week has fallen from 70 hours a week to about 37 hours now, and I expect that it will continue to fall. This is a good thing. Everyone wants more jobs and less work. Robots of various forms will result in less work, but the conventional work week will decrease, so there will be the same number of jobs (adjusted for demographics, of course). This is what has been going on for the last 300 years so I see no reason that it will stop in the decade."

Tiffany Shlain, filmmaker, host of the AOL series *The Future Starts Here*, and founder of The Webby Awards, responded, "Robots that collaborate with humans over the cloud will be in full realization by 2025. Robots will assist humans in tasks thus allowing humans to use their intelligence in new ways, freeing us up from menial tasks."

Francois-Dominique Armingaud, retired computer software engineer from IBM and now giving security courses to major engineering schools, responded, "The main purpose of progress now is to allow people to spend more life with their loved ones instead of spoiling it with overtime while others are struggling in order to access work."

Possibility #2: It will free us from the industrial age notion of what a "job" is

A notable number of experts take it for granted that many of tomorrow's jobs will be held by robots or digital agents—and express hope that this will inspire us as a society to completely redefine our notions of work and employment.

Peter and Trudy Johnson-Lenz, founders of the online community Awakening Technology, based in Portland, Oregon, wrote, "Many things need to be done to care for, teach, feed, and heal others that are difficult to monetize. If technologies replace people in some jobs and roles, what kinds of social support or safety nets will make it possible for them to contribute to the common good through other means? Think outside the job."

Bob Frankston, an Internet pioneer and technology innovator whose work helped allow people to have control of the networking (internet) within their homes, wrote, "We'll need to evolve the concept of a job as a means of wealth distribution as we did in response to the invention of the sewing machine displacing seamstressing as welfare."

Jim Hendler, an architect of the evolution of the World Wide Web and professor of computer science at Rensselaer Polytechnic Institute, wrote, "The notion of work as a necessity for life cannot be sustained if the great bulk of manufacturing and such moves to machines—but humans will adapt by finding new models of payment as they did in the industrial revolution (after much upheaval)."

Tim Bray, an active participant in the IETF and technology industry veteran, wrote, "It seems inevitable to me that the proportion of the population that needs to engage in traditional full-time employment, in order to keep us fed, supplied, healthy, and safe, will decrease. I hope this leads to a humane restructuring of the general social contract around employment."

Possibility #3: We will see a return to uniquely "human" forms of production

Another group of experts anticipates that pushback against expanding automation will lead to a revolution in small-scale, artisanal, and handmade modes of production.

Kevin Carson, a senior fellow at the Center for a Stateless Society and contributor to the P2P Foundation blog, wrote, "I believe the concept of 'jobs' and 'employment' will be far less meaningful, because the main direction of technological advance is toward cheap production tools (e.g., desktop information processing tools or open-source CNC garage machine tools) that undermine the material basis of the wage system. The real change will not be the stereotypical model of 'technological unemployment,' with robots displacing workers in the factories, but increased employment in small shops, increased project-based work on the construction industry model, and increased provisioning in the informal and household economies and production for gift, sharing, and barter."

Tony Siesfeld, director of the Monitor Institute, wrote, "I anticipate that there will be a backlash and we'll see a continued growth of artisanal products and small-scale [efforts], done myself or with a small group of others, that reject robotics and digital technology."

A network scientist for BBN Technologies wrote, "To some degree, this is already happening. In terms of the large-scale, mass-produced economy, the utility of low-skill human workers is rapidly diminishing, as many blue-collar jobs (e.g., in manufacturing) and white-collar jobs (e.g., processing insurance paperwork) can be handled much more cheaply by automated systems. And we can already see some hints of reaction to this trend in the current economy: entrepreneurially-minded unemployed and

underemployed people are taking advantages of sites like Etsy and TaskRabbit to market quintessentially human skills. And in response, there is increasing demand for 'artisanal' or 'hand-crafted' products that were made by a human. In the long run this trend will actually push toward the re-localization and re-humanization of the economy, with the 19th- and 20th-century economies of scale exploited where they make sense (cheap, identical, disposable goods), and human-oriented techniques (both older and newer) increasingly accounting for goods and services that are valuable, customized, or long-lasting."

Point of agreement: Technology is not destiny … we control the future we will inhabit

In the end, a number of these experts took pains to note that none of these potential outcomes—from the most utopian to most dystopian—are etched in stone. Although technological advancement often seems to take on a mind of its own, humans are in control of the political, social, and economic systems that will ultimately determine whether the coming wave of technological change has a positive or negative impact on jobs and employment.

Seth Finkelstein, a programmer, consultant and EFF Pioneer of the Electronic Frontier Award winner, responded, "The technodeterminist-negative view, that automation means jobs loss, end of story, versus the technodeterminist-positive view, that more and better jobs will result, both seem to me to make the error of confusing potential outcomes with inevitability. Thus, a technological advance *by itself* can either be positive or negative for jobs, depending on the social structure as a whole….this is not a technological consequence; rather it's a political choice."

Jason Pontin, editor in chief and publisher of the MIT Technology Review, responded, "There's no economic law that says the jobs eliminated by new technologies will inevitably be replaced by new jobs in new markets… All of this is manageable by states and economies: but it will require wrestling with ideologically fraught solutions, such as a guaranteed minimum income, and a broadening of our social sense of what is valuable work."

About this Report and Survey

BY AARON SMITH AND JANNA ANDERSON

This report is the latest in a sustained effort throughout 2014 by the Pew Research Center's Internet Project to mark the 25th anniversary of the creation of the World Wide Web by Sir Tim Berners-Lee (The Web at 25).

The report covers experts' views about advances in artificial intelligence (AI) and robotics, and their impact on jobs and employment. The previous reports in this series include:

- A February 2014 report from the Pew Research Center's Internet Project tied to the Web's anniversary looking at the strikingly fast adoption of the Internet and the generally positive attitudes users have about its role in their social environment.
- A March 2014 *Digital Life in 2025* report issued by the Internet Project in association with Elon University's Imagining the Internet Center focusing on the Internet's future more broadly. Some 1,867 experts and stakeholders responded to an open-ended question about the future of the Internet by 2025. One common opinion: the Internet would become such an ingrained part of the environment that it would be "like electricity"—less visible even as it becomes more important in people's daily lives.
- A May 2014 *Digital Life in 2025* report on the Internet of Things from Pew Research and Elon University examining the likely impacts of the Internet of Things and wearable and embedded networked devices. A majority of the more than 1,600 respondents said they expect significant expansion of the Internet of Things, including connected devices, appliances, vehicles, wearables, and sensor-laden aspects of the environment.
- A July 2014 report on Threats to the Open Internet from Pew Research and Elon University canvassing a number of experts and other stakeholders on what they see as the major threats to the free flow of information online. A majority of these experts expect the Internet to remain a place where people can freely access and share content, even as they anticipate a number of potential threats to this freedom in the coming years.

This report is a collaborative effort based on the input and analysis of the following individuals.

Aaron Smith, *Senior Researcher, Pew Research Center's Internet Project*
Prof. Janna Anderson, *Director, Elon University's Imagining the Internet Center*
Lee Rainie, *Director, Pew Research Center's Internet Project*

Find related reports about the future of the Internet at http://www.pewInternet.org/topics/future-of-the-Internet/.

About this canvassing of experts

The expert predictions reported here about the impact of the Internet over the next 10 years came in response to one of eight questions asked by the Pew Research Center Internet Project and Elon University's Imagining the Internet Center in an online canvassing conducted between November 25, 2013, and January 13, 2014. This is the sixth Internet study the two organizations have conducted together. For this project, we invited more than 12,000 experts and members of the interested public to share their opinions on the likely future of the Internet and 2,551 responded to at least one of the questions we asked. Nearly 1,900 responded to this open-ended question about the impact of artificial intelligence and robotic on the future of employment.

The Web-based instrument was fielded to three audiences. The first was a list of targeted experts identified and accumulated by Pew Research and Elon University during the five previous rounds of this study, as well as those identified across 12 years of studying the Internet realm during its formative years. The second wave of solicitation was targeted to prominent listservs of Internet analysts, including lists titled: Association of Internet Researchers, Internet Rights and Principles, Liberation Technology, American Political Science Association, Cybertelecom, and the Communication and Information Technologies section of the American Sociological Association. The third audience was the mailing list of the Pew Research Center Internet Project, which includes those who closely follow technology trends, data, and themselves are often builders of parts of the online world. While most people who responded live in North America, people from across the world were invited to participate.

Respondents gave their answers to the following prompts:

The economic impact of robotic advances and AI: Self-driving cars, intelligent digital agents that can act for you, and robots are advancing rapidly. Will networked, automated, artificial intelligence (AI) applications and robotic devices have displaced more jobs than they have created by 2025?

Please elaborate on your answer: Describe your expectation about the degree to which robots, digital agents, and AI tools will have disrupted white-collar and blue-collar jobs by 2025 and the social consequences that will emerge from that.

Bonus question: To what degree will AI and robotics be parts of the ordinary landscape of the general population by 2025? Describe which parts of life will change the most as these tools advance and which parts of life will remain relatively unchanged.

Since the data are based on a non-random sample, the results are not projectable to any population other than the individuals expressing their points of view in this sample. The respondents' remarks reflect their personal positions and are not the positions of their employers; the descriptions of their leadership roles help identify their background and the locus of their expertise. About 84% of respondents identified themselves as being based in North America; the others hail from all corners of the world. When asked about their "primary area of Internet interest," 19% identified themselves as research scientists; 9% said they were entrepreneurs or business leaders; 10% as authors, editors or journalists; 8% as technology developers or administrators; 8% as advocates or activist users; 7% said they were futurists or consultants; 2% as legislators, politicians or lawyers; 2% as pioneers or originators; and 33% specified their primary area of interest as "other."

About half of the expert respondents elected to remain anonymous. Because people's level of expertise is an important element of their participation in the conversation, anonymous respondents were given the opportunity to share a description of their Internet expertise or background.

Here are some of the key respondents in this report:

Rob Atkinson, president of the Information Technology and Innovation Foundation;**Fred Baker**, Cisco Systems Fellow; **danah boyd**, a social scientist

for Microsoft; **Stowe Boyd**, lead at GigaOM Research; **Bob Briscoe**, chief researcher for British Telecom;**Robert Cannon**, Internet law and policy expert; **Vint Cerf**, vice president and chief Internet evangelist at Google; **David Clark**, senior scientist at MIT's Computer Science and Artificial Intelligence Laboratory; **Glenn Edens**, research scientist at PARC and IETF area chair; **Jeremy Epstein**, a senior computer scientist at SRI International; **Bob Frankston, Internet** pioneer and technology innovator; **Jonathan Grudin**, principal researcher for Microsoft; **Joel Halpern** a distinguished engineer at Ericsson; **Jim Hendler**, Semantic Web scientist and professor at Rensselaer Polytechnic Institute**; Jeff Jarvis**, director of the Tow-Knight Center at the City University of New York; **Michael Kende**, professional economist; **Mike Liebhold**, distinguished fellow at the Institute for the Future; **Geoff Livingston**, author and president of Tenacity5 Media; **John Markoff**, senior writer for the Science section of the *New York Times***; Raymond Plzak**, former CEO of the American Registry for Internet Numbers, now a member of the board of ICANN; **Jason Pontin**, editor in chief and publisher of MIT Technology Review; **JP Rangaswami**, chief scientist for Salesforce.com; **Howard Rheingold**, pioneering Internet sociologist and self-employed writer, consultant, and educator; **Mike Roberts**, Internet Hall of Famer and longtime leader with ICANN; **Marc Rotenberg**, president of the Electronic Privacy Information Center; **Paul Saffo**, managing director of Discern Analytics and consulting associate professor at Stanford; **Henning Schulzrinne**, a member of the Internet Hall of Fame, IETF leader, and professor at Columbia University **Doc Searls**, director of ProjectVRM at Harvard's Berkman Center; **Hal Varian**, chief economist for Google; and**Amy Webb,** CEO of strategy firm Webbmedia Group.
Here is a selection of other institutions at which respondents work or have affiliations:

Yahoo; Intel; IBM; Hewlett-Packard; Nokia; Amazon; Netflix; Verizon; PayPal; BBN; Comcast; U.S. Congress; EFF; W3C; The Web Foundation; PIRG: NASA; Association of Internet Researchers; Bloomberg News; World Future Society; ACM; the Aspen Institute; Magid; GigaOm; the Markle Foundation; The Altimeter Group; FactCheck.org; key offices of U.S. and European Union governments; the Internet Engineering Task Force; the Internet Hall of Fame; ARIN; Nominet; Oxford Internet

Institute; Princeton, Yale, Brown, Georgetown, Carnegie-Mellon, Duke, Purdue, Florida State and Columbia universities; the universities of Pennsylvania, California-Berkeley, Southern California, North Carolina-Chapel Hill, Kentucky, Maryland, Kansas, Texas-Austin, Illinois-Urbana-Champaign, the Georgia Institute of Technology, and Boston College.

Complete sets of for-credit and anonymous responses to this question can be found here:

- http://www.elon.edu/e-web/imagining/surveys/2014_survey/2025_Internet_AI_Robotics.xhtml
- http://www.elon.edu/e-web/imagining/surveys/2014_survey/2025_Internet_AI_Robotics_credit.xhtml
- http://www.elon.edu/e-web/imagining/surveys/2014_survey/2025_Internet_AI_Robotics_anon.xhtml

Predictions for the State of AI and Robotics in 2025

BY AARON SMITH AND JANNA ANDERSON

The sizeable majority of experts surveyed for this report envision major advances in robotics and artificial intelligence in the coming decade. In addition to asking them for their predictions about the job market of the future, we also asked them to weigh in on the following question:

To what degree will AI and robotics be parts of the ordinary landscape of the general population by 2025? Describe which parts of life will change the most as these tools advance and which parts of life will remain relatively unchanged.

These are the themes that emerged from their answers to this question.

AI and robotics will be integrated into nearly every aspect of most people's daily lives

Many respondents see advances in AI and robotics pervading nearly every aspect of daily life by the year 2025—from distant manufacturing processes to the most mundane household activities.

Jeff Jarvis, director of the Tow-Knight Center for Entrepreneurial Journalism at the City University of New York, wrote, "Think 'Intel Inside'. By 2025, artificial intelligence will be built into the algorithmic architecture of countless functions of business and communication, increasing relevance, reducing noise, increasing efficiency, and reducing risk across everything from finding information to making transactions. If robot cars are not yet driving on their own, robotic and intelligent functions will be taking over more of the work of manufacturing and moving."

Vint Cerf, vice president and chief Internet evangelist for Google, responded, "Self-driving cars seem very likely by 2025. Natural language processing will lead to

conversational interactions with computer-based systems. Google search is likely to become a dialog rather than a client-server interaction. The Internet of Things will be well under way by this time and interaction with and among a wide range of appliances is predictable. Third party services to manage many of these devices will also be common."

Stowe Boyd, lead researcher for GigaOM Research, predicted, "Pizzas will not be delivered by teenagers hoping for a tip. Food will be raised by robotic vehicles, even in small plot urban farms that will become the norm, since so many people will have lost their jobs to 'bots. Your X-rays will be reviewed by a battery of Watson-grade AIs, and humans will only be pulled in when the machines disagree. Robotic sex partners will be a commonplace, although the source of scorn and division, the way that critics today bemoan selfies as an indicator of all that's wrong with the world."

K.G. Schneider, a university librarian, wrote, "By 2025 AI, robotics, and ubiquitous computing will have snuck into parts of our lives without us understanding to what extent it has happened (much as I just went on a camping trip with a smartphone, laptop, and tablet)."

Lillie Coney, a legislative director specializing in technology policy in the U.S. House of Representatives, replied, "It is not the large things that will make AI acceptable it will be the small things—portable devices that can aid a person or organization in accomplishing desired outcomes well. AI embedded into everyday technology that proves to save time, energy, and stress that will push consumer demand for it."

JP Rangaswami,chief scientist for Salesforce.com, wrote,"Traditional agriculture and manufacturing will both be affected quite heavily, with AI and robotics having greater roles to play at scale, while high-touch 'retro' boutiques will exist for both sectors. Service sector impact will continue to be lower in relative terms; knowledge/information worker sector impact, on the other hand, will be transformational."

Marc Prensky, director of the Global Future Education Foundation and Institute, wrote,"The penetration of AI and robotics will be close to 100% in many areas. It will be similar to the penetration of cell phones today: over two-thirds of the world now have and use them daily."

Nilofer Merchant, author of a book on new forms of advantage, wrote, "Let me put it this way: my son, who is 10, doesn't think he needs to learn to drive or do grocery

shopping because he says he'll just click something to arrive. All the fundamentals of life can and will be automated, from driving to grocery shopping. Chores effectively disappear in terms of time consumption."

A Syracuse University professor and associate dean for research wrote, "Robots and AI are moving beyond simple rules into framed judgment spaces. There will be several spectacular failures (to give voice to the dystopian seers) and so many subtle impacts. I see them in public transport, long-distance driving, traffic routing, and car-to-car interactions. I also see them moving into the built environment through post-market sensor networks reflecting energy monitoring, maintenance for household appliances, and supporting more distributed education. My expectation is that much of medicine will be in the midst of a transformation based on better sensors tied to more powerful analytics."

David Clark, a senior research scientist at MIT's Computer Science and Artificial Intelligence Laboratory, noted that AI is already a part of daily life for many users: "AI methods and techniques are already part of the ordinary landscape. The problem with the term 'AI' is that it is constantly redefined to describe things we don't yet know how to do well with computers. Things like speech recognition (like Siri), image recognition (face recognition in consumer cameras), and the like used to be hard AI problems. As they become practical commercial offerings, they spin off as their own disciplines."

However, some experts sounded a note of concern that the gains from these new advances risk being limited only to those with the financial resources to afford the latest technologies, which may reinforce economic inequality.

The CEO of a professional not-for-profit society responded, "We will have more and more robots and AI in our lives, although I fear the benefits will accrue to the top 1-2% who can afford the gadgets." And an information science professional and leader for a national association wrote, "In terms of day-to-day living, AI and robotics could easily be something that only the 1% can afford or have access to. In fields like medicine, though, advances have the potential to help everyone."

A journalist, editor, and leader of an online news organization wrote, "Typically, this will depend on socioeconomics. The rich will spend almost no time doing things that can be

automated; the poor will continue as is, more or less, although with superior communication abilities."

Bill Woodcock, executive director for the Packet Clearing House, responded, "The degree of integration of AI into daily life will depend very much, as it does now, on wealth. The people whose personal digital devices are day-trading for them, and doing the grocery shopping, and sending greeting cards on their behalf, are people who are living a different life than those who are worried about missing a day at one of their three jobs due to being sick, and losing the job, and being unable to feed their children."

These technologies will be integrated so completely as to be nearly invisible to most users most of the time

Depictions of robotics and artificial intelligence in popular culture often lean towards powerful anthropomorphic robots (Transformers, The Terminator) and hulking mainframes with human-like intelligence (HAL in 2001). But many of the experts who responded to this survey expect technology to evolve in the opposite direction, with machine intelligence being hidden deep in the complex workings of outwardly simple or even invisible devices and digital interactions.

John Markoff, senior writer for the Science section of the New York Times, likens this process to a kind of magic: "Over the next decade the ubiquitous computing era will come into full force. Computers will 'disappear' and ordinary objects will become magic. Significantly, Steve Jobs was the first one to really understand this. But the pace is relentless."

Nishant Shah, a visiting professor at The Centre for Digital Cultures at Leuphana University in Germany, wrote, "The primary function of care robots or companion AIs is to be invisible. They are already ubiquitous in the world that we live in, but largely they work under the surface, and below the networks. Advancements in nanotechnologies and wearable computing are going more in the direction of creating tools that we do not see."

David Organ, CEO of Dotsub, wrote, "The progressive availability of more and more robust AI systems, with deeper predictive power and broader contextual understanding will make them almost invisible. The people who are not specialists of the field will react to their advances being pointed out with a sense of natural acceptance

because the progressive arrival of better and better features and performance will have created a sense of familiarity. It will be natural to talk to computers of any shape, and expect them to understand the words, and the meaning, and to establish a dialog leading rapidly to the desired goal."

Elizabeth Albrycht, a senior lecturer in marketing and communications at the Paris School of Business, replied, "By 2025 we may well be witnessing the disappearance of AI and robotics *into* the ordinary landscape as they follow the usual path of technology. First we see it, then it becomes invisible as it integrates into the landscape itself."

The fact that the "invisible" technologies of the future may be doing jobs currently held by human beings was not lost on some respondents:

Jamais Cascio, a writer and futurist specializing in possible futures scenario outcomes, wrote, "By 2025, robots/AI (although likely not 'true' self-aware autonomous constructed intelligence) will start to become background noise in the day-to-day lives of people in the post-industrial world. From self-driving taxis to garbage collectors to autonomous service systems, machines will start to exist in our social space the way that low-paid (often immigrant) human workers do now: visible but ignorable. (To be clear: I'm not celebrating this, I'm just acknowledging it.) We'll know they're there, we'll interact with them in perfunctory ways, but they will less and less often be seen as noticeable."

Olivier Crepin-Leblond, managing director of Global Information Highway Ltd. in London, UK, offered similar thoughts when he predicted that, "…An enormous amount of automata will replace humans—from automated passport gates at border control, to onsite vending machines, automated floor cleaners, window cleaning machines, driving trains, cars etc. Our day-to-day life will remain the same, but those jobs performed in the past by what some call 'invisible people,' will be performed by 'invisible robots.' How many people remember the face of the ticket collector on their train? That's what I mean by 'invisible people.' Now the life of the people performing the work of 'invisible people' will be heavily affected as they'll be out of work. The life of others too: I rely on these 'invisible people' to bring a human face to the world and to my life—a hello, a smile, a thanks."

Driving, transportation, and logistics will experience dramatic changes

Many respondents predicted that self-driving cars will enter the ordinary landscape in a meaningful way within the next decade. **Howard Rheingold**, a pioneering Internet sociologist and self-employed writer, consultant, and educator, expressed his belief that this can only be for the best: "I, for one, welcome our self-driving automobile overlords. How could they possibly do a worse job than the selfish, drugged, drunk, and distracted humans who have turned our roads into bloodbaths for decades?" A self-employed programmer and Web developer offered similar thoughts: "We might wonder how we accepted so many car accidents in 2013 and wonder why we even bothered to perform the necessary but menial task of, say, parking."

Other respondents imagined a future with many more driverless cars, but many fewer truck drivers, delivery people, and taxi operators. **danah boyd**, a research scientist for Microsoft, responded, "There will be a lot more automation but much of it will be as invisible as it is now. So in that sense, yes, it will be part of the ordinary landscape. The biggest change will be to the movement of atoms—food, consumer goods, etc. The majority of the disruption will be at the blue-collar level, and I suspect that the biggest impact will be in warehouses (or 'fulfillment centers')."

Tom Standage, digital editor for The Economist, wrote, "Self-driving vehicles promise to upend existing approaches to car ownership, car design, car sales and insurance, urban planning, logistics, deliveries, taxi services, etc. That will be a big change, as significant as the advent of smartphones." And **Linda Rogers**, the founder of Music Island in Second Life and grant writer for Arts for Children and Youth in Toronto, concurred: "We already see it in grocery scanners, bank machines and can extrapolate from there as automated parking lots add robotic valet service, subway lines no longer require drivers, and garbage pickup services are robot-controlled."

Other respondents envisioned a wide range of impacts that might arise from the driverless car revolution—from the economic to the cultural.

Andrew Rens, chief council at the Shuttleworth Foundation, wrote, "AI and robotics will change the way that Western society thinks about cars. Once control over driving passes to software the romance of cars will diminish. There will be far less cachet in owning large and powerful cars since the riding (rather than driving) experience will be indistinguishable."

Robert Bell of IntelligentCommunity.org responded, “Technology will continue to make things better, faster, cheaper and safer: the impact of self-driving cars alone will be immense in terms of reduced traffic congestion, lower costs for insurance and transport, and driver safety.”

A professor at Aoyama Gakuin University in Tokyo, Japan, wrote, “Self-driving cars may change a lot. Car renting and sharing will be far easier and thus more popular, which will be a good thing. On the other hand, spending long hours in cars will be easier (because you can sleep or work or watch a movie while driving), which is not necessarily a good thing.”

Intelligent agents will increasingly manage our day-to-day lives and be omnipresent in our homes

As computer intelligence becomes increasingly integrated in daily life, a number of experts expect major changes in the way people manage their households and day-to-day lives.

Hal Varian, chief economist for Google, views the current wave of smartphone-enabled assistants as the tip of the iceberg: “We will rely on personal assistance from devices such as Google Now, Siri, Watson, etc. Much of the interaction will be verbal, so this will look a lot like the Star Trek computer interaction. We will expect computers that we meet to know us and our history of interaction with them. In general, they will infer what we want, and our role is simply to refine and verify that expectation. We will be well on our way to universal access to all human knowledge via the worldwide network of mobile devices and data centers. Day-to-day interaction with devices and data will be by voice. One industry that will be hugely affected is education: what should be people be taught when they can access all human knowledge all the time?”

A CEO for a company that builds intelligent machines wrote, “The creative class by 2025 will have a digital assistant in their work and personal lives who all but replaces what we think of today as administrative help. That entity (actually a collection of distributed software) will answer phones, schedule appointments (handling the logistics far more accurately than any human), manage the care and maintenance of that person’s living quarters and work environment, do the shopping and (where appropriate) be responsible for managing that person’s financial life.”

Frederic Litto, a professor emeritus at the University of Sao Paulo in Brazil, responded, "It will probably be in 'concierge'-type services—that is, everyone's device (be it smartphone, tablet, or Dick-Tracy-on-the-wrist devices) will have built-in applications to remind users of things to be done, and featuring unlimited lists of contacts, past and present, as well as the contents of global and local reference works, model decision-trees, and other handy information devices. Concierge-type services will give citizens greater autonomy in everyday activities, as well as in highly specialized professional activities (like on-the-wrist 'specialist systems' for medical diagnoses)."
A technology policy expert wrote, "Where I think the public will see it more is via mobile devices and home automation. I expect that new construction will include learning thermostats, embedded smoke detectors, smart appliances, automated door locks, etc., all run by apps."

A general manager for Microsoft replied, "Robotics and AI will have a broader role in daily life. We are already seeing trends in home automation and maintenance, for example, that if extrapolated to 2025 at the same development rate will create substantially different experiences in a future-modern home."

Large swathes of the service sector—both online and off—will be impacted

Many experts anticipate that advances in AI and robotics will produce dramatic changes in the service industry by 2025. **Glenn Edens**, a director of research in networking, security, and distributed systems within the Computer Science Laboratory at PARC, a Xerox Company, predicted, "It is likely most consumer services (banking, food, retail, etc.) will move to more and more self-service delivery via automated systems."
Joe Touch, director of the Information Sciences Institute's Postel Center at the University of Southern California, replied, "They will continue to replace certain simple tasks, including, I would expect, mail and package delivery, and will increasingly shift from warehouses to public shopping areas (e.g., restocking shelves, or avoiding the need for bulk shelf displays in stores altogether). Interfaces will increasingly involve speech recognition and vision, interacting with people on more 'human' terms."
An anonymous respondent wrote, "A large portion of service jobs may be taken over by AI—ticket clerks at movie theaters, bank tellers, automated clerks in most service

positions. Once we begin to program the software to manage intelligent response to human interaction we may find that simpler tasks may be taken over completely by AI."

Per Ola Kristensson, a lecturer in human-computer interaction at the University of St Andrews, UK, responded, "While automation will be less than perfect by 2025, we are likely to witness a trend in which routine white-collar jobs, such as routine legal work, accounting, and administration, will be replaced by AI tools."

Several experts predicted that most of our online and telephone interactions with customer service "personnel" in the future will be with intelligent algorithms. **Judith Donath**, a fellow at Harvard University's Berkman Center for Internet & Society, responded, "Conversations with intelligent-seeming agents will be far more common. It will be frequently difficult to tell (online at least) if you are speaking/chatting with a person or program—and people will have become accustomed to this and will have ceased to care in many cases. Dealing with a machine will often be more efficient, and many people will come to use the sort of shorthand commands—no greetings or niceties, imperative forms—that they use with AI agents with anyone in a subordinate position."

Thomas Haigh, an information technology historian and associate professor of information studies at the University of Wisconsin, observed, "AI will make it increasingly easy to interface with computer systems in flexible ways. Automated decision making has largely automated fairly complex business processes like credit card applications, and coupled with big data will continue to displace human judgment in routine transactions."

Mary Joyce, an Internet researcher and digital activism consultant, replied, "Customer service, which firms have been trying to automate and outsource to the frustration of customers, are likely to adopt interactive automated customer service agents more sophisticated than current voice-recognition systems."

Advances in AI and robotics will be a boon for the elderly, disabled, and sick

A number of experts surveyed predicted that caring for the sick, elderly, and physically challenged will be revolutionized by advances in robotics.

David Clark, a senior research scientist at MIT's Computer Science and Artificial Intelligence Laboratory, said, "I like to consider questions such as this by asking what

problem needs a solution. I believe that one reason the 'smart home' has not taken off so well is that the dumb house is good enough. I think commuting is a problem (so self-driving cars as well as telework will be popular). We will see robots in health care and care of the elderly. But these may not be humanoid robots, but devices designed to work in specialized spaces designed for them."

Jonathan Grudin, principal researcher for Microsoft, responded, "I expect more robotic assistance for the elderly and infirm, because the demands are manageable and the need is increasing."

Gary Kreps, professor of communication and director of the Center for Health and Risk Communication at George Mason University, wrote, "Smart interactive virtual human agents will be a common part of modern life, providing the public with access to relevant information and support wherever they are and whenever they need help. This will be particularly important in providing consumers with access to relevant health information and support for making important health promotion decisions and guiding self-care and care for loved ones at home. This will improve the quality of self- and other-care, as well as enhance adherence with health regimens in the future."

The head of the department of communication at a top U.S. university wrote, "The low-hanging fruit for AI and robotics are areas of labor that still involve high degrees of routine. Special areas of need in the developed world involve domestic assistance for aging populations and other vulnerable groups."

Daren C. Brabham, assistant professor at the Annenberg School for Communication & Journalism, University of Southern California, says these developments could help expand health coverage in hard-to-reach populations: "I see robotics/AI taking a stronger hold in medicine, both in medical research and testing and in doctor-patient interactions. On this latter point, basic telemedicine applications/robots will serve a significant portion of healthcare needs for rural and poor populations by 2025, with robot-doc-in-a-box pods dispersed throughout the country that can automatically take blood pressure, draw blood, and other simple diagnostic procedures."

The CEO of a software technology company and active participant in Internet standards development, responded, "Hopefully one of the areas where this will have most impact

is the medical field—this is an area where there are high costs, a shortage of highly skilled people and a growing demand for advanced and complex services."

Janet Kornblum, a self-employed media trainer and journalist, observed, "Robotics is already a part of our landscape. Medically, many of us will use intelligent devices that help us function, be they smart replacements for little reminders that tell us when to take our pills, etc. Will robots be caring for us? Maybe. I think medical robots will lead the way."

Larry Magid, a technology journalist and an Internet safety advocate, responded, "People won't have to drive cars unless they want to, and senior citizens and people with disabilities will be able to live more independently."

Minority viewpoint: expect these changes to be gradual and incremental

Although most of our respondents expect dramatic advances in AI and robotics in the coming decade, some expect that these changes will occur much more gradually.

Seth Finkelstein, a programmer, consultant, and EFF Pioneer of the Electronic Frontier Award winner responded, "We're still a very long way from 'AI' as generally seen in the movies, i.e. humanoid robots. A picture of a city street scene of 2013 doesn't look too different from 50 years ago. Well, there are all the people looking into handheld little rectangles, but still, for many years there were people walking along with small oblong boxes pressed to their ears. It's when you consider the difference between what they're carrying, the smartphone versus the transistor radio, that the magnitude of the change is located."

A program director focusing on ICT standards policy, Internet Governance and other issues wrote, "It will still be limited. Although we can already do some pretty cool stuff, there will still be plenty of kinks and bugs and vulnerabilities that need to be resolved before market confidence will be widespread."

The former chair of an IETF working group wrote, "Change will continue to be pretty gradual in the next 12 years. AI and robotics are making great strides but will not suddenly take over a lot of domestic / household functions. The areas that border on

factory automation are the candidates for change—perhaps low skill assembly and clothing fabrication jobs will be affected next."

A professor at a major U.S. business school responded, "Automated cars will not make it into use—this is way harder than anybody is letting on in public conversation. IBM's Watson was so specialized to one application that it will take enormous effort to reapply it to anything else. We will see advances in little things, like better phone trees, and smarter applications online, but nothing dramatic."
The principal architect at an enterprise computing firm wrote, "Partial solutions will dominate—parking aids, automatic mowers and the like. People underestimate the value and convenience of cheap labor."

An executive at an Internet top-level domain name operator replied, "Considering the percentage of the U.S. population that remains offline to this day, we shouldn't get ahead of ourselves in predicting some kind of *I, Robot*-type world within 10 years—which is less time than the commercial Internet has been available."

"Out of the box" responses

Along with the major themes highlighted above, several experts made thought-provoking predictions about the future of AI and robotics that did not fit cleanly into any of these major categories. Among the more interesting ideas proposed:

Warfare and police work will be increasingly mechanized

Several experts expressed concerns about increased mechanization of warfare, surveillance, and police work. **Marc Rotenberg**, president of the Electronic Privacy Information Center (EPIC), noted, "You will see early versions of RoboCop on city streets. Looking at the current evolution of surveillance drones we can anticipate that that they will have the ability to interpret sound and images. They will also sense chemical compositions to help identify explosive and other harmful elements. They will likely have both infrared detection as well as the ability to see through solid materials and detect heat signatures. They will certainly have facial recognition capabilities and be integrated with a national biometric center. An interesting question is whether they will also have non-lethal weapons, such as tasers. Several incidents of attacks on robots will be reported."

Jamais Cascio, a writer and futurist specializing in possible futures scenario outcomes, expressed similar concerns: "The big exception [to the increased use of AI and robotics] will be in the world of civic response and emergency drones, whether for police work, fire suppression, emergency responders, climate mitigation, and the like. These will be designed to be visible, imposing (especially if they're needed to assist civic authorities), and a little scary—imagine autonomous fire trucks."

Increased automation will spark a "machine free" movement

Andrew Rens, chief council at the Shuttleworth Foundation, wrote, "The rise of AI and robots will also likely change extreme sports and outdoor pursuits not by increased reliance on AI and robotics but by provoking a movement to purge extreme sports of them. Extreme sports and outdoor pursuits such as hunting are one area of life that encourages immersion in the natural world, self-reliance, and human excellence. As other areas of life become increasingly dominated by machines that are faster, more accurate, and more reliable than humans, outdoor pursuits and extreme sports will become increasingly valuable to a substantial minority as they seek to carve out space from a frenetically connected world. The perception of extreme sports and outdoor pursuits as a machine-free zone will provoke debate about the ethics of relying on machines. A significant minority of sportspeople will attempt complete human self-reliance, even refusing current technologies such as GPS except in emergencies."

The nature of memory and imagination will change

Tiffany Shlain, filmmaker, host of the AOL series *The Future Starts Here*, and founder of The Webby Awards, responded, "The parts of life that will change most will be our sense of memory and interactions with new ideas. We will have robotic aids to help us remember facts, memories and access to ideas that will give our minds amplified abilities. Everyone human on the planet who wants to be connected will definitely be connected by 2025. This intersection and recall of diverse ideas will have led to great innovation. What will not change—is our human desire for authentic connection and eye contact."

The world will contain more "magic"

A research scientist working at a major search engine company responded, "There will be more 'magic' in the world. I mean this in the sense that more actions will be taken for

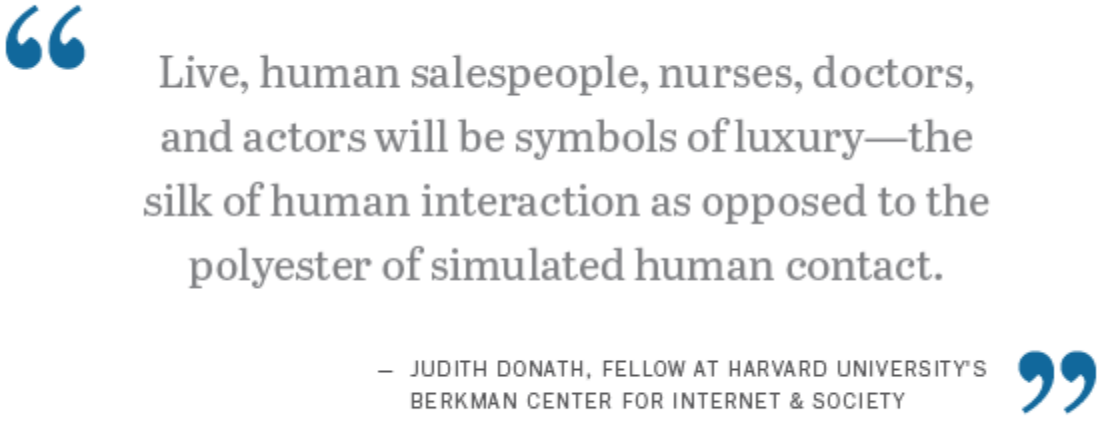
us, to us, by our systems that will not have explanations attached or perceivable reasons why they're being taken. Example: recommender systems will become everyday interactions multiple times per day. In many cases, even the software engineers have no idea, really, why a particular recommendation is being made. That's surprising, and magical. You decide if it's net good or not. Opinions will be split."

How will we interact with each other?

Vytautas Butrimas, the chief adviser to a major government's ministry, expects technological advances to increase the distance between people: "AI and robotics will change the way we interact with other members of society. The tendency will be toward more social isolation and fewer human-to-human contacts taking place. Just look at what is happening at our airport waiting lounges. People sit next to each other but the interaction is not taking place with the neighbor sitting nearby but with a device communicating to some other device. The world will be more bureaucratic and 'cold' in 2025 than it is today."

On the other hand, a self-employed writer, researcher, and consultant wrote, "I expect there will need to be a 'human please' option on most commercial and transport interfaces as there are always unpredictable elements. I also expect that consumers will demand tech-free places like restaurants where they can interact with each other."

As more daily activities are automated, human interaction may become a luxury



Judith Donath, a fellow at Harvard University's Berkman Center for Internet & Society, responded, "Even simple technologies have been doing this—most of what was a secretary's job has been replaced by answering machines and Word. Robots will be able to stock store shelves and check out and bag groceries and other store purchases. They'll do much of today's custodial work, delivery services, and transportation. Customer service will be almost entirely done with scripted agents. Software agents will work their way up from the crowd scenes in movies to smaller speaking roles, and eventually to fully automated 'live' films. Employment will be mostly very skilled labor—and even those will jobs will be continuously whittled away by increasingly sophisticated machines. Live, human salespeople, nurses, doctors, actors will be symbols of luxury, the silk of human interaction as opposed to the polyester of simulated human contact."

Andrew Bridges, a partner and Internet law litigator and policy analyst at Fenwick & West LLP, wrote, "'Brain work' will increasingly become a commodity as computing power enables more artificial intelligence. We already see Google Translate displacing translators, investment advice algorithms displacing investment advisors, automated landing systems replacing airplane piloting skills, and so forth. I expect that the world will become increasingly divided between 'standard' service and 'concierge' service in many aspects, with standard service left entirely to the machines and concierge service resting more upon human relationships."

On the political economy of self-driving cars

Doc Searls, director of ProjectVRM at Harvard University's Berkman Center for Internet & Society, wrote at length on what might need to happen for self-driving cars to reach wide-scale adoption:
"First, prototypes of self-driving cars are already here, thanks to Google and a few others. Driving, however, has been a human activity from the start, with century-old norms and a regulatory framework spanning global, national, interstate, state and local jurisdictions. Getting self-driving cars to work within all of that, and for regulations to adapt as well, seems a tall order that will require a lot of time and many trials and errors along the way. If it happens, 2025 is probably too early a date for seeing lots of self-driving cars, except perhaps in a few isolated geographies.

So far, the strongest arguments for self-driving cars are savings and safety. So let's say savings is covered, and the cost of owning a self-driving car is cheaper than owning a conventional one. On the safety side, according the June 2012 NHTSA Traffic Safety Facts report (pdf), 5,419,000 crashes in the U.S. killed 32,885 people and injured 2,239,000. That should make a good argument (especially around the number of crashes); but those numbers—fatalities especially—have been going down. And how much do people, or industry, actually care?

Consider that the third leading cause of death in the U.S., according to the Center for Disease Control (after heart attacks and cancer) is medical error. The Journal of Patient Safety puts the medical error fatality total in the U.S. at between 210,000 and 440,000 per year. Many studies suggest that a large percentage of those deaths could be prevented with better patient information, which today is scattered among many health care providers with incompatible systems that barely communicate with each other, much less doctors and patients. Yet reform, both within the health care industry and within legislative and regulatory systems, has ranged from difficult (e.g. the Affordable Care Act) to impossible—at least in the U.S.

Would the insurance industry, which basically runs health care in the U.S. (the vast majority of payments are B2B, not C2B), welcome self-driving cars? If so, that would help the cause. But insurance itself is a shell game, depending on a high degree of knowledge asymmetry to the advantage of insurance companies over other players, including car makers and owners. Insurance companies might prefer the game they

know over one that would put far more power in other hands, such as the government, car owners and the likes of Google. If that turns out to be the case, the car insurance industry might be as reluctant to reform driving as the health insurance industry has been to reform medical care, with far more cause."

Views from Those Who Expect AI and Robotics to Have a Positive or Neutral Impact on Jobs by 2025

BY AARON SMITH AND JANNA ANDERSON

Despite near-universal agreement that AI and robotics will make huge advances in the coming decade, the experts who participated in this survey are evenly split on the question of what impact those advances will have on human employment.

Some 52% expect these technologies to have a neutral to positive impact on jobs—that is, they *disagreed* with the statement that "networked, automated, artificial intelligence applications and robotic devices [will] have displaced more jobs than they have created by 2025." When asked to explain their reasoning for feeling this way, they offered a number of rationales.

Throughout history, technological advances have produced as many new jobs as they displace—there is no reason to think that this long-standing trend will change now

The largest number of these experts used the historical link between technological advancement and employment levels (or lack thereof) to make their case. **Celia Pearce**, an associate professor of digital media at the Georgia Institute of Technology, was one of many to take this approach, saying,"Although they certainly shift and disrupt the labor ecosystem, if you look at the total net effect, history does not bear out the myth that technology replaces people. First, people make technology, and since technology becomes obsolete at an increasingly accelerated pace, the need for people who make it will only grow; second, people are required to maintain technology—technology is

notoriously poor at taking care of itself; third, people are also required to assist other people in using technology; and fourth, most technology requires new labor forms."

Rob Atkinson, president of the Information Technology and Innovation Foundation, responded, "I don't think that automation is advancing any more rapidly than it has been. But in any case, automation has never led to fewer jobs in the economy in the past and never will in the future, for the simple reason that automation lowers prices which increases demand for goods and services, which in turn creates jobs."

A Cisco Systems principal engineer wrote, "While the nature of work will change, there will be plenty of work. We don't have many people making wagon wheels today, but we don't attribute that to overall unemployment."

A researcher for a major U.S. computer software and hardware company wrote, "This is a common misconception. If you read the economic literature, the evidence points to new technology creating new, different kinds of jobs. There is little to no correlation on unemployment and technological advancement."

A long-time leader of technology development for the World Wide Web responded, "Since the Industrial Revolution an argument has been posited that technology will displace humans in the job market. It has not happened. Advances in robotics and AI are likely to provide new opportunities for human workers that are not realized at this time."

Agustin Rossi, a PhD candidate at the European University Institute (EUI), Florence, Italy, wrote, "Disruption is not the same as displacement of aggregate jobs, as history since the Industrial revolution has shown us. It is safe to assume that technology will change how we produce goods and services, and that will probably mean that some people will lose their jobs in some sectors, but the economy will be able to create new jobs in different sectors that we cannot predict or imagine today."

Brad Templeton, a leader with the Electronic Frontier Foundation and Singularity University, responded, "They will displace many jobs but the rate of job creation will outpace this. Why is uncertain—it always has, in spite of regular predictions to the contrary."

John Wooten, founder and CEO of ConsultED, replied, "I don't believe it will achieve a higher displacement over creation ratio by 2025. Current trends related to

automation and business intelligence tools have surprisingly led to more job creation in the markets I have been involved with. For example, cloud computing has actually brought greater business necessity for hiring more IT persons, not less, as the implementation of 'cloud' affords IT personnel the ability to perform functions more critical to the organization as a whole."

Niels Ole Finnemann, a professor and director of Netlab, DigHumLab Denmark, wrote, "The idea that use of digital media will reduce labor seems to contradict all former experiences. The labor market will change, but new jobs will be produced in the very same process, maybe in other places."

Thomas Haigh, an information technology historian and associate professor of information studies at the University of Wisconsin, observed, "My position is basically historical. Over the past 200 years many technologies have boosted productivity by eliminating jobs; yet large-scale technological unemployment has never been a long-term reality. So it seems unlikely that new productivity technologies will destroy more jobs than they create. The economy will continue to shift towards personal services of a kind hard to automate."

Carlos Castillo, a scientist working at a national research lab in the Middle East, responded, "In the long term the net effect of disruptive technologies such as the mentioned ones has historically been more prosperity, not job losses."

An assistant professor at Radboud University Nijmegen in the Netherlands wrote, "Robots and computers have been around for quite some time. It has not displaced work. Workforces are just allocated in other sectors in the long run. In the short run it'll displace jobs, but not in the long run. Robots, computers, AI will enable us to do more and more complex work, not the same work with less effort."

Daren C. Brabham, assistant professor at the Annenberg School for Communication & Journalism, University of Southern California, wrote, "It is a long-standing sci-fi fantasy that someday our advances in automation/AI/robots will make human labor obsolete and allow us to live happier, healthier lives of leisure. That has never proven to be true—we work harder and longer in the U.S. now than we ever have, despite technological advances."

Bill St. Arnaud, a self-employed green Internet consultant, wrote, "Robots and autonomous cars have been predicted and overhyped since the 50s. There will be niche

applications but the decline in blue-collar manufacturing has been going on for decades because of productivity. Robots, AI, etc., are just an ongoing aspect of these productivity gains and do not represent anything special."

A professor at a university in Wales, responded, "I find this hypothesis a scaremongering one. Technological growth of this kind is not like the sudden automation of a factory, it is an organic change in the nature of our work-lives on a global scale. An advanced Western nation like ours has an unemployment rate not significantly different from that it had in 1850 or 1950, barring the recent economic crisis. There is no reason to think that AI will shift employment rates significantly by 2025, or by 2055."

Brian Butler, a professor at the University of Maryland, responded, "Most of the job losses are related to (a) shifting labor intensive work to parts of the world where labor is inexpensive (often enabled by communication and transportation technologies); and (b) relatively mundane automation (which is more reliable than AI). There is little evidence that large-scale shifts in employment are clearly attributable to AI/Robotics, despite fears of this occurring for the last 30-50 years. A key issue with this is risk management—how do we handle mistakes/errors/failures? The reality is that people are still better for this, if only because they can be held accountable/sued/fired/etc. That said, we probably will continue to see deskilling and reduced wages in many areas due to these technologies."

Jobs will shift, as the same forces that displace certain jobs create entirely new types of employment—some of which we can only imagine today

Another large group of experts predicted that, while advances in technology might shift or displace jobs, these losses will be more than made up for by new jobs designing, building, servicing, and utilizing the same technologies that are displacing other types of work.

Gary Kreps, professor of communication and director of the Center for Health and Risk Communication at George Mason University, wrote, "The use of AI systems will supplement human systems and not replace them. For example, in health promotion I foresee the use of automated AI health education programs that will be used to provide

additional channels for educating consumers about relevant health issues, but not replacing consultations with live health care providers. Additionally, there will be tremendous demand for experts to design, test, implement, and refine smart automated information systems, generating more jobs in the future."

Bob Ubell, vice dean for online learning at New York University, wrote, "The history of technological advances can go either way. In some economic transitions, technological innovation can spur economic growth, creating vast new industries, with large new worker populations; but in other periods, technological advances can have the opposite effect, causing older industries to shed millions of workers. It's far too soon to tell. In the meantime, for digital and other advanced technologies, the immediate effect of 'creative destruction' will more often be the loss of jobs. But, as history tells us, once initial destructive tendencies displace workers, some industries emerge with greater economic power beyond the overturned industry, creating large-scale new industries requiring an even larger labor force than the one displaced. But there is no guarantee that that will be the result in the industries identified."

Nishant Shah, visiting professor at Leuphana University in Germany, wrote, "The question presumes that the advent of technology will not create new kinds of jobs. So while traditional jobs might be performed by machines and automated technologies, there will always be more jobs and more kinds of jobs that are catalyzed by the emergence of such technologies. The number of jobs is not merely going to decrease or deplete because the machines take over."

Charlie Firestone, executive director of the Aspen Institute Communications and Society Program, responded, "Certainly there will be disruption with current jobs and more importantly, job functions. In the 2025 scenario, new jobs will be created by the robotic advances, and new functions will be created in the white-collar jobs of today. That is, there will still be a need for certain intermediaries but their functions will adapt to the needs of the new technologies and services."

A general manager at Microsoft replied, "It is clear that advances in automation will eliminate some jobs, but it will create others as well as free up some resources that could be applied to other pursuits. I do not foresee a situation where we will have successfully automated humans out of work. On the contrary, I see a situation where we have greater need for higher-skilled workers who are comfortable with using and creating technologies."

Joe Kochan, chief operating officer for U.S. Ignite, a company developing gigabit-ready digital experiences and applications, observed, "The design, programming, and creation of these devices and robots will still require, in 2025, more effort than they replace. These robots will, however, change the kind of work people do—robots will replace service and manufacturing jobs, but will open up more possibilities in tech and development."

A pioneering academic computer scientist from Princeton University wrote, "Jobs will be displaced, but the improvements in efficiency and quality of life will lead to the emergence of more and better jobs elsewhere in the economy. The new jobs will be diffuse and it will be difficult to attribute the role of robots in facilitating their creation, but on the whole they will exist and will outnumber the displaced jobs."

Luis Hestres, a doctoral candidate and graduate research assistant at American University's School of Communication, wrote, "The emergence and spread of robotic advances and AI will inevitably eliminate the need for many jobs. However, it will also create new jobs that must be filled; for example, jobs that involve designing, manufacturing, maintenance and repair, and disposal after these devices are no longer functional. These devices will also probably create ancillary markets, much like the iPhone created the apps and accessories markets. The catch is that these jobs will require both more and better education than the U.S. currently seems prepared to offer its citizens on an equal basis."

Jamie LaRue, a writer, speaker, consultant on library, technology, and public-sector issues, wrote, "The result of rapidly improving technology is not unemployment; it is a*shift* in employment. The lower level jobs will disappear. But new ones, designing and managing those systems, will grow exponentially."

Rajnesh Singh, regional director in the Asia-Pacific region for the Internet Society, wrote, "Society has always evolved, and will continue to do so. Yes, some jobs will be displaced, but yet others will be created, and out of this will come further opportunities."

A research fellow at the Global Cities Research Institute at RMIT University replied, "I tend to think technological 'disruption' is often overstated, and applied in too simplistic a fashion. There is considerable difference between the complete obsolescence of professions and associated ways of life under, for example, 18th century automation of the textile industry, and the various employment market adjustments that many

contemporary innovations bring about. Self-driving cars and robots in particular are potentially transformative innovations in sectors that are chronically under-resourced today in developed societies, such as aged-care, rehabilitation and disability services. Hence the introduction of these technologies, even if pervasive, is unlikely to elicit massive change in any one sector, but rather is likely to continue an ongoing evolution towards high-skilled, specialized and 'adaptive' forms of labor."

Estee Beck, a doctoral candidate at Bowling Green State University wrote, "In America, we have witnessed the shift from a largely manufacturer society to an increasingly software society, where capital and labor derives from the automations performed by computer algorithms. While we continue shifting from one source of revenue to another due to technological advancements, there will continue to be a need for people to oversee and work in the design, production, marketing, etc., of AI technologies."

A law professor at Georgetown University and former U.S. Federal Trade Commission official wrote, "There is value to having machines making decisions and taking actions now taken by humans. AI is the new tool that may free humans from certain labor burdens—driving in traffic; lifting heavy objects; doing difficult computational functions—in exchange giving humans more time for even more productive labor. Every substantial technological breakthrough has been accompanied by a short-term drop in labor demand, then followed, as new applications developed, by periods of robust economic and job growth."

Lillie Coney, a legislative director specializing in technology policy for a member of the U.S. House of Representatives, replied, "AI will be achievable because of advances in computing. However, it is still AI not human intelligence. There will be jobs to teach machines to perform their functions. People will work to perfect the technology to perform certain jobs, while determining the level of intelligence needed by each device. Creating something to perform mining that has the IQ of Einstein would be wasteful. Monitoring of technology to be sure that it is performing as intended will create opportunities."

There are many jobs that robots simply will never be able to do, no matter how advanced they become

A sizeable number of respondents noted that there are many attributes—such as empathy, creativity, judgment, or critical thinking—that are uniquely human, and that technology may never be able to duplicate. As such, jobs requiring these skills will remain relatively immune from encroachment by automation.

Celia Pearce responded,"I actually see us moving away from AI and towards more crowdsourcing approaches. These tend to work better because it's been proven when you throw a large number of human minds at a problem you can often get a better result than trying to get a computer to resolve it. Truth be told, computers are not very smart. All they are is giant calculators. They can do things that require logic, but logic is only one part of the human mind. Inspiration, creativity and intuition, meaning-making, storytelling and communication are all things that humans can do that computers will never be able to achieve fully."

The dean/provost of a research university and former CEO of the California Virtual University wrote, "Intelligent devices calculate better than human beings, but they are not creative and don't have judgment. They operate according to laws, and law has from the beginning needed human intervention to prevent it from behaving like an idiot."

An anonymous respondent wrote, "Anything involving creativity, the arts, or nontrivial conceptual synthesis will remain the domain of human thought for the time being—I've seen no indication that machines could produce an award-winning screenplay or a work of true scholarly genius."

Herb Lin, chief scientist for the Computer Science and Telecommunications Board at the National Research Council of the U.S. National Academies of Science, wrote, "Those areas in which human compassion is important will be less changed than those where compassion is less or not important."

A university professor and researcher wrote, "I imagine that anything that can be better accomplished through a decision structure will be accomplished through AI entities, but I also see a growing value of the work that can better be accomplished by people. Detecting complaints is an AI problem. Sending the complaints to the correct customer service entity is an AI problem. But customer service itself is a human problem."

The CEO of a professional not-for-profit society responded, “While I firmly believe we will have more AI and robots in our lives, none of those tech advances have judgment, and the human race and its enterprises will always value and need judgment.”

Fred Hapgood, a self-employed science and technology writer, responded, “Most of the people we interact with in real life are service people, and services are very hard to automate—especially the more expensive services. When you go to even a medium-quality restaurant in 2025, you will still be waited on by a human.”
Other respondents argued that our desire for human conversation and interaction will prevent many industries from going fully automated:

DIGITAL LIFE IN 2025

> Humans will always have the need for affective and embodied interactions with other humans, which can never be replaced by robots.
>
> — DEBORAH LUPTON, A RESEARCH PROFESSOR ON THE FACULTY AT THE UNIVERSITY OF CANBERRA, AUSTRALIA

Deborah Lupton, a research professor on the faculty at the University of Canberra, Australia, wrote, “These technologies will displace some jobs, but they will also create others. Humans will always have the need for affective and embodied interactions with other humans, which can never be replaced by robots. This will particularly be the case in the context of healthcare, education, childcare and the care of the elderly. The attempted introduction of too many robotic devices may well lead to a backlash, in which humans who can provide care and education will become valued.”
Valerie Bock, technical services lead for Q2 Learning, responded, “Robotic servants will likely be part of the domestic and industrial appliance landscape. But I think we’ll attempt, and then give up on, machines as caregivers. We aren’t going to find a replacement for the human touch any time soon.”

An anonymous respondent replied, “There are always going to need to be areas that need a human’s touch. Even with the advancement of AI, I doubt they will get to a point in the next 11 years that will eliminate [the need for] human empathy and sensibilities.”

An administrator for technology-focused units in educational nonprofits responded, “People will have opportunities to have access and, as important, time to engage more types of information/activities/resources as they are freed from doing (or thinking about) ‘physical and mental basics’ for themselves. Relatively unchanged areas of life may cluster around aspects of living and working involving human needs for social, educational, economic, and political interactions that occur optimally (functionally) in the physical presence of other people—for example, working with babies or the elderly, or working with hands-on/minds-on aspects of peoples’ healthcare or educational needs.”

Political and sociological factors will prevent widespread elimination of jobs

A smaller but notable group of respondents anticipate that cultural and sociological factors—including regulatory inertia, liability fears, and public resistance to widespread displacement of jobs by robots and AI—will prevent new technologies from taking too big of an employment bite.

William Schrader, the co-founder and CEO of PSINet Inc., the first commercial ISP, observed, “Let’s start by imagining self-driving vehicles eventually working flawlessly and inexpensively in 2025. In that case, you imagine why anyone would need taxi drivers in 2025? Or truck drivers? Or limo drivers? Or pilots? Or boat/ship captains? Whether you call these white- or blue-collar jobs, if self-driving vehicles become reliable then how could we still have these jobs? In fact, why would we drive to the grocery store to pick up fresh food? We can already place the order on the Internet, the store picks what we want and (in 2025) the automatic self-driving truck would make the delivery to our doorstep (in some fashion). *If* self-driving vehicles are working flawlessly, and they spread across the planet within the next 25 years, then people will eventually forget how to drive. It is a concept like “rolling down the window”, after these rolling machines were replaced with electric switches for the past twenty years. People will still need to go places, and they will say ‘I am going to drive over,’ but perhaps no

one will drive. But, the answer is no. By 2025, society will *not* allow free roving self-driving vehicles. It will take longer to have society embrace this change. And job loss will be one of the major contributing factors to the slow adoption."

Liam Pomfret, a PhD student in online consumer privacy at the University of Queensland, Australia, thinks that government regulation will delay the widespread implementation of technologies like driverless cars: "I do not see robotic devices having much impact outside of the manufacturing sector (where they're already firmly entrenched) by 2025. It's unlikely that AI will see much penetration into markets by 2025, if only because government regulation regarding self-driving cars, etc., will be as slow to catch up with the changing landscape there as it has been with regards to Internet issues."

A technology policy expert agrees, noting, "There will be a steady growth in this area, but it's hard for me to say what its impact will be outside of certain niche sectors of the economy. Sure, certain factories will become highly roboticized, and I do think we will see self-driving cars in the next 5 years, but how long for market penetration to a point that it becomes more than a niche? How long for regulations to change that will allow some of these developments to operate within current conditions? That, I think, is more than 13 years away."

An employee of the Network Information Center thinks that we are not prepared to live with the inevitable mistakes along the way: "Robotic advances and AI will obviously make tremendous headway by 2025, but there will be several highly visible screw-ups that result from these advances, which will generate widespread skepticism about how broadly AI can be used effectively. Note: these screw-ups will be the result of flawed decision-making logic that a reasonable human being would disagree with, which will create a significant backlash against an automated and programmed world."

A technology developer and administrator wrote, "Forgiveness of human mistakes will continue to be higher than that of AI, as AI mistakes will be seen as systemic since the same mistake will be present in all versions of the software. Therefore AI and robotic use in more advanced applications will continue to be stalled in favor of simple robotics such as is used in manufacturing. The cost of human labor in many times will be lower than the larger scale robotics that could displace it."

A program manager for an international nonprofit that promotes access to electronic resources in developing and transition countries replied, “No way, this is illusionary fear that comes with every technological innovation…it is naive to believe that businesses and organizations and people will have enough resources needed acquire most advanced tools. We can also expect some movement to stay ‘robot and AI free.’”

The technology won’t be advanced enough to widely displace jobs by 2025

A final group of experts simply feels that 10 years is not long enough for AI and robotics to become sufficiently advanced—or cost-effective—that they can replace huge portions of the workforce.

Chris Donley, director of advanced networks and applications for CableLabs, responded, “By 2025, no, I don’t think so. In this timeframe, I see robotics as primarily addressing convenience—allowing me to read a book while I commute to work, cleaning my house, or serving as a digital concierge. In this timeframe, robotics will primarily address things I would otherwise do myself, rather than pay other people to perform.”

Jane Vincent, a fellow at the Digital World Research Centre, responded, “These are aspirational aims that by 2025 will have had a major impact on some areas of work and society but will by no means be the norm. Perhaps the biggest change will be in automated management of public services reducing human interaction at the first line of enquiry.”

Uta Russmann, a professor of strategic communications based in Europe, responded, “Even though technological developments are developing faster each decade, it will take more than another 10 years until such a scenario will be reality. In 10 years the use of robots, digital agents, and AI tools will still be too expensive for everyday use and broad economic use.”

John Lazzaro, a research specialist and visiting lecturer in computer science at the University of California-Berkeley, wrote, “As an engineering community, we’ve been working on robotics and AI for a long time. The rationale behind today’s optimism is that with every process technology generation, Moore’s Law brings us closer to having enough computational resources to solve these problems well. The adult human brain has about 500 trillion synapses, but enough racks full of GPUs fabbed in the fully-scaled

5 nm CMOS process may be able to simulate the pattern recognition abilities of those synapses, at the right level of abstraction for solving engineering problems. This is the basic line of reasoning. I'm skeptical, because don't think we will have identified the full complement of ideas yet to write the algorithms that would run on the GPU cluster…Someday I believe we'll have those ideas. But 2025 feels too soon—it takes decades for fundamental ideas like quantum mechanics to be fully worked out by a research community, and so we would know it was coming by now if it were ready to deploy by 2025."

Stephan Adelson, president of a technology consulting company, predicted, "Robotic advances will displace jobs, but at a slow rate. 2025 is not very far off and the technology needed to create serious disruption in employment will take more time. Innovations such as self-driving cars will take a great deal more time than small innovations such as we see now."

Peter S. Vogel, Internet law expert at Gardere Wynne Sewell, LLP, replied, "I have been following artificial intelligence (AI) technology since 1971, and in spite of today's great innovations I am not optimistic that AI will displace all that many applications or robotic devices by 2025."

Views from Those Who Expect AI and Robotics to Displace More Jobs than They Create by 2025

BY AARON SMITH AND JANNA ANDERSON

On the other hand, 48% of our survey respondents *agree* with the statement that "networked, automated, artificial intelligence applications and robotic devices [will] have displaced more jobs than they have created by 2025." Their responses incorporate several major themes.

Advances in technology will absolutely reduce human jobs—this process is already underway, and the logic of our economy and technological advancement make it a sure thing to continue

Many of the experts in our survey who expect technology to be a net job destroyer also looked to the history of technology and employment in making their case. But in contrast to the group discussed above, these respondents see a much different story—one in which advances in automation have been taking jobs and putting downward pressure on wage growth for years.

Alex Halavais, associate professor of social and behavioral sciences at Arizona State University, predicted, "They have probably already replaced more jobs than they have created. The slow recovery in the U.S. is closely tied to our worker productivity, which is in turn related to our use of technology. We are only at the cusp of this, and I suspect it will be far more obvious and pronounced by 2025. I suspect that ATMs and self-checkout are just the starting points. The biggest shift will be fairly invisible in the

next 10 years, because they will be in manufacturing, particularly at small scale. Tesla's factory is new standard for relatively small-scale production. As some kinds of standardized service jobs become more easily addressed by scalable technology, they will go the way of phone operators and bank tellers. That is, they will not disappear entirely, but they will be radically reduced. Right now, things like food service, travel, and hospitality are being kept human for cultural rather than purely economic reasons, I suspect."

Larry Gell, founder and director of the International Agency for Economic Development (IAED), responded, "After 50+ years working for the heads of the world's biggest corporations all over the globe—watching them cut costs every place starting with the biggest cost: PEOPLE; moving labor to cheapest markets, then replacing them as fast as possible with robots and automation—why would it stop? It will accelerate. Anything and everything that can be automated to replace humans will be done. You can bet on it!"

Mary Joyce, an Internet researcher and digital activism consultant, replied, "To the extent that human workers can be replaced by robots and algorithms, they will be. There's no reason to believe that firms would behave in any other ways. And social forces, like unions, that would limit these actions, don't have the strength to prevent these changes."

Karl Fogel, a partner with Open Tech Strategies and president of QuestionCopyright.org, wrote, "The reason people are investing in machine agents is precisely that they will replace more (lower-paid) humans than the number of (more

highly-paid) humans needed to build and maintain the machines. But this is not a new phenomenon—it's been going on for more than a century. We're going to have to come to grips with a long-term employment crisis and the fact that—strictly from an economic point of view, not a moral point of view—there are more and more 'surplus humans.'"

John Wilbanks, chief commons officer for Sage Bionetworks, wrote, "There remain enormous market gaps where digital tools can replace people, from parking lot attendants to call centers to checkout lanes in retail. Those jobs will go and won't come back."

A distinguished engineer working in networking for Dell wrote, "It's a given that computers will get more powerful and be able to perform more and more intelligent tasks. This is going to create more unemployment and I'm not sure how all this gets resolved."

Dean Thrasher, founder of Infovark, Inc., wrote, "More and more fields seem ripe for automation, but it's hard to think of areas of our economy that are suffering from lack of staff—possibly teaching or healthcare? Yet we are applying more robotics and AI in these fields as well. I think technology's negative impact on employment is likely to grow worse in the near future, rather than better. It's easier to think of the few areas that will be resistant to robotics: sports leagues, symphony orchestras, craft brewing, ballet, and fine art. If the human touch is not essential to the task, it's fair to assume that it could be automated away."

Bernard Glassman wrote, "I'm honestly trying to think about the last time I heard anyone of any importance argue with a straight face that we should adopt a new technology because it will create jobs. At best, new robotics technologies move people into the service sector, at least until the service itself can be automated. Take 3-D printing—can we honestly believe that it will generate more high-level jobs than it kills?"

Lyman Chapin, co-founder and principal of Interisle Consulting Group, wrote, "Anything that can be automated will be, and to a greater or lesser extent depending on circumstances businesses will be reluctant to hire people to perform tasks that can be performed by robots, digital agents, or AI applications."

Dave Kissoondoyal, CEO for KMP Global Ltd. and Internet consultant active in Internet governance activities, wrote, "We have already witnessed the effects of mechanization and automation on the labor force. Similarly—networked, automated,

artificial intelligence (AI) applications and robotic devices will have displaced more jobs than they have created by 2025. The effects this time will be for both white and blue-collar jobs."

Mark Johnson, CTO and vice president for architecture at MCNC wrote, "The trend towards automation of every job seems inexorable. This probably has a disproportionate effect on older workers of all kinds who are less agile in their ability to move about in the economy than younger workers."

Serge Marelli, a past member of IEEE and ACM, wrote, "Automated cars can cheaply replace public transportation drivers, and automated cleaners and caregivers might very well replace human-help and caretakers for the sick and elderly. While this may seem in the short term more economic, it will be a fatal blow to the last local jobs for those with less skills (formal education)."

These advances are different from what has come before them—the changes are more rapid, and are going to impact people and professions that have thus far been insulated from automation

Many respondents worry that the current wave of technological change is going to impact previously insulated professions, and will happen so quickly as to prevent people from adjusting to new career paths.

Jeremy Epstein, a senior computer scientist at SRI International, responded, "The net number of jobs displaced will be fairly small, but they will be disproportionately blue-collar and pink-collar jobs going away and new white-collar jobs created. Just as travel agents (a pink collar job) have been largely replaced by Kayak and the like, many other service jobs like taxi drivers will largely disappear. There are no elevator operators left in the Western world (I've seen them still in India, though), why would anyone need a human to pilot a car to a location? Having a human driver may be seen as a status symbol for the wealthy, but even they will see the value in not having to worry about their driver's sobriety or willingness to share overheard secrets. Blue-collar jobs like construction will still exist, because the costs of automation are too high. However, even they will be reduced as there's more factory-built housing, which allows for cost effective use of robots in the construction process. It's hard for me to guess how things like garbage collecting will be affected—use of equipment has reduced the number of people

involved, and self-driving vehicles could reduce it further, but given the low wages it might not be worth eliminating people altogether."

Joel Halpern, a distinguished engineer at Ericsson, wrote, "While the advent of automated assistive technology will enable many new jobs, it will likely render irrelevant many current jobs. I expect that in the same time frame other technologies will likely create many opportunities, but in terms of the direct job destruction, creation, and disruption from automated operational technologies such as implied by the question will likely be negative in terms of numbers of jobs. While the effect will be felt more on the 'blue-collar' level, it will likely also occur at the 'white-collar' level as well."

An attorney at a major law firm responded, "The field within which I work currently employs many thousands to review documents. They are already being replaced by predictive coding algorithms. By 2025, those jobs will not exist for any but the most opaque documents and thus there will be many thousands of lawyers out of work. I find it difficult to imagine any industry which is more knowledge and thought intensive than law and we are already being replaced by machines. I suspect this will disrupt most industries."

David Allen, an academic and advocate engaged with the development of global Internet governance, replied, "The underlying, fundamental determinant is rate of change, between invention and the workforce. The last century plus has seen the most phenomenal acceleration in the rate of change for innovation. The rate seems likely to continue high. On the other hand, people change and adapt to these changes in the real world only with difficulty. If this is correct, then the rate of change in invention will continue to overwhelm the ability of people—in this case the workforce—to adjust to that change."

The CEO of a company that makes intelligent machines to make you smarter about your money wrote, "Most information work isn't all that complicated. Rarely, in fact, does it require the kind of creative manipulation of symbols that usually counts for human intelligence. Where such tasks can be automated, they will be with an appropriate reduction in the human effort required. We're just seeing the first fruits of this automation today, in fields like banking, where traditional retail banking services have been reduced to a couple of clicks in a mobile application—who needs a branch teller when you can have that teller in your pocket? This goes double for truly mundane tasks

like securities trading, where algorithms running in server farms located in the same co-lo as the exchanges execute 50% of a day's trades on many markets. Where the money goes, so goes the society. I expect the service industries will survive for another 50 years or so past 2025, but then they will be ripe for automation as well, once we can build computers that can process natural human language more accurately, and robots that can simulate human behavior more closely."

A university professor from the United States wrote, "The impact of AIs and robotics is often, I think, overstated, but automation of vehicles and improvements in robotics in warehousing operations should lead to a steady loss of employment in all areas of logistics, with the impact felt initially in warehouse operations and then moving into delivery of goods/materials. If Amazon is already seriously contemplating delivery-by-drone, I cannot believe they are not also planning on automating warehouse operations to a greater extent than they already have."

Mike Osswald, vice president for experience innovation at Hanson Inc., wrote, "Many jobs—truck drivers, customer support, light assembly, bank tellers and store checkout staff—will be diminished for businesses who can afford the upfront implementation costs. People will be displaced, businesses will slowly transition their older workforce to different jobs and not hire younger people or veterans. Businesses who let go of many people when adding robots will face backlash from citizens, but only for a time."

Tom Folkes, an Internet professional, replied, "We will shortly be able to replace low level information workers—these being teachers, lawyers and librarians. In the not distant future, taxi, bus, and truck drivers. Delivery and food workers will be replaced by 3D printing. The number of people required to develop these systems will be relatively small."

As the split between highly skilled workers and others continues to grow, current problems with inequality are going to get even worse

A number of these experts offered thoughts on how advances in AI and robotics may lead to increased income inequality and contribute to the ongoing hollowing-out of the middle class.

Bob Briscoe, chief researcher in networking and infrastructure for British Telecom, replied, "Robotics is more likely to have displaced blue-collar jobs, deepening the divide between the haves and the have-nots, and protecting the 'haves' from withdrawal of labor and similar industrial action. Rather than increasing leisure time, the 'haves' will use the freed-up time to achieve more, because maintaining the previous level of achievement would be rewarded less (relative to a living wage). The greater intensity of economic activity will maintain employment for blue-collar workers, but with similar levels of unemployment as today."

Robert Cannon, Internet law and policy expert, wrote, "During the Industrial Revolution, although Adam Smith will disagree, our economy has been based primarily on labor. The Industrial Revolution displaced labor from agriculture to the city—but the labor existed. Where there was work to be done, humans were the best "machines" to do the labor. The humans would be paid for their labor; the humans would then pay for goods produced by other people's labor. As production became more efficient, labor continued but moved into non-essential vocations (where essential is food and shelter). In the future, that foundation of our economy—labor—will be gone. Humans will not be the best "machines" to get work done. What will be left? Capital (ownership) and creativity (human contribution), and perhaps competition (sports, other competitions of humans as we are keen on the realization of the best among us). This will be a massive displacement of the middle class. There will be an ownership class and there will be a poor class that works at a rate below what would economically justify bringing in automation."

S. Craig Watkins, a professor and author based at the University of Texas-Austin, replied, "This is already happening and while the rise of intelligent machines will contribute to the loss of jobs it will also create new jobs—managing, designing, building, and managing the new systems that will emerge. The challenge is will those new jobs require high skills that only a select portion of the population will be able to acquire? In general, the jobs loss will not likely be matched by the jobs created, thus creating a net loss of jobs overall."

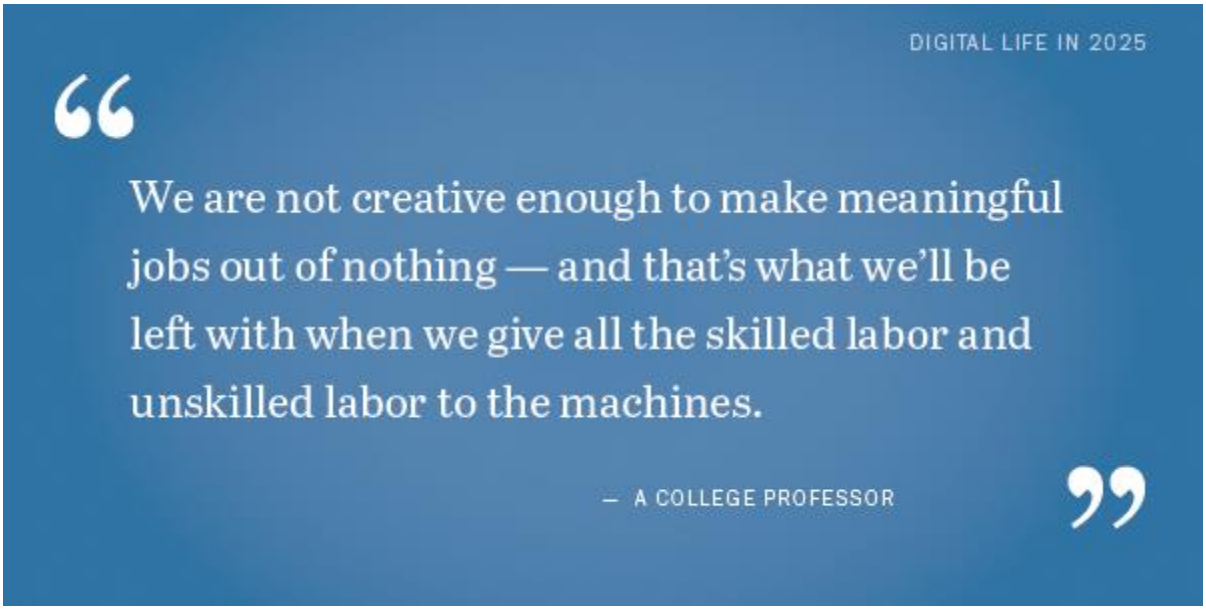
Henning Schulzrinne, an Internet Hall of Famer and technology developer and professor at Columbia University observed, "Many routine information aggregation and information routing jobs (e.g., in sales, customer support, health care and legal support) will be endangered, as well as some janitorial tasks. I don't see self-driving cars

displacing livery or truck drivers, as they are more likely to be used for parts of driving (e.g., on interstates) or to support drivers. You still need to unload delivery trucks, for example. However, in some cases, jobs won't be replaced, but rather be down-skilled or bifurcated into a small number of high-skill, high-pay and a much larger number of low-skill, low-pay positions."

John Anderson, director of broadcast journalism at Brooklyn College, wrote, "It's the same pattern we saw in manufacturing: the de-skilling of some forms of work due to improvements in technology. The social consequences are also the same: displacement, increased insecurity, growing inequality."

A professor of communication at the University of Southern California and well-known researcher of Internet uses and users replied, "I worry that these technological developments will further erode opportunities for working class labor in the United States and around the world, further destabilizing the employment situation for many people and further exaggerating the divide between have and have not. I don't think smashing the machines has ever worked as a response to such developments, but this points all the more urgently to the needs of governments and citizens to more directly address inequalities in economic opportunity."

A private law firm partner specializing in telecommunications and Internet regulatory issues wrote, "The ability of robots and AI to take on many basic tasks and jobs will relentlessly increase. That means that our total output/production may well increase even as the number of people required to generate that production goes down. That will create vexing problems of distribution of wealth/income, as the folks who own the robots etc. will claim entitlement to all or nearly all the production—yet the ability of people to buy that production will be in the aggregate declining. Over time (again, decades, not 11 years) I suspect that there will be a move towards, and an increase in the value of, unique personal-service type jobs. But that will simply highlight the conflict between different groups."



A college professor wrote, "This has already begun happening. If we're lucky, we'll all be put on middle-class welfare to keep people from becoming destitute and desperate. We are not creative enough to make meaningful jobs out of nothing—and that's what we'll be left with when we give all the skilled labor and unskilled labor to the machines."

An Internet engineer and machine intelligence researcher responded, "With the erosion of manufacturing and manual labor jobs, the underpinning economies of the lower and middle classes have been and will continue to be undermined. Wealth will continue to migrate towards the select few who have control over information resources. The control of information will be markedly enhanced by advances in machine intelligence."

Mikey O'Connor, one of two elected representatives to ICANN's GNSO Council, representing the ISP and connectivity provider constituency, wrote, "There will always be a LOT of jobs that are more cheaply performed by extremely low-wage humans than technology. Life at the grinding bottom of the income ladder will be largely unchanged, with any hope of improvement coming from other sectors and technologies. Life in the middle will be changed dramatically. A decreasing few will graduate into wealth and comfort, while most will slip towards the bottom. The middle will continue to become a smaller proportion of the population. Robotic and AI technology, once hoped to mitigate this trend, again disappoints. Professionals are coming under increasing pressure and have joined the middle class on the knife-edge between jumping up or sliding down. Their lives will become ever more stressful as they fight to maintain their position. Life

at the top will not change much, although it will be more luxurious (if that's possible to imagine)."

Oscar Gandy, an emeritus professor at the Annenberg School, University of Pennsylvania, wrote, "If 'displaced' means or includes 'replaced with lower paying jobs', there is no question in my mind about that: this is a process already clearly visible. While not the only determinant, the hollowing out of the middle class that we are seeing is due in no small part to the replacement of mental/creative/analytical workers with software/systems. This can only increase."

A retired software engineer and IETF participant responded, "To the extent that our culture focuses on monetary value, and to the extent that labor cost has become the primary dimension in which Western corporations are able to optimize, the only way that automation will be permitted to create more jobs than it destroys will be if those new jobs are at *substantially* lower wages than the existing ones."

Stuart Umpleby, a systems theory expert and professor at George Washington University, sees these advances leading to a new type of digital divide: "It is very easy to make a digital device that will make a routine decision. This frees up time to do other things. However, it also makes life more complicated, because one then needs to monitor and control one's digital agents. It also requires a different type of thinking. For example, instead of going to the store to buy food, one needs to learn how to sign on to a website, order food, monitor delivery and payment. One lives increasingly in an informational environment rather than a physical environment. A virtual environment is more easily monitored by businesses and simulated by scam artists. People must learn how to identify scams, which most likely will become more sophisticated. The gap between those who live primarily in a virtual world and those who live primarily in a physical world will grow."

We run the risk of creating a "permanent underclass"

A notable number of respondents expressed concern that we will see the emergence of a large class of people who have lost their jobs to automation, and who have little hope of gaining the skills needed to obtain meaningful employment in the future.

Bill Woodcock, executive director for the Packet Clearing House, responded, "We're seeing AI and expert systems beginning to replace or augment customer-service jobs now, and that trend will continue. I believe that's a good thing, as they're replacing

jobs starting with the most tedious, leaving the ones that require the most critical thinking and ingenuity for humans. As always, people will find ways to occupy themselves, and I believe AI are not a problem here. Far more troublesome is the trend toward greater social divide, that leaves a larger portion of the world's population in poverty and unable to garner any advantage from self-driving cars or robot vacuum cleaners, because they simply can't afford cars or vacuum cleaners of any sort, nor services that come with customer service, whether AI or human. Implicit in this question is an assumption about a middle class that still makes up the bulk of the population of Western nations, and to which many developing countries aspire, but which is, in reality, facing a decline if current trends continue."

A technology writer observed, "Look at yard maintenance, which employs hundreds of thousands. As soon as there's a safe, cost-effective, lawn-mowing robot, that robot will take over all the lawn mowing jobs there are. Artificial intelligence that will be able to answer questions over the telephone will displace the average call center employee for most calls. Those with only minimal education will be forced even more to the margins of society. Likely there will have to be a new social safety net for those that are simply unable to earn more than a poverty wage."

Mark Johns, a professor of media studies at a liberal arts college in the U.S., said, "Many manufacturing and service jobs will be eliminated by intelligent agents in the next decade. Social problems associated with a growing "underclass" will increase...The middle class will continue to shrink, and there will be a greater gap between the educated and tech-savvy 'haves' and the uneducated 'have-nots'."

The research director at a technology trade association responded, "More people will be forced out of growing sectors of the workforce, with downward mobility, unemployment and underemployment resulting. Growing alienation and fear of the future will mark the lives of some members of the baby boomer population. Traditional jobs across the board, from entry-level service jobs through higher-skilled production and intellectually-challenging jobs, will be reduced in number."

Jamais Cascio, a writer and futurist specializing in possible futures scenario outcomes, sees this new underclass having a gender component when he writes, "Unlike the numerically-controlled factory robots of the 1970s, today's general purpose machines are designed to be easily-adapted to new job requirements. It won't just be

dropping a robot into the human's seat…The self-checkout system at many grocery stores is a perfect example of what I mean: we didn't just build a robot checker, we made machines that split the checkout task with the customer. Digital travel websites replacing travel agents is another example. We're already seeing some grey-collar and specialized white-collar jobs being absorbed by machines, from legal assistants to surgeons. I expect that to continue, even accelerate. The biggest exception will be jobs that depend upon empathy as a core capacity—schoolteacher, personal service worker, nurse. These jobs are often those traditionally performed by women. One of the bigger social questions of the mid-late 2020s will be the role of men in this world."

Dan Coates of YPulse responded, "A great thinker in this space is Tyler Cowen who in his book *Average is Over* outlines a dual track economic reality wherein those who leverage automation enjoy an escalating standard of living, while those displaced by automation descend into a dramatically reduced standard of living."

A doctoral student in information science at the Universidade Estadual Paulista, in Sao Paolo, Brazil, wrote, "Robots and automatization will only release qualified personnel from heavy duties. But big masses of unqualified people will still be available, but now, competing with machines. Wages will reduce as well as labor protection in advanced countries. In undeveloped countries the situation will remain the similar as today. Big masses of poor people will suffer starvation and pandemias in developing countries."

Frank Pasquale, a law professor at a state university, wrote, "The key here is not that there is some predetermined path tech will take. Rather, current levels of inequality will be reinforced by robotization as more of these computers are used both to a) do present human-performed jobs better and b) suppress dissent or political action designed to better distribute the gains from technological advance. Think about Occupy Wall Street being dispersed on its first day by land-based robotic policemen and aerial LRADs. They will make the lives of the top 5% or so a virtual paradise, and will surveill and discipline the bottom 95% to keep them in line."

A principal engineer for Cisco wrote, "Robotics will add a new twist to the global redistribution of manufacturing; if a robot can operate as cheaply in Detroit as in Shenzhen, why pay to ship materials and finished goods around the world? The social consequences will be driven by chronic underemployment and how we choose to manage it economically. Traditional unemployment schemes will not suffice. Some kind

of negative income tax based system may be needed to ensure that everyone has enough to live on. Nevertheless a huge social and economic gulf will open up between those who work (even occasionally), and those who never work, and this will have dramatic political consequences."

If we aren't careful, increased income inequality and mass unemployment may lead to social unrest

Taken to their logical extreme, these trends—increased unemployment, widespread inequality, the emergence of a permanent poverty class—caused a number of experts to predict riots and other types of social instability in the relatively near future.

Vytautas Butrimas, the chief adviser to a major government's ministry, responded, "Robotics and the assembly line have been with us for a long time. The jobs are still there but they now require more specialized training and skills. It seems there is a decline in general education while the elites continue to become more educated and more likely to get the high level jobs. The divide between the educated and less educated is growing wider. By 2025 we will have experienced our first major social unrest from this." The director of innovation a multi-country company aiming to tap into the gigabit Internet wrote, "I am participating in several international projects to develop agents and to bring about factories of the future (including hybrid factories with a mix of robots and blue-collar workers). I'm also participating in two international projects with major cities as partners, looking at ways of introducing enabling technologies such as the Internet of things. And I live in a city that has been chosen as a test site for replacement of some bus routes by AI-based vehicles. All of this leads me to set the job-displacement date earlier, 2020. And between 2020 and 2025 I expect a lot of social unrest, because insufficient attention is being paid to the needs of people displaced by technology. This will lead to a Winner Take All society, in which such workers can earn 10 or 20 times their current salary. Many of those citizens currently pay for part-time or full-time cleaners, gardeners, handy-people. Most of those local jobs will go (to judge from the people I know who already have robot cleaners and robot mowers). Very, very sad for the people affected."

A technology risk and cybersecurity expert for a U.S.-based financial services association responded, "We have already observed how automation reduces employment, creates

gaps in skills needed to be valued workers in multiple industries including the automotive industry. While it may be more efficient, leads to global trade, and moves complex supply chains, it also creates new challenges and problems for individuals and society. One of these challenges/problems is the gap in the skills and training that is necessary for workers to be valued. Another is increasing income inequality between those that have the valued skills and employed and those who do not and are unemployed or underemployed. Unless industry and government steps in to provide the necessary training, this could lead to greater political unrest."

A browser engineer at Mozilla wrote, "Current trends indicate that the economy in its current form is ill-suited to support large numbers of low- and un-skilled workers. As more jobs become replaceable, I predict large societal upheavals as the gap between highly skilled (and highly paid) workers and a high proportion of partially, or totally, unemployed people continues to widen."

A software engineer who works for a major U.S. technology company said, "I expect AI developments to take people by surprise by 2025. AI was oversold for so long and had so little success that people have forgotten about it. But I expect AI to be able to pass adult reading comprehension tests by 2020. There are large areas of the economy that will be affected by this and the skills needed to manage the AIs will be highly specialized and out of the reach of 95% of people. This will be very socially divisive. As power shifts from labor to capital, inequality will increase and social stability will decrease."

Areas Where Both Groups Agree

BY AARON SMITH AND JANNA ANDERSON

Even as they disagree on the ultimate impact for jobs, there are several points on which these groups concur. Some of their predictions are rooted in extreme pessimism about our ability to adapt to the coming wave of technological change, but others offer a more hopeful outlook.

Our public institutions—especially our educational system—are not adequately prepared for the coming wave of technological change

One major area of agreement between both groups is that we are not adequately preparing our workforce for the technological changes that are on the horizon.

Robert Cannon, Internet law and policy expert, wrote, "Aggravating this is an educational system designed to meet the needs of Henry Ford and a compartmentalized work force. Henry Ford's assembly line included workers, and lawyers, and accountants, and sales people, and managers. And each discipline was compartmentalized. And education involved rote learning of fundamentals that had to be memorized and mastered. In a future era where all knowledge is available on a smart device in your pocket and where Watson-type tech can analyze that knowledge for you what is the point of the Henry Ford Education? We are teaching our kids for yesterday's workforce—and we punish kids who dare to out-maneuver teachers teaching skills from two decades ago. Our educational system is deeply broken and will reach a pressure point as it continues to produce an educated work force unable to get jobs."

Barbara Simons, a highly decorated retired IBM computer scientist, former president of the ACM, and current board chair for Verified Voting, responded, "We are already seeing job displacement, especially in manufacturing. Increasingly unskilled or low-skilled jobs will be automated. That is why it is so important for the country to invest in education at a far, far greater level than we are now doing. Otherwise, we will

create a permanent underclass with low educational skills, something that is already happening, given the inequities of public education funding."

Russell Bailey, the director of the library at Providence College, wrote, "The propensity for narrow job-training instead of broader career-training will restrict and limit employability for many, until or unless they accept longer-range, broader career-training as the default path to ongoing employability."

Ed Lyell, a college professor of business and economics and early Internet policy consultant dating back to ARPANET, observed, "The diminishing literacy skills, especially math and science, of our young people leave them less able to contribute to a new world based on needing those skills. The increasing 'smarts' of AI and robotics will continue to displace low level worker skills, except for those that are place bound."

Paul Saffo, managing director of Discern Analytics and consulting associate professor at Stanford, wrote, "The largest impact of these systems is not on the jobs eliminated, but the jobs never created to begin with because they were born digital. Worry less about losing your current job and more about the job you will never be offered in the future because it was designed to be done by a 'bot from the very start."

A senior administrator at the University of Maryland-Baltimore replied, While there may indeed be a disruption, more different jobs will be created. The challenge will be that our education system may not keep pace hence we will have a group of perhaps blue-collar workers who will not have the education and expertise to work in these new jobs. We need to disrupt our educational system."

Still others view the challenges of our educational system as part of a larger failure of our political and economic discourse. A senior policy adviser for a major U.S. Internet service provider replied, "Virtually all customer service work involving telephonic and online contact with human beings will be rendered unnecessary by better communications and computing services and by AI. Vast amounts of manufacturing, maintenance, and other lower-skill jobs will give way to robots. The nation will have failed to make the necessary changes in either its education system or its commitment to promote economic and social equality, so the impacts on those with lesser skills, training, and motivation will be dramatic, with some socially disruptive results."

A top digital media strategist at a U.S. national public news organization responded, "Our continuing failure to re-train underskilled workers will continue to create a glut of

un- and under-employed as advances in AI and robotics require workers that are more educated than ever before. Those who attain those education levels will find new opportunities while underskilled workers are left on the curb."

Fernando Botelho, a social entrepreneur working to enhance the lives of people with disabilities wrote, "The quality of education is not evolving at the same rate as technological improvements, so dislocation is inevitable. Solutions exist, but there is no evidence that these are being deployed at the scale our societies need."

A former chair of an IETF working group wrote, "There will be disruption, as there has been, but new technologies will continue to create jobs and opportunities.

Just *where* those jobs are located is a different question. The United States is not committed to sufficient education to continue to lead in technology sectors."

Rebecca Lieb, an industry analyst for the Altimeter Group and author, responded, "Enterprises will require a highly educated, digital and data literate workforce, which does not bode well for blue-collar workers, or softer skill white-collar workers. Given trends in U.S. education, this could lead to high demand for engineers from foreign countries (as we've seen in the past) with advanced degrees in engineering, mathematics, etc., as institutions of higher learning in this country fail to produce enough graduates with the requisite skill sets."

Gail Ann Williams, an online community management consultant, wrote, "One curious possibility is to consider that assorted technologies could be applied to the task of making job opportunities. That sounds possible, but it is hard to imagine a change in our economic, charitable or governmental systems that could fund such a task. It's nobody's problem, and everyone's."

Garland McCoy, president and founder of the Technology Education Institute, said, "Over the last several years I have found it very curious that article after article on robotics and self-driving cars have skipped over the huge impact all of this will have on jobs. The wave after wave of disruptive technology coming from the West Coast is crashing headlong into the policies, lobbyist and special interest of the East Coast (i.e. Washington DC)."

These technological changes may result in new skills being valued, and may also lead to a rethinking of the concept of "work"

A number of experts predicted that our entire concept of "work" will undergo a significant shift in the next decade thanks to advances in AI and robotics. Among the major themes this group identified:

We will experience less drudgery, and more leisure time

Paul Jones, a professor at the University of North Carolina and founder of ibiblio.org, responded, "I for one welcome my new robot masters. I don't welcome the loss of jobs or the depersonalization of services. The social impact is and will continue to force us to refocus on what makes us human, who we are in relation to each other, and the terms of the social contract that binds us. In the South we saw great changes when the plantation system was abandoned. Not for the best—much room for improvement—but certainly for the better."

A professor at Stanford Law School wrote, "Robotics and similar technologies will displace lots of jobs. But those people will find productive things to do—not necessarily in fields created by robotics, but with the time that these advances have given them. Robotics and self-driving cars will free up substantial parts of our day. For some that will be a pure benefit; for others it will be partial compensation for the loss of work."

Micha Benoliel, CEO and co-founder of Open Garden, wrote, "Robots will enable the creation of new environments that will impact local life and enable more and more people to spend time on studying and learning as access to knowledge also becomes ubiquitous. This will disrupt the way we are used to work in centralized organizations and enable the emergence of a new type of horizontal organizations"

Janet Salmons, a PhD and independent researcher and writer with Vision2Lead Inc., wrote, "I expect that the landscape of work will change. I anticipate that there will be more 'hybrid' jobs with some tasks done by AI agents and others by real humans. With any luck, the humans will be able to focus on more creative, innovative efforts with mundane and repetitive tasks completed by AI agents or robots. An optimistic view of social consequences is that our education will focus on higher order and creative thinking with the expectation that AI agents or robots will be taking care of the tasks that require lower levels of thinking."

Jay Cross, chief scientist at Internet Time Group, responded, "The nature of work will change. Heaven only knows what comes after the service economy but it won't be mass unemployment. Perhaps finally people will only need to work a few hours a day." A government executive wrote that the future will have positive and negative outcomes that will bring adjustments, saying, "Yes, the net effect will be negative—more jobs lost than created—[but] the social consequences would be actually positive overall. We will renegotiate the social order's expectation of the optimal mix between leisure and work. We will have less work and more leisure. We can afford this re-alignment because of the gained productivity."

It will free us from the industrial age notion of what a "job" is

John Mitchell, a self-employed lawyer who focuses on antitrust, copyright, trade associations, and free speech, wrote, "As with prior technological and labor-saving advances, they will tend to create other jobs of kinds that do not yet exist. But the jobs debate will continue, because even in 2025, the corporate/lawmaking complex will see it as advantageous to insist that 'having a good job' is the ultimate human aspiration. It will probably take over a century for humans to once again emphasize life, liberty, and the pursuit of happiness as being superior 'job creation.'"

Joe Touch, director of the Information Sciences Institute's Postel Center at the University of Southern California, replied, "Automation will continue to displace certain jobs, but they also create new jobs (creating/maintaining automation) and free us to explore other jobs as well. I don't think this has changed since the dawn of the industrial revolution, even though every shift is decried for those displaced. Jobs will continue to shift, as will our notion of the distinction between white- and blue-collar positions."

Jim Warren, the retired editor and publisher of several microcomputer periodicals, technology futurist columnist, and open-government advocate/activist and founder and chair of the First Conference on Computers, Freedom & Privacy, wrote, "Automation has been replacing human labor—and demolishing jobs—for decades, and will continue to do so. It creates far fewer jobs than it destroys, and the jobs it does create often—probably usually—requires far more education, knowledge, understanding and skills than the jobs it destroys. It is becoming more and more obvious that we (all developed nations) need to move—rapidly!—away from work-based income and well-being,

towards and into more humane cultures, where all citizens are assured a comfortable quality of life, even if they aren't (and cannot become) sufficiently competent and expert to fill the shrinking number of more-demanding jobs that are available now, and will be still fewer in the future."

Rex Troumbley, graduate research assistant at the University of Hawaii at Manoa, wrote, "We can expect robots, artificial intelligences, and other artilects to increasingly displace human labor, especially in wealthy parts of the world. We may see the emergence of a new economy not based upon wage labor and could be realizing the benefits of full unemployment (getting rid of the need to work in order to survive), but we may also see an increase in unpaid micro-labor such as the kind currently relied upon by Google, Facebook, Twitter, and many other companies which get users to volunteer time or energy toward certain ends uncompensated."

Elizabeth Albrycht, a senior lecturer in marketing and communications at the Paris School of Business, replied, "My answer depends on your definition of the word 'job'. If we consider 'jobs' as they are generally thought of today, either in blue-collar or white-collar, the displacement will be extraordinary. But we cannot assume that 'jobs' will stay the same. Our ways of making a living are going to shift at the same time. However, policy and people shift more slowly than technology, so I suspect that in 2025 we will still be suffering through structural changes that are heartwrenching, even though we will already be seeing tremendous benefits in terms of cost of goods, ease of movement and longevity."

We will see an explosion in new types of production—small-scale, artisanal, hand-made, barter-based

Jesse Stay, founder of Stay N' Alive Productions, wrote, "There will be a much stronger, and greater need for engineering, and STEM-related jobs. Those in manufacturing and blue-collar work will be forced into these types of positions. The economy will work itself out on this front. At the same time, the sharing economy will empower individuals to a more socialized, community-driven economy where people sell to each other. The way people do business will change, and people will be more empowered to do business. Jobs won't go away though—what we call 'a job' will change."

Sam Punnett of Fad Research observed, "This is a tough call. As with any hugely disruptive advance, jobs will be lost and jobs will be created. There is a large and

promising popular movement in 'DIY' or Do-It-Yourself innovations and businesses emerging to serve the Internet of Things. DIY enthusiasts work with inexpensive modular components providing the tools for invention where almost anyone can prototype gadget concepts on their own or within locally organized 'hacklabs' which are springing up in many urban centers. Participants participate for the joy of creating homegrown projects while others seek commercial development for their inventions. At the very least these facilities contribute to general technical literacy in a wide variety of areas from fabrication and robotics to coding and design work."

The director for an e-learning strategies company wrote, "There's a growing awareness of the importance of meaningfulness in life, and we can and will recognize that technology should only be used for those tasks that humans want to outsource, and that humans should retain those decisions that they wish to be involved in. We will see a return to craftsmanship coupled with an emphasis on knowledge work. Very large parts of our existence can and will be handed off to technology to free us up to do the things we want to do."

Lillie Coney, a legislative director specializing in technology policy for a member of the U.S. House of Representatives, replied, "The pressure to better educate citizens will be tremendous. Intellectually capacity will become a nation's greatest resource. Fewer students will leave their countries to come to the U.S. to learn and live. There will be less mobility as work can be performed from homes. The arts and craftsmanship will become more important as disposable time is increased. The larger shift is in how people earn a living and how productive member of society is defined."

Ian O'Byrne, an assistant professor at the University of New Haven, wrote, "Robotics, AI, and 'intelligent machines' will displace a ton of jobs over the next 10 years. As these jobs are displaced, we're in store for a revolution of sorts as people search for jobs that the 'robots' have taken. Here's hoping for another agricultural revolution!"

A networking engineer employed by one of the largest cable television companies in the United States wrote, "It's possible that there will be a premium on human interaction and human-made things, because a machine can do the job and replicate something 'mostly' but not quite as well as a human."

The future is not set in stone; it depends on the social and political choices that we make as a society

A number of experts took pains to point out that neither path is predetermined, and that we as a society have a substantial amount of control over our own destiny—even if it may involve making some hard social and political choices.

David Solomonoff, president of the New York Chapter of the Internet Society, wrote, "Hard to give a specific number or statistic here. New jobs will also be created. One hundred years ago pundits predicted something like the Internet, the Web and widespread adoption of mobile communications—but they never would have guessed that there would be a new type of job called "web developer". That being said, societies will have to adapt their economic policies to accommodate growing wealth created by technology and the reduction in older types of job opportunities. Those that do will prosper, those that don't will see large scale unrest fueled by the cheap, ubiquitous weaponization of these same technologies."

Jon Lebkowsky, web developer at Consumers Union, responded, "The answer to this question depends in part on how economies will work (will we still need traditional jobs in order to survive?) and on trends in population growth (fewer people could mean fewer jobs required). No doubt we can assume that engineering sophistication will continue to spawn and improve 'intelligent' machines, and that such technologies will replace workers in some contexts. However it's conceivable that we'll place a premium on human effort and choose meat over machine for many jobs. I suspect that decisions about deployment of potential tech surrogates will be driven by culture and politics as much as by practicality."

Ben Fuller, dean of humanities and sustainable development at the International University of Management in Windhoek, replied, "Just because there is a technology that exists to replace jobs, it doesn't mean that it has to be adopted. Our capitol city, Windhoek, has street sweepers and recently introduced a very effective recycling program that does not require pre-sorting. In both cases machines and automated processes can do the job faster and for lower cost, but the city government had decided that the social benefit of not adopting these technologies and employing people to do the work outweighs any direct savings. Increasingly we will see work places, institutions and societies debate the benefits of new technologies and these debates will include the social impacts of

adoption. The important thing to remember is that we have a choice to adopt one hundred per cent, partially or not at all."

Dan Gordon of Valhalla Partners wrote, "We will not have evolved a new understanding of work, jobs, and the relation of humans to the fruits of society. This is fundamentally an ideological and social question, not a technical or economic one. If we came to believe that humans were some kind of Eloi entitled to live off the labor of robots and intelligent machines, we would easily accept an infrastructure where no one 'worked' in today's sense (or very few), and most people did what we would today call pastimes or hobbies. But we need to get there morally and psychologically, and I doubt we will have gotten there by 2025. 2035 maybe."

Miguel Alcaine, International Telecommunication Union area representative for Central America, responded, "Technology in general will still displace more jobs than it creates. A quality education is a preventive measure to alleviate this trend, and entrepreneurship will need to be instilled in the young people. We definitely need to promote and nurture entrepreneurs ready to invent, discover, sell and offer the products and services of tomorrow. In this scenario, societies and especially governments will have to look solutions to this trend, which cannot pass by stopping or lowering the pace of technology."

Raymond Plzak, former CEO of the American Registry for Internet Numbers, and current member of the Board of Directors of ICANN, wrote, "Just as industrial advances and information technology advances have created new jobs and transformed others the same will continue to happen. Society, businesses and governments must become innovators in finding approaches and means for individuals to have productive and comfortable lifestyles that continue to advance human welfare. Failure to do so will exacerbate the distribution of wealth, goods and services disparities."

A behavioral researcher specializing in design in voting and elections wrote, "All other things being peaceful (the U.S. isn't engaged in any major conflicts abroad or at home), there's a good chance that there will be more jobs than ever available, and that unemployment will be the lowest it has ever been. But for that scenario to play out, policymakers and corporations have to look beyond the next quarter or even the next year. And so do schools. Because the new jobs will demand skills and training that we're not teaching now."

Greg Lastowka, a professor of law at Rutgers University, observed, "The displacement of jobs by automation isn't a consequence of automation alone. Robotics and AI will certainly put an end to a wide range of existing jobs, but with smart economic policy, we could have higher level of employment created by the surplus wealth automation generates. The problem of unemployment should be addressed primarily by creating a smarter political system that serves the citizenry—not by avoiding smarter machines."

Mike Cushman, an independent researcher, wrote, "Levels of employment/unemployment are a function of economic policy and not technologically determined. My preferred answer would be it all depends."

D.K. Sachdev, a consultant and adjunct professor in satellite systems, wrote, "Robot-like devices are introduced in a big way when they are attractive to business or are demanded by users. When that happens, they create new higher level jobs while reducing lower level jobs. Societies that organize constant skill upgrades will not suffer."

A professor of telecommunications at Pennsylvania State University wrote, "There is a gradual process underway in which our ability to produce what humanity needs is being increasingly enabled by the use of information technology. There is always some turnover in the economy in terms of where the most jobs are, e.g., agriculture to industrial to information. When the car was introduced, buggy whip makers went out of business. It will ever be so (I hope—if there's no innovation, we're in trouble!). Yes, of course some sectors will lose jobs, and other sectors will gain, but the question is whether on a net basis social well-being will overall be enhanced—which I believe it will be *unless* the real disruption comes from senseless political decisions, in which Natural Stupidity overcomes Artificial Intelligence. People will get used to AI in the production process, but the much greater, albeit perhaps more subtle, impact will be on society at large."

Different parts of the globe may feel these impacts differently

Finally, a notable number of expert respondents elected to look beyond the borders of the United States. These respondents noted that the ultimate employment impact of AI and robotics will vary across different parts of the globe.

Mike Liebhold, senior researcher and distinguished fellow at the Institute for the Future, wrote, "Globally, more jobs will be created by manufacturing *of* robots, but in developed countries like the U.S. and Europe jobs will be displaced by manufacturing *by* robots."

Gina Neff, associate professor of communications at the University of Washington, wrote, "The displacement of jobs in 2025 will be felt in terms of shifting global geographies of work, but not as direct trade-offs between tools and workers. As long as we as a society frame increased 'technology' as a cause of growth in economies, then the benefits of technology substitution will be viewed by the public as worth the costs of individual jobs."

A professor of ICT and social sciences at the University of California wrote, "We will continue to see displacement of jobs from the lower-paid to the more educated. There will always be a need for *some* people in low-paid service jobs, and some manufacturing, but there will be far fewer. Many of the jobs that will exist in the U.S. will be as care-givers, for older people and for children. The overseas outsourcing of jobs will slow simply because there will be fewer countries where there are low-wage workers, and robotic workers will be cheaper and more reliable. And not subject to political upheaval or natural disasters. People with education and innovative thinking will always make their own jobs, as we see in Silicon Valley. We will see deeper poverty and human suffering in places like Bangladesh, which will suffer from natural disasters as well as the loss of low-wage work."

Rui Correia, the founding director of Netday Namibia, a non-profit supporting information and communications technologies for education and development, replied, "This question should have had a 'maybe' response, since such impact will largely depend on economic and educational status of any region. Some regions will simply not have reached any state of technological advancement to be impacted by AI. Regionally I suspect that first world and emerging economies will see much more AI and robotics—in transport, banking and communication sectors—impacting on the amount of time consumed doing the mundane."

Sakari Taipale, a social policy and new technologies researcher in Finland, wrote, "This is very complicated question: the impact of the rise of robotics will vary geographically. In developed, IT-intensive, and dynamic countries, it is clear that robotic solutions will displace mechanic jobs and repetitive tasks more than they create

new ones. This is actually the reason why robotics are promoted. But it is also likely that some developed countries, not all, will benefit from this new industry as it will bring along the new demand for designers, engineers, etc. The impact of robotics on the developed South is more a question mark. I am afraid that the robotics will be detrimental for these countries, if robots are only developed to serve the economic interests of the industrialized North. Work-related immigration from South to North will decrease if robots will do the work of immigrant workers."

Robert Bell of IntelligentCommunity.org responded, "The job-destroying power of automation is balanced by the job-creating power of the economic growth created by greater productivity. Historically, these forces have tended to balance over the long term and across nations and national regions. At the local level, however, negative impacts can be severe as cities and regions fail to adapt fast enough to changing times, and income disparities become truly dangerous. The biggest question is about speed: will the pace of disruption be so great that labor markets and social norms simply cannot keep up."

David Orban, CEO of Dotsub, wrote, "From a global perspective it is of fundamental importance to distinguish between the adoption and disruption felt in societies that are more receptive to technological advances and those that are more protective of their traditional ways of life. For example the U.S.A belongs to the first group, while parts of Europe and India belong to the second. The flexibility and dynamism of legislation will be a necessary infrastructural basis, similarly to how right of way legislation allowed phone systems or the cable industry to flourish, or how spectrum allocation enabled the mobile industry to emerge."

Larry Magid, a technology journalist and an Internet safety advocate, responded, "Globally there will be fewer manufacturing jobs and robotics might also cut into such occupations and professional drivers and home service workers. While there will be more need for engineers, software developers and people to maintain and repair robots, it's hard to see how these could offset the enormous number of factory jobs that will be lost. *But*—for better or worse depending on your view—it could shift jobs from the developing world back to wealthier countries, because manufacturing will become less labor intensive and there will be a need for more highly skilled workers who are closer to where products and services will be used."

A professor specializing in information studies at the University of Toronto wrote, “Depends on where these jobs are being created. Are American firms outsourcing the manufacturing to developing/emerging economies, where labor standards remain low? If this is the case then I anticipate a shrinking labor force in North America.”

A senior researcher for a government research agency in Canada wrote, “I don’t know about self-driving cars by 2025—however, the domestic and industrial applications of robots will have developed considerably by then. Of course these will displace jobs that previously were done onsite. Whether this also creates jobs will depend on where the robots are made. Probably Germany and Asian countries, [it’s] hard to see the U.S. developing this into a major industry.”

A self-employed consultant wrote, “The displacement will be a continuation of the two main trends. First, low-wage jobs will be replaced but higher-wage, higher education jobs will increase. The second trend will be towards jobs in manufacturing and service continuing to migrate out of the industrialized first world as it becomes largely a knowledge-based GDP and jobs requiring more education move to urban centers—in near-city states rather than national economies.”