

Merging With the Machines: Information Technology, Artificial Intelligence, and the Law of Exponential Growth

An interview with Ray Kurzweil

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WFR: What do you see as the most pressing environmental issues that we should be concerned about as we move forward? And in a world where nanoengineered photovoltaic panels have eliminated fossil fuels, what will our obligation to the environment be?

Kurzweil: The first industrial revolution technologies were a compromise. They are harmful to the environment. Take fossil fuels, for example. We are running out of energy if we limit ourselves to nineteenth century technologies like fossil fuels, but obviously we don't need to do that.

We have the opportunity to move away from fossil fuels. Solar has the most headroom but there are others—for one thing there's a tremendous amount of geothermal energy—and there are many more renewable, decentralized, environmentally friendly technologies that ultimately will be extremely inexpensive. Normally, there's a 50% deflation rate [sic] to the costs of information technology (this is an implication of the law of accelerating returns). But in the case of solar energy, the rate is actually closer to 25% deflation each year—which means that ultimately solar en-

ergy will be very inexpensive—far less expensive than comparable fossil fuels. Plus it has the added advantages of being environmentally friendly and decentralized, unlike today's supertankers and nuclear power plants, which are centralized and therefore vulnerable to catastrophic destruction. New technologies in general are decentralized, and that makes them safer. The Internet is decentralized—if a piece of it goes down, the information just routes around it.

Over the next one or two decades, there will be another food revolution. We'll go from horizontal agriculture, which has dominated humanity for the last several thousand years, to vertical farming—basically, computer-controlled factories creating hydroponic plants for fruits and vegetables and in vitro-cloned meat, which could be engineered to be much healthier. [For example,] you could have beef with Omega 3 fats rather than saturated fat.

Same thing for housing. There's an emerging industry of three-dimensional printing. Right now, the key features are at the microscale, but within 20 years, it will be at the nanoscale and we'll be able to print out three-dimensional objects of extreme complexity. Today, we can print out modules to build inexpensive housing that's very sturdy, earthquake proof, and basically snap

them together Lego-style. These little modules have all the pipes and communication lines built in. One of the projects at Singularity University was to use three-dimensional printing to create low-cost housing for the developing world. We can house people very comfortably if we convert resources in the right way. Ultimately, with nanotechnology being able to produce inexpensive modules for houses as well as everything else we need, we'll be able to do that at very low cost.

People assume that only the wealthy will have access to radical life extension and these other technologies, but today, 5 billion people out of 6 billion have cell phones. Just 15 years ago, what few mobile phones existed weren't reliable, and only the wealthy had them. It took 10 years to put out the first billion cell phones, three years to put out the second billion, 14 months to put out the third billion, eight months to put out the fourth billion, six months to put out the fifth billion, there'll be 6 billion very soon, and within a couple of years, all of them will be smart phones. They are causing economic wealth and redistribution. According to the World Bank, poverty in Asia has been cut by 70% over the last 15 years because of the rise of the information society. Cell phones are ubiquitous in Africa; and the internet is becoming widely available there. At any given moment, there is a have/have-not divide, but because of the 50% deflation rate inherent in every form of information technology, the cost of closing this divide ultimately becomes very inexpensive.

WFR: So, just to clarify, it sounds like you're saying that the digital divide will be nonexistent in the post-Singularity era, that the gap won't widen, and that people in the developing world won't be left behind, as some people fear.

Kurzweil: No, I don't think that's going to happen. I don't think it is happening. I mean, the fact that 5 billion cell phones are in the world already

is a very good example of that. When I was in China recently, I noticed that half the farmers in China have digital devices—gateways to human knowledge—so these technologies are already very widespread. This is not just speculation.

The real problems are not the ones that the pessimists are mired in today. There are new issues we need to be mindful of. One is the potential for damage—both accidental and intentional. In 1975, the Asilomar Conference came up with standards that responsible biotechnology practitioners would follow. They're called the Asilomar Guidelines, they've been updated every few years since, and they've worked very well. The number of accidents over the last 30 years has been zero.

We also need to be mindful of intentional abuse. A very good example of how to deal with this is the technological immune system we've successfully put in place for software viruses. When I say "successfully put in place," I don't mean that we can cross that off our concern list and say, "OK, we've done that, we don't have to worry about that anymore." It's an ongoing cat-and-mouse game, but I do think we can take comfort from how well we have done. Nobody has taken down even a small portion of the Internet for even one second over the last 10 years. It's a very robust decentralized system with a rapid response immune system. We need to put something in place that's comparable for biological viruses. I've been advising the U.S. Army, which is the American agency responsible for bioterrorism protection on that issue. And there is a rapid response system being put in place that involves rapid sequencing of a new biological virus, which we can do now in one day—it took five years to sequence HIV, 31 days to sequence SARS, we can now do it in one day. We can create an RNA interference-based medication that can deactivate a virus.... These are the kinds of things we should be focusing on.

WFR: You recently said in an interview, “Whereas we can articulate technical solutions to the dangers of biotech, there’s no purely technical solution to a so-called unfriendly AI. We can’t just say, ‘We’ll just put this little software code subroutine in our AIs, and that’ll keep them safe.’ I mean, it really comes down to what the goals and intentions of that artificial intelligence are. We face daunting challenges.” In *The Futurist* in 2006, you acknowledged that unlike nanotechnology, “superintelligence by its nature cannot be controlled.” Can you elaborate a little more on the risks and dangers here? Also, given those risks and dangers, if there’s no real way to safeguard things from a dystopian scenario, why is strong AI desirable?

Kurzweil: I don’t think we should imagine that someone’s going to create this Strong AI in a laboratory and unleash it on the world. That’s not the way it’s going to happen. We have hundreds of examples today of Narrow AI—programs doing tasks that used to be done by human intelligence but doing them better and less expensively—and the narrowness is gradually getting less narrow. What’s more, this intelligence is deeply integrated with our own already, even if, for the most part, it’s not yet in our bodies and brains. There’s going to be a continuous exponential progression of computers getting more powerful, getting smaller, and we’re going to become more and more integrated with them. They’ve made us smarter already, and I don’t just mean as measured by IQ tests. I mean by as measured by the intellectual capability of our civilization, which includes all of the things we can do with biological and non-biological intelligence working together.

That integration is going to become more and more intimate. In 2035, you’re not going to be able to walk into a room and say, “humans on the right

side, machines on the left.” It’s going to be all mixed up and integrated—one complex, dynamic, chaotic human/machine civilization. Gradually over time, the non-biological portion of humanity’s intelligence is going to grow exponentially. The biological portion is fixed. It’s really not going to change—not to any significant degree. So, over time, non-biological technology will predominate. But it’s still going to be one civilization with people having different philosophies and arguing about values.

I would maintain that we actually have much greater consensus on human values than might appear. People focus on our differences and talk about culture wars, and yes, there are certain issues that divide us. But what we all agree on is actually much more pervasive than what we disagree on. This includes a belief in progress. The idea of progress is a fairly recent concept in human history. People didn’t think in terms of progress a thousand years ago. There actually was progress, but it was so slow as to be unnoticeable.

And we also share a growing belief in democracy and freedom.... If you go back half a century, very little of the world was democratic. I believe that decentralized electronic communication has facilitated the democratization of the world. In my first book, *The Age of Intelligent Machines*, I wrote that the Soviet Union would be swept away by the then-rising decentralized electronic communication, which included email over teletype lines and early fax machines, and indeed, that’s exactly what happened. The rise of the Web in the 1990s led to a great rise of democracies. So, what we need to focus on is maintaining democratic values in our civilization. It’s a civilization that is already partly biological and partly non-biological, and the non-biological portion is going to get more sophisticated, more intelligent, and more powerful, but it’s still going to be integrated.

I do believe that if we're more intelligent then we're more likely to be able to enhance ourselves morally and ethically. However, it's not a guarantee. The history of the twenty-first century hasn't been written yet. While I believe the increasing power of these technologies is inexorable, what we do with them and what values our civilization deploys is still in our hands. For example, if the Nazis had won World War II, that would have been a setback for human values—and they were using the technologies of their time to advance their “cause.”

Also, certain issues become more complicated. What does “privacy” mean now in the world? Fifty years ago it might have been obvious—not opening your neighbor's mail [for example]. And it is a federal crime to open someone else's letters; but we don't have comparable laws covering e-mail, despite the fact that most messages now are no longer sent on paper through the mail. So we need to focus on translating our values into policies that match how life is lived in the modern world, and that becomes complicated.

WFR: As you know, technology is progressing much faster than legislation can keep up with it. As technology continues progressing exponentially, will our ability to craft legislation around it fall further and further behind?

Kurzweil: [Legislation] is not the only way to approach these things. There was never a law passed that said there should be an Internet. And a lot of the norms and regulations of the Internet—how Wikipedia gets reviewed, and privacy on social networks—is done by group decision making and by companies and their interaction with customers who provide most of the content. There's the development of e-commerce, which is now \$2 trillion ... very little of this was done by legislation.

WFR: So, you're saying that these issues will work themselves out and that the role of the pol-

icy maker is not so crucial in this arena.

Kurzweil: There are policy makers at Facebook and Google and Twitter and Wikipedia. Those are very important policies. The companies that succeed are the ones that can negotiate gracefully with their users who are, in fact, providing the content for these services.

WFR: Speaking of e-commerce, you point to a future economic boom based on the exponentially increasing capability of computer power, coupled with decreasing costs. Can you tell us a little about the explosion of wealth that will follow the explosion of technology?

Kurzweil: We have economic growth every year. If there's a very slight downturn one year, we consider that a disaster and call it a recession. But there is economic growth in almost every year and all of that comes from information technology. The information industries grow 18% in constant dollars each year, despite the fact that you can get twice as much each year for the same price, because as price performance reaches a certain level, whole new applications explode. People didn't buy iPods for \$15,000 each 15 years ago, which is what they would have cost. Social networks weren't feasible six or seven years ago. And as new applications become feasible, they suddenly take off. E-books are now taking off because all the enabling factors are in place.

Every industry is gradually transforming into an information industry. Health and medicine is making that transformation now. Most of the economy will be information technology in the 2020s.... This is what's providing economic growth. The non-information technology industries are shrinking.

WFR: I want to talk about something a little different, and that's the role of creativity in a post-Singularity world. You're the author of some of the first computer programs that compose poetry

and music. What place is there in a post-Singularity world for those classic works of art and literature produced by non-enhanced humans—Shakespeare and DaVinci, for example—and how will we redefine creativity and the creative process in general? What will be lost if we give up these processes to software programs?

Also, is there room in the digital future for analog processes? There's no linear progression when it comes to artistic tools—but there are constellations of widely varying processes that are different from—but not superior to—the others. Movies didn't render plays obsolete, for example. What will be lost if we give up these processes in our haste to embrace a fully immersive technological future?

Kurzweil: Well, first of all, digital technology has already revolutionized the creation of art in every field, including graphic arts and music. Perhaps less so in language—although even there, certainly, search engines and other online tools are certainly helpful. But I was recently at the National Association of Music Merchants show, which I've gone to since 1983, and aside from the elaborately dressed musicians and the cacophony of musical sounds that you hear on the trade show floor, it really looks and reads like a computer conference. I mean, there are some acoustic instruments, but for the most part, the instruments are very sophisticated from a technological perspective and the users are speaking in very sophisticated terms of single-processing and other computer paradigms. Same thing at a graphic arts conference. Graphic artists are using very sophisticated tools. Almost all of commercial music—at least popular music—is done by synthesizers. The digital world is doing a better and better job of emulating specific art forms that have evolved using real-world methods. It's really just one aspect of virtual reality. I've been very involved with

that in the musical field.

The ability of the digital world to emulate the real world is advancing and getting more and more subtle. Virtual reality today is cartoon-like, but if you look at Second Life, over the last 18 months, it's become much more realistic. You can see where it's headed to being very realistic and three-dimensional and full-immersion. That is the goal of the digital world: to emulate the natural world.

There are still many things that we can't do in the digital world. You can simulate brush strokes and so on with digital tools, but you can't yet really achieve the three-dimensional effect of an oil painting. But that's the direction we're headed in.

WFR: One final question: When will the movie version of *The Singularity Is Near* be released?

Kurzweil: *Transcendent Man*, a documentary film about me, premiered a year ago at the Tribeca Film Festival. It's going to be distributed very soon.

The movie that I've made with some collaborators, *The Singularity Is Near: A True Story About the Future*, is an intertwined A-line documentary with a B-line narrative story, and in the A-line, I interview 19 big thinkers—people like Marvin Minsky (the father of artificial intelligence), Eric Drexler (the father of nanotechnology), Alan Dershowitz, and Alvin Toffler. The B-line narrative is a tongue-in-cheek story of my creating an artificial intelligence-based avatar named Ramona who has various adventures that, in an entertaining way, illustrate the ideas being talked about in a serious way in the documentary. She hires Alan Dershowitz, who plays himself, to press for her legal rights to be recognized as a person. She gets coaching from Tony Robbins, who also plays himself, to learn the secret of what it means to be human. And that's intertwined with the documentary interviews.—*Aaron M. Cohen*

[NOTE: Patrick Tucker also contributed to this interview.]