Speaker's Corner

The Future of Intelligent Technology and Its Impact on Disabilities

Ray Kurzweil

I've been involved in inventing since I was 5, and I quickly realized that for an invention to succeed, you have to target the world of the future. But what would the future be like? To find out, I became a student of technology trends and began to develop mathematical models of different technologies: computation, miniaturization, and evolution over time. I've been doing that for 25 years, and it's been remarkable to me how powerful and predictive these models are.

One trend that I think is particularly profound and that many people fail to take into consideration is this: The rate of progress—what I call the "paradigm-shift rate"—is itself accelerating. We are doubling this paradigm-shift rate every decade. The 20th century represented about 20 years of progress in terms of today's rate. And at today's rate of change, we will achieve an amount of progress equivalent to that of the whole 20th century in 14 years, then, as the acceleration continues, in 7 years. The progress in the 21st century will be about 1,000 times greater than that in the 20th century, which was no slouch in terms of change.

The first step in technological evolution took a few tens of thousands of years: fire, the wheel, stone tools. And now paradigm shifts take only a few years' time.

The one exponential trend people have heard of is Moore's Law, pertaining to the accelerating speed of computers and electronics. Every two years, we can place twice as many transistors at the same cost on an integrated circuit. They work twice as fast because the electrons have half the distance to travel, so the speed of computing doubles every two years.

Scientists have been debating when that particular paradigm will come to an end. Optimists say 18 years, pessimists say 12—but sometime in the teen years of the 21st century, we won't be able to shrink computing components any more because they will be just a few atoms wide. Will it be the end of Moore's Law? Perhaps—but other paradigms will emerge that hold even greater potential.

3-D Molecular Computing

When the trend for traditional computers runs out of steam we will have three-dimensional molecular computing. There's been enormous progress in the last four years. In fact, the favorite technology appears to be the one I have felt would win: nanotubes, composed of carbon atoms, that can be organized in three dimensions and that can compute very efficiently. They're up to 100 times as strong as steel, so you can use them to create structural components and little "machines." A 1-inch tube of nanotube circuitry would be a million times more powerful than the human brain.

We are miniaturizing all technology. The first reading machine we created in the early 1970s used a large washing-machine-sized computer that was less powerful than the computer in your wristwatch and cost tens of thousands of dollars. And we are also miniaturizing mechanical systems, which inevitably will lead to nanotechnology by the 2020s.

Threshold of Human Intelligence

Right now, $1,000 of computing power is between that of the brain of an insect and a mouse, at least in terms of hardware capacity. We will cross the threshold of the hardware capacity of the human brain by 2020, and the computers we use then will be deeply embedded in our environment. Computers per se will disappear; they will be in our bodies, in tables, chairs, and everywhere. But we will routinely have enough power to replicate human intelligence in the 2020s.

Critics say, "Sure, we will have computers that are as powerful as the human brain, but they will just be fast calculators and will not have the other aspects of human intelligence." So, really, the challenge is this: Where will the software—the templates of human intelligence—come from? To achieve this, another grand project is needed—comparable to the human genome project— to really understand the methods used by the human brain. This project is already well under way, in terms of scanning the human brain and developing detailed mathematical models of neurons and brain regions.

Resolution, speed, price, performance, and bandwidth of human brain scanning are growing exponentially. An upcoming technology will be able to non-invasively view the structures of clusters of thousands of neurons, giving scientists an ability to see how memories work. At that point, we will begin to understand how the human brain applies different cognitive functions.

In my view, it is a conservative projection to say that within 20 or 25 years we will have reverse-engineered the principles of how the human brain works, and we will be using that knowledge to produce biologically inspired models of computation. We are doing that already. We learned things about how the human auditory system processes sounds. We used that in speech recognition and got better results. We are applying these insights into the software of human intelligence.

Technology for sensory impairments

By 2010, computers will disappear. They will be so tiny that they will be embedded in our environment, in clothing, and so on. We will have high-bandwidth connections to the Internet at all times. We will have eyeglasses for the sighted that display images directly in our retina: contact lenses for full-immersion virtual reality. We will also have relatively powerful (but not human level) artificial intelligence (AI) on web sites—artificial personalities such as the avatar-like Ramona, who greets visitors and answers questions at the KurzweilAI.net web site.

For people who are hearing impaired, we will have systems that provide subtitles around the world. We're getting close to the point where speaker-independent speech recognition will become common. Machines will create subtitles automatically and on the fly, and these subtitles will be a pretty accurate representation of what people are saying. It won't be error-free—but then, our own auditory understanding is not error-free, either. We will also have listening systems that will allow deaf persons to understand what people are saying.

For people who are blind, we will have reading machines within a few years that are not just sitting on a desk, but are tiny devices you put in your pocket. You'll take pictures of signs on the wall, handouts at meetings, and so on. We encounter text everywhere—on the back of packages, on menus, on electronic displays—and these pocket-sized reading machines will enable a blind person to read this material. By 2010, these devices will be very tiny. You will be able to wear one on your lapel and scan in all directions. These devices probably will be used by sighted people as well, because they will allow us to get visual information from all around us.

Such devices will also translate the information from one language to another for everyone. The current reading machine technology used in the Kurzweil 1000 and Kurzweil 3000 reading systems uses a new generation of synthetic speech. Although it sounds relatively normal, it is not recorded human speech.

We are not yet on the verge of creating cybernetic geniuses. But we have many systems in our societies that already can perform intelligently in narrow areas. We have hundreds of examples of these machines. Some of them are flying and landing our airplanes, or guiding intelligent weapons. We have electrocardiogram systems that provide an analysis as accurate as your doctor's. We have some systems that can diagnose blood-cell images, others that automatically make financial decisions involving stock-market investments. In fact, $1 trillion in stock-market investments use these systems. Other intelligent systems look for credit card fraud and find optimal routes for e-mail messages and cell phone calls. Likewise, a disabled person has a narrow need. A person who is blind needs access to ordinary printed material. A person who is deaf needs to be able to understand ordinary speech from people he or she encounters at random. Devices to perform these tasks can work in close concert with the much broader, more flexible intelligence of the disabled persons themselves.

Enhancing our own intelligence

In some ways, machines can perform better than humans. Computers are much faster than people when they master tasks and can share knowledge. Something a computer has learned can be shared with thousands of other computers instantly, whereas, if I learn French, I can't just download that to you.

The implication of this will not be just an alien invasion of intelligent machines to compete with us. We are going to enhance our own intelligence by getting closer and closer to machine intelligence—and that's already happening.

There are many people walking around now who are essentially cyborgs and have computers in their brains interfacing with their biological neurons. The Food and Drug Administration just approved a neural implant for Parkinson's disease that replaces the portion of the brain destroyed by that disease. And there are more than a dozen different types of implants like that in use or being developed. Now, they require surgical implantation; but by 2029, we will be able to send these intelligent devices through the bloodstream.

The importance of hanging around

The most profound implication of these developments will be an expansion of human intelligence. Right now, we are restricted to a mere hundred trillion interneural connections. That may sound like a large number, but I personally find it rather limiting. Many people send me books to read, web sites to visit, conferences to attend, and I would love to be able to do all these things, but our human bandwidth is quite limited.

Ultimately, we won't be restricted to 100 trillion connections. We will able to create new virtual connections with nanobots, so we can expand the number of interneuronal connections we have in our brain many fold. We are today profoundly expanding human intelligence as a species through the Internet and all of our technology. Through much more intimate connections with this technology, we will continue to profoundly expand human intelligence.

Human life expectancy is another one of those exponential trends. Every year during the 18th and 19th centuries, we added a few days to human life expectancy. Now, we are at the intersection of biology and information science. Today, we are adding about 120 days every year to human life expectancy. With the full flowering of the biotechnology revolution, within 10 years, we will be adding more than a year to the human life expectancy every year.

So if we can hang in there for another 10 years, we may actually get to experience the full measure of the profound century ahead.

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