

Why we needn't fear the "singularity"

Gerald E. Loeb, M.D., Professor of Biomedical Engineering, University of Southern California, June, 2015

So what is the singularity? Start with exponential growth in the power of digital electronics (e.g. Moore's Law), combine with exponential growth in the science of the brain, and you get the rapid advances in artificial intelligence that are already threatening middle class jobs and sowing paranoia. Shake well and extrapolate to the point where humans put themselves entirely out of business and you get Kurzweil's "Technological Singularity", Barrat's "Final Invention" and other nightmares of a gaggle of industrialists and philosophers who don't actually work in neuroscience.

Pardon me for a *deja vu* moment. Such projections, usually conveniently far out that their authors expect to be dead or at least retired, have been appearing with every new technology since fire. Alan Turing's invention of the digital computer 70+ years ago led to the first digital neural networks 60+ years ago, based on rapidly developing understanding of how nerve cells in the brain transmit and store information. Thus was born artificial intelligence (AI) and futuristic projections, including Turing's eponymous test to know when AI turned human. So why have most practitioners of AI been quietly backing away from that vision for the last 30 years? And why are we again seeing projections that the singularity is nigh?

The problem is that exponential growth in science has very different implications than exponential growth in technology. Let's use the example of another pairing: the technology of transportation and the science of astronomy. As the technology moved from propeller planes to jet planes to rocket ships, its real and potential disruption of individual jobs and whole economies was readily apparent, providing a highly attentive audience for futurologists. A whole genre of apparently plausible science fiction (Asimov, Bradbury, etc.) imagined how humans would rapidly colonize the whole universe. Astronomy was the science that let us map the known universe and chart clever gravitational strategies to reach it efficiently. At the same time, however, astronomy was expanding the extent of the known universe even faster than our transportation technology was improving. We were just starting to understand that we humans (and our neighbors, the Martians) were tenants of a middling solar system in the suburbs of a very large galaxy. Then we discovered that there were billions of galaxies, some as far away as light itself could travel since almost the beginning of the universe. Now astrophysics is trying to figure out if those galaxies are moving ever further away from us and whether there might be other universes whose nature is completely unknown. So while our technology has now reached and passed the edges of our solar system, our science has moved the goal posts almost infinitely further away.

So it is with artificial intelligence. Microelectronics technology is, indeed, within range of packing as many transistors onto a silicon substrate as there are neurons in the brain. The problem is that neuroscience now understands that the information handling in each individual neuron is vastly more complex than one transistor or logical gate. Biological intelligence emerges from many, very different types of computation in the many distinct parts of the nervous system. The properties and interconnections of the many different types of neurons are the result of hundreds of millions of years of evolution. This has resulted in genetically choreographed processes for development and learning whose complexity we are just beginning to perceive. While futurologists have been counting how many transistors make a brain's worth of neurons, neuroscientists have been moving the goalposts of real intelligence.

This is not to say that these dense artificial networks of 1950s style neurons won't be hugely disruptive. Even if we did nothing more, they will likely make whole professions obsolete, just like the airplane doomed the steamliner. And we will eventually make electronic neurons that are more like biological neurons *as we understand them today*. But by then, we will be trying to discern the importance of many more subtle details that we have yet to observe. This may eventually end with something resembling the intelligence of a human being, but it is in the nature of science that we cannot anticipate what we will learn about that intelligence, what technology would be required to replicate it, and how long that process might take. If the singularity is indeed nigh, it must be that the exponentially increasing rate of fundamental discoveries about the nervous system is about to come to a crashing halt.

Don't bet on it.