

Iliano Cervesato
Carnegie Mellon University
iliano@cmu.edu

July 21, 2015

Fifty years ago, I was not born yet.

The field of computer science, instead, had been going strong for quite a number of years already — nearly 30 if we take Alan’s Turing insight of a universal computing machine as its starting point, more like 20 if we’d rather equate the birth of computer science with when the first programmable digital computer was switched on (the ENIAC, say, although there is debate about which among half a dozen projects from the 1940’s deserves that title). These early years, before 1965, had already given us many of the concepts and technologies at the heart of computer science as we understand it today, and certainly the overarching mindset it has imparted on our society: hardware components such as integrated circuits and RAM enabled unprecedented speed and reliability, operating system concepts such as virtual memory and time sharing decoupled a programming problem from the specifics of the hardware, and so did programming languages as diverse as Fortran, Lisp, and Basic. These languages — a huge advance over the machine code of a decade earlier — pushed the frontier of what computers could be used for from military and business support to intelligent applications such as expert systems and theorem proving, and even video games. Early robots used computing to do physical tasks for the first time. Quicksort, a textbook darling, had just been invented. Seymour Cray’s first parallel computers orchestrated the power of multiple computing units into machines of unimaginable speed at a time where Carl Adam Petri was investigating concurrent computation. Computers were already connected into networks, underlying for example the SABRE airline reservation system which is still in use today. Computing had gone commercial for several years with startups such as HP, DEC, and Texas Instruments, let alone established companies like IBM, selling mainframes to multinationals and large government units (and a few universities).

If these names bring back a certain nostalgia, the tools and products that emerged in the 50 years to follow, 1965 to 2015, are household names today: C and Unix came about in 1969, the first relational database in 1974, the Internet in 1983, the web in 1989, Java in 1995, Google in 1998, the iPhone in 2007, just to cite a few. Many of these technologies are the natural evolution of those early ideas: smaller, faster, more automated. What is truly astonishing is the speed of progress, and the fact that it seems to be all but slowing down: the computing universe is expanding, both in scope and pace. For instance, my first memory of a “computer” is when I was in third grade: that spring day, the teacher brought an electronic calculator to class, a boxy keypad the size of a small dictionary that displayed the result of the four basic operations in glowing green digits. He plugged it to the wall, we waited for it to come on, and then the entire class took turns doing one calculation — this was like magic. Contrast this with the average smartphone that most of us carry in our pocket: each one of them has more computing power than the entire world had in the 1970’s,

carries out more tasks than were imaginable just a few years ago, and is inexpensive enough that half of Earth's population can afford one. That that bulky calculator would eventually turn into the iPhone is a small leap of the imagination; that it would happen in just 30 years is mind-blowing. This convergence of exponentials — performance, cost, scope — has transformed our society from one centered around things into one characterized by information. This is not to say that there were no transformative ideas in the last 50 years: the personal computer, the Internet, the web, cloud computing and smartphones are each inflection points in our society's relation to computing. Each of these technologies evolved from earlier (less usable, more expensive) systems — a friend of mine likes to refer to cloud computing as “the revenge of the mainframe”. These exponential advances have broken one glass ceiling after another, each shattered by a new abstraction that pushed what was practically feasible to a new level. This is especially evident in software, whose sophistication takes a leap every few years.

Fifty years from now, I will be dead.

The direction that computing will take in this time frame has already been established in the last half century. The exponential trend we have witnessed will continue to astonish us: processors and other hardware components will get faster and more energy-efficient (the end of Moore's law will continue being declared imminent, prematurely as in the past 40 years), networked components will become more and more ubiquitous and embedded in everything we touch (even us), there will be a tighter integration of computing in human affairs as more of the things we do every day will be touched by automation, data analytics will make information eminently usable in fields well beyond finance, biology and energy where they are prominent today, and sensor networks will enable nearly perfect efficiencies for things like the power grid, water supply, natural disaster prevention, and much more. Extrapolating from past trends, the next 50 years will also see the rise of half a dozen or so transformative technologies, along the line of the Internet, the personal computer, the web, or the present democratization of computing. What they are nobody knows for sure, but they will most certainly take us by surprise.

This technological progress will have a profound impact on society, possibly making society itself unrecognizable to the people around today. As our ability to analyze biological data improves, there is little doubt that within the next half a century, medicine will have gained a sufficiently deep understanding of processes like development and cognition to cure many of the diseases that afflict us, possibly all of them. We may even figure out how to stop aging at an agreeable age — so maybe I won't be dead fifty years from now after all. At the same time, if current trends continue, we will have automated most (all?) tasks performed by people: truck drivers? vehicles will drive themselves; chefs? we will be printing our meals; lawyers? a Watson-like system will review relevant cases and draw unassailable conclusions in milliseconds; professors? students will get perfectly designed personalized instruction from the cloud; researchers? innovation itself will be automated; doctors? oh yeah, there won't be diseases any more. What will people do then? This newly attained immortality may turn out not to be that much fun after all.

But let's stay positive and focus on the benefits of automation rather than worry that exponential progress will render us obsolete. Computing will undoubtedly become closer to us and more integrated. Early efforts at manipulating the physical world will have been perfected by then and we will be able to orchestrate a swarm of robots to attend to our every need without even lifting a finger. But then, it is a small step going from a computerized system that interprets our thoughts to one that creates them in the first place. Wouldn't it be nice if the business meetings of the

future were just a matter of putting on a small device on the side of our head and all participants would instantly be transported to a common room, talk to each other as if they were in the same place, make jokes, argue about the undertone of the wines they would be virtually sipping? And because all this would happen in our head, it wouldn't be as awkward as talking in public in those early Bluetooth earpieces. Similarly, visiting a place will be a matter for this device to fire the right neurons to bring up sights, smells, feelings of exotic lands. Family reunions would be equally virtual, possibly with ancestors that have long been deceased or that have never existed. Of course, all these "experiences" would be recorded, and possibly policed for "deviant thoughts". Such new human-computer interface, or maybe should we call it human-human interface, would dissolve the physical/mental boundary. The distinction between reality and non-reality, between existence and non-existence would fade. As computers become more like us, we become more like them. What will it mean to be human?