COMMUNICATIONS of the ACM

February 1997–Volume 40, Number 2

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Charlie Rosen

My Computer-Related Wish List for the Next 50 Years

the science of future technology

THE IBM ALMADEN RESEARCH CENTER, A BEAUTIFULLY APPOINTED CLUSter of buildings perched on a hillside overlooking hundreds of bucolic acres in the coastal mountains near San Jose, is one location that strongly influences future developments in computing. Once a year, Ted Selker, an IBM Fellow, convenes a workshop, inviting approximately 100 high-powered computer researchers, entrepreneurs, innovators, and academics to share their latest work (or aspirations), meet with their peers, and essentially collaborate on developing the future of computing. I was probably the oldest participant in the 1996 workshop (pushing close to 80 years old), semi-retired, and very fortunate to be remembered and invited by Ted. By chance, *Communications* editor Tom Lambert was sitting next to me, taking notes in an old-fashioned way via pen and paper. We agreed that some proven methods that had worked for us successfully for many years were difficult to change and perhaps did not require changing even in this new age of powerful machine aids. On later reflection, perhaps this clinging to the old is due to our galling experiences with refractory software or hardware and interfaces that are far from friendly and do not always suit our requirements.

I was invited (as an old-timer in the field) to contribute to this anniversary issue, and present views tempered somewhat by long experience with underestimation of difficulties, especially in the field of artificial intelligence. I can best be described as an optimistic generalist with experience in many different technical and managerial fields over a period of 50 years. I founded two radio and electronic companies in Montreal, Canada in the mid-1940s; was a group head at General Electric in the 1950s, developing some of the first junction transistor and piezoelectric applications. I was at the Stanford Research Institute from 1957 to 1980, founding the Applied Physics Lab and developed electron-beam micromachining technology; founded the SRI Artificial Intelligence Center, which pioneered developments in perceptrons and autonomous robots; and founded the SRI Advanced Automation Group specializing in sensor-controlled industrial robots and machine vision.

For the past 17 years I have been engaged primarily in entrepreneurial activities and serving on the boards of a half-dozen new high-technology companies. I feel very good about the Silicon Valley entrepreneurial process that energizes much of U.S. industrial growth, producing devices, systems, and organizations that have significant economic and social value.

My Wish List for Future Computer-Related Systems

Computer-related applications can be projected in every human activity, physical, and intellectual. I have selected just a few developments for which I have a strong personal interest and that I believe will be socially useful. I am assuming the following hardware/software components will have become affordable commodities to serve as basic elements in my selected applications:

- Single-chip supercomputers.
- Essentially unlimited RAM and mass storage, and means for fast selective retrieval.
- Highly-developed interface hardware and software subsystems. In particular control by speech, mouse, pointing device, pen, gesture, and keyboard to be seamlessly available either singly or in combination as needed.
- Worldwide high-bandwidth communication networks, fiber-optic, cable, satellite, and general wireless systems.

> "I think a computer will be so small that it will fit in my pocket. I will talk to the computer and it will talk back to me—it won't need as many buttons since all you have to do is talk into it."
>
> —Jessica Pitt, age 9
> Computer user for the past five years

Presuming these elements exist and are commonly available, my wish list for the next 50 years is comprised of the devices and systems described in the following sections.

Natural-Language Interface

The most important and perhaps most difficult functional improvement of sophisticated computer usage would be the capability of conversing with the computer in natural language, approaching human capabilities, at least partially. One should be able to engage the computer in two-way conversation in natural language telling the computer the desired functions to be performed (e.g., computation, filing, archiving, mail, information search and retrieval, acting as agent, and controlling processes). These functions would presumably be stored subroutines to be selected with appropriate parameters that can be determined as needed by the human or computer during the interchange. Ultimately even programming the computer for a new function could be effected in this manner, with the computer being "smart" enough to transform its understanding of the desired function into an efficient computer program. This capability implies not only the further development of continuous speech-recognition programs, but the solution of the far more difficult problem of determining the meaning of the recognized words, in context. This will probably require the computer to select from its own stores or from other sources a large set of related facts associated with the domain of interest. Perhaps the vast resources of the Internet can be used in supplying the required information stored in appropriate graphs or trees at different locations, accessed by powerful search algorithms.

Advanced Learning Machine

The present multilayer neural-net computers can perform pattern recognition and some modeling functions by "learning" from examples, although the iterative learning process is excessively lengthy and inefficient. Augmenting the neural net procedures with algorithms derived from other artificial intelligence programs, such as expert systems, planning, modeling, and improving the iterative learning mode may result in a powerful means of programming the machine by examples—that is, the machine will learn to model a complex process based on the sequence of input/output data presented to the machine during the learning phase. For example, the machine could learn to generate a program to control a vision-controlled multi-degree-of-freedom industrial robot to perform an assembly operation. This capability would significantly impact the growing automation in our factories, in agriculture, in the performance of dirty, dangerous, and otherwise

undesirable jobs. Furthermore, this is a fertile field for future development of intelligent machines (investors and speculators take note!).

Portable Personal Reader/Library

Within a decade high-quality bright flat-panel active-matrix displays, and relatively unlimited mass memory, will be available at very low cost. Energy requirements will be low, and new storage batteries will have been developed. These technologies will make possible a portable reading device that can present the contents of a book, magazine, or newspaper one page at a time, in any print size or font, with the legibility of present print media, without requiring external light sources. The mass memory will be capable of storing a personal library of hundreds of books, articles, and notes, all of which are accessible by author, title, date, and using hypertext principles, by content. Some desirable features would include:

- The electronic reader should be about the size and weight of today's typical hardcover book with a display area of at least 8" by 10".
- Interactive commands effected by speech and pen input device.
- Very simple controls for brightness, print size, page selection, page skipping, and browsing.
- Modem incorporated to permit the downloading of new material as temporary or permanent additions to the personal library.
- Software to include powerful search algorithms to facilitate access. Book publishers will include appropriate indexing and abstracting terms for this purpose.
- Price not to exceed several hundred dollars.

Semi-Autonomous Teleoperators

For the past 20 years there has been a great deal of research and development in the field of completely autonomous robots, with rather disappointing results. It is now quite apparent that emulating a human's sensor-controlled physical activities, together with the required planning, control, and many other cognitive functions are quite beyond our present capabilities. There is little doubt that useful autonomous robots will ultimately be designed and built, especially for specific task domains. Robots whose motions and manipulations are completely controlled by human interaction are here today in the form of teleoperators.

In the next 50 years it will be possible to develop advanced hybrid machines, which will incorporate many programmed subroutines that provide a considerable degree of autonomy. For example, a human will point (via laser pointer) to an object and say "bring that here." The teleoperator will be able to "see" the designated object, analyze the surrounding environment, plan a route, adjust its multi-degree-of-freedom arm to acquire the object and bring it to the human, undamaged. Many other useful operations can be partially autonomous. Thus the teleoperator can call up vision, manipulative, obstacle-avoiding, and other subroutines, together with other sensors to carry out the task (but always under human control), to do whatever is necessary to avoid either failure or destructive or inefficient behavior. These machines would increase their degree of autonomy as more sophisticated routines are developed. There are many applications for such machines in industry, in agriculture, in fire fighting, in police work, in dangerous or dirty jobs, in outer space and beneath the oceans, and especially as aides for the disabled, the infirm, and the aged.

Is This All There Is?

The items described in this essay are a tiny sample of computer applications of the future, and one can argue that some early forms of these items exist today. A somewhat far-off but likely development will be computer system capabilities that approach the complexity of human thought processes. Furthermore these inorganic systems will be essentially immortal, capable of continuously learning new concepts and processes and storing immense quantities of new data and relations. It is possible that these systems will ultimately become more "intelligent" than many humans. Their expertise in specialized domains will be unsurpassed. Single systems will serve as intelligent controllers for autonomous robots performing dirty, dangerous, and undesirable tasks, and as creative aids for the arts and entertainment—socially-acceptable personal "slaves."

Since many such systems can be linked together in worldwide networks, they will constitute an accessible "World Brain" with incomparable intellectual power, hopefully providing humane services for all people. It is my wish that this will come to pass and that we humans will be enlightened enough not to abuse these miraculous machines. ◻

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