1 Interactive Futures

How do you deal with yet another device? How does technology mediate your dealings with other people? When are such mediations welcome, and when are they just annoying? How do you feel about things that think, and spaces that sense? You don't have to distrust technology to want it kept in its place.

The new field of interaction design explores these concerns. The more that interactive technology mediates everyday experience, the more it becomes subject matter for design. Like the electric light that you are probably using to read this book, the most significant technologies tend to disappear into daily life. Some work without our knowing about them, and some warrant our occasional monitoring. Some require tedious operation, and others invite more rewarding participation, as in games, sports, or crafts. These distinctions are degrees of interactivity.

The need for interaction design has become especially acute with respect to computers, the first truly interactive technology. No longer just a tool for producing documents, networked computing has long since become a social medium. As interactivity pioneer Brenda Laurel declared in the early 1990s, "the real significance of computing has become its capacity to let us take part in shared representations of action."[1] These representations can be of organizations, activities, problems, work practices, communities of interest, and not just predictable numerical models. Some of these representations are coded explicitly, but at least as many remain implicit in the contexts and configurations of technology usage. Representations of work and play now become, in effect, the software of places. These need more intentional design.

Software engineers think they know what they mean by design, and so do architects. When information technology becomes a part of the social infrastructure, it demands design consideration from a broad range of disciplines. Social, psychological, aesthetic, and functional factors all must play a role in the design. Appropriateness surpasses performance as the key to technological success. Appropriateness is almost always a matter of context. We understand our better contexts as places, and we understand better design for places as architecture.

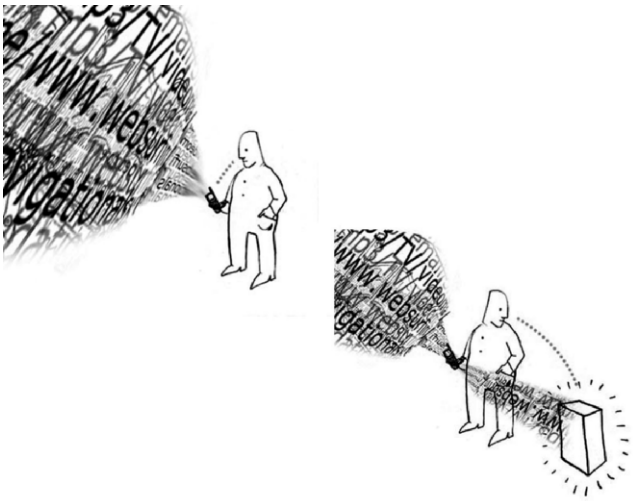
Like architecture before it, and increasingly as a part of architecture, interaction design now becomes a critical liberal art. However, to discuss such propositions is to get ahead of the story.

Ubiquity

At the theater one night, you might find yourself wanting to jam all the mobile phones in the house. Sliding through the EZ Pass lane on the way home afterward, you might notice how the idea of fixed devices interacting with mobile devices is not so unusual (figure 1.1).[2] Walking into your house preheated by its programmable thermostat, you might realize that just as much computation is built into your surroundings as is carried about in your bag.

Just as text long since escaped medieval monasteries and can now be found not only in portable books, but also on stickers, shirts, street signs, and all over product packaging, similarly computers have long since escaped the glassed-in laboratory and the beige office cubicle.[3]

We see them everywhere and sometimes they see us. Far more microchips go into objects we hardly think of as computers than into



1.1 Offloading information onto context. The mobile device meets the fixed and embedded device. (*Courtesy of Analia Cervini, Interaction Design Institute Ivrea.*)

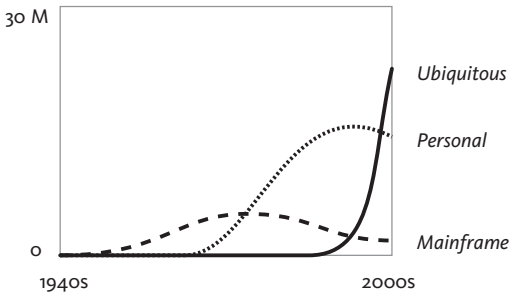
boxes used through a keyboard, mouse, and screen. Today less than a quarter of the chips produced by Intel, the largest manufacturer, are put into desktop or laptop computer motherboards.[4] The rest are embedded into things that you carry about, drive, or wear; or they are embedded into physical locations. They drive personal gadgets, information appliances, smart tags, responsive rooms, environmental monitors, and location-based services.

Since about 1994, microprocessors have outnumbered humans on this Earth. As of 2002, for each person in the United States, there existed a microelectromechanical system (MEMS) chip, which is an essential component in physical-digital interfaces. Technology visionary Mark Weiser defined ubiquitous computing as "hundreds of computers per person." Also known as ambient, physical, embedded, environmental, or pervasive computing, ubiquity has succeeded cyberspace as Silicon Valley's party line on the technological future (figure 1.2). When the Association for Computing Machinery (ACM), the world's largest membership organization of information technology researchers, launched a general-readership publication named Ubiquity, and called its plenary conference "After Cyberspace," the paradigm-shift had become more or less official.[5]

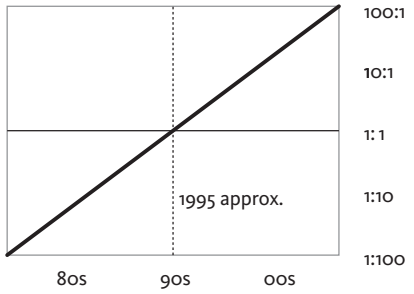
Many of these terms have become overexposed. The word *interaction* has lately been applied to just about any relationship between people or things, as though shapes interact in a Picasso painting. More properly, the word implies deliberation over the exchange of messages.[6] Thus you don't interact with a book, you just read it. But using electronic communication, you can interact with other people who are not physically present, or who take part in the interaction at some other time. Thus through digital media, we interact indirectly.

Similarly the word *ubiquity* was seldom heard until recent years, but now is applied to all manner of globalizing technology. Within the continual noise of technology hype, and like the word cyberspace before it, ubiquity has quickly come to mean just about anything having to do with universal connectivity. To people still catching up with the Internet, ubiquitous computing seems to mean wiring up every last seat in their workplace, or wirelessly browsing the Internet from any location on Earth.

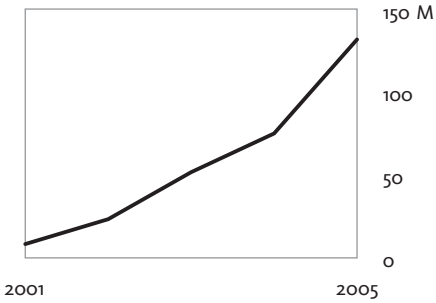
Major trends in computing (*after Mark Weiser*)



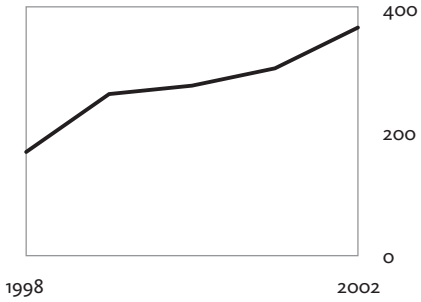
Ratio of microchips to humans on Earth (approximate order of magnitude)



Five-year market forecast for number of MEMS chips produced for microelectronics. (Source: *MEMS Industry Group*)



Five year trend: number of stories in the *New York Times* including the word "sensors." (Source: *Lexis-Nexis*)



1.2 Indicators of growth in pervasive computing

To emphasize the invisibility of chips in everyday things, the word pervasive has become more usual. According to a characterization from the year 2000 by the National Institute for Standards and Technology pervasive computing is "(1) numerous, casually accessible, often invisible computing devices, (2) frequently mobile or embedded in the environment, (3) connected to an increasingly ubiquitous network structure."[7] Intel announced the technological future at the turn of the millennium:

> Computing, not computers will characterize the next era of the computer age. The critical focus in the very near future will be on ubiquitous access to pervasive and largely invisible computing resources. A continuum of information processing devices ranging from microscopic embedded devices to giant server farms will be woven together with a communication fabric that integrates all of today's networks with networks of the future. Adaptive software will be self-organizing, self-configuring, robust and renewable. At every level and in every conceivable environment, computing will be fully integrated with our daily lives.[8]

Project Oxygen at the Massachusetts Institute of Iechnology presented a similar picture (figure 1.3):

> In the future, computation will be human-centered. It will be freely available everywhere, like batteries and power sockets, or oxygen in the air we breathe. It will enter the human world, handling our goals and needs and helping us to do more while doing less. We will not need to carry our own devices around with us. Instead, configurable generic devices, either handheld or embedded in the environment, will bring computation to us, whenever we need it and wherever we might be. As we interact with these "anonymous" devices, they will adopt our information personalities. They will respect our desires for privacy and security. We won't have to type, click, or learn new computer jargon. Instead, we'll communicate naturally, using speech and gestures that describe our intent ("send this to Hari" or "print that picture on

1.3 Recognizing faces and poses in Project Oxygen, MIT's initiative about ambient and ubiquitous computing. (*Courtesy of Project Oxygen.*)

> the nearest color printer"), and leave it to the computer to carry out our will.[9]

Business Week, in its "21 Ideas for the 21st Century," said:

> In the next century, planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit sensations. This skin is already being stitched together. It consists of millions of embedded electronic measuring devices: thermostats, pressure gauges, pollution detectors, cameras, microphones, glucose sensors, EKGs, electroencephalographs. These will probe and monitor cities and endangered species, the atmosphere, our ships, highways and fleets of trucks, our conversations, our bodies - even our dreams.[10]

So much future tense just annoys many of us. Consider why.

Technofutures and Their Limits

You may have thought that the future of computing was all about virtual worlds, intelligent agents, and cyberspace. If you travel among technical circles, you may have been hearing much lately about nanotechnology and breaking down the hardware-software barrier. Or perhaps you were just dreaming of the paperless office. These are examples of technological futures. Expectations about the role of technology seem especially important to designers.

Recently we have witnessed a paradigm shift from cyberspace to pervasive computing. Instead of pulling us through the looking glass into some sterile, luminous world, digital technology now pours out beyond the screen, into our messy places, under our laws of physics; it is built into our rooms, embedded in our props and devices—everywhere.

This may not impress anyone who conflates either of these notions with the technologies of the Internet. Lumping these ideas together was common enough amid the economic frenzy of the 1990s, when these technologies were all new. Indeed if cyberspace were the Internet itself, hardly anybody would be referring to it in the past tense. What has passed is expectation for a coherent there, there; the chaotic reality of the Internet lives on. When the pundits of Silicon Valley do use the past tense, they are referring to a unifying futurist paradigm, and not to what remain very viable applications of spatial data visualization, networked organizational change, and online community building.

At least in the popular imagination, cyberspace consisted of the notion that the Internet was a coherent place apart that you could immersively inhabit. This "consensual hallucination," as it was so often called, was more than a metaphor, and at times seemed more like a societally enacted myth. That is an instance of a technofuture. When by late 1996 no less august an institution than the New York Times not only discussed but promoted it, cyberspace had become a household word. Apparently everyone believed there was a there, on the other side of the looking glass.[11] In a full-page ad for itself, the Times proclaimed a new civics. "It's part newspaper, part gathering place. . . . In a world as complex as the Web, it's reassuring to know there is, in fact, a town square."[12]

It might as well have been puppet theater. You entered the net through the looking glass of the computer screen, or goggles, and there, at the edge of the aided senses, you saw ephemeral projections of things from higher, more abstract realms. You imagined "visiting" sites when in fact your browser software downloaded packets of data to wherever you were sitting.

This disembodiment had its limits. Suspension of disbelief didn't make it to the inner ear. To most of us who experienced immersive virtual reality at any length, the result was "simulation sickness": nausea induced by the disconnect between reverse-engineered visual space and our bodily kinesthetic orientation systems.

Meanwhile at a more practical level, the management consultancies have generally established how the knowledge that computer systems aim to represent resides in communities, organizations, and physical arrangements of props and devices. Protocols, so essential to the social role of the net, remained a function of embodiment. And usability, that foremost goal of interface design, proved to be less a question of immersion than of embodied activity in habitual context.

When a term spreads through a culture quickly, it often represents a passing wave of seeing the unexplainable world in some particular way. Then the metaphor wears off. The need to explain new technologies in terms of older realities generally tends to diminish. Thus automobiles eventually ceased to be horseless carriages. "Ban cyberspace," ran an *Economist* headline in June 1997, "The word, not the thing itself, whatever it may be. And dump the rest of the Internet's lame metaphors too."[13]

The cutting edge dulls on everyday life. Often the technologies on which new expectations are based blend into the fabric of everyday existence. Like the telephone before it, for instance, the Internet has begun to fade into banal, unlovely normalcy. Other technologies are rejected for errors in principle. Much as bloodletting turned out to be inaccurate in medicine, so virtual reality left out some important details—such as the fact that we orient spatially not just with our eyes, but also with our body.[14] Then too, other technologies are rendered obsolete by unforeseen alternatives, as freight trains were by interstate trucking.

Ubiquitous computing, in its universalist version has overlooked the value of context. Humanity has had thousands of years to build languages, conventions, and architectures of physical places. Wave upon wave of technology has transformed those cultural elements, but seldom done away with them. Context appears to have unintended consequences for information technology.

Meanwhile, the disembodied quality of global digital information flows has become a source of fear. Like some medieval map with monsters rampant in its margins, popular notions of cyberspace involve some dark fear of terra incognita.[15] Especially to those left on the wrong side of the digital divide, which was effectively represented by the monitor screen, the innate response was distrust. Cyberspace was dark, it was vast, and it was full of tricksters.[16]

As a form of urbanism, cyberspace was perhaps also some last version of what is sometimes called the project of transparency. At the risk of oversimplifying the academic significance of this word, in this context transparency describes how the idealized modern city sought to overcome the squalor and Victorian ponderousness of the industrial city with light and motion. Modernity espoused the belief that humanity must remake the world according to its own rational abstractions. It sometimes quite literally paved over anything that detracted from the predictability of its methods. As the modernist city was primarily a response to fears of disease, disorder, and impenetrable density, so fear of dark space led city planners to bulldoze entire neighborhoods in the name of the open plan.[17]

A similar ambition may explain cyberspace imagery, at least in the seminal Gibsonian version: "panoptic windows onto unified, glowing urbanistic infrastructures of flow.... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding."[18]

Much as by the 1960s, dissenting writers like Jane Jacobs and Aldo Rossi were explaining how the modernist city was all wrong, now current work in situated, embodied interaction design questions the aims of universalizing, disembodied, cyberspace. We now see harm in the belief that computer usage must be the same everywhere, and

that it will transport us to some fantastical otherworld. Instead, much as Jane Jacobs found living service ecologies in the apparent chaos of premodern neighborhoods, interaction designers now turn to the patterns of the living world as something other than a clean slate, and something to be understood, not overcome.

To illustrate this fundamental shift away from the limits of world making, consider a more detailed story. This concerns that most emblematic instance of urban technofuturism, The World of Tomorrow, the 1939 New York World's Fair.

The fair's identity remains highly recognizable to many of us. Its identity still receives a lot of attention, from revisionist historians to television cartoons.[19] There has been a lot of swooping architecture lately that recalls its buildings. The fair's memorable combination of unornamented curving surfaces, transparent cockpits, and supremely confident newsreel voiceovers has become an emblem of futurism. Its domestic science fiction has since been topped in outrageous imagination by the 1960s British mod architecture magazine *Archigram* and 1990s cyberpunk novels such as *Snow Crash,* for example, but the fair's popular impact may remain without equal.

As introduced in its official guidebook, The World of Tomorrow was a high-water mark of belief in worldmaking. "The Fair you are now enjoying is the result of the happy combination of the dreams, the experience, and the courage of many men and women," it declared. "The true poets of the 20th century are the designers, the architects, and the engineers who glimpse some inner vision, create some beautiful figment of the imagination, and then translate it into valid actuality for the world to enjoy.[20]

"The story we have to tell," the urbanist and historian Lewis Mumford remarked at a fair strategists' dinner, "and which will bring people from all over the world to New York, not merely from the United States, is the story of this planned environment, this planned industry, this planned civilization."[21]

Most of all, the fair illustrated that modern space was all about freedom of movement. "In order to grasp the true nature of space the observer must project himself through it."[22] As promulgated through much of the twentieth century by Sigfried Giedion's canonical text-

1.4 Modern space and technofuturism: Futurama, the General Motors pavilion at the 1939 New York world's fair. (*Courtesy of the Norman Bel Geddes collection, Harry Ransom Center for the Arts, University of Texas.*)

book Space, Time, and Architecture, which was published two years after the fair, the fundamental act of design became the shaping not of buildings, but of space. Flow itself now became the fundamental concern of the architect, not only for people and their vehicles, but for conceptual space. As in cubism, and in a rather misguided interpretation of Einstein, space became conceived in relation to a moving point of reference. It is no accident that Futurama, the fair's centerpiece, was created by a transportation company (figure 1.4). No wonder that in the decades to follow the traffic engineers were effectively given full power over the form of the city—and no wonder that the most dumbed-down metaphors for the Internet are automotive.

In sum, as modernity remade the world, at almost every instance it preferred motion to rest, the open instead of the concealed, and control rather than complexity. Just how far off the mark all this overconfidence really fell was perhaps best observed by the master essayist E. B. White commenting for the New Yorker on Futurama.

> The countryside unfolds before you in $5-million micro-loveliness, conceived in motion and executed by Norman Bel Geddes. The voice is of utmost respect, of complete religious faith in the eternal benefaction of faster travel. The highways unroll in ribbons of perfection through the fertile and rejuvenated America of 1960—a vision of the day to come, the unobstructed left turn, the vanished grade crossing, the town which beckons but does not impede, the millennium of passionless motion. When night falls in the General Motors exhibit and you lean back in the cushioned chair (yourself in motion and the world so still) and hear (from the depths of the chair) the soft electric assurance of a better life—the life which rests on wheels alone—there is a strong, sweet poison which infects the blood. I didn't want to wake up. I liked 1960 in purple light, going a hundred miles an hour around impossible turns ever onward toward the certified cities of the flawless future. It wasn't until I passed an apple orchard and saw the trees, each blooming under its own canopy of glass, that I perceived that even the General Motors dream, as dreams often do, left some questions unanswered about the future. The apple tree of tomorrow, abloom under its inviolate hood, makes you stop and wonder. How will the little boy climb it? Where will the little bird build its nest?[23]

Accursed Computing

With the lessons of cyberspace and Futurama in mind, we turn to pervasive computing. The saturation of the world with sensors and microchips should become a major story, and an active concern for all designers, but so far it has not. Because digital technology was so oversold and overbuilt during the recent Internet boom, people no longer want to hear about computing.[24] Because genetics have taken over as the next big thing, people no longer look to computing for their deepest cultural challenges. Compared with the possible consequences of decoding the human genome, desktop computing seems clumsy and quaint.

Such neglect is unwise, for computing is hardly going away. No longer the province of overenthusiastic young entrepreneurs, digital

technology has been left to governments and corporations with far less felicitious goals.[25]

Surveillance, for instance, has become an unfortunate fact of life. The loss of privacy has become a central theme in cultural studies of information technology.[26] Much as smog is objectionable but does not make us surrender our cars, surveillance is a bad side effect of information technology but it is not intrusive enough to make us give it up. Now as inexpensive cameras and sensors show up in more places, that side effect worsens. Our devices are watching us (figure 1.5). This is the foremost purpose and the most usual objection to pervasive computing.

One usual response to surveillance has been to revive Orwellian fears of some unblinking, totalitarian Big Brother. Although America, for one, has a deep concern in the erosion of civil liberties, the twentieth-century version of the panopticon may be outdated now.

First of all, omniscience is elusive. As anyone who has ever tried to resolve a simple billing dispute knows, even the telephone company lacks enough internal coordination to make sense of its data about you. And as anyone who has ever dealt with a state-level bureaucracy knows, the odds of omnicompetance remain low. Generally as information becomes more and more abundant, clear views through it become less and less possible.

Furthermore, there are a lot more parties doing the looking. Instead of Big Brother, this is more like ten thousand little brothers. For example, one order for radiofrequency identification tags that made the news in late 2002 involved half a million units. Besides having people nervous about privacy, pervasive computing raises concerns about the proliferation of autonomous annoyances. Does anyone want chirpy little advisors (such as the animated paperclip in Microsoft Word) to escape beyond the desktop and hit the streets? Instead of "Hi! You appear to be writing a letter!" you would have to put up with "Hi! You appear to be walking past our shop!" Nevertheless, even without speculation, we can observe plenty of annoyance in the form of petty information pollution.[27] It is muzak spewing out of gas pump handles. It is messages waiting in more devices than one cares to monitor. It is safety labels that pack text files.

1.5 One response to surveillance: Bhutto performance art by Daniel Beaubois: "In the event of amnesia the city will remember." (*Courtesy of Daniel Beaubois.*)

It is robotic pets, home automation systems, and relentless entertainment. Its purveyors assume no more responsibility for information pollution than nineteenth-century industrialists did for dumping sludge in the river. The assumptions behind its cultural ambition and its availability are made at the source, not the destination. Proactive information feeds treat all quiet time and space as something that needs filling. Portable and embedded devices take these streams out from your computer screen and into the world, where they are more difficult to turn off.

And then these devices crash. If a chair held you only 99 percent of the time, you would hesitate to sit on it. If a face-recognition security system mistook an identity just a thousandth of the time, terrible legal and social difficulties would result. If your car had some exciting new interface, it might be more dangerous to drive. Would you care to begin the day by reading a message that your house's software was down?

Finally, even before reliability becomes an issue, the programmability of physical-world systems has been the prime objection to pervasive computing (figure 1.6). We have neither the time to program so many systems ourselves nor the willingness to accept how others might program them for us.

Doors that swing open for you are one thing, but word processors that rewrite sentences or capitalize words on your behalf are another. Inflexibly configured systems might be tolerable in aesthetic matters such as lighting a room, but it is intolerable in critical matters such as medical equipment. Who programs all this stuff, how much of it can you reprogram, and how much programming and reprogramming can you stand? Since most of us can write little or no computer code, have to memorize far too many instruction sequences and passwords already, and lack time to learn how to operate even one more device, who is going to adopt smart technologies? How unobtrusively, even naturally, can all this activity occur? Few of us want our experiences designed for us; yet just about every one of our experiences that is mediated by technology could be better designed. It is to address this paradox of programmability that the new discipline of interaction design has emerged.

Yes,	But…
Computers are everywhere	Who asked for this?
Anytime-anyplace!	Equals nowhere
Objects will be smart	And they will force us to do something stupid
Anything can be on the internet	Do you need e-mail in a toaster?
Anything can get an interface	Will they all flash 12:00, like VCRs?
We can invent the future	But don't damage what already exists
Microchips are cheap	Dealing with them is expensive
Buildings get nervous systems	Inhabitants get nervous
You can monitor your family	Does that build trust?
Stuff becomes programmable	I don't have time
Stuff becomes programmable	I don't like the way someone else does it
Systems anticipate needs	And they assume we need entertainment
Tags can carry instructions	Mind the step; eat your vegetables
Systems respond to you	Hi!! You appear to be writing a letter!!
Smart conveniences	What, the curtains?
People won't tolerate this	Look how they took up mobile phones
Who could love a computer	Did the farmer love his plow?
Big brother is watching	Through terabytes of data smog
It's all about surveillance	And cars are all about emissions? bad side effects
Computers crash	So do cars, but we still use them
The net boom is over	Computers are not going away; quite the contrary
I'm against technology	Except my dishwasher

1.6 Common objections to pervasive computing

Changing Roles

Interaction designers study how people learn, operate, and assimilate technology, especially information technology. They also study how technological mediation influences what people are doing. Sociologists, psychologists, and management consultants address such concerns as well, but at a more general level. In comparison to those disciplines, interaction designers emphasize the particular mechanisms of product usability. Increasingly, they do so in terms of work practices, social organizations, and physical configurations—in a word, context.

The use of the term interaction design instead of interface represents a cultural advance in the field. Recent mission statements by firms, schools, and publications commonly acknowledge this.[28] Interaction designers claim to know at least partly what is wrong with information technology, and that overemphasis on technical features and interface mechanics has been a part of the problem. By turning attention to how technology accumulates locally to become an ambient and social medium, interaction design brings this work more closely into alignment with the concerns of architecture.

Because architects and designers of noncomputer systems may be unfamiliar with the history of this field whose evolution now leads toward them, a brief overview of this progression may be helpful. If the current stage of computing becoming pervasive constitutes a milestone, it is worth comparing that stage with two others: first, the growth of machine interface design; and second, the achievement of machine interactivity.

In what is often cited as a starting point in the industrial design of interfaces, Henry Dreyfuss, a proponent of the new field (and incidentally a chief designer of Futurama) observed: "If the point of contact between the product and the people becomes a point of friction, then the industrial designer has failed. If, on the other hand, the people are made safer, more comfortable, more eager to purchase, more efficient, or just plain happier, then the design has succeeded."[29]

In contrast to present interests in software usability and participation in information flows, industrial interface design was more often addressed to automation. The early twentieth century imagina-

tion expected advances in interfaces to eliminate participation wherever possible.[30] This is relevant to us because early developments in information technology assumed that legacy. Symbolic processors are not actually moving mechanisms for the transfer of powered motion, but to this day we still call them "machines."

Interactivity changed the role of technology, however. In our review, this is the second milestone. The ascent of human-computer interaction as a design discipline art required a fundamental shift in expectations. What made the personal computer so radical was the notion that someone might look forward to using it.

More specifically, computers became the first technology to provide two-way engagement. Despite common misuse of the word, not everything that is operable is interactive. A film may stir deep reactions; a chisel might let a sculptor feel that work is flowing; a lathe may have several buttons and controls; and a telephone lets people interact remotely; yet none of these technologies is itself interactive. Only when technology makes deliberative and variable response to each in a series of exchanges is it at all interactive. Such exchange is like a conversation in how participants coordinate process as well as content by means of acknowledgments, corrective interruptions, and cues. Although some people too readily attribute thought to symbolic processing technology, nevertheless we rightly experience interaction.[31] A computer might even beat you at chess.

Computer-human interface (CHI) became the subject matter of design only when processing and memory become inexpensive enough that they could be used not only to accomplish storage and calculations, but also to make those processes more convenient to people. The familiar graphical user interface (GUI) represents the latter stage of development. It is of course what first made computing accessible to nonspecialists. The admission of psychological principles into the previously all hard-numbers field of computer science brought it to the mainstream. Twenty years later, and still measured in mechanical first-time usability, building better interfaces remains the goal of much of the CHI community. (Not surprisingly, this community sometimes approaches ubiquity as if that means putting those window-and-menu screens everywhere.)

As interactivity become more widespread, expectations for automation gave way. For example, up until the network computing boom of the 1990s, efforts at artificial intelligence sought to capture knowledge, build inference engines, and, ever in industrialist mindset, proceduralize competent work. Then the spread of networks made information technology into a catalyst of organizational change. Designers and managers then recognized how the kinds of expertise resident in communities were unlikely to be automated, but could be served by better information "environments."

The idea of context has been growing all along. The graphical user interface was a conceived as a context for processing symbols, for instance. Later, the information flow through an enterprise was a context in which new software had to be introduced appropriately. Next that flow moved out onto mobile devices. Those devices meet up in arbitrary locations; others are embedded into relatively permanent local configurations; and sensors and effectors are added to the built environments that house them.

What is at issue is participation. The pushbutton industrial machinery of 1939 and the virtual realities of 1989 both left the human subject just sitting. Well-being requires a better state of human activity. Much of the human sense of environment emerges from our activity in habitual contexts. All this becomes the subject matter of design.

In the words of designer Clement Mok, "The most basic function of an interactivity art is providing a cue for a specific action."[32] Today the context of the digital task has extended beyond the desktop to world of work, play, travel, and dwelling. To anyone with too much gear and too little time, the mere availability of technical capabilities hardly guarantees utilization.[33] Whether features are understood and applied depends on context in which they are encountered. At this point, "contextual design" of information technology has to address such practices in situ.

This is the latest milestone. The role of computing has changed. Information technology has become ambient social infrastructure. This allies it with architecture. No longer just made of objects, computing now consists of situations.

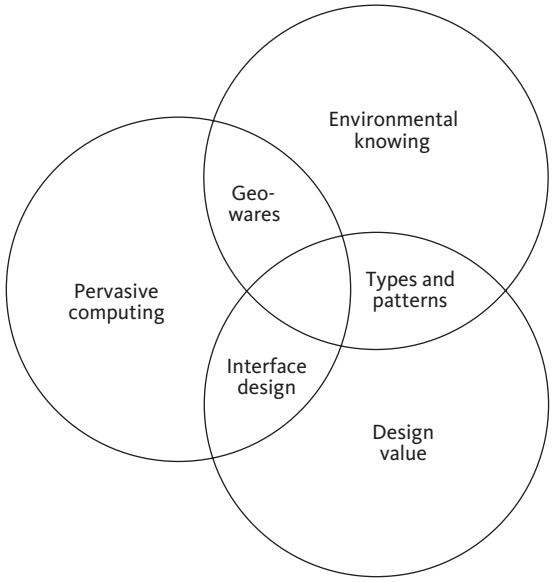
A Cultural Challenge

Rather than turning our backs on pervasive computing because surveillance is objectionable or the Internet boom is over, we should explore its cultural aspects. We should no more ignore this movement than the Internet or personal computing before it. Given our fears about privacy, autonomous annoyances, and rigidly preprogrammed activities, we should pay more, not less attention to this stage of technological development.

As you fuss to assimilate yet another bit of hardware or software into your daily routine, such grand ideas may seem awfully distant. Like the videocassette recorder flashing 12:00 in living rooms all over the world, just about every addition of gear to our lives comes with more technical detail than we are ready to absorb. Some of it is just unnecessary. What if your latest car came with additional pedals on the floor?

Today we can no longer assume that mechanical efficiency is the root of usability, that more features mean better technology, or that separately engineered devices will aggregate into anything like optimal wholes. The kinds of judgment necessary for establishing appropriateness in interaction design are at least as professional as artistic or scientific in character. We need to advance the science of the computer-human-interface into a culture of situated interaction design (figure 1.7). "We" is a lot of us: psychologists, architects, ethnographers, product designers, entertainers, management consultants, policy makers.

This challenge seems inseparable from establishing more general legitimacy for design. When the most conservative accountancies are declaring the value of design, and more creative strategists are understanding design in terms of the propositional thinking that occurs beyond the limits of predictive analysis, then design, writ large, is becoming more important. Under this broader conception of design, better technology is not just faster, prettier, or more usable, although those attributes are usually welcome. It must also be useful, and it should also be more appropriate. Thus it must be the product of cultural deliberation. If it is not, then it is likely to be objectionable, and perhaps costly.



1.7 Intersecting domains

Fortunately, so far in the history of computing, the law of unintended consequences has tended more toward chaos, creativity, and occasional delight, and less toward the sorts of command-and-control anticipated in the industrial era. As in the first fun software of the 1980s, or the first online social lives of the 1990s, our present decade's early delights in smart things and responsive spaces may come from people not burdened by existing expectations about the role of technology.

Expectations are critical. Expectation management dominates technology implementations. What technology can do may not be so important as what we want to do with it, and whether that is reasonable.

To modernity, technology was for world making: to overcome the limits presented to us by our place in the physical world. Its goal has been pure artifice.[34] With an unprecedented confidence in the accuracy of its methods, modernity has imposed its formulas on the world until they have become the world. When it has worked, this approach

has relieved suffering and introduced convenience. When it failed, it was attempting to straighten rivers,[35] house people in high-rise filing cabinets, or plat political borders where no terrain features or language difference suggested them. Whether in government, corporations, or universities, decision makers have become so caught up in modernity's mechanistic beliefs that they reject most appeals to nature.[36]

What is missing in the World of Tomorrow, or its latter-day counterpart in cyberspace, or in the anytime-anyplace version of ubiquitous computing, is the world itself. *Homo faber* has an Achilles' heel; his artifice cuts him off from his nature. This is a fatal separation. In the oft-quoted words of the landscape architect Ian McHarg: "No species can survive in an environment solely of its own making."[37]

Now as environmental limits pronounce themselves more loudly, however, the last century's headstrong attitude toward world making must eventually give way. Under present global environmental circumstances, appeals to place can no longer be dismissed as romanticism.

As the discipline of interaction design continues to mature, it must be measured by increases in human, cultural, and natural capital. It must involve more kinds of observation and critique. As graduate programs sprout in universities, let their proponents find a way beyond business automation. If communication technologies affect imaginations, let there be an awakening of mental environmentalism. Since cultural productions are measured in appreciation, let interactivity inspire staff critics to write weekly columns in the local newspaper.

But let us avoid the future tense. Let us focus on habits rather than novelties, on people rather than machines, and on the richness of existing places rather than invention from thin air. What purpose do we expect pervasive information technology to serve? When, if ever, does it seem natural to use?