There is an important distinction between wearable devices and those that are merely portable, the classic example being the pocket watch and wristwatch. The difference is simple: You have to pull out the pocket watch and open it to see the time, while the wristwatch enables you to see the time instantly, even while working with both hands.

Having to stop everything you are doing and concentrate to use a portable device has driven the evolution of watches, eyeglasses, and radios from handheld portable devices into wearable items. There are now wristwatches that contain medical monitors and pagers; glasses with embedded computer displays that only the user can see; vests, belts, and watches with computers inside them; and mobile phones and pagers with Internet connections and tiny teleconferencing cameras. The need for device integration into everyday life will continue to drive many more of today’s portables to become tomorrow’s wearables.

This next generation of wearable information devices will let us access information wherever we want it—while sitting on the subway or waiting in line at a bank. But even more important, these devices will let us ignore them while attending to other affairs. Such well-designed wearable devices can be much less disruptive to our lives than current technology, and people relate to them more intimately than to merely portable tools. Moreover, a tool that’s with you all the time can also change the sense of who you are and what you can accomplish. Therefore, as wearable devices become commonplace I expect them to shape our personal habits and culture.

IEEE Technical Committee on Wearable Information Devices

The idea of creating wearable devices to enhance human information processing capabilities is very old. Robert Hooke wrote in 1665 (in the preface to Micrographia):

The next care to be taken, in respect of the Senses, is a supplying of their infirmities with Instruments, and as it were, the adding of artificial Organs to the natural…. And as Glasses have highly
promoted our seeing...there may be found many mechanical inventions to improve our other senses of hearing, smelling, tasting, and touching.

One historical search suggests that Edward Thorp and Claude Shannon at the Massachusetts Institute of Technology (the same Shannon of information theory fame) conceived the first wearable (analog) computer in 1955. The device predicted roulette wheel movement, and Shannon and Thorp built a prototype of it in 1961. Subsequently, many experimenters produced other examples of wearable computers, usually aimed at specific applications. By 1991 a research group at Carnegie Mellon University had coined the term wearable computer and a research community began to emerge at other research institutions, including my own group at the MIT Media Laboratory.

The IEEE Computer Society's newest technical committee researches wearable devices. After a series of successful workshops on these technologies in 1996 and 1997, the IEEE formed a Task Force on Wearable Information Systems, and researchers from MIT, CMU, and the Georgia Institute of Technology organized the first three IEEE International Symposia on Wearable Computing. These meetings each averaged more than 400 attendees from diverse disciplines, including computer science, electrical engineering, textile science, industrial design, and the humanities and arts. After these first meetings—among the most successful in IEEE Computer Society history—the task force became a technical committee. The next wearables meeting will be 8-9 October 2001 at the Swiss Federal Institute of Technology in Zurich, Switzerland. For the call for papers and information on all previous meetings visit http://iswc.gatech.edu. See the “Further information” sidebar for a list of interesting resources on wearables.

Hardware that’s fun to wear

Psychological studies show the validity of the phrase, “The clothes make the man.” Our self-perception and self-confidence can indeed change with our clothes. The same is true for any constantly available device, and not always for the better. Those of us who are continually on call via a pager know how fundamentally these types of tools can alter your life. The personal affects of a wearable recall Marshall McLuhan’s dictum, “The medium is the message,” that is, the way in which a new technology changes our lifestyle is more important than the information it conveys. But wearables are more personal than traditional communication tools because they are a constant part of the user’s physical presence: They are not only part of what you wear but also part of who you are.

In the near future, trendsetting professionals may wear several small devices, perhaps literally built into their clothes. A person “Dressed for success” in the manner shown in Figure 1 (see pg. 15) may appear to have a fantastic memory, amazing knowledge, and powers of detection and deduction second only to Sherlock Holmes. These wearable intelligence devices can enhance the user’s “memory” by providing instant access to books, digitized maps, calendars, and various databases. They can also provide a wireless Internet and e-mail connection and boost awareness with various sensors.

It is too early to tell which approach to wearable design will prove most popular. These devices can be built in many ways, and it will take a fashion and style battle to determine what people really want to buy. As with most new technologies, wearables will probably make their biggest inroads in specialized tasks before their wide adoption by the general public.

Because issues such as comfort and power management are central to wearability, this IEEE Micro issue devotes one article to distributing computation over the human body and a second to salvaging power from human motion. The WearARM article by Lukowicz et al. deals with a subject matter familiar to Micro readers: The design of a StrongARM-based wearable computing platform. This article examines the trade-offs between power,

Further information

wearability, and extensibility, arriving at a particular design that is extremely wearable yet allows the easy addition of sensors and other modules via a powered body bus. Next, Shenck and Paradiso address powering a small wearable computer by unobtrusive energy scavenging. Acting on the observation that walking generates a great deal of power, the authors design systems that harvest this power to provide simple sensor and communications capabilities without batteries.

Tailoring for a better fit

Although their potential is vast, current mobile information devices suffer from a common problem: They are mostly oblivious to you and your situation. They cannot discern what information is relevant to you personally or when it’s socially appropriate to chime in. The goal in solving this problem is to make electronic aids that function like a well-trained butler. They should be “aware” of the user’s situation and preferences, so that they can perform appropriate and desirable actions—a task I call situation awareness. These devices should also make relevant information available before the user asks for it and without forcing it on the user—a task I call anticipation and availability.

To achieve situation awareness, a wearable device employs many different types of sensors to determine the user’s location and what he or she is doing. The device can monitor the user’s choices and build a model of his or her preferences. A person can actively train the computer by saying, “Yes, that was a good choice; show me more,” or “No, never suggest country music to me.” The models can also work solely by statistical means, gradually compiling information about the user’s likes and dislikes.

For anticipation and availability, the wearable device can take a few key facts about the user’s situation to prompt searches through a digital database or the World Wide Web. The device then presents the information in an accessible, secondary display outside the user’s main focus of attention.

A good example of a memory augmentation device that uses these design principles is an electronic navigation aid that relies on global positioning system satellites. The typical navigation aid has a display that constantly shows the user’s current position on a map and an arrow that indicates how to reach a desired destination. There are handheld versions of these devices for hikers and plug-ins for laptops, but most are currently found in automobiles.

The promise of never getting lost is a strong selling point for these aids, but they can do much more. For example, these devices can employ a user’s current location to automatically call up information about nearby landmarks. Users don’t have to type in queries to find local restaurants or gas stations—everything is retrieved on the basis of present position. The ease and utility of such automatic indexing is making navigation aids a huge commercial success in automobiles. The wearable equivalent will let people wander around at leisure with a sort of personalized electronic tour guide.

This type of system relies on database filters and agents that use information about the wearer’s situation—for example, location and time of day—to fetch pertinent data and label the images, text, and sounds that the wearer might find interesting. Although software agents will never magically anticipate our desires, they can discern something about our patterns from statistical analyses. For instance, depending on user instructions, today’s tools can call his or her immediate attention to e-mail from a spouse or boss, and save the rest for future perusal.

While it’s impossible to determine exactly where wearable intelligence technology is heading, the wearables research community believes that the trend is toward devices with greater situation awareness, achieved in part with additional sensors, such as cameras and microphones. In “Sensory Augmented Computing: Wearing the Museum’s Guide” Schiele, Jebara, and Oliver discuss one approach to situation awareness: using a head-mounted camera to recognize what object a user is looking at. Computer vision techniques that identify the user’s context let the wearable automatically retrieve appropriate information. This wearable’s particular application—a museum guide—provides insight into the capabilities that may one day become typical of wearable computing.

The body electric

Many people have expressed concern about
the social implications of wearable systems, pointing out their potential to overwhelm users with too much data and leave them feeling burned-out from the lack of downtime. They also worry that wearable devices might encourage people to retreat further into themselves and their machines, leading to greater social isolation.

It’s clear that poorly designed wearables could cause such problems. But information overload and social disruption are usually not caused by too much information or connectivity, per se. After all, business and government leaders have always dealt with huge amounts of information and with organizations of thousands of people. Instead, it seems that most difficulties arise when information and communications are not properly integrated into our daily routine.

To avoid these problems, we need wearable devices that are organized around the patterns of our lives, rather than organizing our lives around them. I think we can accomplish this by making wearable devices that are sufficiently aware of their surroundings and the likes and dislikes of their users.

When books first became cheap and portable, many feared that family life and popular culture would disintegrate as people spent more time reading and less time talking. The impact of wearing eyeglasses and carrying watches was also hotly debated in their time. But despite gloomy predictions, books, watches, and glasses are now an accepted part of our lives. We’ve grown accustomed to them, and I think we’re considerably better off, even though we’re different people because of them. Similarly, wearable intelligence aids will cause adjustments. We should expect them to change both ourselves and our culture.

In the July-August issue of Micro, Thad Starner will address many of these problems and concerns in “Challenges of Wearable Computing.” Starner is perhaps the only person in the world who has worn a computer and head-mounted display more or less continuously since the mid-1990s. He discusses the challenges he has faced while attempting to make wearable computers that are comfortable for people to live with over long periods of time. Starner observes that the great potential advantage of wearable devices is that they are constantly present, serving as a mental aid that is part of a user’s body and everyday life. He argues that with proper design, wearables offer the promise of enhancing human intelligence in a seamless and enjoyable way.

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