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TECHNOLOGY REVIEW

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10 EMERGING TECHNOLOGIES THAT WILL CHANGE THE WORLD

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THE TECHNOLOGY REVIEW TEN

What if you had a crystal ball that foretold the future of technology? Imagine, for example, if you had known in 1990 just how big the Internet was going to be 10 years hence. Sorry, that crystal ball doesn't exist. But in this special issue of *Technology Review*, we offer you the next best thing: the educated predictions of our editors (made in consultation with some of technology's top experts). We have chosen 10 emerging areas of technology that will soon have a profound impact on the economy and on how we live and work. These advances span information technology, biotechnology and nanotechnology—the core of *TR* coverage in every issue. All of these areas merit special attention in the decade to come. In each area we've chosen to highlight one innovator who exemplifies the potential and promise of the field. Keep this issue around and see how well our predictions hold up—even without the aid of that crystal ball.

—The Editors

JOSEPH ATICK

Biometrics

In one sense, the field of biometrics—identifying individuals by specific biological traits—has already emerged. Large companies use fingerprint sensors for logging on to corporate networks, state driver's license authorities employ face recognition for capturing and storing digital photographs, and the first iris-scan-protected ATM in the nation was introduced in Texas in May 1999. Yet consumers have been reluctant to adopt the technology, and so far, it remains largely relegated to military and government applications.

But the emergence of another technology—the wireless Web—could soon change all that, according to Joseph Atick, president and CEO of Visionics, one of the leaders in face recognition technology. "Personal digital assistants (PDAs) and cell phones are becoming our portal to the world, our transaction devices, our ID and maybe one day our passport," says Atick. But entrusting these small gadgets with so much of our personal and financial information carries with it a great risk. "It is this need for security," Atick says, "that is going to drive biometrics."

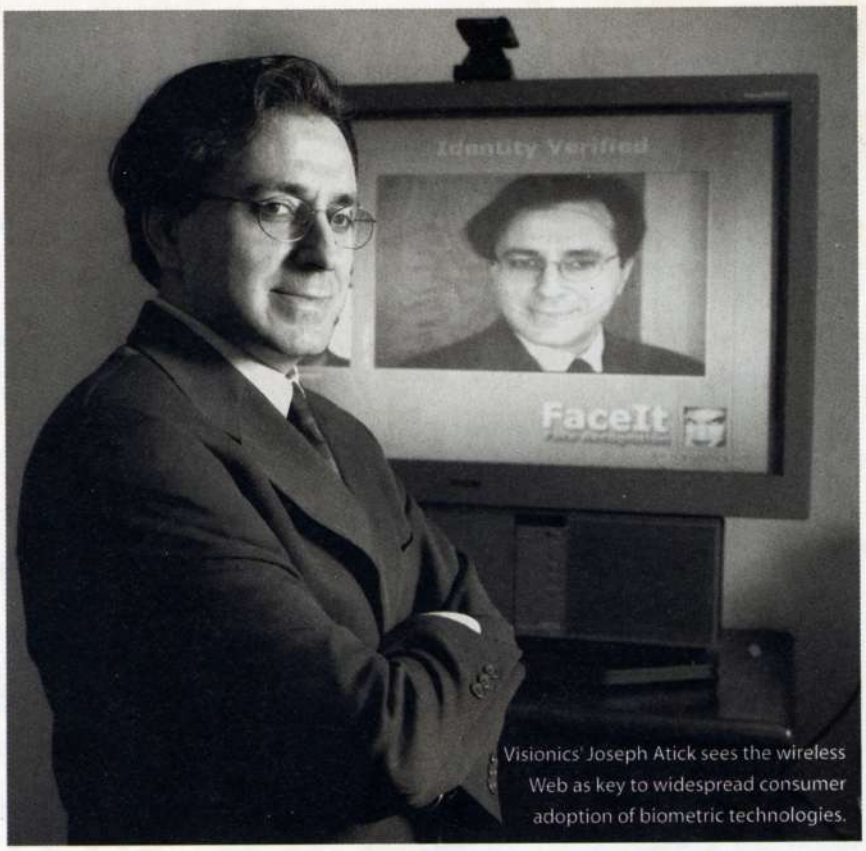
And while the need for security is pushing the demand for biometric systems, other technology developments—increased bandwidth, new cell phones and handheld computers equipped with digital cameras—will create an infrastructure capable of putting biometrics into the hands of consumers. Visionics is taking advantage of this combination of need and infrastructure by developing tools to enable people to authenticate any transaction they make over the wireless Web using their own faces.

Even those in the industry who are skeptical of Atick's vision of a biometric-enabled wireless Web can't deny his ingenuity and ambition. At the age of 15, while living in Israel, Atick dropped out of school to write a 600-page physics textbook entitled *Introduction to Modern Physics*. "I was bored in school. I wanted to show the establishment I was serious about my interests," says Atick. "This book was my ticket to grad school." Remarkably, Stanford University accepted him at 16 into its graduate program, where he earned his master's degree in physics and PhD in mathematical physics.

After graduation, Atick applied his math skills to the study of the human mind. While heading the Computational and Neuroscience Laboratory at Rockefeller University, he sought to understand how the brain processes the abundance of visual information thrown at it by the environment. He and his colleagues discovered that the brain deals with visual information much as computer algorithms compress files. Because everyone has two eyes, a nose and lips, the brain extracts only those features that typically show deviations from the norm, such as the bridge of the nose or the upper cheekbones. The rest it fills in. "We soon realized there was tremendous commercial value to this process," says Atick. In 1994, he and colleagues Paul Griffin and Norman Redlich founded Visionics.

Based in Jersey City, N.J., Visionics develops and markets pattern-recognition software called FaceIt. In contrast to the main competing technology, which relies on data from the entire face, FaceIt verifies a person's identity based on a set of 14 facial features that are unique to the individual and unaffected by the presence of facial hair or changes in expression. In the past few years, the system has found success fighting crime in England and election fraud in Mexico.

In October, the company signed a merger agreement with Digital Biometrics, a Minnetonka, Minn.-based biometric systems engineering firm. Together they plan to build the first line of "biometric network appliances"—computers hooked to the Net with the capacity to store and search large databases of facial or other biometric information. The appliances, containing customers' identification data, can then receive queries from companies wanting to authenticate e-transactions. And while consumers will be able to access the system from a cell phone, PDA or desktop computer, Atick expects handheld devices



Visionics' Joseph Atick sees the wireless Web as key to widespread consumer adoption of biometric technologies.

Photograph by NICK CARDILLICCHIO

Others in Biometrics

Organization	Project
Viisage Technology (Littleton, Mass.)	Face recognition
Iridian Technologies (Marlton, N.J.)	Iris recognition
DigitalPersona (Redwood City, Calif.)	Fingerprint recognition
Cyber-SIGN (San Jose, Calif.)	Dynamic signature verification
T-NETIX (Englewood, Colo.)	Voice recognition

to be the biggest market. Visionics is also working with companies in Japan and Europe to have FaceIt software installed on new Web-ready mobile devices so consumers can capture their own faces and submit encrypted versions over the Net.

Is that it for PINs and passwords? Atick predicts it will still be two to three years before PDA- and cell-phone-wielding consumers are likely to use biometrics instead. And as futuristic as his vision is, he is really striving toward something a bit old-fashioned. "Essentially, we are bringing back an old element of human commerce," says Atick—restoring the confidence that comes with doing business face to face. —*Alexandra Stikeman*

KAREN JENSEN

Natural Language Processing

The 1968 film *2001: A Space Odyssey* gave us a vision of the millennium based on the technological predictions of the day. One result: HAL 9000, a computer that conversed easily with its shipmates like any other crew member. The timing was off: In the real 2001, there's not a computer in the solar system as articulate as HAL.

But maybe it wasn't that far off. HAL's modern-day counterparts are catching up fast (sans the homicidal tendencies, one hopes). Already we have commercial speech recognition software that can take dictation, speech generation equipment that can give mute people voices and software that can "understand" a plain-English query well enough to extract the right answers from a database.

Emerging from the laboratories, moreover, is a new generation of interfaces that will allow us to engage computers in extended conversation—an activity that requires a dauntingly complex integration of speech recognition, natural-language understanding, discourse analysis, world knowledge, reasoning ability and speech generation. It's true that the existing prototypes can only talk about such well-defined topics as weather forecasts (MIT's Jupiter), or local movie schedules (Carnegie Mellon's Movieline). But the Defense Advanced Research Projects Agency (DARPA) is working on wide-ranging conversational interfaces that will ultimately include pointing, gesturing and other forms of visual communication as well.

Parallel efforts are under way at industry giants such as IBM and Microsoft, which see not only immediate applications for computer users who need to keep their hands and eyes free but also the rapid evolution of speech-enabled "intelligent environments." The day is coming when every object big enough to hold a chip actually has one.

Others in Language Processing

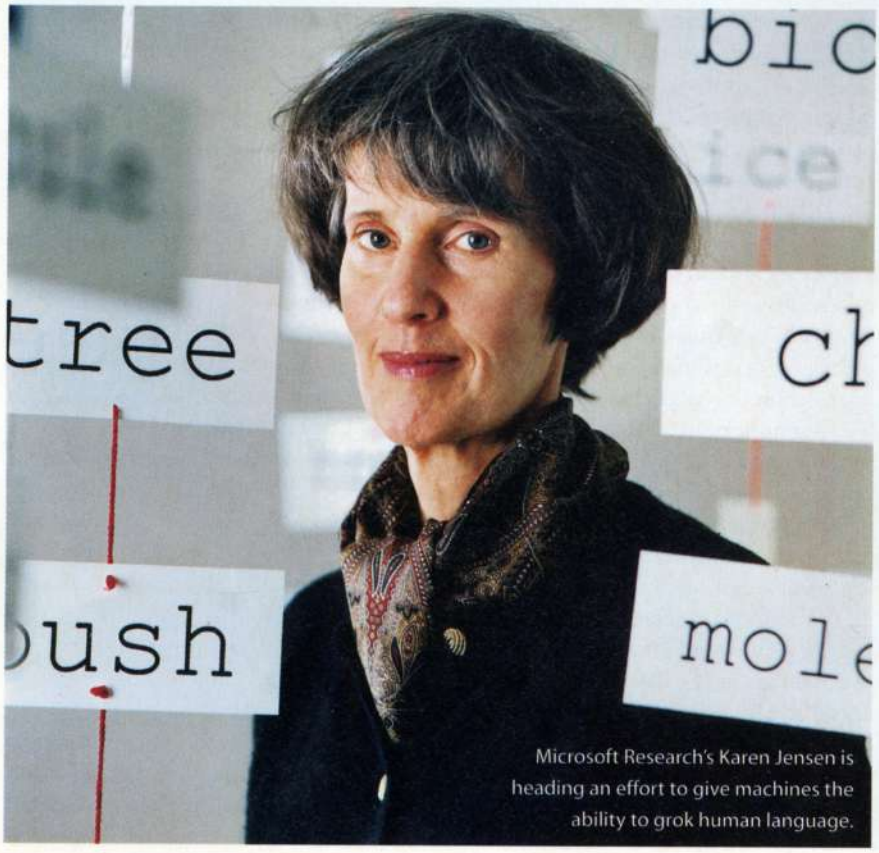
Organization	Project
Victor Zue (MIT Laboratory for Computer Science)	Conversational interfaces
Alexander I. Rudnicky (Carnegie Mellon)	Verbal interaction with small computers
Ronald A. Cole (University of Colorado)	Domain-specific conversational systems
BBN Technologies (Cambridge, Mass.)	Dialog agent

We'd better be able to talk to these objects because very few of them will have room for a keyboard.

Getting there will be a huge challenge—but that's exactly what attracts investigators like Karen Jensen, the gung-ho chief of the Natural Language Processing group at Microsoft Research. Says Jensen: "I can't imagine anything that would be more thrilling, or carry more potential for the future, than to make it possible for us to truly interact with our computers. That would be so exciting!"

Such declarations are typical of Jensen, who at 62 remains as exuberant about technology's promise as any teenager—and just as ready to keep hacker's hours. Indeed, Jensen was one of the first people Microsoft hired when it opened its research lab in 1991. Along with colleagues Stephen Richardson and George Heidorn, she arrived at the Redmond, Wash., campus from IBM's Thomas J. Watson Research Center, where they had worked on some of the earliest grammar-checking software, and immediately started building a group that now numbers some 40 people.

In Redmond, Jensen and her colleagues soon found themselves contributing to the natural-language query interface for Microsoft's Encarta encyclopedia and to the grammar checker that first appeared in Word 97. And now, she says, they've begun to focus all their efforts on a unique technology known as MindNet. MindNet is a system for automatically extracting a massively hyper-



Microsoft Research's Karen Jensen is heading an effort to give machines the ability to grok human language.

Photograph by KAREN MOSKOWITZ