From the Editor in Chief

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Augmenting Cognition

M. Satyanarayanan

In his futuristic essay "As We May Think," written nearly 60 years ago, Vannevar Bush imagined the existence of a device called a "Memex" that would extend and amplify human thought.[1] This is one of the earliest descriptions of using computing to augment human cognition. Until then, computing devices were seen primarily as engines that could reduce the drudgery of laborious hand calculations. It would take another decade, until the mid 1950s, for Herbert Simon and Allen Newell to explore the use of computing devices for emulating higher cognitive functions such as reasoning and problem solving,[2] thus founding the field of artificial intelligence. But the Memex stands as an imaginative first step toward answering the question, "How can computers help humans be smarter?"

Today, we do not see any Memexes around us. But a reasonable approximation to Bush's vision does exist. Instead of individual devices, the World Wide Web serves as a collective Memex for society. Mechanisms such as bookmarks and personal annotation files accomplish a weak form of the personalization Bush described. Information stored in databases and file systems can further customize your personal "Memex."

CAN PERVASIVE COMPUTING HELP?

What is pervasive computing's role in this arena? Consider how instrumentation is organized in a highly demanding cognitive environment such as an aircraft cockpit or a nuclear submarine's control room. If presented unfiltered, the total volume of raw data available in these settings would overwhelm a human operator, hurting his or her ability to perform essential cognitive functions. Only by keeping this data fairly unobtrusive and by spontaneously alerting a user when attention is necessary can we make such environments hospitable to human cognition. The clue to pervasive computing's potential here lies in the phrase, "when attention is necessary." Sensing and context-awareness, key aspects of pervasive computing, are essential to any system that can selectively alert a user.

Decline in cognitive function due to old age or to diseases such as Alzheimer's is one of the low-hanging fruits ripe for pervasive computing. Even modest improvements in an elderly person's cognitive ability can significantly improve that person's quality of life. It can also significantly reduce the attention demanded from caregivers. Indeed, the Applications department in this magazine's inaugural issue described how an elder care facility in Oregon uses pervasive computing technologies. Recognizing the growing importance of the topic, this issue focuses on the role that pervasive computing technologies can play in elder care. Our guest editors, Sumi Helal, Gregory Abowd, and Andrew Sixsmith, represent considerable research experience in this domain (for more information, see the sidebar).

Looking toward the future, we can envision computing technologies converging in tantalizing ways to augment cognition. For example, imagine a wearable computer with a head-up display in the form of eyeglasses and with a built-in camera for continuous face recognition. This would offer the essentials of an augmented-reality system to aid cognition. When you look at a person, his or her name could pop up, possibly with additional cues to guide your greeting. Such "magic glasses" could transform your environment into a helpful smart environment. Imagine "water me" popping up when you glance at your thirsty houseplant, or "take me out" appearing when you look at your long-suffering dog, or "don't forget my birthday" appearing when you say good-bye to your spouse as you leave for work! That would be useful for anyone—and especially valuable for the elderly.

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FROM RESEARCH TO REALITY

Today, this is clearly science fiction. Obvious challenges exist in basic technologies such as image recognition (which is currently nowhere near adequate for these scenarios). Additionally, difficult engineering challenges exist in building a system whose form-factor, size, weight, and battery life make it as unobtrusive as a pair of eyeglasses yet with sufficient computing power to run algorithms for, say, image recognition. One promising approach is to extend a wearable computer's capabilities by using nearby computation servers, a concept known as *cyber foraging*.[3] This issue's Wearable Computing department explores cyber foraging's role in extending battery life. What will such a system do if you go to a place with no compute resources nearby? The most likely fallback is for the "magic eyeglasses" to behave as plain eyeglasses—no longer annotating the physical world. Then, upon returning to a resource-rich environment, cyber foraging would bring back the "magic."

It is hard to predict when systems of this kind will become off-the-shelf products. At the moment, they do not exist even as lab prototypes. Fortunately, compelling visions of the future have a habit of becoming true sooner than most people think possible. So, I am counting on magic eyeglasses to become available by the time I am desperately in need of them, say a decade or two at most. Sooner would be better—on some hectic days, I could already use them! P

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FROM THE GUEST EDITORS

The natural declines in motor, sensory, and cognitive abilities associated with aging impact quality of life and independence. Statistics also suggest that our health and caregiver systems will be stretched to the limits by the increasing size of the elder population, which accounts for the largest growing segment of all populations in the US and many countries worldwide.

In this special issue, we focus on applying pervasive computing research in the domain of "healthy" or "successful" aging. Several research universities and numerous major industries have realized the opportunities pervasive computing can bring in terms of cost-effective and scalable solutions to successful aging.

We have accepted five papers and invited William Mann, an occupational therapy professor from the University of Florida, to introduce the aging population and their needs.

The authors of "Automated Analysis of Nursing Home Observations" show preliminary results of the CareMedia project at Carnegie Mellon University, which uses computer vision techniques to track the progress of patients and staff at a skilled nursing facility for patients with advanced dementia.

In "Technology for Care Networks of Elders," the authors describe some of the work in Intel's Proactive Health Initiative, which aims to provide information systems to an aging adult's supporting social networks.

"Cyber Crumbs for Successful Aging with Vision Loss" evaluates the viability and utility of an indoor orientation and wayfinding system for people with visual impairments.

The authors of "Aware Technologies for Aging in Place: Understanding User Needs and Attitudes" present work from the Aware Home Research Initiative at Georgia Tech, evaluating, from the user perspective, three services designed to offset some of the instrumental and social problems encountered in later life.

Finally, "A Smart Sensor to Detect the Falls of the Elderly" presents an intelligent fall detector system based on a low-cost, passive infrared sensor array. They demonstrate how they analyzed user needs to arrive at a suitable functional specification for the sensor.

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