Today, human-computer interfaces (HCIs) are rather physical in nature. The communication of information from and to computers is limited to the capabilities of individual input and output devices. With a typing speed of less than 50 words per minute and a reading rate of less than 300 words per minute, my transmission rate to and from my laptop is far lower than the communication bandwidth of most computer-to-computer interfaces. Advanced HCI approaches, such as speech recognition, are clearly widening this communication bottleneck. A direct link to the brain, however, would avoid most physiological activities. Ignoring all the required processing tasks for a moment, in the future we might end up at the speed of thinking when communicating with computers.

In addition to a more efficient way of communication, such brain-computer interfaces will introduce completely new possibilities. For instance, they will support people with physical disabilities so that they can control prostheses and other interfaces mentally. BCIs also offer promising new approaches in neurological rehabilitation and even computer games. Futurists predict that, by the mid-21st century, it will be possible to download human brain content onto a supercomputer. Replicating and changing consciousness can be implied from such capabilities—total recall becomes reality.

BCI technology is truly both an exciting and challenging topic. On the way to digital immortality and mental control, there are still many hurdles to overcome. How can brain signals be sensed both noninvasively and efficiently? How can researchers process and interpret these signals? In the five articles in this special issue, leading scientists shed some light on the state of the art in brain-computer interfaces.

IN THIS ISSUE
In “Noninvasive BCIs: Multiway Signal-Processing Array Decompositions,” Andrzej Cichocki and colleagues explain the fundamentals and limitations of basic monitoring and processing of brain signals. They describe how various kinds of neurofeedback can be analyzed online throughout multiple processing stages and explain how neurofeedback can be combined with human-computer interfaces. They argue that machine learning and multidimensional data mining are key elements for interpreting brain signals.

A significant amount of time is spent on software development for implementing various neuroscience concepts and testing their suitability for BCIs. In “Bio-Sig: A Free and Open Source Software Library for BCI
Research,” Alois Schlögl and Clemens Brunner summarize the different data processing steps in a BCI system and explain how common software interfaces can enhance biomedical signal processing.

In “Brain-Computer Interface Operation of Robotic and Prosthetic Devices,” Dennis J. McFarland and Jonathan R. Wolpaw describe studies demonstrating the feasibility of using BCIs to control robotic devices. The authors also outline requirements for practical applications, such as long-term recording stability.

In “Rehabilitation with Brain-Computer Interface Systems,” Gert Pfurtscheller and colleagues review several invasive and noninvasive BCIs for neurological rehabilitation, control of neuroprostheses, operating spelling systems, and stroke rehabilitation. In particular, for desynchronized sensorimotor rhythms, the authors discuss several training strategies, feature selection, and feedback approaches.

Finally, “Brain-Computer Interfaces, Virtual Reality, and Videogames” by Anatole Lécuyer and colleagues explains how BCIs can be used for applications that go beyond providing communication to those who have lost their voluntary muscle control and describe how this technology can be used for interacting with videogames and 3D virtual worlds.

The articles in this special issue impressively outline the state of the art of brain-computer interfaces. They also give a sense of the future potential of such interfaces. Although Total Recall remains a science-fiction movie for now, the possibilities for using BCIs in real-life applications are taking shape. While they might provoke critical thought in some cases, they are promising in most others.

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