Christian Jutten | Editor-in-Chief | Christian.Jutten@grenoble-inp.fr

Advances in Science Must Benefit All Humanity

This issue of *IEEE Signal Processing Magazine* is mainly focused on neurorehabilitation and assistive technologies. For a few decades, microelectronics, signal processing, robotics, and computer science have been the driver of many scientific and technological advances, with applications in many domains, including health.

This is quite clear when considering the fast evolution in medical imaging, robotics for computer-assisted medical and surgical interventions, brain–computer interfaces (BCIs), noninvasive brain stimulation, neurofeedback, and the control of limb prostheses, to cite only a few examples. The main application domain covered by this issue is related—but not limited—to the social fact of the increase in the population of the elderly, who suffer from a loss of mobility and autonomy as well as neurodegenerative disorders.

Based on advances of the last decades, the articles in this special issue show how new sensors, devices, and signal processing methods can finely analyze and use biological signals like electroencephalograms (EEGs) and electromyograms (preferably based on noninvasive recordings) for treating patients with different health issues, e.g., neural disorders or controlling a prosthesis. In addition, new embedded and wearable devices allow patients to safely stay at home with continuous monitoring of their health state, with the data directly sent to their physician or hospital. Many of the existing methods are still in their infancy, and they open wide perspectives for human benefits as well as, especially, the elderly and those with amputations.

Finally, very efficient signal processing and machine learning algorithms can now be run in real time and extract relevant and accurate information about brain activity, even from scalp EEG recordings. This opened the way for BCIs, which constitute a hope for people with serious motor disabilities, to help them recover mobility and communication. BCIs can also be used through neurofeedback for training the brain; there are already preliminary results for children with autism [1] and patient rehabilitation after a stroke [2].

These new methods also arouse important societal concerns, including privacy, reliability, equality in access to care, and ethical issues.

However, simpler and more efficient solutions could be obtained by using sensors closer to the source, e.g., an intracortical sensor. There is a great temptation to use invasive devices for objectives that are not always humanistic.

In fact, these new methods also arouse important societal concerns, including privacy, reliability, equality in access to care, and ethical issues. Many of these devices directly send personal data via Wi-Fi and the Internet. Data privacy is, then, not guaranteed to be preserved, and there is a risk that malicious people could profit from security gaps by publishing private data or hacking health data servers. During the last year and because of the COVID-19 pandemic, which implied increased use of the Internet for so many things, hospitals have been facing a growing number of cyberattacks with ransomware.

On the other hand, the efficiency of wearable devices requires fast and reliable communication with the hospital. Therefore, these advances in health cannot be possible for patients with a weak Internet connection, e.g., those living in a small isolated village or with low financial incomes.

Finally, the data are sent to physicians and medical centers to use them to make an early diagnosis. However, if a serious problem occurs, there is currently no direct feedback or action for taking care of patients, except to tell them to come urgently to their physician's office or hospital. Therefore, research for being able to remotely provide the first vital aid in such situations seems essential.

Beyond scientific issues, researchers must be careful about the future use of such technologies, which surely provide efficient solutions and imply hope for

(continued on page 11)

Digital Object Identifier 10.1109/MSP.2021.3073999
Date of current version: 28 June 2021

then transduced by an analog-to-digital converter into a series of spike patterns spaced in time and transmitted across a conductive material such as a metal wire. "Each sensor node has a different spike pattern that identifies them, like a signature," Tee says. "These spike signatures are then summed together in time with spike signatures from other sensors using a summing amplifier."

The summing process, Tee notes, is entirely asynchronous, without any need for an arbiter or master clock. At the receiver end, a digital input port deconvolves the spike patterns and maps out the spatial temporal nature of the mechanical stimuli, he explains. "The magnitude of the stimuli is encoded in how fast these spike signatures are generated, similar to how skin tactile receptors encode mechanical stimuli," Tee says. An artificial intelligence algorithm at the receiver helps to determine the object's mechanical properties by learning from the various spike patterns.

Tee reports that the project is now at the implementation and proof-of-validation stage. "Packaging our system into the right format for users that's robust to external electromagnetic interference is something we are working toward," he says. "We have gotten very good results in our recent efforts with integration in robotic arms—the next phase is to test our sensors on real humans, performing tasks with the sensorized prosthetic hands."

Author

John Edwards (jedwards@johnedwardsmedia.com) is a technology writer based in Gilbert, Arizona, 85234, USA. Follow him on Twitter @TechJohnEdwards.

SP

FROM THE EDITOR

(continued from page 3)

patients and people's wonder. However, some of these technologies, e.g., artificial intelligence and BCI, have been also adopted by people for promoting a school of thought called *transhumanism*.

I believe that we, as scientists, must pay attention to abusive and dangerous uses of the technologies that we are developing. We can agree to use invasive implants to treat people with serious neural disorders so that they recover a "normal" capacity; we can also promote using neurofeedback for training the brain. However, I believe it is unacceptable to promote the use of neural implants for healthy persons to improve their intellectual capacity. In fact, can you accept becoming a connected human? Are you confident enough in the company that will control your implant? Who will decide the release of your implant?

Yes, we scientists have to promote rehabilitation and assistive technologies for patients and the elderly. No, augmented humans must not be a target for scientists. On the contrary, we scientists have to fight against the crazy and dangerous drifts of science.

References

[1] M. E. Kouijzer, J. M. de Moor, B. J. Gerrits, M. Congedo, and H. T. van Schie, "Neurofeedback improves executive functioning in children with autism spectrum disorders," *Res. Autism Spectrum Disorders*, vol. 3, no. 1, pp. 145–162, 2009. doi: 10.1016/j.rasd.2008.05.001.

[2] G. Lioi, S. Butet, M. Fleury, E. Bannier, A. Lécuyer, I. Bonan, and C. Barillot, "A multi-target motor imagery training using bimodal EEG-fMRI neurofeedback: Pilot study in chronic stroke patients," *Front. Hum. Neurosci.*, vol. 14, p. 37, Feb. 2020. doi: 10.3389/fnhum.2020.00037.

SP