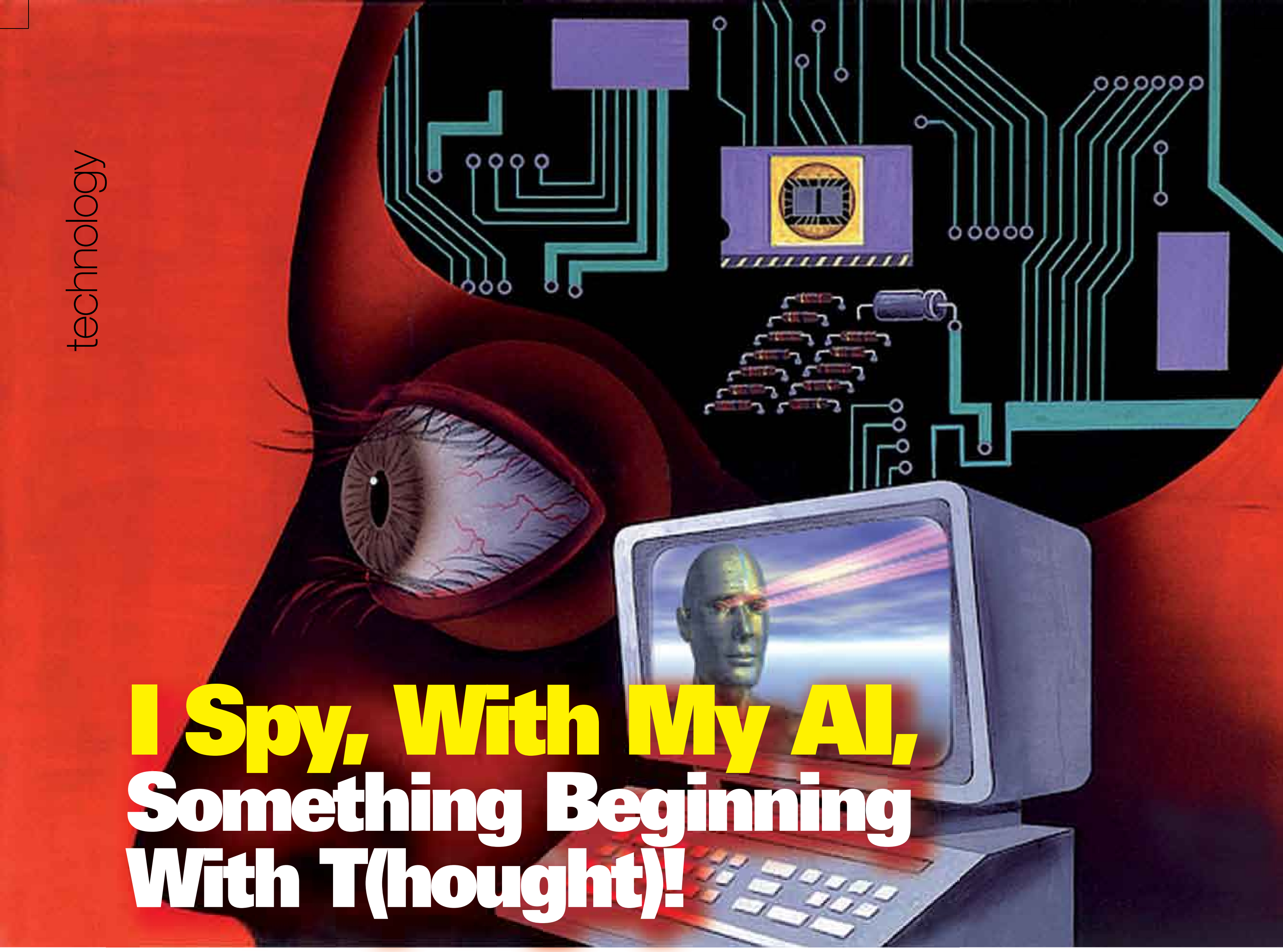

I Spy, With My AI, Something Beginning With T(hought)!

Finally, the last bastion seems all set to fall. It may come across as an invasion of privacy to some, but human-computer interface research has progressed into a new domain—your brain—as it seeks to create a gateway between you and your computer.

Apparently, the field of Human Computer Interface (HCI) is poised to give users new and enhanced performance from their computers. The latest HCI research, aimed at developing a brain-computer interface (BCI), draws on machine learning to create predictive models of the working of the human brain—an interesting and useful process.

HCI research, which focuses on improving a computer user's experience, depends significantly on enhancing the communication channel between humans and computers. To this end, both hardware and software have been adapted to accept more than keyed-in command inputs (voice instructions, for example), and generate output for various human sensory organs (like audible speech output). However, HCI also focuses on analysing these inputs to assess the user's mood, so that the computer can adjust its responses based on a user's mental or emotional state.

Towards mind-reading PCs?

Arguably, every human activity or state-of-mind is manifested in the brain, and tapping into this immensely complex organ would provide the fastest, most effective link for a computer to determine human intention.

For instance, a computer connected to our brain would know when we are feverishly working to complete a report, and when we sit back relaxed, satisfied at a job done well. It would mark this moment as an ideal time to serve us unread e-mail, in a specific priority order, instead of continuously signalling the arrival of incoming messages when our brains are already overtaxed.

Describing Microsoft researcher Eric Horvitz's efforts to build a computer that can read its user's mind, Clive Thompson wrote about an application of 'artificial smarts', to "…re-engineer our e-mail programs, our messaging, and even our phones, so that each tool would work like a personal butler—tiptoeing around us when things are hectic, and barging in only when our crises have passed."

This 'mind-reading' ability is made possible by sensors that are strategically placed on the scalp to read the electrical and chemical changes, corresponding to different thoughts that are taking place in the brain. The data streams picked up by these sensors are akin to the signals transmitted by the electrodes of an EEG (electroencephalograph) device. Machine-learning algorithms then build a model by analysing and classifying data pertaining to 'given' thoughts—including imagined movements—and subsequently test it for its efficacy as a predictive model of general (random) human thought processes.

EEGs help classify human tasks

A Microsoft research team working on *Using Electroencephalography (EEG) for Task Classification in Human-Computer Interaction Research* has achieved high success rates in this preliminary task of classification. Apparently, an experiment conducted in a realistic workplace setting yielded a 92.4 per cent accuracy rate in classifying three non-cognitive tasks—resting (or staring at a static screen), playing Halo (a computer game) alone, and playing the game with another player.

There are many challenges in using EEGs and similar wearable brain sensing technologies (e.g., functional near-infra-red spectroscopy, or fNIR) in HCI research. Speaking of these, Desney Tan, a researcher at Microsoft Research, opines, "The classic ones that are often articulated are: (a) attaining a deeper understanding of the brain and the specific process in which it generates thought, and (b) developing computational techniques that allow us to decode these thoughts, given a set of measurements (EEG, fNIR). These two obviously interact and move ahead in lockstep, and are important for progress in this field."

A brand new interface

Tan also explains a less well-articulated, but an equally important challenge within HCI—the designing of interfaces that take into account the specific properties of direct brain input. "Since many researchers are focused on the first two challenges articulated above, most research attempts to use direct input from the brain to control interfaces, have been designed and optimised for a mouse and keyboard. This is like fitting a square peg into a round hole. I think there are huge opportunities for us to design interfaces that are tailored to direct brain input, or in general, lower bandwidth devices, which have characteristics that are very different from our traditional input devices. Just as it took years after the mouse was invented in order for us to evolve our interfaces from purely command line systems to what we now know as the graphical user interface (GUI), which includes the desktop metaphor, selectable menus, a rich set of direct manipulation techniques, etc, so too, there remains a good deal of work to be done in crafting interfaces specifically to take advantage of BCIs. This is where we are focusing most of our efforts, here at Microsoft Research, finding the killer applications empowered by BCI as a novel input device, rather than trying to emulate existing systems," he says.

Empowering computer users

Eventually, Tan also says intelligent PCs would "…allow the user to increase the number of things they can effectively do," and would also help assess computer programs or systems, such as determining which require more intense concentration. Bearing in mind that this Microsoft team is aiming to create brain-wave detection devices costing less than $100 per computer, this could very well lead to a revolution of sorts in PC capabilities.

However, researchers such as Dr Gary Birch, an adjunct professor at the department of Electrical and Computer Engineering at UBC Canada, and the executive director of the Neil Squire Foundation, have a different goal in sight. They view the long-term objective of direct neural interface (as BCI is also known) research as the development of a multi-position, brain-controlled switch activated by signals measured directly from an individual's brain. Such a switch would be of greatest use to increase the independence of a severely disabled individual, whose range of motion is restricted.

According to Dr Birch, "The weakest link in utilising technology to help people with disabilities is the human-machine interface. It is the ability of someone with a disability to be able to control the technology that is the limiting factor, not the technology itself. The ideal interface would be to tap directly into the brain signals."

Do you think the way I do?

Perhaps the most noteworthy challenge faced by such research teams is the real-time processing of brain signals, picked up by an

EEG, to accurately control the PC. A computer's artificial intelligence, produced as a result of machine learning, may need further refinement by way of customisation for individual users—to take into account any signature brain patterns for specific thoughts, and to discount eye or other involuntary movements.

In fact, it is almost amazing to consider that the algorithms that are the outcome of this research would be useful across the board—that is, that we all think the same thought in a similar fashion! Has BCI research truly progressed to such an advanced extent? Tan believes that, "The state-of-the-art in BCIs is comparable to the early days in speech recognition research. BCI is currently a relatively young research field, and while it may seem a daunting task to find processing techniques that work robustly for long periods of time, or on large groups of people, I would project that as the field moves forward, we will get better and better. I do believe that the field requires some pretty big fundamental leaps in understanding, but have no doubt that these will be made. Speech recognition is still not perfect today, but it is pretty darn good, and there is no reason BCIs cannot one day be just as effective—or even more so."

Hands-free gaming for a good purpose

Having said that, Tan adds that he personally does not believe that BCIs will replace all physical input. "I do not at all expect that we will ever decide to give up our physicality in exchange for pure thought-based communication (even if this 'Matrix-like' prediction may be compelling to the science-fiction community and some popular press outlets). Instead, I see such devices being used in a set of niche scenarios, and as augmentations to standard physical communication devices. Games have traditionally pushed us to consider completely new usage paradigms (the Nintendo Wii is a great example), and gamers tend to be fairly tolerant of new technologies. As such, I would not be surprised if this were the domain in which we will see the initial mass adoption in BCIs. In fact, one could claim it is already starting to happen and researchers, as well as numerous commercial ventures, are already starting to push forward in this area," he says.

Dr Gary Birch, adjunct professor, Department of Electrical and Computer Engineering, UBC (Canada) and executive director, Neil Squire Foundation

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You cannot say that games don't represent an exciting use of real-time processing and translation (into commands) of users' thoughts, especially when these games serve the disabled. Interesting work in this field has already been done by research teams such as the MindGames group at Media Lab Europe. MindGames has created a series of signal processing and games for the disabled, such as Still Life. Still Life, developed in association with Dublin's Central Remedial Clinic (CRC), aims to encourage the physically impaired to keep up with physiotherapy. The system works by noting whether a certain movement is done correctly, in which case it rewards participants for their control, thus introducing some liveliness in what would otherwise be a dull physiotherapy session. This system also helps cater to more patients in situations when the services of physiotherapists are scarce. Yet another game developed by MindGames is Biomelodics, a game that uses musical biofeedback to help teach participants to control their heart rate.

Evidently, BCIs have immense potential in a huge range of human activity, from mundane desktop jobs to specialised medical uses. Irrespective of the sphere of application, it promises to take our interaction with computers to a new high—a high that interestingly, the 'intelligent' PC of tomorrow will detect as soon as it occurs! I.T.

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