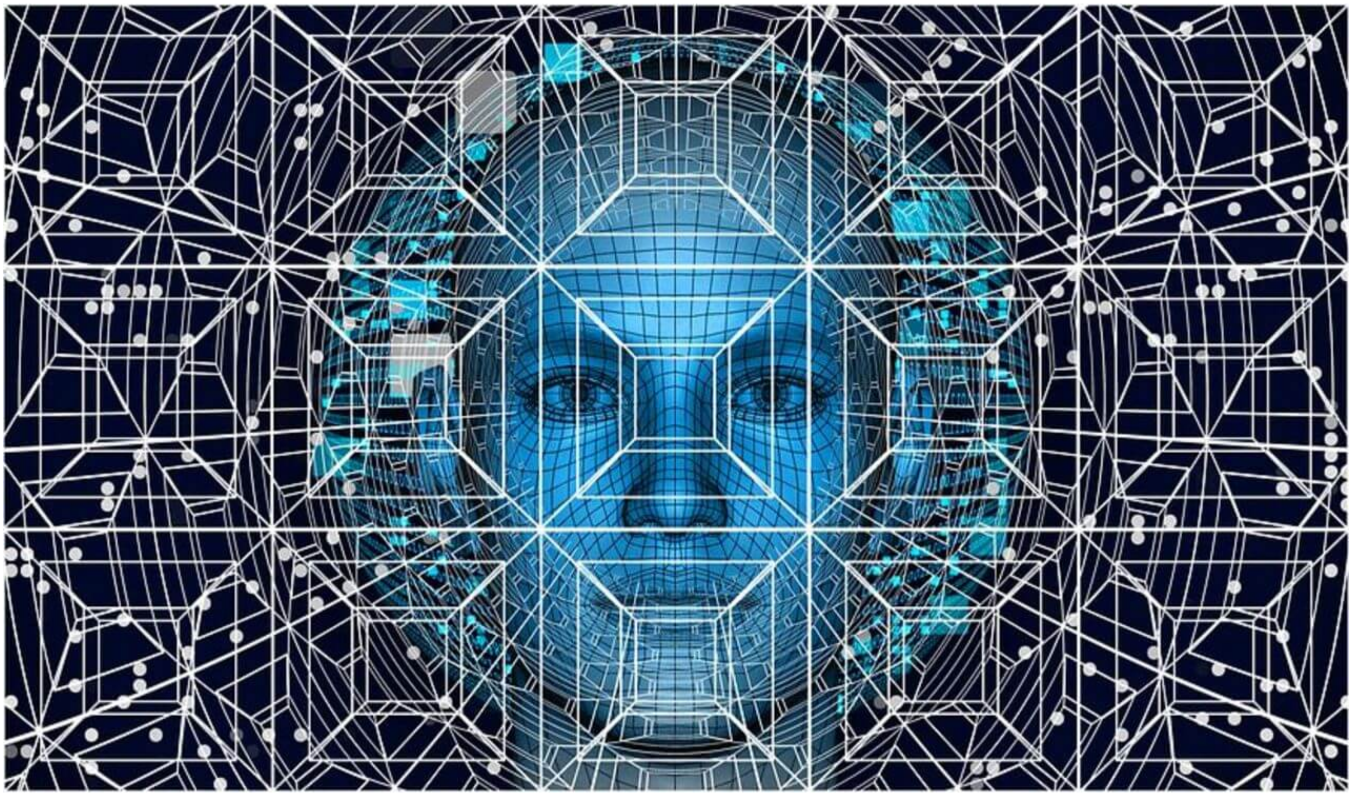
Tech Explained: Brain-Computer Interface



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You may be familiar with the sci-fi trope of a computer that is linked to a human brain. But this technology is actually closer to reality than many realise. Technology that creates a brain-computer interface (BCI) already exists, and could soon allow people to control robots and computers with thought alone. So how does BCI work, and what can it do?

The brain uses specialised cells called neurons to carry messages. Whenever we think, move, feel or remember something, small electrical signals are carried from neuron to neuron. These signals are generated by differences in electric potential carried by ions on the membrane of each neuron. It is possible to detect these electrical signals using a device called an electroencephalograph (EEG), which is attached to the scalp. A higher-resolution signal can also be received by implanting electrodes directly into the brain, although this requires invasive surgery and can have lasting negative consequences.

The EEG or electrodes measure the tiny differences in the voltage between neurons. These differences can then be interpreted by a computer algorithm and used to direct computers. For example, if a person thinks about moving their right arm, the signal is detected and then used to instruct a robot to move its right arm. Conversely, researchers can use an EEG to learn what signals are sent to the brain by the optic nerve when someone sees the colour blue. A camera could then be used to detect colours, and a signal could be sent directly to the brain of a blind person whenever the colour blue is detected. This would allow a blind person to “see” colour. In fact, Researchers are developing optical implants, connected to glasses with a small camera, which could restore sight to some blind people.

Another early use of BCI was the cochlear implant. In a normally-functioning ear, the vibration of sound waves are passed to the auditory nerves by small organs in the ear. If these organs become damaged, hearing loss may result, even though the auditory nerves are functioning perfectly well. For these people, a cochlear implant can be used to convert the sound waves into electric signals and send these directly to the auditory nerves.

Some of the most promising uses of BCI are to restore function to people who have lost it. For example, allowing someone who has lost a hand to control a robotic prosthesis using mental commands. This involves first 'teaching' the computer to understand the brain signals for movement. To do this, the user is fitted with an EEG or implant, and then visualises the movement they want to replicate, for example, opening their hand. Eventually, the software learns the signals associated with hand-opening.

These systems are already in use, but there are limitations. For one, the signal picked up by electrodes is weak and prone to interference. Something as simple as blinking can interfere with the signal. Also, the equipment used to read the signals from the brain is bulky. Although researchers are working to create much smaller and more portable equipment, there is still some way to go. The most difficult problem, however, is the complexity of the brain itself. There is still much that is not understood about how the brain works.

Takeaway: Researchers have already developed BCI that allows users to type their thoughts and to allow stroke victims to communicate emotions. As more research is done, these systems will become more sophisticated. Already in the works are BCI systems that can allow computers to speak words that users are thinking and control a Second Life avatar through thought. What other uses are there for BCI technology?