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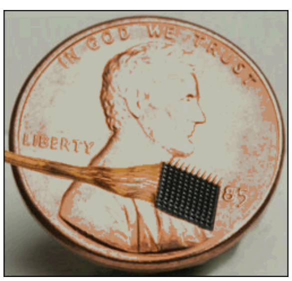
Brain-Computer Interfacing

A Brain-Computer Interface (BCI) is a method of communication based on neural activity, independent of its normal output pathways of nerves and muscles. It bypasses these systems and is inputted directly into a computer to be analyzed. The computer contains algorithms which take the data gathered and translate it into useful information. The neural signals are obtained by measuring action potentials which are fired when neurons want to communicate with each other. Action potentials are electrochemical voltages, which can be measured using electrodes.

These electrodes can be placed on the scalp or more effectively, implanted into the brain itself. Exterior electrode arrays consist of 20 electrodes placed around the entire skull. Because most fine neural processes are only .1 to 2 micrometers apart, the signal from these systems become hard to read. Therefor, researchers at the University of Utah have created an electrode array which can be implanted directly into the brain. The Utah Electrode Array is an array of microelectrodes which consists of a 4 mm by 4 mm base that contains 100 silicon spikes that are 1.0 or 1.5 mm long and each thinner than a human hair. Each electrode is connected to a thin gold wire that runs into the computer.



The silicon electrodes can read the electrical signal (impulses) of when and how neurons are fired.

Around 200,000 people live with partial or nearly total permanent paralysis in the United States. This technology can be very useful in treatment of paralysis as well as nervous system disorders, and missing / artificial limbs. The key is taping into the motor cortex of the brain.

The primary motor cortex, is the part of the brain that controls movement, and contains thousands of neurons. Each of these cells activates at a different intensity depending on the direction the subject intends to move its body. The direction in which a neuron fires fastest is called its "preferred direction" and using algorithms, the average of the preferred directions called the "population vector" can be obtained and used as a control signal.

The algorithms are a series of mathematical formulas, called linear filters that create a model that relates the firing of the specific neurons to a desired movement.

Most testing of this technology has been done on primates. University of Pittsburgh researchers have outfitted a monkey with a child-sized robotic arm controlled directly by its neural signals. It is able to feed itself chunks of fruits and vegetables. The neural prosthetic moves like a natural arm, with a fully mobile shoulder and elbow and a gripper that allows the monkey to grasp and hold food.

The leading company in this field is Cyberkinetics, headed by Dr. John Donoghue, a Brown University neuroscientist. They recently bought the Utah Electrode Array and combined it with their BrainGate system. The FDA has recently given permission for them to begin human testing. Matthew Nagle, a 25 year old quadriplegic is the first human to have the array implanted and implemented. He is able to play pong and control a computer mouse with his mind.

The next step for this technology is to become wireless and to also activate muscle tissue by completely bypassing a damaged nervous system. The US department of defense has given them a 25 million dollar grant in hopes to eventually develop technology that will allow pilots to control planes with their minds.

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