Controlling Computers With Neural Signals

Words to study:

remnant 残余，剩余
hand-free 无需用手的
induced 受诱使的
intact 未经触动的
prostheses 修复术
cursor 游标
metabolic 新陈代谢的
slumber 睡眠，微睡
physiological 理的，生理学的
analogous 类比的
contraction 收缩
blister 水疱
chloride 氯化物
electromyographic 电肌动描绘
corneal-retinal 角膜-视网膜的
electrooculographic 电眼动描绘仪
endoscopic 内窥镜

1. In the classic science-fiction movie Forbidden Planet, space travelers from Earth land on a distant world, where they encounter the remnants of a technologically advanced civilization. Remarkably, the human visitors are able to communicate with one of the alien computers that is still functioning. Connected through glowing head probes, the men's thoughts and feelings are directly conveyed to the machine over a neural link.

2. Many similar examples of people having their minds coupled to computers have appeared in other works of fiction. As often depicted, a person simply thinks of a command, and the computer immediately responds---a scheme analogous to the computer voice recognition in use today. ❶ Thought recognition would be the ultimate computer interface, the machine acting as an extension of the human nervous system itself.

3. Our work over the past decade has helped make such "hands free" control of computers a reality. ❷ Neural linkages with computers can now satisfy a variety of needs, and we expect that enterprising people will soon find additional ways to harness this technique. A view of what the future holds in store requires only some imagination--and a clear understanding of how past work has led to today's accomplishments.

The Body Electric

4. The electrical nature of the human nervous system---the basis for direct neural control of computers---has been recognized for more than a century. In 1849 the German physiologist Emil Heinrich Du Bois-Reymond first reported the detection of minute electrical discharges created by the contraction of the muscles in his arms. But he soon realized that the skin acted as a barrier to the underlying muscle signals. So this dedicated researcher induced a blister on each arm, removed the skin and placed the paper electrodes within the wounds. Du Bois-Reymond was then able to capture electrical signals that were about 30 times stronger than those he could obtain with the skin intact.

5. These early investigations built the foundation for a technique that serves well today to monitor muscle contractions.❸ With modern silver chloride electrodes and sensitive

electronic amplifiers, tiny muscle impulses---even those muted by passage through the skin---provide easily registered voltages. Medical researchers first exploited this phenomenon during the 1970s to devise mechanized prostheses that could operate by sensing muscle contractions. Other scientists realized that electrical impulses from active muscle fibers could also help people who suffered from diseases or injuries that left them too weak to move any of their limbs: they needed only to have lectrodes placed near unimpaired muscles. Following that strategy, even profoundly handicapped individuals can manipulate electronic equipment with the electrical signal from muscles (called an electromyographic signal, or EMG, a name borrowed from the term for a paper tracing of such impulses).

6. But people do not have to be physically impaired to benefit from the ability of muscle signals to control a computer. We are, for example, now experimenting with a hands-free EMG mouse. With it, a person can adjust the position of a cursor on the screen using, for example, forearm muscles. Such a device allows someone to move the cursor without having to lift a hand from the keyboard.

Unrecognized Potential

7. Another approach to controlling computers with biological signals depends on a completely different electrical phenomenon of the human body: the corneal-retinal potential. ❹ This signal arises because the retina, the site of most metabolic activity within the eye, exhibits a slight negative voltage compared with the cornea. In a sense, the eye acts as a weak electric battery. Electronic circuits can detect the tiny voltage fluctuations on a person's face that arise when the eyes shift in orientation. These impulses are called an electrooculographic signal, or EOG (the name for recordings made of them).

8. Measurement of EOG signals has served researchers for decades as a convenient indicator of eye movement in various physiological studies. In 1953, for example, Nathaniel Kleitman of the University of Chicago and Eugene Aserinsky of Jefferson Medical College in Philadelphia used EOG recordings to document eye movement during certain periods of sleep. ❺ These particular intervals were accompanied by intense brain activity similar to that of the awake state, and so the investigators distinguished this curious type of slumber by calling it rapid-eye-movement, or REM, sleep.

9. Tracking a person's gaze with EOG signals can be done so reliably that a number of groups are also attempting to integrate this mechanism in other settings. For instance, having collaborated with other researchers, physicians from Stanford University developed a way to adjust the fiber-optic cameras used during endoscopic surgery (procedures performed remotely, inside the body). An EOG device allows a doctor to change the camera's view with eye movements, while his or her hands are engaged in manipulating other surgical instruments.