TOWARDS A CLINICALLY PRACTICAL BRAIN-COMPUTER INTERFACE

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ABSTRACT

Nearly two million people in the United States have degenerative diseases that impair the neural pathways that control muscles. The most severely affected people lose all voluntary muscle control and become completely "locked in" to their bodies, unable to communicate in any way. Brain-computer interfaces (BCIs) can allow these individuals to communicate again by creating a new communication channel directly from the brain to an output device. Recent studies have shown that BCI technology can allow paralyzed people to share their intent with others, and thereby demonstrate that direct communication from the brain to the external world is possible and that it might serve useful functions.

While these technical demonstrations are encouraging, practical applications of BCI technology to the needs of people with severe disabilities are significantly impeded primarily by three issues. These are the limitations of current sensor technologies, the requirements implied by traditional signal processing approaches, and the non-intuitive tasks that have been used for BCI communication. Mainly due to these three issues have current BCI systems produced impressive laboratory demonstrations but no device of appreciable clinical value.

This dissertation set out to address these problems to work towards a BCI system that can leave the confines of laboratory research to address the actual communication and control needs of the severely paralyzed. The principal results demonstrate that the use of sensors placed on the surface of the brain has favorable characteristics compared to existing non-invasive and highly invasive sensors, that application of a novel signal processing procedure can reduce the substantial expert supervision that is currently required, and disprove the widespread assumption that the use of intuitive tasks requires electrodes that are implanted within the brain.

In summary, the results presented in this dissertation encompass three advances that are critical to the successful translation of brain-computer interface from their current state of primarily laboratory demonstrations into clinically practical communication and control devices for the paralyzed.