University of Michigan Direct Brain Interface: 2002 Update

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A direct brain interface (DBI) is a human computer interface that accepts commands directly from the brain without requiring physical movement. The University of Michigan Direct Brain Interface (UM−DBI) project seeks to detect voluntarily produced event−related potentials (ERPs) in human electrocorticogram (ECoG) as the basis for a DBI.

Research subjects are patients in one of two epilepsy surgery programs who have had subdural macro electrodes implanted for clinical purposes unrelated to the research objectives. The electrodes are 4 mm in diameter and arranged in grids or strips at distance of 1 cm center to center. Each subject has up to 126 subdural electrodes.

Subjects perform simple voluntary movements in a self−paced (non−prompted) manner with at least 4 seconds separating each repetition of the movement. Each dataset contains ECoG related to approximately 50 repetitions of the same action from each recording electrode. An ECoG database with data from 29 subjects has been compiled. Most previous work relied on off−line processing which necessitated the use of movement−related ERPs (instead of preferable motor imagery ERPs) so that movement onset (the trigger point) could be determined from muscle activity or another similar indicator and used to determine detection accuracy. A limited number of on−line experiments employing feedback protocols have also been performed and are reported separately (see Huggins et al. , 2002 in these proceedings).

The basic detection method used by the UM−DBI has been a cross−correlation based template matching method. Triggered averaging of the ECoG from the first half of a dataset is used to create templates of the ECoG corresponding to the action. A template showing a distinct ERP is then selected and cross−correlation is performed with the ECoG from the second half of the dataset (the test data). Detections are defined when the cross−correlation value exceeds an experimentally determined threshold. Valid detections (hits) are defined to be within 1 second before and 0.25 seconds after a trigger point. Detections outside this time interval are considered false positives. Detection accuracy is quantified by the hit percentage, which is the percentage of trigger points in the test data that were detected, and the false positive percentage, which is the percentage of the detections which are false positives.

The most accurate off−line single channel detections have been 96% hits with 0% false positives and 100% hits with 4% false positives. Multiple channel detection methods have resulted in a detection accuracy of 100% with 0% false positives in some trials. In preliminary feedback experiments, 3 of 6 subjects were able to significantly improve the SNR of the selected ERP with the best subject also improving detection accuracy from 79% hits with 22% false positives to 100% hits and 0% false positives.

Current work is focused in two general areas, improved signal processing techniques and feedback experiments, both aimed at increased detection accuracy. Work on signal processing techniques is being addressed by analyzing the underlying assumptions about ECoG signal characteristics in the current detection model and exploring means for improvement (see Sowers et al., 2002 in these proceedings). Additionally, detection methods based on event−related desynchronization and event−related synchronization are being explored and the implications of combining these methods with the cross−correlation based template matching method are being evaluated (see Graimann et al., 2002 in these proceedings). A new experimental feedback system is being designed which will provide feedback based on the cross−correlation value instead of on the SNR. This feedback system will include a range of feedback programs that will start by providing the subject with basic feedback on the cross−correlation value and progress through several training steps to simulated operation of a communication system.