UNIVERSITY OF MICHIGAN DIRECT BRAIN INTERFACE: 2005 UPDATE

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The University of Michigan Direct Brain Interface (UM-DBI) project is pursuing the development of a brain-computer interface for the operation of assistive technologies based on the detection of event-related activity in human electrocorticogram (ECoG). Types of activity utilized include both event-related potentials (ERPs) and event-related desynchronization and synchronization (ERD/ERS). Research subjects are patients in epilepsy surgery programs who have subdural electrodes implanted for clinical purposes unrelated to the research objectives. Movement-related activities (instead of preferred motor imagery activity) have until recently been used for documentation of movement onset in order to assess detection accuracy during off-line analysis. The target interface is an asynchronously operated momentary switch that could replace a mechanical switch for operation of assistive technologies.

The UM-DBI project is composed of three components: development of signal processing and detection methods through off-line analysis of recorded data, on-line functional evaluation and feedback experiments, and functional magnetic resonance imaging (fMRI) studies.

An ECoG database has been accumulated for the development and testing of algorithms off-line. This data base includes 352 datasets, from 44 subjects. Each dataset contains recordings from 15 to126 subdural electrodes made while subjects performed approximately 50 repetitions of a voluntary action. In total, there are over 15,000 ECoG recordings from subdural electrodes in the database. The current detection method is a quadratic detector based on a two co-variance signal model (QUAD) (see Chun, et al. 2005 in these proceedings). The QUAD method provides improved detection accuracy along with improved response time over our previous cross-correlation template matching (CCTM) method which has been previously described (Levine, et al., 2000).

On-line feedback experiments examine the ability of subjects to learn to operate the direct brain interface. To date, feedback experiments have been based on the CCTM method. Some subjects have been able to improve their operation of the system during the two hour feedback session with one subject improving DBI operation from 90% hits with 45% false positives to 90% hits with 10% false positives (Levine, et al., 2003). Another subject was able to transition from operation of the interface using actual tongue movements with 90% hits and 13.5% false positives to operation using imagined tongue movements with 82% hits and 16.3% false positives. Upcoming experiments will utilize the QUAD detection method to improve accuracy and interface response time in experiments utilizing imagined movements.

FMRI experiments are intended to evaluate the feasibility of using fMRI to plan the placement of electrodes for operation of a DBI. Two subjects who had previously participated in ECoG experiments performed both actual and imagined movements during fMRI scanning. Some agreement was found between the modalities, but many outliers exist. Confounding factors in the comparison included extended time (average 16.5 months) and surgical resection between ECoG and fMRI recording (Swaminathan, et al., 2004). Therefore, future subjects will participate in fMRI scanning prior to ECoG recording.

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