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Tensor based decoding of brain neuronal activity for Brain Computer Interface project in CLINATEC

Abstract

Motor Brain Computer Interface (BCI) records brain neuronal signals and converts them to commands for external effectors. Thanks to this, handicapped persons can mentally control a computer cursor, a wheelchair, a robotic arm, an exoskeleton, etc.

BCI project in CLINATEC is based on novel technologies developed at CEA-LETI in the CLINATEC research center. CLINATEC® BCI platform includes a fully-implantable Electrocorticographic (ECoG) recording system, a software environment, signal decoding algorithms, and a 4-limbs exoskeleton EMY (Enhancing MobilitY) dedicated to medical use. ECoG recording systems use electrode grids placed over the cortical surface. ECoG recording device WIMAGINE® has been designed in CLINATEC and manufactured following EC norms for chronic use. Signal processing block is designed to analyze ECoG recordings of tetraplegic subjects during clinical trials.

High performance decoding of brain neuronal activity is a key point for successful BCI. Multi-way (tensor based) analysis was used for limbs trajectories reconstruction. A set of algorithms was invented to respond to BCI challenges of stable, artifact resistant, smooth prediction. Recursive N-way PLS is developed for adaptive BCI system calibration. Penalized NPLS aimed at electrodes and frequency band selection allows group-wise sparsity. Tensor based approach allows simultaneous data analysis in several domains. Generally, it increases the dimension of the analyzed data (up to 200.000 in CLINATEC® BCI project). Efficient algorithms implementation for real-time brain signal processing ensures high decision rate (10Hz) and minimal system latency. Methods were validated in both invasive (ECoG) preclinical experiments and non-invasive (MEG) BCI study.