An Automatic and Improved MEG Method for Diagnosing and Monitoring of Neuronal and Psychiatric Disorders with a Novel Approach for Removing Correlated Noises

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BACKGROUND

Traumatic brain injury (TBI) is a leading cause of sustained impairment in military and

civilian populations. However, mild (and some moderate) TBI can be difficult to diagnose, with only a ~10% positive-finding rate when using conventional neuroimaging methods of CT and MRI. The diffusion tensor imaging (DTI), which is still under development, has a positive-finding rate of ~20-30% in mild TBI patients.

Furthermore pre-surgical functional brain mapping of the brain regions mediating sensation, movement, and language can facilitate surgical planning and reduce function loss.

TECHNOLOGY DESCRIPTION

UCSD researchers have developed a sensitive and automated diagnostic method using magnetoencephalography (MEG) to detect loci of neuronal injury and abnormal neuronal networks, not visible with CT and MRI. The invention is a fast MEG source imaging technique based on a Vector-based Spatial-Temporal Analysis for L1-minimum-norm solution, (namely Fast-VESTAL) to obtain the source amplitude images of resting-state MEG signals for different frequency bands. The Fast-VESTAL technique consists of two steps: 1) obtain L1-minimum-norm MEG source images for the dominant spatial modes of sensor-waveform covariance matrix, and 2) obtain accurate source time-courses with millisecond temporal resolution, using an inverse operator constructed from the spatial source images of Step 1.

Localizing normal and abnormal resting-state human brain signals: TBI patients generate abnormal low-frequency magnetic activity (ALFMA, peaked at 1–4 Hz) that can be measured and localized by magnetoencephalography (MEG). By applying the fast -VESTAL to selectively process the ALFMA frequency-domain, one only need to analyze the complicated MEG source signal for a few frequency bins instead of thousands of time samples in a given time window. MEG slow-wave source imaging is substantially more sensitive to mild TBI than CT, MRI, and DTI. The positive detection rate of mild TBI was 87% using MEG slow-wave source imaging for ALFMA (Huang et al., 2012). A whole brain normative database was also established for all different frequency bands (alpha band 8-12Hz, beta band 15-30 Hz, gamma band 30-100 Hz, theta band 4-7 Hz, and delta band 1-4 Hz). Using Fast-VESTAL, the first set of source images have been obtained for all the neuronal generators in the above frequency bands (Huang et al., 2014), since Hans Berger discovered the human alpha wave in 1924.

Localizing normal and abnormal brain functions in evoked brain responses for pre-surgical functional brain mapping: The application of Fast-VESTAL to human MEG median-nerve responses further demonstrated its power in reconstructing source time-courses that were highly consistent with known electrophysiology of the human somatosensory system. Fast-VESTAL provided the first set of comprehensive MEG source-amplitude images that covered the entire brain in standard atlas coordinates for different frequency bands of resting-state signals and the Fast-VESTAL solution with a low computational cost. In addition, a new objective pre-whitening method, OPWM, when used in conjunction with the Fast-VESTAL provides a novel approach to remove correlated noises.In addition to the somatosensory function, Fast-VESTAL has also been used to examine the receptive and expressive language areas (i.e., Wernicke and Broca's areas) as well as motor areas in many pre-surgical patients.

CONTACT

University of California, San Diego
Office of Innovation and Commercialization
innovation@ucsd.edu
tel: 858.534.5815.

OTHER INFORMATION

KEYWORDS

MEG, Magnetoencephalography, Traumatic brain injury, Slow-wave, Blast, Motor Vehicle Accident, Sport Injury, Alzheimer's, Post-traumatic Stress Disorder, PTSD, Neuronal, Psychiatric Disorders, VESTA

CATEGORIZED AS

- **Medical**
  - Diagnostics
  - Disease: Central Nervous System
  - Imaging

RELATED CASES

2014-024-0, 2012-354-0, 2010-340-0

ADVANTAGES

1) Extremely low computational costs;

2) Ability to localize and resolve a large number (up the limit determined by the number of MEG sensors) of focal and distributed neuronal sources with any degrees of correlations;

3) Ability to obtain accurate source time-courses, and hence the accurate source-based functional connectivity at poor SNR conditions, even at SNRs in the negative dB ranges;

4) Extremely low in the signal leakage of the Fast-VESTAL solution to other areas where no sources exist;

5) Facilitating imaging registration and group analysis by providing voxel-based whole brain imaging of MEG signal;

6) Improved sensitivity of detecting injuries and abnormalities in mild TBI and PTSD.

APPLICATIONS

Diagnosis and monitoring of patients with:

• mild and moderate TBI due to blast and non-blast causes; and

• other neuronal and psychiatric disorders, especially the early stages of the disorders, including but not limited to Alzheimer's, dementia, multiple sclerosis, autism, schizophrenia, post-traumatic stress disorder (PTSD).

RELATED MATERIALS

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PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,433,742	10/19/2019	2014-024
United States Of America	Issued Patent	9,883,812	02/06/2018	2010-340

University of California, San Diego
Office of Innovation and Commercialization
9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910

Tel: 858.534.5815
innovation@ucsd.edu
https://innovation.ucsd.edu
Fax: 858.534.7345