Abstract

To understand "Working of Human Brain", measurements related to the brain function are required. These measurements should be possibly non-invasive. Brain should be disturbed as less as possible during the measurement. Integration of various modalities plays a vital role in understanding the cognitive and the behavioral changes in the human brain. It is an important source of converging evidence about specific aspects of neural functions and dysfunctions under certain pathological conditions. Focal changes in cortical blood flow are tightly coupled with the changes in neuronal activity. This constitutes the option to map the hemodynamic response and infer principles of the cortical processing, even of complex tasks. The very high temporal resolution of EEG and good spatial resolution by NIRS make this concurrent measurement unique to study the spatio-temporal dynamics of large scale neuronal networks in the human brain. Such integration of two techniques will help to overcome the limitations of a specific method. Such as insensitivity of electroencephalogram (EEG) to unsynchronized neural events or lack of near infrared spectroscopy (NIRS) to low metabolic demand. A combination of EEG and NIRS will be more informative than the two separate analyses in both modalities.
- Gary Strangman, David A. Boas, and Jeffrey P. Sutton, "Non-Invasive Neuroimaging Using Near-Infrared Light", Society of Biological Psychiatry, Vol 52:679–693, 2005.
- A. W. Toga, P. M. Thompson, "The Role of Image Registration in Brain Mapping", Image and Vision Computing 19 (2001) 3–24.
- T. S. Koh, Z. Hou, "A Numerical Method for Estimating Blood Flow by Dynamic Functional Imaging", Medical Engineering & Physics 24 (2002) 151–158.
- Ripen Misri, Dominik Meier, Andrew C. Yung, Piotr Kozlowski, Urs O. Häfeli, "Development and Evaluation of a Dual-Modality (MRI/SPECT) Molecular Imaging Bioprobe", Nanotechnology, Biology, and Medicine xx (2011) xxx–xxx (Article is in Press).
- Augusto Buchweitz, Robert A. Mason, Léda M. B. Tomitch and Marcel Adam Just, "Brain Activation for Reading and Listening Comprehension: An fMRI Study of Modality Effects and Individual Differences in Language Comprehension", Psychology & Neuroscience, 2009, 2, 2, 111 – 123.
- Peter T Fox, Marty G Woldorff, "Integrating Human Brain Maps", Current Opinion in Neurobiology 1994, 4:151-156.
- H. Laufs, A. Kleinschmidt, A. Beyerle, E. Eger, A. Salek-Haddadi, C. Preibisch, K. Krakow, "EEG-correlated fMRI of Human Alpha Activity", H. Laufs et al. / NeuImage 19 (2003) 1463–1476.
- Sarah J. Erickson, Anuradha Godavarty, "Hand-held Based Near-infrared Optical Imaging Devices: A Review", Medical Engineering & Physics 31 (2009) 495–509.
- H. Matsuyama, H. Asama, and M. Otake, "Design of differential Near-Infrared Spectroscopy based Brain Machine Interface", The 18th IEEE International Symposium on Robot and Human Interactive Communication Toyama, Japan, Sept. 27-Oct. 2, 2009.
- Farzin Irani, Steven M. Platek, Scott Bunce, Anthony C. Ruocco, Douglas Chute, "Functional Near Infrared Spectroscopy (fNIRS): An Emerging Neuroimaging Technology with Important Applications for the Study of Brain Disorders", The Clinical Neuropsychologist, Volume 21, Issue 1 January 2007, pages 9 – 37.
- Tomi Heinonen, Antti Lahtinen, Veikko Hakkinen, "Implementation of Three-Dimensional EEG Brain Mapping", Computers and Biomedical Research 32, 123–131 (1999).
- Mark E. Pflieger, Randall L. Barbour, "Multimodal Integration of fMRI, EEG, and NIRS".
- D. Mantini, L. Marzetti, M. Corbetta, G. L. Romani, C. Del Gratta, "Multimodal Integration of fMRI and EEG Data for High Spatial and Temporal Resolution Analysis of Brain Networks", Brain Topogr (2010) 23:150–158.
- N. Nagdyman, T. P. K. Fleck, P. Ewert, H. Abdul-Khaliq, M. Redlin, P. E. Lange, "Cerebral oxygenation measured by near-infrared spectroscopy during circulatory arrest and cardiopulmonary resuscitation", British Journal of Anaesthesia 91 (3): 438±42 (2003).
- R. Labounek, M. Lamoš, R. Mare?ek, J. Jan, "Analysis of Connections between
Simultaneous EEG and fMRI Data; IWSSIP 2012, 11-13 April 2012, Vienna, Austria, ISBN 978-3-200-02328-4.

- Herve’ F. Achigui, Mohamad Sawan, Christian J. B. Fayomi; A monolithic Based NIRS Front-end Wireless Sensor; Microelectronics Journal 39 (2008) 1209–1217.
- Emily B. J. Coffey, Anne-Marie Brouwer, Ellen S. Wilschut, Jan B. F. van Erp; Brain–Machine Interfaces In Space: Using Spontaneous Rather Than Intentionally Generated Brain Signals; Acta Astronautica 67 (2010) 1–11, doi:10. 1016/j. actaastro. 2009. 12. 016.
- Nivedita Daimiwal, M Sundhararajan, Revati Shriram; Applications of fMRI for Brain Mapping; (IJCISIS) International Journal of Computer Science and Information Security, Vol. 10, No. 11, November 2012.
- Stephane Perrey, Thibaud Thedon, Thomas Rupp; NIRS in ergonomics: Its application in industry for promotion of health and human performance at work; International Journal of Industrial Ergonomics 40 (2010) 185–189.
- Siamac Fazli, Jan Mehnert, Jens Steinbrink, Gabriel Curio, Arno Villringer, Klaus-Robert Muller, Benjamin Blankertz; Enhanced Performance By A Hybrid NIRS–EEG Brain Computer Interface; NeuroImage 59 (2012) 519–529.
- Katarzyna Blinowska, Gernot Muller-Putz, Vera Kaiser, Laura Astolfi, Katrien Vanderperren, Sabine Van Huffel, Louis Lemieux; Multimodal Imaging of Human Brain Activity: Rational, Biophysical Aspects and Modes of Integration; Computational Intelligence and Neuroscience Volume 2009, doi: 10.1155/2009/813607.
- Maha Khachab, Chafic Mokbel, Salim Kaakour, Nicolas Saliba and Gérard Chollet; Brain Imaging and Machine Learning for Brain-Computer Interface; Biomedical Imaging, In-Tech, ISBN 978-953-307-071-1.
- Elizabeth M. C. Hillman; Optical Brain Imaging In Vivo: Techniques And Applications From Animal To Man; Journal of Biomedical Optics 12_5_, 051402 _September/October 2007.
- I. Kida, F. Hyder et al. (2001): Inhibition Of Voltage-Dependent Sodium Channels Suppresses The Functional Magnetic Resonance Imaging Response To Forepaw Somatosensory Activation In Rodent; J. Cereb. Blood Metab., 21: 585-591.
- P. L. Nunez, R. B. Silberstein (2000): On The Relationship Of Synaptic Activity To Macroscopic Measurements: Does Co-Registration Of EEG With Fmri Make Sense?; Brain Topogr., 13: 79-96.
- J. Daunizeau, H. Laufs & K. Friston; EEG-fMRI Information Fusion: Biophysics And Data Analysis; Institute of Neurology, UCL.
- Amita, Ishikawa, Kohno, Miyai, Oda, Seiyama, Shimizu and Tsuneishi; Removal of the Skin Blood Flow Artifact in Functional Near-Infrared Spectroscopic Imaging Data through Independent Component Analysis; J. of Biomedical Optics, 12(6) 062111, Dec 2007.
- Revati Shriram, M. Sundhararajan, Nivedita Daimiwal; Brain Connectivity Analysis Methods for Better Understanding of Coupling; (IJCISIS) International Journal of Computer Science and Information Security, Vol. 10, No. 11, November 2012.
- Ranganatha Sitaram, Haihong Zhang, Cuntai Guan, Manoj Thulasidas, Yoko Hoshi, Akihiro Ishikawa, Koji Shimizu and Niels Birbaumer; Temporal Classification of Multichannel Near-Infrared Spectroscopy Signals of Motor Imagery for Developing A Brain–Computer Interface; NeuroImage 34 (2007) 1416–1427.
- Dean Cvetkovic, Elif Derya Übeyli, Irena Cosic; Wavelet Transform Feature...
Extraction From Human PPG, ECG, And EEG Signal Responses To ELF PEMF Exposures: A Pilot Study; Digital Signal Processing 18 (2008) 861–874
- S. Deivanayagi, M. Manivannan, Peter Fernandez, "Spectral Analysis Of EEG Signals During Hypnosis;" International Journal of Systemics, Cybernetics and Informatics (ISSN 0973-4864), 2007.
- Aapo Hyv"arinen, Pavan Ramkumar, Lauri Parkkonen, Riitta Hari, "Independent Component Analysis of Short-Time Fourier Transforms For Spontaneous EEG/MEG Analysis;" Elsevier, 2009.

**Index Terms**

Computer Science

Signal Processing

**Keywords**

EEG  NIRS  Brain Mapping  Imaging  ICA  SVM  Spectral Analysis