OJMI > Vol.2 No.4, December 2012

OPEN ACCESS

Detecting the Stable, Observable and Controllable States of the Human Brain Dynamics

PDF (Size:1157KB) PP. 128-136 DOI: 10.4236/ojmi.2012.24024

Author(s)

Ehsan Kamrani, Armin N. Foroushani, Mohsen Vaziripour, Mohamad Sawan

ABSTRACT

A new technique is proposed in this paper for real-time monitoring of brain neural activity based on the balloon model. A continuous-discrete extended Kalman filter is used to estimate the nonlinear model states. The stability, controlla- bility and observability of the proposed model are described based on the simulation and measured clinical data analysis. By introducing the controllable and observable states of the hemodynamic signal we have developed a numerical tech- nique to validate and compare the impact of brain signal parameters affecting on BOLD signal variation. This model increases significantly the signal-to-noise-ratio (SNR) and the speed of brain signal processing. A linear-quadratic regulator (LQR) also has been introduced for optimal control of the model.

KEYWORDS

BOLD Signal; Hemodynamics; Controllability and Observability; FNIRS; Brain Imaging; Brain Dynamics

Cite this paper

E. Kamrani, A. Foroushani, M. Vaziripour and M. Sawan, "Detecting the Stable, Observable and Controllable States of the Human Brain Dynamics," *Open Journal of Medical Imaging*, Vol. 2 No. 4, 2012, pp. 128-136. doi: 10.4236/ojmi.2012.24024.

References

[1] E. Kamrani and M. Sawan, "Fully Integrated CMOS Avalanche Photodiode and Distributed-Gain TIA for CW-FNIRS," Proceeding of the IEEE Biomedical Circuits and Systems Conference, San Diego, 19 December, 2011, pp. 317320. doi: 10.1109/BioCAS.2011.6107791

[2] T. Obata, T. T. Liu, K. L. Miller, W.-M. Luh, E. C. Wong, L. R. Frank and R. B. Buxton, "Dispercencies between BOLD and Flow Dynamicsin Primary and Supplementary Motor Areas: Application of the Balloon Model to the Interpretation of BOLD Transients," NeuroImage, Vol. 21, No. 1, 2004, pp. 144-153. doi:10.1016/j.neuroimage.2003.08.040

[3] K. J. Fritson, O. Josephs, G. Rees and R. Turner, "Nonlinear Eventrelated Responses in FMRI," Magnetic Resonance in Medicine, Vol. 39, No. 1, 1998, pp. 41-52. doi:10.1002/mrm.1910390109

[4] K. J. Fritson, P. Jezzard, R. Turner, et al., "Analysis of Functional MRI Time Series," Human Brain Mapping, Vol. 1, No. 1, 1994, pp. 153-171.

[5] N. K. Logothetis, J. Pauls, M. Augath, T. Trinath and Oeltermann, "Neurophysiological Investigation of the Basis of the FMRI Signal," Nature, Vol. 412, No. 6843, 2001, pp. 150-157. doi:10.1038/35084005

[6] J. Daunizeau, S. J. Kiebel and K. J. Friston, "Dynamic Causal Modelling of Distributed Electromagnetic Responses," NeuroImage, Vol. 47, No. 2, 2009, pp. 590-601. doi:10.1016/j.neuroimage.2009.04.062

[7] R. Buxton, E. Wong and L. Frank, "Dynamics of Blood Flow and Oxygenation Changes during Brain Activation: The Balloon Model," Magnetic Resonance in Medicine, Vol. 39, No. 6, 1998, pp. 855-864. doi:10.1002/mrm.1910390602

OJMI Subscription
Most popular papers in OJMI
About OJMI News
Frequently Asked Questions
Recommend to Peers
Recommend to Library
Contact Us

[8] Y. Kong, et al., "A Model of the Dynamic Relationship between Blood Flow and Volume Changes during Brain Activation," Journal of Cerebral Blood Flow & Metabolism, Vol. 24, No. 12, 2004, pp. 1382-1392. doi:10.1097/01.WCB.0000141500.74439.53

[9] K. J. Friston, A. Mechelli, R. Turner and C. J. Price, "Nonlinear Responses in FMRI: The Balloon Model, Volterra Kernels, and Other Hemodynamics," NeuroImage, Vol. 12, No. 4, 2000, pp. 466-477. doi:10.1006/nimg.2000.0630

[10] T. Deneux and O. Faugeras, "Using Nonlinear Models in FMRI Data Analysis: Model Selection and Activation Detection," NeuroImage, Vol. 32, No. 4, 2006, pp. 16691689. doi:10.1016/j.neuroimage.2006.03.006

[11] I. T. Hettiarachchi, P. N. Pathirana and P. Brotchie, "A State Space Based Approach in Non-Linear Hemodynamic Response Modeling with FMRI Data," IEEE Conference on Engineering in Medicine and Biology Society, Buenos Aires,11 November 2010, pp. 2391-2394. doi:10.1109/IEMBS.2010.5627400

[12] R. B. Buxton, K. Uluda?, D. J. Dubowitz and T.T. Liu, "Modeling the Hemodynamic Response to Brain Activation," NeuroImage, Vol. 23, Suppl. 1, 2004, pp. S220-S233. doi:10.1016/j.neuroimage.2004.07.013

[13] F. Javed, et al., "Recent Advances in the Monitoring and Control of Haemodynamic Variables during Haemodialysis: A Review," Physiological Measurement, Vol. 33, No. 1, 2012, pp. R1-R31.