Editorial

Frontiers in BIOMEDICAL TECHNOLOGIES

Functional Neuroimaging: An Emerging Technology in Basic Research and Clinic

Gholam-Ali Hossein-Zadeh

School of Electrical and Computer Engineering, College of Engineering, University of Tehran, Tehran, Iran

Received: 06 July 2019

Accepted: 25 July 2019

http://FBT.tums.ac.ir

1. Introduction

Like other parts of the human body, brain has been threatened by various diseases and disorders. In addition to its strong protection by skull bone, the complexity of its function made the brain one of the less known organs of human body. Moreover the brain is the source of intelligence in the hierarchy of human actions and decoding the brain function is a golden target for artificial intelligence.

The discovery of the brain structure and function so far is based on several core modalities. I will try to cover the basic techniques of functional neuroimaging here, to highlight the advantages and limitations and also give a perspective on their future applications.

2. Neuroimaging Techniques, their Featured Abilities, Applications and Future Perspective

Shortly after its application in medical imaging, Magnetic Resonance Imaging (MRI) became a favorite modality to examine the brain structure due to its superb contrast and resolution for brain tissues. It is still the best modality to diagnose structural changes in the brain due to Multiple Sclerosis (MS), Tumors, Stroke, etc. It was in the beginning of 1990 decade that Ogawa invented the Blood Oxygenation Level-Dependent (BOLD) technique to make MRI sensitive to brain activity, as named later as functional MRI [1]. Now a day function Magnetic Resonance Imaging (fMRI) is the most popular technique of brain mapping. It is currently used for language mapping, motor mapping, memory mapping in presurgical planning as a new clinical routine based on brain mapping. Fundamental researches are taking place in neuroscience labs to identify the brain functional organization in various cognitive abilities like emotions, audition, vision, etc. It seems that fMRI will continue its clinical applications in presurgical mapping, and will have a more clear and applicable role in neuropsychological evaluations [1]. From the technical side, ultrafast imaging protocols and very high field MRI machines push the temporal and spatial resolution of this technology forward.

Electroencephalogram (EEG) has been used to record the electrical potentials of brain activity over the scalp. Emergence of new connectivity analysis and source localization analysis on high density EEG, make the EEG as a brain mapping technique. It can capture the temporal dynamic of brain activity whereas it suffers from the spatial resolution inside the brain [2]. Simultaneous acquisition of EEG and fMRI created some hopes to create brain maps with both spatial and temporal precision but still waiting for an effective fusion approach of data. A common clinical substrate of EEG-fMRI is source localization for epilepsy. It is noteworthy that the portability, price, and accessibility of EEG still make it as the first choice for some neuroscientific

Corresponding Author:
Gholam-Ali Hossein-Zadeh, PhD
School of Electrical and Computer Engineering, College of Engineering, University of Tehran, Tehran, Iran
Tel: (+98) 2182084178
Email: ghzadeh@ut.ac.ir

evaluations. If access to huge QEEG data becomes possible, the big data analysis and emerging artificial intelligence may offer new standards for health and psychology.

Using the emitted gamma rays from radionuclide tracers injected to brain is a unique technique for quantifying the brain function. This is due to the fact that brain activity and metabolism modulate the concentration of radionuclides, which produces contrast when compared to baseline images [3]. Ignoring its hazards due to ionizing radiation, PET provides very good spatial resolution and poor temporal resolution (speed), and unique specificity and sensitivity due to the selectivity mechanism of radiotracers. Although emergence of new PET-scanners like HRRT scanners improved the performance of this modality but the applications of PET in neuroimaging remains limited due to its safety issue and ultra-high cost.

Functional Near Infra Red Spectroscopy (fNIRS) is recently developed for brain studies. It is capable of measuring the concentration of oxyhemoglobin and deoxyhemoglobin of cortex especially near to hairless parts of the head. Although it is restricted by the slowness of hemodynamic response, but it offers better temporal resolution than fMRI. fNIRS is a relatively low cost and potable technology of brain mapping. It has many promising application in hemodynamic evaluation of other body parts. It is compatible with other neuroimaging modalities thus a very good candidate for multi modal studies. This technology will grow faster in the fields of brain computer interface and clinical evaluations.

Another bunch of brain mapping techniques are based on brain stimulation. They can be used not only for mapping and exploring the brain function, but also for intervention, treatment or enhancement of brain function [4]. Specifically Transcranial Magnetic Stimulation (TMS) is an FDA approved treatment for drug-resistant depression. TMS nowadays is used in many clinical and basic researches on tinnitus, food craving, drug craving, Migren, etc. Another complement modality of brain stimulation is Transcranial Current Stimulation (TCS). It uses injection of very small electrical currents in to the brain to enhance or suppress the excitability of cortex. TMS and TCS provide a very exciting approach in neuroscience called “close loop neuroscience” [4]. Using mechanisms of interventions (like neurofeedback, and brain electromagnetic stimulation) one may change the brain function and then by neuroimaging techniques like EEG, fMRI or fNIRS observe the resulted change. This provides a closed loop to control the brain function. Although closed loop neuroscience is in its beginning, it is a very promising approach in the clinical neuroscience and rehabilitation.

3. Conclusion

I hope that this “Frontiers in Biomedical Technology” special issue will enrich the understanding of new developments in brain mapping applications and techniques and promote the field with the help of all the authors. We give our acknowledgment to all authors, and to the reviewers who have contributed by improving and clarifying these diverse contributions through their valuable comments. Finally, we are grateful to the editor and executive team for their efforts.

References

1- M. J. Singleton, "Functional magnetic resonance imaging," *The Yale journal of biology and medicine*, vol. 82, no. 4, p. 233, 2009.

2- J. J. Heisz and A. R. McIntosh, "Applications of EEG neuroimaging data: Event-related potentials, spectral power, and multiscale entropy," *JoVE (Journal of Visualized Experiments)*, no. 76, p. e50131, 2013.

3- I. Nasrallah and J. Dubroff, "An overview of PET neuroimaging," in *Seminars in nuclear medicine*, 2013, vol. 43, no. 6, pp. 449-461: Elsevier.

4- C. Zrenner, P. Belardinelli, F. Müller-Dahlhaus, and U. Ziemann, "Closed-loop neuroscience and non-invasive brain stimulation: a tale of two loops," *Frontiers in cellular neuroscience*, vol. 10, p. 92, 2016.