

Localization of Seizures in Epilepsy using Low Frequency Fluctuations from Rs-fMRI



A.Allwyn Gnanadas, S.Sathishbabu, P.Arunkumar

Abstract—Epilepsy is a chronic neurological disorder on brain which as indicated by World Health Organization influences around 59 million people worldwide. Epilepsy is often characterized by seizures. Despite that the patient treatment is successful in 70% of the cases; it is conceivable to bring up the adequacy up to 100% by utilizing the advancements in medical imaging and 3D image processing techniques that is been in this paper. Functional Magnetic Resonance Imaging (fMRI) is exploited to analyze the metabolic activities of the brain adding it with suitable image processing the seizure origin can be found and regressed out through appropriate surgery without compromising other regions of the brain. Low frequencies exist in the brain waves and this property is measured and analyzed and found to be in accordance with the functioning of the brain. Ignoring the common artifacts, the image is processed further and is correlation with the epileptic seizure is studied. The investigation revealed the exact location of the epileptic seizure which is complemented by the result obtained by functional connectivity.

Keywords: Functional Connectivity, Resting state – fMRI, fractional ALFF

I. INTRODUCTION

A huge population in the world is affected by Epilepsy, an abnormal brain condition. Epilepsy can be identified from is common symptom, seizure. Although a complete medical diagnosis and analysis can only arbitrate the presence of epilepsy [1]. Epilepsy is diagnosed by iEEG (intracranial Electroencephalography) and was considered as golden standard, however due to the invasiveness and limited space extent another tool for diagnosing the same disease is needed. This issue can be addressed using the rs-fMRI, resting state- functional Magnetic Resonance Imaging [2].

The rs-fMRI images after a proper preprocessing can be made meaningful and the low frequency fluctuations are studied and the analysis is compared with healthy individuals to derive a definite conclusion about the location of the epileptic seizure [3].

The ALFF analysis can highlight the low frequency regions produced by the epileptic seizure as the BOLD (Blood Oxygen Level Dependent) signals capture the data based on the oxygen levels [4].

In BOLD imaging, it is observed that Fractional ALFF is prominent over the conventional ALFF. The fALFF is simply the concentration of the cluster among the whole mass [5].

The fALFF analyzed epilepsy patient data is compared with fALFF analyzed healthy data and the region of that overlaps are examined carefully under various conditions and the seizure localization is identified.

II. PROPOSED METHODOLOGY

The data obtained from fMRI is a raw image which is to be made meaningful to proceed further; the raw image is subjected to number of processes as mentioned below.

A. Limiting initial glitches

When a patient is made to lie in the machine to obtain fMRI images, the patient will take time to get accustomed to the environment. Till he feels comfortable there will be few disturbances in the normal state. Hence the first few volumes of the data obtained are removed.

B. Slice time correction

In F-MRI the slices are obtained at different orientation and at different time, the images are scattered with time pattern, hence to form a pattern a predefined time points are given and TR (repetition time) is provided, so that the images obtained are formed in a uniform pattern and are made easy for the further processing.

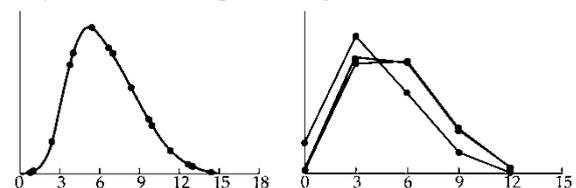


Figure 1 slice time correction

C. Re-orientation

As stated early the images obtained from the fMRI will be scattered at different orientation. When this data is considered for study it will be completely meaningless providing no proper information. so the images must be put in a particular orientation. Here with AC (Anterior Commissure) as the reference the slices are reoriented into a standard template frame [6].

D. Co registration

This an important process in the image preprocessing where the structural MRI volume is co registered with functional MRI volume.

Manuscript published on November 30, 2019.

* Correspondence Author

Mr. Allwyn Gnanadas*, Assistant Professor Department Of Biomedical Engineering KPR Institute Of Engineering And Technology, Coimbatore, Tamil Nadu .

S. Sathishbabu, Associate Professor Department Of Electronics And Communications Thanthai Periyar Government Institute Of Technology, Vellore, Tamil Nadu.

Mr. P.Arunkumar, Assistant Professor Department Of Biomedical Engineering SNS College Of Technology, Coimbatore, Tamil Nadu.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](https://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

Localization of Seizures in Epilepsy using Low Frequency Fluctuations from Rs-fMRI

This is to make sure that both the structural and functional volumes co-exist on the same place.

E. Segmentation

Brain is made of three types of tissues, the grey matter, the white matter and the CSF (cerebra spinal fluid).

However, when it comes to epilepsy study our focus is only on the grey matter [7].

Hence to segregate the grey matter from the other tissues the brain is segmented into three regions using a MNI template that is predefined and widely used [8]. The MNI template here used for segmentation is derived from 452 healthy individuals.

F. Normalization

Normalization is to standardize the images into a particular standard that can be understood globally. Here the 10 epilepsy patient data and 20 healthy individual data are normalized with a standard template as a reference. This step ensures that all the images that are too subjected to preprocessing are of uniform size and structure. Only the normalized data can be used for fALFF analysis.

G. Smoothing

Spatial smoothing is performed on the normalized image. The data is initially convolved with 3D Gaussian Kernel. Then the voxels are one by one replaced by the average that is calculated from the voxels at their vicinity. The filter of 4mm is set as the Full Width Half Maximum (FWHM) value.

H. Filter

In brain, the frequencies of physiological significance are measured using rs-fMRI, and the information obtained proves the existence of frequencies between the ranges of 0.01-0.08 Hz [9]. The grey matter and the white matter of the brain are the major contributors to these frequencies. Of them, the low recurrence band, extending from 0.01 to 0.073 Hz is associated with the grey matter while the high recurrence band from 0.073 to 0.25 Hz is identified from white matter. Apart from the normal physiological process involving cardiac and respiratory functions also produces fluctuations that are involved in the high frequency band.

I. Target region or Region of Interest (ROI)

It was found that the gray matter is responsible for the prominent electrical discharge in the brain compared to the white matter and the Cerebro spinal fluid(CSF). Hence the region of interest is the grey matter of the brain, that way leaving out the white matter and the CSF. To focus only on the ROI, the white matter and the CSF are masked out by a customized mask that is generated from the fMRI images of the healthy individuals.

III. AMPLITUDE OF LOW FREQUENCY FLUCTUATIONS

Amplitude of Low Frequency Fluctuations (ALFF) is the proportion of variances in the cerebrum [10]. Estimating ALFF gives insights concerning brains action in resting state. Every individual has a unique pattern and frequency

value. For the study, the low frequency range of 0.01 to 0.1Hz is alone considered [11]. fALFF estimates the part of the entirety of amplitudes over the detectable signal frequencies.

In a grey matter study both ALFF and fALFF proved to be sensitive, however ALFF are very prone to noise that arise from the ventricles and large blood vessels[12]. Hence, in determining the location of the epilepsy fALFF is used.

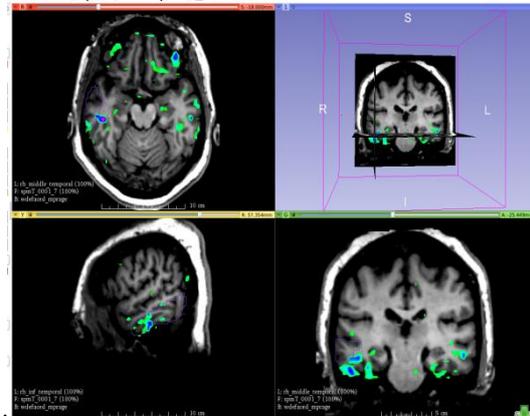


Figure 2 Right medial temporal is the region highlighted as the region with high fALFF.

IV. FUNCTIONAL CONNECTIVITY

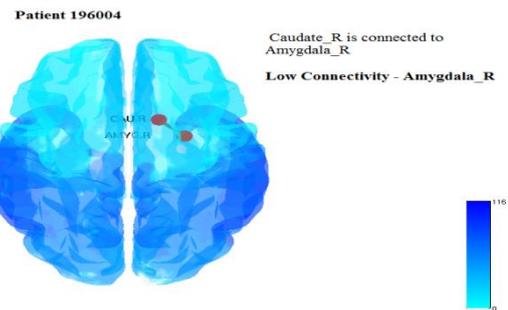


Figure 3 Functional connectivity on the right temporal region of the brain.

Functional connectivity (FC) identifies and characterizes the small fluctuations in the brain even when it is at rest [13]. This study is also helpful in determining the region where the electrical imbalance could be. FC is conducted on the same patients data for which fALFF was conducted and the results are compared and are found to be same and overlapping.

V. TWO SAMPLE T TEST

The data that are processed and analyzed for fALFF will show the region where the epileptic seizure could be. To highlight the specific region the processed patient data is compared with the healthy fALFF data using Statistical parametric mapping which performs sample 2-t test [14]. The sample 2-t test is conducted by setting a threshold value 3.5. The regions exceeding this threshold value is said to be infected regions. The results obtained are then viewed through special 3D image viewer software and the higher correlation region is realized.



The focus is further analyzed and the exact location is extracted. The results thus obtained are compared against Functional connectivity and the golden standard IEEG and is shown in Table.1

Table I Comparison Table Between IEEG, Falff And FC

PATIENT	IEEG	fALFF	FC
196001	Left Occipital	No region	No region
196002	Right Temporal	Right Temporal	Right Temporal
196003	Left Fronto Parietal	Left Fronto Parietal	Left Fronto Parietal
196004	Right Medial Temporal	Right Medial Temporal	Right Medial Temporal
196005	Right Hemisphere	Right Hemisphere	Right Hemisphere
196006	Left Medical Temporal	Left Medical Temporal	Left Medical Temporal

VI. RESULT ANALYSIS

The sample 2-t results are analyzed in spatial parametric map. The affected region is highlighted in the map as grey areas; ignoring the artifacts caused by the cardiovascular system and the respiratory system the highlighted region is corrected. The marked region is viewed on an image in 3D. The area highlighted with high intensity colored markers is the region with abnormality and causing seizures. The precise position is marked and noted. These coordinates are communicated to the surgeon to enable proper regression of the affected area leaving out the healthy parts untouched.

VII. CONCLUSION

IEEG (Invasive Electroencephalogram) is the current reliable method and is practiced widely to focus the epileptic seizures origin. Though considered reliable, it suffers a big disadvantage, the invasiveness. IEEG standards can be conveniently replaced by fractional ALFF and to compliment the result the functional connectivity can also be performed. The fALFF results show higher correlation in the affected area similar to the results obtained through Regional Homogeneity (ReHo) and Functional Connectivity (FC), denoting the correctness in the study. Functional Connectivity known for its exactness, however can't be altogether used in epilepsy, this investigation demonstrates that the FC results concur with the fALFF, at any rate at scope of 5mm separation, The rightness in this examination infers that fALFF and FC can supplant the as of now existing intrusive golden standard in the identification of the location of the seizure occurrence in epileptic patients.

REFERENCE

1. Megiddo I, Colsom A, Chisholm D, Dua T, Nandi A, and Laxminarayan R(2016). Health and economic benefits of public financing of epilepsy treatment in India: an agent based simulation model. *Epilepsia Official Journal of the International League against Epilepsy* doi: 10.1111/epi.13294.

2. Zang YF, He Y, Zhu CZ, Cao QJ, SuiMQ, Liang M, Tian LX, Jiang TZ, Wang YF (2007): Altered baseline brain activity in children with ADHD revealed by resting-state functional MRI. *Brain Dev* 29:83–91.

3. Biswal B, Zerrin Yetkin F, Haughton VM, Hyde JS (1995) “Functional connectivity in the motor cortex of resting human brain using echo-planar MRI. *Magnetic resonance in medicine* “.

4. Hoptman MJ, Zuo XN, Butler PD, Javitt DC, D’Angelo D, Mauro CJ, et al. Amplitude of low-frequency oscillations in schizophrenia: a resting state fMRI study. *Schizophr Res* 2010, 117(1): 13–20

5. Cao, Q., Zang, Y., Sun, L., Sui, M., Long, X., Zou, Q., Wang, Y., 2006. “Abnormal neural activity in children with attention deficit hyperactivity disorder: a resting-state functional magnetic resonance imaging study.” *Neuro report* 17, 1033-1036.

6. Chiang S, et.al. 2017, use of resting state fMRI in planning epilepsy surgery. *Neurol India.* ; 65 (supplement):s25-s33. Doi:10.4103/neuroindia.NI_823_16

7. Tononi G, Sporns O, Edelman GM (1994) “A measure for brain complexity: relating functional segregation and integration in the nervous system.” *Proceedings of the National Academy of Sciences* 91: 5033–5037. doi: 10.1073/pnas.91.11.5033

8. Tzourio-Mazoyer, N., Landeau, B., Papathanassiou, D., Crivello, F., Etard, O., Delcroix, N., Mazoyer, B., and Joliot, M. (2002). Automated anatomical labeling of activations in SPM using a macroscopic anatomical parcellation of the MNI MRI single-subject brain. *Neuroimage* 15, 273-289.

9. Zhang Z, Lu G, Zhong Y, Tan Q, Chen H, Liao W, et al. fMRI study of mesial temporal lobe epilepsy using amplitude of low-frequency fluctuation analysis. *Hum Brain Map* 2010, 31(12): 1851–1861.

10. Miller AKH, Alston RL, Corsellis JAN. Variation with age in the volumes of grey and white matter in the cerebral hemispheres of man: measurements with and image analyzer. *Neuropathol/ Appl Neurobiol* 1980;6: 119-13

11. American Psychiatric Association. “Diagnostic and statistical manual of mental disorders” 4th ed. Washington, DC: American Psychiatric Association; 1994.

12. M.D.Foxand M.E.Raichle, “Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging,” *Nature*, vol. 8, pp. 700–711, 2007.

13. B. Biswal ET. al., “Functional connectivity in the motor cortex of resting human brain using echo-planar MRI,” *MRM*, vol. 34, pp. 537–541, 199.

14. Allwyn Gnanadas, Sathishbabu.S, Vijayarathik.M “Identification of epileptic seizure using ReHo from Rs-fMRI” Second International Conference on Recent Trends and Challenges in Computational Models (ICRTCCM) 2017.

AUTHORS PROFILE



Mr. Allwyn Gnanadas .A is an Assistant Professor in the Department of Biomedical Engineering at KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu . He has 4 years of experience in teaching and 6 months of experience as a Quality Assessor, NABH office in CMC Hospital, Vellore. He is currently pursuing his PhD in Medical Imaging from Annamalai University, Chidambaram. He completed his Masters in Biomedical Engineering from VIT University, Vellore and Bachelor’s degree in Electronics and Communication Engineering from DMI College of Engineering and Technology, Chennai. He was recently awarded as “My Teacher’19 “ at KPRIET, Coimbatore. He was awarded as the best mentor by NPTEL in the academic year 2015-2016. He had been a part in organizing a medical and an engineering workshop. He has published his works in various journals and conferences including IEEE Xplore, IJTCT, IJCTN etc. He is a member of various educational bodies such as ISETE, IEANG and IIMAR



S. Sathishbabu is an Associate Professor in the Department of Electronics and Communications at Thanthai Periyar Government Institute of Technology, Vellore, Tamil Nadu. He had his graduation in the year 1996 in Electronics and Instrumentation Engineering, Master of Business Administration in the year 1998 and Master of Engineering (Process Control and Instrumentation) in 2005 at Annamalai University. He got Doctor of Philosophy in 2013 from Annamalai University in the field of Instrumentation. He has about 17 years of educating experience. His exploration advantages are in the zones of Process Control, Bio medicinal and Image preparing.



Localization of Seizures in Epilepsy using Low Frequency Fluctuations from Rs-fMRI

He has distributed numerous papers in different International Journals, International Conferences, National Journals and National Conferences. He has directed and taken part in numerous National Level Conferences, Technical Symposium, workshops and courses.



Mr. P. Arunkumar is working as an Assistant Professor in the Department of Biomedical Engineering at SNS College of Technology, Coimbatore, Tamil Nadu. He has 4 Years of experience in teaching profession. He is currently pursuing his PhD in the field of Rehabilitation from

Anna University, Chennai. He had his Post graduation in the year 2015 at VIT University, Vellore. He has published a patent in the year 2018. He has been awarded three times for academic excellence at SNS College of Technology. He has guided 5 Industry supported projects. He has published several papers in reputed journals including IEEE Xplore. He has conducted several events including Research conclave, Medical camps and National Conferences. He is recently given a position as Innovation Activity Coordinator by SNS College of Technology in MHRD- IIC (Government Body). His research interests are in the areas of Rehabilitation, Biomaterials and Instrumentation. He also has published a book in Lambert Academic Publishing. He has been awarded as the best mentor for the project contest (NSTF' 19), Coimbatore.