Incursion Model for Nomenclature of EEG Signals via Wavelet Transform

P.V.RamaRaju.
E.C.E. Department
S.R.K.R.Engineering College, ChinaAmiram, Bhimavaram,
W.G.Dt., A.P., India.
pvramaraju41@rediffmail.com

V.Malleswara Rao.
E.C.E. Department
G.I.T., GITAM University, Visakhapatnam, A.P., India.

N.AnogjnaAurora
E.C.E. Department S.R.K.R.Engineering College, ChinaAmiram, Bhimavaram, W.G.Dt., A.P.

Abstract: EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. In advance EEG signals used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders. The structure generating the signal is not simply linear, but also involves nonlinear contributions [7, 8, 9].These non-stationary signals are may contain indicators of current disease, or even warnings about impending diseases. This work aims at providing new insights on the Electroencephalography (EEG) fragmentation problem using wavelets [2, 5]. The present work describes a computer model to provide a more accurate picture of the EEG signal processing via Wavelet Transform [16, 17, 18, 19]. The Matlab techniques have been uses which provide a system oriented scientific decision making modal [16, 17]. Within this practice the applied signal has been compared in a sequential order with dissimilar cases in attendance in the database. Special EEG signals have been considered from Physio bank [1] and Vijaya Medical Centre, Visakhapatnam, India. Analyze the signal under consideration and renowned the holder 100% truthfully.

Keywords: Electroencephalography (EEG), Matlab, Continuous wavelet transform.

I. AN OVER VIEW OF EEG SIGNAL [7-14].

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study [3]. A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death. EEG used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders, but this use has decreased with the advent of anatomical imaging techniques such as MRI and CT. Derivatives of the EEG technique include evoked potentials (EP), which involves averaging the EEG activity time-locked to the presentation of a stimulus of some sort (visual, somatosensory, or auditory). Event-related potentials (ERPs) refer to averaged EEG responses that are time-locked to more complex processing of stimuli; this technique is used in cognitive science, cognitive psychology, and psycho physiological research.

A. Normal activity and Alpha wave

The EEG is typically described in terms of rhythmic activity and transients as shown in Fig.1. Rhythmic activity within a certain frequency range was noted to have a certain distribution over the scalp or a certain biological significance. Any rhythmic activity between 8–12 Hz can be described as "alpha" as shown in Fig.2. This was the "posterior basic rhythm" seen in the posterior regions of the head on both sides, higher in amplitude on the dominant side. The posterior basic rhythm is actually slower than 8 Hz in young children. Most of the cerebral signal observed in the scalp EEG falls in the range of 1–20 Hz. Activity below or above this range is likely to be artifactual, under standard

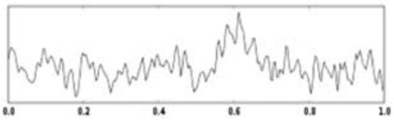
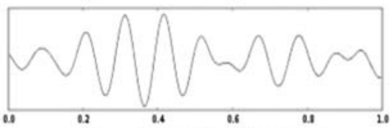


Figure 1. EEG signal of one second.



[1] Figure 2. Alpha wave

B. Clinical use

A routine clinical EEG recording typically lasts 20–30 minutes (plus preparation time) and usually involves recording from scalp electrodes. Routine EEG is typically used in the following clinical circumstances.

- to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-cortical movement disorders and migraine variants.
- todifferentiate"organic" encephalopathy or delirium from primary psychiatric syndromes such as catatonia
- to serve as an adjunct test of brain death
- to prognosticate, in certain instances, in patients with coma
- to determine whether to wean anti-epileptic medications

C. Epilepsy monitoring

· to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-cortical movement disorders and migraine variants.
· to characterize seizures for the purposes of treatment
· to localize the region of brain from which a seizure originates for work-up of possible seizure surgery

D. To monitor certain procedures

· to monitor the depth of anesthesia
· as an indirect indicator of cerebral perfusion in carotid endarterectomy
· to monitor amobarbital effect during the Wada test
· In Intensive care units for brain function monitoring:
· to monitor for non-convulsive seizures/non-convulsive status epilepticus
· to monitor the effect of sedative/anesthesia in patients in medically induced coma (for treatment of refractory seizures or increased intracranial pressure)
· to monitor for secondary brain damage in conditions such as subarachnoid hemorrhage (currently a research method).

E. Research use

EEG, and its derivative, pt-Encoding: gzip, deflate Accep, are used extensively in neuroscience, cognitive science, cognitive psychology, and psycho physiological research. Many techniques used in research contexts are not standardized sufficiently to be used in the clinical context. A different method to study brain function is functional magnetic resonance imaging (fMRI).

F. Some benefits of EEG compared to fMRI include

· Hardware costs are significantly lower for EEG sensors versus an fMRI machine
· EEG sensors can be deployed into a wider variety of environments than can a bulky, immobile fMRI machine
· EEG enables higher temporal resolution, on the order of milliseconds, rather than seconds
· EEG is relatively tolerant of subject movement versus an fMRI (where the subject must remain completely still)
· EEG is silent, which allows for better study of the responses to auditory stimuli
· EEG does not aggravate claustrophobia

G. Limitations of EEG as compared with fMRI include

· Significantly lower spatial resolution
· ERP studies require relatively simple paradigms, compared with block-design fMRI studies.
· The meninges, cerebrospinal fluid and skull "smear" the EEG signal, obscuring its intracranial source.
· It is mathematically impossible to reconstruct a unique intracranial current source for a given EEG signal.

H. EEG characteristics that compare favorably with behavioral testing

· EEG can detect covert processing (i.e., processing that does not require a response)
· EEG can be used in subjects who are incapable of making a motor response
· Some ERP components can be detected even when the subject is not attending to the stimuli
As compared with other reaction time paradigms, ERPs can elucidate stages of · processing (rather than just the final end result).

II. <u>CONTINUOUS WAVELET TRANSFORMS</u> (CWT) [2-5].

The continuous wavelet transform (CWT) is a time–frequency analysis method which differs from the more traditional short time Fourier transform (STFT) by allowing arbitrarily high localization in time of high frequency signal features. The CWT does this by having a variable window width, which is related to the scale of observation—a flexibility that allows for the isolation of the high frequency features. Another important distinction from the STFT is that the CWT is not limited to using sinusoidal analyzing functions. Rather, a large selection of localized waveforms can be employed as long as they satisfy predefined mathematical criteria (described below). The wavelet transform of a continuous time signal, x (t), is defined as:

$$T(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} x(t)\psi^*\left(\frac{t-b}{a}\right) \mathrm{d}t$$

Where ø" (t) is the complex conjugate of the analyzing wavelet function ø (t), a is the dilation parameter of the wavelet and b is the location parameter of the wavelet.

A. Advantages of wavelet transforms over STFT and Wigner-Ville Distribution.

· The Fourier transforms of the windowed signals are not taken, and therefore single peak will be seen corresponding to a sinusoid, i.e., negative frequencies are not computed.

- The width of the window is changed as the transform is computed for every single spectral component, which is probably the most significant characteristic of the wavelet transform.
- No cross term calculations and aliasing effect as in the Wigner-Ville Distribution which is have much better resolution than STFT.

II. PROJECT IMPLEMENTATION [16-19].

This project has implemented by developing system model software in Matlab by means of continuous wave let transform. In general the EEG signal is in analog appearance. This signal is digitized using a specified soft ware. Wave let coefficients or mathematical polynomials are generated and a data bank has developed. A case classification programme has established to categorize the given signal by comparing it with all those signals present in the data bank.

The present work describes the appliance of Wavelet Transform to provide a more perfect picture of the localized time-scale features.

III. CASE1: EEG - SLEEP HEART HEALTH STUDY POLYSOMNOGRAPHY DATABASE (shhpsgdb).

The EEG - sleep heart health study polysomnography database (shhpsgdb) signal has been taken from the Physio Bank [1].The order of the equations S1, S2 …S1294 is 10 and the coefficients are arranged in decreasing order. The total numbers of samples 5001 are shaped into 1294 parts [16, 17] for better accuracy in matching points.

Part S1 : (1.417176643529183e+020)*x^10
+ (-2.880726121195994e+019)*x^9
+ (2.506254715814662e+018)*x^8
+ (-1.218244996617862e+017)*x^7
+ (3.621138138865001e+015)*x^6
+ (-6.764781827450236e+013)*x^5
+ (7.846075976823987e+011)*x^4
+ (-5.355143574968560e+009)*x^3
+ (1.907742966638381e+007)*x^2
+ (-2.677273025801071e+004)*x^1
+ (-6.863000000508535e+000)*x^0
....

Part S1294 : (1.393354300400206e-008)*x^10
+ (-5.843595766864796e-007)*x^9
+ (7.275783599029971e-006)*x^8
+ (-3.206600952674375e-005)*x^7
+ (1.845880005825452e-003)*x^6
+ (-2.462051876851030e-002)*x^5
+ (-8.649056122733305e-001)*x^4
+ (1.306848504574544e+001)*x^3
+ (1.746150335189878e+001)*x^2
+ (-5.961825475124522e+001)*x^1
+ (2.690112174140154e-078)*x^0

The time interval of these parts is:
S1 is 0< t < 0.0400
....
S1294 is 19.9960 < t < 20.0000

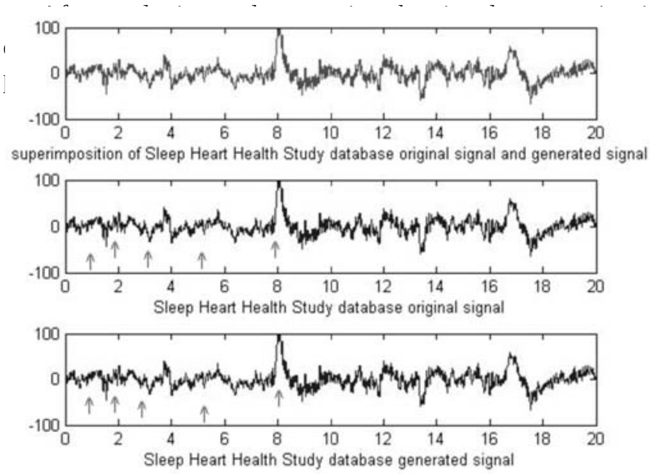


Figure 3. Sleep heart health study polysomnography database duration: 0-20 sec

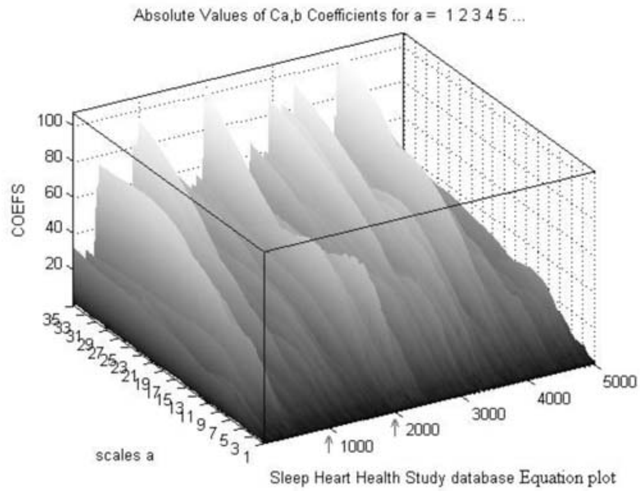


Figure 4. Wavelet coefficients of shhpsgdb signal in case 1.

The first subplot shown in Fig. 3 represents the equation plot superimposed on the original plot for the purpose of knowing the difference between actual signal and generated signal. Second subplot represents original plot and the third subplot represents the Equation plot. The Wavelet coefficients of the above signal have been plotted in MATLAB [18, 19] as shown in Fig. 4.

IV. CASE2: EEG FP1-F3 SIGNAL OF RAMAYYA DATABASE.

The EEG FP1-F3 signal of Ramayya Database has been collected from the Vijaya Medical Centre, Visakhapatnam, A.P., India. The EEG record of 68 year old male has handedness in right and is under medication shows an Alpha Rhythm of 8-9 Hz and 20-30 mcv, under HV and PS. There are no Epileptiform Discharges or Phase Reversals. The order of the equations P1, P2 …P848 is 5 and the coefficients are arranged in decreasing order. The total numbers of samples 4120 are shaped into 848 parts [16, 17] for better accuracy in matching points.

Part P1 :
(5.354267939124183e+013)*x^5
+ (-2.588306444396728e+012)*x^4
+ (4.815146013915829e+010)*x^3
+ (-4.243647907319404e+008)*x^2
+ (1.720218578014819e+006)*x^1
+ (-2.382781554297733e+003)*x^0
....
Part P848 :
(3.417701110429096e+007)*x^5
+(-1.064379769934287e+009)*x^4
+(1.242227348731339e+010)*x^3
+(-6.438996405755914e+010)*x^2
+(1.250676140585772e+011)*x^1
+ (3.277949070332032e-008)*x^0

The time interval of these parts is:
P1 is $0 < t < 0.0103$
....
P848 is $7.9839 < 7.9895$

After analyzing and processing the signal an equation is consequent using the continuous wavelet transforms and is plotted [18, 19] as shown in Fig.5. The first subplot shown in Fig. 5 represents the equation plot superimposed on the original plot for the purpose of knowing the difference between actual signal and generated signal. Second subplot represents original plot and the third subplot represents the Equation plot. The Wavelet coefficients of the above signal have been plotted in MATLAB [18, 19,20] as shown in Fig. 6.

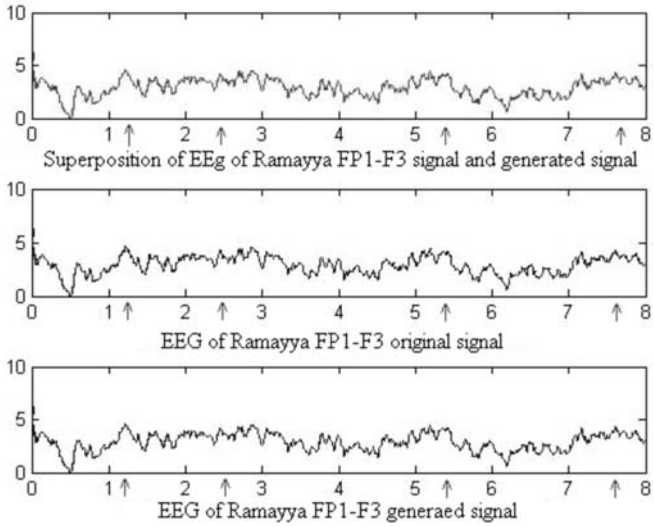


Figure 5. EEG FP1-F3 signal of Ramayya

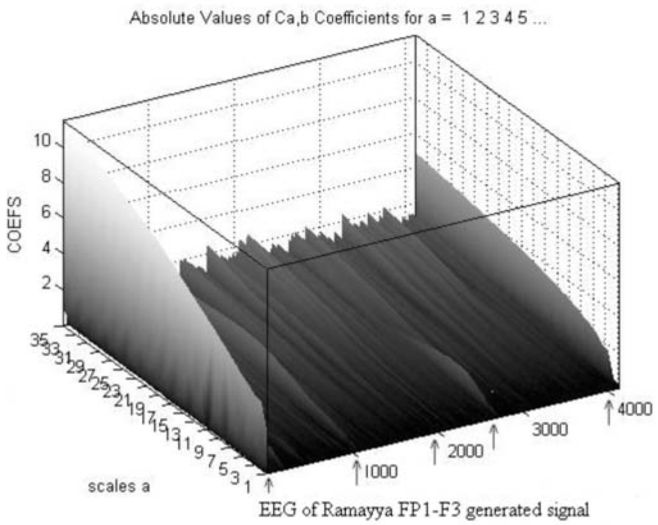


Figure 6. Wavelet coefficients of EEG FP1-F3 signal of Ramayya in case 2.

V. ASSESSMENT

Form figures 3 and 5 at around different time instants as indicated with arrows it is the imperative summit to learn. In these figures 3 and 5 the signal strength is comparable. Considering subplots 2 or 3 in figures 3 and 5 the signal strength is swindle to infer erroneous diagnosis. Similarly from figures 4 and 6 at around different samples location it can be easily identifies the difference among them. An analogous intricacy in the midst of cases exposed in figures 4 and 6. As indicated with arrows in figures 4 and 6 at higher frequency scale, the coefficients strength is harmonizing and at stumpy frequency scale it is awfully thorny to identify the *disparity. Hence likelihood for deceitful diagnosis. The complexity in building a declaration has been eliminated efficiently with this exertion.*

VI. CONCLUSIONS

Most prominently as the signal is analyses through system oriented it eliminates the human indiscretion which may be allied with a medical doctor in the EEG psychoanalysis. This medical diagnosis is safer and more rapid. The EEG so analyzed can be premeditated by an expert sitting at aloofness through internet thereby enabling long distance diagnoses possible.

VII. ALARMING PART AND DEVELOPMENT

In the deficiency of a doctor, the program can itself give the report of the stipulation of the patient. Emergent an embedded system it is quite possible to assist the medical practitioners in making further precise and swift diagnosis.

REFERENCES

[1] http://www.physionet.org/cgi-bin/chart

[2] Wavelet toolbox User's guide By the Math works

[3] www.wavereport.,com/tutorials/Wavelets.htm

[4] www.wavelet.org

[5] www.pubmedcentral.nih.gov/articlerender,.fcgi

[6] A Hydrocel Geodesic Sensor Net by Electrical Geodesics, Inc.

[7] Niedermeyer E. and da Silva F.L. (2004). Electroencephalography: *Basic Principles, Clinical Applications, and Related Fields.* Lippincot Williams & Wilkins.

[8] *Atlas of EEG & Seizure Semiology*. B. Abou-Khalil; Musilus, K.E.; Elsevier, 2006.

[9] Tatum, W. O., Husain, A. M., Benbadis, S. R. (2008) "*Handbook of EEG Interpretation*" Demos Medical Publishing.

[10] Nunez PL, Srinivasan R (1981). *Electric fields of the brain: The neurophysics of EEG*. Oxford University Press.

[11] Klein, S., & Thorne, B. M. (2007). *Biological psychology.* New York, N.Y.: Worth.

[12] Whittingstall K, Logothetis NK. (2009). *Frequency-band coupling in surface EEG reflects spiking activity in monkey visual cortex*. Neuron. 64(2):281-9. PMID 19874794

[13] Towle VL, Bolaños J, Suarez D, Tan K, Grzeszczuk R, Levin DN, Cakmur R, Frank SA, Spire JP. (1993). "*The spatial location of EEG electrodes: locating the best-fitting sphere relative to cortical anatomy*". Electroencephalogr Clin Neurophysiol 86 (1): 1–6.doi: 10.1016/0013-4694(93)90061-Y. PMID 7678386.

[14] H. Aurlien, I.O. Gjerde, J. H. Aarseth, B. Karlsen, H. Skeidsvoll, N. E. Gilhus (March 2004). "*EEG background activity described by a large computerized database*." Clinical Neurophysiology 115 (3): 665–673. doi: 10.1016/j.clinph.2003.10.019.PMID 15036063.

[15] Nunez P.L. and Pilgreen K.L. (1991). "*The spline-Laplacian in clinical neurophysiology: a method to improve EEG spatial resolution*". J Clin Neurophysiol 8 (4): 397–413.doi: 10.1097/00004691-199110000-00005. PMID 1761706.

[16] Prof. P.V. Rama Raju, Dr. V. Malleswara Rao, " *Obvious Modeling for Organization of Late Potentials in ECG Signals in the Itinerary of Wavelets*" International Journal of Electronics and Computers (IJEC), Volume-2,Number1, January-June 2010, PP.37-44.

[17] Prof. P.V. Rama Raju, Dr. V. Malleswara Rao, Dr B.Prabhakar Rao, "*Symphony Modeling For Tagging Of Late Potentials In ECG Signals Inside Wavelets*" Paper ID 556, International Journal of Recent Trends in Engineering [ISSN1797-9617] by the ACEEE, NAME, NCE and Academy Publishers, Finland.

[18] P.V. Rama Raju & V. Malleswara Rao, "*Scientific Modeling for credentials of Late Potentials in ECG Signals using Wavelets*", IEEE Bangalore Section - 18th Annual Symposium on "Emerging Needs in Computing, Communication, SignalsandPower",SP06,29Aug2009,lcm.csa.iisc.ernet.in/IEEE_Symposium/ENCCSP09.

[19] P.V. Rama Raju ,V. Malleswara Rao, and B. Prabhakar Rao, "*Composition Modeling for Cataloging of Late Potentials in ECG Signals via Wavelets*",IEEEComputerSociety,DOI={http://doi.ieeecomputersociety.org/10.1109/ITC.2010.38}, Los Alamitos, CA, USA

Prof. P.V.Rama Raju, Dr.V.Malleswara Rao, G.Sarvesh , "Exertion Chisel of EMG Signal Immoderation During Wavelet Transform", with paper ID: ICCMS 2011 has been selected for ICCMS 2011 which will be held during January 7 - 9, 2011, Mumbai, India, (unpublished)