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DESIGN OF REMOTE USER INTERFACE FOR WAVELET ANALYSIS OF NON STATIONARY SIGNALS FOR SPIKE DETECTION

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***Abstract* – The biological signals such as EEG, ECG are non stationary in deterministic signals. The processing of these signals requires special analysis and computations. The chaoticity of these signals are analyzed. This result can be used as feature spaces for diagnosis of various diseases. In this paper, the EEG signals of epileptic patients are analyzed using wavelets and are provided with user interface. Epilepsy is a chronic neurological disorder in brain which results in high spikes. The noise in raw EEG signals is eliminated by applying optimal FIR filter. These signals can then be finely separated into different frequency bands and analyzed instead of taking as a whole for efficient diagnosis of diseases. A novel approach for the sub band separation of EEG signals for analysis is done using wavelet packet transforms. Wavelet transforms are done to obtain time frequency localization of the signal. The signal is separated into its alpha, beta, gamma, theta and delta sub bands. This gives good temporal resolution than Fourier transforms. The scaling and wavelet functions are applied on the input signal. This is mainly useful in clinical applications to view fine tuned results. The results are analyzed using a suitable graphical user interface.**

Keywords: Epilepsy, Park mc-clellan filter, Wavelet packet transforms, Matlab, GUI.

I. INTRODUCTION

Electroencephalogram signals are basically measurements of time varying potential differences in the brain. Epilepsy occurs in these signals due to hyper synchronous neuronal activity in brain [3]. The normal rate of EEG signals would be 80 times/second whereas of the epileptic patients it would be 500 times/second. Anything that disturbs the normal pattern of activity in the brain can trigger epilepsy. The major causes of epilepsy are Brain chemistry, hereditary causes, Brain tumors, Alzheimer's disease, Stroke, heart attacks, and other conditions that affect the blood supply to the brain, Infectious diseases such as meningitis, viral encephalitis, AIDS, Cerebral palsy, autism, Head injuries, exposure to lead, carbon monoxide, and certain chemicals ,use of drugs and alcohol.

The signal conditioning of EEG signals are done using FIR filters. Since the IIR filters have the drawbacks of non linear phase response, more susceptible to problems of finite-length arithmetic, such as noise generated by calculations, and limit cycles. They are harder (slower) to implement using fixed-point arithmetic. They don't offer the computational advantages of FIR filters [8]. The FIR filters can be implemented using optimal method, Windowing method, Frequency sampling method. In the Window design method and the frequency sampling method for an FIR filter, there are drawbacks such as Lack of flexibility, Poor amplitude response, Pass band and stop band frequencies cannot be precise, and the filter is non-causal [2]. The order of the filter is infinitely large. The resulting filter has a frequency response that exactly interpolates the given samples, but there is no explicit control of the behavior between the samples.

Hence in this paper, the optimal Parks-McClellan algorithm is used. The Parks-McClellan algorithm, published by James McClellan and Thomas Parks in 1972, is an iterative algorithm for finding the optimal Chebyshev finite impulse response (FIR) filter [1]. The Parks-McClellan algorithm is utilized to design and implement efficient and optimal FIR filters. It uses an indirect method for finding the optimal filter coefficients. In the design of a low pass filter using the Parks–McClellan algorithm, there are three parameters to be determined, the pass band edge the stop band edge and filter order. The advantages of this method are Efficient to calculate filter coefficients, Good amplitude response characteristics. The present work after FIR filtering is carried over to sub band separation of EEG signals [7]. The EEG taken as a whole is less informative for the diagnosis of diseases which cause small variations in the signal. This will often lead to inaccurate diagnosis. The wavelet transforms is a time-frequency localization of a signal which gives all the hidden information regarding frequency in Fourier transforms. There are several families of wavelets and we have to choose the one that best fits our application. Here the Daubechies Wavelet transforms is used to analyze the signal. An overview of the proposed methodology is presented schematically in Fig.1.

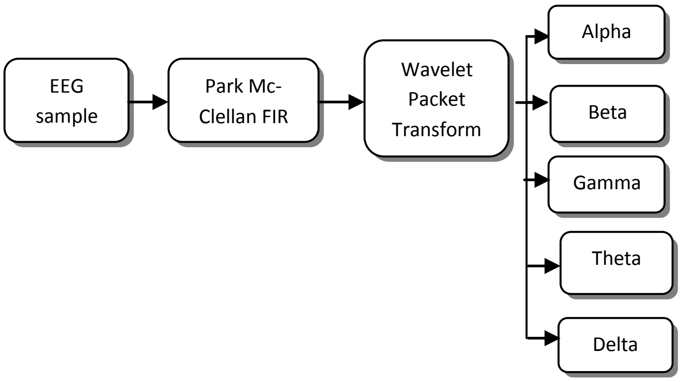

Fig.1.Schematic diagram of the methodology

II. EEG DATASET

The EEG databases are taken from [5]. The EEG samples are taken as three categories: normal, ictal and inter-ictal patients. Five sets denoted A–E each containing 100 single channel EEG segments of 23.6-sec duration, were obtained [8]. Volunteers were relaxed in an awake state with eyes open A and eyes closed B respectively. Sets C, D, and E originated from our EEG archive of presurgical diagnosis. The signals are taken from a 128-channel EEG system and After 12 bit analog-to-digital conversion, the data were written continuously onto the disk of a data acquisition computer system at a sampling rate of 173.61 Hz. Band-pass filter settings were 0.53–40 Hz. The plot of the input signals is done in MATLAB.

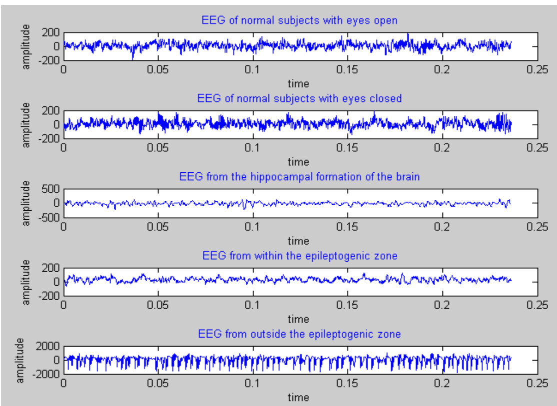

Fig.2. Signals from normal, ictal and inter-ictal subjects

III. FIR FILTERING

The optimal FIR filtering approach is by using the Parks-McClellan algorithm. The goal of the algorithm is to minimize the error in the pass and stop bands by utilizing the Chebyshev approximation.

$$Apass = 20 \log (1+\delta p)$$

$$Astop = -20 \log \delta s$$

$$N = a*Fs/\Delta F$$

a=0.22+0.0366SBR, where SBR is Stop Band Attenuation. The values of the Pass band , Stop band attenuation, Filter order (N), Filter coefficient are computed using the formulas above.

IV. WAVELET TRANSFORMS

Fourier transforms which computes only the time response of the signal. The Fourier analysis brings only global information which is not sufficient to detect compact patterns. Also the Fourier transforms are not applicable for non-stationary signals [4]. Hence to overcome these drawbacks of Fourier transforms the wavelet analysis is done. A wavelet series is a representation of a square-integral (real- or complex-valued) function by a certain orthonormal series generated by a wavelet. This method gives the response in both time and frequency domain. It gives better response for non-stationary biological signals. No information is lost, however, and the result of the wavelet transform can be perfectly reconstructed into the original data.

A. DISCRETE WAVELET TRANSFORMS

The Discrete Wavelet Transform is applied to the filtered data and it splits the signal to series of low and high frequencies [6]. Then the signals are down sampled since the data points will be doubled when applied to filter banks. It splits the frequencies as

1^{st} level decomposition: 1/ (2*dt)

2^{nd} level decomposition: 1/ (4*dt)

3rd level decomposition: 1/ (8*dt)

4th level decomposition: 1/ (16*dt) and so on.

Wavelets are defined by the wavelet function ψ (*t*) (i.e. the mother wavelet) and scaling function φ (*t*) (also called father wavelet) in the time domain. The wavelet function is in effect a band-pass filter and scaling it for each level halves its bandwidth.

B. WAVELET PACKET TRANSFORMS

The wavelet packet tree is constructed using the wavelet packet transforms which splits both the low and high pass coefficients further into two. Thus the frequencies can be still fine tuned comfortably using wavelet packet transforms. The initial root node is (0, 0). This is the original signal. This can be split as (1, 0) and (1, 1). This (1, 0) is a low frequency coefficient and (1, 1) is high frequency coefficient. Then further while it is split it leads to (2, 0), (2, 1), (2, 2), (2, 3). If we need only (1, 1) and (2, 1) then those two nodes can alone be reconstructed.

V. GRAPHICAL USER INTERFACE

The GUI is developed in MATLAB in order to get the input signal from the user end and produce results. The user controls are properly set to store the patient details such as their name, address, contact information etc. From this the doctor can refer to the previous records of the patients for convenient analysis of the disease. The first form is created for doctor's login for protected access of the details of the patient. Once the next button is clicked in the first form after typing the username and password it enters into the second form. The details of the patient are stored in a database as they are inputted to the form.

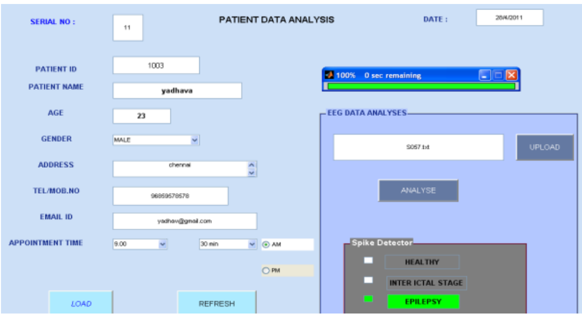

Fig.3.GUI for getting user input and analysis

The main program is attached to the "analyze" button on the GUI so that the entire process takes place and it classifies the data into either of the normal, inter ictal or epileptic stages. The EEG digital data is loaded using the "upload" button. This process takes up to 2-3 minutes.

1	DATE	ID	NAME	AGE	GENDER	ADDRESS	PHONE	EMAIL	HOUR	MIN	AM/PM	RESULT
2	23/3/2011	1001	KIRUTHI	23	FEMALE	CHENNAI	9962026079	KIRTHI.CH	4	o clock	PM	HEALTHY
3	23/3/2011	1002	kiruthi	23	FEMALE	chennai	9962026079	kirthi@gm	3	10 min	AM	INTERICTA
4	15/4/2011	760	nanditha s	23	FEMALE	rajakilpau	9940314303	sree_nanc	3	10 min	PM	INTERICTA
5	16/4/2011	1004	naveen ku	19	MALE	gjhgxv	9941396468	naveenkm	3	15 min	AM	HEALTHY
6	16/4/2011	1005	s.kiruthiga	23	FEMALE	chennai.	9855867897	kiruthi@g	5	5 min	PM	EPILEPSY
7	1/2/2011	1008	bala	18	MALE	royapetta	545848949	sbala@yal	3	5 min	PM	HEALTHY
8	26/4/2011	123	sumathi	22	FEMALE	12,chenna	2555355445	sumaest@	3	15 min	AM	HEALTHY
9	1/1/2011	321	anu	22	FEMALE	chennai	96592	asf@gmai	2	10 min	PM	INTERICTA
10	28/4/2011	345	kiruba	22	FEMALE	18/3070,JE	9791874433	kirubavl@	4	25 min	PM	INTERICTA
11	28/4/2011	980	yadhava	23	MALE	chennai	9.686E+10	yadhav@g	9	30 min	AM	EPILEPSY

Fig.4. Storing contact details of patients in database

VI. RESULTS

A. Using FDA Tool

The Filter Design and Analysis Tool (FDATool) is a powerful graphical user interface (GUI) in the Signal Processing Toolbox™ for designing and analyzing filters. FDATool enables you to quickly design digital FIR or IIR filters by setting filter performance specifications, by importing filters from your MATLAB® workspace or by adding, moving or deleting poles and zeros. FDATool also provides tools for analyzing filters, such as magnitude and phase response plots and pole-zero plots. In section (), the formulas for computing the specifications of optimal FIR filter is given and the values are computed and tabulated in Table (1).

TABLE (1) Specifications for FIR filter

SPECIFICATIONS	VALUES
Sampling frequency	173.61 Hz
Pass band frequency	60 Hz
Stop band frequency	70 Hz
Pass band attenuation	1 db
Stop band attenuation	40 db
Filter order	30

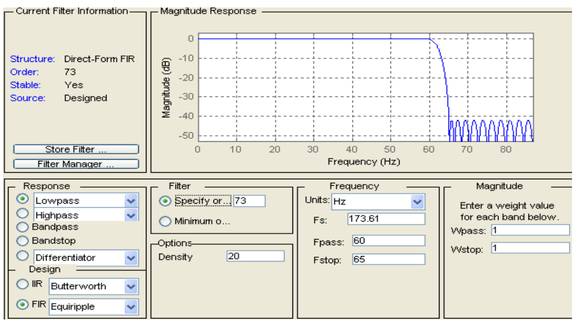

Fig.5. Magnitude response of FIR filter using Park-McClellan algorithm

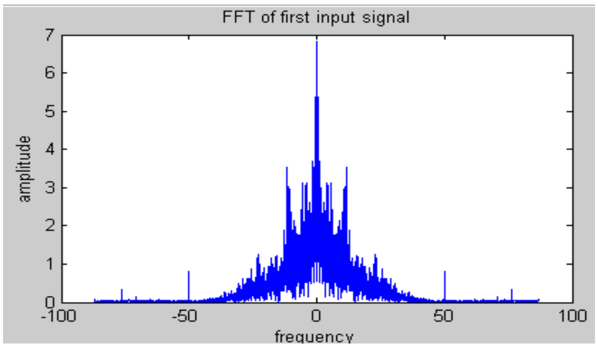

Fig.6. FFT of input with noise

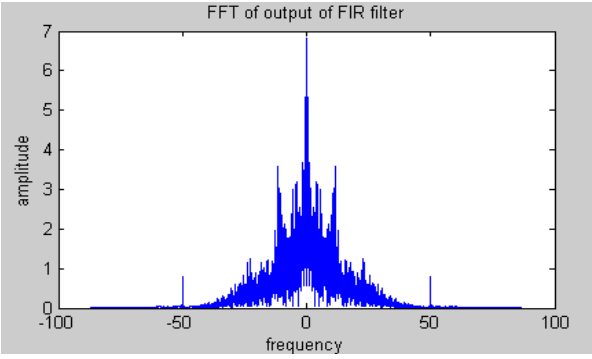

Fig.7. FFT of optimal FIR filter output

B. Wavelet packet analysis

The Daubechies wavelet transforms is used with fourth order and fourth level so that frequencies are split into finer parts. We can do any further computations by operating on those frequencies. The frequencies at various nodes of the tree can be viewed using wavelet packet transforms. The sampling frequency is double the cut off frequency, and then your first level wavelet detail coefficients will represent features in the input signal in the approximate octave band [43.4025, 86.8050]. The second level detail coefficients in the approximate octave band [21.7013, 43.4025] and so on. We can further fine tune the frequencies by using suitable filters for post processing. The band limited EEG in the range 0-60 Hz from the optimal FIR filter is given as input to the wavelet filters banks. W = dbaux (N, SUMW) is the order *N* Daubechies scaling filter such that sum (W) = SUMW. Possible values for *N* are 1, 2… The band separation is as follows: Gamma: 30-60 Hz, Beta: 13-30 Hz, Alpha: 8-12 Hz.

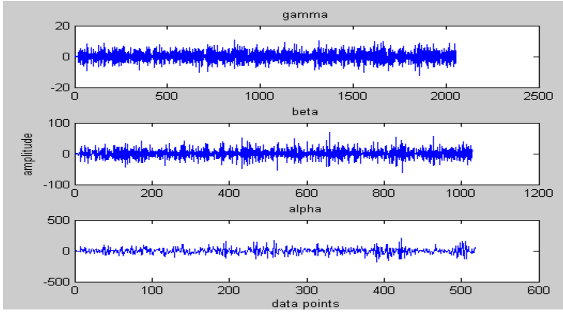

Fig.8. separation of sub bands

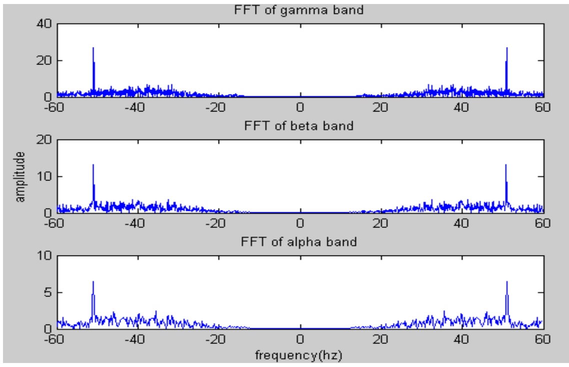

Fig.9. Frequency domain of output from wavelet filter

The wavelet coefficients are first generated and then the desired arrays of the wavelet packet tree such as the left child or the right child node can be reconstructed to get the data in that particular node.

VII. OBTAINING RESULTS IN SIMULINK

Simulink is an environment for multidomain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing. Here the data is loaded in Simulink from workspace and appropriate outputs are obtained.

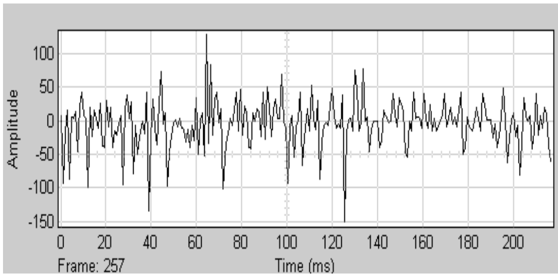

Fig.11. output of gamma band

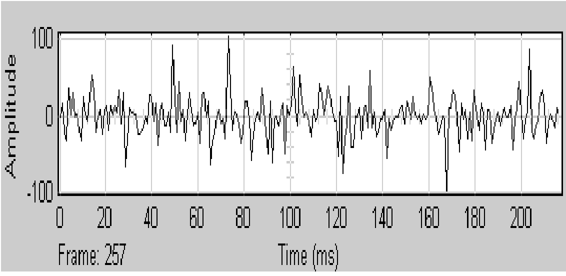

Fig.12. output of beta band

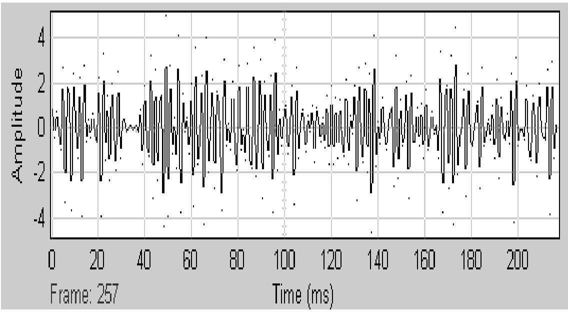

Fig.13. output of alpha band

CONCLUSION

Thus in this paper the EEG signals are analyzed for Epilepsy by first filtering with optimal FIR algorithm and then applying wavelet packet transforms for fine tuned analysis. A convenient user interface is created for quick access for the doctors to detect the disease with password protected user login. We have modeled a system for separation of sub bands of EEG signals after optimal preprocessing using SIMULINK.

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[8] "*Indications of nonlinear deterministic and finite-dimensional structures in time series of brain electrical activity: Dependence on recording region and brain state"*Ralph G. Andrzejak,1,2,* Klaus Lehnertz,1,† Florian Mormann,1,2 Christoph Rieke,1,2 Peter David,2 and Christian E. Elger11*Department of Epileptology, University of Bonn, Sigmund-Freud-Strasse 25, 53105 Bonn, Germany*2*Institut fu¨r Strahlen- und Kernphysik, University of Bonn, Nußallee 14-16, 53115 Bonn, Germany*~Received 14 May 2001; published 20 November 2001!