

EPILEPTIC SEIZURE DETECTION USING VLSI

^{#1}Ragini Vanmare, ^{#2}Shaikh Tanzeela, ^{#3}Patel Rashmi, ^{#4}Prof. Meenakshi A.

¹raginivanmare78@gmail.com,
²stanzila25@gmail.com

^{#123}B.E Student, E&TC Department
^{#4}Asst. Professor, E&TC Department

JSPM's BSIOTR, Pune, India.



ABSTRACT

The low energy two stage strategies for an energy-efficient circuit/architecture to detect the onset of epileptic seizures with high efficacy. The architecture consists of two stages. The first stage is a low complexity Coastline parameter algorithm that consumes very low energy per computation. The second stage is a more efficacious wavelet-based algorithm (discrete wavelet transform-quasi- averaging) that consumes relatively high energy and is powered ON only if determined by the low-complexity first stage. This methodology accomplish sufficiently great reduction in the energy consumption of the circuit by avoiding redundant calculations, thereby increasing the long life of the battery. Epilepsy is a common chronic neurological disorder. It is characterized by involuntary physical convulsions or seizures due to synchronous firing of groups of neurons. In spite of availability of pharmacological treatments, such as antiepileptic drugs and surgery, a sizable 30% of the affected population remains medically refractory. Epileptic seizure is a dynamically nonstationary transient symptom of excessive or synchronous neuronal activity in certain sections or the whole of the brain. Often, it culminates into physical convulsions, commonly known as fits. Such a condition prevalent in human body is called Epilepsy.

Keywords: Epilepsy, low power VLSI, coastline parameter algorithm, DWT algorithm

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I. INTRODUCTION

Technology scaling has allowed the integration of millions of transistors, enabling more complex functionality to be implemented in a single silicon chip. However, such complex functionality may require significant amount of computation leading to power consumption of insurmountable proportions. This is further aggravated in biomedical applications, especially in case of implants, which are powered by limited energy source and must ensure reliable operation to avoid any catastrophic failure. Hence, the designs of biomedical implants have stringent constraint on power consumption. This is to keep the on-chip temperature within safe limits and to increase durability, reducing the frequency of replacement of the energy source, which might be expensive, requiring intrusive surgery. Epilepsy is a common chronic neurological disorder, affecting about 50 million people worldwide .Seizures are detected by classifying and marking out 'events' in the recorded local field potential data and measuring the inter-event-intervals (IEI)[1] It is

characterized by involuntary physical convulsions or seizures due to synchronous firing of groups of neurons. In spite of availability of pharmacological treatments, such as antiepileptic drugs and surgery, a sizable 30% of the affected population remains medically refractory. For such patients, alternative therapy in the form of neurostimulation (chemical, electrical, or optical) has been proposed. Efficacious detection of seizure is a prominent prerequisite of such therapy. Implantable epilepsy prosthesis, enabled by integrated circuit technology, is the means to administer this therapy. Currently, the vague nerve stimulator. By Cyberonics Inc. is the only commercially available device approved by U.S. Food and Drug Administration. It is based on continuous neurostimulation that is argued to be detrimental and ineffective in the long run due to neuronal learning. Advantages of MLPNNs over LR that a MLPNN-based classifier can be developed quickly makes such classifiers efficient tools that can be easily re-trained.[5]Responsive neuro stimulation, which delivers focal stimulation based on detection of the seizure onset, is

more effective “Epileptic Seizure Detection” wherein, it is absolutely essential to conserve energy. Epileptic seizure is a dynamically non stationary transient symptom of excessive or synchronous neuronal activity in certain sections or the whole of the brain. These parameters were explicitly used to develop a highly accurate low complexity algorithm[4]. Often, it culminates into physical convulsions, commonly known as fits. Such a condition prevalent in human body is called Epilepsy. It is one of the most common chronic neurological disorders. Medical treatments for epilepsy have focused mainly on controlling the occurrence of seizures and not on curing it. Among the estimated 50 million people affected worldwide, about 30% do not show any improvement in reduction of seizure frequency with medication. This justifies alternative treatments, among which electrical stimulation seems to be a promising one. Some of the commercially available stimulators are based on continuous stimulation which arguably has long term negative effect. Hence, responsive stimulation is preferable mode of treatment. This, however, has prerequisite of a correct and confident detection of seizure, before administration of necessary treatment/stimulation. Hence, it is essential to design an algorithm which detects epileptic seizures with high efficacy. Over 50 million people worldwide and a million people in the U.S alone suffer from unpredictable, recurrent seizures[1]. About 30% of this population does not respond to medication or meet eligibility requirements for respective surgery by detecting normal chi and from a child having an epileptic seizure by (STFT) short time Fourier transform and (WT) wavelet transform it applied to EEG signals.[2] The possibility of applying electrical stimulation to suppress seizure activity has been reported as early as 1954 by Penfield and colleague’s .Vague nerve stimulation and direct electrical stimulation of the focal tissue have both shown great promise as an alternate therapy for this large patient population. Excessive or continuous neuro stimulation, however, has shown to reduce the responsiveness of the neurons to external stimuli, and decreases the efficacy of this therapy. An important aspect to providing on-demand closed-loop stimulation is the design of an efficient seizure detection algorithm that can work in real-time and be feasible in an implantable application. Discrete Daubechies and harmonic wavelets are investigated for analysis of epileptic EEG records [3].

II. LITERATURE SURVEY

M. K. Kiymik et. al. applied short-time Fourier transforms (STFT) and wavelet transform (WT) were applied to EEG signals obtained from a normal child and from a child having an epileptic seizure and developed a program using Lab view software. The WT is of interest for the analysis of non-stationary signals, because it provides an alternative to the classical STFT. When these methods were compared in term of process time, the STFT took the shortest time and it was applicable on line. On the other hand, the CWT took longer time but it produced more accurate result in recognizing of the EEG signals. Especially, detection of the epileptic seizure and classification of EEG signals with wavelet is useful because adjustment of wavelet analysis parameters and the

evaluation of the results obtained with new techniques such as neural networks give better results than STFT. [1]

A. Alkan et. al. introduced two fundamentally different approaches for designing classification models (classifiers); the traditional statistical method based on logistic regression (LR) and the emerging computationally powerful techniques based on artificial neural networks (ANNs). LR as well as multilayer perception neural network (MLPNN) based classifiers were developed and compared in relation to the accuracy in classification of EEG signals. Using PSDs of EEG signals, two classifiers were constructed and cross-compared in terms of their accuracy relative to the observed epileptic/normal patterns. The comparisons were based on analysis of the receiving operator characteristic (ROC) curves of the two classifiers and two scalar performance measures derived from the confusion matrices; namely specificity and sensitivity. Essentially, MLPNNs require deciding on the number of hidden layers, number of nodes in each hidden layer, number of training iteration cycles, choice of activation function, selection of the optimal learning rate and momentum coefficient, as well as other parameters and problems pertaining to convergence of the solution. Other advantages of MLPNNs over LR that a MLPNN-based classifier can be developed quickly makes such classifiers efficient tools that can be easily re-trained, as additional data become available, when implemented in the hardware of EEG signal processing systems[2]

S. Raghunathan et. al. presented an event-based seizure detection algorithm that can be implemented in real-time using low power digital CMOS circuits to form to implantable epilepsy prosthesis. Seizures are detected by classifying and marking out ‘events’ in the recorded local field potential data and measuring the inter-event-intervals (IEI). The circuit implementation can be programmed post-implantation. Its computational efficiency makes it possible to implement on silicon using ultra low power circuits, increasing its viability in an implantable application. One of the primary goals of the ongoing large animal trial is to quantitatively describe the threshold fitting process and relate it to baseline measurements for each individual. The aims to optimize the number of stages used in detection and present the trade-offs in increasing or decreasing this count. This would increase the efficacy of the algorithm significantly and also provide the clinician with additional flexibility to make changes on a case to case basis.[3]

H.Markandeya et. al. developed a novel low-power epileptic seizure detection system based on wavelet transform and quasi-averaging operation, tunable to user specific needs, by utilizing power efficient design techniques at various levels of abstraction. These parameters were explicitly used to develop a highly accurate low complexity algorithm. Further, this algorithm was mapped to a low power hardware implementation. Multiplier-less techniques were utilized at architectural level to reduce the power consuming logic elements.[4]

The two-stage algorithm for detecting epileptic seizure was designed and synthesized using 65-nm bulk-Si (TSMC) library, nine-metal process. It used 22831 combinational and 8939 sequential cells. The SPICE netlist was extracted and simulated in Nanosim with a typical set of data. The average power consumption of an individual stage as well as that of the full system was obtained. Using the duration of the

recording and number of vectors, the energy/computation was calculated. Live kainite-treated animals with implanted LFP neural recording system provided the data.[5]

III. PROPOSED WORK

A. Block Diagram

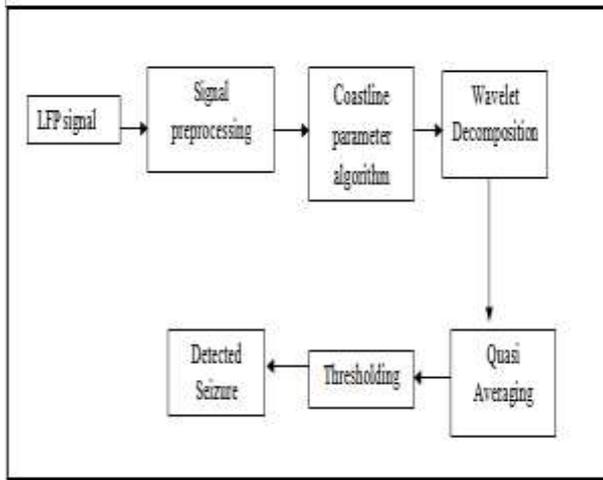


Fig1. Proposed System Block diagram

B. Block Diagram Description

In this block diagram, we put forward a two-stage, low power VLSI strategy to achieve significant energy savings while maintaining a high detection efficacy. We have faith in this method to provide a basic solution to the detection system of epileptic seizure. The section IV will explain the algorithm methodology. The results and discussion is provided in section V.

IV. ALGORITHM METHODOLOGY

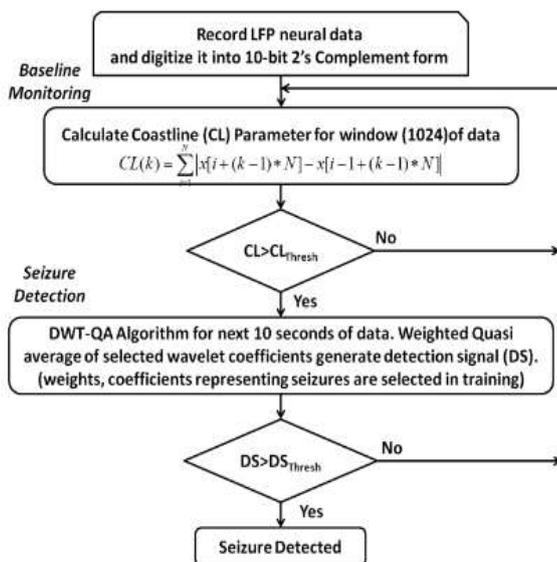


Fig 2. Algorithm methodology and flow chart

The proposed methodology is shown in Fig. 1. The onset of the seizure is detected in two stage, i.e. monitoring stage and detection stage.

1) Monitoring Stage: The monitoring stage is the coastline parameter (CL)-based algorithm. The CL measures the trace length of the signal by accumulating the distance between adjacent peaks over a prefixed window of data. The CL can be calculated using

$CL(k) = \sum_{j=i-1+(k-1)*N}^{i+(k-1)*N} |x[j+(k-1)*N] - x[i-1+(k-1)*N]|$ where x is data, k is window, and N is window width. The CL is computed over adjacent windows. In the baseline signal, the CL value will be, on an average, invariant. However, closer to the onset of seizure it gradually increases because of occurrence of high-amplitude spikes in the signal. The CL is compared with a threshold to raise a warning flag that activates the detection stage. The monitoring stage also filters out a large number of false positives (FP). An FP which passes the monitoring stage will be classified by the detection stage. This has a direct impact on the energy consumption of the system.

2) Detection Stage: The detection stage consists of the DWTQA algorithm as was presented in. The warning flag from the monitoring stage is used to activate the detection stage. The DWTQA takes the digitized input data and resolves them into narrow frequency bands in terms of wavelet coefficients. The wavelet chosen is Daubechies-4 (DB-4) due to its ability to capture the spiking and smoothing nature of the LFP. The patient-specific significant coefficients are quasi-averaged, weighted, and added over a prefixed window to produce the detection signal. This is compared with a prefixed threshold to classify the signal as seizure or baseline.

APPLICATIONS

LFP Signal can be used to find mood of person.
Can be used to detect sleepy state of human.

V. DISCUSSION AND RESULT

Figure 3 shows the row LFP signal which is consist of random set of recorded LFP with four identified seizure and equal duration of baseline.

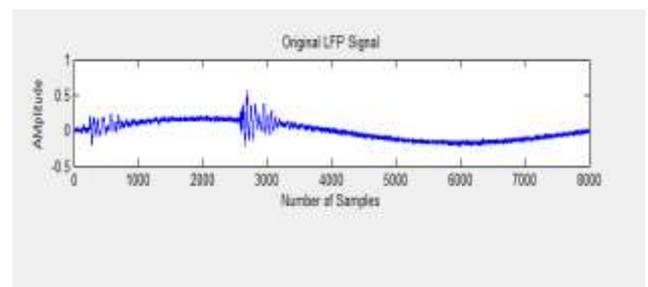


Fig3. Row LFP signal

The figure 4 shows pre-processed LFP signal. The acquired signal in Mat lab software. For detection of seizure this signal need to be transmitted to FPGA.

Before that it converted each sample of signal into binary and then into ASCII characters

