

**Detection of Epileptic Seizures based on Electroencephalogram
using Enhanced Signal Processing and Soft
Computing Techniques**

By

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CERTIFICATE

This is to certify that the thesis entitled “ **Detection of Epileptic Seizures based on Electroencephalogram using Enhanced Signal Processing and Soft Computing Techniques** ” submitted to the Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for the award of the degree of **Doctor of Philosophy in Computer Science**, is a record of original research work done by **G. Geetha**, during the period of her study in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under my supervision and guidance and the thesis has not formed the basis for the award on any Degree/Diploma/Associateship/ Fellowship or similar title to any candidate of any University.

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DECLARATION

I hereby declare that the matter embodied in the thesis entitled “**Detection of Epileptic Seizures based on Electroencephalogram using Enhanced Signal Processing and Soft Computing Techniques**” is the result of investigations carried out by me in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under the supervision and guidance of **Dr.S.N.Geethalakshmi**, Professor, Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, and that it has not been submitted for the award of any Degree/Diploma/Associateship/Fellowship or similar title of any University or Institute.

Signature of the Supervisor

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Abstract

A myriad of epilepsies indicate that its arousal could be due to manifold reasons, but the entirety culminates into a communal phenomenon – the seizure. Requirement of an accurate and reliable seizure detector is highly indispensable not only for the better understanding of seizure generation but also a boon for medicos who are subjected to fatigue in visualizing a continuous and enormous long-term recording. The confound intricacies in the process of evaluation of seizure detection algorithms are typically overwhelming with cognitive predispositions that consensus could not be reached by the experts.

Despite substantial innovations in an automated detection of epilepsy over the past decade, the quench for an appropriate blend of methodology, emphasizes the need for an appropriate seizure detection systems. A broad range of strategies is being investigated thoroughly, and an effort is put forth with utmost intervention to yield an approach for seizure detection. Automated seizure detection system fundamentally aims in providing a consistent algorithm by excavating in-depth knowledge of dynamical properties of the signal and clinical domains. Impediments are overcome and contingent cautioning is provided for the commencement of therapy for controlling seizures thereby minimizing the risk of injury to patients.

The objective of this study is to design and implement an Automated Seizure Detection System using Electroencephalogram (ASDEEG) by incorporating enhanced signal processing and soft computing techniques. The ASDEEG comprises of three major phases for accomplishment of Seizure

detection and they are as follows i) Signal preprocessing ii) Feature Extraction and iii) Classification. EEG signals are often obscured by the presence of artifacts, and these interruptions introduce spike in signals which in turn disrupts correct diagnosis and analysis. The EEG signals are degraded by the presence of 50 Hz line noise, which are adaptive in nature and are removed by implementing a conventional notch filter. The resultant EEG signals were still encountered with different types of artifacts and hence require further processing. The next step of preprocessing used spatially constrained Independent Component Analysis along with Wavelet denoising technique to improve the quality of EEG signal. Five types of artifacts were analyzed and they are eye ball movement, eye blinking, split swallowing, jaw clenching and artifacts introduced due to electrical inconsistency (arising due to popping up of electrodes).

Need for extracting relevant information in EEG by relating it to pathological cases is a major challenge. The above mentioned requirements were satisfied by a transformation called Fast Walsh-Hadamard Transform (FWHT), which adopts a speed optimizer to improve the time complexity. A sliding Hanning window was used to isolate the EEG bands alpha, beta, delta, theta and gamma. The Welch power spectrum estimator was used to calculate the spectrum and the power in delta, alpha and beta band. These values were used to form the feature vector that was used as input to the next phase.

The proposed classification algorithms Hybrid Extreme Learning Machine (HELM) and Fast Adaptive Neuro-Fuzzy Inference System (FANFIS) used for detecting the presence of seizure in EEG signal were based on Extreme Learning Machine (ELM) and Adaptive Neuro-Fuzzy Inference System (ANFIS) respectively. An improvement to the above specified classifiers was made by introducing a modified Levenberg-Marquardt algorithm (MLM), to reduce the time complexity of the algorithm during training. The Epileptic Seizure Detection

system is truly a full-fledged system because; the accuracy supported by the system is 99.56%.

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ACRONYMS

Abbreviation	Description
AEEG	Ambulatory Electroencephalograph
AHP	Analytical Hierarchical Process
ANFIS	Adaptive Neuro Fuzzy Inference System
ANN	Artificial Neural Network
ApEn	Approximate Entropy
AR	Auto Regressive
ARC	Average Response Computer
ARMA	Auto Regressive Moving Average
ASDEEG	Automated Seizure Detection system
ASICs	Application Specific Integrated Circuits
BMI	Brain Machine Interface
BP	Back Propagation
BPN	Back Propagation Network
BSS	Blind Source Separation
CAL	Cosine function with respect to Walsh
CAT	Computer Aided Tomography
CC	Connected Component
CD	Correlation Dimension
CNS	Central Nervous System
CRB	Cramer-Rao Bounds
CT	Computed Tomography
CVA	Cerebrovascular Accident
DALYs	Disability Adjusted Life Years
DSA	Digital Signal Analysers
DSP	Digital Signal Processors
DWT	Discrete Wavelet Transform
ECG	Electrocardiogram
EEG	Electroencephalogram
ELM	Extreme Learning Machine
EMG	Electromyogram
En	Entropy

EOG	Electro- Oculogram
EPP	Exploratory Projection Pursuit
EV	Eigen Vector
FANFIS	Fast Adaptive Neuro Fuzzy Inference System
FE	Feature extraction
FEBANN	Feedforward Error Back Artificial Neural Network
FFT	Fast Fourier transform
FIR	Finite Impulse Response
FIRDA	Frontal Intermittent Rhythmic Delta
FIS	Fuzzy Inference System
fMRI	functional Magnetic Resonance Imaging
FPGA	Field Programmable Gated Array
FV	Feature Vector
FWHT	Fast Walsh Hadamard Transform
GD	Gradient Descent
GN	Gauss Newton
HCI	Human Computer Interaction
HE	Hurst Exponent
HELM	Hybrid Extreme Learning Machine
IC	Independent Components
ICA	Independent Component Analysis
IEA	Indian Epilepsy Association
ILAE	International League Against Epilepsy
JADE	Joint diagonalization of cumulant matrices
KFM	Kohonen's Feature Map
K-NN	Kohonen Neural Network
LBDWT	Lifting- Based Discrete Wavelet Transform
LDA	Linear Discriminant Analysis
LLE	Largest Lyapunov Exponent
LM	Levenberg- Marquadt
LMS	least mean square
LR	Logistic Regression
MDPE	Multidimensional Probability Evolution
MEG	Magnetoencephalogram
MFs	Membership Functions
MI	Mutual Information

MLE	Maximum Likelihood Estimation
MLFN	Multi Layer Feed Forward Network
MLM	Modified Levenberg Marquardt
MLP	Multi Layer Perceptron
MRI	Magnetic Resonance Imaging
MSE	Mean Square Error
MS-ICA	Molgedey and Schuster ICA
MUSIC	Multiple Signal Classification
NBC	Naive Bayesian Classifier
NIH	National Institutes of Health
NIRS	Near Infrared Spectroscopy
NN	Neural Networks
OA	Ocular Artifact
OGWE	Optimized Generalized Weighted Estimator
OIRDA	Occipital Intermittent Rhythmic Delta
OS-ELM	Online Sequential Extreme Learning Machine
PCA	Principal Component Analysis
PCs	Principal Components
PE	Permutation Entropy
PET	Positron Emission Tomography
PI	Performance Index
PNN	Probabilistic Neural Network
PNS	Peripheral Nervous System
PSD	Power Spectral Density
PSNR	Peak Signal to Noise Ratio
PWE	Patients With Epilepsy
QV	Quality Value
RADICAL	Robust, Accurate, Direct Independent Components Analysis Algorithm
RBF	Radial Basis Function
RBFN	Radial Basis Function Network
RLS	Recursive Least Square
RMS	Recorders & Medicare Systems
RMSE	Root Mean Square Error
RNNs	Recurrent Neural Network
ROC	Receiver Operating Characteristic

SAL	sine function with respect to walsh
SC	Spatially Constrains
SCICA	Spatially Constrained Independent Component Analysis
SHIBBS	SHifted Blocks for Blind Separation
SLFN	Single Layer Feedforward Network
SNR	Signal to Noise Ratio
SOBI	Second Order Blind Identification
SOFM	Self Organizing Feature Maps
SOM	Self Organizing Maps
SPECT	Single Photon Emission Computed Tomography
STFT	Short Time Fourier Transform
SVD	Singular Value Decomposition
SVM	Support Vector Machine
TBI	Traumatic Brain Injury
TFD	Time Frequency Distribution
TSK	Takagi- Sugeno-Kang
TV	Television
WAL	Walsh functions
WD	Wavelet Denoising
WHO	World Health Organization
WNN	Wavelet Neural Network
