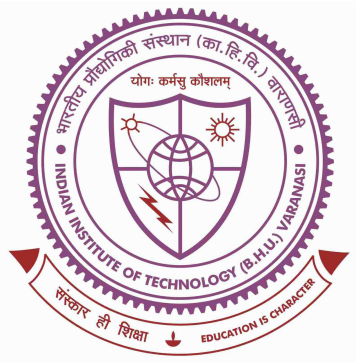
INTELLIGENT COMPUTING TECHNIQUES FOR EPILEPTIC SEIZURE PREDICTION



Thesis submitted in partial fulfillment
for the Award of Degree

Doctor of Philosophy

by

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2023

To

My Beloved Family

and

My Beloved Family-in-law

CERTIFICATE

It is certified that the work contained in the thesis titled "*INTELLIGENT COMPUTING TECHNIQUES FOR EPILEPTIC SEIZURE PREDICTION*" by "*ANVITI PANDEY*" has been carried out under my supervision and that this work has not been submitted elsewhere for a degree. It is further certified that the student has fulfilled all the requirements of Comprehensive Examination, Candidacy, and SOTA for the award of Ph.D. Degree.

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DECLARATION

I, "*ANVITI PANDEY*", certify that the work embodied in this thesis is my bona fide work and carried out by me under the supervision of "*PROF. SANJAY KUMAR SINGH*" from "*JULY-2017*" to "*JULY-2023*", at the Departement of "*COMPUTER SCIENCE AND ENGINEERING*", Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not willfully copied any other's work, paragraphs, text, data, results, etc., reported in journals, books, magazines, reports dissertations, theses, etc., or available at websites and have not included them in this thesis and have not cited as my work.

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Acknowledgments

"No one who achieves success does so without acknowledging the help of others. The wise and confident acknowledge this help with gratitude." -Alfred North Whitehead

I take this opportunity to express my gratitude towards the people who have, in some form or the other, helped me throughout my doctoral program. First and above all, I bow in great reverence before the Almighty. When times seemed dark, You became the light for me as You do for all of humankind. I want to express my profound gratitude and sincere regards to my supervisor, Prof. Sanjay Kumar Singh, for giving me invaluable guidance, support, and motivation throughout my candidature. His innovative ideas inspired the successful completion of this thesis work. I am indebted to Prof. K. K. Shukla, for his advice, motivation and his faith in me. I want to express my gratitude to the Research Progress Evaluation Committee members, Prof. Subir Das, and Dr. R. S. Singh, for their wise criticism, support, and advice, which broadened my horizons and helped me enhance my studies.. I want to convey my sincere gratitude to the other faculty members of the Department of Computer Science and Engineering, Prof. A. K. Tripathi, Prof. Rajeev Shrivastava, Dr. Pratik Chattopadhyay, Dr. Amrita Chaturvedi, Dr. Bhaskar Biswas, Dr. H. P. Gupta, Dr. Sukomal Pal, Dr. A.K Singh, Dr. R. Gupta, Dr. L. Kailasam, Dr. R.N. Chaudhary, and Dr. Tanima Dutta, for their guidance and support throughout this tenure. All the faculty of this department have always been kind to me while providing their support and motivation. I extend special thanks to the non-teaching and technical staff in the department, particularly Dr. Ram P. Meena, Mr. Raghuvir S. Tripathi, Mr. Ravi K. Bharti, Mr. Ritesh Singh, Mr. Prakhar Kumar, Mr. Shubham Pandey, Mr. Biplav Biswas, Mr. A K. Pal, and Mr. M. K. Rai. I want to thank my seniors and colleagues Dr. Mridula Verma, Dr. Ashish Kumar Maurya, Dr. Abhinav, Dr. Anshul, Dr. Aneesh Nath, Dr. Dipty, Mrs. Sneha and Mr. Ritesh Sharma for their help and support.

My time here gave me a wealth of friendships that I will cherish for my entire lifetime.

Dr. Manisha Singla and Dr. Vandana Bharti were not only my labmates, but they are my close friends who constantly kept me motivated and yearning for my goal. Looking at them persevere in their own research inspired me to keep going at mine. Also, I would often ask for their help with technical doubts, which they always attended to with utmost sincerity. Even outside the lab, Manisha and I have spent a lot of time sharing fears and joys of life with each other, which bonded our friendship even further. The same goes for Dr. Priya Singh who I would like to thank for keeping my spirits high, for her invaluable friendship and presence during my time at IIT(BHU).

I am eternally grateful to Dr. Sandeep Sambhaji Udmale, who is my senior and my mentor. This work and this thesis have been able to see the light of day because of him. His technical and non-technical insights and feedback helped me find it in me to do the kind of work seen in this thesis. It was only because of his continuous guidance and faith in me that I could muster up the courage to continue with my doctoral program when I was defeated and almost giving up on my goal. Also, I acknowledge access to the expertise and facilities created under the Center of Excellence in Artificial Intelligence (CoE AI) of Veermata Jijabai Technological Institute (VJTI), Mumbai-19.

I am profoundly grateful for the love and affection I got from Mrs. Jyoti Rani. She was my roommate, and through her, I got to experience a kind of sisterhood I never thought I needed in my life. It is said that friends are the family you choose, but there are very few friends who come close to being family. She is one such friend who has cried and laughed with me. She has been my cheerleader since day one, and even today, she inspires me with the grit she has shown these past few years.

This tenure of Ph.D. showed and tested a supreme strength that I have, and I am privileged to call them my family. This includes my parents, my husband, my blood family, and my family-in-law. They say it takes a village to raise a child, but my family took up the task of raising my newborn child along with helping me raise my Ph.D. as well. I am eternally grateful to my parents, Dr. Anil K. Pandey and Mrs. Preeti Pandey, who provided me with all the love, support, and resources that I needed to become what I am today. I have always looked up to them to be who I am. They always ensured they were present for me in every form a parent can be for their child. For me, this is a privilege in itself and has taught me the kind of parent one should aspire to be. I am blessed to have another set of parents who, through their example, have taught me what it is to stand up for your family. They are my parents-in-law, Dr. Anoop K. Gupta, and Dr.

Rashmi Gupta. They took up a lot of responsibilities off my plate, including the time I had to give to my newborn son, Avyaan. If I can be half as capable as these parents are, I will consider my life worth. I cannot put into words the continuous support and infallible love my husband, Mr. Apaar Gupta, has given me. His words of encouragement and his willingness to persevere alongside me gave me immense strength to overcome the hurdles I faced. There were times when I didn't think I could go on, but he was always there to put things in perspective.

I am profoundly thankful to my aunt Prof. Anita Ojha and my uncle Mr. Rajendra P. Ojha, who were not only my local guardians but are also my ardent motivators. They have always showered me with their love and affection and continued to do so when I needed it the most. They kept my spirits up by providing home-cooked food, showing up for me whenever I needed them, and becoming my home away from home. I am grateful to my uncle Prof. Neeraj Pandey for providing me with words of encouragement and tips on how to go about my doctoral program smoothly while citing his own experiences as a research scholar and a research supervisor. Other members of my family who rose to the occasion to help me in my journey were my sisters, Mrs. Rupam Ojha and Anugya Pandey, along with my brothers, Anvay Pandey, Ayushkam Pandey, and my brother-in-law Anunay Gupta. Special mention to my brother Mr. Ritesh Ojha who used to help me with technical queries regarding signals and electrical engineering concepts over calls late at night after his working hours. Mrs. Rupam Ojha has been my pillar since the beginning and is always there for me, no matter the situation. Also, I am grateful to my brother-in-law Dr. Anany Gupta who kept cheering for me and also helped me get in touch with neurologists during the initial days of this research work. I want to thank all my family members who knowingly and unknowingly became a part of something important to me. I am eternally grateful to you all.

Date: *ANVITI PANDEY*

List of Figures

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List of Abbreviations

1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional
AE	AutoEncoder
AC	Artifact Combination
AD	Alzhiemers' Disease
AdaBoost	Adaptive Boosting
ADHD	Attention-Deficit/Hyperactivity Disorder
AiP	Artifacts in Pairs
AM-FBC	Adaptive Median Feature Baseline Correction
ANN	Artificial Neural Network
AR	Artifact Removal
BCI	Brain-Computer Interface
BLSTM	Bidirectional LSTM
BPNN	Backpropogation NN
BRO	Battle-Royale Optimization
BRRO	Battle Royale Search and Rescue Optimization
BS-LSTM	Bidirectional Stochastic LSTM
BSCN	Bidirectional SCN
BSO	Brainstorm Optimization
BSS	Blind Source Separation
CA	Cardiac Artifacts
CCR	Common Component Rejection
CE-stSENet	Channel-Embedding Spectral-Temporal Squeeze-and-Excitation Network

CESP	Convolutional ES Predictor
CNN	Convolutional Neural Network
Conv1Ds	1D Convolution Layer
CoTA	Combination of Three Artifacts
CV	Cross Validation
DCGAN	Deep Convolutional GAN
DFA	Detrended Fluctuation Analysis
DL	Deep Learning
DNN	Deep NN
DWT	Discrete Wavelet Transform
ECG	Electrocardiography
EDF	European Data Format
EEG	Electroencephalogram/Electroencephalography
EMD	Empirical Mode Decomposition
EMG	Electromyography
EMRVFLN	Error-Minimised RVFL Network
EOG	Electrooculography
ES	Epileptic Seizure
ESA	EEG Signal Analysis
ESN	Echo State Networks
EWT	Empirical Wavelet Transform
FB-SARO	Forensic based Search and Rescue Optimization
FBIO	Forensic Based Investigation Optimization
FC	Fully-Connected
FD	Fractal Dimension
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
FLN	Functional Link Neural Network
FN	False Negative
FP	False Positives
FPA	Flower Pollination Algorithm
FPGA	Field Programmable Gates Array

FPR	False Prediction Rate
FR	Fletcher Reeves
FS	Failed Search
FV	Fisher vector
GA	Genetic Algorithm
GAN	Generative Adversarial Networks
GLCM	Gray-Level Co-occurrence Matrix
HC	Healthy Controls
HE	Hurst Exponent
HFD	Higuchi Fractal Dimension
HNN	Hierarchical Neural Network
HP	Hjorth Parameters
HT	Hilbert Transform
ICA	Independent Component Analysis
IDE	Integrated Development Environmet
iEEG	Intracranial EEG
IMFs	Intrinsic Mode Functions
KNN	K-Nearest Neighbor
LGCN	Linear Graph Convolution Network
LMD	Local Mean Decomposition
LoG	Laplacian of Gaussian
LR	Linear Regression
LSTM	Long Short-Term Memory
MA	Muscle Artifacts
MAS	Mean Amplitude Spectrum
MFS	Maximum FS
MI-EEG	Motor Imagery EEG
ML	Machine Learning
MLP	Multilevel Perceptron
MMNN	Multi-Module Neural Network
MoA	Motion Artifacts
MOFPA	Multi-Objective FPA

MPSD	Mean Power Spectral Density
MPSO	Modified PSO
MRBF	Multiscale Radial Basis Function
MSE	Mean Squared Error
NN	Neural Network
OA	Ocular Artifacts
OCNN	Optimised CNN
OLS	Orthogonal Least Squares
PCA	Principal Component Analysis
PF	Product Functions
PL	PowerLine Interference
PRD	Percentage Root Mean Square Difference
PS	Patient-Specific
PSD	Power Spectral Density
PSO	Particle Swarm Optimisation
RAM	Random Access Memory
RF	Random Forest
RGB	Red, Green and Blue
RNN	Recurrent Neural Networks
ROC	Receiver Operating Characteristic
RS-DA	Random Selection and Data Augmentation
RVFL	Random Vector Functional Link
SA	Single Artifact
SARO	Search and Rescue Optimization
SC-EEG	Single-Channel EEG
SCN	Stochastic Configuration Network
SCNN	Stacked CNN
SD	Standard Deviation
SE	Squeeze-and-Excitation
sEEG	Scalp EEG
SER	Sparsity based EEG Reconstruction
SLSTM	Stacked LSTM

SNR	Signal to Noise ratio
SOP	Seizure Occurrence Period
SPH	Seizure Prediction Horizon
SRNN	Stacked RNN
SSD	Sparse Spectrotemporal Decomposition
STFT	Short-Time Fourier Transform
SVD	Singular Value Decomposition
SVM	Support Vector Machine
TL	Team Leader
TN	True Negatives
TP	True Positives
TQWT	Tunable-Q-WT
TrP	Training Percentage
TSIN	Temporal–Spatial Information Network
UPSO	Uniform Search PSO
VMD	Variational Mode Decomposition
WDESN	Wide Deep ESN
WFB	Wavelets Filter Bank
WPFs	Wavelet Packet Features
WPT	Wavelet Packet Transform
WT	Wavelet Transform

List of Symbols

$a(\cdot)$	Activation function
b	Biases of the hidden layer
w_k^1	Central frequency
C	Contaminated signal
α	Contamination coefficient
(X_i, Y_i)	Data sample
D	Denoised signal
$Y \times Z$	Dimension of the weight values
c	Element of the signal C
r_n	Error computed from the current network
ε	Error Threshold
E	Evidence matrix
u_k^1	First modes
Q	Fixed number of nodes
Hz	Hertz
hr	Hour
λ	Input weights
imf_i	Intrinsic mode function
ϕ	Lagrangian multipliers
$L1$	Layer in LSTM
N_{max}	Maximum number of nodes that can be added to the network
$r(t)$	Monotonic trend
l	Node order
n	Number of nodes in the hidden layer of the current network