

TABLE OF CONTENTS

	Description	Page No.
	Candidate's Declaration	ii
	Abstract	iii
	Acknowledgments	v
	List of Figures	xii-xviii
	List of Tables	ix-xx
	List of Publications	xxi-xxii
	List of Abbreviations and Symbols	xxii-xvi
	Chapter-1: Introduction and Literature Survey	1-39
1.1	Cardiovascular Diseases (CVD)	2
1.2	Electrocardiogram (ECG)	2
1.3	The Heart's Electrical System	3
1.4	Activation of the Heart	4
1.5	Electrocardiogram Generation and Action Potential Propagation	6
1.6	Standard 12-Lead ECG System	6
1.6.1	Einthoven Lead	8
1.7	ECG features	8
1.8	Artifacts in the ECG signal	10
1.8.1	Cause of Artifacts	10
1.8.2	Characteristics of the Artifact	11
1.8.3	Types of Artifacts	11
	(a)Baseline wanders Noise	
	(b)Muscle tremor Noise	
1.8.4	Removal of Artifacts	12
1.9	Overview of Arrhythmias	13
1.9.1	ECG Signal Properties in Arrhythmias	15
1.9.2	Electrocardiogram of the heart: Normal vs. Abnormal	16
1.9.3	Problem Definition of Arrhythmias	17
1.9.4	Various types of Arrhythmias	17
1.9.4.1	Ventricular Arrhythmias	17

	Description	Page No.
1.9.4.2	Supra-ventricular Arrhythmias	18
1.9.4.3	Premature Ventricular Contraction (PVC)	18
1.9.4.4	Atrial Premature (AP)	19
1.9.4.5	Bundle-Branch Block	20
1.9.4.5.1	Right Bundle Branch Block (RBBB)	20
1.9.4.5.2	Left Bundle Branch Block (LBBB)	21
1.10	Ischemia	22
1.10.1	Causes of Ischemia	23
1.10.2	Ischemia Symptoms	23
1.10.3	Myocardial Infarction	23
1.10.4	Graphical view of Ischemia	25
1.10.5	The Ischemic Zone's Geographical Location	25
1.10.6	Differentiation between Ischemia, Infarction, and Necrosis	26
1.11	Literature Survey	26
1.12	Our Contributions	37
1.13	Organization of the thesis	38
	Chapter-2: Resources and Methods	40-72
2.1	Databases	40
2.1.1	European ST-T Database (EDB)	40
2.1.2	MIT-BIH Database	42
2.2	Methods	42
2.2.1	Savitzky-Golay	42
2.2.2	Wavelet transforms	45
2.2.2.1	Approximations and detail co-efficient	47
2.2.2.2	Multiple level Decomposition	48
2.2.2.2.1	Number of Levels	49
2.2.2.3	Reconstruction of Wavelet Transform Signal	49
2.2.2.4	Reconstruction Filter	50
2.2.2.5	Approximation and details reconstruction	51
2.2.2.6	Multi-Level of Decomposition and reconstruction	52
2.2.2.7	Frequency and Scale	53

	Description	Page No.
2.2.2.8	DWT (Discrete Wavelet transform)	53
2.2.2.9	Fast wavelet transform	54
2.2.2.10	Comparison between Wavelet Transform-based analysis and the Fourier Transform, Short Time Fourier Transform	55
2.2.2.10.1	Fourier Transform based Analysis	55
2.2.2.10.2	Short Time Fourier Transform based Analysis	56
2.2.2.10.3	Wavelet Transform based Analysis	57
2.2.2.11	Characteristics of wavelet transforms	58
2.2.2.12	Families of wavelet transform	58
2.2.2.13	Maximum Overlap Wavelet Packet Transform (MOWPT)	59
2.2.2.13.1	Algorithm for MOWPT	61
2.3	Encryption and Authentication	63
2.3.1	Data Encryption Standard (DES)	63
2.3.2	Single Round Description	64
2.3.3	Decryption with DES	65
2.4	Data Security for ECG	65
2.5	Water Cycle optimization (WCO)	68
2.6	Internet of Things (IoT)	69
2.6.1	Components of an IoT systems	70
	MATLAB	72
	Chapter-3: Research Gaps & Objectives	73-74
	Chapter-4: Methodology	75-113
4.1	Introduction	75
4.1.1	Elimination of noises in ECG signal for European ST-T and MIT-BIH database using SG filter	75
4.1.2	Wavelet Thresholding	77
4.1.3	Technique for De-noising of Electrocardiogram Signals	78
4.2	Detection of Characteristics point of Electrocardiogram (ECG) Signal	80
4.2.1	Techniques for Detecting QRS for MIT-BIH database	81
4.3	Detection of Features of ECG signal	82

	Description	Page No.
4.3.1	Morphological Characteristics	82
4.3.2	Statistical Characteristics	83
4.4	The Proposed Classification of Arrhythmias using Deep Learning	84
4.4.1	Convolution Neural Networks	86
4.4.2	Activation Function	87
4.4.3	Pooling Layers	87
4.4.4	Soft-max activation and fully interconnected layer	88
4.4.5	Dropout and Flatten layers	88
4.4.6	Literature Survey of Classification of Arrhythmias	89
4.4.7	Deep Convolutional Neural Network (DCNN)	89
4.4.8	Genetic algorithm based back-propagation neural network (GA-BPNN)	90
4.4.9	CNN+LSTM	90
4.4.10	BaROA DCNN classifier	91
4.4.11	Proposed Work	92
4.5	Proposed Water Cycle Optimization Process (WCO)	97
4.5.1	Evaporation Condition	102
4.5.2	Raining Process	102
4.5.3	Handling Constraints	103
4.5.4	Criteria for Convergence	103
4.6	The Proposed Triple Data Encryption Standard (3-DES)	104
4.7	The proposed ThingSpeak IOT Platform	105
4.7.1	Architecture of Internet of Things (IoT) technique	106
4.8	Modified Isoelectric Energy Function	108
4.8.1	Deviation in region of interest (ROI) and ST-Segment Assessment	110
4.8.2	A Novel Modified Isoelectric Energy Measuring Function	111
4.8.3	Threshold	111
4.8.4	Characterization of Beats	112

	Description	Page No.
4.8.5	Detection of Ischemia Episodes	112
4.8.6	Algorithm for Myocardial infarction (MI) Beat Characterization	113
	Chapter-5: Results and Discussion	114-171
5.1	Results of Elimination of Baseline Wanders noise for European ST-T and MIT-BIH database using Savitzky-Golay filter	114
5.2	Elimination of High frequency noise in ECG signals for European ST-T and MIT-BIH database using MOWPT	123
5.3	Compared with Existing Approaches	132
5.4	Detection of ECG Characteristic Points	133
5.4.1	Onset and Offset Points Detection	134
5.4.2	Calculation of Heart Rate	134
5.4.3	Isoelectric Reference Detection (IR)	134
5.4.4	Identifying Amplitude Characteristics	137
5.4.5	Identifying Time Plane Characteristics	137
5.5	Effects of Artifact Removal on the Delineation Process	140
5.5.1	Comparisons with Existing Methods	142
5.6	Flow Diagram of R-peak detection using MIT-BIH Database	143
5.6.1	Detection of QRS complex using MIT-BIH database	144
5.7	Results for detection of characteristics point using MIT-BIH database	145
5.7.1	Detection of R-peak	145
5.7.2	Amplitude and Time Plane Features Statistical Analysis	151
5.7.3	Results and Discussion of Feature Extraction Process	151
5.7.4	Morphological Features calculation	152
5.7.5	Statistical Features calculation	152
5.8	Results of Classification Using Deep Learned CNN	153
5.9	Flow diagram of Water Cycle Optimization Algorithm Flow Diagram (WCOA)	160
5.10	Complexity Time	161

	Description	Page No.
5.11	Performance Metrics	161
5.11.1	Avalanche Effect	161
5.11.2	Mean Square Error (MSE)	162
5.11.3	Number of Pixels Change Rate	162
5.11.4	Unified Averaged Changed Intensity	162
5.11.5	Execution Time	163
5.11.6	Frequency Test	163
5.11.7	Run Test	163
5.11.8	Comparison with Existing Approaches	163
5.12	Internet of Things	165
5.13	Identification of ST Deviation	167
5.14	Comparison with existing Approaches	169
	Chapter-6: Conclusions and Future Scope	172-175
	References	176-201