International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)
Web Site: www.ijettcs.org Email: editor@ijettcs.org, editorijettcs@gmail.com
Volume 11, Issue 4, July – August 2022 ISSN 2278-6856

ECG Feature Extraction and Classifications using Deep Learning techniques

Vijendra V[1], Meghana Kulkarni[2]

[1]Visvesvaraya Technological University, Center for PG Studies,
Jnana Sangama, Visvesvaraya Technological University, Belagavi, Karnataka, India,

[2]Visvesvaraya Technological University, Center for PG Studies,
Jnana Sangama, Visvesvaraya Technological University, Belagavi, Karnataka, India,

Abstract: ***ECG Pattern recognition for features is most crucial factor in diagnostic systems. Identifying the diseases based on morphological features: Widely used techniques include ECG beats annotation and classification, Spatial domain Classification, time-frequency intra-domain Classification. The Optimized Computational deep learning Algorithms based on the parameters of Sensitivity, Specificity, Positive Predictivity Accuracy, True positive detection, True negative detection and false positive detection, false negative detection of ECG beats. The detection and Classification of beats based on Machine learning algorithms and comparison on convolutional neural networks (CNNs) by using Tensor Flow Platform. The implemented of ECG feature extraction and classification using Binary neural networks on Jupyter Notebook. The Classification of Artificial Neural Networks as 98.39% Accuracy with Adaptive thresholding on fiducial mean square algorithm. Different techniques and their accuracy parameters are compared with Advance Neuro Fuzzy Interface System, Autoencoders, Convolution neural network and Recurrent network Layers, Long short term memory.***

Keywords: Supervised Learning, Unsupervised Learning, Convolutional Neural Networks (CNNs), Lifting based Discrete Wavelet Transform (DWT), Positive Prediction, Sensitivity

1. INTRODUCTION

Heart rhythms in ECG signals are critical for diagnostics of heart diseases and its related symptoms. ECG feature extraction and classification Using different classifier and algorithms for implementation of entire system. ECG Pattern recognition can be done using computational Intelligence algorithms such as AI based Peak detection algorithms, Neural Network based Single layer, Multi-Layer Perceptron Networks. ANN implementation as Feed forward or Feed Back ANN's which depends on weights, and it adjust itself with error. The training of datasets are classified into supervised, Unsupervised, Reinforcement Learning. Support Vector Machine is one of the solutions with Curve fitting for ECG data sets along with MOC mixture of classifiers and components. The statistical ratio of Number of Papers vs Algorithms on ANN, SVM, HMM and KNN data sets. There are different algorithms Popular usage of Pattern recognition: Fuzzy Interface system (FIS) - Fuzzy an rule based algorithm with states as Logic high, Logic low, Logic medium and Logic Very high and code with if and else rule based algorithm, further developed as Advanced Neuro Fuzzy Interface system (ANFIS). Radial Basis function Network - Use Linear least square error and reconvergence of data nodes, Multi-Layer Perceptron Neural Networks. QT Prolongation due to high Moxifloxacin 200 to 400mg content and calculate using delta difference QTc time interval period. Hyperkalemia based disease detection based on the morphological change in the T -wave, Quantified as shortened T, Prolonged time interval T, more duration with shortened T wave with Interlinking diseases as Hypokalemia, Hypocalcemia, Hypercalcemia, Hyperkalemia.

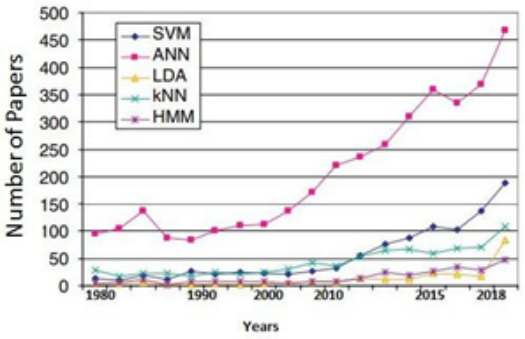


Figure 1 Number of algorithms on machine learning techniques

2. BACKGROUND

A key part of human life is the early diagnosis of diseases. It's critical to identify disorders in their early stages so that mortality can be minimized with the help of appropriate medicine. An electrocardiogram (ECG) gives specialized information about rhythm and distinctive patterns for the various cardiovascular diseases. Electrocardiograms (ECGs) show the polarisation and depolarization of the heart as P-QRS-T and U waves, respectively. The right atrium takes blood from veins and pumps it into the right ventricle. The right ventricle then receives blood from the right atrium and pumps it to the lungs, where it is

replenished with oxygen. The heart has four chambers. The left atrium collects blood from the lungs that is rich in oxygen and pumps it to the left ventricle. For the rest of the body, the left ventricle will pump. the electrical activity that is created by the heart's polarization and depolarization mechanisms. With the use of devices like holter monitors and other ECG tape recorders, the electrical activity can be recorded. By affixing several electrodes to the body's surface, the ECG signal is acquired.

The ECG was recorded at a pace of 25 mm/sec, and the voltage was calibrated at 1 mv (representation on paper squares/sec). Usually lasting 0.08 to 0.10 seconds, the P wave originates from the Sino atrial node (SA node) via the atria. The conduct velocity through the bundle of his atrium-ventricular AV node is slowed. Then, the QRS complex with the beginning of atrial depolarization and the beginning of ventricular depolarization typically happens between 0.06 and 0.10 s later. The baseline that follows the QRS complex, also known as the isoelectric. When both ventricles are fully depolarized at the beginning of the T-wave, the wave symbolizes the ventricular repolarization and has a duration that is equal to or less than the QRS complex. Sometimes, the U wave comes after the T wave, signifying the last stage of ventricular repolarization.

The QT interval is typically defined as the time between ventricular depolarizations and repolarizations; this corrected interval is known as the QTc interval. The distinctive characteristics of ECG signals, such as amplitude, position, and morphological aspects, can be used to automate the interpretation of those signals. ECG signals are frequently used as a common diagnostic paradigm for various cardiac/arrhythmia issues. For the design of multi-variable control systems, fuzzy logic has become the norm. With a conditional rule-based approach, each cluster corresponds to a fuzzy relationship. Starting the clustering process with a larger-than-anticipated number of clusters and subsequently removing less-important ones as the clustering develops In the Automatic Sequence, an attempt is made to find an appropriate partitioning method. To identify and exclude less significant clusters, a strategy for managing the fuzzy clustering process for rule extraction has been described. a relative lower criterion for the contribution of the rules to the rule base should be established. The algorithm chooses the right number of clustered designs to be considered for data interpretation using this threshold.

Using the normal traits and structural features, such as the heart's electric axis, to interpret the ECG signal monitoring your heart rate, Arrhythmias, increased atrioventricular and ventricle wall thickness or size, as well as impacts on the heart's cardiac walls, are all examples of abnormalities in the activation sequence. ischemia and infarction of the myocardium Ischemia, drug's impact, Digitalis Myocarditis, an electrolyte imbalance, and pacemaker monitoring the successive activation, depolarization, and repolarization of the atria and ventricles result in clearly distinguishable deflections because of the structural differences between them. Even if they don't come after one another in the right order, this might still be possible: A typical wave characterization is P-QRS-T.

The electrical wave is caused by the blood's Na+ and k+ ions depolarizing and repolarizing. The electrical activity of the heart is captured by an electrocardiogram. Doctors use ECG sheets to examine the free lead running ECG data from CRO (Cathode ray oscilloscope). To eliminate the need for manual intervention in the diagnosis of ECG signals indicating the stages of heart attack occurrence, heart blocking, and the relationship between various diseases and body chemical imbalances. Prevention of the death penalty through early detection of several ECG-related disorders. An effective approach for signal interpretation, feature extraction, and processing for automatic diagnoses of ECG signals from the MIT-BIH database, PTB-XL, AHA, and clinical data from hospitals has been developed to address this.

3. ECG DATASET

3.1 PhysioNet database

The PhysioNet Bank is where the ECG database is obtained [1]. For the creation of an algorithm or design strategy, the MIT-Beth Israel Hospital Normal Sinus Rhythm Database is employed. The information was gathered from 1.5 lakh patients worldwide. The MIMIC II and MIMIC III major databases contain recordings from intensive care units. Binary files make up the database file. information in the patient record file system's header file

4. LITERATURE SURVEY

4.1 Pattern Recognition in Fuzzy Interface System

Fuzzification can be described by fuzzy membership function Input is converted into fuzzy membership function, can be characterized as lower state, very lower, medium state, high state, and very high state membership function will be feed inside the Inference Engine. Inference Engine have the prior knowledge on ECG morphological feature values and standard type sets converted into Rule based (Thumb rule) algorithm and decryption done by defuzzification. 1. Reduced PR interval 2. delta function in the QRS Complex 3. Spatial length of QRS Complex The datasets consist of diseased wolffs Parkinson white syndrome annotation files consist of bell-shaped membership function have the changes in QRS with respect to inference system linguistic rules. The thresholding condition is mapped between 0 to 1. The datasets taken from PTB diagnostics from PhysioNet ECG database.

4.2 Pattern Recognition in support vector machine (SVM)

Here power spectral density-based features in that spatial domain consider as non-parametric based estimation. which uses a novel technique as Particle swarm optimization with tweaking parameters such as Gaussian radial basis function

(GRBF) the kernel parameter" row" and C snag framework of SVM classifier. Power spectrum estimation is one of the best methods to analyze the ECG signal processing techniques.

4.3 Pattern Recognition using two stage KNN classifier model

ECG characteristic feature defines the wave patterns of P, QRS complex, T and U wave. Hyperkalemia defines the change in T-wave characteristics and in turn leads to Hyperkalemia and hypokalemia diseases, to diagnosis the disease using two stage classifier with an K-means Algorithm through the 12-lead ECG signals. A simulator is used to simulate the Hyperkalemia based pattern ECG signals from mild to severe ion imbalance. The sensitivity, specificity and Accuracy of two stage classifier model can be increased by sensitivity from cents of 0.6 to 0.85 percentage and the specificity true value increased from 0.6 percent.

4.4 Pattern Recognition using PCS with Bayesian framework model

PCA is used with an optimal filter developed by using Bayesian framework to improve the signal quality of ECG signal and also PCA (Principal Component Analysis) is a analytical technique which is used to reduce the information of a substantial deposit of Harmonize variables into a few un-harmonized variables called Principal Components. The Kalman filter is used to extract the unknown parameters of ECG and discussed the TWA signals before filtering and after filtering using adaptive Kalman filter and performance was assessed based on the normalized MSE indicating the filter and their proto typical ECG signal.

4.5 Pattern Recognition using moving window integration and Fiducial marks

The clinically important parameters such as the span of the QRS complex, the R-R interval, the occurrence, amplitude and duration of the P, R, and T waves are measured by using an PT- algorithm and the design of Pan-Tompkins Algorithm is discussed which consists of (LPF) Low pass filter, BP-band pass filter, high pass filter, derivative, squaring function, moving window integration and Fiducial marks.

4.6 Pattern Recognition using Adapative threshold and moving window integration

Using the open-source data to get the real-time QRS detection and implemented requires lot of resources like memory, power, and number of duty cycles of computation time for two hundred eighty assembly language codes. Preliminary the Coefficients are feed to the BP filter, to reduce the noise, in the next successive stages derivative of amplitude function passing through the moving windows designed by 18 cluster points, based on the thresholding factor the peaks gets detects like RR, SS and TT intervals. These intervals used for localization parameter and diagnostics of diseases.

4.7 Pre-processing techniques for Pattern Recognition using double-density dual-tree discrete wavelet transform

ECG Signal as property of overshoot complex noises and to remove the effective noises without losing the features based on different wavelet transform technique. The implemented of these techniques using MATLAB software and signals features of 1-D Wavelet Transform, Double-Density, Dual-Tree DWT, and advanced tree-based techniques. Signal to noise ratio (SNR) and root mean square error (RMSE) are the specifications cast off substantial. Finally concluded that double-density dual-tree (DDDT) DWT gives highest SNR which is improved from 57.6166db to 57.7387db and RMSE is improved from 0.3368 to 0.3321 for power line noise.

4.8 Implementation of ECG Pattern Recognition using hard-ware modelling in real time diagnostics

fuzzy clustering is used to prototype of signals based on the decision of ECG data points or clusters. To Interpretation of ECG signals can be done through the Fuzzy states and fuzzy Boolean equations. The equations and parameters of correlation between two signal, execution outcome is dispensed in terms of sensitivity (Se), positive predictivity (Pp) and accuracy (Acc). The calculations are implemented in a hardware by using VHDL. The proposed system was implemented in a Xilinx FPGA boards total of 213 samples are used and gives the result as 18 times faster than the traditional processing methods and achieves 97 percent correct diagnoses.

5. PATTERN DETECTION AND IMPLEMENTATION OF MACHINE LEARNING ALGORITHMS

This section lists some of the notable concept mapping and ECG morphological mapping applications which are available using

- MATLAB with appropriate toolbox for implementing Neural Network
- Python with all the libraries for opensource software
- SDK based eclipse
- MATLAB Simulink and system generator for Hardware HDL Coders toolbox
- Xilinx FPGA implementation using Reconfigurable architecture.

6. CUSTOM CLASSIFICATION USING DEEP NEURAL NETWORK TOPOLOGY

The feature extracted sets of ECG kernel are fed into the input layer of DNN without losing any crucial information, the extracted features are transformed into the spectrogram picture and sent to the AlexNet (227x227) network. 900 photos with 750 training sets, 150 testing sets, and cross validation on the custom layer. Specific ST and TWA

signals are confirmed for the illness hyperkalemia. Applying and contrasting the CNN, RNN, and LSTM layers with the CIFAR classifier. Better outcomes like accuracy, sensitivity, and positive predictivity are demonstrated by CNN with RNN.

Author	Feature Extraction - Reduction Method	Classification Model	Accuracy (%)
Vijendra et al	DWT with 5/3 Lifting schematic	Adaptive threshold in ANN	98.39
I Gular et al	DWT	ANN	96.4
M Ben Messaoud et al	Heart Beat rate	RBFNN	96 for MLP
S N Yu et al	DWT	PNN	99
S Meghriche et al	Amplitude, duration & interval of P, QRS, S		87.9
G K Prasad et al	DWT	ANN	96.0

Table 1 - ANN and adaptive methods for ECG Classifications

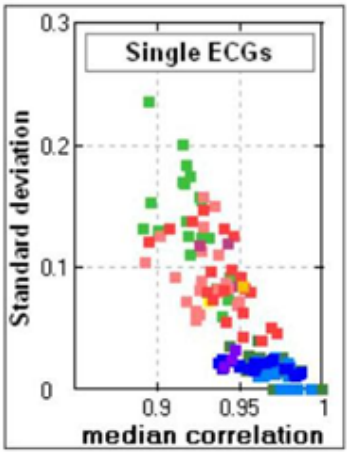
The hybrid custom Deep NN layer with ReLu and the activation functions for the scalogram images fed into the Alex Layer for performance is 94.3 percent accurate using the suggested technique. A better understanding of the training of ECG data sequence for the design and implementation of Artificial Intelligence of ECG device is provided by the illustrative study on KNN, Fuzzy, ANFIS, DWT, Hybrid PSO, and Supervised learning approaches.

Author	Feature Extraction - Reduction Method	Classification Model	Accuracy (%)
Y Zbay et al [8]	Segmentation of arrhythmias	MLP BP+CNN	98.9 99.9 for FCNN
A Sengur et al [13]	Wavelet transforms	AIS based Fuzzy	95.9
Z Dokur et al [12]	Fourier analysis	ANN+GAs	96
K lewenstein et al [9]	Segmentation of QRS complex, P & T	ANN+Expert System	92
C W CHU et al [6]	Moving average and differential technique approach	ANN+CBR	Very high cluster performance
Ceylan et al [7]	Segmentation of arrhythmias	T2FCM+CNN	99
Acharya et al [4]	Spectral Entropy	ANN + Fuzzy	80-85

Table 2 - Hybrid Methods for ECG Classifications

7. HYBRID METHODS FOR ECG CLASSIFICATIONS

The Mixing Composition of two or more models to get higher Accuracy, Sensitivity, Specificity and more precise ECG Annotation signals. The hybrid model with Combination of MLP-BP CNN or AIS based fusion or T2FMC based architecture to get the very high-performance cluster. Training the cluster and data points to achieve the better results. FCNN -fuzzy clustering neural network, AIS-Artificial Immune system, T2FMC-Two type Fuzzy C-Means.



8. CONCLUSION

Tensor flow and deep learning techniques provide the appropriate solutions for training data sets and Prediction data sets to develop an artificial intelligence to the entire flow. The proposed method provides the 94.3% Accuracy on the hybrid custom Deep NN layer with ReLu and the activation functions for the scalogram images fed into the Alex Layer for the performance. The illustrative study on KNN, Fuzzy, ANFIS, DWT, Hybrid PSO, Supervised learning techniques give a better understanding in training of ECG data sequence for design and implementation of Artificial Intelligence of ECG device.

References

[1] [Online] https://www.physionet.org.
[2] Yun-ChiYeh and Wen-JuneWang, QRS Complex detection for ECG Signals: The Difference operation Method (DOM), Computer methods and Programs in Biomedicine, Elsevier, Vol. 91, Issue. 3, pp. 245-254, September 2008.
[3] Vijendra V and Meghana Kulkarni, ECG signal filtering using DWT Haar Wavelets coefficient techniques, IEEE International Conference on Emerging Trends in Engineering, Technology and Science, pp. 382-387, India, February 2016.
[4] Jiapu Pan and Willis J. Tompkins, A Real-Time QRS Detection Algorithm, IEEE Transactions on Biomedical Engineering, Vol. 32, No. 3, pp. 230–236, March 1985.
[5] Vijendra and Meghana Kulkarni "Automatic ECG Signals Recognition Based on Time Domain Features Extraction Using Fiducial Mean Square Algorithm" in Computational Intelligence: Theories, Applications and Future Directions - Volume I pp 81–94, December 2017.
[6] Pratik D. Sherathia and V. P. Patel, Fuzzy Interfaced system-based detection of Wolff Parkinsons White Syndrome, International Journal of Science, Engineering and Technology Research, Vol. 6, Issue. 4, pp. 660-664, April 2017.

[7] Shweta H.Jambukia, Vipul K. Dabhi and Harshad kumar B. Prajapati, Classification of ECG signals using Machine Learning Techniques : A Survey, IEEE International Conference on Advances in Computer Engineering and Applications, pp. 714-721, India, March 2015.
[8] Vijendra V and Meghana Kulkarni, Fuzzy Controlled Interpretation Based ECG diagnostics Systems, Advanced Science Letters, American Scientific Publishers, SCOPUS Indexed Volume 23, Number 3, pp.1734-1740, March 2017.
[9] N Bianchi, P Bottoni, M Cigada, A De Giuli, P Mussiol and F Sessa, Interpretation Strategies in a Cardiologist Controllable Automatic Assistant for ECG Description, IEEE Proceedings of Computers in Cardiology, pp. 673-676, Italy, 1991.
[10] Richard Mengko and Fredrick Sutjiady, Design and Implementation of 12-Lead ECG Signals Interpretation System, 3rd IEEE International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering, pp. 278-282, Indonesia, November 2013.
[11] Vijay Kr. Srivastava, Lalit Maurya and Er. Rajesh Mehra, Detection of Noise in High Pass Butterworth IIR Filter using MATLAB, International Journal of Engineering Research and Technology, Vol. 3, Issue. 2, pp. 1232–1235, February 2014.
[12] Helton H Carvalho Jr, Evaldo R F Cintra, Tales C Pimenta and Robson L Moreno, An Electrocardiogram Diagnostic System Implemented in FPGA, IEEE Conference of the Bio signals and Robotics for Better and Safer Living, pp. 1–5, Brazil, January 2012.
[13] Namita Thomas and Deepthy Mathew, KNN Based ECG Pattern Analyais and Classification, International Journal of Science, Engineering and Technology, Vol. 5, Issue. 5, pp. 1630–1634, May 2016.
[14] Pratik D. Sherathia, Prof. V. P. Patel, Fuzzy Inference System based Detection of Wolff Parkinson as White Syndrome, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 06, Issue 04, April 2017, ISSN: 2278 –7798.
[15] Febina Ikbal, Prof. M.Mathurakanl, PCA Enhanced Kalman Filter for ECG Denoising, IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), PP 06–13.

AUTHOR

Vijendra. V, Research Scholar, Department of ECE, Center for PG Studies, Visvesvaraya Technological University, Belagavi, India**.** Completed the B.E., in Electronics & Communication Engineering from CBIT, Kolar in 2013 and M.Tech in VLSI Design & Embedded Systems at Center for PG Studies, Visvesvaraya Technological University, Belagavi, India in 2015. His major Area of interest on Biomedical Signal Processing, VLSI Design, Chip front End Design and Verification, Artificial intelligence, and Machine Learning, developed various algorithms on DSP, Image processing and Video processing.

Dr. Meghana Kulkarni, Associate Professor and Chairperson, Department. of ECE, Center for PG Studies, Visvesvaraya Technological University, Belagavi, India. Her major areas of Interest Include VLSI Design methodologies, Optimization of Analog circuits, Low power circuits, Artificial intelligence, and Machine Learning techniques.