Detection Of Atrial Fibrillation In Compressively Sensed Electrocardiogram Measurements

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Abstract
For the evaluation of several disorders, an electrocardiogram (ECG) is a crucial diagnostic tool. We use a machine learning-based Random Forest framework in this procedure to carry out automatic ECG diagnoses by categorising patient ECGs into relevant cardiac diseases. The Random Forest framework was previously trained on a broad signal data set. Implementing a straightforward, trustworthy, and simply used machine learning approach for the categorization of the chosen signals from the dataset is the main goal of this procedure. The outcomes showed that a standard back propagation neural network in cascade with transplanted deep learning classification was able to achieve very high performance rates.The major goal of this research is to forecast the ECG signal employing an effective classification algorithm in order to increase classification accuracy and decrease miss classes.

Keywords: Neurological Disorder, Electrocardiogram (ECG), Atrial Fibrillation, Random Forest framework, Machine Learning.
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1. INTRODUCTION

Systems engineering, electrical engineering, and applied mathematics all include areas of study known as signal processing that deal with the manipulation or analysis of analogue and digital signals that reflect time-changing or spatially variable physical characteristics. Sound, electromagnetic radiation, pictures, sensor readings, such as electrocardiograms for biological measures, control system signals, telecommunication transmission signals, and many other types of signals can all be considered signals of interest.

The following categories closely correspond to the objectives of signal processing.

- Signal acquisition and reconstruction is the process of taking measurements of physical signals, recording them, and then perhaps reconstructing the actual signal or a close approximation of it in the future. This often comprises sampling and quantization for digital systems.
- Enhancement of the quality, such as echo cancellation, picture enhancement, and noise reduction.
- Audio, picture, and video compression are all types of signal compression (source coding).
- Feature extraction is used in processes like speech and image interpretation.

Signal processing in communication systems can take place at OSI Layer 1's Physical Layer (modulation, equalisation, multiplexing, etc.) and OSI Layer 6's Presentation Layer (source coding, which includes analog-to-digital conversion and signal compression). Calculus, differential equations, vector spaces and algebra, functional analysis, probability along with stochastic processes, detection theory, estimation theory, optimisation, programming, numerical methods, and iterative methods are some of the mathematical techniques used in signal processing. They also include transform theory, system identification and classification, and theory of linear time-invariant systems. Both linear and non-linear electrical circuits are used in analogue signal processing.

Advanced processing of gigahertz signals still uses discrete-time signal processing, which is only specified at discrete moments in time and only applicable to sampled signals. The processing of discrete-time sampled signals by digital means.

The study and processing of signals generated by nonlinear systems in the time, frequency, or spatiotemporal domains is known as nonlinear signal processing. Complex behaviours that cannot be created or studied using linear techniques, which include bifurcations, chaos, harmonics, and subharmonics, can be formed by nonlinear systems. In the field of applied mathematics and signal processing known as statistical signal processing, signals are treated as stochastic processes. The spectral content of a time series is estimated via spectral estimation. The purposeful modification of auditory signals is known as audio signal processing, and it frequently uses an audio effect or effects unit. Due to the widespread use of digital audio equipment in studios nowadays, audio signal processing is constrained.

The study of voice signals and their processing techniques is known as speech signal processing. It is strongly related to natural language processing (NLP), since it may use NLP applications as input or output. Speech processing is primarily used to recognise, synthesise, and compress human speech. Speech coding, speaker recognition, voice analysis, and speech synthesis are all subfields of the field of speech processing. Speech synthesis, often known as computer-generated speech, is the artificial synthesis of speech.

The accessibility of the computer for those who are blind is improved by developments in this field. voice enhancement is the process of improving a voice signal's perceived quality and/or intelligibility. For a given set of time and space limits, speech compression is crucial in the telecommunications industry to increase the amount of information that can be transported, saved, or heard. Any type of signal processing that involves the input of an image, such as a picture or video frame, and produces an image or a collection of parameters or characteristics associated to an image is known as image processing. Video processing is a specific type of signal processing that frequently uses video filters and uses video files or video streams as both the input and output signals.

Information can be sent wirelessly between two or more sites without the use of an electrical link. The most widely used wireless technologies make use of radio and other electromagnetic wireless telecommunications. It includes a range of stationary, transitory, and portable applications, including those for two-way radios, mobile phones, personal digital assistants (PDAs), and wireless networking. Light, sound, magnetic, and electric fields may all be used to achieve wireless communications, however these are less often used techniques. To monitor physical or environmental factors like temperature, sound, pressure, etc. and to jointly send their data across the network to a central point, wireless sensor networks (WSN) are made up of geographically distributed autonomous sensors.Military uses, such as battlefield monitoring, spurred the growth of wireless sensor networks, which are now employed in a wide range of commercial and consumer applications.

2. LITERATURE SURVEY

Signals from electroencephalograms (ECGs) are frequently used to examine brain activity, such as to identify different stages of sleep. These ECG signals are by their very nature nonlinear and nonstationary. Sleep staging using linear methods and visual interpretation is challenging. Therefore, to uncover buried information in the sleep ECG signal, we employ a nonlinear method called higher order spectra (HOS). This study provided novel bi-spectrum and bi-coherence plots for distinct stages of sleep. These can be applied in a variety of diagnostic applications as visual aids. From these plots throughout the various phases of sleep (Wakefulness, Rapid Eye Movement (REM), Stage 1-4 Non-REM), a number of HOS-based characteristics were retrieved. Using the ANOVA test, these features were determined to be statistically significant with p-values less than 0.001.For automated identification, these characteristics were loaded into a Gaussian mixture model (GMM) classifier. Our findings show that the suggested system can identify different phases of sleep having an accuracy of 88.7%.

The feature stability was improved as a result of the extraction of features from different stages. However, because of the categorization, the process's accuracy is poor [1].

The fact that "THE SMART CAP" technology records brain waves and deters intoxicated drivers from creating accidents is the most crucial information in this article. It is based on the observation that alcohol consumption causes a drop in alpha activity and an increase in theta activity. The forehead band-shaped smart cap has five integrated electrodes that are utilised to collect the ECG signal. Preprocessing is done on the obtained ECG signal before it is sent over Bluetooth to the intelligence unit, which is a CPU, for analysis. In accordance with the presence or absence of ECG anomalies, the decomposed ECG signal is examined for signs of alcoholic activity, and the voltage generated by the algorithm is then employed to operate the relay system.Small electrodes are positioned on the scalp to detect electrical activity from the brain, which is amplified then captured as brain waves by electroencephalography. The activity that is occurring in various parts of the brain is shown by these brain waves [2].

Through several electrode sensors positioned on the scalp, an electroencephalogram (ECG) records electrical activity in the brain. Different forms of normal waves might signify different mental states or levels of activity. ECG signal pattern analysis can be used to identify several brain illnesses that may manifest as abnormal brain electrical. Electroencephalogram (ECG) at relaxation while Evoked Potentials (EPs) are used to assess brain impulses. Alcoholics and non-alcoholics have very different brain activities, with an imbalance in their brains' excitation and inhibition processes.The analysis of brain pictures and the electrophysiological mapping of the brain are two methods for revealing the activity of the alcoholics' brains. The mapping of brain signals approaches that can most effectively show the brain activity of alcoholic people as it develops over time are summarised in this procedure. The method is more trustworthy. When compared to other processes, the process has a higher level of complexity [3].

The suggested mechanical device to stop drunk driving and the accidents that follow by watching the driver's ECG is the most crucial information in this work. Alpha, beta, and theta wave threshold values are used by this technique to distinguish between alcoholic and non-alcoholic ECGs. Additionally, to avoid upsetting other drivers and minimise accidents brought on by vehicle collisions, special indicators known as preventative indications are utilised. If there is any proof of drunk driving, an SMS is delivered to the police control centre through a GSM module. This method is a very effective and economical way to stop drunk driving accidents. In order to make the feature more stable, the threshold limit is defined for the two level. Only the smaller datasets are eligible for the input [4].

Numerous methodologies, including complexity measurement, nonlinearity, disorder, and unpredictability, have been used to analyse and make diagnoses based on the electroencephalographic (ECG) representation of brain electrical activity. Alcohol misuse causes various social and economic problems, including problems with focus, decision-making, memory, and decision-making processes. To quantify the complexity of long-range temporal correlation time series ECG of Alcoholic and Control individuals received from University of California Machine Learning repository, Multiscale Permutation Entropy (MPE), a recently developed signal analysis technique, is proposed. Higher significant values are obtained from the findings computed using MPE against each electrode than using MSE or mean rank differences, respectively. When employing MPE instead of MSE, ROC and Area under the ROC also provide more separation against each electrode.The method is quite effective in differentiating between alcoholic and non-alcoholic signals. However, the complexity along with time required are greater [5].

3. PROPOSED SYSTEM

Heart disorders are among the top five causes of mortality globally, according to several surveys. Traditional heart disease diagnosis, which relies on symptoms and common tests like the ECG, is greatly dependent on the doctor's experience and changes in the test results. Any of the aforementioned circumstances might lead to errors that have detrimental effects. Existing systems propose a method that includes wavelet data pre-processing and Euclidean Distance Classifier classification of the data.

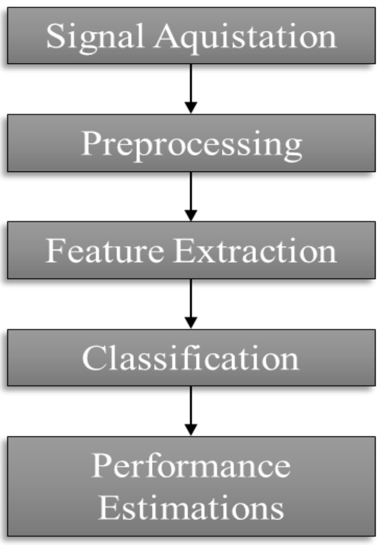

Fig 1: System Architecture

Due to the inevitable trade-off between time and frequency firmness, STFT fails in the majority of situations. The crucial uncertainty principle places restrictions on wavelet theory. The fundamental challenge of the WVD is the severe cross terms, which are shown by the occurrence of negative power for particular frequency ranges. The first is to directly take into account all data in a single optimisation formulation, and the second is to divide a multi-class issue into a number of binary problems. Unclassifiable areas are a drawback of pair-wise and on-against-all fuzzy neural networks.

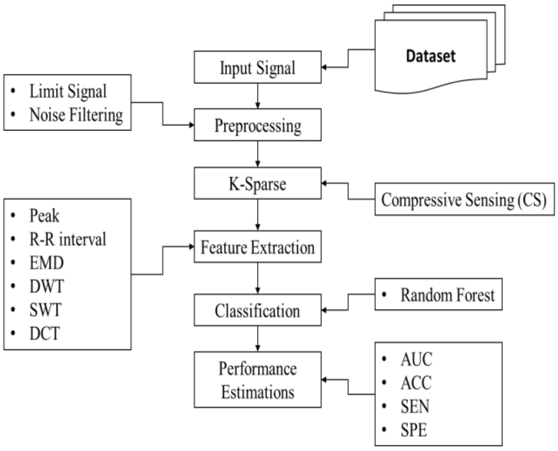

Fig 2: Data Flow diagram

In order to automatically identify the abnormalities of heartbeats using the ECG signals, we suggest an Atrial Fibrillation in ECG signal in this method. Three sets of inputs, including Test features, Train features, and labels, make up the bulk of this classification model. The signal is classified using the Random Forest classifier. Most notably, in the validation set of dataset, our suggested technique produced favourable results with an accuracy of over 95%. The characteristics were stable, and there were less misclassifications, therefore this procedure performed better. The following are some of the proposed approach's benefits:

- The minimization of the cross validation and post optimisation functions is the proposed classification's key benefit over existing classifiers.
- Due to the integrated global optimisation functions, this approach outperforms other classifiers in terms of classification outcomes.

The next section provides an explanation of the many phases that are involved in putting the suggested technique into practise:

1. Input Signal

The electrophysiological monitoring technique electroencephalography (ECG) is used to record the electrical activity of the brain. Although invasive electrodes are occasionally employed in particular applications, the procedure is normally noninvasive and involves placing electrodes along the scalp. The ECG monitors voltage changes brought on by ionic current flowing through the brain's neurons. The type of brain oscillations that may be seen in ECG data is called spectral content, and it is used in diagnostic applications. ECG is most frequently used to identify brain death, en-cephalopathies, coma, sleep disorders, and epilepsy.

2. Butterworth Filter

Filters, often known as signal processing filters, are methods or devices used to remove undesired components from signals. Filtering is the process of eliminating particular frequencies from the audio spectrum in order to lessen background noise and decrease interfering sounds. A form of signal processing filter called a Butterworth filter is made to have a pass band frequency response that is as flat as feasible. The term "maximally flat magnitude filter" is also used to describe it. Low pass Butterworth filters and digital Butterworth filters are two examples of the numerous types of Butterworth filters.

3. Feature Extraction

This work suggests a real-time QRS detection and R point recognition approach that is highly accurate and has a low processing complexity. The suggested approach reorders the data while applying a threshold to the wavelet coefficient using DWT, and after that, it derives an approximation of the raw data value. As a contribution to previously published feature extraction algorithms for beat categorization, SWT features were employed to extract time-frequency information and to calculate time frequency entropies. A combination of three of the graphic deflections found on a standard ECG is known as Q-R-S detection. This work suggests a real-time QRS detection and R point recognition approach that is highly accurate and has a low processing complexity.

The suggested ECG signal alteration, which also results in the removal of baseline wandering, enhances QRS segments and restrains P and T waves. Based on the converted signal's identified crests and troughs, the four QRS waveform templates and an initial categorization of the heart rhythm are used to identify the QRS fiducial point.

4. Classification

A large number of decision trees are built during the training phase of the random forests or random decision forests ensemble learning approach, which is used for classification, regression, and other tasks. The class that the majority of the trees choose is the output of the random forest for classification problems. The mean or average forecast of each individual tree is returned for regression tasks. The tendency of decision trees to overfit their training set is corrected by random decision forests. Although they frequently outperform decision trees, gradient enhanced trees are more accurate than random forests. However, their effectiveness may be impacted by data peculiarities.

5. RESULTS

This research introduces a machine learning based Random Forest framework to perform automated ECG diagnostics by categorising patient ECGs into relevant cardiac conditions. The Random Forest system was previously trained on a broad signal

data set. This procedure's major goal is to construct a straightforward, trustworthy, and simply used machine learning approach for the categorization of the dataset's chosen signals. The suggested method demonstrated promising results, with an accuracy of over 95% in the validation set of datasets, respectively. The signals used in the proposed innovative ECG beat categorization methods are collected from the MIT/BIH data set.
The study gives an overview of noise reduction, waveform recognition, and heart rate classification and includes a table comparing the results of several techniques that have been previously presented for the ECG data, as shown in the images below. Additionally, it identifies the issue with the current job and offers solutions.

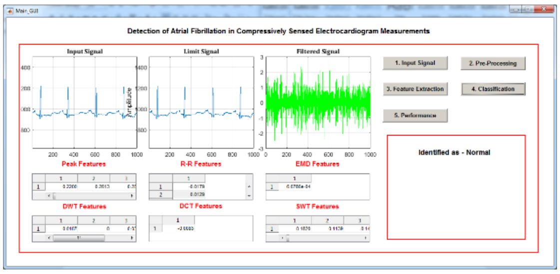

Fig 3: Classification Result

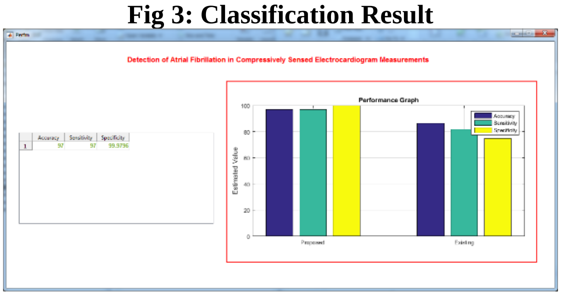

Fig 4: Performance Analysis

6. CONCLUSION

The signals used in this work come from the MIT/BIH data set, and innovative ECG beat categorization techniques are suggested. Give a succinct overview of ECG categorization. Numerous heart illnesses have been extensively diagnosed via ECG analysis. For ECG signals, a number of methods and transformations have been presented in the past. This suggested study gives a general overview of noise reduction, waveform identification, and heart rate categorization. The performance of several methods that were previously presented for the ECG signal was also evaluated in a comparative table in this study. Additionally, you present the issue with the current job and offer the solution.We observed that the majority of the time while removing noise, filters were combined. The majority of methods for classifying heart rates employ the QRS complex.

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