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ANN Based GUI for ECG Classification and Normality Detection

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ABSTRACT

The Electrocardiogram (ECG) is the most clinically used biological signal and it is the means of detecting several cardiac diseases and abnormalities. Among various abnormalities related to the functioning of the human heart, Premature Ventricular Contraction (PVC) is the contraction of the lower chambers of the heart (the ventricles) which occur earlier than usual, because of abnormal electrical activity of the ventricles.

ECG provides lots of information about heart abnormalities in the concerned patient [1]. ECG trace is an image based on which disease detection is made. It represents signal of cardiac physiology, useful in diagnosing cardiac disorders, where ECG can provide a lot of information regarding the abnormality in the concerned patient. ECG are analyzed by the physicians and the interpretation may vary depending upon their experience. Hence this project focuses on computer based automated system in the analysis of the ECG signals in which the images are fed into the system and the software extracts the ECG signal from the image and feed it to the ANN (Artificial Neural Network) classifier.

ANN has its own database of diseased ECG recordings which will match the inputted ECG to the existing one so that they must be diagnosed and interpreted accurately irrespective of the physicians. Furthermore, it shall display the normality or abnormality of the signal so as to start the early treatment for the problems and many lives could be saved [2]. Furthermore dedicated GUI has been developed for ECG classification for normality detection.

Key words : ECG, Arrhythmia, Artificial Neural Network, Correlation, Dilation, Image Binarization, Morphological Filtration, Radon Transform, Standard Deviation, Wavelet Coefficient, MATLAB.

1. INTRODUCTION

Cardiac diseases are one of the most common causes of death, killing millions of people worldwide each year. However, they can be effectively prevented by early diagnosis. ECG signal is the most important and powerful reference tool used contains the diagnosis and treatment of heart diseases. ECG represents the electrical activity of the heart and contains vital information about its rhythmic characteristics.

The medical state of the heart is determined by the shape of the electrocardiogram, which contains important pointers to different types of diseases affecting the heart. However, the electrocardiogram signals are irregular in nature and occur randomly at different time intervals during a day [3]. Today many patients are suffering from cardiac problems. Heart disease is the most common cause of death in the world. In recent years considerable work has been done to assist cardiologists with their task of diagnosing the ECG recordings. The biggest challenge faced today is the early detection and treatment of arrhythmias. All the samples taken have one thing in common and that is, they are analyzed by the experienced doctors who depending upon their knowledge predict out the problems associated with the patient which is disturbing the normal morphology of the signal. If this morphological disturbance becomes somewhat complex then it is analyzed by them depending upon their experience. This experience based analysis gives different interpretations [4].

Conventionally, each ECG has to be printed on a thermal paper and stored in the hospital for further diagnosis. Hence there is a need of a system that could analyze the ECG signals properly and with a great accuracy so that there is a less chance of mistake as well as the problem is spotted in time so that an early treatment could be started [4].

The models for proposed for heart beat classification is challenged by the variability of the ECG waveforms from one patient to another even within the same person. However, different types of arrhythmias have certain characteristics which are common among all the patients.

Thus, there arises the need for continuous monitoring of the ECG signals, which by nature are complex to comprehend and hence there is a possibility of the analyst missing vital information which can be crucial in determining the nature of the disease. Thus computer based automated analysis is recommended for early and accurate diagnosis. So to achieve this objective many works have been done in this field based

on image processing, Digital Signal Processing etc. and prominent among them is the use of Artificial Neural Networks which has given promising results to such complex problems [5].

2. METHODOLOGY

The paper basically consists of two parts. The first is the digital time series signal generation of the input ECG signal and the other is the classification of the ECG using MATLAB based Neural Network Toolbox. The output signal generated from the first step *i.e.* digital time series signal generation serves as an input or real data to the second step i.e. the classification of ECG using neural network for the normal or abnormal diagnoses of the ECG.

2.1 Scanning and Standardization

The data obtained through thermal ECG papers needs to be scanned. In the present work, scanning resolution is fixed at 600 dpi for a black and white scan together with the JPEG format. These choices are made keeping in mind, the necessity to use lesser memory space. Figure 1, lists out various scanning resolution and formats that can be handled by the algorithm proposed.

Scanning Resolution (in dpi)	Type/Color	Image Format
200	True color	jpeg/Tiff/Bmp/Png
300	Gray scale	jpeg/Tiff/Bmp/Png
600	Color,Gray scal	jpeg/Tiff/Bmp/Png

Figure 1. Various scanning resolution and ecg trace formats

2.2 Skew Detection and Correction using Radon Transform

Scanning process of paper ECG may results in image skewness occurrence either due to human error or faulty scanners. In order to extract faithfully the ECG signal from images, the skewness has to be eliminated. To remove the skew [6], an axis is required. Here, in this work, we have applied Radon transform to find the angle of skewness. The skew angle has been selected, based on the maximum variance.

2.3 Image Binarization and Morphological Filtering using Dilation operation

The extraction of ECG Signals from an image depends on its accurate separation from rest of the attributes present in the image like grid lines, textual characters, noise signals etc [2]. For this input image is binarized using image processing filters and image thresholding. Morphological filtering is based on mathematical morphology (set theory description of the Images). It deals with tools for extracting image components that are useful in the representation and description of the shape. Dilation adds pixels to the boundaries of objects (*i.e.*, changes them from off to on).

2.4 Otsu's Algorithm and R-peak detection

Otsu's algorithm has been performed for image adaptive binarization. Adaptive threshold technique for image binarization yields better results as compared to global thresholds [2].The R-peaks which have maximum amplitude in an ECG signal which is extracted by differentiating the ECG signal. Taking the first derivative of the ECG signal and discarding the negative values provides the location of the R-peaks. Subsequently, the number of peaks is used to calculate the heart rate.

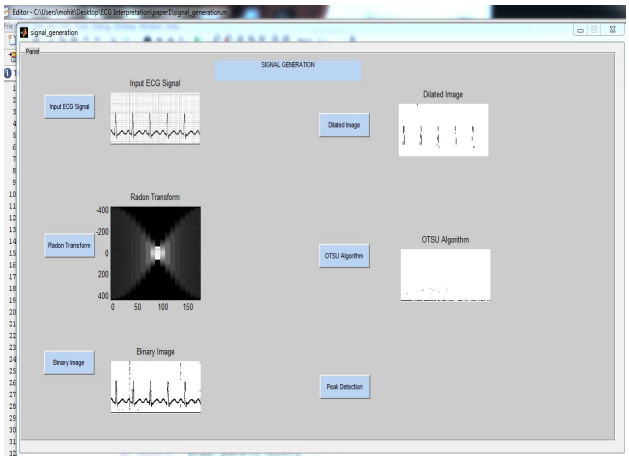

Figure.2 Output Form digital time series Signal generation

2.5 The Classification of ECG using Neural Network

The output generated signal from the first step i.e. Signal generation serves as Real data input to the second step i.e. the Classification of ECG using Neural Network for the normal or abnormal diagnoses of the ECG.The signal is imported and pre-processing or Filtration of the image is done which thereby undergoes parameter calculation such as Standard Deviation, Correlation, and Wavelet Coefficient etc for the performance of the image. Finally the Neural Network is trained and tested using these values and normality and Abnormality of the ECG is obtained.

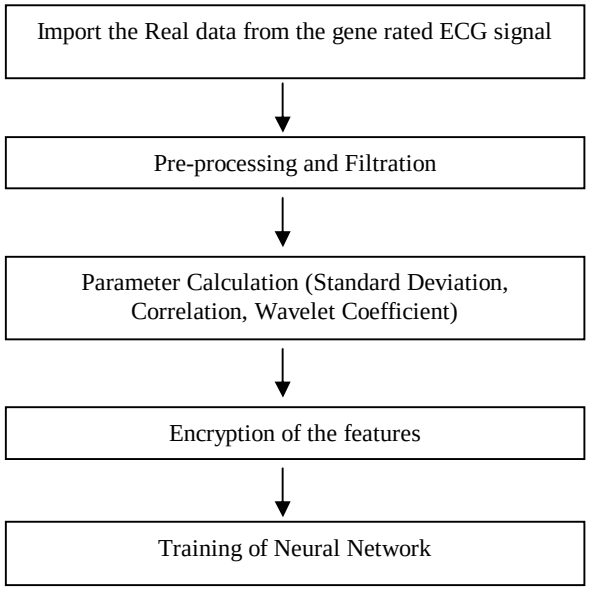

Figure.3 Flow chart

3. RESULT AND DISCUSSION

For the specific ECG input, the testing results after training neural network is normal signal. From this test results it is analysed that the concerned person ECG is detected as normal and the person is not suffering from any cardiac problem. In the same way analysis can be carried out for number of other ECG inputs and the respective diagnoses can be made on the basis of the testing result as normal or abnormal and the patient can be helpful in the early treatment in case of abnormality.

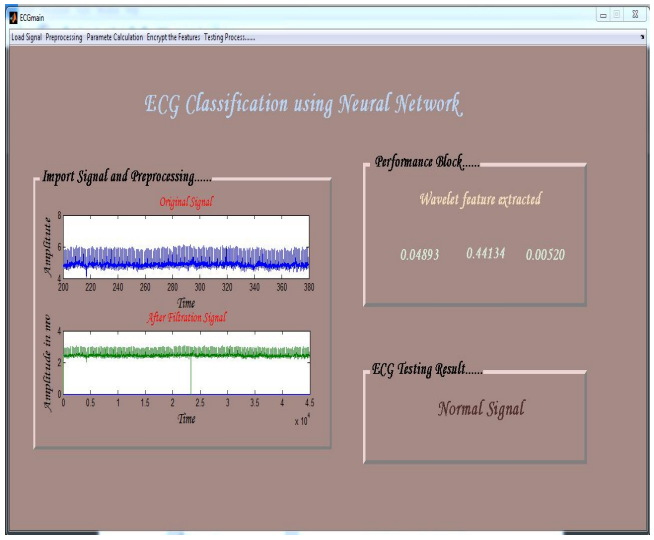

Figure.4 ECG Testing result

4. CONCLUSION AND FUTURE WORK

An improved method for extraction and digitization of ECG signal from various sources such as thermal ECG printouts, scanned ECG and captured ECG images from devices is proposed. The methodology produced a reasonably accurate waveform as tested through heart rate calculations. Further work is in progress to improve the accuracy including arriving at the appropriate dpi and the format. Also, in the pipeline is the generation of automated report and identifying possible diseases based on the estimated parameters. The same network is tried with different number of training input sizes, but the time taken to train the network differs. The network based on Cascade-Forward network algorithm with trainbfg training algorithm was best for the case of normal beat analysis because it has an accuracy of about 99.9% as well as the memory requirements were also low. Hence we preferred this network for the normal beat analysis. In this GUI has been developed for ECG classification and normality detection. Various modules of this GUI can be used in future by medical stream.

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