Use of Digital Image Processing in ECG Diagnosis

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Abstract **-** Electro Cardio Gram provides useful information about the condition of the heart. ECG is basically the graphical representation of the flow of electrical signals within the heart muscles. Practically no diagnosis is done only based on the ECG. The expert needs additional information such as subject's Medical History. Therefore questions have been raised on the usefulness of the automation of diagnosis through ECG. Nevertheless this technique is still gaining popularity as it not only helps in providing the initial clues to an expert in diagnosis in common day-to-day situations but it also proves to be very helpful in situations where no immediate medical expertise is available, for example the first aid.

The most vital aspect of any automatic ECG diagnosis system is its ability to correctly decipher the location and the width of the QRS complex. In this project, different segmentation methods namely, Otsu method, K-means method, Fuzzy C Means and Thresholding algorithm for QRS detection has been used as it is comparatively less sensitive to variations. Results lead to conclusion that Fuzzy C –means algorithm when used with morphological operations give the best accuracy i.e. 91.72% and the least time to compute the results i.e. 2.02 is taken by thresholding algorithm. The difficulty in automating the process of ECG diagnosis is due to the variation in the morphology of the ECG waveform.

Keywords **-** Electrocardiogram; peak detection; QRS detection; RR intervals; signal transmission; system

I. INTRODUCTION

The ECG data is recorded by placing surface electrodes on the chest. It is an information of Heart's electrical activity, with an each segment corresponding to depolarization, repolarization of a particular region of the heart muscles. Firstly there is a rapid positive transition from Q wave to the R wave, immediately followed by a negative change from the R to the S wave making up high frequency spike known as the QRS complex.(As shown in the following figure). ECG is used to diagnose the abnormal rhythms and heart rate. Therefore a fundamental requirement of ECG analysis is computation. Measuring the interval between successive QRS complexes is simplest way to measure the rate of Heart. The ambulatory conditions along with the possibility of shift of the ECG leads provides a lot of scope for introduction of NOISE. Hence a need for Band-Pass filtering arises. In this project, different segmentation methods namely, Otsu method, K-means method, Fuzzy C Means and Thresholding algorithm for QRS detection has been used as it is comparatively less sensitive to variations. Algorithm used in this project is based upon the slope information, consisting of Band Pass filtering, differentiation and squaring to emphasize the high frequency spikes, followed by Moving Window Integration to highlight the upslope and down slope of the QRS complex.

After the successful detection of the position as well as the amplitude of the QRS complex, a rule based approach has been followed to compare the test sample values with the standard values to classify it as a aberrant type. The classification done in this project is for only one category of disease known as Premature Ventricular Contraction (PVC), in which the gap between two successive Ventricular contractions is abnormally reduced.

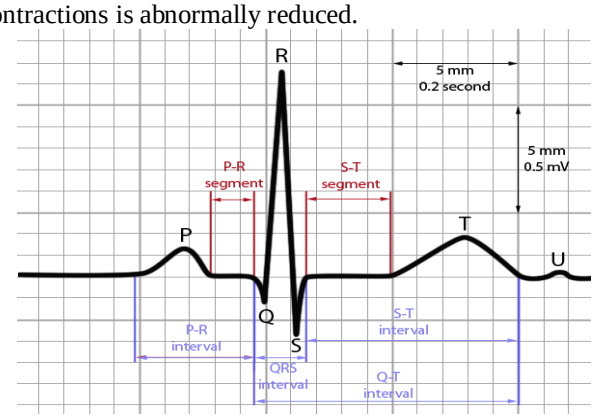


Figure 1: Typical Single Cycle of ECG Signal

Required Tool: Matlab, Turbo C
Area of Research: Digital Image Processing.

II. LITERATURE REVIEW

A. Image Enhancement - Image enhancement is the leading field for doing research work in Digital Image Processing. In any applications namely, military application, home entertainment, medical science and media etc., the image enhancement plays a crucial role. To find out the difference between the two images, the quality of image compared with a sample image like typical methods are used [1]. This pre-processing method was not very effective. Today importance is being given for improving the image's quality by improving the image's content. The other techniques used to do the same are histogram equalization contrast enhancement, etc [2]. Denoising ECG Images is also a greatly studied topic. The major parameter for applying the Pan and Tompkins algorithm is the Signal to Noise ratio (SNR) [3]. It provides a great way to choose the algorithms to apply on such images. The newest method for processing of ECG images is the use of multi resolution image decomposition technique. With a host of multi resolution techniques, the input image is taken for treatment.

These techniques improve the pertinent features of the image which help in further processes [4].

B. Image Segmentation - As segment means Fragments so the Image Segmentation is segmenting the image into various fragments using different methods. A semi automatic method was being used to find the require boundaries of the ECG Diagnosis in early days. A slice with ECG is selected from the image and then the chosen slice was segmented using Fuzzy C-means method [5]. However, Human induced errors and time consumption made semi automatic methods unsuccessful. A much better application of ECG Diagnosis was made using Markov Random Fields method which was a fully automated method. It had a three step segmentation process to segment the ECG [6]. Fuzzy C-means (FCM) is a clustering algorithm which has been used in most of the medical image segmentations. But the drawback of Fuzzy C-means is that it is highly susceptible to noise. Hence a modified Fuzzy C-mean method was also employed [7]. The major part of research in medical image segmentation consider ECG Graph. Pictures from the distinctive division strategies were contrasted and each other and investigated by expert radiologists to discover the division method which is the most precise. Trial results demonstrate that the Otsu's thresholding technique is the most reasonable picture division strategy [8].

Computer aided methods which combine two separate algorithms for ECG Diagnosis have also been tested. These methods have a greater accuracy and take less time [9].An enhanced version of K-means method for ECG detection has also been developed. It is considered to be an efficient method for ECG detection [10]. The latest trend for detecting ECG Diagnosis is the use of Neural Networks.

C. Morphological Analysis - Morphological Analysis forms an essential part of Digital Image Processing. Binary Morphological analysis works only on a set value and does not consider the gray level value r intensity of pixels. Fuzzy mathematical morphology (FMM) is a traditional and robust approach of image morphological analysis. Deciding the shape of the structuring element to be used with the input image is the only concern. [12]. If image has salt and pepper or Gaussian noise, Multi scale morphology is used. The image is classified into two regions as background and foreground [13]. Mathematical morphology because it uses inbuilt set functions, has a clear advantage for image processing. Morphological framework is considered very important not because it performs various tasks but because it can perform operations on almost all the images in all fields of image Processing [14]. Computer Aided Design (CAD) systems also help the radiologists with ECG detection. CAD systems usually don't make use of morphological operators, but use techniques such as histogram equalization etc [15]. The combination of morphological operator allows the locally segmented image to be processed using the most suitable morphological operator and hence extract the QRS from it. It is a very useful tool for ECG Diagnosis

Applications - There is still a lot of room for improvement in this project according to us. More specifically we would like to index at three particular aspects.

Firstly, all the classification done is solely based on the RHYTHM pattern observed. This method of classification can be improved by taking into consideration the previously observed patterns and thereby making the classification more reliable.

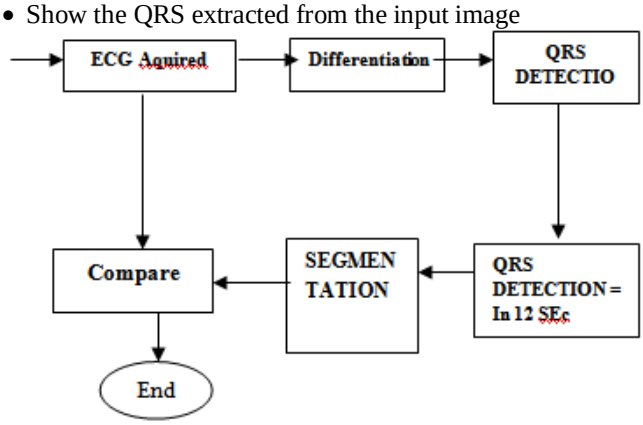
Secondly, even though we use low and high pass filters to filter out the noise due to the ambulatory and other real-life disturbances there is still scope for bettering this filtering process and hence ameliorating the classification.

And finally the adaptiveness of this project to different types of beats in a person, or many different persons can be taken into account by using Neural Networks.

In the coming time we would like to work on these aspects to enhance the functionality and efficiency of this Classifier.

III. RESEARCH METHODLOGY

- The methodology to be adopted during the development of the system is:
- Take an input as a gray scale ECG Graph.
- Perform Pre-Processing on sample image.
- Using suitable segmentation method, Segment the image
- Apply Morphological operators on the segmented image.
- Calculate the accuracy of the results.
- Show the QRS extracted from the input image



IV. PROBLEM FORMULATION

A. Design

i). Existing System - The existing system of ECG Diagnosis in mainly based on locating the manually from the ECG Graph of the patient. Experts have a detailed look at the ECG Graph and then try to locate and detect the heart rate. This approach is not very accurate and is also considered to be very time consuming. Due to the lack of fully developed and sophisticated automated systems, there is no option but to rely on the manual approach as of now.

ii). Proposed System - The proposed system of ECG Diagnosis is fully automated system and is based on the MATLAB platform. No human intervention is required. The ECG Graph of the patient is consider as input data and the final output data is the image of the heart beat. The

proposed system is seen to be less time consuming, more efficient, accurate, and more reliable than the current approach.

B. Implementations - The proposed system is implemented on the MATLAB platform. The system is divided into the following modules:

i). Image Pre-processing: This module involves applying basic pre-processing operations such as filtering, contrast enhancement etc on the image to obtain a better resultant image than the original image. The system applies the following operation on the image:

High Pass Filter: From experimentation it was found that high pass filter works in a best way for removal of the noise from the image. A high pass filter also enhances the features of an image in the best possible way.

Contrast Enhancement: Contrast enhancement is also done on sample image to enhance the region which is darker.

Brightness Adjustment: Image Brightness is also adjusted so that the users have no problem in viewing the image properly.

Image Segmentation: Image segmentation is implemented after pre processing by various segmentation techniques to segment the image. The QRS can be distinguished from the healthy tissue ob basis of many parameters like shape, size etc. Different Segmentation techniques applied are:

K-Means Segmentation: It is an effective segmentation method to divide the image into a fixed number of clusters. The number of clusters is called as k. Initially the user selects the number of clusters he wants to divide his image into. After that the algorithm assigns points randomly to various pixels in the image present in the clusters. During the time the algorithm runs, an objective function is calculated.

Otsu's Thresholding: In this method, image is divided into two sections namely foreground and background. The pixels are divided in the two regions using a threshold value set by the user. The main aim is to have the class sum of foreground and background regions as minimum.

Fuzzy C-Means Clustering: It uses fuzzy logic to divide the input image. The Fuzzy logic assigns a membership value to every pixel. The output value is between the range of 0 to 1. The main advantage of fuzzy clustering is that the member of one class can also be a member of the other class.

Image Thresholding: In Digital Image processing, Image Thresholding is the simple method for segmentation of Image. This method is usually used to produce a binary image from a grey level image. In this method, firstly Threshold is defined and then various pixels of an image against the threshold is tested.

Morphological Analysis: Morphological Analysis of the segmented image takes place after segmentation. An analysis of shapes and boundaries of an object is termed as Morphological analysis. Morphological Analysis is of great use to extract QRS from the segmented image. The system uses two morphological operators namely:

Erosion: The erosion operator removes pixel from boundaries of the objects. Determination of size and shape of aligning element is done by removing pixels which is used to process the image.

Dilation: This operator adds pixel to the boundary of the object. Determination of size and shape of aligning element is done by adding pixels which is used to process the image.

Open: The open operator performs erosion followed by a dilation operation. Both erosion and dilation use the same structuring elements.

Close: The close operator performs dilation followed by erosion. Both erosions and dilation use the same structuring element.

Accuracy of Results: Accurate results are measured by the system using following expression:

$$\textbf{Accuracy (\%)} = \frac{\textbf{Total area of the pixels in the final image}}{\textbf{1000}} \times$$

where ground truth is the exact position of QRS value in the image. The above expression is used to find out the accuracy of all the segmentation methods and then chose the best method accordingly.

Final Output: Finally the output of the system consisting of the QRS detection only is shown to the user. The user can verify the accuracy of the output and can also use different segmentation methods if the results are not satisfactory.

V. RESULT AND ANALYSIS

Table 1: Computation Accuracy of Algorithms

S.no	Name of Algorithm	Accuracy (%)
1.	K-means	90.08
2.	Otsu's Method	90.68
3.	Fuzzy C-means	91.72
4.	Thresholding	88.42

Table 2: Computation Time of Algorithms

S.no	Name of the Algorithm	Computation Time(sec)
1.	K-means	2.72
2.	Otsu's Method	2.11
3.	Fuzzy C-means	3.17
4.	Thresholding	2.02

It can viewed from the results of experiments that most accurate is Fuzzy C-means and thresholding method has the least accuracy amongst all the qrs detection algorithms. It can be derived is that Fuzzy C-means should be the first method to be used for any input image as it will have the highest probability of giving accurate results. Another consideration is the computational time of the algorithm. It is seen that thresholding method takes less time to generate results while Fuzzy C-means takes maximum time. Hence choosing the right algorithm will depend on the priority of the doctor. If the doctor wants to compute the results as quickly as possible, then thresholding method should be

preferred. If the doctor wants highest accuracy, then Fuzzy C-means should be preferred.

VI. OBJECTIVE & FUTURE PROSPECTS

Objectives - ECG analysis functions of beat detection and classification are enforced as C functions. The beat detector functions are freelance of the beat classification functions and should be used alone in applications that don't need beat classification.

VII. CONCLUSION AND FUTURE PROSPECTS

The developed system is able to meet its objective which were stated when the project was started. The focal point of the project was to prepare a system which can provide the rate of heart beat from brain ECG Graph. The project is able to succeed at the stated objective. The results given by the system is also acceptable. This project presents a speedy and automatic method for segmentation of QRS. It was also found out that from all the segmentation algorithms, Fuzzy C-means method when combined with morphological operators present the experimental results but results that are produced in less amount of time are because of thresholding approach. In extraction and filtering of image, Morphological processing technique has proved helpful. The structuring elements of the image can be changed according to the morphological operators need. The performance of the given method was strong because results that are available for all methods took only few seconds.

The given system can be made accurate with deep research and time in coming future. Also new algorithms in ECG Diagnosis can be added so that doctor can choose from various options.

VIII. REFEREENCES

[1]. Pan,J and Tompkins,W : A Real-Time QRS detection Algorithm, IEEE transactions based on Biomedical Engineering,32(3) (1985),230-236

[2]. George B. Moody : WFDB Programmer's Guide , Harvard-MIT Divisions of Health Sciences and Technology.

[3]. Rajini, N.H and Bhavani, R., "Enhancing k-means and kernelized fuzzy c-means clustering with cluster center initialization in segmenting ECG images", 2011 3rd International Conference onElectronics Computer Technology (ICECT), 259 – 263, 2011.

[4]. Deepa, S.N and Devi, B.A., "Artificial neural networks design for classification ofECG ", 2012 International Conference on Computer Communication and Informatics (ICCCI), 1-6, 2012.

[5]. Kikuchi, T, "Characteristic extraction from an ambiguous image using fuzzy mathematical morphology with adaptive structuring elements", The 10th IEEE International Conference on Fuzzy Systems, 228-231, 2001.

[6]. Kun Wang, Jianhua Wu, Liqun Gao, Zhaoyu Pian and Li Guo, "Magnetic Resonance Images Edge Detection Based on Multi-scale Morphology", IEEE/ICME International Conference on Complex Medical Engineering, 744-747, 2007.

[7]. Zijuan Yu, Yuqian Zhao and Xiaofang Wang, "Research advances and prospects of mathematical morphology in image processing", 2008 IEEE Conference on Cybernetics and Intelligent Systems, 1242-1247, 2008.

[8]. Ananda, R.S. and Thomas, T., "Automatic segmentation framework for primary tumors from brain ECG using morphological filtering techniques", 2012 5th International Conference on Biomedical Engineering and Informatics (BMEI), 238-242, 2012.

[9]. Thapaliya, K. and Goo-Rak Kwon, "Extraction of ECG based on morphological operations", 2012 8th International Conference on Computing Technology and Information Management (ICCM), 515-520, 2012.

[10]. Diaz I. , Boulanger P. , Greiner R. , Hoehn B. , Rowe L., Murtha A. "An automatic ECG segmentation tool", 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 3339-3342, 2013.

[11]. Corso JJ and Sharron E, "Efficient Multilevel ECG Segmentation with Integrated Bayesian Model Classification", IEEE Transactions on Medical Imaging, 629-640, 2008.

[12]. Selvakumar J, Lakshmi A and Arivoli T, "ECG Segmentation and Its Area Calculation in Brain ECG Images using K-Mean Clustering and Fuzzy C-Mean Algorithm", 2012 International Conference on Advances in Engineering, Science and Management (ICAESM), 186 – 190, 2012.

[13]. S.Xavierarockiaraj, "ECG Detection Using Modified Histogram Thresholding Quadrant Approach, 2012 IEEE International Conference on Computational Intelligence & Computing Research (ICCIC), 1 – 4, 2012.

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