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Conversion of ECG Graph into Digital Format

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Abstract

An Electrocardiogram (ECG) is a biomedical record for the patient. ECG is an important diagnostic tool for assessing heart functions. A MATLAB can convert images to (x,y) data by using image processing techniques. Even small curves can converted into data without any problem. The input is the ECG graph that is interrupted as an image by the system. The fine details of the image is extracted and the equivalent digital information is indexed in the form of matrices. This matrix is converted into digital data which is a fine replica of the input ECG image. The digitized ECG data is saved as (.dat file) is generated by using gradient based feature Extraction method that results in convenient storage and retrieval of ECG information.

Key Words : ECG, MATLAB,gradient based feature Extraction, image retrieval, Digitization.

1 Introduction

Digital equipment are flexibility of working their output. Electro cardiogram signals recorded to digital format. Therefore digital signals are high signal processing retrieval for the information[3-11] The advantages of ECG signal are digital technology for turns to first choice. Therefore digital technologies are high cost for modern digital equipment[8]. The serious barrier are crossed by working analogical device limitations. The analog devices are used to convert the analog values for suitable interface to digital microcomputer[7]The digitizing analogical data are many areas, medicine history of patients would be kept and case studies are correlated. The storage ECG signals are inefficient data are processing for unfeasible. The designing acquisition values are interface to microcomputers and instead of purchasing sophisticated computerized equipment[4].The trivial task are assemble to design for ECG signals. The MATLAB software tool is used analog version of signals and spectra digitalized ECG scanning data file are efficiently processed and stored. Therefore alternative approach for A/D conversion without requiring specific hardware[5].

Electrocardiogram signals are plotted from electrical activity. ECG signals are measured using electrodes. ECG signal are consists of P, Q, R, S and T. Therefore ECG signals consists of strong background noise for treated hardware and enlargement steps for avoid noise signal and amplification of the signal at the same time. ECG Signal monitoring using electrical circuits, amplifiers and analog digital converters.

The main problem for digitalized signals are interference to noisy signals like power supply network 40 Hz frequency and breathing muscle artefacts[8-9]. Noise elements are removed signal is next data processing like heart rate frequency detection. Digital signal processing are designed effective for next real-time applications in the embedded devices.

J.I.Willams et.al.[2-10] has proposed carried out the measurement analysed is independently cardiologists &AHA. ECG signal analysis for set of standardizing measurement in quantitative. The AHA recommendations are in the world wide recognition. Y. Zheng et.al[1-6] has proposed carried out artificial neural network using ECG signals are analysed for time domain and corresponding arrhythmias are determined, around 94%result is achieved identification of arrhythmia. Lins, R.D., et.al [4-5] has proposed efficient arrhythmia detection algorithm for correlation coefficient in ECG signal, the correlation coefficient and RR interval are utilized to calculate the similarity of arrhythmia. S. .M. Seul et.al[12-13]combined to modify Wavelet transform for Quadratic spline wavelet is QRS detection for Daubechies six coefficient wavelet used P and T detection for cardiac disease.

2 ECG Pattern Recognition

ECG processing proposed to pattern recognition, parameter extraction, spectro temporal techniques for assessment for the hearts status [7], de noising, baseline correction and arrhythmia detection. Three basic waves are P, QRS and T (Figure 1.1). These waves are far field induced by specific electrical phenomena cardiac surface, namely atrial depolarization (P), ventricular depolarization (QRS) and ventricular depolarization (T). Numerous techniques are developed to recognize and analyse waves from digital filtering techniques are neural network (NN) and spectro-temporal techniques. A great deal of research devoted to digital processing of ECG waves, are QRS, P and T wave detection (Figure 1.1). The P wave detection is the problem (especially in the presence of noise in the case of ventricular tachycardias).

QRS and T wave detection have been developed .In this cases clinically acceptable results arrhythmia analysis are received a great deal of attention, directed to QRS and PVC classification and supra ventricular arrhythmias. In shifted from arrhythmia to ischemia detection and monitoring.

It causes depolarization for resting membrane potential of ischemic region with respect to resting membrane potential of normal region. The potential difference between the flows of injury current is manifested in the ECG by an elevated or depressed ST segment (Figure 1.1) [10]. ST segment detection and characterization of major problem of ECG processing inhibiting factors are slow baseline drift, noise, sloped ST, patient dependent abnormal ST depression levels, and varying ST-T patterns in the ECG patient. A number of methods proposed in the literature for ST detection based on digital filtering, analysis of first derivative signal, and syntactic methods. To measure specific parameters in ways critically dependent upon the correct detection of J point on the ECG, which is the inflection point following the S wave. Where ST segment is sloped, or the signal is noisy, it is impossible to identify this point with reliability (Figure 1.1).

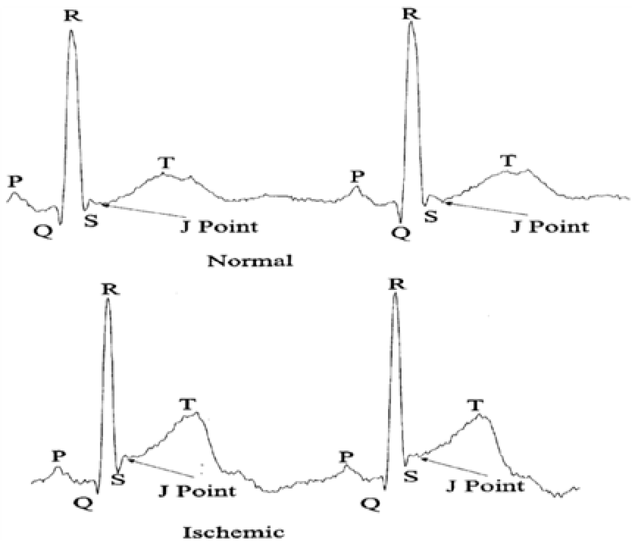

Figure 1.1 : Normal and abnormal ECG Waveform

The constituent ECG waves and J point. In the ischemic ECG, we observe the ST elevation, and observe the second beat that the J point is not easily discernible. The biomedical signal processing are based on standard in the normal case, annotated databases and forming a common reference. The database are ischemia detection in the MIT-BIH database can be used. The performance of ischemic beats episodes performance are often used [11].

3 Existing Work And Problem Identification

In the paper, *Context-based Multiscale Classification of Document Images Using Wavelet Coefficient Distributions,* by M. Li and R. M.

Gray .The related work to the 2-dimensional images as the class of graph images has been identified below. However, the related work requires extension to other class of graph images. Related work consists of two parts: 1) Categorization of images into predefined types, and 2) Information retrieval from images and indexing to support search[13]. To the best of our knowledge, there does not exist any prior standards for metadata of graph images.

In *ECG Paper Records Digitization through Image Processing Techniques* by M.Shweta Bhardwaj, Image categorization bears a direct relationship to image annotation and document image understanding. Image annotation refers to tagging the images with the keywords that are representative of the semantic of its content[14], while document image understanding aims at processing the raster from of image documents, e.g. scanned documents with the goal of tagging the image with its high-level semantic representation.

In *Converting ECG and Other Paper Legated Biomedical Maps into Digital Signals* by R.D Lins. statistic models are used to classify images based upon the features present in the image and the text describing the image in the document. There has been an extensive work on image understanding, content-based structure analysis, indexing and retrieval methods for partially understood images[15]. Generally, domain knowledge is also employed in image understanding task, e.g., parallel line detection in automated form processing using the hidden Markov model. People identification in images also utilizes both text based and content based analysis to identify people.

In *Electrocardiogram Display Data Capturing and Digitization Based on Image Processing Techniques*, by Wee, Eko Supriyanto .The image categorization part of our work bears a similarity to image understanding, but we are only interested in deciding whether a given image contains a 2-d plot[16]. Wavelet transform based and context sensitive algorithms to perform texture based analysis of the image and separate camera-taken pictures from non-pictures[16]. Content based image search and retrieval of image objects has been extensively studied. Using image understanding techniques, features are extracted from image objects such as texture features or color features and a domain specific indexing scheme is applied to provide efficient search for related image objects.

In, *ECG Scan: a method for conversion of paper electrocardiographic printouts to digital electrocardiographic files*, by Wojciech Zareba.Previous work in locating text in images consists of different application based approaches such as page segmentation, address block location, form, and, color image processing. Text can be located in an image using two primary methods[17]. The first treats text as textured region into the image and applies well-known texture filters such as Gabor filtering, Gaussian filtering, spatial variance, etc. The second method uses connected components analysis on localized text regions and is applicable to binary images, i.e. images having two pixel intensity levels. Generally, both methods are used in conjunction to first isolate the suspected text regions using texture analysis and then using the binarized connected component analysis. These methods are highly application-sensitive and image structure drawn from domain knowledge is generally applied.

4 Proposed Work

The electrocardiogram is a signal functional investigation. The electric signals are generated from human heart and create cardiac cycle generate blood circulation. The basic components are P wave, QRS complex and T wave as show in (figure 1.2) P wave is generated atrium depolarization[17]. The QRS complex is generated for ventricle depolarization and T wave is generated from cardiovascular disease is one of the leading causes of death. The lacking of physician expert for analysis on ECG signal is serious problem especially on rural area. Therefore ECG classification are ECG printout is relieve this problem.The digitization process is done by ECG graph to obtain the digitized data by reducing the noise present in the ECG signal.

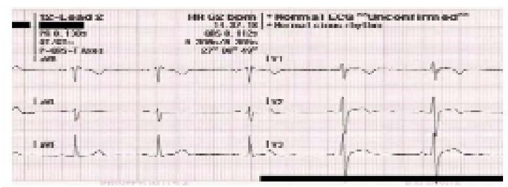

Figure 1.2 : Example image of paper based ECG printout

In this paper proposed filters used to reduce influence of noise, such as muscle noise, power line and baseline wonder.

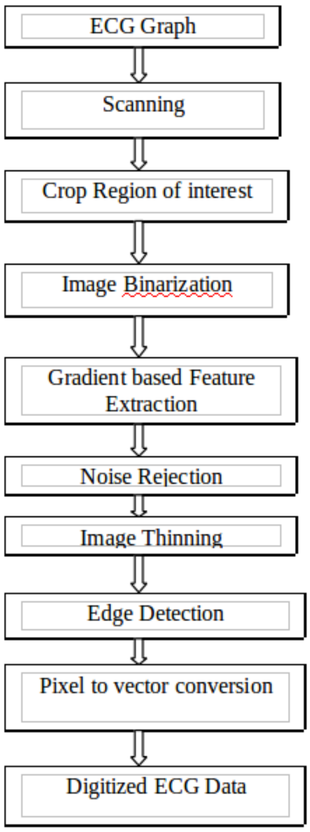

Figure 1.3 : Generic ECG digitization process

Scanning

ECG paper recordings are scanned. The scanning resolution are 600/400/200 dots per inch. Preferred algorithm is compression for the JPEG image. Figure 1.2 represents scanned ECG paper recording.

Crop region of interest

ECG graph is selected the particular region of interest to obtain the data. In order to retrieved the information from the ECG image. To detect the extract data cropping is necessary to avoid the grid lines present in image.

Image Binarization

It is a process and translate for colour image into a binary image. It is widespread process for image processing and especially images are contain neither artistic nor iconographic. In binarization operation reduces to number of colours to a binary level are apparent gains of storage and besides simplifying the image analysis as compared to the true colour image processing as shown in figure(1.4). The axis are composing the image and then applied binarization process by Otsus algorithm, since it has been shown to provide satisfactory results in many applications. Binarization is an important step for moving from a biomedical map image towards a digital signal are target of the process obtain a sequence of values that corresponded amplitude of a uniform time series

Gradient based Feature Extraction

The gradient is a vector which has both magnitude and directions as shown in figure(1.5). Magnitude indicates edge strength and Directions indicates edges direction (i.e) perpendicular to edge direction.

Noise Rejection

To remove the noise of the image after binarization process. The following process starts by scanning vertically to find out the black pixel. If the black pixel is found and all adjacent pixels around it are white background color, then this black pixel will be considered and treated as a noise which will be replaced with white background color as shown in figure(1.6).

Image Thinning

The line of ECG trace of original scanned image from ECG printout has a thickness which thickness which is a redundant of data in time series domain as shown in figure(1.3). Thinning process with moving average algorithm is used to eliminate this redundant of data .Moving average is a top down fashion and it is used for thinning process for binary images.

Edge detection

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision and machine vision. Edge detection algorithm includes Sobel, Canny, Prewitt, Roberts and fuzzy logic methods. It uses Laplacian to detect the edges. Edge detection is detected by looking the maximum and minimum in the first derivative of the image as shown in figure (1.7). The Laplacian method searches for zero crossings in the second derivative of the image to find the edges. The steps involved in Edge detection are:

- *Smoothing :* suppress as much noise as possible, without destroying true edges.
- *Enhancement:* apply differentiation to enhance the quality of edges (i.e., sharpening).
- *Thresholding:* determine which edge pixels should be discarded as noise and which should be retained (i.e., threshold edge magnitude).
- *Localization:* determine the exact edge location sub-pixel resolution might be required for some applications to estimate the location of an edge to better than the spacing between pixels.

Pixel-to-Vector conversion

Better data retrieving from the image, vectors have twice the number of columns of pixels analyzed, because some peaks are found as successive vertical black lines for low resolution images. Each component of the vector is a complex number. The two consecutive imaginary parts (same real part) quantify the upper and lower limits of a vertical black line.

The algorithm searches the data since the first pixel (bottom-left) until the last one (top-right). When there are no axis present in the map (no clear vertical and horizontal bounds), the value of the bottom vertical and the first column positions are used as a reference for image scanning. These axes are assumed as data scanning reference. In order to convert the 2D-vector into one dimension, the algorithm computes the modal distance between the imaginary part of two consecutive components, which means the amount of vertical black pixels composing the signal at a specific column. If the difference between the imaginary components of the two coordinates is within the limit , then only the imaginary part of the second element is stored in the 1D version of the vector.

In order to provide a one-dimension vector, the components at those places are estimated through linear interpolation. Data retrieving can be performed from a broad range of plottings. Horizontal and vertical lines differ from the box only by the fact that there is no upper bound in data acquisition. In appendix to this paper one may find two additional examples of data extracted from image strips and the corresponding plotted data signal.

The vector is extracted from the beginning of the image until the mark for the first stretch, from the first mark to the second one for the intermediary stretches and from the mark until the end of the image for the last stretch.

Digitization Process

The image is widely used in research to determine primary and secondary end points and to assess the effect of output image. Despite a technology that permits storage of raw data in digital format in many years, many image analysis are still performed on paper printouts, either directly on paper copies or with the support of on-screen caliper methods applied to the scanned printout .

Academic research will also indirectly benefit from these efforts; indeed, there still exist today many large databases collected on paper images that must be converted to digital format to be efficiently archived. The task of actually deriving a digital image from a paper printout has been already approached, although it was generally limited to research applications and often specifically designed to the execution of the well-defined studies. Moreover, the methods used were often based on commercial products the main objectives and contexts of which were not in the image arena and that could not be optimized and tuned for the task of deriving an image waveform from a grid-supported image. The digitization of data(.dat file) gives the extract value of all pixels present in the ECG graph as shown in figure(1.8).

5 Results

1. The following figure shows plots for Image Binarization, Gradient based Feature Extraction , Noise rejection, ECG graph Edge detection, Digitized ECG data (.dat file).

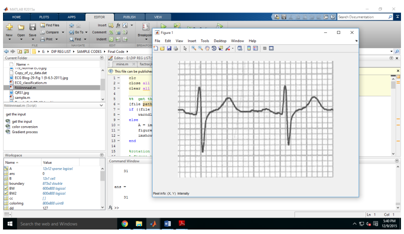

Figure 1.4 : Image Binarization

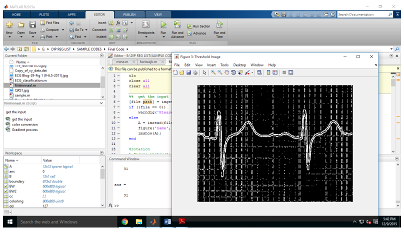

Figure 1.4 : Gradient based Feature Extraction

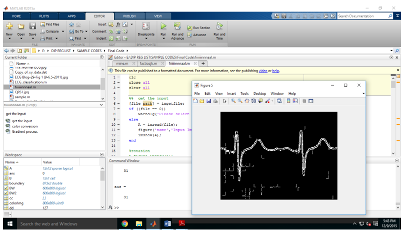

Figure 1.6 : Noise rejection

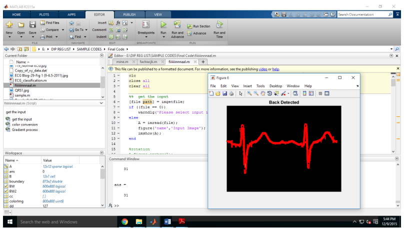

Figure 1.7 : ECG graph Edge detection

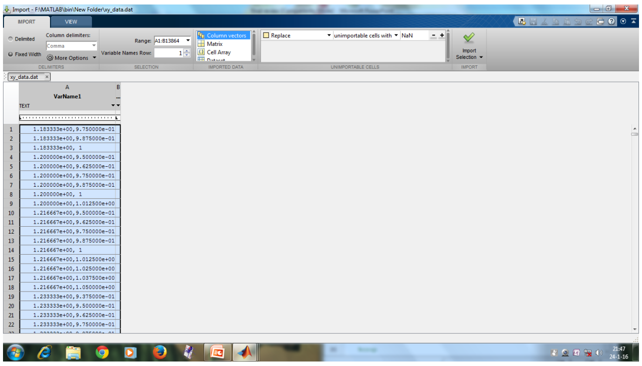

Figure 1.8 : Digitized ECG data (.dat file)

6 Conclusion and Future work

An efficient 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 proposed system uses the MATLAB software to get digitized data. The gradient based feature Extraction method converts the ECG graph into matrices. These matrix is converted into digital format (.dat file) that is called as digitized data. The original image can be retrieved easily by decoding the output digital format, at any time. The digitization process provides high level of accuracy, faster processing and can handle of large volume of data.

To Enhance the overall efficiency of the method and also identifying a diseases present in ECG data without using a dedicated hardware.

References

[1] B.Dhivyapriya and V.Vijayabaskar , *Automated Feature Measurement for Human chromosome Image Analysis in Identifying Centromere Location and Relative Length Calculation using Labview*, International Conference on control, Instrumentation, Communication and Computational Technologies(ICCICCT),July 2014,pp.186-192.

[2] J.I.Willems and CSE working party, *Recommendations for measurement standards in quantitative ECG* European Heart Journal 1985)6,815-825.

[3] Justyna Inglot, *Advanced Image Processing with Matlab*, in Bachelors Thesis Information Technology, May 2012, Date of the bachelor's thesis 07.05.2010 ,Mikkeli University of Applied Sciences.

[4] M. Li and R. M. Gray, *Context-based Multiscale Classification of Document Images Using Wavelet Coefficient Distributions*,IEEE Transactions on Image Processing, vol. 9, no. 9, pp. 16041616, Sept. 2000.

[5] M.Shweta Bhardwaj, Deepak Kumar Garg, Diksha Thakur *ECG Paper Records Digitization through Image Processing Techniques* International Journal of Computer Applications (0975 888) Volume 48 No.13, June 2012.

[6] M. Sanroman, I. Mora, E. Everss, J. Almendral, A. Alberola, F. Atienza, L. Castilla, J.L. Rojo, *Quality evaluation and effect of time synchronization on the digital recovery of intracardiac electrograms*, in: Computers in Cardiology, Park City, UT, USA, 2009, pp. 801804.

[7] Prashanth Swamy, J Srinivasan, M.Girish Chandra, *An Improved Method for Digital TimeSeries Signal Generation from Scanned ECG Records*, IEEE Proceeding Issue April2010, pp: 400-403.

[8] R.D.Lins, vila, B.T.: *A New Algorithm for Skew Detection in Images of Documents*. In: Campilho, A.C., Kamel, M. (eds.) ICIAR 2004. LNCS, vol. 3212, pp. 234240. Springer, Heidelberg (2004)

[9] R.D Lins, A.R.Gomes e Silva, H.M. de Oliveira, *Converting ECG and Other Paper Legated Biomedical Maps into Digital Signals*,Federal University of Pernambuco- UFPE, Signal Processing Group Volume 50_20,2000

[10] S.C.Saxena, V. Kumar and S. T. Hamde, *Feature extraction from ECG signals using wavelet transforms for disease diagnostic* International Journal of Systems Science, 2002, volume 33, number 13, pages 10731085.

[11] Shen, T. Laio, *Image processing on ECG chart for ECG signal recovery*, in: Computers in Cardiology, Park City, UT, USA, 2009, pp. 725728.

[12] S. Ahmadi, M. V. Zoej, H. Ebadi, H. Moghaddam, and A. Mohammadzadeh, *Automatic urban building boundary extraction from high resolution aerial images using an innovative model of active contours*, Int. J. Appl. Earth Observ. Geoinf., vol. 12, no. 3, pp. 150157,Jun. 2010.

[13] T.W. Shen, TF Laio Tzu Chi *Image Processing on ECG Chart for ECG Signal Recovery*,University, Hualien, Taiwan, Computers in Cardiology 2009;36:725728.

[14] V. Wu, R. Manmatha, and E. M. Riseman, *Finding Text in Images*, inProceedings of the Second ACM international conference on Digital Libraries, New York, NY: ACM, 2010, pp. 3-12.

[15] V. Seul, L. OGorman, and M. J. Sammon,*Practical Algorithms for Image Analysis: Description*, Examples, and Code, New York, NY, USA: Cambridge University Press, 2011.

[16] Wee, Eko Supriyanto, *Electrocardiogram Display Data Capturing and Digitization Based on Image Processing Techniques* New Aspects Of Applied Informatics, Biomedical Electronics & Informatics And Communications, ISBN: 978-960-474-2007.

[17] WojciechZareba , MD, Arthur J. Moss, F. Badilini , *ECG Scan: a method for conversion of paper electrocardiographic printouts to digital electrocardiographic files*, Journal of Electrocardiology 38 (2005) 310 318.

[18] G. Gasper, M. Rahman, *Basic Hypergeometric Series*, Cambridge University Press, Cambridge (1990).

[19] M. Rosenblum, Generalized Hermite polynomials and the Bose-like oscillator calculus, In: *Operator Theory: Advances and Applications*, Birkhäuser, Basel (1994), 369-396.

[20] D.S. Moak, The q-analogue of the Laguerre polynomials, *J. Math. Anal. Appl.*, **81** (1981), 20-47.