A New Method for Acquisition and Analysis of ECG Signal using Virtual Environment

Divya Savani, Ukshit Prajapati, Harsh Shingala, Prashant Tanti
Parul Institute of Technology, Parul University,
Vadodara, Gujarat, India

Abstract

Electrocardiogram is used to measure the rate and regularity of heartbeats and to detect any heart arrhythmia. Different ways are submitted and used for cardiogram feature extraction with a reasonable percentage of right detection. Although the problem stays open especially with respect to superior detection accuracy in ECGs. The ECG signal is very sensitive in nature having voltage level as low as 0.5 to 5mv and frequency components fall into the range of 0.05-100Hz and most of the information contained in the range of 0.05- 45Hz. The recorded ECG signal contains different type of noises such as baseline wander, channel noise which becomes very essential for us to remove for the better clinical result which helps in the treatment of the patient. For the feature extraction and classification task we'll be using discrete wavelet transform (DWT) as wavelet transform could be a two dimensional timescale process technique, therefore it's appropriate for the nonstationary ECG signals(due to adequate scale values and shifting in time) in LabVIEW. The flexibility, standard nature and simplicity to use programming possible with LabVIEW, makes it less complex. The proposed algorithm is executed in two steps. First step, it pre-processes de-noises the signal to get rid of the noise from the cardiogram signal, Then it detects pulse, Our extracted parameters are Heart rate, P wave amplitude, T wave amplitude, S value, Q value, R-value, P offset location, P onset location, T onset location, T offset location and the location of P, Q, R, S and T wave.

Keywords — *Electrocardiogram, discrete wavelet transform, heart arrhythmia, LabVIEW.*

I. INTRODUCTION

An ECG (electrocardiogram) represents cardiac signals generated by cardiac muscles. A typical ECG cycle contains wave segments P, QRS and T which represents periodic depolarization and repolarization of atria and ventricles in a sequential manner. QRS, being the most striking segment of the waveform assumes special significance for the cardiac interpretation of ECG signal. With the semiconductor technology advancement, embedded systems are adopted to implement an ambulatory ECG monitor as a primary signal-processing device for detecting irregular heart conditions by evaluating ECG signals [2]. The ECG detection that shows the data of the heart and heart condition is important to support the patient living quality and applicable treatment. It is valuable and a very important tool within the identification and the condition of the heart diseases. In recent year, numerous research and algorithm have been developed for the work of analyzing and classifying the ECG signal. The ECG features can be extracted in a time domain or in a frequency domain. Manual beat-by-beat measurements of all characteristic points in each lead are impractical in routine clinical observe. Especially for long term ECGs. For this reason, automatic ECG feature extraction methods are more relevance. Beat or QRS advanced detection is the most significant part which is Associate in Nursing ECG feature extraction system. Therefore peak detection Algorithms are needed. Wavelet Transforms will present a time versus frequency illustration of the signal and work well on the non-stationary signal. Wavelets also overcome the present resolution problem of the short time Fourier transforms by using a variable length window. The large range of various wavelet functions provides an exclusive area to look for wavelet with efficiency represent a symbol of interest. Although there are some methods available in order to select the best wavelet for an application. The orthogonal Daubechies wavelet family, specifically Db6 is used here. We have enforced here the DWT to extract ECG signal features. In ECG signals, instrumentation plays a major role, since signals generated by the human body are very low in amplitude. High gain must be obtained with a high common-mode rejection ratio (CMRR). Two electrical circuits were studied in the present work, using common electronic parts and application-specific parts. LABVIEW is a software application from National Instruments that is specially designed for easy and powerful data acquisition purpose. Thus, LABVIEW software was used for data recording and visualization, due to its known capabilities [1]. Finally, LABVIEW were used again to implement real-time filtering of the signal.

II. METHODOLOGY

The ECG signal is obtained using three lead system i.e., Einthoven Triangle. The solution for the abnormality detection problem contain 4 vital parts First phase is that the acquiring of the signal, here we have a tendency to use the ECG signal within the system and provides to our program for the analysis. The second phase is the filtering of the raw ECG signal to remove unwanted noises. A third is the core phase to extracting the features from the signal i.e. ECG signal in terms of its parameters by the actual analysis of it. The last is the detection of different types of abnormalities on the basis of different values of parameters obtained [3]. The parameters are obtained in LabVIEW software where its features are known.

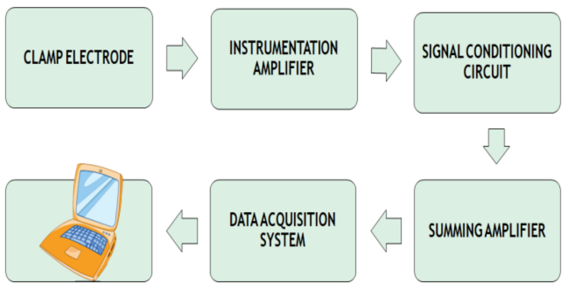


Fig. 1 Flowchart of the proposed system

A. *Signal Amplification*

The combinations of differential amplifiers are used to construct to achieve the obtained output from the noised input signal which is collected from bio-potentials that is called an instrumentation amplifier. In this proposed project we have used INA126 instrumentation amplifier. An instrumentation amplifier is typically the very first point in an instrumentation system. This is as for the very small voltages generally received from the probes have to be amplified. The ECG signal is too small and contains a lot of added noise. Also, the signal extracted from the heart has an amplitude of approximately 0.5mV. Since it is essential to amplify the signal and remove the noise, and then extract the QRS complex. The INA126 is used for the low-level amplification. The gain of the amplifier is 13v/v.

B. *Signal Conditioning*

The Filtering circuit includes Bandpass filter with the non-inverting amplifier. In that, the frequency range of the Bandpass filter is 0.5-30 Hz and the Gain of the non-inverting amplifier is 100v/v. Thus, after the filtering stage noise will be removed and get the better signal of ECG. After that with the use of a summing amplifier, the signal has been summed in the range of 0-5v. There are many types of noises which are removed using this filtering technique such as power line interference, Electrode contact noise, muscle artifact, motion artifact and baseline wander.

C. *Summing Amplifier*

The signal must be in a range of 0 to 5 volts so that the signal will be converted from analog to digital form to perform analysis on it.

$$Vout = \left(1 + \frac{Rf}{R1}\right)\left(\frac{V1 + V2}{2}\right)$$

D. *Data Acquisition*

Analog to digital conversion is one of the most important things in the data acquisition system. It is basically performed using ADC0804. Which is generally done in two ways: First, parallel mode where data is transferred at a faster rate with more number of lines which is used for short-range data transfer and Secondly in Serial mode where it uses one or two data lines which are used for longer range data transfer.

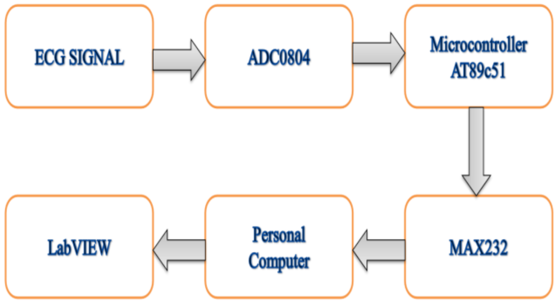


Fig. 2 flowchart of DAQ

E. *LabVIEW (Laptop)*

A Virtual ECG Instrumentation system is a new Instrumentation system, which is much better and flexible with the aid of computer intelligent resource.

1. *Continuous Wavelet Transform*

A Continuous wavelet transform is used to divide a continuous time function into wavelets. It is a convolution of the input data sequence with a set of functions generated by the mother wavelet. It is represented as:

$$W_s(a, b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)\bar{h}\left(\frac{t-b}{a}\right) dt$$

2. *Discrete wavelet transform*

A discrete wavelet transform is used for functional analysis and numerical analysis. The DWT of signal x is calculated by using a series of filters. The sample is passed through a low pass filter with the impulse response g resulting in a convolution of both parameters.

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k]$$

3. *Feature Extraction*

There are so many features can be extracted from the ECG signal and all are specific to heart function and conditions. Before feature extraction, we have to remove baseline wander and filter the noise present in the raw ECG signal. For this used VI is as follow:

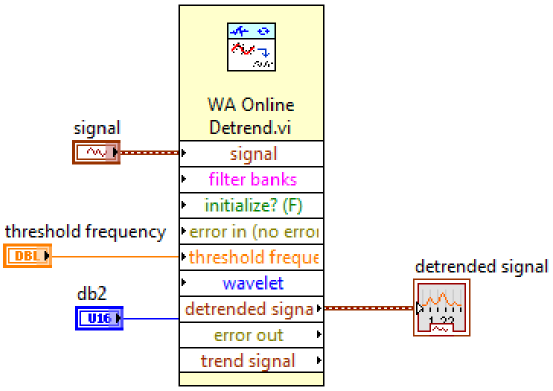


Fig. 3 Wavelet Detrend VI

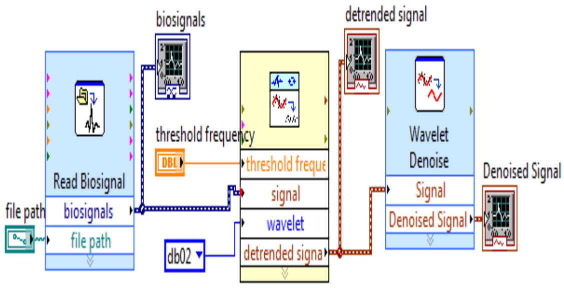


Fig. 4: VI diagram to remove Baseline Wandering and Wideband Noise

III. RESULT AND CONCLUSION

This evaluation system was tested and validated on a few healthy subjects. Our extracted parameters are Heart rate, P wave amplitude, T wave amplitude, S value, Q value, R-value. The display window of our VI also gives the location of P, Q, R, S and T wave. It also gives output value of P offset location, P onset location, T onset location and T offset location. Heart measurement is done by detecting the R-pecks which is detected by providing threshold value to the ECG signal. If the signal is exceeded from the threshold value it will be counted as an R peak. We have put 0.8 mV threshold values according to the ideal peak value of R. In our analysis first, Wavelet detrend VI is used which removes baseline wander of ECG signal. So, the output of this VI will remove the trend of ECG signal. The Output of Wavelet detrend VI applies to the Wavelet denoise. Transform type of Wavelet denoise is UWT (Undecimated Wavelet Transform) with db02 and level 5, which denoise the signal and wideband type noise. The output shows the smoother ECG signal and it displays sharp peaks. After filtering of ECG signal, Each and every individual ECG superimposed on single ECG cycle and after overlapping of ECG signal we can get averaged ECG signal.

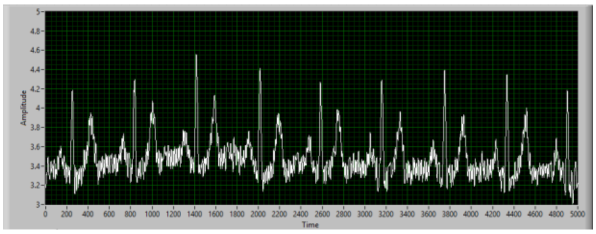


Fig. 5(a): Row ECG signal

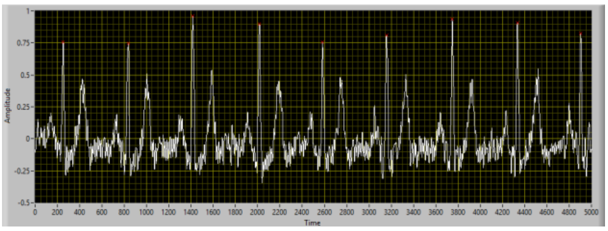


Fig. 5(b): R-peak detection

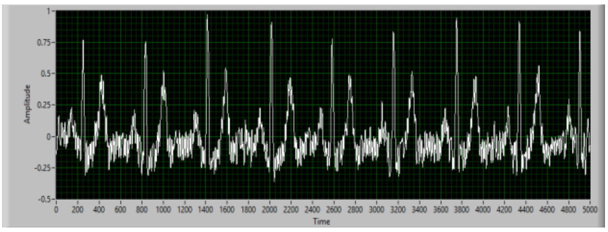


Fig. 5(c): Detrended ECG signal

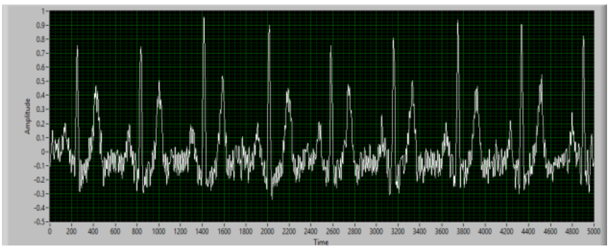


Fig. 5(d): denoised ECG signal

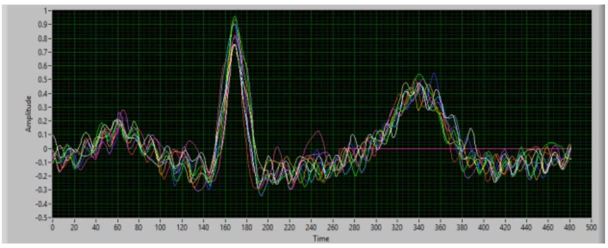


Fig. 5(e): Overlapping of ECG waveforms

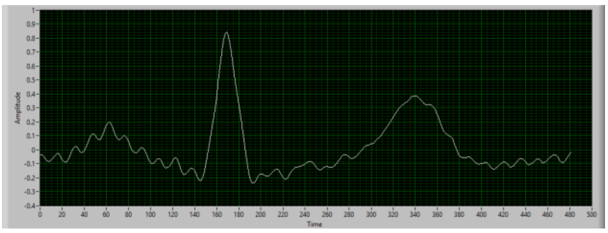


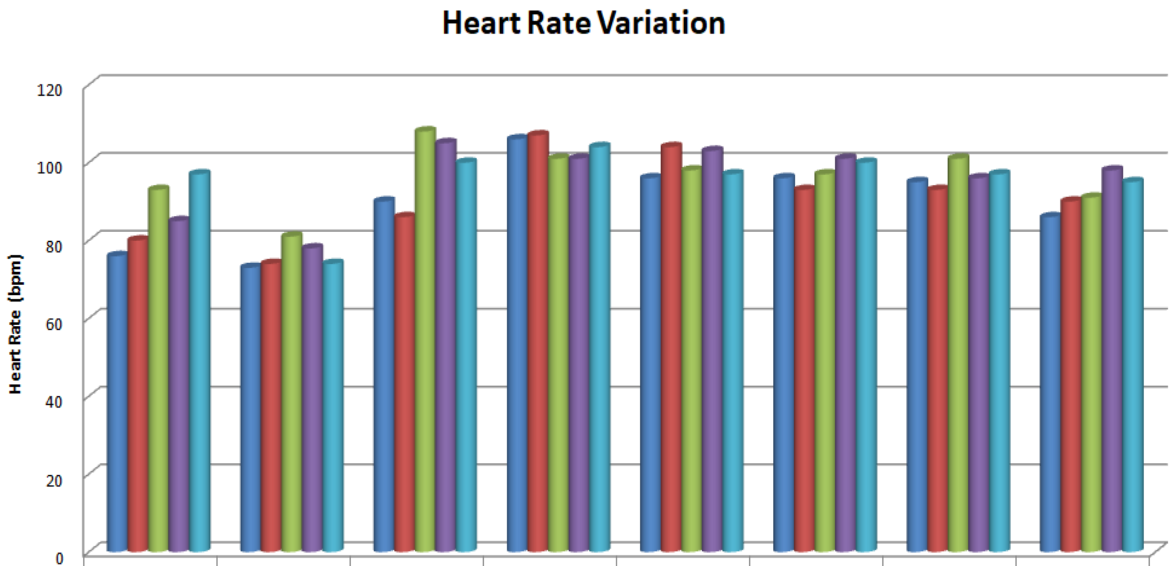
***Fig.* 5(f): ECG waveform after averaging**

Table 1: ECG Analysis and feature extraction components

Sr No.	P Wave amplitude	Q value	R value	S value	T Wave amplitude	P Location	Q Location	R Location	S Location	T Location	P onset location	P offset location	T onset location	T offset location	HR
1	0.206	-0.192	1.220	-0.232	0.267	85	146	166	221	361	62	105	310	393	95
2	0.198	-0.221	0.844	-0.236	0.387	63	145	169	193	340	40	83	291	378	96
3	0.076	-0.122	0.568	-0.130	0.146	35	56	96	136	251	31	39	245	257	56
4	0.113	-0.159	0.892	-0.326	0.339	72	112	149	171	303	53	82	265	350	85
5	0.278	-0.187	1.345	-0.268	0.244	37	93	143	184	322	13	57	292	358	82
6	-0.010	-0.183	1.193	-0.280	0.560	29	68	108	149	252	29	29	214	292	61
7	0.047	-0.324	1.340	-0.319	0.714	43	112	136	181	296	32	51	248	337	78
8	0.109	-0.191	0.850	-0.187	0.399	18	70	123	191	295	8	23	242	328	70
9	0.077	-0.161	1.147	-0.553	0.284	42	96	122	140	290	27	52	242	322	70
10	0.289	-0.251	1.173	-0.442	0.186	58	116	141	189	401	37	66	394	403	82

Above table shows the features extraction of acquired ECG signal from 10 healthy people.

Analysis of heart rate variability of various subjects is shown in below figure 6.



	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6	Subject 7	Subject 8
Trial 1	76	73	90	106	96	96	95	86
Trial 2	80	74	86	107	104	93	93	90
Trial 3	93	81	108	101	98	97	101	91
Trial 4	85	78	105	101	103	101	96	98
Trial 5	97	74	100	104	97	100	97	95

Fig. 6: Heart rate variability (HRV chart)

IV. CONCLUSION

In the proposed work, After the complete analysis of all ECG signal, we were able to determine and calculate the parameters with high precision and use these parameters to detect and confirm heart abnormalities. We additionally checked for baseline wandering because of motion artifact, so that we do not come out with wrong measurements due to movement of electrodes. Hence the analysis could be a very economical technique and much quicker than the present technology. This is less expensive, very less time consuming and can be done without any expert. Therefore we are able to term this methodology as a life-saving system. We have with efficiency calculated the Various ECG signal parameters however they might be used a lot effectively to seek out more heart abnormalities with higher accuracies exploitation a lot of advanced case structures. We can conjointly study and analyze the ECG patterns of various diseases using the parameters found higher than which can help in deciding higher algorithms for heart diseases. We have targeted solely on software System design however the work may be extended as portable hardware design that a user will wear continually and instantly sees the heart condition.

ACKNOWLEDGMENT

This work is supported by Parul University, Vadodara. We would like to express our gratitude to our guide Prof. Dimpal Khambhati, Assistance Professor at Department Of Biomedical Engineering, Parul Institute of Technology, Vadodara for all her diligence, guidance, encouragement and help throughout the period of work. Also we would like to express our sincere thanks to each and every person who supported our project and data collection.

REFERENCE

[1] Sahil Dalal,Rajesh Birok , 'ECG Signals Analysis using PCA with Neural Network and Fuzzy Logic',IJARECE-journal, Volume 5, Issue 7, July 2016.

[2] Islam, M. K., G. Tangim, T. Ahammad, and M. R. H. Khondokar. "Study and analysis of ecg signal using matlab &labview as effective tools." International journal of Computer and Electrical engineering 4, no. 3 (2012): 404.

[3] Olarte, N., and D. Lara. "Design of Medical Information Storage System–ECG Signal." World Academy of Science, Engineering and Technology, International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering 5, no. 11 (2011): 608-612.

[4] Kumar, Amit, Lillie Dewan, Mukhtiar Singh, and H. A. R. Y. A. N. A. Kurukshetra. "Real time monitoring system for ECG signal using virtual instrumentation." WSEAS Transactions on biology and biomedicine 3, no. 11 (2006): 638-643.

[5] Ashok Kumar Dohare ,'Wonder Baseline Drift Removing in the Electrocardiogram Signals Using Variable Window in Median Filter' , IJARCSSE, Volume 5, Issue 5, May 2015.

[6] Chandel, Savita, and Kuldeep Singh. "ECG denoising using wavelet transform and soft thresholding." International Journal of Advanced Research in Computer Science and Software Engineering 6, no. 9 (2016).

[7] Priyanka and Gurjit Kaur,'Noise Removal in ECG Signal using Windowing Technique and its Optimization', Adv Biotech & Micro (Juniper Publishers), Volume 6 Issue1 - August

[8] Rajni, Rajni, and Inderbir Kaur. "Electrocardiogram signal analysis-an overview." International Journal of Computer Applications 84, no. 7 (2013): 22-25.

[9] Bhat, Abdul Qayoon, Vineet Kumar, and Sunil Kumar. "Design of ECG data acquisition system." International Journal of Advanced Research in Computer Science and Software Engineering 3, no. 4 (2013).

[10] Vimala, K., and Dr V. Kalaivani. "Classification of cardiac vascular disease from ECG signals for enhancing modern health care scenario." Health Informatics-An International Journal (HIIJ) 2, no. 4 (2013): 63-72.

[11] Srivastava, V. K., and Devendra Prasad. "DWT-based feature extraction from ECG signal." American J. of Eng. Research (AJER) 2, no. 3 (2013): 44-50.

[12] Anjali Deshmukh, Yogendra Gandole , 'Simulation of ECG signal using Advanced Virtual Instrumentation system Based on LAB VIEW', International Journal of Science and Research (IJSR), Volume 3 Issue 9, September 2014 .

[13] Abed, Bassam H., Raaed K. Ibrahim, and Mahmood Hamza Almuifraje. "Design and Implementation of ECG (Electrocardiograph) Feature Extraction using Biomedical Workbench and LabView." International Journal of Computer Science and Mobile Computing 4, no. 5 (2015): 29-32.

[14] Savita Chandel , 'A Review on Wavelet Techniques for Different Noises Removal from ECG Signal', International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 5, May 2016.

[15] Prasad, S. Varadarajan , 'ECG Signal Processing Using Digital Signal Processing Techniques' , International Journal of Scientific & Engineering Research,Volume 4, Issue 12, December-2013.

[16] Kumar, Rakesh, and Rajvir Singh. "Design and Comparative Analysis of ECG Data Acquisition System using Low Power Microcontroller." International Journal of Bio-Science and Bio-Technology 7, no. 5 (2015): 11-20.

[17] Subha, B., Subha SV, M. Anitha, M. Eniya, and M. Gaayathri. "DESIGNING A VIRTUAL MACHINE FOR IDENTIFICATION OF CARDIAC ARRHYTHMIAS USING LAB VIEW." (2013).

[18] Kumar, Anil, Jagannath Malik, and Vinod Kumar. "Virtual Lab: Real-time Acquisition and Analysis of ECG Signal." International Journal of Online and Biomedical Engineering (iJOE) 7, no. 3 (2011): 19-23.

[19] Nayak, Seema, M. K. Soni, and Dipali Bansal. "Filtering techniques for ECG signal processing." International Journal of Research in Engineering & Applied Sciences 2, no. 2 (2012): 671-679.

[20] Kaur, Harjeet, and Rajni Rajni. "Electrocardiogram signal analysis for R-peak detection and denoising with hybrid linearization and principal component analysis." Turkish Journal of Electrical Engineering & Computer Sciences 25, no. 3 (2017): 2163-2175.

[21] Mohamed, Muhidin A., and Mohamed A. Deriche. "An approach for ECG feature extraction using daubechies 4 (DB4) wavelet." International Journal of Computer Applications 96, no. 12 (2014).

[22] Saritha, C., V. Sukanya, and Y. Narasimha Murthy. "ECG signal analysis using wavelet transforms." Bulg. J. Phys 35, no. 1 (2008): 68-77.

[23] Khelil, Besma, Abdennaceur Kachouri, Mohamed Ben Messaoud, and Hamadi Ghariani. "P wave analysis in ECG signals using correlation for arrhythmias detection." In 4th International multi-conference on systems, signals & devices, vol. 3. 2007.

[24] van Alste, Jan A., W. Van Eck, and O. E. Herrmann. "ECG baseline wander reduction using linear phase filters." Computers and Biomedical Research 19, no. 5 (1986): 417-427.

[25] Lascu, Mihaela, and Dan Lascu. "LabVIEW electrocardiogram event and beat detection." WSEAS Trans (2008).

[26] Joshi, Anand Kumar, Arun Tomar, and Mangesh Tomar. "A review paper on analysis of electrocardiograph (ECG) signal for the detection of arrhythmia abnormalities." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 3, no. 10 (2014): 12466-12475

[27] "The ECG Leads, Polarity and Einthoven's Triangle – The Student Physiologist." [Online]. Available: https://thephysiologist.org/study-materials/the-ecg-leads-polarity-and-einthovens-triangle/. [Accessed: 16-Feb-2019]

[28] Crawford, Jacqui, and Linda Doherty. "Recording a standard 12-lead ECG: filling in gaps in knowledge." Journal of Paramedic Practice 1, no. 7 (2009): 271-278.

[29] Kumar, Amit, Lillie Dewan, Mukhtiar Singh, and H. A. R. Y. A. N. A. Kurukshetra. "Real time monitoring system for ECG signal using virtual instrumentation." WSEAS Transactions on biology and biomedicine 3, no. 11 (2006): 638-643

[30] Agham, N., and V. Thool. "Labview based physiological parameters monitoring system for patient health-care." Int. J. Eng. Res. Technol 3 (2014).

[31] C. Bhyri, V. Kalpana, S. Hamde, and L. Waghmare, "Estimation of ECG features using LabVIEW," *Int. J. Comput. …*, vol. 2, no. 1, pp. 320–324, 2009.

[32] Bhyri, Channappa, V. Kalpana, S. T. Hamde, and L. M. Waghmare. "Estimation of ECG features using LabVIEW." International Journal of Computing Science and Communication Technologies 2, no. 1 (2009): 320-324.

[33] Lascu, Mihaela, and Dan Lascu. "LabVIEW electrocardiogram event and beat detection." WSEAS Trans (2008).

[34] Sörnmo, Leif, and Pablo Laguna. "Electrocardiogram (ECG) signal processing." Wiley encyclopedia of biomedical engineering (2006).

[35] van Alste, Jan A., W. Van Eck, and O. E. Herrmann. "ECG baseline wander reduction using linear phase filters." Computers and Biomedical Research 19, no. 5 (1986): 417-427.

[36] Bhyri, Channappa, Satish T. Hamde, and Laxman M. Waghmare. "ECG Acquisition and Analysis System for Diagnosis of Heart Diseases." Sensors & Transducers 133, no. 10 (2011): 18.

[37] Chowdhury, E., and L. C. Ludeman. "Discrimination of cardiac arrhythmias using a fuzzy rule-based method." In Computers in Cardiology 1994, pp. 549-552. IEEE, 1994.

[38] Bailey, James J., Alan S. Berson, Arthur Garson Jr, Leo G. Horan, Peter W. Macfarlane, David W. Mortara, and Christoph Zywietz. "Recommendations for standardization and specifications in automated electrocardiography: bandwidth and digital signal processing. A report for health professionals by an ad hoc writing group of the Committee on Electrocardiography and Cardiac Electrophysiology of the Council on Clinical Cardiology, American Heart Association." Circulation 81, no. 2 (1990): 730-739.

[39] Ara, Iffat, Md Najmul Hossain, and Md Abdur Rahim. "ECG signal analysis using wavelet transform." Int J Sci Eng Res 5 (2014).

[40] Wolthuis, Roger A., Victor F. Froelicher, Andrew Hopkirk, Joseph R. Fischer, and Neal Keiser. "Normal electrocardiographic waveform characteristics during treadmill exercise testing." Circulation 60, no. 5 (1979): 1028-1035.