Retraction

Retraction: Depression Detection Using Comparative Analysis of QRS Detection Algorithms and HRV Of ECG Signal Implemented on MATLAB and Verilog (J. Phys.: Conf. Ser. 1916 012018)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Depression Detection Using Comparative Analysis of QRS Detection Algorithms and HRV Of ECG Signal Implemented on MATLAB and Verilog

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Abstract. Nowadays depression is a major health issue with critical psychological wellness, that influencing the world lives. It impacts emotionally as well as physical and physiological individuals Condition. It can also lead to suicide. Ongoing studies say 43% Indians experience depression. Depression can detect using HRV ECG signal, before getting into Severe depression because HRV has been associated with depression. The QRS detection algorithm is utilized for calculating heart rate. In this project, comparative analysis of QRS detection algorithms is executed in MATLAB and performance compared for analyzing HRV of various MIT-BIH ECG information base acquired from physio.net. The QRS detection algorithm technique has been decided for R peak detection and heart rate calculation, proposes a simple method and it doesn't include complex numerical model. The detection design plans in Verilog to figure heart pulse. Thus, the designed code for analyzing QRS detection algorithms and HRV ECG signal simulated in MATLAB as well as on XILINX ISE 14.7. Keywords: ECG(Electrocardiography), QRS, MATLAB, VERILOG, HRV (Heart rate variability), peak, threshold.

1. Introduction
In the human body, heart is a vital organ, which transport the nutrients, oxygen, and hormones to cells throughout the body and removes metabolic wastes. It pumps blood around the body which never rest. It will beat up to 60 to 120 times, contingent upon the condition of heart. Without the appropriate working of heart, the human life will be flimsy. Electrocardiography is a test that checks heart functioning by the portrayal of the electrical action of heart wave graphically. Figure.1 Portrays a general ECG signal and its part. It determines essential data about the patient's heart.
Abnormal heart rhythms or improper beating conditions that can prompt to many risk factors like cardiovascular failure, blood clots and stroke, etc. As same as depression, stress, anxiety are also related with heart rate. Nowadays depression can lead to suicide. Every year close to 8,00,000 people die due to depressed suicide. So depression detection is very important to maintain our health. Depression can be detected using HRV. There is a connection among depression and HRV [1-6].

1.1 Heart rate variability
Based on the level of activity and amount of pressure, normally HRV levels changed from day to day. Over the past decades, research has appeared a relationship between low HRV and worsening depression or anxiety. High HRV has greater cardiovascular, fitness, and quiet stress. But low HRV and depression is related with an increased risk of death and cardiovascular infection. When heart beats slowly, HRV is higher. When the heart begins to beat faster, HRV is slower. HRV is calculated as standard deviation from entirety of the R-R intervals which is the distance between each heart beat or the R of the QRS complex.

1.2 QRS complex
The ECG signal comprises various waves p wave, QRS complex and T wave. QRS complex is the fundamental piece of ECG waveform. It is exceptionally confounded and gives a dominant part of the data about the heart action usefulness. QRS complex represents ventricular depolarization which incorporates Q, R, and S wave. For peak detection of QRS complex QRS detection algorithms are used. This paper organized as follows. Section II covers various QRS recognition Algorithm Techniques. Segment III covers the MATLAB Implementation of QRS Algorithms for calculating HRV of ECG signal. Segment IV presents discovery of pulse utilizing Verilog Implementation. Section V covers, the computation of Heart pulses on MATLAB using R peak detection of various ECG database, simulation outcomes and performance measurement. Segment VI closes the paper with better explanation [7-11].

2. QRS detection algorithm
ECG is a essential graphical representation device that's used for screening the heartbeat signal. The heartbeat signal that provides the impact on emotions, on cardiac activity. The necessary portion of the ECG signal is QRS complex, which incorporates Q, R and S wave. Each of the ECG signal waves to convey significant information about the heart activity and the way it's functioning. Several algorithms have been implemented for QRS complex detection of ECG data signals. The R top edge values of electrocardiography wave illustrated by the QRS algorithm. Heart rate variability calculated using RR interval employed by the QRS detection algorithm for various input ECG signal databases on MATLAB. For the startup testing the QRS recognizing algorithms have been implemented and tested on MATLAB. Later, It's been executed in Field-programmable gate array as a hardware design.
2.1 Various QRS detection algorithms

Various algorithm techniques depend on first and second ECG QRS detection is a two stage process in a signal, noise will be removed and enhanced in first filtering stages and then the pulses that are analyzed to determine the QRS complexes presence in the second stage. Many algorithm approaches were depending on ECG signal derivatives like first and second order, for the peak detection of QRS complex. So far, in order to get better performance for the peak detection of QRS different algorithms had been implemented.

2.1.1. Murthy and Rangaraj algorithm. This QRS figuring out algorithm, which follows simple steps for the peak R detection on ECG signal like squaring, taking derivatives and applying Moving normal Filter.

2.1.2. Pan And Tompkins Algorithm. In this algorithm different progress like bandpass filter, derivative, squaring, Moving window integration filter are utilized for the peak detection in ECG signal. The analysis of the slant, width and amplitude of QRS complexes are performed.

2.1.3. Histogram algorithm. The entire process involves the expulsion of undesirable commotion on signal and Discovery of peaks. In histogram algorithm, firstly QRS complex is distinguished, trailed by T wave and P wave. All peaks are detected that are in one specific pattern of ECG signals. The noise elements are found in the recorded ECG signal and this noise eliminated using a finite Impulse response from the signal. Median filter has been taken out the low level frequency components. Detection of the Peaks is done based on the threshold values setup. In view of a set limit, R peak and T peak are detected. Peaks All lay over the edge threshold value are considered R top value. The R peak is the main reference to find out the other peak waves, then the T peaks are detected by erasing past limit threshold worth and setting up another threshold value. To identify the P wave peaks same process is followed.

2.1.4. Wavelet Transform For describing ECG signal efficiently, Wavelet algorithm is an eminent algorithm. It provides temporal and spectral information simultaneously. For noise evolution technique this algorithm is utilized. It measures the noise quantity and selects the wavelet information on low noise level in the signal. In the pre-processing step high valued frequency components are not eliminated. Desire for wavelet functions of a various properties offered by wavelet. To find the efficiency of the wavelet algorithm, the addition of false negatives and false positives are utilized. It gives a better outcome of the wavelet functions that supports symmetry and compactness. Table 1 shows the comparison of QRS detection algorithm on ECG signal.

| S.no | Method of feature extraction | Accuracy  |
|------|-----------------------------|-----------|
| 1    | Pan and Tompkins            | 86%       |
| 2    | Murthy and Rangaraj         | 93.2%     |
| 3    | Histogram approach          | 99.7%     |
| 4    | Wavelet transform           | 99.75%    |
| 5    | Hilbert transform           | 98%       |
| 6    | Auto regression             | 96.6%     |
| 7    | Linear prediction           | 92%       |

Table 1. Comparison of QRS detection algorithms
3. Matlab Implementation of QRS Detection Algorithm

In this paper, combination of PAN & TOMPKINS and MURTHY & RANGARAJ ALGORITHM have been used for peak detection and heart rate calculation. MATLAB implementation which helps to develop the algorithm a lot quicker by using concept validation, plan alternatives and the best form of algorithm distribution. Pan & Tomkins and Murthy & Rangaraj algorithms are actualized in MATLAB. At that point, the performance examination is done. After QRS detection, HRV calculated using R-R interval in MATLAB for the different input ECG data signals taken from MITBIH Database. Depression detected for the different ECG database using HRV. The identification architecture is planned in Verilog to figure the heart pulse. Designed code simulated in MATLAB as well as on Xilinx ISE 14.7.

3.1 Matlab Implementation of HRV

Heart rate variability implemented in MATLAB using a QRS detection algorithm. The various peaks of ECG have been distinguished and its precision is determined. The algorithm method doesn't include any complex numerical model.

3.1.1. Pan & Tompkins algorithm QRS Detection. The examination of slope, width and amplitude are performed of QRS complexes. In this algorithm different progress bandpass filter, derivative, squaring, Moving window integration filter is shown in the schematic figure 2.

![Figure 2. Steps Of Tompkins Algorithm](image)

Band-pass filter stacking a low-pass channel at the end of a high-pass channel, or the alternate way. Bandpass filter performs low pass and high pass filtering operations are done related to the input. The yield of low pass channel is identified with the input contribution to the condition as in equations (1)-

\[
ecg_i = 2ecg1 (i-1) - ecg1(i-2) + 32[x(i) + 2x(i-6) x (i-12)]
\]  

The yield of high-pass channel comes in equation:

\[
ecg_i = x (i-16) - 32[ecg3(i-1) + x(i) + x (i-32)]
\]

Low-frequency components are suppressed in a derivative operation and it gives a high increase to the high recurrence parts that are taken from the high slants of the QRS complex. In moving-window integration, filtering step regulating a set of the sampled signal. It takes sample tests of input contribution at a time and takes normal to deliver a solitary yield point. It performs like simple LPF. The output of following operations through a moving window integration filter is smoothed by this algorithm. The output of the MWI filter equation as

\[
ecg_i = \frac{1}{N} [(x (i) - (N - 1)) + x (i) - (N - 2) + \cdots + x(i)]
\]

Waveforms got from the usage of the algorithm in MATLAB, comparing to each advance is appeared underneath figure 3.
3.1.2. Murthy And Rangaraj algorithm QRS Detection. This algorithm plays out a similar activity with less delay and by keeping away from the utilization of pointless filter process. This QRS detection algorithm, which follows the simple steps for the peak R detection on ECG signal. The information input signal doesn't go through some other filter.

\[ g(i+1) = x(n-i+1) - x(n) \]

where x (i) is ECG signal, N is a window width and (N - n + 1) is weighted factor. The weighting factor diminishes directly from the current distinction of the distinction N tests prior as expected and Smoothing is completed by a Moving normal Filter. The condition of peak detection with no ripples in a waves is:

\[ g_{MWaveform} = \frac{1}{M} \sum_{i=1}^{M} \sum_{j=1}^{N} |x(n-l-j+1) - x(n-l-j)(N-l+1)| \]

Waveform got from the usage of the algorithm corresponding to each process of MATLAB is appeared underneath in figure 5.

3.1.3. Combination of Pan & Tompkins And Murthy & Rangaraj algorithm. Electrocardiography signal info goes through low pass and high pass filtering tasks prior to going for derivatives in Pan & Tompkins algorithm. While according to Murthy and Rangaraj, the information signal doesn't go through any channel, rather it’s straightforwardly gets separated. In the wake of finding the derivative of a function in the signal, It goes through the moving normal filter process. The modified algorithm is a mix of Pan & Tompkins and Murthy and RANGARAJ calculation. This algorithm gives diminished commotion and sharp pinnacle yield, which is very hard to acquire in other
technique algorithm's. The combination of algorithm’s with the threshold comparison of input ECG signal, makes this algorithm more compatible and reliable than other methods. The ECG input value when compared with estimated threshold value, peaks all lying over the edge esteem is indicated as R wave peak. It will give a logic output low characteristic for ECG input esteem lesser than the edge esteemed threshold value, else output logic characteristic high. Wave forms obtained from the implementation of the modified algorithm corresponding to each process, in MATLAB are shown below in figure 6 and in figure7.

![Figure 6. Waveforms of the implemented Modified algorithm](image)

![Figure 7. Flow chart to calculate the heart rate](image)

3.1.4. HRV Calculation In Matlab. HRV is higher. when the heart begins to beat faster, HRV is slower. HRV is calculated as the standard deviation of entirety of the RR intervals which is the distance between each heart beat or the R of the QRS complex. After the QRS discovery, the R-R span is utilized for computing the pulse. It is an ordinarily utilized clinical procedure to ascertain the pulse from ECG Signal. We determined the pulse for the diverse information ECG signals utilizing both the algorithms. The diverse ECG information base is given as a contribution to Matlab, taken from MIT/BIH data set as .dat record format. To compute the pulse, the accompanying methodology has been utilized.
Since R peak to R peak stretch differs, normal pulse ought to be assessed by deciding the quantity of RR spans in 10 sec time strips and it gets multiplied by 6.

3.1.5. Depression detection using heart rate variability. Measuring of heart rate variability has repeatedly been associated with depression low HRV causes the stress and depression. Heart rate vary according to the physical needs, gender, age, physical fitness, psychological status, diet, hormonal status and etc. figure 8 shows the max and min heart rate characteristics.

![Figure 8. Max and min heart rate](image)

4. Verilog implementation in HRV calculation
In Verilog execution several modules are there. It comprises input, output, pointer, RAM, ALU, PC and Data bus. In Verilog HDL For HRV computation, ECG database documents gave as an input information.

- PC: Count the number of heart beats in each 10 clock cycles and the incentice stored in an area A on ram locations.
- Random Access Memory: Stores the information onto RAM areas, at whatever point Read signal is empowered.
- First information is put away in RAM area A. It’s transferred onto RAM area B at whatever point new information must be put away again in the area A.
- SHIFT Arithmetic logic unit: to discover the heart pulse rate, the math computations on the information put away in RAM, is Performed in it.

Architecture of proposed configuration appeared in figure 9.

![Figure 9. Architecture of proposed design](image)

Proposed method of Register Transfer Level pre-optimized design appeared in figure 10.

![Figure 10. RTL schematic of proposed design](image)
5. Simulation results and performance measurement
In this project, the simulation result has been taken using the MatlabR2020b and XILINX 14.7 software and the performance analysis are taken from MatlabR2020b software. HRV calculated using R-R interval in MATLAB for the different input ECG data signals taken from MIT-BIH database. Depression detected for the different ECG database using HRV.MATLAB implementation obtained for the R wave peak identification of various ECG information set is appeared in below figure 11.

![Figure 11. R peak detection for different ECG database](image)

Table 2. Shown the HRV calculation of various ECG signal databases obtained from the QRS detection algorithm.

| Input ECG data-base | Heart rate using Murthy Pan algorithm | Heart rate using (Hybrid algorithm) function & Rangaraj algorithm Threshold value | HRV | Heart ECG data-base | Sensitivity | Predictivity | Accuracy |
|---------------------|--------------------------------------|---------------------------------------------------------------------------------|-----|---------------------|-------------|-------------|----------|
| Ecg database 1      | 63                                   | 72                                                                               | 72  | Normal              | Normal      | Normal      | Normal   |
| Ecg database 2      | 72                                   | 73                                                                               | 73  | Normal              | Normal      | Normal      | Normal   |
| Ecg database 3      | 117                                  | 105                                                                             | 113 | Low HRV             | Brady cardia with anxiety and depression | Normal      | Normal   |
| Ecg database 4      | 72                                   | 72                                                                               | 73  | Normal              | Normal      | Normal      | Normal   |
| Ecg database 5      | 45                                   | 42                                                                               | 45  | High HRV            | Moderate depression | Normal      | Normal   |

Below figure 12. Shown the detection of peaks in ECG signal using VERIOG implementation.

![Figure 12. Peak detection in Verilog implementation](image)

Performance measurement. Sensitivity, predictivity and accuracy parameters measured for the performance that aids to decide how precisely the peak detection perceived to the utilized information base. These parameter statements are given underneath. Sensitivity characterizes the number of accurately identified events to the complete occasions happen
in a specific circumstance. TP stands for true positive. While analysis, the events are missed in false negatives (FN) as shown in equations (6-8),

\[
\text{Sensitivity} = \frac{TP}{TP + FN} \times 100\% \tag{6}
\]

Predictivity is characterized same as sensitivity, however the allout number of occasions contains the occasions that re distinguished containing defects as well.

\[
\text{Predictivity} = \frac{TP}{TP + FP} \times 100\% \tag{7}
\]

Accuracy is acquired by obtaining the level of the relative multitude of identifying peaks to the complete number of peaks accessible.

\[
\text{Accuracy} = \frac{\text{Detected Peaks}}{\text{Total Peaks}} \times 100\% \tag{8}
\]

Table 3. Shown the performance of modified algorithm measurement.

| S.no | Parameter | Matlab  |
|------|-----------|---------|
| 1    | Sensitivity | 99.5%   |
| 2    | Predictivity | 99.94% |
| 3    | Accuracy   | 99.75%  |

6. Conclusion

Basically the depression can be detected utilizing the heart rate inconstancy of the individual and the blood flow-MRI image obtained from PET scan for the brain, analyzed by image processing. In this paper proposed, we detected, depression of the human being using HRV. To execute our idea, we initially take different ECG information base record that is accessible in physio.net MIT-BIH data set. ECG database files extracted on MATLAB using a QRS recognition algorithm. The output ECG waveform acquired utilizing QRS detection algorithms by evaluation of various operations in it. The output ECG waveform used for calculation of heart rate variability. The distance between R to R interval and the R peak values in a specific time span used for computing the heart rate in an ECG signal. Pan and Tompkins algorithm & Murthy and Rangaraj algorithm both are basic algorithms, proceeded as a QRS detection algorithm, with superior characteristics of these two algorithms, the better one is gotten from combining these two algorithms. Murthy and Rangaraj algorithm offered noise reduction adequately and the ECG output taken from this algorithm had sharp peak values. Getting sharp peak waves to ECG output signal, it’s difficult in other QRS detection algorithms like Pan and Tompkins algorithm. The hybrid algorithm is more reliable and compatible. It provides reduced noise and performing the activity with less delay HRV calculated with the least mathematical complexity. To discover the peak values of ECG signal different filtering operations, scaling, squaring is performed. We took different ECG signal three signals were ordinary, while the other two signals were seemed as through abnormal that shows moderate depression and bradycardia with anxiety and depression. Additionally, designed code executed on Verilog for getting a hardware design platform.
The architecture of the process designed of Verilog HDL and performed. It will facilitate accommodating for creating as a product that is utilized by the people. Individuals can undoubtedly comprehend their feelings which acquired from their heart rate variability, and they can fix their unusual feelings by examining their extreme feelings early. The designed code actualized on both MATLAB and Xilinx. May is that will assist us with improving the elements of this proposed project in the future. This proposed project thought, unquestionably helpful for the modern science and technology that valuable in individual’s lives.

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