Various Methods To Detect Respiration Rate From ECG Using LabVIEW

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Abstract-Human body contains many biological signals like ECG, EMG, EEG, respiratory signal, BP. Among all these, ECG and respiratory signals are the most important biological signals. Almost all the parameters can be obtained from ECG. Every activity of human body affects the respiratory signal, thus study of this signal is also important. Thus, it is necessary to both the signals simultaneously in clinical conditions. Hence, it is necessary to design a model which derives respiratory signal as well as respiration rate from ECG. In this paper, two different ways are shown by which respiration rate can be derived from ECG. One method contains mathematical model and R-wave algorithm has been designed to calculate respiration rate from ECG. This method uses two lead ECG, lead-I and lead-II. Other method uses only one 12 ECG. ECG contains respiration information upto 0.4 Hz. Hence, ECG is filtered. In first method R-wave is detected to understand variation in QRS complex to detect abnormality. The mean electrical axis is obtained and spline interpolation is taken for getting respiratory waveform. The respiration rate has been found out from respiratory waveform. In second method, the pattern of ECG is studied and respiratory signal and respiration rate is derived by checking zero-crossing of the signal. The algorithms are developed on the platform of Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW). Biomedical signals are very low-frequency, low-amplitude signals, hence processing and analysis of biomedical signal is very difficult in hardware conditions. Thus, a simulation model has been implemented in LabVIEW which processes on ECG signal and generates respiratory signal along with the respiration rate.

Keywords-ECG Derived Respiration (EDR), Spline interpolation

Hence current study provides a method by which ECG is processed and respiratory signal can be derived. Many researchers use mathematical model to derive respiration rate from multi lead ECG [1]-[3]. Research on derivation from single lead ECG has also been done which uses ECG from single lead to obtain respiratory waveform [4].

Automatic detection of respiration rate on moving subject is also performed in which respiration rate is found out while subject is doing daily activities [5]. Respiratory signal is also derived from eight lead ECG which shows direction of breath-representative points in 8-D space and then through interpolation, respiratory waveform is obtained [6]. R-wave is very important part of ECG. Proper detection of R-wave gives actual output. One method of R-wave detection has used LabVIEW software which uses adaptive difference threshold value method for R-wave detection [7]. In this paper, unique method of R-wave detection has been designed and implemented which compares the data points of ECG signal and detects the maximum difference. It also avoids the false peak, if any. The threshold for R-wave detection has been kept as 1mV. In current study ECG signals were taken from MIT-BIH database for Normal Sinus Rhythms [8]. Ten pairs of ECG signals are taken and respiration rates have been derived by first filtering signals, detecting R-wave and finding mean cardiac electrical axis. Normal respiration rate found out to be 15 to 30 breaths per minute. The general flow chart is shown in figure 1.

Figure 1. Flow Chart of the algorithm

The model is constructed in LabVIEW which is graphical programming environment, a Graphical User Interface. It has advantage of fast processing and high detection rate. Programs in IDE are called Virtual Instruments (VIs), consists of a Block Diagram and a Front Panel. A Block Diagram provides a graphical code development environment whereas a Front Panel allows the user to interact with a VI. It provides an efficient and easy-to-use environment for code development and makes
program user friendly. It is more effective especially when the user needs to interact with the program and visualize the results. Unlike text-based programming languages like C and MATLAB which follow a control flow execution model, the environment of programming follows a dataflow execution model [9-10].

2. Procedure

2.1 Database

All data used in this model are MIT-BIH database for Normal Sinus Rhythm. The database is collection of two lead ECG data, lead-I and lead-II. One minute duration is taken so that the respiration rate can be measured of one minute only. Ten records have been taken and respiratory rate has been found out. For second method Apnea-ECG database is taken and respiration rate is calculated. In both the cases, it is coming between 15 to 30 breaths per minute.

2.2 Method-I

ECG database is converted in waveform from text format using LabVIEW. So, initially, the text file is read using the function available in LabVIEW. ECG data is available in 2-D array form, so, it is converted to two 1-D arrays. Then, two ECG signals are separated and mean electrical cardiac axis has been found out in which two lead ECG has been taken, lead-I and lead-II. The main reason of taking these two leads is, signals of these leads are orthogonal to each other, and there will not be interference. The first step is to filter the signal with low pass filter with cutoff frequency of 0.4 Hz, because the respiratory signal exists upto 0.4 Hz only. The Butterworth Filter with N=3 is used.

R-wave detection algorithm has been designed for deriving respiratory signal. The algorithm takes both the signals as input and subtracts each data point from the next data point. When the highest value of difference is found out, it is compared with threshold value and peak is obtained. It also checks whether there is false peak or not by dividing subtracted array by maximum of the subtracted data to detect false peak. If the value is greater than 0.5 then there is a false peak and the value is excluded from the waveform. The procedure is repeated for both the ECG signals. The threshold of R-wave is kept as 1mV. Figure 2 shows the block diagram of R-wave detection.

Fig. 2. Front Panel of R-wave detection

Areas under R waves are calculated. In this case, the maximum value of R will be the area. Ratio is taken of areas to find mean electrical angle with taking arctangent which gives respiration information. For normal readings, the angle lies between -30⁰ to 90⁰. The next step is to interpolate the array of mean electrical cardiac angles. Spline interpolation has been used because it works more appropriately on unequally spaced data points. Peak detector has been used for getting respiration rate. The GUI is designed within while loop to have user control on the application. Figure 3(a,b) shows the Front Panel and Block Diagram of the GUI developed.

Fig. 3a. Front Panel of main program
2.3 Method-II

In this method, pattern of ECG is studied. It can be seen from the ECG pattern that the respiratory waveform follows the path as ECG. Thus, the algorithm has been designed which derives respiratory waveform as well as respiration rate. The Front Panel of the algorithm is shown in figure 4.

3. Derived Respiration rate

The developed model gives respiratory waveform as well as respiration rate from ECG signals taken from MIT-BIH database for Normal Sinus Rhythms. The database is converted in waveform from text format using LabVIEW and shown in figures 5-10 for method-I and figures 11-12 for method-II.

Figure 5 and 6 represent ECG signals for one patient of lead-I and lead-II. Figure 7 represents the respiratory waveform and respiration rate which comes out to be 18 breaths/min. Figure 11 represents the 12-lead ECG signal of patient 3 and figure 12 represents the respiratory waveform as well as respiration rate for the patient 3.
4. CONCLUSION

Respiration rate of the patients from both the methods is calculated and both the methods are giving appropriate results. Depending upon convenience, any of the methods can be used. Both methods give respiration rate from 15 to 30 breathes/minute. The designed R-wave detection algorithm gives appropriate detection of QRS complex in ECG. LabVIEW cost effective fast way of computation.
5. REFERENCES

[8] www.physionet.org/cgi-bin/ATM/database