Can Peak-Picked ECG Work For Heart Rate Variability?

Richard E. Gregg, Reza Firoozabadi, Saeed Babaeizadeh

Advanced Algorithm Research Center, Philips Healthcare
Andover, MA, USA

Background: Use of peak-picked ECG is generally not recommended for heart rate variability (HRV) calculations because the apparent R-wave peak moves around within the QRS due to the peak-picking operation. This study quantifies the RR error in an algorithm used to recover high resolution RR intervals from peak-picked ECG.

Methods: Twenty minute samples of single lead ECG (n = 1000) were generated by the Physionet HRV ECG simulator. Each ECG record had a random combination of heart rate standard deviation and additive noise. ECG was decimated to 250sps from 1000sps and then peak picked to the final sample rate of 125sps. The second peak picking method preserved the phase of the chosen peak for near linear 250sps reconstruction. High resolution RR interval recovery was based on up-sampling. The first method chose R-wave peaks. The second method used template matching to align beats. RR interval reference was the R-wave markers from the ECG simulator. HRV standard deviation of RR intervals (SDNN) was calculated for each record using three variations of low resolution ECG input and three RR interval recovery algorithms. Bland-Altman analysis was used to assess bias of SDNN error across the SDNN range from 10 to 90ms.

Results: The table below shows median SDNN error (ms) for selected combinations of low-res ECG input and RR recovery algorithm. The bias of SDNN error at low values of SDNN is pronounced when up-sampling is not used in the RR recovery. Template matching reduces the SDNN error at low levels of SDNN.

RR recovery algorithm	Lo-res ECG input	Reference SDNN (ms)				
		10	20	40	60	90
R peaks	125sps	0.53	0.28	0.13	0.08	0.04
R peaks, 1000sps	125sps	0.05	0.02	0.00	0.00	-0.01
R peaks, 1000sps	125sps PP	0.24	0.10	0.04	0.04	0.03
R peaks, 1000sps	250sps PP	0.20	0.09	0.03	0.02	0.01
Template match	125sps PP	-0.01	-0.03	-0.09	-0.16	0.16
Template match	250sps PP	-0.01	-0.03	-0.08	-0.15	0.14

Conclusion: The template matching RR interval recovery algorithm provides low levels of SDNN error for the low range of SDNN values. Low SDNN error may be possible using low sample rate peak picked ECG. More study is required using ECG datasets with high resolution ECG and abnormal HRV.