Wavelets for correction of ECG images

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Abstract

A method for removing noise in ECG signals consisting of the decomposition occurs at L level, the signal using a wavelet Daubechies. Each segment is analyzed to determine whether or not components are reduced or attenuated; modified from the original data signal is reconstructed preserving the values of CAL approximation and all those details CDi components whose contribution is relevant to the shape of the ECG signal. To determine if a signal should be preserved or not a rule based on the standard deviations of the reporting segment and the original signal is used.

ECG, noise, wavelet.

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Introduction

The activity of the heart can be amplified and be recorded on an electrocardiogram *(ECG)*, which can be used to diagnose heart disease. With each heartbeat, an electrical signal spreads from the top to the bottom part thereof. This signal causes the walls of the heart to contract. When the walls contract, blood is pumped into the circulatory system. Internal and external to the chambers of the heart valves ensure that blood flow is in the right direction.

The typical layout of an electrocardiogram, as shown in Figure 1, consists of a P wave, a QRS complex and a T wave Small wave U is usually invisible. These are electrical events not to be confused with the corresponding mechanical events, ie the contraction and relaxation of the heart chambers. Thus, the mechanical systole or ventricular contraction begins just after the start of the QRS complex and ends just before the T wave end diastole is the relaxation and ventricular filling begins after culminating systole corresponding to the contraction of the atria, right after the start of the P wave This process is repeated for each heartbeat.

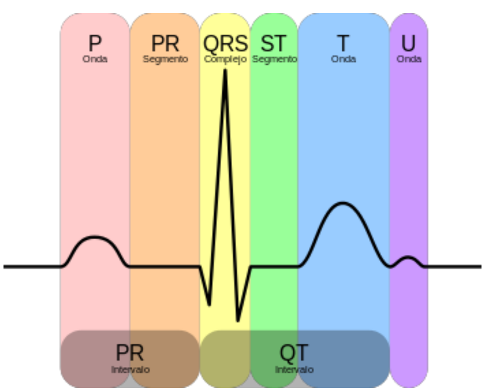

Figure 1 ECG Signal

The frequency of the ECG signal may be between 0.5 Hz and 100 Hz, this sen~ to be corrupted due to various types of devices, such as line interference power, noise contact with the electrodes, motion artifact, muscle contractions, baseline shift or noise generated by electronic equipment among others.

A corrupt signal these devices lead to misdiagnosis. Therefore, reduce and remove the noise contained in these signals is a starting point for the analysis thereof. In addition to conventional filtering techniques (FIR and IIR filters) [1], have been exploited other noise reducing means, such as using wavelets [2].

It is proposed to use the decomposition of the signal from the wavelet transform to suppress noise in the signal. This process is carried out by partial or total removal of detail coefficients that are generated from the decomposition of the signal.

Implementation

The overall process is illustrated in Figure 2, this process comprises the following steps:

- Signal reading and parameters
- Calculating reference values
- Signal decomposition
- Travel segments decomposition
  - Calculation of values of the segments
  - Reduction or elimination of components
- Signal Reconstruction

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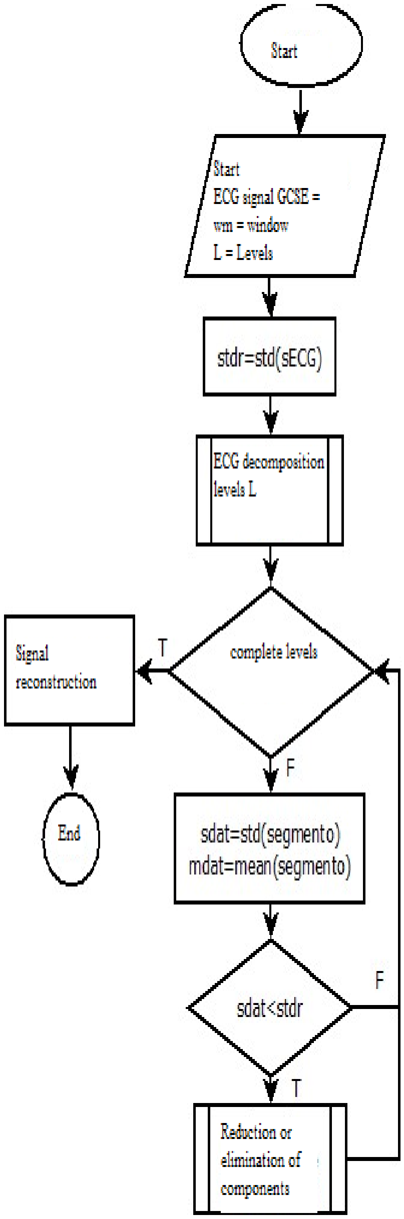

Figure 2 Overall process

A. Reading and signal parameters

Shown process is performed using MatLab programming environment; data from the study of electrocardiogram, stored in a CSV or XLS file is read and stored in memory for use for validating a synthetic ECG signal is generated from the individual functions $sECG=ecg(N)$ of MatLab.

The levels of decomposition and wavelet used are determined from experimentation with a synthetic signal and defined functions MatLab.

Decomposition of the signal B.

For the decomposition of the signal wavedec function of MatLab environment it is used. This function develops multi-level analysis to trave's of the application of a one-dimensional wavelet. It has the syntax: $[C,Le] = wavedec(X,N,'wname')$;

Returns the decomposition of N-level signal X using the mother wavelet *'wname'* in vector *C* the length of each of these segments in the *Le* vector. Figure 3 shows the decomposition of S signal using 5 levels of decomposition.

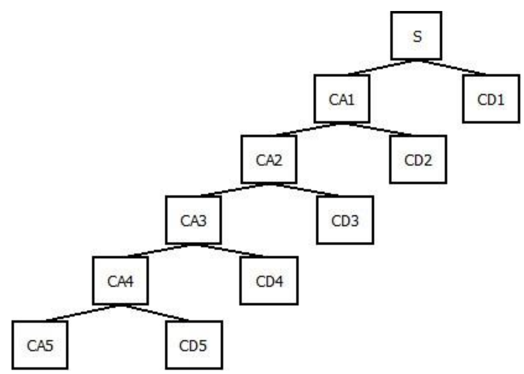

Figure 3 Breakdown of a signal into 5 levels

At each level of decomposition ISC CDi data and data is generated; the first coefficients corresponding to the approximation of the signal, while the latter contain coefficients details thereof. As the number of levels in the decomposition increases, coefficients generally ran CAI two new data sets and CA_{i+1} y CD_{i+1} $\forall i = 1,2,...,L-1$. Consider the data shown in Table 1, these displayed ISC and CDi coefficients generated from the decomposition for L = 4, 5, 6 and 7 levels.

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C. Tour of the segments and elimination or reduction of components

Depending on the *L* value selected, the vector *C* will have *L +1* corresponding to the decomposition of the signal in the coefficients CA_L y $CD_i \quad \forall i = 1, 2, \ldots, L$.

While the coefficients may be reduced or CDi entirely eliminated, the coefficients in CA_L

Levels	Data							
4	CA4				CD4	CD3	CD2	CD1
5	CA5			CD5	CD4	CD3	CD2	CD1
6	CA6		CD6	CD5	CD4	CD3	CD2	CD1
7	CA7	CD7	CD6	CD5	CD4	CD3	CD2	CD1

They are retained, then a route is through the CDi coefficients to determine whether they should be eliminated.

For each of the segments having the standard deviation is calculated, if the segment in question has a lower than that observed in the original signal standard deviation, this segment will be a candidate for the reduction of its components. Thus, segments with lower standard deviations correspond to elements listed throughout uniformly signal and therefore its contribution to the waveforms in the ECG will not be significant, corresponding mostly noise present in the signal.

Partial or total reduction will lead to a signal which retains most of its characteristics, not their amplitudes. Completely eliminate certain segments, for example, it produces a reduction in amplitude at the maximum or minimum *QRS* points of the signal to be treated. To prevent this effect, the following formula is used:

$$C_{seg}(n) = \begin{cases} 0 & |C_{seg}(n)| > \frac{\sigma_{seg}}{K} + \mu_{seg} \\ C_{seg}(n) & otherwise \end{cases} \quad (1)$$

Where (n) is the value of the analyzed segment, while σseg and usec are the mean of this, with standard deviation and K≥4.

Consider the data in Table 2, with the contribution of each of the segments of a synthetic noise signal with uniform ADDED shown. Columns 3 and 4 show the average of each of the segments and standard deviation, which compared with the value of the standard deviation of the original signal (σ_{ref} = 0.2943) shows that the segments CD_1 to CD_4 are candidates reduction in its components. For these segments, the App column shows that these do not provide data to the waveform pseudo-noise but only along uniform signal.

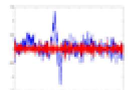
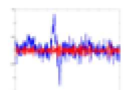
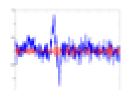
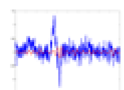
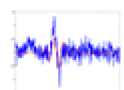
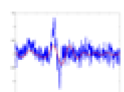
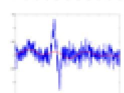
Seg	App	σ_{seg}	μ
CD1		0.1879	-0.0017
CD2		0.2124	0.0046
CD3		0.2306	-0.0258
CD4		0.2121	-0.0047
CD5		0.5837	0.0021
CD6		0.5614	-0.0158
CA6		0.3886	0.5568

Table 2 Decomposition of an ECG signal with σ_{ref} = 0.2943 in 6 levels of wavelet decomposition using a DB34

Reconstruction of the signal D.

With the new vector C reduced, we proceed to the reconstruction signal for this function MatLab Wave-rec is used. This function takes C and Le vectors generated by the wavedec function, plus the type of wavelet decomposition used for reconstructing the original signal from these. It has the syntax:

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Experimental results

There is a maximum level of decomposition that can be made to a signal; but generally 5, 6 or 7 levels can be performed without problem. Table 3 shows the correlation between a synthetic signal (without noise) and filtered versions of this (after the addition of noise). Data is filtered by using a threshold signal value K = 4, completely eliminating the corresponding segment and also applying the Savitzky-Golay filter MatLab, for 2-10 levels of decomposition. It is noted that the correspondence maximum levels are 4, 5, 6 and 7 levels of decomposition. Different tests showed a value of $L = 6$ generates good results, without increasing processing time.

Performing a similar process, but now alternating windows used, the most suitable for the task wavelet window was determined, showing that windows db28 DB34 and produce the best results in tests, the data are summarized in Table 4.

Using the information obtained noise reduction process of the synthetic signal is performed, producing the output shown in Figure 4. The data obtained through wavelet remain very close to those shown by the Savitzky-Golay filter in most 'ıa of its points.

$$else \qquad C_{seg}(n) = C_{seg}(n) \qquad (2)$$

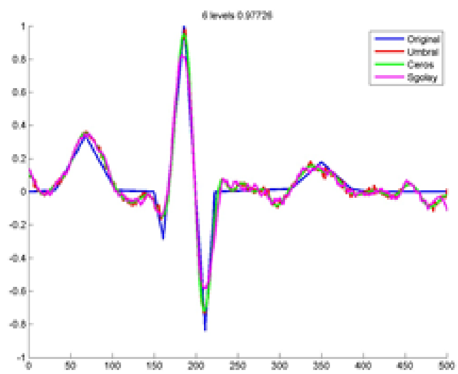

Figure 4 Filter a synthetic signal, using the process in Figure 2, with wn = DB34, L = 6 and K = 4.

Conclusions

Table 5 shows the relationship between the synthetic signal without noise and filtered versions of the same signal with white noise. Data show that noise reduction using wavelet following results using Savitzky-Golay; however it has a higher correlation with the original signal, which can be seen on the peaks of the QRS complex in Figure 4, where the Savitzky-Golay filter has a lower amplitude than the original signal using wavelet or results.

	Correlation(X_{fil} ,X_{or})
Thres	0.9761
Savitzky-Golay	0.9628

Table 5 Comparison of results

Following the same procedure the filtering process a sen~ the actual ECG is performed, resulting in the signal in Figure 5.

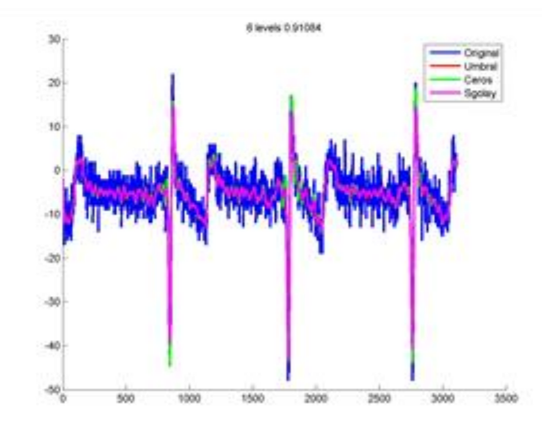

Figure 5 Noise reduction in real ECG signal with wn = DB34, L = 6 and K = 4

It is concluded that the use of wavelet on other filters produces similar or better outputs, reducing in most cases time for the filtration result.

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Levels	2	3	4	5	6 7 8 9	10
Thres	0.9140	0.9639	0.9761	0.9761	0.9761 0.9648 0.9676	0.9642
Savitz ky-					0.9628	

Table 3 correlation with decomposition levels using a DB34 window.

Wavelet	db28	db34	dmey	bior2.2	bior6.8	rbio3.9	rbio6.8	coif4	sym16
Thres	0.9762	0.9761	0.9699	0.9588	0.9485	0.9640	0.9435	0.9727	0.9741
Savitzky-Golay					0.9628				

Table 4 Correlation of the filtered relative to the reference through several windows using 6 levels of decomposition signal.

References

[1] B. Chandrakar, O.P. Yadav, V.K. Chandra, “A survey of noisse removal techniques for ECG signals”, In- ternational Journal of Advanced Reserch in Compu- ter and Comnunicacion Engineering, vol. 2, no. 3, pp. 1354-1357, 2013

[2] S. Baduru, S. Reddy, P. Jagadamba, P. Satyanarayana, “Noise Cancellation on ECG and Heart Rate Signals Using the Undecimated Wavelet Transform”, Interna- tional Journal of Engineering Research and Applica- tions (IJERA), vol. 1, no. 4, pp. 1962-1970, 2011

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