Compressed sensing implementation in cardiac signals

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Abstract:

This work presents the study of a compressed sensing implementation in a system which acquires three cardiac signals, ballistocardiogram, electrocardiogram and photoplethysmogram. In order to accurately estimate heart rate and its variability, cardiac signals must be acquired at frequencies of about 1 kHz, but since these signals have a sparse representation in some transformation basis, namely in the wavelet domain, compressed sensing paradigm states that they can be recovered from a small number of projections in another basis incoherent with the first. The signals' compressibility was assessed, then TwIST algorithm was applied and reconstruction quality was measured for a number of different signal-to-noise ratios, compression rates, and sparsity basis. The analysis was completed by evaluating the algorithm's computation time and heart rate deviation of the reconstructed signals.

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I. Introduction

Frequently, electrophysiological signals, such as electrocardiogram (ECG) and photoplethysmogram (PPG), are acquired at moderate sampling frequencies of a few hundred hertz (e.g. 200 Hz), both in commercial and in research tailor-made systems [1]–[2]. Accurate

computation of the heart rate from these signals and subsequent trustworthy estimate of the heart rate variability (HRV) requires the sampling frequency to be appropriately dimensioned, at least 1 kHz, to fulfill an exactness constraint of about 1 ms [3]. Errors taking place in the calculation of events occurrence time will provide incorrect heart rate information and distort HRV results, particularly in spectrum estimates, which has been studied in the ECG case [4]. The QRS complex is a sharp isolated event during a cardiac cycle period, but the same does not occur with other biological signals dependent on the cardiac cycle, such as the photoplethysmogram, which is smoother, and the ballistocardiogram (BCG), where most waves have similar amplitudes.

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