Simulation and Analysis of Eletrocardiogram-like Signals under Microgravity Conditions

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The electrocardiogram (ECG) is a time-varying signal reflecting the ionic current flow which causes the cardiac fibers to contract and subsequently relax. A single normal cycle of the ECG represents the successive atrial depolarization/repolarization and ventricular depolarization/repolarization which occurs with every heartbeat. In the first part of this paper we have compared synthetic ECG, obtained from two different models, where the noise level of gravity potential influence on the oscillations is explicitly considered in the models. The synthetic data were generated from (i) the Fitzhugh Nagumo equation and (ii) MCTS dynamical model [McSharry et al.; IEEE, v.50, n.3, 289-294, 2003]. From the asymmetry spectra of the Gradient Pattern Analysis [Rosa et al.; Braz. J. Phys. 33(3): 605-610, 2003; Advances in Space Research, 2007, 10.1016/j.asr.2007.08.015] we shown that the MCTS dynamical model is closer to the o real ECG variability pattern. Although the Fitzhugh Nagumo model can capture the electrical characteristics of the heart beat, it is not able to represent the PQRST wave's morphology in detail. In the MCTS dynamical model this limitation is solved taking into account the 3D cycle dynamics explicitly. Even this implies a very fine complex structure in the ECG signal (2%) this "very low noise level" can be captured by the asymmetry spectrum. In the second part, the same analytical approach is employed to assess simulated ECG without the gravity potential influence. In that case the gradient spectra have shown between -2% to -1 % of asymmetries that is captured using the mutual information distance. Thus, this "very low noise level" due to the microgravity also can be captured by the ECG asymmetry spectrum. Based on these results we discuss how to analyze signal in a large database like the Physionet in order to get an indication of the accuracy of our simulation when applied to real data including the ECG from space missions. Finally, we show, based on non-Gaussian power spectra and chaotic phase portrait reconstructions how the characterization performance would vary in different environmental and clinic settings with a range of noise levels and sampling frequencies.

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