A Chaotic Model for Generating Heart Rate Variability Signal using Integral Pulse Frequency Modulation

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Heart Rate Variability (HRV) is a very useful signal to investigate the activity of the Autonomic Nervous System (ANS), which affects and the heart function. Constructing a mathematical model for producing artificial HRV signal is needed to get a conceptual understanding of how ANS controls the heart rate (HR). In addition, an accurate HRV model can be used to drive an Electrocardiogram model for producing artificial ECG. The Integral Pulse Frequency Modulation (IPFM) structure is employed in this paper to model the Sino-Atrial Node (SAN). Considering the complexity and nonlinear dynamics in the real HRV signal, a chaotic input is used in the proposed model. Also, the effects of both Respiratory Sinus Arrhythmia (RSA) and Mayer waves were incorporated in the proposed model. Instead of using a fixed threshold in IPFM model as in most previous works, we applied an appropriate variable signal, which has nonlinear chaotic dynamics. After implementation and running the model, the power spectrum of the output signal is extracted, which was then followed by calculating the nonlinear characteristics. The simulation results showed that the calculated power spectrum and the nonlinear parameters of the output HRV signal are closely correlated with the real ones which confirm the effectiveness of the proposed model.