A Computational Model of Autonomic Nervous System for Heart Rate Variability

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Heart Rate Variability (HRV) is the subtle beat to beat change in heart rate. Autonomic Nervous System (ANS) does heart rate control by regulating the neurotransmitters, mainly Norepinephrine (NE) and Acetyl choline (Ach) from sympathetic and parasympathetic branches respectively. HRV analysis is a noninvasive tool for assessing the integrity of ANS. HRV changes are observed in the onset of not only heart disease but in a number of health conditions like sleep apnea, psychiatric disorders, diabetes, hypertension etc.

A mathematical model of ANS for heart rate variation is proposed in this study. An understanding of the relationship between ANS activities and heart rate change helps to identify biological changes associated with various diseases. This can lead to targeted diagnosis and therapy. Release of neurotransmitters, its interactions with the surroundings, and degradation are modeled. Interaction between sympathetic and vagal branches of ANS is modeled using standard Hill's equation. Output of the model is in continuous time form; hence Fitzhugh Nagumo (FHN) model is used as the successive stage of proposed model to generate a discrete time heart beat interval series.

ECG data were recorded from a group of healthy individuals having balanced sympathetic and parasympathetic activities and analyzed using KUBIOS HRV tool kit for typical HRV parameters of time domain, frequency domain and nonlinear analysis. HRV signal was synthesized by the model for the same autonomic state and analyzed using the same methods employed for original ECG data. Calculated parameter values for the original and model synthesized data fall in the same range.

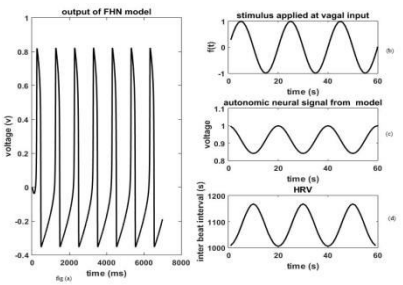

Fig (a) FHN model output, (b) vagal input to model, (c) neural signal from the model, (d) HRV