

Identification of Sympathetic and Parasympathetic Nerves Function in Cardiovascular Regulation using NARX Model

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In this study, a new nonlinear system identification approach for dynamical quantification of cardiovascular regulation is developed. This approach is specifically focused on the identification of Heart Rate (HR) baroreflex mechanism. The specific aim of this study is to improve the model accuracy in the estimation of HR by proposing a modified nonlinear model. The proposed HR baroreflex model is based on inherent features of autonomic nervous system. A Nonlinear Auto-Regressive Exogenous (NARX) model is employed to estimate the HR series as the output of the HR baroreflex mechanism. Also, an Adaptive Neuro-Fuzzy Inference System (ANFIS) structure is developed to estimate the NARX model. This method allows incorporation of physiological understandings about the sympathetic and parasympathetic nerves through selection of membership functions in the ANFIS structure. Membership functions are selected so as to represent the sympathetic and parasympathetic nerve functions. The hybrid learning method is applied as a learning algorithm of the ANFIS structure. Finally, an A-Information Criterion (AIC) is applied in order to select the appropriate order of the model. Required data for system modeling, training and testing are collected from the Physionet database. The model is trained by data obtained from four subjects and tested with the data acquired from eight subjects. The mean Normalized Root Mean Square Error (NRMSE) resulted in this study is 0.191. The results show significant improvements in HR prediction by calculating NRMSE in comparison with other developed methods. It is shown in this study that for cardiovascular system regulation, as a complicated system, our proposed nonlinear model is more accurate than other recently developed methods. Such accurate HR baroreflex modeling would enable clinicians to have more reliable information for their patients.