MODELING, ANALYSIS AND CONTROL OF LONG TERM ARTERIAL BLOOD PRESSURE REGULATION SYSTEM

Abstract of the Thesis Submitted by

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ABSTRACT

Cardiovascular research in general has assumed greater importance of late due to the ever-increasing number of heart-related ailments. Of the many issues related to cardiovascular research, those associated with long term regulation of arterial blood pressure (ABP) have always received wide attention. The long term ABP regulation involves multivariable, nonlinear dynamic processes that provide adequate blood flow to various organ tissues. Abnormal blood pressure regulation acts as a potential trigger of hypertension and hypotension.

Experimental as well as modeling studies have been reported on various aspects of long term ABP regulatory dynamics. However, most of them have considered the characteristics of only a unique segment such as neural, hormonal or renal blocks without having an integrated view of the regulatory system. The high complexity of those few models which used an integrated approach inhibits their use in parameter estimation and clinical applications. Hence a less complex model which can still retain the important dynamic behaviors of the system is required for its analysis and control. This work is an attempt made in this direction.

The thesis explores the pathophysiological aspects of the long term ABP regulation system using system theory approach encompassing model development, analysis, and control. In this work, a hormonal controlled regulation model capable of explaining a considerable share of the operational characteristics of the ABP regulatory system is developed. The importance of nervous activity in the regulation dynamics is also revealed. The structural stability analysis is carried out using the affine linear state space models. Two new methods Nonlinear Element Extraction Technique (NLEET) and Multiple Linear Approximation Modeling Technique (MLAMT) have been proposed to assess the performance of nonlinear system with the help of linearised models. This hybrid approach helps to reduce the sensitivity problems due to operating point shifts. Finally, the thesis proposes a simple PI controller which controls the stimulation rate of aldosterone hormone in accordance with the output mean arterial pressure (MAP) level. Simulation results show that it provides satisfactory control performance for the blood pressure maintenance in hypertensive and hypotensive conditions under dynamic sodium infusion.

Keywords: Arterial Blood Pressure, Cardiovascular System, Hypertension, Long Term Regulation, Nonlinear System, Parameter Tuning, Renal System, Stability, State Space Model.