Abstract

The aim of this thesis is to design robust steady-state steering scheme for the Synergism Saturation system (S-system) model of the metabolic pathways. S-system is a nonlinear canonical framework which can model nonlinear behaviour of the biochemical reactions. The scheme is designed by both static and dynamic approaches. In static approach, the robustness is improved by synthetic design of the kinetic parameters and steady-state is steered by changing enzyme concentration of the pathways. A Linear Matrix Inequality (LMI)-based multi-objective framework is proposed to find control parameter matrix for improving robustness. Similarly, a control parameter vector is designed for steady state steering of the metabolic pathway. Solving these optimization frameworks, the robustness is improved by minimizing sensitivity bounds of the different parameters. The steady-state is steered within a prescribed error bound. All these static design techniques are proposed at steady state. These static design methodologies are verified by considering the S-system model of the TriCarboxylic Acid (TCA) cycle and the Glycolysis and Glycogenolysis (GG) pathway. Using this static design approach, the transient response is not controllable. Dynamical robust steering of steady-state is proposed to regulate the transient part of the steered response. Dynamic controller is designed in a closed-loop control scheme. In closed-loop scheme, the in-silico controller is implemented. The controller generates input signal by sensing the concentration of the steered state. A linear quadratic regulator associated with external feedback linearization is proposed for closed-loop control scheme. In order to improve the robustness, an H_∞ loop shaping, associated with robust feedback linearization, is designed for robust steady-state steering.

Keywords: *S-system, Glycolysis, Glycogenolysis, TCA Cycle, Robustness, Sensitivity, Controllability, Linear Matrix Inequality (LMI), Feedback Linearization, Hamiltonian Function, Linear Quadratic Regulator (LQR), H_∞ Loop Shaping Control.*