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Qualitative Control of a Bistable Genetic Network

The control of a generic model for a genetic network is studied using piecewise affine differential systems. The system is the well-known bistable switch with two genes and proteins x_1, x_2:

$$\begin{aligned} \dot{x}_1 &= u\kappa_1 s^-(x_2, \theta_2) - \gamma_1 x_1 \\ \dot{x}_2 &= u\kappa_2 s^-(x_1, \theta_1) - \gamma_2 x_2. \end{aligned}$$

where κ_i denote production rates, γ_i denote the degradation rate constants, and θ_i the threshold concentrations. The step function represents the inhibition of the expression of each gene by the other.

$$s^-(r, \theta) = \begin{cases} 1, & r < \theta \\ 0, & r > \theta. \end{cases}$$

This class of piecewise affine systems (PWA) was first introduced by [1], and is widely used for modeling genetic regulatory networks [2]. It is assumed that the state measurements of x_1, x_2 are qualitative (each variable is at high or low concentration) and that the possible input values of the control u are also qualitative (no control, high value or low value). The advantage of this approach is to obtain control laws which can be implemented in the laboratory, using only qualitative knowledge of the system's variables. Solutions are given for the problem of controlling the bistable switch to either of its three steady states [3].

References

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