

Abstract

ZABAIKINA, Iryna. *Hybrid gene expression models* [dissertation thesis]. Comenius University Bratislava. Faculty of Mathematics, Physics and Informatics; Department of applied mathematics and statistics. Supervisor: doc. Mgr. Pavol Bokes, PhD.. Bratislava, 2024.

Regulation of gene expression is represented by a variety of control motifs, mathematical models of which can provide a theoretical estimate of the process parameters. In this project, we study two particular examples of regulatory networks. The first one is negative feedback when mRNA indirectly inhibits its production. The second one is an incoherent feed-forward loop, which is represented by the interaction between mRNA and antagonistic microRNA. We construct a generalized hybrid model using a Markovian drift-jump framework with random production bursts and continuous degradation. Combined with the Chapman-Kolmogorov equation, it provides the means to determine the probability distribution of mRNA concentration. We derive the mean steady-state concentration of mRNA for both models. Subsequently, we show that it is less sensitive to the production rate in the feed-forward loop than in the negative feedback. In addition, it turns out that in presence of the low noise, FFL maintains the concentration of mRNA at a steady level despite disturbance in production rate, i.e. is perfectly adaptating.

Keywords: gene expression, hybrid model, negative feedback, feed-forward loop, perfect adaptation