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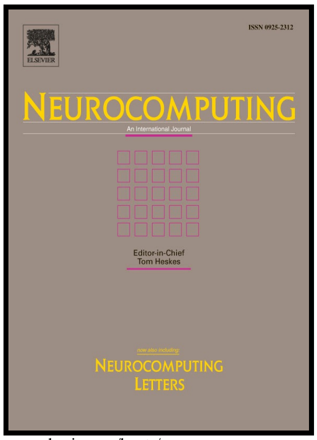

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Finite-time stability of genetic regulatory networks with impulsive effects

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Abstract

We study the finite-time stability of genetic regulatory networks with impulsive effects. Using the method of Lyapunov function, sufficient conditions of the finite-stability, in terms of linear matrix inequalities, are established. A numerical example is provided to further illustrate the significance of our results.

Keywords: impulsive genetic regulatory networks, finite-time stability, linear matrix inequalities approach, Lyapunov functions method

1. Introduction

It is well-known that the study of genetic regulatory networks (GRNs) has become a focus of interest in the past few years. It has been proved that many diseases are actually originated from the sicknesses of GRNs of the corresponding cell lineage, which mainly includes cancer, diabetes and AIDS. It is crucial to examine the dynamical behaviors of the GRNs. The stability of GRNs has been analyzed ([1, 2, 3, 4, 5, 6]) to some extent. GRNs illustrate the reciprocities among products of mRNA, genes and proteins, in terms of transcriptional and translational processes. It has been studied extensively over the last couple of decades through biological experiments (see ([7, 8]) for example). However, it is formidable to fully understand this kind of networks. One way is to set up mathematical models and perform rigorous mathematical analysis. Since time delays are ubiquitous in these processes and have influences on the stability of GRNs, it is indispensable in studying the effects from the time delays on the stability of GRNs. In 2002, L. Chen ([9]) presented a model for GRNs, which is described by delayed differential equations. Based on this model, some interesting results have been obtained ([10, 11, 12, 13, 14]). Considering the environment fluctuations between intracellular and extracellular, we focus on the stability of impulsive GRNs with time-varying delays. It is widely accepted that the study of finite-time stability for networks is significant ([15, 16, 17]). Meanwhile, the expression of gene and mRNA translated protein are accomplished in a much relatively short period of time. It is natural to consider the finite-time stability of GRNs. Some results have been obtained ([18, 19, 20]). In our paper, we will study the finite-time stability of GRNs with impulsive effects and time-varying delays.

The paper is organized as follows: In section 2, we give a brief account of the model, problem formulation and some preliminaries. In section 3, we design a lyapunov function that consists of three parts, and derive sufficient conditions represented by linear matrix inequalities for the finite-time stability of GRNs with impulsive effects. In section 4, we give a numerical example to demonstrate the significance of our result.

2. Problem Formulation and some Preliminaries

We study GRNs containing n mRNAs and n proteins represented by the differential equations as

$$\begin{cases} \dot{m}_i(t) = -k_{mi}m_i(t) + c_i(p(t-\tau_p(t))) \\ \dot{p}_i(t) = -k_{pi}p_i(t) + r_i m_i(t-\tau_{mi}(t)) \end{cases} \tag{1}$$

where $i = 1, 2, ..., n$, and $m_i(t) \in R^n_+$ denote the concentrations of mRNAs i ,$p_i(t) \in R^n_+$ denote the concentrations of protein i. k_{mi} and k_{pi} are positive real numbers that describe the degradation rates for mRNAs i and protein i, respectively. r_i is a positive constant which indicate the rate of translating mRNAs i to protein i. $c_i(p(t-\tau_p(t)))$ is a non-linear function of $p_1(t-\tau_{p1}(t)), ..., p_n(t-\tau_{pn}(t))$ which present the regulation function of gene i. $\tau_{mi}(t)$ and $\tau_{pi}(t)$ are time delays for mRNAs i and protein i, respectively.

In the translational process represented by the second equation in model (1), $r_i m_i(t)$ mean that one protein is produced by only one mRNA. In the transcriptional process described by the first equation in model (1), a gene or