Abstract

This talk is concerned with the modeling, analysis and control of synthetic transcriptional networks using nonlinear ODEs [1], [2]. A novel synthetic biology network recently developed at the Telethon Institute for Genetics and Medicine in collaboration with the University of Naples Federico II will be used as a case of study [3]. The synthetic network, named IRMA, was built in the yeast *Saccharomyces Cerevisiae* to provide for In-vivo benchmarking of Reverse-engineering and Modelling Approaches. The network is composed of five genes regulating each other through a variety of regulatory interactions; it is negligibly affected by endogenous genes and is responsive to small molecules.

In this talk, we will discuss the various stages that were followed to derive an appropriate qualitative model of the network and how experimental data was collected and used for model identification purposes [4]. We will show that a dynamical model of IRMA is able to capture and predict its behaviour and can effectively be used to further understand its function using bifurcation analysis. In particular, continuation tools will be used as an in-silico design tool to re-engineer the network topology and show that the network topology and parameters can be modified so as to behave as a switch or an oscillator [5].

The problem will then be discussed of how the insight gained from modeling and in-silico experiments can be effectively used to design in-vivo control strategies to steer the network behaviour in a desired way. Specifically, we will describe the in-vivo implementation of a feedback control based on hybrid systems theory that can be used to achieve both regulation and tracking control of a biological network of interest [6]. Entrainment and synchronization of cell populations will also be discussed. It will be shown that contraction theory, a classical tool in the theory of nonlinear systems, can be effectively used to give conditions on the biochemical parameters of the networks of interest that guarantee entrainment [7] or synchronization [8].

References


