Semi-quantitative modelling of biological systems with extended Fuzzy Petri nets

Jure Bordon, Miha Moškon, Miha Mraz

University of Ljubljana,
Faculty of Computer and Information science,
Slovenia,
jure.bordon@fri.uni-lj.si

Abstract. State of the art approaches for modelling biological systems can be classified as qualitative or quantitative. Qualitative models are relatively simple and require only basic knowledge of the system, but may only be used to get a rough image about the system's dynamics. On the other hand, quantitative models are able to mimic accurate dynamical properties of observed system, but require accurate kinetic data, which is often lacking. Existing fuzzy Petri net approaches only consider qualitative modelling. We propose a new, semi-quantitative approach based on fuzzy logic and extended Petri nets (PNs). Fuzzy logic allows us to linguistically describe biological processes, even if kinetic data are unknown. We present the details of fuzzification, defuzzification and the definition of IF-THEN rules on a model of degradation from a repressilator. We demonstrate how our approach circumvents the problem of missing kinetic parameters and how it can be used to augment existing quantitative methods such as models based on ordinary differential equations. By using fuzzy logic we were able to obtain comparable results to those of existing methods while using only rough estimation of kinetic parameter values, showing our method can be used for sufficient system analysis that helps with designing a novel biological system even when accurate kinetic data are unknown.

Keywords: biological switching systems, modelling biological systems, fuzzy logic, Petri nets, Fuzzy Petri nets

G. Balbo and M. Heiner (Eds.): BioPPN 2013, a satellite event of PETRI NETS 2013,
CEUR Workshop Proceedings Vol. 988, 2013.