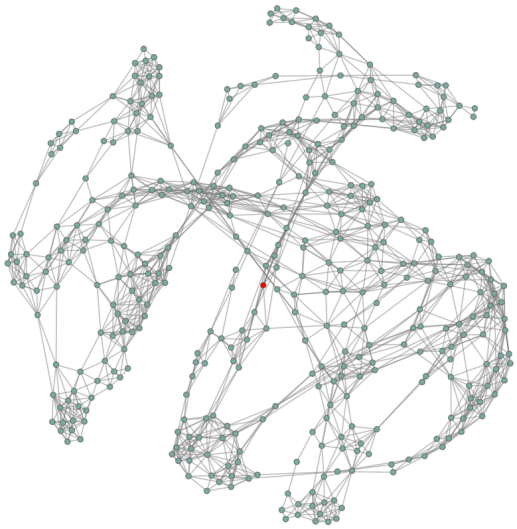
Control Systems Group
Department of Energy and Automation Technology
School IV - Electrical Engineering and Computer Science
Technische Universität Berlin

Monotone Boolean dynamical systems: duality and control

Motivation



Monotone Boolean dynamical systems (MBDSs) are a class of non-linear monotone systems in which every element of the state vector can assume only two values (0 or 1). Such systems are useful for modelling communication networks, social interactions, spread of biological/computer viruses, etc [2]. As the evolution of timed event graphs can be described as linear systems in the max-plus algebra [1], equations driving MBDSs become linear when described in terms of a special algebra called Boolean algebra.
Since Boolean algebra and max-plus algebra share similar properties, many analysis and control techniques from max-plus linear systems can be applied to MBDSs. Moreover, due to the simple nature of Boolean algebra, algorithms can be implemented very efficiently in this framework. Despite these facts, the study of MBDSs from a system-theoretic point of view is still missing in the literature. Hence, the aim of this thesis is to lay the foundations of a control theory for MBDSs.

The first goal of this thesis is to investigate and formalise two aspects of MBDSs: (i) duality and (ii) control. In particular, (i) the student will formalise the description of MBDS in a dual algebra, where equations become static; (ii) the dual description of MBDS will be then applied to study and solve a class of optimal control problems. The second goal consists of developing a software library for modelling, analysing, simulating and controlling MBDSs.

Requirements

We are looking for a motivated Master student eager to undertake a highly theoretical thesis. Basic knowledge of and great interest in discrete-event systems are required. Good skills in any programming language are appreciated.

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References

[1] L. Hardouin, B. Cottenceau, Y. Shang, J. Raisch, et al. Control and state estimation for max-plus linear systems. *Found. Trends Syst. Control.*, 6(1):1–116, 2018.

[2] D. Zorzenon, F. Molinari, and J. Raisch. Low complexity method for simulation of epidemics based on dijkstra's algorithm. *arXiv preprint arXiv:2010.02540*, 2020.