Dynamical Analysis and Control of Compartmental Models with Applications

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Abstract

Compartmental systems are nonnegative dynamical models used to describe the change of distribution of various objects (e.g., molecules, particles, vehicles) among different storage compartments in time [1]. Compartments can be physically distinct subsystems such as interconnected containers, but they can also represent disjoint states like different stages of diseases in the case of epidemic models. Therefore, the potential application areas of compartmental modeling are really wide including (bio)chemistry, systems biology, ecology or even transportation engineering. The following recent results are summarized in the lecture:

- The so-called 'generalized ribosome flow model' class is introduced which is an extension of the well-known ribosome flow models [4] both in terms of network structure and the possible nonlinearities [5]. The port-Hamiltonian structure and the robust stability of such systems can be proved by contraction analysis and entropy-like logarithmic Lyapunov functions. It is also shown that a non-conventional finite volume spatial discretization of widely used flow models given in PDE form (e.g., vehicle flows), results in generalized ribosome flow models.

- The successful application of kinetic compartmental modeling and nonlinear systems and control theory is shown for the analysis of the COVID-19 pandemic in Hungary. Using trajectory tracking control, system inversion, and nonlinear state estimation, several unobserved time varying quantities including the possible actual number of infections or the reproduction numbers can be reconstructed [2, 3].

References

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Short Bio

Gábor Szederkényi is a professor at the Faculty of Information Technology and Bionics of the Pázmány Péter Catholic University, and a part-time scientific advisor at the Systems and Control Laboratory of the Institute for Computer Science and Control (SZTAKI), both in Budapest, Hungary. His background is computer engineering and nonlinear control. His main research interest is the computation-based analysis and control of nonlinear dynamical systems with special emphasis on models with biological and biochemical motivation. He is the author or co-author of three books with international publishers, 80 journal papers and 110 conference papers. He has been the advisor of 7 PhD graduates. He is the member of IEEE Control Systems Society, and served as the secretary of IEEE Hungary Section between 2010 and 2016.