Analysis and design of networked k-contractive systems

Gustavo Penaforte Brito*[1], Irinel-Constantin Morarescu , and Mattia Giaccagli

[1]Centre de Recherche en Automatique de Nancy – Université de Lorraine - CRAN CNRS UMR 7039 – France

Résumé

A dynamical system is contractive if the distance between any two of its trajectories is exponentially decreasing in time. In recent years, contraction theory emerged as a relevant tool to solve several control problems. Despite its effectiveness, not all systems exhibit contractive behaviors. For this reason, researchers started looking for generalizations of such a notion. This thesis focuses on one of such extensions, which is the notion of k-contraction. A system is k-contractive if its trajectories contract k-dimensional objects. Thus, 1-contraction corresponds to the contraction of lengths, i.e., contraction in the usual sense. Consequently, 2-contraction corresponds to the contraction of surfaces, 3-contraction to the contraction of volumes, and so on. The interest in k-contraction lies in the asymptotic behavior that these systems share. Indeed, such a notion can be used for nonlinear systems to characterize their asymptotic behavior in terms of convergence to (possibly multiple) equilibrium points, and limit cycles. These kinds of behaviors are typical of many nonlinear systems that can be described as multi-agent systems. For this reason, in this thesis, we study the k-contractive properties of nonlinear and multiagent systems. The scope of this thesis is twofold. On the one hand, it aims to advance the study of the k-contraction properties of nonlinear systems, by developing novel constructive techniques to analyze and design k-contractive controllers. On the other hand, the interest is to use such a notion to study and justify the asymptotic behaviors of the solutions of network systems, by examining their k-contractive properties. Finally, we believe that the use of k-contraction properties applied to networked systems would enable the development of new tools to control this class of systems by appropriately imposing k-contractive properties on the network, either through feedback design or by modifying the communication protocol.

Mots-Clés: Contraction theory, Incremental stability, Networked systems, Nonlinear systems

*Intervenant