Research Proposal

Discernibility of Networks from Sparse Measurements

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Team: NeCS (http://necs.inrialpes.fr)
Duration: 6 months

Topic description:
This assignment regards security problems in networks of dynamical systems. When monitoring the functioning of a network, unexpected changes in the network structure can signal failures or malicious intrusions. For instance, in smart grids we want to be aware of losses of connectivity that may represent local blackouts. Thus, it is important to identify unexpected changes in the network topology, even from sparse measurements. Saying that measurements are sparse, we mean that only few nodes can be directly observed. Such observations, indeed, correspond to the placement of suitable sensors at the nodes.
This project aims at studying the conditions for this identification and, consequently, the chances for malicious adversaries to make it impossible. We consider a network whose behavior can be represented via a linear dynamical system. The problem of interest is then detecting a node or link disconnection from prior knowledge of the nominal network topology and measurements of some of the network states. Recent work has cast the problem in an observability problem, thus obtaining a set of sufficient/necessary conditions, based on simple algebraic tests [BT15]. However, at present it is unclear what these conditions entail in terms of network topology. In this research, we shall aim to identify the topological features that make networks discernible or not. To this goal, we shall focus on certain networks of interest, such as paths, grids, geometric graphs [PN12].
The approach of the research will build on classical control theory and matrix theory and will include simulations on synthetic or real data. In a first phase of work, prior results will be reformulated and refined. Next, their implications in terms of network topology will be sought in some specific examples. Finally, we shall abstract away from the examples and seek more general conclusions on the structural constraints to discernibility. Even though the research will mainly have theoretical intents, we expect to derive insights on how detection can be addressed in practice, as well as guidelines for the development of sensor placement algorithms.

Candidate profile: The candidate will have a solid background in (linear) systems theory and some knowledge of graph theory.

Context: This work will be carried out in the NeCS team (Networked Control Systems), a joint CNRS/INRIA team at GIPSA-Lab laboratory in Grenoble, France. The team's innovative research concerns control and estimation of networked systems, with a broad spectrum of applications including security and privacy in control systems.

Bibliography
[BT15] G. Battistelli and P. Tesi, Detecting topology variations in dynamical networks, *2015 54th IEEE Conference on Decision and Control (CDC)*, Osaka, 2015, pp. 3349–3354.
[KC14] A.Y. Kibangou and C. Commault, Observability in connected strongly regular graphs and distance regular graphs, *IEEE Transactions On Control of Networks*, vol. 4, no. 1, pp. 360–369, 2014.
[PN12] G. Parlangeli and G. Notarstefano, On the reachability and observability of path and cycle graphs, *IEEE Transactions on Automatic Control*, vol. 57, no. 3, pp. 743–748, 2012.

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