Master Research Internship proposal

Research Center of Nonlinear Theory and Applications

Research tutors :

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Title of the project : **From dynamical control to network topology**

General Context : The research work will fall in the general context of dynamical systems and complex networks. The study of complex networks is currently in a booming progress. In fact, applications of complex networks can range from biology to social sciences. These systems can be considered as systems composed of many agents, most often in interaction through non-linear processes on complex networks. Recent developments in this area have focused on the creation of the network, and currently consist of consider dynamics on these networks or the dynamics of the network himself. One important aspect is when the network models some critical communications between agents, since we expect nonlinearities and time delays a chaotic behavior arise naturally in these systems. This chaotic behavior is usually not desired, and needs to be controlled. Indeed when considering actual practical situations with technological applications, the non-predictive behavior is not always, if not almost never a suitable regime. To avoid this phenomena some control strategies have been devised, however these are network dependent, they cover some partial system failure, but usually depend on the specific network topology [3].

In the last few years the notion of lace networks emerged, these networks can be constructed and monitored through their fractal dimension[2, 4]. Depending on this parameter, the dynamics of a coupled rotators system could change drastically from displaying regular behavior to much more complex and chaotic dynamics[1]. The goal of this internship is to test this kind of topology on another type of dynamical system, namely some model systems with applications to control theory. How will the automated control strategy defined on such network fare? Based on the results and a few observables can we devise an optimal topology such that for instance the controlled system will not only scale well with the number of nodes, but as well minimize some quantity : power consumption, data transmission etc...

In this internship, the goal is to set up the basis for a thorough investigation of the response and behavior of some specific control strategy when defining them on lace type of networks. Moreover, the since this is part of a burgeoning international collaboration between Aix-Marseille University and Shenyang Aerospace University, the interested candidate must be willing to step in an be part of an of "adventure".

Keys words : non-linear dynamics and chaos, complex networks, switched system, privacy safety of control systems, control theory

If at the master 2 level, this internship could naturally lead to a PhD.

Scientific Environment : This internship work will be part of a collaboration of the CPT with the Shenyang Aerospace University within the Center For Nonlinear Theory and Applications.

Location : The internship will be localized in the *Center of Nonlinear Theory and Applications* in *Shenyang Aerospace University*, Shenyang, China. Mobility is thus required.

Required Knowledge : Good knowledge of dynamical systems and classical statistical physics will be a plus, the mastering of numerical tools in the spirit of being able to perform numerical simulations (programming language of the type fortran90, C,C++) and data analysis (octave, matlab, python) is necessary. Knowledge of english is mandatory,

as well as good communications skill in order to work in this international environment.

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[1] Martin Belger, Sarah De Nigris, and Xavier Leoncini. Slowing down of chaotic states : Freezing the initial state. *Discontinuity, Nonlinearity and Complexity*, 5(4) :427–435, 2016.

[2] Sarah De Nigris and X. Leoncini. Crafting networks to achieve, or not achieve, chaotic states. *Phys. Rev. E*, 91 :042809, 2015.

[3] Hao Liu. Sampled-data-based consensus of multi-agent systems under asynchronous denial-of-service attacks. *IEEE Trans. Cybernetics*, submitted, 2018.

[4] Sarah De Nigris and Xavier Leoncini. *Hidden dimensions in an Hamiltonian system on networks*, volume 15 of *Nonlinear Systems and Complexity*. Springer, 2016.