State-state estimation design and optimal sensor placement algorithms for large-scale evolutionary dynamical networks

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Application type: PhD. Gross salary: 1757 Euros/M (CNRS PhD official salaries).
Start: any time from Sept 2017 **Duration**: 36 months. **Employer**: CNRS. **Location**: Grenoble, France
Applications: http://scale-freeback.eu/openings/

Context. **Scale-FreeBack** is an ERC Advanced Grant 2015 awarded to Carlos Canudas-de-Wit, Director of Research at the National Center for Scientific Research, (CNRS), during Sept. 2016-2021. The ERC is hosted by the CNRS. The project will be conducted within the NeCS group (which is a joint CNRS (GIPSA-lab)-INRIA team), at Grenoble France in collaboration with Alain Kibangou from the University of Grenoble. Scale-FreeBack is a project with ambitious and innovative theoretical goals, which were adopted in view of the new opportunities presented by the latest large-scale sensing technologies. The overall aim is to develop *holistic scale-free control methods of controlling complex network systems in the widest sense, and to set the foundations for a new control theory dealing with complex physical networks with an arbitrary size*. Scale-FreeBack envisions devising a complete, coherent design approach ensuring the scalability of the whole chain (modelling, observation, and control).

Topic description. The research proposal deals with the problem of state-state estimation design and optimal sensor placement algorithms for large-scale evolutionary dynamical networks. The estimation design build upon scale-free aggregated models, where the aims is to reconstruct some "average" measure of the systems states instead of observe the whole high-dimension system states. The following specific objectives will be undertaken:

- **Observability notions.** Study new concepts/definitions of observability consistent with the scale-free models properties, their associated output measures, and their evolutionary nature (time-varying state dimensions). The objective is to estimate some *aggregated* measures of the original system state variables (i.e. averaging values, distributions). Observability will then depends on the selected aggregating function. Finding appropriate functions is part of the study.

- **Optimal sensor placement** concerns the problem of finding a sensor configuration that entails the minimum cost while meeting pre-specified performance criteria. Conventional approaches includes geometrical-based methods, and methods based on Gaussian Processes maximizing points of mutual information. These methods have usually given rise to combinatorial optimization problems impractical for large-scale sensing fields. One specific goal is optimizing the distribution and minimizing the number of a set of expensive static sensors given a random distribution of cheap sensors with an unknown level of cardinality in order to meet the operational observability conditions. Based on the new observability concepts the PhD candidate will investigate an equivalent formulation of dynamic set covering problem along with ideas related to matrix completion processes and the scenario approach.

- **Observer/Estimation design.** Standard estimation design typically consists in feeding the estimator with the available measurements and then compute the optimal gain, giving rise to a closed-loop estimator. A second option consists in viewing the problem as an optimization problem making possible to account for additional state constraints during the estimation process. Although these two approaches are related, the latter approach seems to be more suitable for the evolutionary nature of the consider network system. The specific target here will be to formulate a new estimation paradigm for evolutionary scale-free networks as a constrained optimization problem, using the new observability notions defined before.

Request Background., Control Systems, Applied mathematics.