PostDoc Proposal 2021

School - Location: CentraleSupélec, Rennes campus	
Laboratory: IETR	Web site: https://www.ietr.fr/
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Title: Adaptive Failure Detection in Distributed Energy Systems
Scientific field (one among the list- remove other choices): Engineering & Technology: Electrical, Electronic and Telecommunication Engineering
Free Key words: Adaptation and Learning, Smart Grids, Energy Systems, Fault Detection

General context:

Distributed energy systems are made up of a set of actors who have to coordinate to ensure a balance between energy production and consumption. These agents exchange both physical signals and digital information through communication protocols. Their coordination is essential to allow a massive integration of renewable energies and to enable the energy transition. For these systems, a set of controllers are designed to collectively ensure the safe and efficient operation of the installations. This may be the case for voltage regulation of power networks or the generation-consumption balance in these same networks [1,2,3]. A failure of one of these controllers may result in the violent destruction of the controlled element or in deviant behavior that is more difficult to detect. Such behavior results in de-optimizing the overall operation or even slowly leads the system to a state of non-functioning or instability.

Exchanges between agents can be of a complex and varied nature, but modern control and estimation techniques provide tools and methods to monitor and detect unexpected and undesirable changes in behavior. When such changes arise due to changes in system parameters or operation mode, one can apply fault detection techniques that are based on adaptive parameter estimation yielding adaptive fault detection solutions.

The objective of this post-doc work is therefore to set up adaptive estimation techniques to detect the corruption of one of the agents of the energy system. These estimates can be done both on the observation of physical quantities of the network (energy vector) or communication signals exchanged by the agents, thus participating in the cyber-physical safety of the energy network.

Description of the work:

This work can be divided into three main axes:

- The first axis to be considered is the characterization of the nominal behavior of the exchanges between the agents of the energy system. The techniques of online estimation of parameters, as developed within the team [4,5] are the first track to be favored.
- Once the characteristic parameters of the nominal behavior have been determined, the second point developed is to understand the impact of non-cooperative behavior on these parameters. These studies could also help to identify the most vulnerable elements of the energy system and those that can be the most destabilizing for the network.
- Finally, the third part aims to propose real-time methods for detecting changes in the behavior of different agents. This detection should allow the rest of the agents to review their organization and decision making taking into account the corruption of the agent to preserve as well as possible the good functioning of the network.

Supervision:

This research will benefit from double supervision by Stanislav Aranovskiy (on parameters estimation and adaptivity) and Romain Bourdais (on distributed energy systems).

References:

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[3] Renshi Luo, Romain Bourdais, Ton Van den Boom, B. De Schutter. **Multi-agent model predictive control based on resource allocation coordination for a class of hybrid systems with limited information sharing**. *Engineering Applications of Artificial Intelligence*, Elsevier, 2017, 58, pp.123-133.

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[5] Aranovskiy S., Bobtsov A., Ortega R., Pyrkin A.. **Performance Enhancement of Parameter Estimators via Dynamic Regressor Extension and Mixing**, *IEEE Transactions on Automatic Control*, vol. 62, no 7, pp. 3546-3550, 2017.