LABORATOIRE D'ELECTROTECHNIQUE ET D'ELECTRONIQUE DE PUISSANCE DE LILLE

Master project, 2024-2025

— Distributed learning for Adaptive Control — of Local Batteries for Renewable Energy Integration in electrical networks —

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Context

Climate change calls for more resilient electrical networks. The integration of distributed energy resources (DER) as Photovoltaics and wind generators into electrical systems also requires more intelligent and adaptive controls to connect these intermittent and uncertain power sources. At the same time, the increase in computing power has enabled the development of learning techniques, which improve control algorithms for electrical networks. Distributed learning techniques offer the advantage of being able to control electrical networks more resiliently than current centralized techniques. These techniques are beginning to be used in electrical systems.

Objective

Frequency control within microgrids was historically managed through power reserves that were provided by synchronous machines. The significant penetration of DERs, connected to networks by power electronics, tends to reduce the number of synchronous machines on the network. Power reserves must therefore be partly provided by these DERs, which are more difficult to control than synchronous machines. This is because DER power is intermittent, and highly dependent on external conditions (wind, sun, etc.). The impact of these external factors on power output and frequency control is not easy to model. By using data from measurements and prediction tools, the use of learning algorithms overcomes this problem.

The case study is an electrical microgrid, which includes only element of each DER (one battery, one PV, one synchronous generator). To control this microgrid, the centralized learning method are well adapted. However, a microgrid or a distribution network can include several DER elements. A centralized control is less adapted for technical, privacy and resilience aspects. Hence, the development of a distributed learning algorithm to control the frequency in the microgrid is a hot topic.

Three types of distributed learning are currently under study: the common distributed learning, the federated learning, and the assisted learning. Distributed and federated learning required communication with a central server while assisted learning only require communication between agents. The two first methods are already used in power systems management while assisted learning has not been applied on power systems.

The use of learning models may increase energy consumption compared to usual model. The CO_2 emissions of these new techniques is less studied in literature. It is hence important to estimate the CO_2 emissions of AI models aimed at reducing CO_2 emissions. A method to quantify both his negative impacts (quantity of CO2 emissions emitted by the training and use of the model) and his positive impacts (quantity of CO2 emissions saved when the model is used) can be applied to our case study.

This internship proposes to develop an assisted learning to increase the adaptively in the real time coordination of DERs in a microgrid or a distribution network.

This work will be carried out in parallel with Antonella Tannous' PhD thesis on the integration of a machine learning module in a Battery energy management system for local adaptive balancing. With the help of engineer, the implementation on a control board will be tested. According to the excellence and skills of the student, this laboratory internship (at L2EP) can be extended toward a 3-year PhD thesus.

Work steps

1. Conduct the state of the art on the distributed learning applied to energy management in electrical networks.
2. Identify the AI techniques, which is adapted to secondary frequency control.
3. Get familiar with the microgrid model developed by Antonella. Adapt this model to a case of distributed learning (i.e. several DERs). Perform classical microgrid control.
4. Determine the powers that can be controlled and identify the input variables for assisted learning.
5. Develop an assisted learning algorithm in Python or Matlab.

Key word

Artificial Intelligence, Distributed learning, renewable energy, electrical networks, energy management, Matlab/python langage

Profile candidate

We are looking for a student who is curious and interested in electrical energy, renewable sources and AI for management of electrical systems. The candidate must have the ability to work independently, to well organize himself and also to implement a regular reporting with supervisors. Good writing skills and communication in English are mandatory.

Please send a CV, a motivation letter, and the academic results of the two past years to ferreol.binot@centralelille.fr antoine.bruyere@centralelile.fr and bruno.francois@centralelille.fr.

Location : L2EP - Bâtiment ESPRIT Villeneuve d'Ascq

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