PhD Position: **Distributed learning for Adaptive Control**

of Local Batteries for Renewable Energy Integration in electrical networks

Keywords: Distributed computing, intermittent renewable energy integration, Supervised and unsupervised learning, power systems, adaptive prediction, local area balancing, optimal operation control

Lab: L2EP, Laboratory of Electrical Engineering and Power electronics, located at Lille – France (https://l2ep.univ-lille.fr), power system group.
The research project is managed by professors Bruno FRANCOIS and Ferréol BINOT

Context:
Frequency control within micro grids was historically managed through power reserves that are provided by synchronous machines. The significant penetration of DERs, connected to networks by power electronics, tends to reduce the number of synchronous machines. Power reserves must therefore be partly provided by these DERs. But, their controllability is much more difficult because PV and wind generation are intermittent, and highly dependent on external conditions (wind, sun, etc.).

Scientific objective:
More adaptive controls are required to connect renewable, intermittent and uncertain power sources. Balancing of power systems in time scales of one day ahead to instantaneous time involves contextual information coming from predictions (load demand, PV production, …) and state measurements (grid voltages, currents, ….) that contain various types of uncertainties. The edge computing and the increase in computing power have enabled the development of learning techniques, which improve local control algorithms in on line operation. Distributed learning techniques offer the advantage of being able to control electrical networks more resiliently than current centralized techniques.
The aim is to investigate the design of a distributed grid control system with ANN that will improve the local real time balancing and not require complex physics based models of power systems. This research project is based on developed works by the research group “Power systems”. The considered use case will be a local energy community, which includes several types of each DER (batteries, PV, water heater, controllable electrical vehicle charger, a small synchronous generator) and tests will be performed onto the experimental demonstration EPMLAB of the L2EP lab.

Ideal profile:
- A MSc in Computing Science or Electrical Engineering with a focus on process control
- Sound knowledge in power systems, control engineering, artificial neural networks, distributed and parallel computing
- Strong analytical and programming skills, experience in at least one : Python, MATLAB
- Research experience/publications in project related areas
- The candidate must have the ability to work independently, good analytical, synthesis and innovation skills
- Good communication and writing skills in English
- Experience in Hardware In the Loop Simulations and power system software as OPAL-RT, DSpace, Spherea, Typhoon

Benefits:
- Fully funded position with competitive stipends
- Mentorship of experts in the field and guiding by a current PhD on a neighborhood research topic
- Support for international conferences and research related travels
- Access to lab facilities, computational ressources and home industrial demonstrators for tests

Starting date: As soon as possible from now or delayed to maximum 1st December 2024, duration 36 months, full time position

How to apply ?

The application must include in the first round:

- Curriculum vitae (CV).
- Cover letter
- Obtained grades obtained during your last 3 years of graduate studies and program of courses attended by students graduated from a university abroad. Official academic transcripts must be provided for each semester of each year. If you do not have a transcript (examples: internships, breaks,...), you must enclose a justification.
- Copy (pdf) of your personal works (internship reports, professional experience, academic projects, etc...)

And in the second round:

- Photocopy of diplomas. For students with foreign degrees, the translation must be certified by a consular officer.
- Letter, name and email address of two referees
- Deadline : 30th May, 2024

Send your application to the following email address: bruno.francois@centralelille.fr

Key bibliography of the research group:

[1] "Orthogonal Considerations in the Design of Neural Networks for Function Approximation", B. FRANCOIS, Mathematics and Computers in Simulation, Vol. 41, p.95-108, Elsevier, July 1996

[2] Artificial Neural Network for Real Time Load Flow Calculation : Application to a Micro Grid with Wind Generators, H. HADJ ABDALLAH, L. KRICHEN, B. FRANCOIS, Journal of Electrical Systems, 1-3, 2005, p. 1-14

[3] Solar Radiation Forecasting Using Artificial Neural Network for Local Power Reserve, Xingyu YAN, Dhaker ABBES, Bruno FRANCOIS, Conférence Internationale en Sciences et Technologies Electriques au Maghreb : CISTEM 2014, 3-6 Novembre 2014, Tunis, Tunisie

[4] A review of self-learning and adaptive techniques for grid balancing, Antonella Tannous, Ferréol Binot, Bruno Francois, Symposium de génie électrique (SGE 2023), Jul 2023, Lille, France.

[5] Artificial Neural Network-Based Fast Power Reserve Control for Active Power Balancing, A. Tannous, R. Razi, F. Binot, and B. Francois, Electrimacs 2024: 15th International Conference of TC-Electrimacs Committee, 2024.

Are you interested in Artificial Intelligence methods for power system balancing ?

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.

The application of learning at the edge and especially at the consumer level should automatize the intelligence layer of applications at that level.

The power system group has developed first approaches for learning based on artificial neural networks focusing on the real time balancing.

Requirement of adaptability, feasibility of decisions, replicability and privacy and confidentiality of required shared data.

Energy community with smart homes or microgrid management.

Coordinated control of dispersed energy reources.

The employment of unsupervised learning controls enables the improvement of local controller performance and robustness during the power system operation.

, the impacts on power output and frequency control are not easy to model. By using data from measurements and prediction tools, the use of learning algorithms overcomes this problem.

The integration of distributed energy resources (DER) as Photovoltaics and wind generators into electrical systems requires more adaptive controls to connect these intermittent and uncertain power sources.

The type of uncertainty is changing from the uncertainty in the forecasting errors to the uncertainty in measurement quality.
These information are used to take decisions as the dispatching of controllable loads (water heaters, electrical vehicle charging, private batteries for electricity storage, …).