Research Grants for PhD students from the China Scholarship Council

Information Form (please read the guidelines carefully on the website www-csc.utt.fr)

Supervisor's name : LAGHROUCHE Given names : SALAH

Status (prof., assistant prof., ...) : Professor

Laboratory : FEMTO-ST Institute Website address : https://www.femto-st

Institution : University of Technology of Belfort-Montbéliard (UTBM), Website address : https://www.utbm.fr/english/

Scientific competence of the supervisor:

S. LAGHROUCHE is Full Professor in control engineering at UTBM FEMTO-ST. He has been directed numerous National and European projects and has the experience of working with global, leading industrial partners. Dr. Laghrouche research interests include variable structure systems, automotive and fuel cell control systems, renewable and smart energy management and power systems. Dr. Laghrouche serves as an Editorial Board Member for IEEE/ASME Transactions on Mechatronics, International Journal of Robust and Nonlinear Control, Journal of The Franklin Institute, and Asian Journal of Control. He is a member of the Conference Editorial Board of IEEE Control Systems Society.

Two major publications in the field proposed for the PhD :

1. X. Shi, F. Didier, A. Badji, S. I. Azid, M. Cirrincione and S. Laghrouche, Online Reinforcement Learning Approach for Real-Time Energy Management of Grid-Connected Battery Storage Microgrid System. IECON 2025–51st
2. X. Shi, F. Didier, A. Badji, S. I. Azid, M. Cirrincione and S. Laghrouche, A Double Deep Q-Learning Based Real-Time Energy Management Optimization for Microgrids. 2025 IEEE International Conference on ETFG

Website address of the personal page : https://scholar.google.fr/citations?user=wDS6t8EAAAAJ&hl=fr

Supervisor's email : salah.laghrouche@utbm.fr

Description of the research work proposed for a PhD ***Topic # (see list) :*** V-4, I-17

Title : Safe and Efficient Energy Management for Renewable Microgrids via MPC-Shielded Deep Reinforcement Learning

Subject :

This research focuses on developing an Energy Management System (EMS) for microgrids integrating renewable sources, hybrid storage, and controllable loads under real-time pricing. The goal is optimal power scheduling that enhances self-consumption and reduces grid exchanges, despite uncertainties in generation, demand, and prices.
Deep reinforcement learning (DRL) provides a promising MDP-based framework, yet state-of-the-art methods may suffer from instability, limited generalization, and, critically, a lack of explicit enforcement of physical and operational constraints. We propose a hybrid DRL–MPC strategy: the DRL agent optimizes power allocation, while a supervisory Model Predictive Control (MPC) layer enforces constraints and minimally corrects unsafe actions. Concretely, the MPC safety filter solves a short-horizon constrained optimization that projects the DRL action onto the feasible set defined by power balance, storage SOC/power/ramp limits, and grid-exchange constraints. To reduce the mismatch between proposed and applied actions, learning is made correction-aware to progressively generate feasible decisions; in addition, Lyapunov/barrier-function constraints can be incorporated to promote safe policy updates during training. The approach targets improved performance, safety, and reliability. It will be benchmarked against MPC-only and DRL-only baselines, and validated via real-time Hardware-in-the-Loop (HIL) experiments.

Keywords :

Microgrids, Energy Management System (EMS), Deep Reinforcement Learning (DRL), Model Predictive Control (MPC), Safe Reinforcement Learning, Real-Time Pricing, Uncertainty

Expected collaborations :

Background required from the applicant :

The ideal candidate should have a strong foundation in applied mathematics and control/optimization, or electrical engineering. Basic knowledge of nonlinear systems and an interest in machine learning (especially reinforcement learning) are expected. Familiarity with programming and simulation tools is desirable.

Existence of a PDF file detailing the proposal ("yes" or "no") : No

(see guidelines on the website www-csc.utt.fr)