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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

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Link “Pagina docente”: **https://www.simlab40.deib.polimi.it/**
Department Name: **Dipartimento di elettronica Informazione e bioingegneria**

Research topic**: Impact of Ev charging infrastructures in power systems**

MSCA-PF Research Area Panels:

- ☐ ENG_Information Science and Engineering

Brief description of the Department and Research Group (including URL if applicable):
The Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB) aims at being a world-class scientific institution committed to forefront research, education, and technology transfer in computer science and engineering, electronics, electrical engineering, systems and control, telecommunications, and bioengineering.

The research Group simlab 40 is involved in the digital transformation and modeling of traditional electrical systems integrated with their digital component. The heart of the laboratory’s activities is the realization of Digital Twins of electrical systems using mixed techniques of Hardware in The Loop simulation in order to validate the behavior of electrical architectures integrated with digital systems of supervision, automation and data collection. In particular, the activities of the laboratory are related to the implementation of “4.0 enabling technologies” for complex electrical systems

https://www.deib.polimi.it/eng/home-page
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TITLE of the project: Integrating Incentive-Based and Reinforcment learning in Electric Vehicles Charging Management

Brief project description:

The number of electric vehicles (EVs) on the road has steadily increased over the years. As a result, the demand for the energy needed to power these vehicles is also increasing, which can lead to spikes in demand. In the context of smart grids, EVs are considered distributed energy resources that can provide services for grid operations, rather than simply being loads to be served.

Effective use of the flexibility of electric vehicle charging loads requires periodic decision making to adjust power profiles and achieve optimal performance, considering uncertain external factors such as prices. However, users are unlikely to willingly participate in these decision-making processes. Aggregators are therefore responsible for coordinating the behavior of a large number of distributed energy resources, where each EV contributes a small amount of energy capacity that, collectively, can help balance the power grid due to its flexibility. Aggregators can provide demand response (DR) programs by acting as intermediaries between EV owners and grid operators. These DR programs can be implemented through incentive-based structures or direct controllers. In the former case, aggregators have access to aggregated data and limited information; in the latter case, aggregators establish a direct connection that allows them to manage the charging behavior of each EV.

This type of decision problem associated with demand response lends itself well to being modeled as a Markov decision process (MDP) and solved with Reinforcement Learning (RL).
For example, logic similar to that used in energy trading could be used to maximize the costs/revenues associated with demand response.
costs/revenues associated with electric vehicle charging and the potential provision of Vehicle-to-Grid (V2G) services.
Specifically, it is possible to decide whether to buy, sell, or retain electric vehicle energy based on the results obtained through an RL model trained using historical price data.
In addition, it would also be possible to change the objective function of the algorithm, focusing on useful services to the grid, such as frequency and voltage control.

Therefore, the main objectives of the research project are:

- Propose an incentive-based mechanism to regulate the connection time of EVs and adjust the EV arrival time;
- Develop an EV battery model considering both battery degradation and the computational capacity of an aggregator that aims to control hundreds of EVs;
- Propose a control strategy for an aggregator capable of handling the EV charging and discharging power profiles and minimizing the battery degradation.
- Implement an RL-based model for the provision of DR and grid services using EVs;
- Develop an RL-based multi-agent model for optimally managing an MV-distribution grid with a high penetration of RES, distributed generation and EVs.

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