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Decentralized smart energy systems play a vital part in the transition towards a low ...

Moving towards sustainability and climate security, electric power systems are going through a major paradigm shift to enable wide integration of distributed energy resources such as solar power, wind power, energy storage, demand response assets, and electric vehicles.

This is a formidable challenge due to the volatility and uncertainty of renewable energy. Today"s grid cannot handle the voltage rise and fast voltage fluctuations from high penetration of renewables, which threaten the security of grid operations and damage electrical equipment. It is widely recognised that the lack of adequate control mechanisms to regulate the voltage within a secure region is a key hindrance of wide integration of renewables into the grid.

Nevertheless, the grid has never been better equipped to handle these challenges than now due to the ongoing digital transformation of the grid, with wide integration of sensors, communications, and advanced data analytics. To meet the full promise of this digital transformation, the technological investments must be coupled with sophisticated control algorithms that can handle the grid"s fast nonlinear dynamics and its stochastic and highly distributed nature.

The goal of this project is to leverage the ongoing digitalization of the grid and state-of-the-art AI approaches to achieve data-driven and communication-efficient control and coordination of smart converters. In particular, our goal is to study how the converters can learn by experience how to make optimal decisions.

We will develop our algorithms in a simulation environment that capture important converter dynamics and interactions. The algorithms will be tested in real experimental microgrids. The developed software will add significant value to industry including advanced reinforcement learning solutions, active grid management, and grid data analytics that have been tested on real hardware. We will make all developments easily accessible for use by practitioners and publicly available.

The full title of this project is "Data-driven control and coordination of smart converters for sustainable power system using deep reinforcement learning".

Researchers at KTH have developed an open-source artificial intelligence (AI) solution to counter the challenges posed by integrating renewable energy and electric vehicles (EVs) in power grids. The increasing reliance on variable sources like solar and wind, combined with the demand for charging EVs, creates voltage fluctuations and deviations, potentially leading to power grid failure. According to Qianwen Xu, Assistant Professor at KTH and a member of the Digital Futures Faculty, the inconsistency of wind power and solar radiation, coupled with unpredictable EV charging needs, introduces many uncertainties.

The team has introduced open-source deep reinforced learning (DRL) algorithms for power converters deep within the grid. These algorithms enable the coordination of energy sources on a large scale, optimizing the system’s performance in the face of fast fluctuations without real-time communication. The decentralized management approach of the solution ensures voltage levels are maintained within required limits, preventing detrimental effects on electrical equipment and overall grid stability.

The researchers have demonstrated the effectiveness of their solution in a real-world smart microgrid hardware platform at KTH. The open-source software package is available on GitHub, and the research paper has been published in the IEEE Transactions on Sustainable Energy. The work is part of Digital Futures collaborating with researchers from the University of California, Berkeley, and Stockholm University.

Learn more in this article on AI protects power grid from fluctuations caused by renewable power and EVs, by David Callahan at KTH.

Photo: Assistant Professor Qianwen Xu in her lab at the Department of Electric Power and Energy Systems, KTH Royal Institute of Technology (by David Callahan)