

SYMPLEX 2025: SYNERGIZING MULTIDISCIPLINARY PERSPECTIVES FOR COMPLEX GLOBAL CHALLENGES SMART GRID AND MICROGRID STABILITY USING MACHINE LEARNING

Bhaskar Jyoti Ray

Research Scholar,
Asian International University,
Ghari, Imphal, Manipur

ABSTRACT

The high rate of development of modern power systems into decentralized, renewable-based architectures has compounded the necessity to have solid stability measures and management techniques in smart grids and micro-grids. The introduction of variability, uncertainty, and two-way flows of power, as well as lowering the system inertia, are the reasons that can create complex dynamic behaviours that are difficult to address using conventional model-based methods. This study suggests a machine learning-based system to improve stability monitoring and prediction and control in smart grid and microgrid settings. The framework incorporates data-driven algorithms to provide analysis of high-dimensional operational data, incipient instability, disturbance events classification, and prediction of transient and small-scale stability margins. The stability state classification is done using supervised learning models, whereas regression and time-series methods are used to predict voltage, frequency and rotor angle deviations in different conditions of load-generation. Also, reinforcement learning is discussed in the context of adaptive control and real-time decision-making to reduce oscillations and other issues and achieve resilience of the system. The suggested solution is tested on simulated and benchmark datasets of a power system of renewable intermittency, faults, and islanded/grid-connected changes. Accuracy, precision, recall and stability indices in performance evaluation have proven that machine learning models are more responsive, scalable, and predictive when compared to traditional methods of analysis. The findings indicate the opportunity of smart, data-oriented solutions to enhance grid resilience, facilitate proactive stability control, and facilitate the shift to sustainable, autonomous energy networks.

Keywords: *Smart Grid, Microgrid Stability, Machine Learning, Stability Prediction, Reinforcement Learning, Renewable Energy Integration.*
