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Master's Thesis on the topic:
Grid Situational Awareness in the Era of Inverters-Based Energy Resources Integration

Abstract: With the proliferation of inverter-based resources and with the increasing availability of sensors data from distribution and transmission networks, many research studies and works have been dedicated to developing useful tools and applications for power grid operation, protection, control, and planning. One of the primary use cases of sensors data has been for enhanced grid situational awareness, such as steady-state and dynamic state estimation, network events and faults detection, classification, and oscillation characterization due to loss of load, generation, or lines. However, the use of edge sensors data, such as inverters terminals, to characterize the dynamics of grid in response to causes, such as plant controller's response, reactive power source switching, or inverter-based controller responses during weak grid conditions are less explored in the existing works. Therefore, a fundamental research question is *"How can we develop abrupt change detection and characterization of the underlying grid causes using edge sensors data in an automated and scalable way?"*.

Research Goals and Objectives: This master's thesis project aims to develop novel, automated, and scalable methods and provide the fundamental understanding and systematic exploitation of edge sensors data using novel signal filtering methods combined with feature extraction, window selection, and clustering approaches for robust and automated abrupt-change detection, characterization, grid response clustering, and root cause analysis. To achieve the project's goals, we will perform the following tasks: 1) Creating a database of real-world scenarios of power assets operation using the smart grid testbed platform at the Smart Grid Technology Lab (SGTL), 2) Developing detection mechanism for abrupt changes in different channels of edge sensors signals, 3) Extracting sensors features and selecting a proper window using time-series signal processing approaches such as shape-based algorithms; 4) clustering and grouping the detected changes using the extracted features and other power system knowledge base to characterize the underlying causes as the response of the grid to scenarios, such as tap changer controllers response, reactive power sources switching, or inverter-based controllers.

Research Tasks: The research tasks are divided into three tasks as below:

Task 1: Experimental setup and testing in the SGTL.
- Subtask 1.1: Model a distribution feeder in the SGTL.
- Subtask 1.2: Model operation of tap changer, inverters controllers, capacitor banks or large loads

Task 2: Abrupt change detection using edge sensors data.
- Subtask 2.1: Develop detection and thresholding methods using edge data from Task 1.
- Subtask 2.2: Evaluation and parameter and data window selection and tuning

Task 3: Edge sensors feature extraction.
- Subtask 3.1: Develop shape-based feature engineering using edge data from Task.
- Subtask 3.2: Evaluation and fine-tuning

Task 4: Grid situational awareness and root cause analysis.
- Subtask 4.1: Signal shape-based clustering algorithms using edge data from Task 1.
- Subtask 4.2: Testing and fine-tuning using synthetic and smart grid technology lab data.

This work will be Co-supervised by:

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