Auto Parameter & Mode Discovery from Ambient Data

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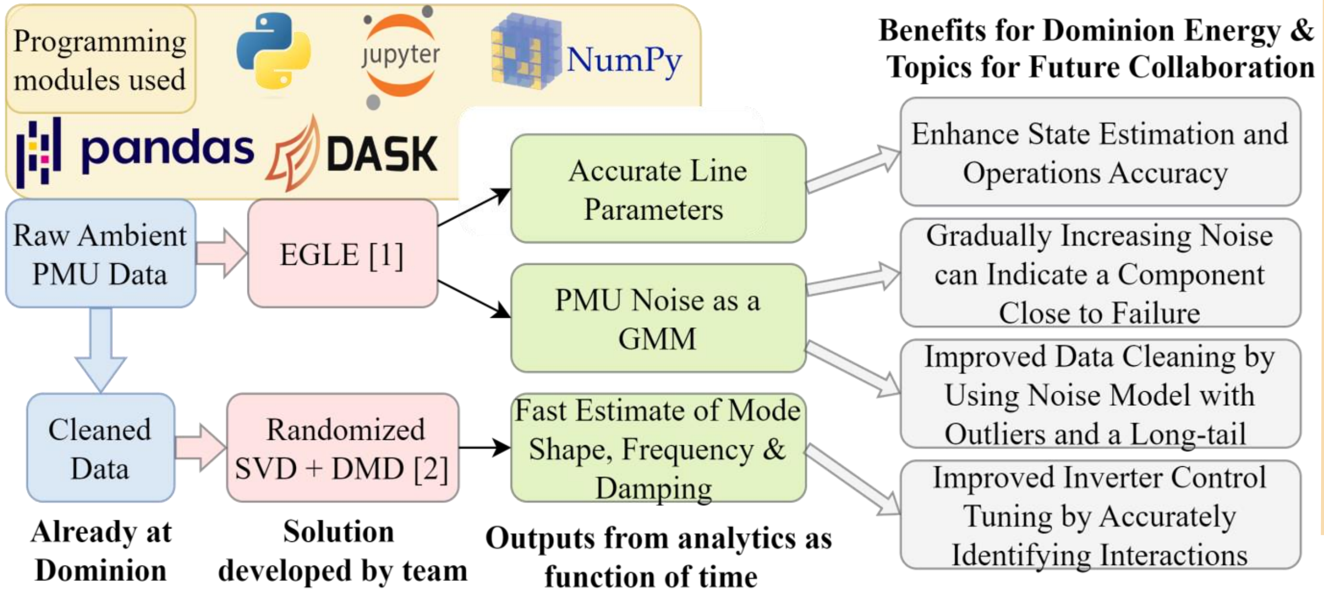
Project Summary

The proposed project will develop physics-driven analytics that significantly reduce the effort required by Dominion to rectify parameters in their models and diagnose unexpected grid behavior. The objective is achieved by a framework (figure below) consisting of scalable methodologies from robust estimation & random linear algebra to analyze ambient PMU data and output meaningful quantities (line parameters and mode properties) as a function of time. The team has deep expertise in power grid dynamics, synchrophasor technologies, Koopman Operators & development of software modules for data-analytics in python. The proposed methods address issues that hinder scalability in approaches published by Dominion. The proposed solution is easily translatable to other utilities with PMU measurements as they only need current/voltage/frequency measurements.



Goals & Deliverables

1. **Transmission line parameter estimation** (TLPE) in presence of non-Gaussian measurement noise using EGLE [1]. EGLE can be performed on batches of data to track the variation of the line parameters over time and has been demonstrated at a US utility using PMU measurements [1].
2. **Noise characterization of PMU** current and voltage measurements as a Gaussian Mixture Model (GMM) using EGLE [1]. EGLE can handle non-gaussian measurement noise using robust statistics.
3. **Scalable estimation of mode shapes, frequencies, and damping** using randomized SVD to perform dynamic mode decomposition (DMD) [2]. This approach accelerated the DMD method (that is in use by Dominion to estimate mode properties) by up to 3.5 times [2].

Project Impact

The impact of the proposal is evident from its physics-driven solutions to address the scalability & accuracy of applications that use ambient PMU data to provide actionable information to operators and planners - such as using EGLE to accurately estimate line parameters in presence of non-Gaussian noise & exploiting low-rank dynamics to quickly identify modes.

[1] A. C. Varghese, **A. Pal** and G. Dasarathy, "Transmission Line Parameter Estimation Under Non-Gaussian Measurement Noise," in IEEE Transactions on Power Systems, 2022

[2] **A. R. R. Matavalam**, et. al., "Efficient Data-Driven Uncertainty Propagation in Power System Dynamics Using Low-Rank Randomized Koopman Operator Approximation," IEEE PMAPS 2022.

Key Takeaway: ***Physics-based data-analytics that reduce effort to parametrize models & diagnose unexpected grid behavior***