Optimal Adaptive Power Flow Linearizations: Expected Error Minimization using Polynomial Chaos Expansion

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Challenges in Power System Optimization

- Large-scale
- Uncertain
- Nonlinear (nonconvex)

Traditional Approach: Linearizations use assumptions regarding typical system characteristics based on a single operating point forecast.

Problem: Excessively large linearization errors lead to inefficient and unreliable operation.

Optimal Adaptive Power Flow Approximations

Specifically tailored to a particular system and operating range.

Minimize a specified error metric.

Computed using algorithms adapted from machine learning:

- Regularize estimators to exploit prior information and network sparsity.
- Sample complexity bounds establish performance characteristics.

Minimize Expected Linearization Errors

- Statistical Distributions of Loads and Generator Outputs
- Propagate Distributions through the Power Flow Equations
- Approximate Distributions for Quantities of Interest (Line Flows)
- Compute Linearization Parameters that Minimize the Expected Error

Constraint generation algorithm based on importance sampling.

Minimize Worst-Case Linearization Errors

Advantage: Smaller linearization errors.

References


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