Flexible Distribution State Estimation System

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Technology Summary

The developed flexible distribution state estimation platform consists of a time-series analysis-based data fusion engine, a distribution system state estimator, and the corresponding output analysis and visualization functions. The data fusion engine will be responsible for performing data preprocessing to regulate the multi-channel data to a standardized input format for distribution system state estimator. In the state estimator, we have topology identification, kernel-driven estimation, partial measurement recovery tool to ensure the estimation accuracy. Finally, the estimated results will be generated and outputted with visualization options.

Key Algorithm - DSES Algorithm 1 Kernel-Driven Estimation 1 Get ith sampled data tuple $x_i = (u_i, a_i, o_i) \rightarrow \text{voltage, angle, other;}$ 2 Compute the distance d_i between x_i and x_{i-1} ; 3 Compute the distance d_u between $g_{i-1}(x_i)$ and u_i , a_i ; 4 if $d_u > \varepsilon_u$ or $d_i > \varepsilon_d$: Construct $\Phi_i^T \Phi_i$ using $\left[\Phi_i^T \Phi_i\right]_{m,n} = k(x_m, x_n)$, where k() is the kernel function; Compute $\mathbf{z}_i = \mathbf{0}_{i-1} \left[\Phi_i^T \Phi_i\right]_{1:i-1,i}$ Compute $\mathbf{r}_i = \alpha_d + k(x_i, x_i) - \mathbf{z}_i^T \left[\Phi_i^T \Phi_i\right]_{1:i-1,i}$ Update $\mathbf{0}_i = r_i^{-1} \begin{bmatrix} \mathbf{0}_{i-1} r_i + \mathbf{z}_i \mathbf{z}_i^T & -\mathbf{z}_i \\ -\mathbf{z}_i^T & 1 \end{bmatrix}$ Update weight vector $\mathbf{a}_{j,i} = \begin{bmatrix} \mathbf{a}_{j,i-1} - \mathbf{z}_i r_i^{-1} e_i \\ r_i^{-1} e_i \end{bmatrix}$ 5 Output $\mathbf{y} = \mathbf{A}_i \, \mathbf{K}(\mathbf{x}_i)$ where $\mathbf{K}(\mathbf{x}_i) = [\mathbf{k}(\mathbf{x}_t, \mathbf{x}_i)] \, \forall t \leq i$ 6 Remove $\mathbf{a}_{j,t}$, and $\mathbf{k}(x_{j,t}, x)$ when $\|\mathbf{a}_{j,t}\| < \varepsilon_a, t \leq i, \forall j$

Main Structure

AMI T

uPMU

Others

Time-series Analysis-based Data Fusion

- Bad Data Detection
- Missing Data Recovery
- Data Synchronization

Distribution State Estimator

- Graph-based topology Identification
- Kernel-driven based estimation
- Pseudo-measurement-based Partial Data recovery

1

Basic Topology Information Historical data measurement

Output & Visualization

- Topology change update
- State variable estimation
- Bad data identification

Key Personnel/Organizations

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