Robust Recovery of PMU Signals under Corruption: Approaches and Guarantees

Chatterjee, Kaustav

A moving window Kernel PCA-based metric proposed for detecting event-induced outliers in PMU data -- A data-driven recursive Bayesian framework adopted for selecting the most appropriate subspace from the library for use in post-event signal recovery.

Proposed approaches part of RPCA-based Robust Anomaly Correction and PMU Data Recovery scheme.

Publications from this Award

IEEE 5-area 16-machine NY-NE Test System

Subspace Library

K-PCA-based detection of event-induced outlier: Data recovery is suspended in event window

Recursive Bayesian Approach for Subspace Selection: Likelihood and Posterior probabilities of a subspace being the true subspace given a set of PMU observations

Selection accelerated with a suitable termination criteria

Case Studies

IEEE 5-area 16-machine NY-NE Test System

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CPS: Small: Fusion of Sensory Data and Expansivity of System Dynamics for Detection and Separation of Signature Anomaly in Energy CPS Wide-Area Monitoring and Control


2019 NSF Cyber-Physical Systems Principal Investigators' Meeting

November 21-22, 2019 | Crystal City, Virginia

To include the outcome of our research as a module of one course EE 488: Power Systems Analysis at Penn State through Problem-based Learning (PBL)

To integrate the proposed research into iTech: Summer Technology Camp for Teens – a free week-long interactive day camp, coordinated through Penn State’s College of Information Sciences and Technology (IST), designed to introduce high school students (9th-12th grades) to information technology.

To distinguish between event-induced outliers and bad data – recover clean PMU data

Spurious or maliciously injected outliers in PMU data – Need for anomaly correction – To distinguish between event-induced outliers and bad data – recover clean PMU data

Signal recovery under noise injection attack in 2 PMUs

Signal recovery under fault resembling attack in 2 PMUs – also shown, no recovery during actual event (fault)

Subspace selection is accurate, therefore, reconstruction quality is good

PDC Event Detection & Classification

Data Preprocessor

Robust PCA

PCP

Guarantees for Data Recovery: Signal grouping to ensure that for a given set Restricted Isometry Constant is below a threshold

Signal set I: poor RIC – recovery not guaranteed – shows incorrect reconstruction

Signal set II: RIC below threshold – recovery guaranteed – shows correct reconstruction

Signal recovery under missing data attack in 3 PMUs

Better visualization of dynamic events Real time monitoring and event detection

Quantify the effect of PMU signature anomalies on Principal Components in the higher versus lower dimensional subspaces

Can potentially benefit a wide range of CPS: control, oil and gas, energy, robots and future transportation systems employing autonomous vehicles

Protect critical infrastructures from cyber-attacks and facilitate improved system diagnosis, lower downtime, better service, and higher resiliency

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