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

The proposed research focuses on innovation in the area of detection and separation of anomaly in sensory data used for real time monitoring and control of cyber-physical systems (CPS). In this work, bulk power grid is considered as an example CPS, which is a critical infrastructure of our nation. The problem of spurious or maliciously injected sensor data originating from cyber-attacks is very important, because it can seriously jeopardize the monitoring and stabilization controls of power grids. This can lead to system-wide blackouts and cost our economy billions of dollars. This project aims to solve this problem by leveraging the system's expansive dynamic behavior to distinguish disturbances from data anomalies. To that end, the aim of this research is to bridge the gap between the developments in the area of singular value perturbation theory and Principal Component Analysis (PCA) – traditionally focused on the 'signals' side of the CPS, with the intrinsic properties from the 'systems' side of the CPS. Fusion of sensory data with the dynamic properties of the physical system will help in gaining fundamental insight into the coupling between the cyber and the physical layer and use this knowledge to detect and separate spurious signals or malicious data manipulations originating from cyber-attacks. A successful conclusion of this project will quantify the effect of Phasor Measurement Unit signature anomalies on Principal Components in the higher versus lower dimensional subspaces. In addition, emerging concepts of Robust PCA will be explored to separate the anomalous signatures and correct the data for real-time application.

In today's world of 'Industrial Internet' where sensory data is being utilized for system health monitoring and controls, this work has the potential to make significant stride in understanding data quality and anomaly. Therefore, a successful completion of this project can help protect critical infrastructures from cyber-attacks and facilitate improved system diagnosis, lower downtime, better service, and higher resiliency. The proposed research can potentially benefit a wide range of CPS including process control, oil and gas, energy, and probably other systems involving robots or even future transportation systems employing autonomous vehicles. This project will integrate its research outcome with power systems course modules to broaden the undergraduate experience on the newer developments in energy CPS. In addition, this project will integrate the proposed research into iTech: Summer Technology Camp for Teens, which is a free week-long interactive day camp, designed to introduce high school students (9th -12th grades) to information technology. All materials created and developed in this project including software data, primary research data and metadata, and teaching material will be publicly available on an open source basis at the following site: https://sites.psu.edu/nilanjan/. For faster dissemination of the research results, published papers will be made available in PDF format in this site.