Cyber-Physical Contingency Detection in Modern Power Systems: A Stochastic Hybrid System Method

Reliability of modern power systems mandates fast and accurate detection of contingencies in diversified categories, including line faults, generator failures, sensor malfunctions, communication system disruptions, and many others. Due to their critical importance, contingency detection in power systems has been recognized as a critical task, and unique and dedicated local sensors, monitoring devices, and protection systems have been implemented extensively.

In this talk, we will present a new stochastic hybrid system framework for cyber-physical contingency detection (CPCD) in modern power systems. The framework uses stochastic hybrid system representations in state space models to expand and facilitate capability of CPCD. Uncertain power system contingencies can be modeled as randomly switching discrete events, leading to stochastic hybrid systems, and their detection is an event estimation problem. Power system contingencies interrupt system structures and parameters, and introduce some fundamental technical challenges in state and event estimation. In this presentation, we will summarize some recent progress in developing a comprehensive framework on observer design and event detection for randomly switched linear systems whose subsystems are unobservable. An operator must combine information from different subsystems and integrate observer designs with stochastic data of the switching process to achieve simultaneously estimation of the entire system's continuous states and detection of discrete events. The coordinated design methods for subsystem observers and their organization for estimating both continuous and discrete states will be discussed. This framework allows detection of a broad class of contingencies in power systems by using only limited sensors, and hence forms a new promising foundation for contingency detection in a new and different perspective from the traditional methods.