

This dissertation contributes to the field by developing and applying novel state estimation techniques in three distinct areas: the detection of cyber-physical systems (CPS) intrusion, the estimation of State-of-Charge (SOC) and capacity for Lithium-ion battery cells, and multi-object tracking in video sequences.

In the first area, emphasis is placed on the detection of unknown intrusion signals within CPS. A pioneering detection scheme is formulated to discern potential cyber-attacks on industrial control systems. A novel intrusion model is first introduced and subsequently incorporated into the Multi-Model Adaptive Estimation (MMAE) technique for the identification of sensor or actuator attack signals. Simulation results underscore the effectiveness of the proposed technique in detecting unknown intrusions. Furthermore, the integration of a fading memory technique into the MMAE approach expedites the detection process, as evidenced by simulation results.

The second area addresses the estimation of SOC and SOH of Lithium-ion batteries. Three innovative estimation techniques are developed to precisely estimate SOC and capacity of Lithium cells in an online fashion. Initially, an adapted MMAE technique is employed for online SOC estimation, and subsequent improvement is achieved by combining MMAE with EKF to enhance accuracy and reduce computation cost. Finally, a simultaneous SOC and cell capacity estimation technique is introduced, demonstrating superior performance compared to existing methods under similar conditions, as validated by simulation results.

The third area centers on the multi-object tracking problem. Herein, an enhanced motion model and a novel reduced-order Kalman filter are introduced to augment multi-object tracking accuracy while concurrently alleviating computational burdens. Experimental results substantiate the heightened tracking performance without incurring additional computational costs. Additionally, a novel steady-state reduced-order Kalman filter is presented, further contributing to the reduction in computation costs. The proposed techniques can also be adapted to other areas.