



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Cyber-Physical Systems (CPSs) are pervasive in critical infrastructures such as power grids, transportation networks, and industrial control processes. Ensuring their reliable operation is crucial, particularly in the presence of unforeseen failures and malicious external attacks. This thesis addresses the problem of resilient control for CPSs equipped with multiple sensors, where the communication channels of both sides of the control structure are susceptible to Denial-of-Service (DoS) attacks. To systematically handle such disruptions in a multi-sensor framework, the DoS are categorized into two types: Multi-Channel DoS (MCDoS) and Full-Scale DoS (FSDoS). The thesis focuses on the characterization of MCDoS and FSDoS, and proposes a resilient control strategy that guarantees system stability despite the presence of such attacks.

To begin with, a switched observer-based approach is developed to address the challenges posed by MCDoS. Following this, an Event-Triggered Mechanism (ETM) is introduced to tackle the FSDoS condition. The changing frequency of MCDoS in the absence of FSDoS is characterized while ensuring the Input-to-State Stability (ISS) of the closed-loop system. The parameters of both the switched observer and the ETM are optimally designed by solving an optimization problem formulated with Linear Matrix Inequalities (LMIs), thereby enhancing the system's resilience against the maximum allowable MCDoS changing frequency.

Secondly, a comprehensive ISS-based analysis is conducted to characterize both the frequency and duration of FSDoS, complementing the earlier characterization of MCDoS changing frequency. The parameters of the switched observer and ETM are designed using a multi-objective optimization framework involving LMIs, ensuring system resilience against the maximum allowable MCDoS changing frequency as well as the maximum frequency and duration of FSDoS. An asynchronous triggering policy is also developed to further enhance the system's resilience, particularly in scenarios where FSDoS attacks occur at different times on the Sensors-to-Controller (StC) channels and Controller-to-Actuator (CtA) channel.

Finally, the Static ETM (SETM) is replaced with a novel Dynamic ETM (DETM). The control architecture of DETM is modified to effectively handle the maximum allowable MCDoS changing frequency. A comparative analysis between SETM and DETM demonstrates that DETM requires significantly fewer triggering instants, thereby reducing the overall control cost. Furthermore, an optimization algorithm is developed to determine the optimal parameters for both the DETM and the observer, enhancing the system's resilience against high-frequency MCDoS attacks.

