Workshop Speaker

  

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Title: Event-Based State Estimation and Sensor Scheduling: A Stochastic Perspective

Abstract: In engineering systems, limitations on energy consumption, computation power and communication resources exist in all time, e.g., the application of model predictive control to large scale slow processes such as paper machines and to small scale fast processes such as motor drives, and the computation complexity restrictions in image processing algorithms. The recent increasing number of applications of wired and wireless networked control systems, however, further exaggerate the demand to consider these limitations in control system design, providing strong motivation to investigate event-based control and estimation problems. The scope of this workshop focuses on event-based state estimation and sensor scheduling, aiming to provide a general introduction of this topic and a thorough overview of the emerging approaches proposed to tackle challenges in developing event-based state estimates.

The first part of the workshop is devoted to a general introduction of event-based state estimation and sensor scheduling. After describing the background and motivation of the topic, the basic components of event-triggered estimation systems are introduced, with an emphasis on system models considered and different event-triggering schemes. The basic problems that need to be considered in event-based estimation and sensor scheduling are then provided, highlighting the up-to-date developments and investigations on each of the basic problems.

The second part of the workshop presents two distinct approaches to event-based estimation problems subject to deterministic event-triggering conditions from a stochastic perspective. In the first approach, a state estimation problem in the minimum mean square error (MMSE) sense is considered, based on information from multiple sensors which provide their measurement updates according to separate event-triggering conditions. This problem is the natural generalization of the Kalman filtering problem to the case with event-triggered measurement updates. Under a commonly-accepted Gaussian assumption, the optimal estimator that corresponds to general event-triggering conditions is derived. Two interesting special cases are discussed, for which closed-form expressions of the estimators can be obtained and performance improvement can be proved. In the second approach, the information contained in the event-triggering conditions is treated as non-stochastic information, and the event-based estimator becomes a set-valued estimator (rather than a point-valued one as in, e.g., the Kalman filter). The properties of the exact and approximate set-valued Kalman filters with multiple sensor measurements for linear time-invariant systems are investigated. The results are applied to event-based estimation, which allow the event-triggering conditions to be designed by simultaneously considering the requirements on performance and communication rates.

The last part of the workshop presents a systematic approach to event-based estimation subject to stochastic event-triggering conditions. Open-loop and closed-loop stochastic event-triggered sensor schedules for remote state estimation are introduced, which successfully eliminate Gaussian approximations utilized in finding event-based estimators with deterministic event-triggering mechanisms. Under these two schedules, the MMSE estimator and its estimation error covariance matrix at the remote estimator are given in a closed form. Stability results in terms of the expected error covariance and the sample path of the error covariance for both schedules are provided. Finally, an optimization problem is formulated and solved to give the minimum communication rate under some estimation quality constraint using the open-loop sensor schedule.

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