Constrained distributed state estimation for surveillance missions using multi-sensor multi-robot systems

Soutenance de thèse – Antonello Venturino

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Résumé :

Distributed algorithms have pervaded many aspects of control engineering with applications for multi-robot systems, sensor networks, covering topics such as control, state estimation, fault detection, cyber-attack detection and mitigation on cyber-physical systems, etc. Indeed, distributed schemes face problems like scalability and communication between agents. In multi-agent systems applications (e.g. fleet of mobile robots, sensor networks) it is now common to design state estimation algorithms in a distributed way so that the agents can accomplish their tasks based on some shared information within their neighborhoods. In surveillance missions, a low-cost static Sensor Network (e.g. with cameras) could be deployed to localize in a distributed way intruders in a given area.

In this context, the main objective of this work is to design distributed observers to estimate the state of a dynamic system (e.g. a multi-robot system) that efficiently handle constraints and uncertainties but with reduced computation load. This PhD thesis proposes new Distributed Moving Horizon Estimation (DMHE) algorithms with a Luenberger pre-estimation in the formulation of the local problem solved by each sensor,

resulting in a significant reduction of the computation time, while preserving the estimation accuracy. Moreover, this manuscript proposes a consensus strategy to enhance the convergence time of the estimates among sensors while dealing with weak unobservability conditions (e.g. vehicles not visible by some cameras). Another contribution concerns the improvement of the convergence of the estimation error by mitigating unobservability issues by using a *l*-step neighborhood information spreading mechanism. The proposed distributed estimation is designed for realistic large-scale systems scenarios involving sporadic measurements (i.e. available at time instants a priori unknown). To this aim, constraints on measurements (e.g. camera field of view) are embodied using time-varying binary parameters in the optimization problem. Both realistic simulations within the Robot Operating System (ROS) framework and Gazebo environment, as well as experimental validation of the proposed DMHE localization technique of a Multi-Vehicle System (MVS) with ground mobile robots are performed, using a static Sensor Network composed of low-cost cameras which provide measurements on the positions of the robots of the MVS. The proposed algorithms are compared to previous results from the literature, considering several metrics such as computation time and accuracy of the estimates.

Mots clés : Distributed state estimation; Constrained state estimation; Distributed Moving Horizon Estimation; Sensor Networks.