Multimode navigation for degraded fixed wing unmanned aerial vehicule operation under sensor and actuator faults

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Résumé :
Actuator or sensor faults occurring in an unmanned aerial vehicle can compromise the system integrity. Fault diagnosis methods are therefore becoming a required feature for those systems.
In this thesis, the focus is on fault estimation for fixed-wing unmanned aerial vehicles in the presence of simultaneous actuator and sensor faults. To deal with the challenging nature of some fault scenarios, such as simultaneous and ambiguous faults that induce multimodality, a jump-Markov regularized particle filter and enhanced versions of it are presented in this thesis.
This method is based on a regularized particle filter that improves the robustness thanks to the approximation of the posterior density by a kernel mixture, and on a jump-Markov system. The jump strategy uses a small number of particles « called sentinel particles » to continue testing the alternate hypothesis under both fault free and faulty modes.
The numerical results are obtained using linear then non-linear longitudinal dynamics of fixed wing unmanned aerial vehicle. It is compared to interacting multiple model Kalman filters and regularized particle filters and shown to outperform them in terms of accuracy, robustness and convergence time in the scenarios considered. The state estimation is also more accurate and robust to faults using the proposed approach. Performance enhancement compared to other filters is more pronounced when fault amplitudes increase. An enhanced version of this method named the robustified jump-Markov regularized particle filter is also presented and allows one to accurately and rapidly estimate faults with no prior knowledge of the fault dynamics. Finally, a new approach to compute an adaptive transition probability matrix is introduced by computing the false alarm and missed detection probabilities using a saddlepoint approximation.

Mots clés :
Particle filters, jump-Markov system, actuator/sensor faults, UAV