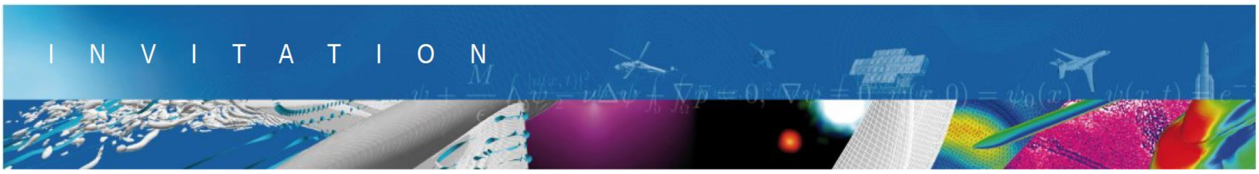

Construction d'ensembles invariants pour la commande d'un quadrotor sous contraintes

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Résumé :

Unmanned Aerial Vehicles (UAVs) quadrotors are versatile platforms capable of agile motion and stable hovering. The use of drones in civil application and industry has considerably increased in the last years, and is foreseen to continue growing. The design of autonomous UAVs should take into account safety and technological constraints, such as distance to obstacles, actuator limitations or real-time computational constraints for embedded implementation.

Here we focuse on quadrotor control for applications in a cluttered environment, where we want to account for the presence of external disturbances. External disturbances and modelling mismatches can affect the execution of a mission and its impact on the closed-loop trajectories must be assessed. A systematic way to assess the influence of disturbances is to compute invariant sets. The goal is to compute control laws that generate collision-free trajectories by bounding them within safe flight regions, characterized set-wise by invariant sets, where all constraints satisfaction is guaranteed. In particular, we study the design of control laws leading to invariant sets that are as small as possible.

The first part of the thesis considers the broader topics of the implementation and experimental validation of a control law for the stabilization of the translational dynamics of a quadrotor that ensures recursive constraint satisfaction and closed-loop stability in presence of disturbances. For this task, we chose Tube Based Model Predictive Control as control scheme for its strong theoretical properties. Its implementation is based on the construction of an invariant set one wishes to be as small as possible. To that extent, we propose a novel system identification approach in view of its minimization. The experiments are performed on the Parrot AR.Drone 2.0 quadrotor.

The second part considers the broader class of constrained discrete-time linear systems subject to bounded additive disturbances from a theoretic point of view. Here, the control law is the only design parameter of the invariant sets. Our first approach uses the invariant sets associated to discrete-time sliding mode control laws. These invariant sets have a remarkable geometrical structure, inherited from the selection of a stable sliding surface. The choice of such invariant sets offer several advantages, among which the low computational complexity of their characterization and their minimality properties among the collection of invariant sets. Our second approach is based on the exploration of set-iterative procedures for the refinement of any initial invariant set towards its minimization. The results presented in this part are illustrated in simulation.

Mots clefs : Invariant sets, Sliding Mode Control, Model Predictive Control, UAV, Set theoretic methods.

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