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ADAPTIVE CONTROL SYSTEM: A ROBUST MULTI MODEL ADAPTIVE CONTROL FOR LAUNCHING VEHICLES

Abstract

My Phd thesis is concerned with the rigid and flexible body dynamics and the stabilization of an unstable launch vehicle. Due to the wide range of mission configurations and trajectories, the existing control laws need to be updated and tailored to each mission. Considering the need to provide greater robustness and performance, as well as reducing the cost of flight, a model reference adaptive control algorithm and a robust multiple-model adaptive control are implemented, ensuring a good tracking and avoiding the loss of the vehicle in case of unpredicted scenarios. A model reference adaptive control is implemented for a rigid launching vehicle and its robustness is tested for various scenarios, including the failure ones. The control system is composed of a classical PD controller, completed by an adaptive control law. This adaptive control provides minimal adaptation under nominal conditions and improves the robustness in the event of vehicle malfunctions and offers extensive safety capabilities. Then the bending modes are included, as the flexibility of the launching vehicle can cause instability. In order to attenuate the effects of the bending modes, second-order filters are being used, such as Butterworth and adaptive notch filters. Simulation results showed that the model reference adaptive control system containing a bending filter for the launcher can guarantee stability, without affecting the performance of the system. Several cases were tested during the atmospheric phase of the flight, proving the robustness of the control system. Robust multiple-model adaptive control is a multiple model approach that calculates and uses the posterior probabilities of uncertain process model parameters located in a specific region to switch or mix the outputs of a set of controllers, each designed for a certain region of uncertainty. The identification subsystem uses a Kalman filter bank, while the control subsystem is composed of a set of mixed controllers. These controllers are designed for a lower uncertainty interval, as it produces better performance compared to a single controller designed for total parameter uncertainty. The algorithm is tested for different variations of the flight parameters during the trajectory of the atmospheric phase, validating the control system in terms of performance, stability and robustness. A comparison between the two control methods is made, considering the simulations for the high dynamic pressure region, as it represents the worst-case scenario. The two approaches are illustrated by a case study for the VEGA launcher.