Hyper-differential sensitivity analysis for control under uncertainty of aerospace vehicles

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Trajectory planning of aerospace vehicles requires the solution of an open-loop optimal control problem constrained by nonlinear dynamics. In practice, feedback controllers are used to mitigate uncertainties and track the trajectory generated by the open-loop problem. However, typical feedback controllers are easily saturated when exposed to many sources of uncertainties. Accordingly, we have developed a computational strategy consisting of ODE-constrained optimization, specialized sensitivity analysis, and mixed integer quadratic programming to direct data acquisition which facilitates efficient feedback control. By judiciously sampling costly high-fidelity simulations, the robustness of the open-loop solution is improved thereby making the feedback controller more effective. We demonstrate our approach on a simple navigation problem and on a real aerospace vehicle.