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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.