Abstract

Stochastic Optimal Control of Spacecraft

by

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This dissertation studies the influence of uncertainty on spacecraft control. The sources of the uncertainty are either imperfect state measurements or stochastic acceleration due to thruster noise. First, we analyze the impact of uncertainty in state measurements on the long-term cost of controlling an unstable periodic system. Under a specific procedure for updating control laws, we show that for unstable systems, there is an optimal time to perform updates in order to minimize the long-term cost per unit time.

Second, we consider the effect of stochastic acceleration due to thruster noise, which results in multiplicative noise on the control. Feedback control laws are obtained by numerically solving the stochastic Hamilton-Jacobi-Bellman equation using the spectral method. The optimal feedback control law for realistic noise levels is shown to differ significantly from the deterministic control. This suggests that trajectory planning would benefit from the inclusion of these stochastic effects.

Finally, we show that Taylor series expansions can be also be used to solve the stochastic Hamilton-Jacobi-Bellman equation under the fairly nonrestrictive assumption that the expansion is performed about an equilibrium point and that the gradient of the value function about the expansion point is zero. The Taylor series approach produces a system of ordinary differential equations describing the evolution of the coefficients in the power series. We show that in steady-state, a proper Taylor series may not exist, and that the proper solution

is obtained through a Frobenius series expansion.