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ENHANCED EXPLORATION DESCENT THRUSTER MODELING AND CONTROL

Abstract

This paper documents enhancements to pulsed thruster modeling and an associated control approach in the application of future exploration missions. These include modeling non-ideal engine performance such as finite rate thrust ramping, minimum on and off times, and engine quantization. Ideal thruster models use only constant, steady-state torque and force outputs based on the geometry of the thrusters on the vehicle. Real thrusters cannot ramp up or down instantaneously due to physical limits on the system such as time for propellant to flow through fuel lines after valve opening or closing. They also have limits for how long a the minimum time a thruster can be on or off. Finally, engine quantization is used which reduces the space of feasible on-time commands. Adding non-ideal thruster models results in control challenges because commanded on-time and actual on-time of thrusters do not match. For exploration descent control algorithms requiring rapid pulsing of multiple thrusters, these challenges must be addressed by additional control approaches. An engine response lookup table is generated pre-flight which provides the feasible set of on-time commands and the effective on-time given non-ideal thruster models. During flight, target on-times are generated for each engine during each control period based on an ideal thruster model. An on-time command is selected to produce an engine response on-time as close as possible to the targeted on-time. The approach can be posed as an optimization problem where the difference between targeted and actual on-time are minimized.