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CLOSED-LOOP MINIMUM-JERK EXPLICIT GUIDANCE FOR POWERED DESCENT PHASE OF SOFT LANDING ON MARS ACCOUNTING FOR SURFACE WIND

Abstract

A minimum jerk guidance law is applied in the powered descent phase of soft landing on Mars. This guidance law ensures high precision soft-landing of the spacecraft with vertical terminal orientation. The soft-landing objectives are met by enforcing 'hard constraints' on position, velocity and acceleration variables at the final time. The thrust acceleration is the 'physically realizable' guidance command obtained from the minimum-jerk optimal control formulation. The time-to-go is computed by minimizing a second cost function that ensures minimum deviation in the acceleration vector from the average value and the time-to-go is updated for every guidance cycle. This feature makes the entire guidance loop work as a closed loop system. The initial value of time-to-go, a tuning parameter, is fixed prior. The subsequent values for every guidance cycle are computed using the predicted states and the predicted time-to-go. This parameter makes the guidance law robust in unforeseen path perturbations. The guidance technique incorporates the atmospheric drag force and the surface wind which are present due to the Martian atmosphere. Another feature included in the proposed technique is the altitude excursion feature which allows guaranteed ground collision-free trajectories. In summary, the proposed physically realizable explicit guidance technique ensures soft and precision landing on Mars with vertical orientation. Moreover, by appropriate tuning, it ensures a collision- free, smooth landing trajectory within the available thrust bounds.