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Author: Dr. Yanning Guo
Harbin Institute of Technology, China

Ms. Yao Zhang
Harbin Institute of Technology, China
Prof. Guangfu Ma
China
Prof. Yuanchun Li
Changchun Universityof Science andTechnology (CCUT), China
Dr. Bo Dong
Changchun Universityof Science andTechnology (CCUT), China

AUTONOMOUS COLLISION AVOIDANCE GUIDANCE DESIGN FOR MARS POWERED DESCENT PHASE

Abstract

With the development of the deep space explorations, the autonomous planetary landing guidance is considered as an advanced guidance scheme for the next generation missions, and it also presents a set of challenges. For a Mars precision landing mission, one such challenge is that the landing safety should be ensured together with the landing accuracy and the fuel efficiency. Current studies about landing safety problems treat the no Martian surface collision requirement as a no-subsurface constraint, so that the altitude of the lander is always nonnegative, but the fuel efficiency is diminished to some extent. This paper aims at the landing safety problem for the Mars powered descent phase and proposes a novel autonomous guidance scheme to meet the requirements of the collision avoidance capacity, the landing precision and the fuel efficiency. The proposed guidance can successfully ensure no Martian surface collisions with any initial positions and velocities of the lander, which is analyzed by the convergence monotonicity proof. More importantly, the proposed guidance has potential to be fuel optimal during driving the lander to the target landing site safely. Furthermore, the dust storm phenomenon, model uncertainties and the complex Martian atmosphere are fully considered in this paper, and the robustness of the proposed guidance is guaranteed by a sliding mode observer, which is proven fixed time convergent by a Lyapunov function. The fixed time convergence theorem is employed to design the observer in this paper because of its unique advantage that any initial states lead to a same upper bound of the convergence time. The effectiveness and the landing safety property are proven with Monte Carlos method in the part of simulation, in which the thruster limitation is taken into account. The offline fuel optimal guidance would be also tested for the sake of evaluating the fuel efficiency of the proposed guidance. The robustness would be verified by Monte Carlos simulations, in which the initial perturbations caused by model uncertainties, etc. are included.