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ADVANCED APPROACH BASED ON CONVEX PROGRAMMING FOR MARS POWERED DESCENT GUIDANCE

Abstract

In recent years, direct investigation in lander or rover missions for Mars has attracted widespread interest all over the world. So far, many kinds of Mars explorers have been launched. Then, the improvement of technology has changed the exploration way from orbiting to landing. Nowadays, Mars exploration missions require payload weight for scientific achievements as well as reliability. This trend directly means that landing site will be set more challenging location. Considering these scientific requirements, the future spacecrafts have to ensure more accurate, more reliable, and more autonomous landing. Capability of onboard generating trajectory is critical to the success of those future missions. Thus, various researches have been carried out on onboard powered descent guidance algorithms. Polynomial approximation methods have been used in actual missions. Convex optimization based approach achieved a great success in Mars pin-point landing and played a key role in various aerospace applications. So far, however, there has been little discussion about onboard autonomy. From the rigors of the fuel restrictions, considerable research attention has focused on fuel-optimality. In order to increase the probability of success, onboard autonomy of powered descent phase is one of key technologies. In particular, autonomous trajectory generation is important for avoiding obstacles, tracking landmarks, specific observation during landing process. These functions are realized by generating trajectory in the particular direction. In this paper, a new convex optimization based approach is proposed to solve this problem. The main contributions of this paper are as follows.

1. It is proven that the optimal autonomous powered descent guidance problem, which has non-convex constraints, can be formulated as convex optimization using the maximum principle.
2. This paper presents that the solution follows a bang-bang profile, which is appropriate for actual Reaction Control System.
3. In addition, this problem can be solved by SOCP, which is a subclass of convex optimization problem to be solved in polynomial time.

We demonstrate the performance of the proposed method by numerical simulations. A Mars landing scenario including obstacle avoidance is selected. The performance analysis reveals that the proposed algorithm can handle the problem within *a priori* known bounds, in spite of the wide range of initial values. Consequently, the newly proposed approach can be implemented as a part of onboard autonomous powered descent guidance algorithm. Future work is needed to adapt the proposed method to highly nonlinear gravitational field, which will be realized by the successive iteration method.