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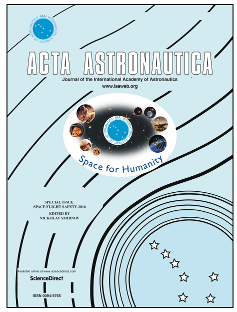

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Visual navigation using edge curve matching for pinpoint planetary landing

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Abstract

Pinpoint landing is challenging for future Mars and asteroid exploration missions. Vision-based navigation scheme based on feature detection and matching is practical and can achieve the required precision. However, existing algorithms are computationally prohibitive and utilize poor-performance measurements, which pose great challenges for the application of visual navigation. This paper proposes an innovative visual navigation scheme using crater edge curves during descent and landing phase. In the algorithm, the edge curves of the craters tracked from two sequential images are utilized to determine the relative attitude and position of the lander through a normalized method. Then, considering error accumulation of relative navigation, a method is developed. That is to integrate the crater-based relative navigation method with crater-based absolute navigation method that identifies craters using a georeferenced database for continuous estimation of absolute states. In addition, expressions of the relative state estimate bias are derived. Novel necessary and sufficient observability criteria based on error analysis are provided to improve the navigation performance, which hold true for similar navigation systems. Simulation results demonstrate the effectiveness and high accuracy of the proposed navigation method.

Keywords：Visual navigation; Crater edge curve; Observability criterion; Pinpoint landing

1. Introduction

Future space exploration missions will require a pinpoint landing capability, both for sample acquisition and return missions and landing on scientifically interesting sites precisely [1]. However, severe time delays which is caused by the long distances between target and the earth poses technical challenges. In addition, the lack of acknowledgement of planetary environments results in the limited accuracy of navigation system for processing reliable scientific and engineering operations [2, 3]. To address these problems, the lander is required to rely on an accurate navigation system to