ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (3)

Author: Dr. Zhengshi Yu
School of Aerospace Engineering, Beijing Institute of Technology, China, yuzhengshi@gmail.com

Prof. Pingyuan Cui
School of Aerospace Engineering, Beijing Institute of Technology, China, cuipy@bit.edu.cn
Mr. Shengying Zhu
School of Aerospace Engineering, Beijing Institute of Technology, China, zhushengying@gmail.com
Dr. Ai Gao
Beijing Institute of Technology, China, gaoai@bit.edu.cn
Prof. Jili Rong
Beijing Institute of Technology, China, yuzhengshi@gmail.com

RADIOMETRIC MEASUREMENT BASED NAVIGATION AND PERFORMANCE TREND FOR MARS LANDING

Abstract

Future Mars landing missions will require the capability of precisely landing at certain site of special scientific interests to gather more valuable scientific materials. Autonomous navigation in the Mars approach, entry, and landing plays an important role in fulfilling a precision landing mission. To improve the performance of traditional dead reckoning based navigation approach, radiometric measurement based navigation scheme has been proposed. However, there are no sufficient number of beacons capable of navigation. Therefore the navigation scheme has to be optimized in order to use the limited information efficiently. This paper aims to analyze the feasibility and performance of the radiometric measurement based navigation scheme in the Mars approach, entry, and powered descent phases. Furthermore, a novel performance based optimization method for navigation scheme is proposed. The observability of navigation system is used as an index describing the navigation capability. Focusing on the relationship between the configuration of radio beacons and observability, the Fisher information matrix is introduced to analytically derive the degree of observability in each phase, which gives valuable conclusions for navigation system design. In order to improve the navigation performance, the navigation scheme is optimized via two different approaches based on the observability. Firstly, the configuration of beacons is optimized using genetic algorithm, which gives the best locations of beacons (or the best orbit of navigation orbiters). This is the main approach to improve the navigation capability. Secondly, if the locations of beacons are fixed and not optimal, the trajectory of spacecraft is then optimized using pseudospectral method to further improve the acquisition efficiency of navigation information. Numerical simulations of Mars approach, entry, and powered descent phases demonstrate the feasibility and significance of proposed approaches for the optimization of navigation scheme. The navigation accuracy can be greatly improved by locating the positions of beacons appropriately. Furthermore, a 3D simulation and analysis system is developed for Mars landing. Simulation results show the potential advantage of radiometric measurement based navigation scheme, which provides a possible solution to the accuracy navigation for future Mars landing missions.