System architecture and GNC algorithms for lunar surface precision landing and transfer trajectories optimization

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SYSTEM ARCHITECTURE AND GNC ALGORITHMS FOR LUNAR SURFACE PRECISION LANDING AND TRANSFER TRAJECTORIES OPTIMIZATION

Abstract

Space Exploration is currently at the center of a renewed wave of interest, with particular attention devoted to manned missions towards the Moon, Mars and beyond.
In line with ESA Exploration Roadmap, current efforts are being focused on the concept of a Moon village, capable of functioning as a permanent human outpost and thought as intermediate step for further exploration towards more remote destinations. The sustained human presence at the outpost demands for frequent transfers between the lunar surface and the Deep Space Gateway (DSG) required for the provision of resources to the village and for crew transportation.
The landing and take-off of transfer vehicles is expected to exploit spaceport facilities, built in specific locations on the lunar surface and, therefore, requiring the landing procedure to be as precise and reliable as possible, with the aim of reducing the risk of damage to structures or vehicles.
A further constraint concerns the minimization of propellant consumption during transfers between the surface and the lunar orbit.
Approaches based on Convex Optimization have already been successfully employed in space applications to increase performances and reliability of landing procedures. Characterised by efficient and deterministic convergence capabilities, the associated algorithms are able to provide numerical solutions to minimization problems with computational times compatible with real-time onboard applications.
The purpose of this paper is to provide an overview of the architecture of the systems involved in the guidance, navigation and control of transfer elements required to travel between the lunar surface and the DSG. Specific attention is devoted to Convex Optimization algorithms for trajectory optimization and control, analysing both the landing and the DSG targeting processes.