IAF SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (Part 1) (4A)

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SPACECRAFT TRAJECTORY SIMULATION FOR AUTONOMOUS LANDING ON SMALL PLANETARY BODIES

Abstract

The exploration of small planetary bodies such as asteroids, comets and moons has been gaining attention in recent years. Besides providing valuable information about the formation of our solar system, small bodies can serve as test beds and sources of raw materials for future deep space missions, including crewed missions to the Moon and Mars.

Successful missions were able to obtain valuable information by performing fly-bys or orbiting small bodies, with a few being able to land on their surface. However, there are still significant gaps in the knowledge about their physical and chemical characteristics. The internal composition, which is crucial for the identification of resources, is especially difficult to obtain, as it requires in-situ measurements that can only be performed by landing on the surface of the body.

Landing on asteroids is very challenging due to their irregular gravitational field and influence of other disturbances. Besides, remotely controlling a spacecraft to land on such destinations is often not possible, therefore such missions bring the need for further technological development in the field of autonomous landing.

The main goal of the project presented in this paper is the hardware-oriented development, validation and testing of methods, algorithms and sensors used to safely and reliably perform autonomous landing on small bodies. The manuscript presents the environment created for the development, validation and test of the GNC system of an autonomous lander. This environment is composed of two modules: model simulation and multicopter flight module.

The model simulation module consists of the small body environment model, the spacecraft dynamics and actuators model and the GNC algorithms. The flight module uses a multicopter to emulate the landing. The multicopter will operate in an asteroid-like environment and be equipped with the navigation sensors in order to provide realistic data for terrain relative navigation and hazard detection and avoidance.

The second part of the paper focuses on the model simulation module. The current design of the lander and its dynamics and actuator model are presented along with the guidance and control algorithms, which will be used to calculate the minimum-propellant consumption landing trajectory and corresponding thrust commands. During the entire path, the spacecraft simulator will receive sensor data from the navigation suite of the multicopter, the trajectory is then updated and scaled before being transmitted to the multicopter.

The paper concludes with future plans regarding the integration of the individual elements of the development and validation environment, which will then serve as a valuable tool for tests and improvements of GNC algorithms for autonomous landing on small planetary bodies.