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A TESTBED TO EVALUATE GUIDANCE AND CONTROL ALGORITHMS FOR PLANETARY LANDINGS BY EMULATING SPACECRAFT DYNAMICS WITH A QUADCOPTER

Abstract

Close proximity operations near planetary bodies have different possible options. The planetary bodies could be Moon, Mars, Asteroids and Comets. The two most common operations are orbiting close to the body or landing on the body when in situ measurements are made. Regardless of the operations, studying a planetary body poses a different problem like unknown gravity, irregular shapes, surface spin rate etc. Due to these problems, a highly precise guidance, navigation and control system is required. In addition, the communication delay induced by the large distance between the earth and targeted planetary body results in developing autonomous algorithms for close proximity operations. In order to have a success mission, firstly an orbit around the planetart body should be selected. Secondly, a low altitude flyover of the surface is performed to study the planetary body features. Thirdly, to study the in situ measurements a landing is performed on the surface.

This paper is thus targeted to the development of novel autonomous guidance and control algorithms for pinpoint landing on small bodies. A pin point landing is defined as designing a fuel optimal trajectory to guide the spacecraft lander to a pre-defined target on the small body surface with an accuracy of less than several hundred meters. The most commonly used technology is to design a guidance trajectory using a cubic or quadratic in time and a variable structure controller to track the trajectory leading to a tracking problem. This is the concept used in the Apollo mission. In this paper, a guidance trajectory using convex optimization techniques is implemented. The advantages of solving the problem using convex optimization techniques are low complexity and could be solved in polynomial time. This method has been proven to be more robust in the sense that a finite number of iterations could lead to the convergence of the guidance algorithm. The second novelty of this paper is to emulate spacecraft landing dynamics on a readily available off-the-shelf quadrotor unmanned aerial vehicle and evaluate the performance of spacecraft guidance and control algorithms during landing. This will enable the designers to test a range of novel algorithms on an affordable testbed before implementing on the real spacecraft for future missions.