SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Poster session (2D)

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MODELLING AND CONTROL OF A SMALL QUADROTOR FOR TESTING PROPULSIVE PLANETARY LANDING GUIDANCE, NAVIGATION AND CONTROL

Abstract

The problem of on-ground testing guidance, navigation and control (GNC) algorithms for planetary accurate and safe landing can be approached through the flight of small quadrotors (¡ 1kg mass), suitable for indoor and outdoor operations. This way was undertaken for instance by the STEPS project funded by Regione Piemonte, Italy, and is under development. The literature is full of studies and experiments with such aerial vehicles (sometimes referred to as aerial robots) aiming at very different exploration, commercial and education goals. Here we focus on the test of GNC algorithms for planetary landing that are partly presented in a companion paper submitted to this conference and in other papers submitted elsewhere. Only simulated results will be presented as a baseline, as the relevant hardware, to be employed outside the aforementioned project STEPS, is under procurement. Modelling and control design will follow the Embedded Model Control methodology. Firstly, the main difference of an on-Earth-flying quadrotor dynamics with respect to a generic planetary landing vehicle is analyzed, showing that a similitude can be formulated, capable of scaling down mass, geometry and trajectories to indoor and outdoor tests, and of compensating the different gravity acceleration. As a result, indoor tests look rather critical as they would require small quantization to quadrotor thrusts, in order to keep landing flight duration constant. Similitude to be very accurate needs a careful model of propeller dynamics and response. A further problem comes from emulating radar altimeter and velocimeter; both can be emulated by a GPS receiver but reliably only in outdoor tests. Indoor tests should require camera. Radar altimeters are massive. Altimeter may be also emulated by a barometric altimeter. Ultrasonic range sensor are used at touch-down. Initial alignment must be provided by some attitude sensor either magnetometers or external markers, or the accelerometer themselves (on–ground). Subsequently under a short flight time (¡ 200s), attitude, velocity and position can be obtained by gyro and accelerometer integration. Thus essential sensor devices are assumed, namely IMU (accelerometers and gyros) and ultrasonic range sensor (conservative conditions). An outline of the guidance, navigation and control algorithms will be included. Simulated runs and possibly experimental tests will be provided.