HUMAN SPACE ENDEAVOURS SYMPOSIUM (B3)
Enablers for the Future Human Missions (7)

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AN INNOVATIVE NAVIGATION SCHEME FOR HIGH PRECISION LANDING ON MARS

Abstract

Accurate navigation systems are required in the scope of Mars precision landing missions. Several international space missions scheduled for 2010-2013 have as an objective the turn of Mars surface samples to the Earth. Contrary to the pathfinder and Mars Exploration Rover entry missions, the upcoming missions need to land at precise locations on Mars in order to gather samples of high scientific quality. Therefore, the next generation of landing systems, often called pinpoint landing systems, will be used to autonomously and safely land on a site selected by scientists. The three most significant sources of landing dispersion at Mars are the following: (1) position and velocity errors at the atmospheric entry point; (2) uncertainties in the atmospheric density and the vehicle aerodynamic characteristics during the hypersonic aerobraking phase; (3) drifts caused by strong winds during the parachute descent phase. In this scope, terminal landing systems based on radar navigation are being developed to autonomously find and track a safe site. However, during the atmospheric entry phase, there are no simple solutions for absolute navigation. Unlike on Earth, for Mars missions, the problem arises when only the accelerations and angular rates from an inertial measurement unit (IMU) are available because altimeter or optical sensors can not be used during the atmospheric hypersonic entry into atmosphere. Most nonlinear trajectory-tracking methods presented in the literature still assume full state feedback. It is demonstrated that currently IMU measurements are not sufficient to get complete observability of the entry dynamics, which has much influence on high precision navigation. To achieve pinpoint precision landing on Mars, the first step of this work is the implementation of the unscented particle filter techniques for state estimation during atmospheric entry. The second step is the investigation of novel navigation scenarios to improve the observability of the system. Among the possible sensor technologies, radio communication reveals that one-way radio ranging from emitting beacons might be efficiently used for navigation. Therefore, an innovative measurement scenario based on radio ranging is proposed to resolve the observability issue. The analyses show that the addition of the range measurements from known references helps to estimate accurately the position states along with some critical model parameters contrary to IMU navigation alone. The simulation results are presented to validate the performance predictions and demonstrate the benefits of the proposed the navigation scheme for high precision landing on Mars.