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Author: Mr. Rolando Cortés
CINVESTAV, Mexico, rolando_cor@hotmail.com

Dr. Krishna Kumar
Ryerson University, Canada, krishnadevkumar@yahoo.com
Dr. Hugo Rodríguez
CINVESTAV, Mexico, hrodriguez@cinvestav.mx

# PRECISE POWER DESCENT CONTROL OF SINGLE GIMBALLED THRUSTER MOON LANDER.

**Abstract**

The problem of precise powered descending for a lunar lander is addressed in this paper. In the literature, the problem has been solved assuming a fully actuated attitude dynamics; this paper explores the option of using one single actuator with three control inputs: a force command and two angles to direct this force. The system is then a 12-order dynamic system; six states for translational dynamics and six for the rotational dynamics, with three nonaffine and coupled control inputs.

The underactuated system is modeled in cylindrical coordinates to point out the coupling between the elements of the state vector. Two control techniques are addressed in this paper; the first one is the gain scheduling algorithm with LQR gains selection; the second approach is the result of a nonlinear variable structure controller VSC. In the LQR controller first we compute the linear system equivalent for every operation point, then we test controllability and LQR computes the gain matrix, all this is done at every sample time. Results show that although the linear system is not controllable per se, the linear part of gravity gradient disturbances augments the controllability of the whole linear system.

On the other hand, the VSC uses a fixed gain matrix that results from exploiting the cascade structure of the system and selecting a sliding surface according to the magnitude of disturbances. The nonaffine inputs are uncoupled by the use of a high order filter.

The numerical simulations are presented to compare the performance of both controllers. A mass estimator and angular rate observer are also designed to add robustness against possible sensor failures. Both approaches represent a valid alternative for a precise lunar landing.