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VISION BASED GNC ARCHITECTURE FOR RETRO-LANDING ROCKETS

Abstract

Reusable rockets are becoming more common in the space industry due to their low-cost launch rates as most components can be reused and the only expenditure is fuel. Retro landing is one of the few methods to recover a rocket body, in recent times it is the most common method used by launch vehicle companies such as SpaceX and Blue Origin. All subsystems must work in coordination to accomplish this complex task. One of these subsystems is GNC (Guidance Navigation and Control), this paper will discuss the implementation of optical navigation in GNC architecture(OGNC).

We present an approach that employs computer vision for the detection and the pose estimation of the rocket with respect to the landing pad for retro landing. The algorithm mainly focuses on the data obtained from the optical sensor. The sensor data is filtered for noise using equalization and canny edge algorithms. A Convolutional Neural Network (CNN) is used for detection and recognition of the landing pad. The CNN model, after recognition of the landing pad, measures the distance and the position of the landing pad with respect to the rocket. The landing pad is printed with a specific pattern and reference marker. The pattern is used for attitude determination and the reference marker is used during the final course of landing. Extended Kalman filter is used for attitude estimation with the attitude data from the optical navigation system, the Inertial Measurement Unit and predictive dynamic model of the system. The data obtained after the estimation is fed into the control system architecture.

A robust 3-axis stabilized, coupled attitude and position control system is required to control and stabilize the rocket with high precision in the final landing phase with a negligible margin of error in the presence of disturbances such as wind gusts. The reaction control system is designed to meet the precision and agility requirements under heavy mass and space constraints. The latency of a hybrid engine is considered in control system architecture to provide real-time control of the rocket during the descent phase. Simulations and static tests were conducted to finalize the design. The above research demonstrates the feasibility of a vision-based OGNC system for retro-landing rockets and is being implemented on a hybrid propelled rocket.