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TRAJECTORY PLANNING AND MONTE CARLO SIMULATION OF RE-ENTRY VEHICLE DURING A/L PHASE

Abstract

Space shuttle is developed at 1980's and has been operated continuously. Recently, space tour concept is appeared as well as transportation service to space, Reusable Launch Vehicle (RLV) which is alternative concept of space shuttle for reducing launch cost is one of the principle research fields in space technology.

Trajectory planning is important to land on the desired location in high accuracy. In reentry phase, various disturbances affect reentry vehicle, so onboard trajectory planning is necessary. In this study, Trajectory Planning using Geometric Parameters (TPGP) algorithm is studied for approach and landing onboard trajectory generation and the monte carlo simulation is performed for the verification of robustness.

The A/L phase, third phase of re-entry stage, consists of altitude range from 3 km to touchdown. A/L phase is separated by Steep Glide-Slope phase, Circular Flare phase and Flare Maneuver phase. The initial condition of A/L phase trajectory is parameters from final conditions of TAEM phase and the final condition is the touchdown, and each phase has geometric characteristics.

The process of TPGP algorithm is roughly separated in 4 steps. At first, flight path angle is determined to make the change of dynamic pressure into zero in the SGS phase. Next, trajectory which satisfies the vertical descent rate constraint is integrated backward from the touchdown point. This phase is referred to FM phase, and trajectory is generated by the cubic equation in this part. Third, trajectory of CF phase is generated to connect initial position of FM phase with the final position of SGS phase, and its shape is a circular arc. Finally, SGS capture phase is generated by the cubic equation as same as FM phase. SGS capture phase is generated for connecting final conditions of TAEM phase with calculated SGS phase smoothly.

The RLV is affected by many effects because the altitude range is close to ground in the A/L phase. These disturbances make it hard to follow the generated trajectory, and it requires the re-calculated trajectory. For this reason, wind effect, lift variation, drag variation and initial conditions (flight path angle, energy) are considered as perturbed parameters. The robustness verification is performed using simple guidance and control method. The vehicle is guided by normal acceleration command, and PD controller based fuzzy theory is used for simulation.