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FULLY AUTONOMOUS ASCENT GUIDANCE FOR SMALL COMMERCIAL SOLID ROCKET

Abstract

Due to low cost, short preparation cycle, and quick launch ability, the solid propellant launch vehicle has drawn significant interest in commercial launch. In china, almost all the recently developed commercial rockets adopt solid propellant, especially focus on the small solid rocket. However, the existing ascent guidance methods are hard to support these rockets to fully achieve these abilities. Even though plenty of close-loop optimal guidance methods has been proposed, most of them aim at exo-atmospheric phase and in the atmosphere, the traditional open-loop mode is still used. This not only leads to the decrease of performance and precision, but also needs much offline work to design open-loop trajectory for specific mission. Considering this, a fully autonomous ascent guidance method used for small commercial solid rocket is designed in this paper. This method adopts the recently developed Generalized Quasi-Spectral Model Predictive Static Programming(GS-MPSP) technique, in which the control vector is represented by the spectral functions and the accordingly sensitive matrix is computed using the gaussian quadrature collocation method rather than recursive manner. Due to the efficiency of the sensitivity matrix computation as well as of the improved static programming, this technique has superiority computational efficiency compared to the existing MPSP approach. In practice, the elapsed time for each command generation can be lower than 0.01s. Based on this technique, the real-time, optimal and smooth command generation that satisfies terminal orbit constraint can be achieved. Besides, this technique is further extended to fulfill the requirement of ascent guidance. First, an integral type performance index is introduced to achieve the optimization aim at fuel assumption. Second, the aerodynamic bending moment constraint is considered, which is important for the safe of flight in the atmosphere. The proposed method is used to a four stage solid rocket to demonstrated its performance. A comparison with the traditional methods is also conducted. The results indicate the effectiveness of the proposed method that has an increase of 10% in payload and 30% on injection accuracy, compared with the traditional method, for the specific LEO mission.