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A RADAU PSEUDOSPECTRAL METHOD-BASED GUIDANCE REENTRY ALGORITHM

Abstract

Atmospheric Reentry has always been hard problem for engineers since the beginning of the first space missions. The challenge is made hard by all the constraints that must be taken into account, such as dynamic pressure, load factor, heat flux, as well as other variables, like the manoeuver limits of the spacecraft and the need to reach a precise final position within relatively small limits (it is obvious that an error for example of relatively small values with respect to the trajectory length, e.g. 5 km is not acceptable in a real mission). Finally, other environment uncertainties like the wind should be considered. Many methods have been developed over the years, and many of them are based on offline precomputed trajectories, like in the case of Space Shuttle, which worked well. However, new increased, computational power allows new, only partially explored, possibilities. Moreover, more flexible approaches are able to better deal with the several (and only partially foreseeable) in-flight scenarios that can be experimented during a real mission. These considerations give us the premise for the development, in the frame of DLR-led mission Shefex-3, of a new algorithm based on pseudospectral method in order to generate an optimal trajectory, and the corresponding guidance and control to successfully complete the mission in real time. The biggest advantage of this new approach is an increased ability to adapt the trajectory to the effective, current inflight situation, which yields improved performances compared with a precomputed reference trajectory. Additionally, operational costs are reduced in significant way, since less mission analysis is required and a similar module can be reused more easily than a unique reference precomputed static trajectory. In this paper, after having introduced the Shefex-3 mission, an overview on pseudospectral methods will be given, with a particular emphasis on Radau method, the transcription of the optimal control problem as NLP will be derived and implemented using WORHP optimizer. Moreover, the results found for several simulations will be shown and analysed in order to be sure that for each case all the constraints of the problems are fulfilled along the generated trajectory.