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THE OPTIMAL FUEL-CONSUMPTION MULTI-IMPULSE RENDEZVOUS TRAJECTORY DESIGN USING WHALE OPTIMIZATION ALGORITHM.

Abstract

The optimal rendezvous trajectory design has been studied to save time and fuel for efficient rendezvous missions. In the close-range rendezvous, there is a possibility of the collision caused by several common failures such as thrust control ceases. For this reason, the rendezvous trajectory design methods should consider not only efficient fuel consumption but also trajectory safety. In this problem, design methods using optimization algorithms have been studied to obtain the optimal rendezvous trajectory with the safety constraints. However, it is difficult to find the optimal rendezvous trajectory because of the performance of the optimization algorithms. In this paper, we studied the optimal fuel–consumption multi-impulse rendezvous trajectory design using whale optimization algorithms (WOA). First, we constructed the mathematical model based on the Clohessy-Wiltshire (CW) equations. The CW equations of motion are widely used for designing the proximity relative motion in space rendezvous. And then, an optimization model including several kinds of constraints such as the minimum time between imposing impulse, the total velocity change magnitude, the maximum impulse magnitude, and the passive trajectory protection was established to represent a practical rendezvous. The passive trajectory protection is to design all trajectory elements such that the resulting free trajectory will remain collision-free even if a thrust control ceases. Second, we introduced the WOA with both stronger global searching ability and faster convergence speed. And we compared the WOA with other optimization algorithms to verify the performance and efficiency in practical rendezvous problems. Finally, numerical simulation was performed to acquire the optimal three-impulse rendezvous trajectory. The optimal rendezvous trajectory is calculated by using WOA and our mathematical model. As a result, we have confirmed that our approach is effective in obtaining a global solutions and can save more propellant. Therefore, we expect our study contributes to efficient rendezvous trajectory design.