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AN IMPROVED SHAPE-BASED METHOD USING FOURIER SERIES FOR LOW-THRUST ORBIT DESIGN

Abstract

Low-thrust trajectory design in space mission is becoming increasingly popular. Thanks to its high specific impulse, low-thrust propulsion offers several advantages, but orbit design and optimization become complex and computationally demanding. The shape-based method can provide suitable initial guesses for trajectory optimization, which is benefit to converge a more accurate trajectory quickly. However, the disadvantages of traditional shape-based methods are also obvious. Traditional methods did not consider the first order optimal necessary conditions, thus cannot guarantee an optimal preliminary orbit. Besides, the thrust direction is assumed to be tangential, and the flight time is usually known prior. In this paper, an improved shape-based method using Fourier series is proposed, it can avoid those shortages mentioned above. Firstly, an improved spacecraft dynamics model without time variable in polar coordinate is developed. Secondly, the first order necessary conditions are derived from the Hamilton function, and through the series expansion of the state variables, the optimal control problem is converted to a nonlinear programing problem with Fourier series coefficients. Lastly, Escape trajectory case and orbit raising case are used to verify the applicability of the proposed method for time-free low-thrust orbit design. The advantages of the proposed method in offering initial guess are proved by comparison with the traditional shape-based methods.