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LOW-THRUST MINIMUM-TIME ORBITAL TRANSFER USING PICARD-CHEBYSHEV HOMOTOPY METHOD

Abstract

As the title of this research topic suggests, the interest in low-thrust spacecraft trajectories among engineers and scientists arises from its potential to significantly reduce space mission costs and enhance the reliability and flexibility of complex missions. However, optimizing low-thrust trajectories presents challenges, including extended flight times and a narrow convergence window based on the initial trajectory guess. The pursuit of efficient and versatile space mission design has led to the increasing adoption of low-thrust propulsion systems. These systems, characterized by their continuous and low thrust, provide unique orbital transfer capabilities and promise longer mission durations and reduced propellant requirements. However, optimizing trajectories for spacecraft with low-thrust engines remains a complex challenge. This research study investigates the application of the Picard-Chebyshev homotopy Method (PCM) to optimize low-thrust trajectories with a focus on minimizing flight time. The objective of the trajectory optimization in the orbital transfer problem is to minimize the time required for orbital transfers. To address this, PCM based on homotopy is used as a problem-solving tool for numerical optimization, determining the spacecraft's minimum-time orbital transfer trajectory. Motivated by the potential computational efficiency and flexibility through the PCM, our research addresses its practical implementation to optimize low-thrust trajectories. By systematically examining the low thrust scenario, this study aims to provide valuable insights into the field of orbital mechanics and trajectory optimization. Numerical results demonstrate the validity and computational efficiency of this proposed homotopy method. The analysis of numerical results in the context of low-thrust problems, as a part of the homotopic approach, is discussed towards the end of the research. The results of this research not only aim to provide a robust methodology for optimizing low-thrust trajectories but also aim to improve our understanding of the challenges and opportunities associated with low thrust scenarios. As space exploration continues to evolve, the results of this study are expected to help refine mission planning techniques and further advance the use of low-thrust propulsion technologies in future space missions.

Keywords: Low-thrust, Orbital transfer, Trajectory optimization, Picard-Chebyshev, Homotopy method