ICCES, 2023, vol. 25, no.4
DOI: 10.32604/icces.2023.09294

PROCEEDINGS

Optimal Plasma Plume Detumbling and Prescribed Performance Control for Tumbling Spacecraft

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ABSTRACT

Detumbling is a crucial first step for on-orbit service and space debris removal. Plume is an efficient medium for failed spacecraft detumbling which can avoid direct contact to ensure the safety of the spacecraft. However, traditional molecular plume may lead to an unaffordable fuel consumption. This paper proposes a novel detumbling strategy by using plasma plume with the popularization of Hall effect thrusters on spacecraft. To overcome the difficulty of real-time calculation in traditional models, a fully analytical plasma plume model is established which can improve the autonomy of the chaser[1]. An optimal detumbling guidance law is proposed to mitigate the spin angular velocity while stabilizing the nutation by adjusting the direction of the plasma plume and the position of the chaser in real time[2]. In order to improve the control efficiency of the chaser, a prescribed performance framework is established and a terminal non-singular sliding mode controller (TSM) is designed in this framework[3]. This adaptive controller is used to track the time-varying desired chaser position to realize closed loop control. Numerical results indicate that the proposed plasma plume model can significantly improve the computational efficiency and the optimal guidance law can stabilize the target within an acceptable time. Compared with traditional control methods, TSM controller shows better stability and faster convergence under nonlinear disturbance. This study provides important technological supports for autonomous spacecraft detumbling.

KEYWORDS

Spacecraft detumbling; plasma plume; optimal guidance law; prescribed performance control

Funding Statement: This work was supported by National Key Research and Development Program of China (No. 2021YFA0717100). Honghua Dai received this grant, and sponsors' website is "service.most.gov.cn".

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

References

1. Dai, H. H., Zhao, H. Q., Yue, X. K. (2022). Plasma detumbling of failed spacecraft by using hall effect thrusters. *Journal of Guidance, Control, and Dynamics, 45(12),* 2389-2397.
2. Liu, Y., Pan, Y., Li, Q. (2018). A Research on Strategy of Plume Impingement De-Tumbling Technology. *2018 Chinese Control and Decision Conference (CCDC)*, pp. 4539-4544. Shenyang, China.
3. Madani, T., Boubaker, D., Karim, D. (2016). Non-singular terminal sliding mode controller: application to an actuated exoskeleton. *Mechatronics, 33,* 136-145.