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PROCEEDINGS

A Data-Driven Model for Real-Time Simulation of the Contact Detumbling of Satellites

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ABSTRACT

The number of malfunctioning satellites is dramatically increasing with the development of space technology in recent decades. These malfunctioning satellites are normally in rotating or tumbling states due to residual angular momentum, gravity gradient, et al, making direct capture impossible. Therefore, stabilizing these objects within acceptable angular velocities is an indispensable stage for in-orbit capture. The contact method using a flexible device (e.g., brush or rod) to detumble these satellites is considered to be safe and efficient enough. However, it is extremely time-consuming to solve the dynamic model of the detumbling system, which is a very tricky problem for in-orbit computation and real-time simulation. There are two main limitations: (i) The finite-element-based dynamic model of the large-deformation device is high-dimensional. (ii) The contact-impact model depends on small time steps to correctly describe the contact-impact process. To address this problem, this paper proposes a data-driven model to simplify the dynamic model of the large-deformation device and the contact-impact model. The large-deflection cantilever beam under the follower force is utilized to describe the deformation of the flexible device in any moment of the contact process. Huge amounts of data, covering all deformations of the device during contact, can be got by solving a series of differential equations based on the Euler-Bernoulli beam theory. Then, the data is trained by the neural network method to obtain the data-driven model that maps the deformation of the flexible device and the contact forces acting on the device. Finally, the simplified model of the detumbling system is established by combining the data-driven model, the robot model, and the target satellite model. Simulation results verify that the data-driven model is reliable and the real-time simulation is feasible.

KEYWORDS

Detumbling satellites; contact detumbling method; data-driven model; real-time simulation

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