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Nonlinear Dynamics of a Flexible Tether-Net System for Space Debris Capture

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ABSTRACT

Here, a flexible tether-net system is applied to capture the space debris and a numerical framework is established to explore its nonlinear dynamic behaviors, which comprises four principal phases: folding, spreading, contacting, and closing [1]. Based on the discretization of the whole structure into multiple nodes and connected edges, elastic force vectors and associated Jacobian matrix are derived analytically to solve a series of equations of motion. With a fully implicit method applied to analyze the nonlinear dynamics of a slender rod network, the involved mechanical responses are investigated numerically accounting for the interactions. Contact between the deformable net and a rigid body is handled implicitly through a cost-effective modified mass algorithm while the catenary theory is utilized to guide the folding process (from planar configuration to origami-like pattern). The dragging and spreading actions for the folded hexagon net could be realized by shooting six corner mass toward a specific direction; next, the six corners would be controlled to move along a prescribed path producing a closing gesture, when touch between the flying net and the target body is detected, so that for the space debris could be captured and removed successfully. We think the established discrete model could provide a novel insight in the design of active debris removal (ADR) techniques and promote further development of the model-based control of tether tugging systems.

KEYWORDS

Tether-net system; geometric nonlinearity; contact mechanics; space debris capture

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