Deployable cable nets for active removal of derelict rocket bodies

Paolo Fisicaro[1,*], Angelo Pasini[1], Paolo S. Valvo[1]

[1]University of Pisa, Italy

* Presenting author: paolo.fisicaro@ing.unipi.it

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Spent rockets and defunct satellites represent most of the mass of the current space debris population. Such objects constitute the main sources of small-size debris, that are produced mostly because of break-ups and collisions. Enabling the technology for their capture is one of the steps needed towards the development of an effective active debris removal (ADR) mission.

Tethered nets has been considered for the capture of derelict non-cooperative vehicles, since their employment would simplify the approaching manoeuvres to the target. Besides, cable nets are light, easily packable, scalable, and versatile, even though modelling their behaviour in the capture and post-capture phases is not a trivial task.

Two main mechanical models have been proposed to describe the deployment and capture processes by using cable nets. In the first approach, the net is considered as a system of concentrated masses connected to each others by spring-dampers. Springs react only in tension and infinitesimal strains are considered [1, 2]. Alternatively, a finite element model of a cable net can be developed according to the absolute nodal coordinate formulation (ANCF). In this case, finite strains are considered through the Green-Lagrange strain tensor and a weak flexural behaviour for the cable can be included [3].

We developed a new finite element model for the cable net, adopting the nodal positions as the main unknowns of the problem in line with the displacement-based finite element formulation (DFEF) [4]. Large displacements and finite deformations are considered through the Green-Lagrange strain tensor. Cable elements are assumed to react only in tension according to a hyper-elastic constitutive law [5]. Global damping is introduced into the model according to Rayleigh's hypothesis. The governing equations for the dynamical problem are solved numerically by means of the Newmark method.

As an illustrative example, we present the simulation of the three-dimensional deployment of a planar, square-mesh net. The proposed approach turns out to be computationally effective and accurate.

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