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VALIDATED SIMULATOR FOR SPACE DEBRIS REMOVAL WITH NETS AND OTHER FLEXIBLE TETHERS APPLICATIONS

Abstract

Purpose

In the context of active debris removal technologies and preparation activities for e.Deorbit mission, the simulator for net-shaped elastic bodies dynamics and their interactions with rigid bodies was developed. Its main application is testing of scenarios for space debris deorbitation with nets and designing nets themselves, but it is also able to simulate any system of rigid bodies and elastic tethers. The underlying model is experimentally validated.

Methodology

Simulator models all phases of debris capturing process: launch of the net, its flight and wrapping around the target. It's a coupled simulation of rigid and flexible bodies dynamics. Flexible bodies are implemented using Cosserat rods model, which allows to simulate flexible threads (wires, cables, cords, etc.) with elasticity and damping for stretching, bending and torsion. They may be combined into structures of any topology, so the software is able to simulate nets, pure tethers, tether bundles, cages, trusses, etc. Involved model and numerical method allow to handle very large number of DOFs at reasonable computational cost. Full and efficient contact dynamics is implemented for rigid and elastic objects. Programmatic interaction with simulation is possible – i.e. for control implementation or simulation of actuated mechanisms.
Validation experiment was performed in parabolic flight. It was wrapping a satellite model with throw net. Full 3D trajectories of individual net knots were reconstructed and compared to simulations to validate the simulation tool.

Results

Validation results show that model reflects physics accurately enough, so it may be used for scenario evaluation and mission design purposes. Also the benchmarks performed prove that the simulation engine is robust enough to be involved in such demanding tasks as Monte Carlo campaigns or simulation supported iterative design of space systems with close to real-time speed.

Conclusion

Functionality of the simulator is described in detail in this paper, as well as its underlying model, sample cases and methodology behind validation. Results are presented and typical use cases are discussed showing that the software may be used to design throw nets for space debris capturing and deorbitation, but also to simulate general interactions between rigid and elastic bodies or to design control for tethered systems – all in convenient and efficient way.

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