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► To cite this version:

Victor Romero, Mickaël Ly, Abdullah Haroon Rasheed, Raphaël Charrondière, Arnaud Lazarus, et al.. Physical validation of simulators in computer graphics. European Solid Mechanics Conference - ESMC 2022, Jul 2022, Galway, Ireland. pp.1 - 19, 10.1145/3450626.3459931 . hal-03960328

HAL Id: hal-03960328

<https://inria.hal.science/hal-03960328>

Submitted on 27 Jan 2023

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Physical validation of simulators in Computer Graphics

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Keywords: Slender elastic structures, dry frictional contact, code benchmarking..

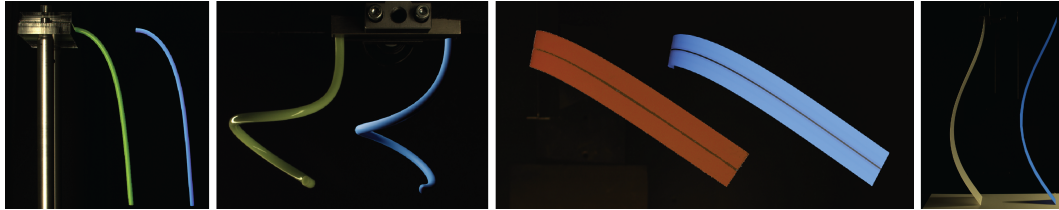


Fig. 1: Experiments and simulations of slender objects side-by-side for our four validation protocols. From left to right. **Cantilever test**, Discrete Elastic Rod simulation. **Bend-Twist test**, Super-Helix simulation. **Lateral Buckling test**, FenicsShell simulation. **Stick-Slip test**, Argus simulation.

Slender elastic objects, such as rods, shells or plates, exhibit a rich behaviour driven fundamentally by geometrical non linearities. Theoretical or experimental approaches for this kind of systems, while very important, are usually not enough for a complete and comprehensive description, and numerics has proven to be a versatile tool to systematically explore phenomena observed in these kind of systems.

For decades the Computer Graphics (CG) community has developed highly efficient numerical engines for diverse complex scenarios, among which one can find a large set of solvers specifically dedicated to slender elastic objects. However, these simulators were originally designed for feature film animation and visual effects, hence they are rarely validated in any methodical way and only aim for visual plausibility. To take advantage of the huge potential of all this work, we evaluate the physical realism of CG simulators for slender structures and frictional contact by using 4 protocols from the soft matter physics community [1]. Our tests, experimentally verified, are designed to evaluate carefully the predictability of these simulators on various aspects, such as bending elasticity, bend-twist coupling, and frictional contact. We have passed a number of well-known, free, and open-source codes of Computer Graphics through our benchmarks by defining a rigorous, consistent, and as fair as possible methodology. Our results show that while some popular simulators for plates/shells and frictional contact fail even on the simplest scenarios, more recent ones, as well as well-known codes for rods, generally perform well and sometimes even better than some reference commercial tools of Mechanical Engineering.

References

- [1] Victor Romero, Mickaël Ly, Abdullah Haroon Rasheed, Raphaël Charrondière, Arnaud Lazarus, Sébastien Neukirch, and Florence Bertails-Descoubes. “Physical validation of simulators in computer graphics: a new framework dedicated to slender elastic structures and frictional contact”. *ACM Transactions on Graphics* 40, 4 (2021). DOI: [10.1145/3450626.3459931](https://doi.org/10.1145/3450626.3459931)