Elastica compass, elastica catapult and soft robot arms

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The key to the design of soft structures lies in the development and use of nonlinear mechanical models, among which, the Euler's elastica allows the description of large deflection of elastic rods. A basic problem of soft robot arm [1], [2], [3], [4], [5] is addressed through new theoretical, numerical, and experimental developments. The large deflection of a cantilever beam are considered, with its free end subject to a dead load, in the case when the clamp is subject to a continuous rotation. When the load is lower than that corresponding to buckling, the system behaves as an *elastica compass*, so that smooth transitions of the deformed shape are observed and the free end traces a closed curve, which approaches a circle as the stiffness of the rod is increased. Differently, when the load is higher than that leading to buckling, an unstable configuration is reached at a specific value of the clamped angle and the rod displays a snap back instability, realizing an "elastica catapult" which resembles a drawing by Leonardo Da Vinci. An analytical model is developed to predict the critical angle for which the snap back occurs, while the subsequent dynamic motion is simulated through the definition of a specific numerical procedure. A specifically designed experimental set-up is realised to investigate the structural system and to validate the reliability of the theoretical results. Furthermore, the presented solution represents a useful tool in the design of a soft robot arm, whose performances have been investigated in terms of the distances that can be reached.

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