The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Simulation of soft robots with nonlinear material behavior using the cosserat rod theory

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Keywords: *Soft Robotics, Cosserat Rod, Nonlinear Material*

Soft material robots are an emerging and fast-growing field of research with potential application in various technical fields. These applications include, but are not limited to, medical applications, gripping applications and all sorts of human-machine-interaction. In contrast to conventional rigid robots usually soft robots are made of soft materials, like silicone, that undergo large deformations. Therefore, besides new actuators and sensors also new modeling concepts are currently developed.

Many soft robots use the bending deformation of long slender rods to generate the necessary motion. For example, the fingers of a flexible hand can be modeled as such a deformable rod. Therefore, besides piecewise constant curvature models various rod theories are very popular for modeling soft robots. Especially different forms of the Cosserat rod theory are widely used [1].

In this contribution a simple soft robot segment based on [3] is modeled with the geometrically exact rod theory in the form of [2]. While in [2] linear material is assumed, this model is extended here with different nonlinear material laws to allow a more accurate modeling. For a practical use of these models an easy way to determine the required material parameters for a real robot is of importance. Additionally, for model-based control the computation time is of great importance. Therefore, the different models are compared concerning the achievable accuracy, the required computation time and the effort to determine experimentally the required material parameters of the model from a real robot.

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