Spatial nonlinear beam theory for soft pneumatic actuators

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In the emerging research field of soft robotics recent investigations examine how cylindrical beam like structures made of silicone can be described using spatial nonlinear beam theories. These structures are frequently actuated by inflating multiple eccentrically embedded pressure chambers. The talk extends the classical spatial nonlinear beam theories, given in the variational framework of the principle of virtual work, by pressurized chambers. This contains the formulation of the internal virtual work contribution of the pressurized medium which is restricted to the beam-like kinematics of the enveloping material. Using the principle of virtual work, which demands the total virtual work to vanish for all admissible virtual displacements, the equilibrium equations follow by an integration by parts procedure. The silicone's elastic material response is modeled by using a nonlinear Ogden-like material law for the beam's axial direction. Further, the radii of the embedded pressure chambers are linearly coupled with the applied pressure. The unknown material parameters of the proposed material laws are identified using an optimization procedure with respect to selected experimental measurements. The talk is completed by showing that the proposed model together with the identified material parameters is capable of reproducing the results of a different unknown experiment.