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AN ACCURATE AND GENERIC FRAMEWORK FOR REAL-TIME FINITE ELEMENT METHOD SIMULATION OF SOFT ROBOTS USING MODEL ORDER REDUCTION

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Soft robotics is a new trend in robotics where robots are made of compliant materials, rather than rigid metallic ones. This leads to several potential benefits, such as manipulation of fragile object, exploration of narrow cavities, safe interaction with the environment, or simply the possibility to build those robots at low cost. These advantages come at the price that modelling soft robots is far from trivial since the robots have a high number of degrees of freedom and few actuators in comparison. Controlling those robots and let alone, simulating their deformation, is a challenging task since in the general case, deriving an analytical kinematic model is not feasible. It is hence necessary to use an approximation through a numerical method, typically the finite element method (FEM). In [1, 3], FEM was used successfully on different kind of soft robots, but using coarse meshes and artificially simple constitutive laws (linear elasticity) of the materials involved.

In this contribution, we use a projection-based model order reduction approach to reduce the cost of the FEM simulation, and we show that we are able to compute the deformation of the soft robots accurately and in real-time. The main deformations of the robot are captured in an attractive subspace of small dimension using the proper orthogonal decomposition (POD) [2]. To keep the numerical efficiency of the reduced model, a hyperreduction method is used. The method is tested assuming a hyperelastic Mooney-Rivlin law for silicone.

This opens up the possibility to control soft robots interactively and in a reliable way. We show various examples, including some contacts of the robot with its environment.

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