Plant-inspired actuator, motion prediction and measurement.

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Abstract

The pulvinus of Mimosa pudica (Touch-me-not plant) is a fast motion-generating organ resilient to damage. It is made of roughly 350 000 cells that may inflate or deflate to create motion by deformation. Based on this functioning, we investigate the possibility of creating a versatile and resilient actuator made of pressurizable cells.

We present a 64-cells prototype that moves in 3D. The control of such an actuator with 64 degrees of freedom is complex. We investigate two models to predict the shape of the actuator considering different pressure patterns: (i) A rough modeling of the deformations at the cellular level combined to a kinematic chain (Denavit–Hartenberg parameters) and (ii) A neural network model trained on finite element simulations. The two predictions are compared with the physical prototype.

The neural network is very efficient at determining the shape of the actuator. It is more accurate than the analytical model. It is extremely light (50 ko), runs in a web browser and is trained in a few seconds on a laptop. The most consuming step is the training data generation by numerical simulations (FEA).

Finally, we show that considering small deformations and a linear material the neural network is equivalent to an optimization by Moore-Penrose inverse matrix.

These findings represent an important step forward in understanding the movement mechanisms of pressurized cellular actuators and provide a solid basis for further exploring the resilience induced by the multi-scale architecture of the pulvinus of Mimosa pudica.

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