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Modelling geometrically constrained fluidic soft actuators

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The study of soft robots has been receiving significant attention, due to the potential for soft robots to be used in a variety of applications, such as medical devices, search and rescue devices and assistive robots. As the field of soft robotics continues to grow and develop, it is increasingly important to have access to a library of soft actuators, capable of producing many different motions. Fluidic soft actuators have the potential to achieve complex motions with simple control inputs. These complex motions are often achieved by imposing geometric constraints on the actuators.

Here, we analyse cylindrical elastomeric actuators with constraints in the form of fibres arranged helically around the outside of the actuator. When an actuator of this type is pressurized, it extends axially, expands radially, and twists about its axis. We use the theory of nonlinear elasticity of anisotropic materials to derive an analytical model describing this deformation. This model describes how the deformation of the actuator upon pressurization depends on the initial constraint geometry. The idea of using geometric constraints to influence actuator deformation can be extended to 'two dimensional' actuators. We consider flat sheets containing embedded channels, which can be fluidically actuated to take on the shape of a two dimensional surface embedded in three dimensional space. We use analytical modelling and finite element simulations to demonstrate how we can design the initial geometry of the sheet so it achieves a desired configuration when actuated.