Soft Robotics and Morphological Computation

How material properties shape robot behavior

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Soft robotics is redefining the boundaries between mechanics, materials science, and computation. Unlike conventional rigid robots, soft robotic systems leverage the intrinsic properties of compliant materials (elasticity, nonlinearity, and stimuli-responsiveness) to generate adaptive behavior without centralized control. This paradigm, known as morphological computation or embodied intelligence, treats the material body itself as an active computational substrate, encoding sensing, actuation, and control into the physical architecture of the robot.

Two examples illustrate how targeted exploitation of material properties can give rise to complex functional behaviors. In a soft pump for an artificial heart ventricle simulator, the large deformability of an elastomeric shell is harnessed to trigger mechanical instabilities, transforming a simple actuation input into a highly efficient pumping stroke. In a magnetically-loaded elastomer composite, the magnetic responsiveness of the material is exploited to investigate resonance principles for actuators without rigid components or piezoceramics.