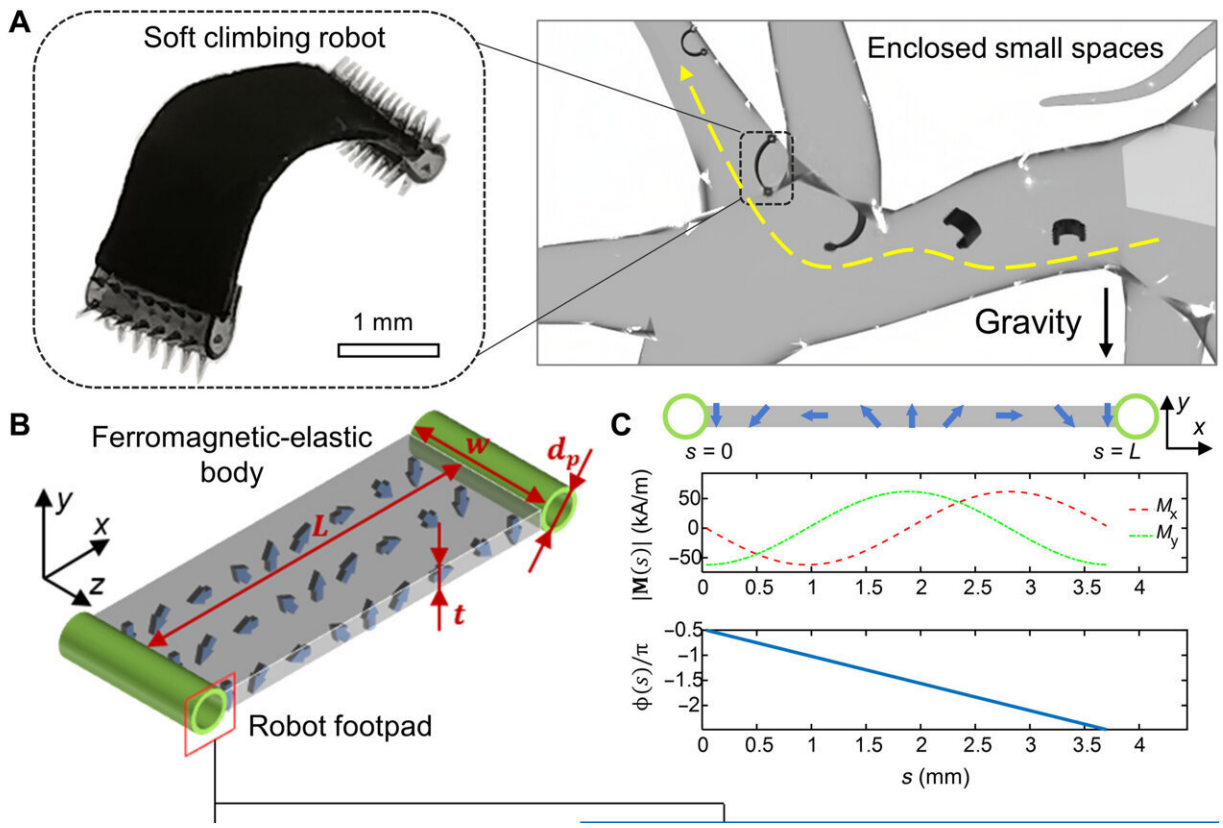
A millirobot for climbing around in the gut to deliver drugs

May 30 2022, by Bob Yirka



Wireless millimeter-scale soft climbing robot capable of traversing complex 3D surfaces in enclosed and confined spaces. (A) The concept of the soft climbing robot reaching spots previously inaccessible in enclosed small spaces. Left: Image of the deformed soft climbing robot controlled by external magnetic fields. Right: Illustration of climbing in enclosed small spaces. (B) Dimensions of the soft climbing robot with a ferromagnetic soft body (length, L = 3.7 mm; width, w = 1.5 mm; thickness, t = 150 μm). The robot has two nonmagnetic soft footpads with a flat surface for rigid substrates or a structured surface for

slippery and deformable surfaces. (C) The magnetization profile of the soft climbing robot. Magnitude profile, M(s); phase profile, $\phi(s)$, $s \in [0, L]$. The blue arrows indicate the distribution of magnetic dipole moments. (D) Illustration of the robot footpad with mushroom-shaped dry adhesives for climbing 3D dry and rough surfaces. (E) Illustration of the unique robot footpad with both coated bioadhesives and microspikes for climbing tissue surfaces covered by mucus. Photo credit: Yingdan Wu and Xiaoguang Dong, Max Planck Institute for Intelligent Systems. Credit: *Science Advances* (2022). DOI: 10.1126/sciadv.abn3431

A team of researchers at the Max Planck Institute for Intelligent Systems, has designed and built a tiny millipede-like robot that can climb around in the gut to deliver therapeutic drugs. In their paper published in the journal *Science Advances,* the group describes the inspiration for the robot, how it was built and how well it worked when tested on animal tissue.

The researchers began their work by noting that soft-bodied robots capable of moving around inside confined spaces have already been developed. But they also noted that improvements needed to be made to allow for controlled surface adhesion and long-term retention on three dimensional objects. That led them to design their own tiny robot that could overcome problems encountered with other designs. The result of their efforts was a tiny robot, just a few millimeters long, with tiny feet that stick to the mucus covering internal organs without leaving damage behind as the robot walks. The millirobot was also able to climb in any direction, even upside down, and was able to maintain its grip even when liquid was flushed over it.

The key to the success of their robot, the researchers claim, is the feet. They first tried footpads that clamped onto tissue but found it difficult to get them to relax their grip. They finally settled on spiked footpads made

of chitosan, which they note are similar to plant burrs that attach themselves to pant legs during walks in a field. The body of the robot was made of flexible metal and it was directed using a magnetic current. It makes its way across a mucus covered surface by first planting a foot and attaching and then flipping its body over as it releases another foot. The researchers call it "peeling and loading."

The team tested their tiny robot by having it climb around inside a pig lung and digestive tract. As part of the test, they found that they could direct the millirobot down the esophagus and then through bronchial tubes. They also found that they could direct it all the way down the digestive tract. Further testing showed it to be capable of carrying cargo up to three times its own size and up to 20 times its own weight. They suggest that with improvements, the robot could one day be used to take biopsies and to deliver drugs to various parts of the body.

More information: Yingdan Wu et al, Wireless soft millirobots for climbing three-dimensional surfaces in confined spaces, *Science Advances* (2022). DOI: 10.1126/sciadv.abn3431