An intersection of math and biology: Clams and snails inspire robotic diggers and crawlers (w/ Video)

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Engineering has always taken cues from biology. Natural organisms and systems have done well at evolving to perform tasks and achieve objectives within the limits set by nature and physics.

That is one of the reasons Anette Hosoi, professor of mechanical engineering at the Massachusetts Institute of Technology, studies snails. Snails can move in any direction—horizontally, vertically, and upside down—on various surfaces, be it sand, shells, tree barks or slick walls and smooth glass. One of the reasons for this is the sticky substance on their underbellies, which acts as a powerful lubricant and reduces friction during movement.

By studying and adapting the biological properties of the snail to robotic devices, Hosoi's group has been able to create a "RoboSnail," which can climb walls and stick to overhead surfaces much like its living counterpart. Such a device can have potential uses in invasive surgery and oil well drilling, among other applications.

Another organism of interest to Hosoi is the razor clam, which has an amazing ability to dig and wedge itself; it can burrow up to 30 inches in the sand. Hosoi's "RoboClam" has been developed with the intention of understanding the organism's behavior and mechanics as well as to explore the possibility of automated digging devices that use less energy than current technology and equipment.

The researchers found that while digging, the clam's up-and-down movement accompanied by opening and closing of its shell turns sand into the consistency of liquid quicksand. This in turn allows the clam to move quickly through the sand. Similar to the human version, the RoboClam vibrates, changing the solid seabed into fluid, allowing a worm-like foot to push down.

Clam-inspired robotic diggers could find use as automatic tethers and lightweight low-cost anchoring devices for small robotic submarines and even large ships and oil platforms. Devices that burrow into the seabed could also potentially be used as detonators for underwater mines.

Hosoi is not alone in looking to biology to instruct robotics development. Engineers around the world are turning to natural organisms like insects, fish and turtles to inspire the design of robots capable of performing specific tasks that automated devices have traditionally been unable to achieve. Mimicking natural organisms can also aid in improving the efficiency of many applications that are energetically expensive, since biological entities perform the same tasks with much higher efficiency.

It is important to not only copy the animals, but also to understand the biology of their mechanisms in order to take away the key features that allow them to do what they do. These types of biomechanical studies have led to a mutually beneficial partnership between mathematicians and biologists. Biologists can inform mathematical scientists as a goldmine of data is emerging as biology becomes more and more quantified. Mathematicians, in turn, can employ the tools of engineering and computation to analyze this data and offer new insights into the way animals move.

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