Creating a Soft Biomimetic Robotic Snake With an Anisotropically Frictional Skin Design Optimized for a Lateral Undulation Gait for Rubble Search and Recovery

Thinagar, Nichelle (School: Shrewsbury High School)

In the first 6 hours following a building collapse, the chance of finding a survivor is approximately 60%, but drops to less than 10% by the 48th hour. This research developed a soft biomimetic robotic snake with the goal of creating a cost-effective device capable of delivering nutritional aid and facilitating victim-rescuer communication for survivors trapped in rubble until their extraction. To do this, emphasis was placed on the anisotropic friction properties of natural snakes' ventral skin that facilitate their limbless locomotion. Four novel designs for an artificial anisotropically frictional skin were fabricated and tested on a concrete, carpet, and hardwood surface. These designs were compared to a kirigami-inspired design created by Bryanan et. al. The best performing design had a coefficient of static friction delta of 0.359 when comparing forward and backward movement, a significant improvement over the control with $p<0.00001$. This design created directional friction using ball bearings embedded within a deformable silicon skin with scales inserted in it. The scales are designed to generate greater friction when the skin is unstretched. This design was then refined due to constraints introduced by an initial full-system prototype to embed the ball bearings in the scale surface, allowing them to disengage from surface contact when the skin is contracted. A prototype of the final design of the robot was created using the cable actuation of an omnidirectional motion-capable origami structure. The prototype was programmed to replicate the sine-wave motion of a lateral undulation gait. The fully operational soft robotic snake is calculated to cost $3,600, making it more feasible for the local search operations conducted in the first 6 hours following a disaster.

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