UC SANTA BARBARA

THE Current

February 13, 2020
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Growing into Solutions

Picture emergency crews arriving on the scene of a collapsed building. Rather than sending in a canine unit to search for survivors only from the surface, they place a small cylinder near the debris pile and flip a switch. A tube of soft material, folded inside itself, similar to an inside-out sock, extends deep into the pile of rubble, navigating tight angles and slithering its way like a fast-moving vine. Pressurized air, pumped in from a cylinder on the other end, allows the vine robot to grow, pushing tubing through the center of still more plastic tubing. A camera, placed at the robot's tip, allows rescuers to see inside the tight spaces; sensors on its body could guide it toward survivors deep in the rubble.

From aiding disaster relief efforts to helping neurosurgeons remove blood clots from the brains of stroke patients, the soft robot holds tremendous scientific, educational and societal value. Elliot W. Hawkes, an assistant professor of mechanical engineering at UC Santa Barbara, developed this technology with colleagues at Stanford University. As a result, he has now been awarded a prestigious Early CAREER Award from the National Science Foundation. Hawkes will receive more than $600,000 in funding to pursue scientific advancement through the NSF Faculty Early Career Development program.

"Winning the NSF CAREER award is an incredible honor," said Hawkes, who joined UCSB's College of Engineering in 2017. "I feel incredibly lucky and greatly indebted to all of my mentors who have helped me along the way."

“We’re extremely proud of Professor Elliot Hawkes for receiving this important and well-deserved NSF CAREER award, which recognizes his highly innovative robotics research and supports his future endeavors,” said Rod Alferness, dean of the UCSB College of Engineering. “Elliot exemplifies the engineer as problem-solver and solution creator. We offer hearty congratulations to him.”

Hawkes said a vine on a bookshelf in his office inspired the soft robot, which *Science Robotics* named one of its “Ten Robotics Technologies of the Year” in 2019.

“I noticed how the vine had grown, slowly but deliberately, to navigate around a corner of the shelf to gain access to the sunshine,” he recalled. “That’s when I realized that navigating the environment through growth, like a vine, is a compelling way for robots to move. It’s much different than animal-like locomotion, but with interesting limits and benefits.”

In recent years, Hawkes and his team have put vine robots to the test. They created an obstacle course that required the vine robot to travel through glue, nails and ice. A robot pulled a cable through its body while growing above a dropped ceiling. They also helped discover 3,000-year-old tunnels that contained ceramics and human remains during an archaeological dig in an ancient Peruvian temple.

The NSF CAREER award will allow Hawkes to design new robots for potentially life-saving applications by better understanding the factors that govern the movements of vine robots, which offer unique challenges due to their plant-like extension and mechanism of growth.

Hawkes will study a vine robot’s fundamental limits of size, speed and steering dynamics in free space. Analytical models will be followed by hypothesis-driven experiments to examine different vine materials in action. He also plans to examine the behavior of vine robots while they interact in different environments. He will study a robot’s movements as it traverses down pre-existing pathways, like tunnels or blood vessels, and through mediums, such as soil and sand, with no premade paths.

“Through these investigations, we hope to explain the underlying physical principles that will improve our understanding of this type of movement to realize exciting new applications for vine robots and open doors to benefit humans in the home, workplace, hospital and emergency scenarios,” said Hawkes, who received the mechanical engineering department’s Faculty of the Year Award in 2018-19.

Hawkes is interested in pursuing two designs in particular: a burrowing vine robot and a medical vine robot. The burrowing vine robot will enable subterranean navigation by creating a path with water or air emanating from its tip. A medical vine robot could be used by surgeons to safely access a point inside the body for diagnosis and therapy delivery, while imparting little trauma to the patient. Hawkes says the robots, due to their durability and adaptability, could have transformative implications for numerous fields of study.

“Burrowing vine robots could help geologists to investigate soil layers, archaeologists to explore buried ruins, environmentalists to study pollution in soil, biologists to navigate underground burrows, crews to route cables under roads or buildings, and emergency personnel to locate survivors during natural disasters,” said Hawkes. “The medical vine robot could transform minimally invasive procedures in fields such as urology and neurology, be used during endovascular surgeries, and even grow into the lungs to revolutionize emergency tracheal intubation.”

About UC Santa Barbara

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