New simulator helps robots sharpen their cutting skills

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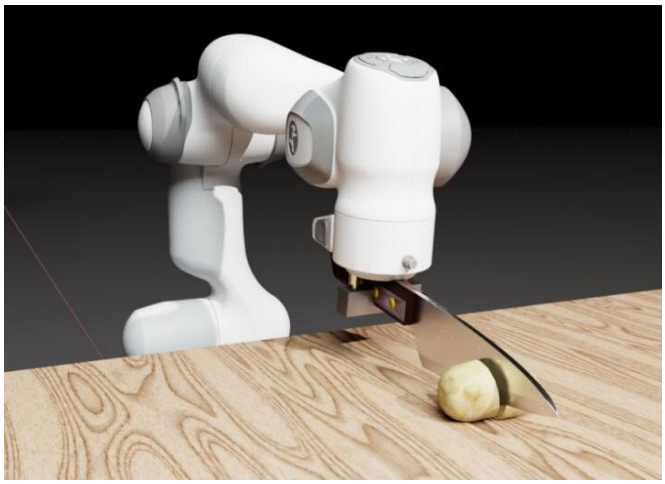

USC PhD student Eric Heiden, working with NVIDIA researchers, has created a new simulator for robotic cutting that can accurately reproduce the forces acting on the knife as it presses and slices through common foodstuffs. Credit: Eric Heiden/NVIDIA

Researchers from the University of Southern California (USC) Department of Computer Science and NVIDIA have unveiled a new simulator for robotic cutting that can accurately reproduce the forces acting on a knife as it slices through common foodstuffs, such as fruit and vegetables. The system could also simulate cutting through human tissue, offering potential applications in surgical robotics. The paper was presented at the Robotics: Science and Systems (RSS) Conference 2021 on July 16, where it received the Best Student Paper Award.

In the past, researchers have had trouble creating intelligent robots that replicate cutting. One challenge: in the real world, no two objects are the same, and current robotic cutting systems struggle with variation. To overcome this, the team devised a unique approach to simulate cutting by introducing springs between the two halves of the object being cut, represented by a mesh. These springs are weakened over time in proportion to the force exerted by the knife on the mesh.

"What makes ours a special kind of simulator is that it is 'differentiable,' which means that it can help us automatically tune these simulation parameters from real-world measurements," said lead author Eric Heiden, a Ph.D. in computer science student at USC. "That's important because closing this reality gap is a significant challenge for roboticists today. Without this, robots may never break out of simulation into the real world."

To transfer skills from simulation to reality, the simulator must be able to model a real system. In one of the experiments, the researchers used a dataset of force profiles from a physical robot to produce highly accurate predictions of how the knife would move in real life. In addition to applications in the food processing industry, where robots could take over dangerous tasks like repetitive cutting, the simulator could improve force haptic feedback accuracy in surgical robots, helping to guide surgeons and prevent injury.

"Here, it is important to have an accurate model of the cutting process and to be able to realistically reproduce the forces acting on the cutting tool as different kinds of tissue are being cut," said Heiden. "With our approach, we are able to automatically tune our simulator to match such different types of material and achieve highly accurate simulations of the force profile." In ongoing research, the team is applying the system to real-world robots.

More information: The full paper (open access) and blog post are available here: diff-cutting-sim.github.io/

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