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Robots With Knives: A Study of Soft-Tissue Injury in Robotics

POSTED BY: ERICO GUIZZO / GIO, MAGGIO 06, 2010

UPDATE: It turns out the brave individual in the video is Sami Haddadin, the study's lead author, who was clearly confident in the collision-detection system he devised. I incorporated some additional details he gave me into the story.

The idea of a robot in the kitchen cooking us meals sounds great. We better just watch out for that swinging knife.

To find out what would happen if a robot handling a sharp tool accidentally struck a person, German researchers set out to perform a series of stabbing, puncturing, and cutting experiments.

They fitted an articulated robotic arm with various tools (scalpel, kitchen knife, scissors, steak knife, and screwdriver) and programmed it to execute different striking maneuvers. They used a block of silicone, a pig's leg, and at one point a human volunteer's bare arm as their, uh, test surface.

The researchers -- Sami Haddadin, Alin Albu-Schaffer, and Gerd Hirzinger from the Institute of Robotics and Mechatronics, part of DLR, the German aerospace agency, in Wessling, Germany -- presented their results today at the IEEE International Conference on Robotics and Automation, in Anchorage, Alaska.

The main goal of the study was to understand the biomechanics of soft-tissue injury caused by a knife-wielding robot. But the researchers also wanted to design and test a collision-detection system that could *prevent* or at least minimize injury. Apparently the system worked so well that in some cases the researchers were willing to try it on human subjects.

We applaud the guy *[editor's note: see update above]* at the end of the video who put his body on the line in the name of robotic science.

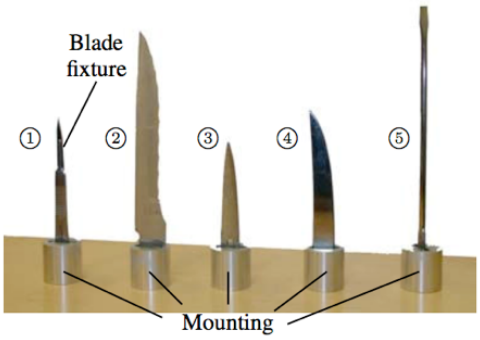
Warning: Some people may consider content graphic or upsetting.

The researchers acknowledge that there are huge reservations about equipping robots with sharp tools in human environments. It won't happen any time soon. (Sorry, you'll still have to chop that cucumber salad yourself). But they argue that only by getting more data can roboticists build safer robots.

The experiments involved the DLR Lightweight Robot III, or LWRIII, a 7 degrees-of-freedom robot manipulator with a 1.1

meter reach and moderately flexible joints. The robot, which weighs 14 kilograms, is designed for direct physical interaction and cooperation with humans.

The tools the researchers tested included [photo, right]: (1) scalpel; (2) kitchen knife; (3) scissors; (4) steak knife; (5) screwdriver.



The researchers performed two types of experiments: stabbing and cutting, testing the different tools striking at various speeds, with and without the collision-detection system active.

In most cases, the contact resulted in deep cuts and punctures, with potentially lethal consequences. But remarkably, the collision-detection system was able to reduce the depth of the cuts and in a few cases even prevent penetration altogether.

Although the robotic arm has a force-torque sensor on its wrist, this sensor is not used in the collision-detection system; it only serves as a measurement reference in the experiment. "The collision detection and reaction," Haddadin told me, "is based on a very good dynamics model of the robot and the fact that, unlike other robots, we have torque sensors and position sensors in every joint."

With the dynamics model (which includes rigid body dynamics, joint elasticity, and motor model) and the sensor measurements, the robot can detect a collision nearly instantaneously. (The control system relies on a "nonlinear disturbance observer.")

"This method does not require any additional external sensors and only relies on the internal capabilities of the robot," says Haddadin.

This is the first study to investigate soft-tissue injuries caused by robots and sharp instruments. Previous studies by the same researchers, as well as other groups, have focused on blunt collisions involving non-sharp surfaces.

The video below shows impact experiments using crash-test dummies and large industrial robots. Ouch.

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