Tiny Toilers: Precision-Controlled Microbots Show They Could Take On Industrial-Scale Jobs [with Video]

Magnetically levitated microbots, some the size of a pinhead, demonstrate construction skills on the small scale

By Steven Ashley | Friday, October 21, 2011

A pioneering research institute that introduced the computer world to the mouse, hypertext and networks is now setting its sights a bit lower. A team of engineers at SRI International, a nonprofit contract research and development lab in Menlo Park, Calif., has harnessed simple, magnetically levitated microbots to build structures and perform other sophisticated tasks at small size scales. Many such floating microbots could be made to work in concert, something like mechanical ant colonies, to construct objects and carry out many other useful applications, says Ron Pelrine, chief scientist at SRI's Robotics, Engineering Research and Development Division. He suggests, for example, that they would be suited for micro-assembly jobs in plants that fabricate micro-electromechanical system (MEMS) chips or rapid prototyping of novel structures with embedded electronics such as sensors and portable diagnostic devices. They might also do small-scale tasks in biological and medical fields such as cell printing or forming complex tissue-growth media. The current laboratory demo devices range from a 0.1 to one centimeter across—about the size of a pinhead to somewhat smaller than the diameter of a AAA battery—tiny enough to carry lightweight objects (such as short lengths of carbon fiber) by attaching them temporarily to manipulator arms using only the feeble surface tension of water droplets. Despite their petite size and basic simplicity, operation of the precision-controlled devices is fast and highly repeatable, characteristics that SRI researchers demonstrate in the video below. The air hockey puck–like devices can move as much as 217 body lengths a second and offer potential motion repeatability to within an estimated 40 nanometers, roughly the diameter of a virus. The next video exhibits the technology's further potential for use in future microscale factories: The magnetic mechanisms are shown scooping up objects onto mini forklifts, actuating syringes and executing rudimentary electric arc–cutting tasks. Another video segment displays the bots moving across surfaces held at steep angles and upside-down as well.

A novel path to microbotics

Microbot research has been growing worldwide in recent years because of the new availability of the necessary parts—minuscule motors, actuators, batteries and so forth, according to Pelrine, who notes, "A lot of the recent work was done by hobbyists, and they've demonstrated more and more capabilities." But as small as the components get, installing new features and functions on the diminutive devices is not getting any easier. "Conventional micro-robots have lots of stuff on them," which often adds to their size, Pelrine says. That's why SRI researchers opted for a different design approach, one that off-loads most complexity and size from the mobile-robot equation. The tiny robotic elements are electromagnetically levitated above the workspace and controlled with digital precision. "What we have is a simple set of magnets to which various tools and end-effectors can be attached," Pelrine explains. The bots, which feature multiple degrees of freedom, are manipulated using magnetic fields that are generated by electric circuits that lie beneath the workspace. "All the complexity of the typical micro-robot system—the power, the sensors and most of the actuation—is off-board," he says. "That keeps things small, simple and low cost."

The fact that the floating bots suffer "zero wear" as they travel could be a key consideration if engineers were to build large systems with thousands of robotic elements, Pelrine adds.

Building smaller

Magnetic microbots could be downsized to operate in even smaller realms, Pelrine continues. Perhaps by using micro-fabricated magnet technology to build the bots themselves, researchers could at some point move manufacturing operations toward the micron size scale. He stresses, however, that such an advance "would no doubt require successive generations" of the downscaled microbots and control systems. Such proposed activity would traverse the macro/micro-scale interface, wherein the bots could perform microscale functions and yet be able to move long distances—centimeters or even meters—to directly interact with the macro world as well. At that size level, for instance, a microbot could work on minute objects using a probe tip like those used in atomic force microscopes and then travel macroscopic distances to carry out other chores such as washing or calibrating the tip.

Well-ordered swarms

On the broader scale, the implications of automated systems with potentially millions of tiny, individually controlled agents could be profound. One might imagine swarms of microbots constructing novel, high-performance materials with microstructures that are engineered down to the grain-size scale, Pelrine says. Even the self-replication of parts by microbots could be feasible, a concept that evokes concepts introduced by K. Eric Drexler in his 1986 book Engines of Creation: The Coming Era of Nanotechnology (Anchor). The SRI team has demonstrated, for example, that the microbots can build end-effectors for other microbots and assemble small robot bodies from magnets to form larger robot bodies. "It's really a new class of machine," Pelrine concludes, "something that is perhaps hard to recognize at present."

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