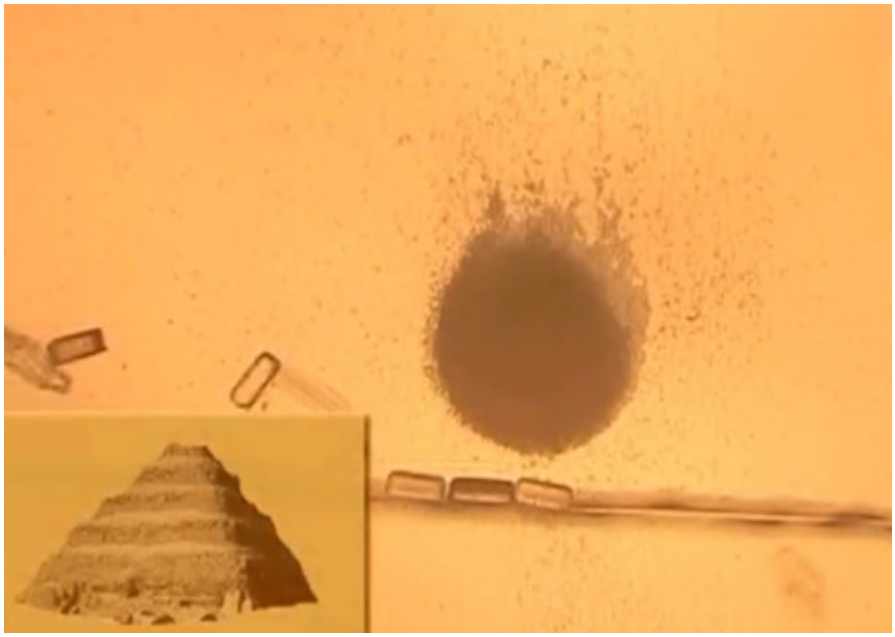
BLOGS // AUTOMATON

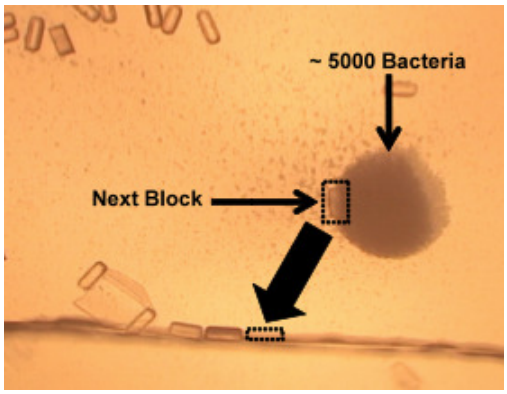
Computer-Controlled Swarm of Bacteria Builds Tiny Pyramid

POSTED BY: ERICO GUIZZO / JEU., MARS 25, 2010



Researchers at the NanoRobotics Laboratory of the École Polytechnique de Montréal, in Canada, are putting swarms of bacteria to work, using them to perform micro-manipulations and even propel microrobots.

Led by Professor Sylvain Martel, the researchers want to use flagellated bacteria to carry drugs into tumors, act as sensing agents for detecting pathogens, and operate micro-factories that could perform pharmacological and genetic tests.



They also want to use the bacteria as micro-workers for building things. Things like a tiny step pyramid.

The video below shows some 5,000 bacteria moving like a swarm of little fish, working together to transport tiny epoxy bricks and assemble a pyramidal structure -- all in 15 minutes.

The video was presented at the IEEE International Conference on Intelligent Robots and Systems last year, along with a wonderfully titled paper, "A Robotic Micro-Assembly Process Inspired By the Construction of the Ancient Pyramids and Relying on Several Thousands of Flagellated Bacteria Acting as Workers."

The bacteria, of a type known as magnetotactic, contain structures called magnetosomes, which function as a compass. In the presence of a magnetic field, the magnetosomes induce a torque on the bacteria, making them swim according to the direction of the field. Place a magnetic field pointing right and the bacteria will move right. Switch the field to point left and the bacteria will follow suit.

Each bacterium has flagella capable of generating about 4 piconewtons. It's a very small amount of thrust force, but put thousands of bacteria to work together and they can move mountains. Well, micro mountains.

Several research groups are trying to develop MEMS devices that emulate the propulsion mechanisms of bacteria. Martel asks, Why mimic the bacteria when you can use the little things themselves?

Martel and his colleagues developed an electronic microcircuit that contains both the bacteria and an array of conductors that produce magnetic fields. By carefully controlling which conductors are active, the microcircuit can make the bacteria move in specific directions. A computer and an optical microscope provide a feedback loop, tracking the motion of the bacteria and adjusting the conductors to achieve the desired behavior.

In addition to pyramid building, Martel's bacteria has done some other neat tricks, such as traveling through the bloodstreams of rats, steered by an MRI system, a la "Fantastic Voyage."

One of their current projects is developing an autonomous bacterial microrobot. They plan to use standard CMOS processes to create a chip containing both electronics and bacteria. The bacteria would reside in micro-reservoirs designed to generate thrust. For control, small conductors inside each reservoir would produce magnetic fields.

Several of these microrobots could then be used to perform tasks collectively, perhaps one day swimming inside our bodies, delivering drugs, detecting disease, and fixing an organ here, a blood vessel there. Who knew bacteria could be good robots?

UPDATE: *If you're wondering which ancient pyramid inspired the researchers -- and is shown in the video on the left bottom corner -- it's the Djoser step pyramid, in Egypt, which the researcher note was "an important, initial milestone in the history of man-made structures."*

Images and video: NanoRobotics Laboratory, École Polytechnique de Montréal