Computer scientists show how bacteria can fuel low-power sensors

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Computer scientists at the University of California San Diego are showing how soil microbes can be harnessed to fuel low-power sensors. This opens new possibilities for microbial fuel cells (MFCs), which can

power soil hydration sensors and other devices.

Led by Department of Computer Science and Engineering (CSE) Assistant Professor Pat Pannuto and Gabriel Marcano, a Ph.D. student working with Pannuto, this research was presented today at the first Association for Computer Machinery (ACM) Workshop on No Power and Low Power Internet of Things.

"Our most immediate applications are in agricultural settings, trying to create closed-loop controls. First for watering, but eventually for fertilization and treatment: sensing nitrates, nitrogen, phosphorous, potassium. This could help us understand how to limit run off and other effects," said Pannuto, senior author on the study titled "Soil Power? Can Microbial Fuel Cells Power Non-Trivial Sensors?"

Current sensors are often powered by batteries or small solar or wind generators, but that creates other problems. Batteries must be changed periodically and above-ground generators are easily damaged by plows or other machinery.

MFCs are self-contained, eliminate the need for above-ground infrastructure and periodic maintenance and can be buried with the sensors below till lines. Ultimately, biodegradable fuel cells and associated circuity could just melt away, alleviating the need to retrieve dead sensors.

"In some cases, we're dropping these sensors in ecologically sensitive habitats to monitor the environment," said Pannuto. "We don't want to make the problem worse by leaving a bunch behind."

Powering the Internet of Everything

Pannuto joined the Computer Science and Engineering faculty in 2019

and specializes in embedded systems and how computing can be deployed in the physical world.

"A lot of my research looks at energy scavenging, which is where this paper comes in, and long-range and low-power communications," said Pannuto. "How are we going to support the eventual internet of everything?"

While all microbes produce energy—and can be found in virtually any random handful of dirt—the researchers are particularly interested in a family of anerobic bacteria called geobacter.

"These have been used to reduce uranium and heavy metal toxicity in soil," said Marcano. "Recent studies have shown they are quite prolific at electricity generation."

While the current paper was done in house in the Department of Computer Science and Engineering at the UC San Diego Jacobs School of Engineering, it is part of larger project with Colleen Josephson at UC Santa Cruz and Josiah Hester, Weitao Shuai and George Wells at Northwestern.

In addition to farm monitoring, the researchers are also working with wetland protection groups. The unifying theme is supporting long-term measurement in areas that lack supporting infrastructure.

And while MFCs won't be powering anything that requires a lot of energy, they do offer tremendous potential to support passive monitoring systems and provide enhanced data for farms and wetlands.

"We're not going to run a cell phone off soil anytime soon, but we can harvest enough energy to kick out a data packet a couple of times a day," said Pannuto. "We can develop monitoring infrastructure just using the

available energy in dirt."

More information: Gabriel Marcano et al, Soil Power?: Can Microbial Fuel Cells Power Non-Trivial Sensors? *Proceedings of the 1st ACM Workshop on No Power and Low Power Internet-of-Things* (2021). DOI: 10.1145/3477085.3478989