Researchers work to add function to 3-D-printed objects

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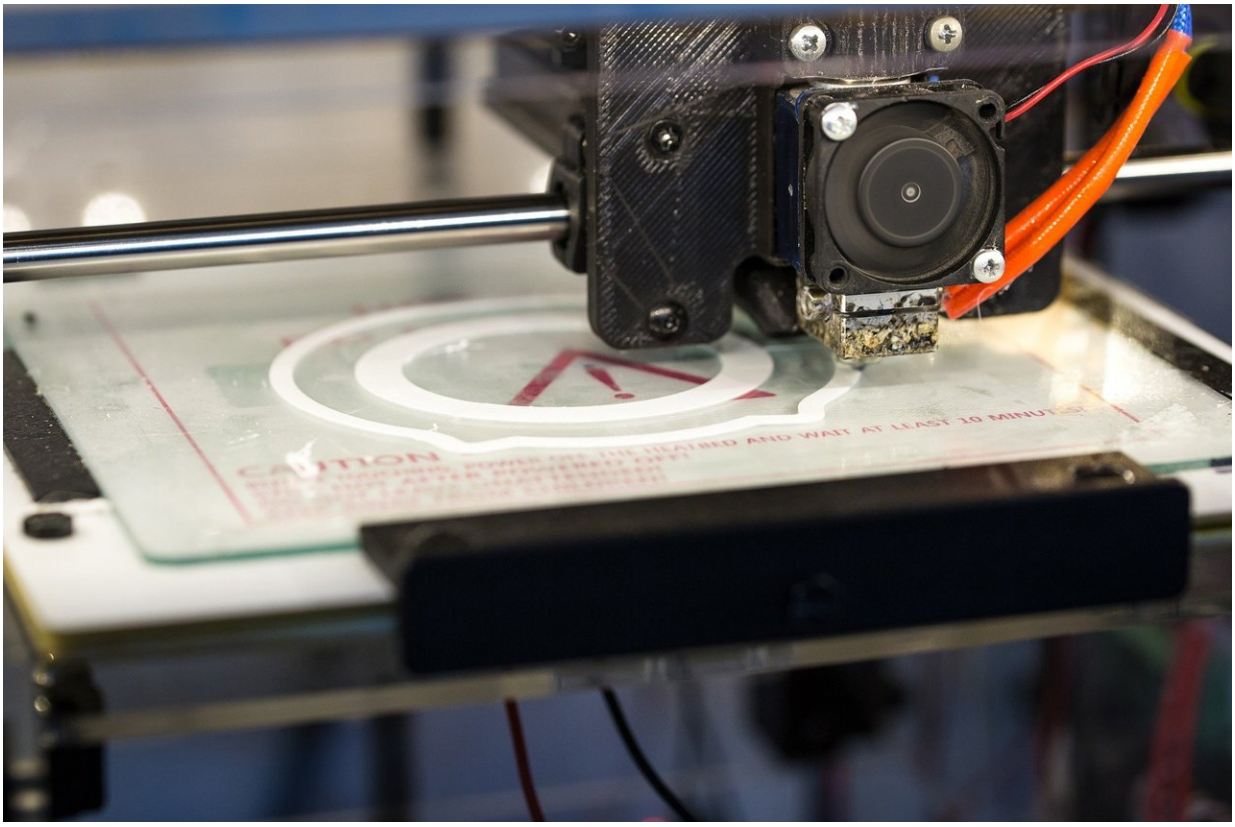

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In the movie *Terminator 2*, the T-1000 robot pours itself through the ceiling of an elevator. That scene started a flow of ideas for Purdue Polytechnic Institute professor Richard Voyles.

"The point is, he's computing while pouring," said Voyles, a professor in engineering technology. "It may be fiction, but there's sensing, computation and actuation that are all happening simultaneously while in that liquid state."

Purdue Polytechnic Institute and the College of Engineering faculty are working to develop a multi-functional printer that could eventually let people print out "smart" objects, including entire cellphones.

The project combines 3-D structure printing with electronics printing and even algorithms to infuse sensing, computation and actuation throughout the materials, a melding of form and function.

"We are synthesizing new materials that we can print in 3-D that embody sensing and computation as well as structure," Voyles said. "Science fiction just keeps producing ideas."

The technology aligns with Purdue's giant leaps celebration, acknowledging the university's global advancements made in health, space, artificial intelligence and sustainability as part of Purdue's 150th anniversary. Those are the four themes of the yearlong celebration's Ideas Festival, designed to showcase Purdue as an intellectual center solving real-world issues.

Voyles, head of Purdue's Collaborative Robotics Lab, is principal investigator on the multi-year research with Karthik Ramani, the Donald W. Feddersen Professor of Mechanical Engineering; Bedrich Benes, a professor of computer graphics technology; and six other faculty members.

Voyles said the challenge of the project is in the integration of the different approaches, some thorny issues in moving from 2-D electronics to 3-D, and solving the material compatibility issues between layers.

3-D printers have simplified the idea of rapid prototyping, allowing almost anyone to design and create an object. But while creating the form of a product is possible, adding any necessary functions are a completely separate process.

"Some nice design you create doesn't include a microprocessor if it needs to do computation, you can't include sensors if you need sensing," Voyles said. "You don't have motors if you need to actually move something."

A "smart product printer" carries with it dual questions: Creating the printer itself and figuring out what new materials can be invented. No 3-D printers exist on the market today that combine the printing of a structure with the printing of electronics, sensing and other functions.

"If we start with soft materials, polymers, that are at least flexible, maybe we'll get closer to the bigger question of not only can liquids think, as in the Terminator movie, but where will that take us if we create these new materials with "thinking" distributed throughout them," Voyles said.

As part of the work, researchers will try to show they can print polymer conducting and semiconducting materials in thin layers that are repeatable, similar to integrated circuits for mass-scale transistors in the 1960s and 1970s.

He noted one example of developing a material with temperature-sensing properties that could expand or shrink depending upon the use.

"These are the precursors we want to explore while we're developing this next generation 'form-plus-function' printer," Voyles said, adding the work could enable entirely new areas of discovery in the fields of smart materials and the basic polymer science of active materials, among

others.

Provided by Purdue University