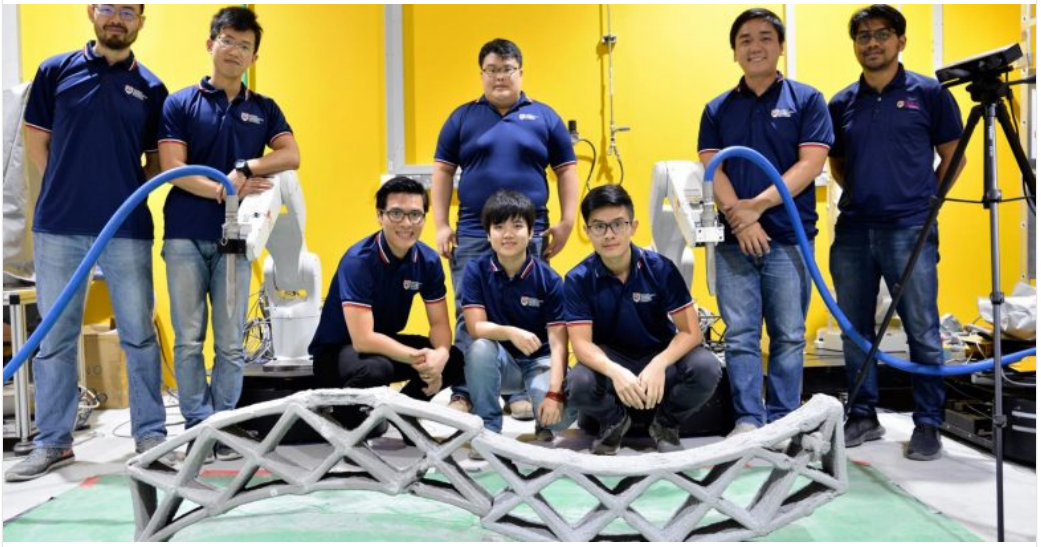
NTU Singapore shows two 3D printing construction robots are better than one

NTU Singapore's Centre for 3D Printing uses two robots to print a concrete structure in eight minutes.

Tess Boissonneault • October 2, 2018



What's better than one 3D printing construction robot? Scientists from NTU Singapore would likely say two construction robots. And seeing what the research team has been capable of, I can't say I disagree.

A team of NTU researchers led by assistant professor Pham Quang Cuong has developed a construction 3D printing process that relies on two mobile robots that work in unison to build up concrete structures. The technique, called swarm printing, could enable larger structures to be built using 3D printing than we've seen before.

The dual robotic 3D printer was designed at NTU Singapore's Centre for 3D Printing and is built to extrude a special cement mixture into complex structures. With two robots working simultaneously, the configuration can print forms that would be impossible to create using traditional construction process and in a much shorter time frame.

It takes two to 3D print

The underlying idea behind the construction robots is that if they are mobile and can move around a construction site with relative ease, they can print buildings more easily and effectively than many existing construction 3D printers (which themselves can be bulky and more large-scale than the structures they print).

"We envisioned a team of robots which can be transported to a work site, print large pieces of concrete structures and then move on to the next project once the parts have been printed,"

commented Assistant Professor Pham, who also developed an Ikea Bot this year which assembled an Ikea chair in under nine minutes.

He continues: "This research builds on the knowledge we have acquired from developing a robot to autonomously assemble an Ikea chair. But this latest project is more complex in terms of planning, execution, and on a much larger scale."

Concurrent challenges

In showcasing the new process, the NTU research team 3D printed a concrete structure measuring 1.86 x 0.46 x 0.13 meters in only eight minutes. Once the printing was complete, the structure required two days to solidify and a week to reach its full strength. Of course, while these results are impressive, the research team did face challenges in developing the process.

For one, the team had to figure out a way for the robots to work together and ensure that they wouldn't run into one another or collide during a build. Further, the team realized that structures could not be built as separate segments, as the strength of the joints would be compromised if they didn't overlap during the printing process.

To overcome these challenges, the team devised a method wherein a computer would first map out the print path and then assign a part of the build to one of the robots. Then a special algorithm was implemented which could ensure that the two robotic arms would not collide during the print process.

In the printing stage, the robots are controlled using precise location positioning as they print parts with good alignment, making sure that joints between the separate sections overlap. Also crucial to a successful build is that the cement mixture extruded by the robots is evenly blended and synchronized.

The more the merrier

"This multiple robot printing project is highly interdisciplinary, requiring roboticists to work with materials scientists to make printable concrete," said **Professor Chua Chee Kai**, Executive Director of the Singapore Centre for 3D Printing. "To achieve the end result of a strong concrete structure, we had to combine their expertise with mechanical engineers and civil engineering experts.

> *"Such an innovation demonstrates to the industry what is feasible now, and proves what is possible in the future if we are creative in developing new technologies to augment conventional building and construction methods."*

Indeed, being able to 3D print a structure of that size in so little time does show promise for the advancement of construction 3D printing. The next stage in the project, the researchers say, will be to integrate even more robot modules to increase the scale of printed structures; to optimize the print algorithm to improve consistency; and to further develop the cement mixture so that it solidifies faster.

A detailed study about the robotic 3D printing construction technique was recently published in the journal *Automation in Construction*.