

Origami-inspired robot folds into more than 1000 shapes

Composed of small cubes, the robot needs only a few motors to be active at any one time to transform between configurations.

Robots that imitate life may capture the imagination, yet even simplistic-seeming robots can perform complex tasks. Jie Yin and his colleagues at North Carolina State University have developed a robot that is made up of 3D-printed cubes and employs simple movements to transform into hundreds of arrangements. The robot executes origami-like folds on multiple scales because of joints that connect different levels of the tessellated framework. The multilevel structure minimizes the power the robot needs to perform those actions.

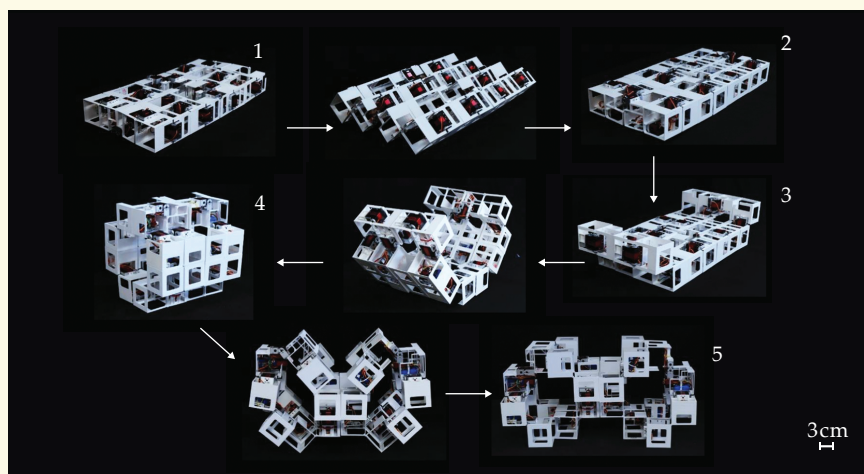
The robot comprises 32 plastic cubes, each measuring about 8 cm across, that start in a flat 4×8 arrangement. Adjacent cubes can be linked by one of two types of joints: a flexible connection or a small, motorized hinge. The hinges can actively power the robot's movement, passively respond to the movement caused by another motor, or lock its current position to prevent movement. The joint positioning enables the cubes to be controlled individually or as a collection of mod-

ules. That multilevel, or hierarchical, design overcomes the typical dependence of a robot's shape-changing ability on the complexity of the actuation and control system.

Engineers in Yin's lab demonstrated that the 32-cube structure could arrange itself into more than 1000 configurations. For example, the figure below shows how the robot transforms from the initial flat structure to a 3D structure with hollows. It has 36 total hinges. Although a maximum of 16 rotate during a single step (from step 4 to 5), at no point are more than 3 motors active at the same time to power the movement. The array of configurations isn't just for show. Different sequences enable the robot to achieve forward locomotion at 1 m/min, faster than similarly structured robots. The robot can also roll along a flat surface and crawl up a 10° ramp.

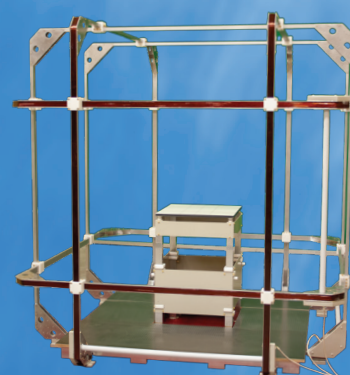
Yin says that future robots designed with the hierarchical, origami-based concept could prove useful for navigating unpredictable terrain. In distant environments, such as the Moon, similar configurable robots could also function as modular structures or even divide into smaller robots to perform discrete tasks, with minimal power required, before reassembling again. (Y. Li et al., *Nat. Commun.* **15**, 6247, 2024.)

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A ROBOT MADE UP OF 32 CUBES transforms from a flat arrangement into a structure of two loops. No more than three motors are active for any one step. (Adapted from Y. Li et al., *Nat. Commun.* **15**, 6247, 2024.)

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