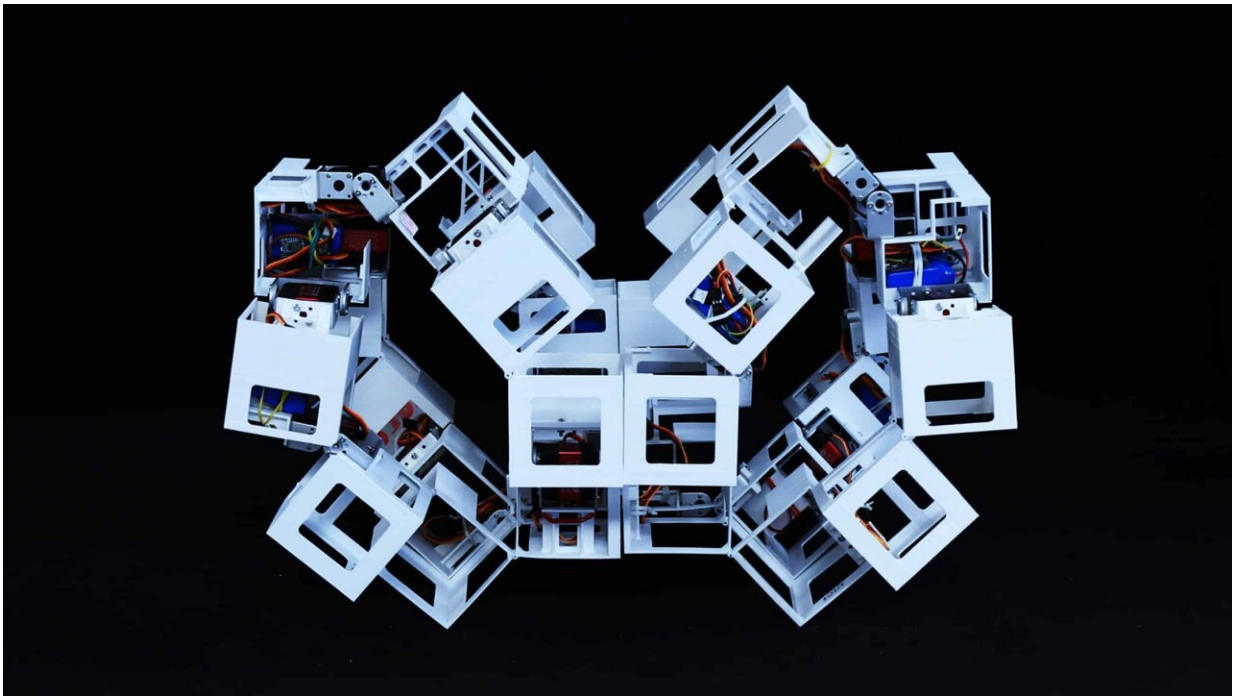
Shape-shifting 'transformer bots' inspired by origami

July 29 2024, by Mick Kulikowski



Transformer bots can form more than 1,000 shapes. Photo courtesy of Jie Yin, NC State University. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-50497-5

Inspired by the paper-folding art of origami, North Carolina State University engineers have discovered a way to make a single plastic cubed structure transform into more than 1,000 configurations using only three active motors. The findings could pave the way for shape-

shifting artificial systems that can take on multiple functions and even carry a load—like versatile robotic structures used in space, for example.

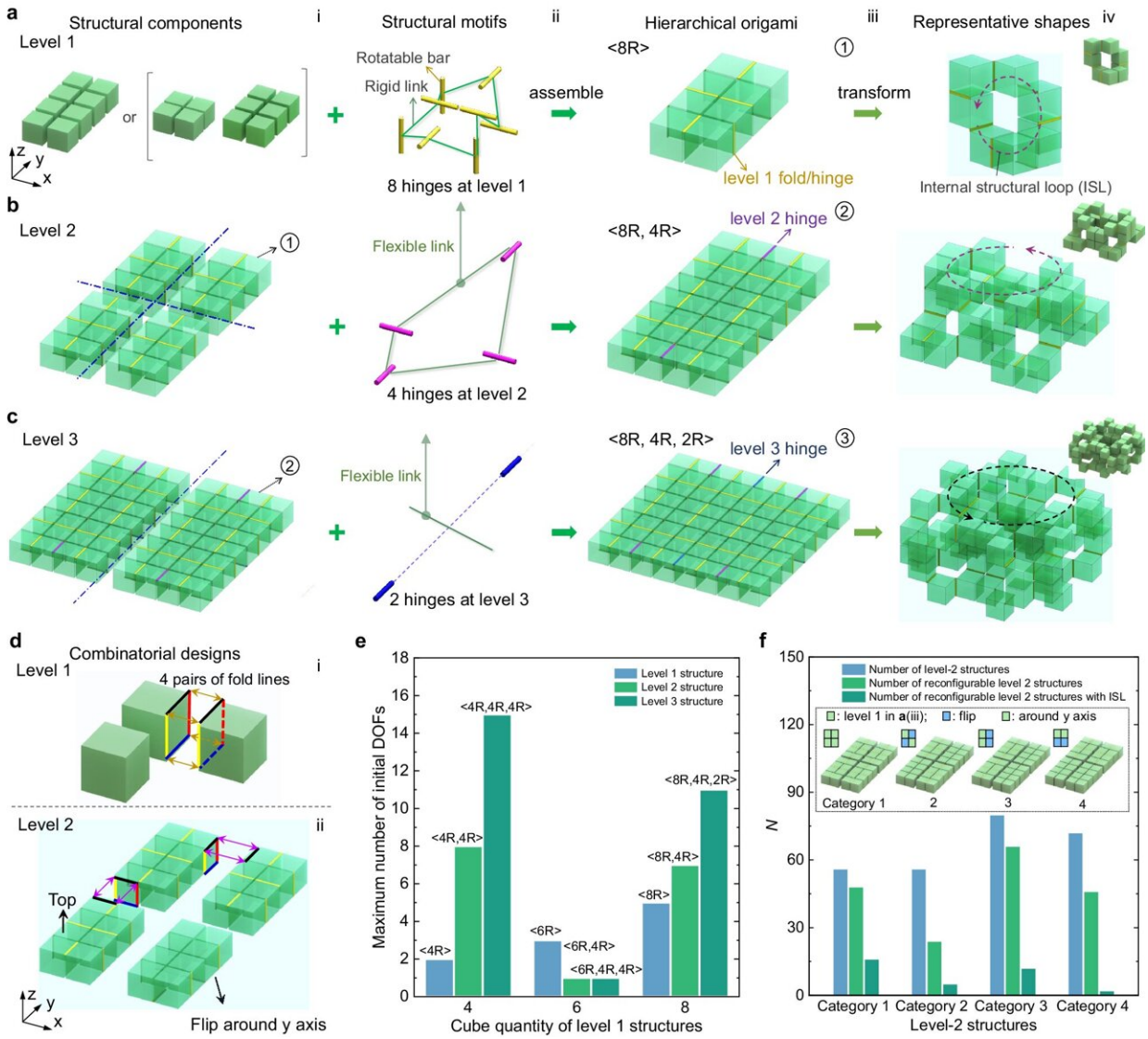
The findings are published in the journal *Nature Communications*.

"The question we're asking is how to achieve a number of versatile shapes with the fewest number of actuators powering the shapeshifting," said Jie Yin, associate professor of mechanical and aerospace engineering and co-corresponding author of a paper describing the work. "Here we use a hierarchical concept observed in nature—like layered muscle fibers—but with plastic cubes to create a transforming robot."

The NC State researchers assembled hollow, plastic cubes using a 3D printer and assembled 36 of them together with rotating hinges; some hinges were fixed with metal pins, while others were activated wirelessly with a motor.

The researchers were able to move the cubes into more than 1,000 shapes using only three active motors. Those shapes included tunnel-like structures, bridge-like structures and even multi-story architectures.

The untethered transformer bots can move forward, backward and sideways—without feet—merely by controlling the ways the structure's shape changes. The bots can also transform relatively quickly from flat, or fully open, to a boxlike larger cube, or fully closed. The bots also can carry a load about three times their own weight.



Design of hierarchical origami-based shape-morphing metastructures. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-50497-5

Next, the researchers will attempt to make the transformer bots even better.

"We want to make a more robust structure that can bear larger loads," said Yanbin Li an NC State postdoctoral researcher and co-

corresponding author of the paper. "If we want a car shape, for example, how do we design the first structure that can transform into a car shape? We also want to test our structures with real-world applications like space robots."

"We think these can be used as deployable, configurable space robots and habitats," said Antonio Di Lallo, an NC State postdoctoral researcher and co-first author of the paper. "It's modular, so you can send it to space flat and assemble it as a shelter or as a habitat, and then disassemble it."

"For users, it needs to be easy to assemble and to control," Yin said.

Hao Su, associate professor of mechanical and aerospace engineering, is a co-corresponding author of the paper. Junxi Zhu, an NC State Ph.D. student, Yinding Chi, a former Ph.D. student at NC State, also co-authored the paper.

More information: Yanbin Li et al, Adaptive hierarchical origami-based metastructures, *Nature Communications* (2024). DOI: 10.1038/s41467-024-50497-5

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