Metric-Changing Transformable Surfaces

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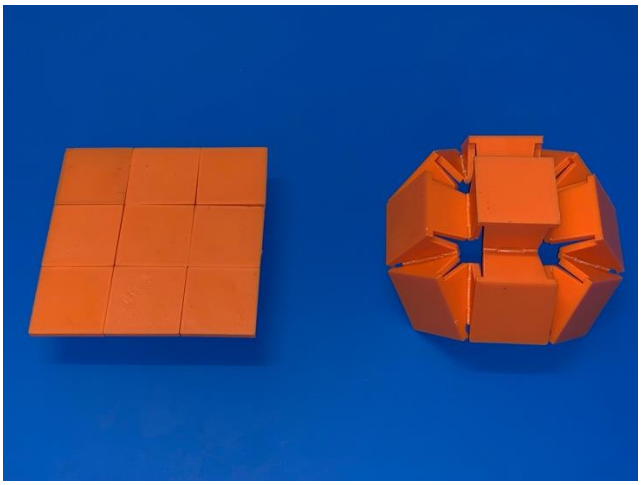
Abstract

We consider the problem of designing surface structures that can change their metric, to transform for example from flat to cylindrical and to spherical configurations. A key challenge is that there is no isometric mapping between spherical and developable surfaces. Since we also require that all transformations should be controllable and repeatable, and that all of the target configurations should be mechanically stiff, intuitive solutions such as thin shells made of soft polymers or rubber, are not practical.

Multi-Degree Of Freedom (DOF) origami patterns that can achieve such reconfigurations include the Waterbomb pattern and several Resch's patterns. Their motion is isometric, but the overall fitted shape is metric-changing. However, due to the large number of folds and DOFs, these structures are complex to manufacture and need many actuators.

We propose a new family of solutions with a greatly reduced number of DOFs. It consists of square panels connected by compliant sub-folds that come into contact when extreme configurations are reached. The square panels define a (fitted) surface whose metric can be changed, as shown in the photo below. We demonstrate the capabilities of the proposed solutions through a complete kinematic analysis. With the addition of compliance in hinges, the energy landscape of these structures is such that the desired reconfigurations can be achieved with only a small number of actuators. Physical prototypes will be shown.



Example of a metric-changing surface.