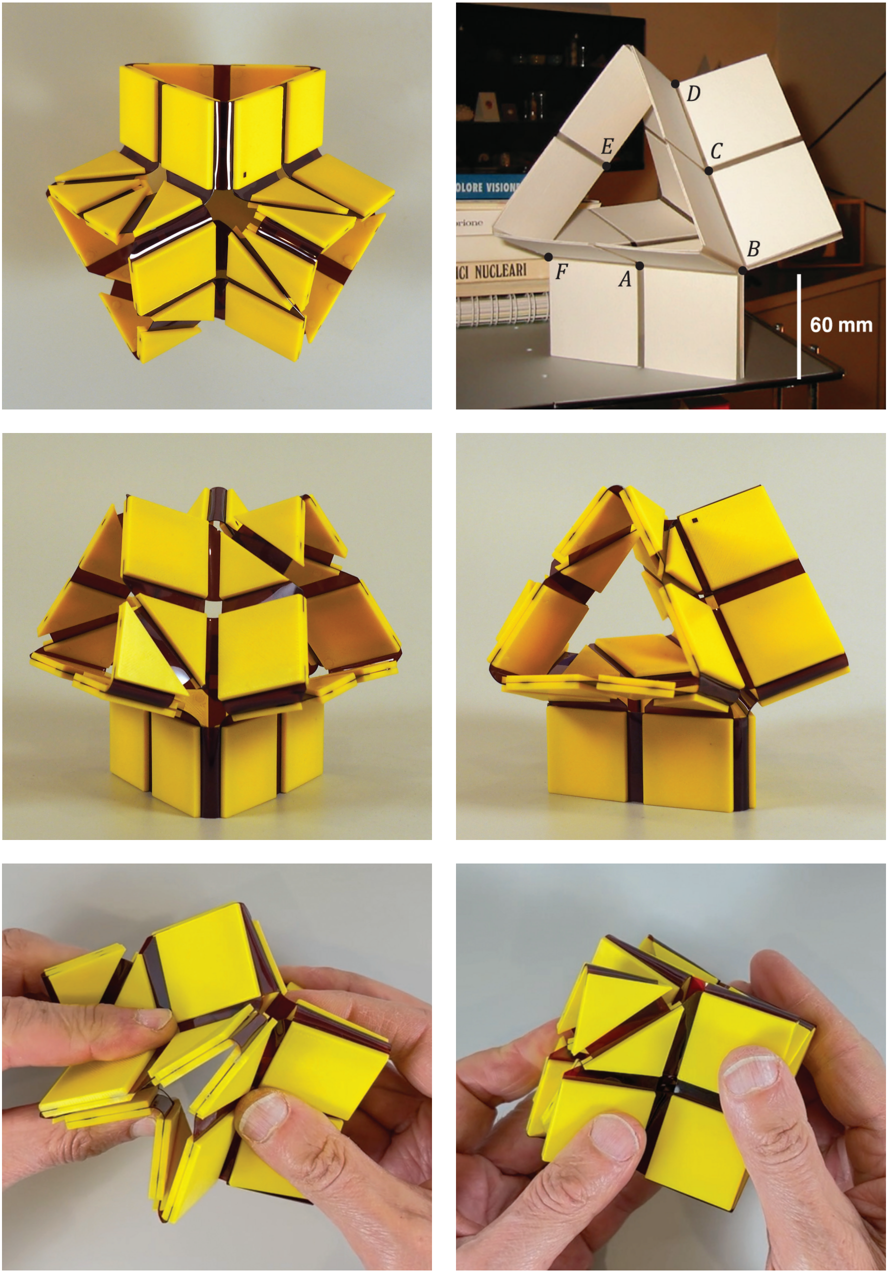
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Kinematic Modeling of a Flat-foldable Auxetic Metamaterial*

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***Abstract* –** Although many metamaterials can change shape, this flexibility often comes at the expense of the structural integrity which is difficult to preserve in their reconfigured mode. In this work, we introduce a transformable, flat-foldable shape designed in 1996 by the Italian topology researcher Giorgio Scarpa, consisting of a prismatic tetrahedron with additional hinges which bisect the walls of the extruded prisms. The shape is rigid when unfolded, and when scaled into a periodic, space-filling honeycomb, it yields a flat-foldable, prismatic metamaterial that preserves its developed, structurally sound unfolded state in the absence of external stimuli or mechanical loads. However, this new metamaterial is still kinematically rigid when only revolute hinges are admitted. To overcome the limitation that this improved design still relies on bending of the plates and torsional hinges, we introduce additional bisecting hinges along the diagonal of eight of the twenty-four square plates in the extruded tetrahedral unit cell. This modified design, now with only rigid plates and revolute hinges throughout the material, preserves both the rigidity and the flat-foldability, while also introducing the rigid foldability due to the presence of the additional diagonal hinges. A kinematic analysis of the folding motion of the tetrahedral unit cell is presented, showing how this bisecting technique can be generalized to yield auxetic metamaterials with both rigid foldability and negative Poisson's ratio. The straightforward bisecting of rigid plates connected by standard revolute hinges offers great opportunity for the design of reconfigurable metamaterials, mechanisms, and robots that combine flat-foldability and self-supported structural integrity when unfolded.

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