

The Spinning Cyclic ‘Miura-oRing’ for Collision-Robust Aerial Robots

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Abstract

Impact protection structures enable aerial robots to navigate in confined or heavily-cluttered environments. As weight is a major limitation in designing aerial vehicles, origami-inspired folded structures made of thin material sheets can offer novel, lightweight solutions to tackle collision resilience challenges. Here, we study the use of the energy absorption properties of origami structures for the protection of a miniature aerial robot in horizontal collisions. A ring-shaped, cyclic symmetric descendant of the Miura-ori, which we call the ‘Miura-oRing’ in this paper, is studied. It acts as a light-weight radial spring used as a collision-cushioning structure to be assembled on a quadrotor frame in order to provide horizontal impact protection (Figure 1). A parametric model of this fold pattern (Figure 2a) is created to establish a direct relation between its initial geometric variables and its structural performance, through a series of Finite Elements simulations (see Figure 2b for example results). An optimal structure for the aerial robot is manufactured by laser cutting a thin sheet of polypropylene, followed by manual folding. A rotational degree of freedom is introduced to the protective system to decouple the protector from the platform, resulting in minimising the destabilising effects of tangential collision forces. Collision experiments (Figure 2c) validate that the spinning cyclic Miura-oRing remarkably improves the impact-resilience of the miniature quadrotor aerial robot (Figure 2d) in a variety of collision scenarios.

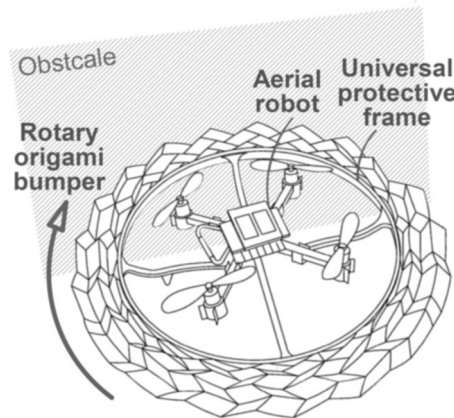


Figure 1: A quadrotor aerial robot equipped with the spinning cyclic Miura-oRing

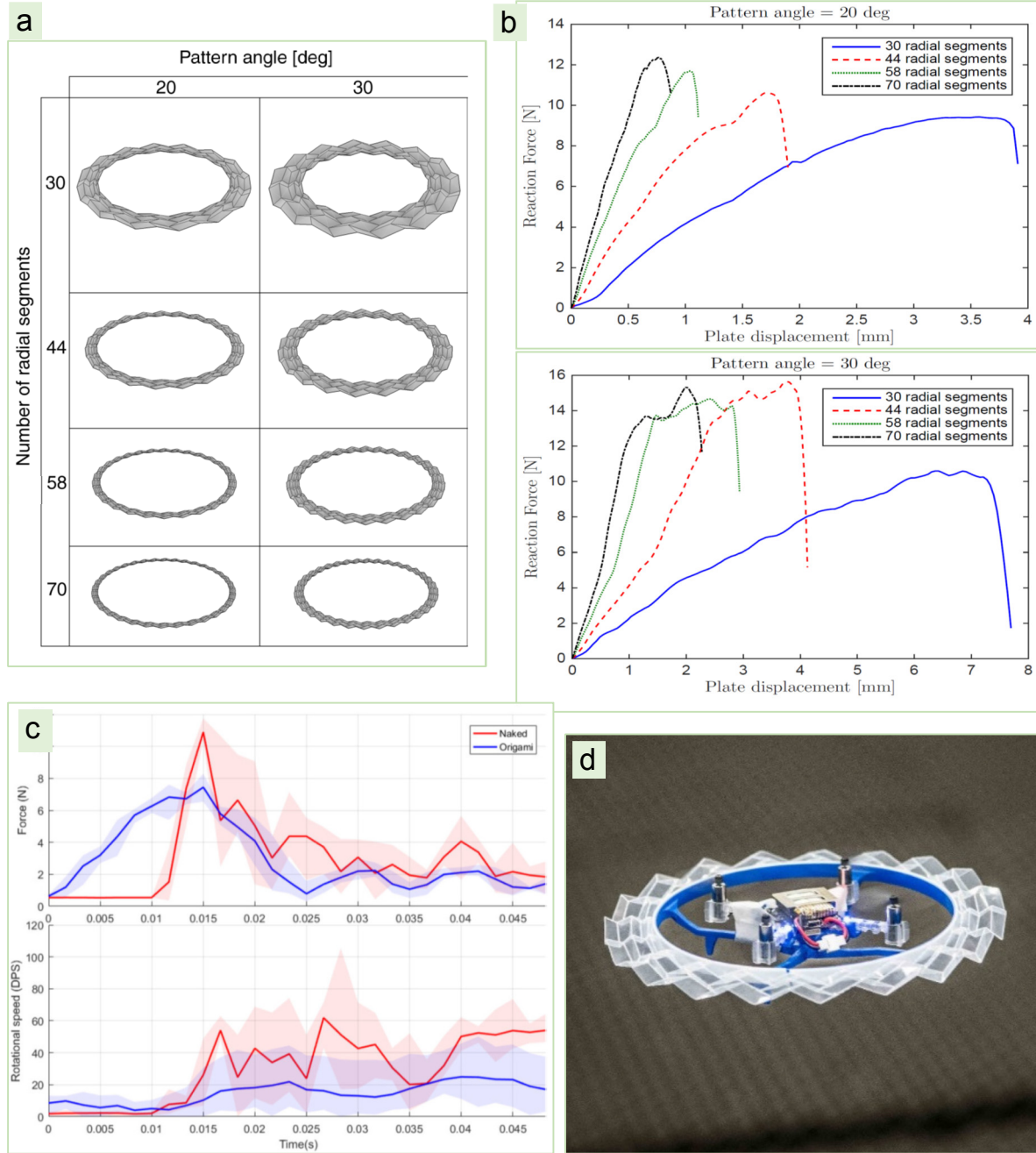


Figure 2: (a) Cyclic symmetric Miura-oRings with different initial geometric parameters and (b) their corresponding structural behaviours in quasi-static FEA simulations. (c) Collision experiments results for a (d) quadrotor aerial robot equipped with a spinning cyclic Miura-oRing.