

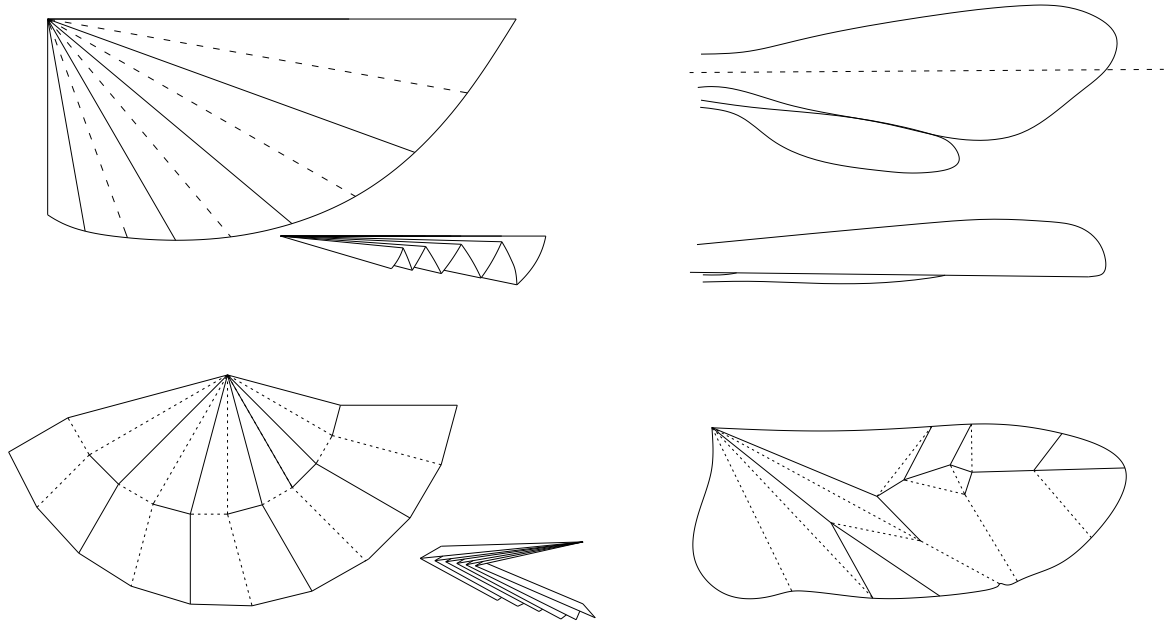
# Deployable Structures Inspired by Insect Wing Folding

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keywords: biomimetics, deployable structure, insect

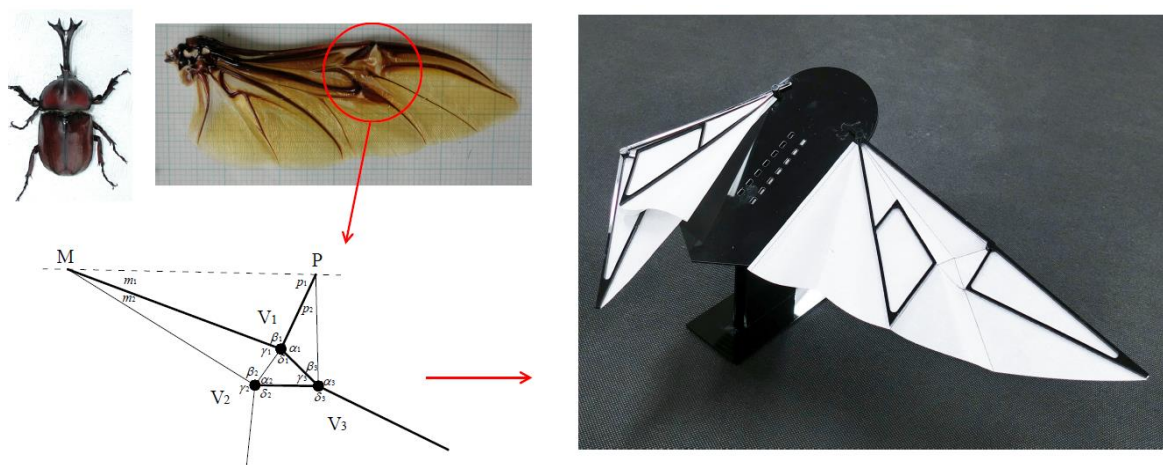
## Abstract

Technologies to fold large-sized structures into compact shapes are required in a variety of engineering applications with multiple scales and purposes, such as space-deployable structures represented by solar array paddles and antenna reflectors of satellites, medical devices, and many articles of daily use like fans and umbrellas. Insects have addressed the same issue for hundreds of millions of years as they acquired flight wings and developed several interesting solutions [1-3] (Fig. 1). Foldable wings ironed out the disadvantages of the wing, bulkiness and vulnerability, and gave the abilities of high-speed locomotion on ground and penetrating into narrow space like leaf litter layer and under soil without loss of flight ability enabling fast and long-range migration. In the same way, folding technologies are expected to generate innovative ideas for usage and application in various engineering products.



**Figure 1:** Representative folding methods in insect wings. (a) Fun-like folding in locusts (Orthoptera) and praying mantises. (b) Simple longitudinal folding line in ants and bees (Hymenoptera). (c) Advanced fun-like folding in earwigs (Dermaptera). (d) Hypothetical wing showing the typical crease pattern in beetles (Coleoptera) proposed by Forbes [1].

From an engineering standpoint, these foldable wings have an interesting property: they can achieve compact storing without compromising the strength and stiffness of the wing structure. The purpose of this study is to clarify the geometry of crease patterns and folding/unfolding mechanisms in insect wings, and to utilize these excellent properties in artificial deployable structures. In the presentation, we discuss the geometry of the crease patterns found in these foldable hindwings, and show the designing methods of some patterns which can be used in artificial deployable wings. The wing folding/unfolding mechanisms in some species are investigated by using the highspeed camera and the micro computed tomography. Based on these results, some prototypes of the insect inspired deployable structures are introduced.



**Figure 2:** Prototype of deployable wing inspired by horn beetle.

## References

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