

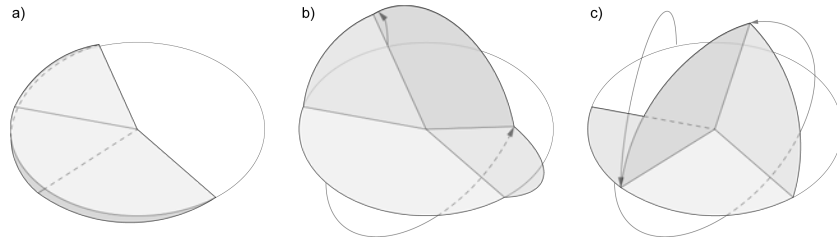
# Folding Mechanisms with discriminate extremal configurations for Structural Purposes

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## Abstract

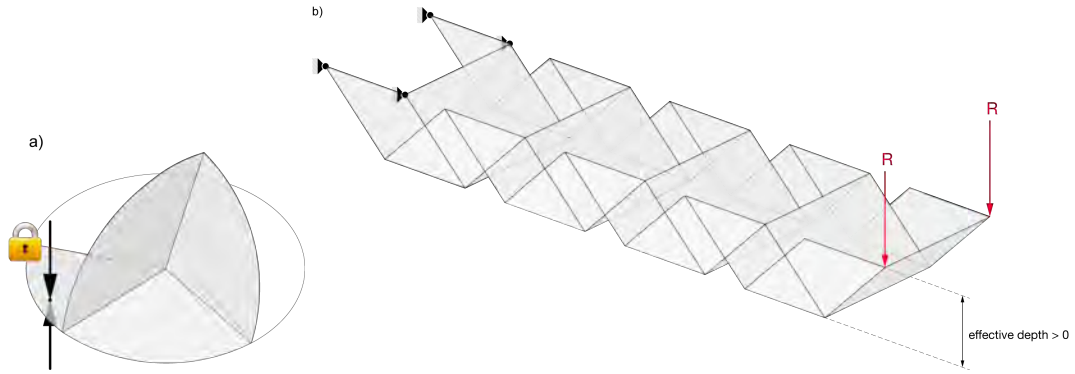
In order to get a general notion of folding mechanisms that feature the extremal configuration of flat compaction as well as a structurally useful spacial terminus, this paper investigates the configurability of single-vertex, non-symmetrical folding mechanisms. These mechanisms are by nature non-developable [Gattas and You 13] and therefore feature non-flat deployability, specified in [Buffart et al. 17]. Subsequently, the characteristics of reciprocal mechanism arrays composed from isometric tessellations of these vertices is examined.



**Figure 1:** Non-developable, synclastic mechanism with discriminate extremal configurations. a) flat compacted configuration. b) transitional state (synclastic pyramid state). c) the spatial extremal state.

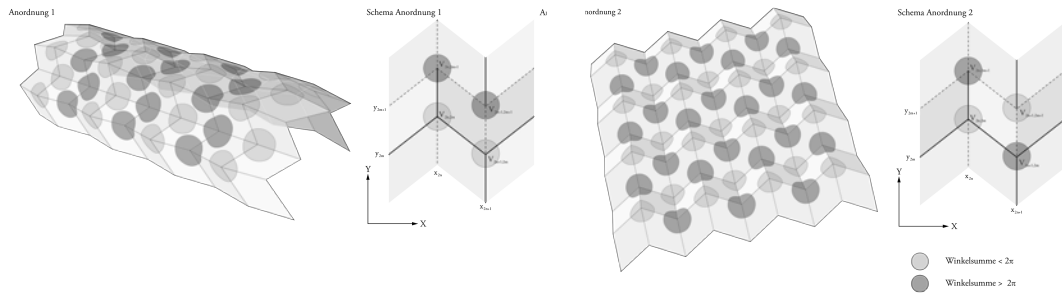
Structures are designed to be transformable when their task is to adapt to two or more divergent shapes at different times. Most commonly, large convertible elements are realised as retractable roofs and portable buildings. In terms of shape, this means the structure has two stationary configurations that it can shift between. In one situation the design target is reaching the maximum compaction either to reduce the structure surface to a minimum (roof), or by reaching transportable dimensions, and the other situation is being in the utilization state as a reliable, expanded structural build.

Folding mechanisms can constitute transformability, self-support and a continuous envelope. They are structurally feasible when they feature constrained motion, remain in a spatial build at all times and lack bifurcation as well as dead-center configurations. Beyond regular developable 4-Fold Origami vertices, non-flat folding vertices provide these qualities [Buffart et al. 17].



**Figure 2:** a) locking a a non-flat compactable 4-fold vertex into a 3-sided, rigid pyramid. b) Transformable origami-based structure with discriminate extremal configurations. Here: cantilever as structurally utilised extremal configuration.

In a geometrical sense, the most elegant way to design a transformable structure for the uses described afore is to furnish it with folding mechanisms that have a strictly continuous, constrained motion with expedient extremal configurations. These serve as immanent physical arrests that are useful regarding general structural stability. When the two overlapping facets of a 4-fold mechanism in a non-flat extremal configuration are seen as unified, the mechanism geometrically turns into a rigid, 3-sided pyramid which has better structural features. The arresting facets allow more direct force flows in a functional configuration. Subsequently, this allows smaller acuating forces, since their task of also sustaining mechanisms is funtional positions becomes obsolete.



**Figure 3:** alternation possibilities of synclastic and anticlastic non-developable folding mechanisms. a) line-wise alternation. b) chessboard-alternation.

Useful mechanisms consist of series of reciprocally transformable, elementary, single-vertex folding mechanisms. To understand these arrays of interdependent mechanisms, this paper examines additional features of isometric tessellations assembled from non-developable mechanisms in contrast to known developable rigid-foldable quadrilateral mesh origami [Klett 13].

## References

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