Deployable versus foldable modular structures

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Abstract

Most of modular kinetic structure thought at the scale of architectural components are the so-called scissor-like structures. Apart from the introduction of angulated bars in the '90s by Chuck Hoberman [1], the theoretical bases date back to the '70s [2]. Either case, each module is a *4R* - planar closed linkage, i.e. a closed chain of four rigid bodies connected by means of four revolute joints whose axes meet at infinite. Meanwhile, supported by custom construction possibilities, the research on kinetic computational origami is now fervent, its fields of application are wide, while constructed architectural examples are lacking [3]. These are also linkages, precisely they are *4R*- spherical linkages, which are closed chains where however the four revolute joints have axes meeting at a real point. As the definitions suggests, there are analogies between *4R*- spherical and planar linkages. Interestingly, however, such connections have been practically unexplored both at the morphological and at the structural levels.

We set up and discuss such a relationship. The classification is based on kinematics, and thus, we simply consider the links as rigid bodies whose motion in constrained to certain reciprocal rotations by the distance between the connecting joints. Such a distance, we clarify, in case of planar linkages is the linear distance between their axes, while, in case of spherical linkages, where joints meet at a point, is the angular distance between the axes, as elongating a link would create no difference. The classification of the single linkages is based over the reciprocal distance between the joints and related symmetry, as by the classical Grashof's criterium, and similarly symmetry rules of the distance between the joints govern the possible combinations of different linkages [4].

We present therefore mechanisms that have been previously separately developed in the two forms; and we also present mechanisms which are novel in one form, but which are here obtained by the simple translation of the shared symmetry rules from one form to the other, further extending previous research [5], and comprising simply foldable as well as transformable and retractable motions.

Within the above classification, an introductory comparison is made between the stiffens under lateral and under gravity load of the two types, assuming equal weight, equal volume enclosing the modules, as well as the insertion of cladding over the bar structure.

References

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