An attack on the smooth analogue of flexible quad-meshes: beyond V-hedra and T-hedra

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Abstract: A flexible quad-mesh (quad-mesh rigid origami) is a polyhedral surface with quadrilateral faces connected in the combinatorics of the square grid that admits a continuous isometric deformation. Known variations include the Miura-ori (Miura, 1985; see https://en.wikipedia.org/wiki/Miura_fold); V-hedra (Voss, 1888; Sauer and Graf, 1931; Montagne et al, 2022); anti-V-hedra and hybrid V-hedra (Tachi 2009; 2010); T-hedra (Sauer and Graf, 1931; Sharifmoghaddam et al, 2020); and anti-T-hedra (Erofeev and Ivanov, 2020). Izmestiev's list of flexible Kokotsakis quadrilaterals (2017) paves the way for the generalization of large flexible quad-meshes through providing 3×3 'building blocks'. We made an initial attempt on constructing large patterns by stitching Kokotsakis quadrilaterals in He and Guest (2020). Successful examples include using the linear compound type and the equimodular type.

I developed a keen interest in identifying the smooth analogue of flexible quad-meshes. The correlation between the isometric deformation of a discrete surface and its smooth counterpart is not only intriguing from a mathematical standpoint but also holds significant practical value in the fields of structural engineering and architectural design. The smooth analogue of a V-hedron is known to be a V-surface (Bianchi, 1890; Sauer, 1970), and the smooth analogue of a T-hedron is known to be a T-surface (Izmestiev et al, 2023). I will report some new observations beyond V-hedra and T-hedra.