

On rigid-foldable structures of the T- and V-hedral type

We consider a composition of quadrilateral panels hinged by rotary joints along their edges in a way that each interior vertex has valence four. Such structures are generically rigid, but certain geometries allow for a 1-parametric change of the dihedral angles without any panel deformation. This rigid-foldability is not a property of the extrinsic geometry but of the intrinsic one, which is determined by the corner angles of the quads. Nonetheless, particular surface classes, like T-hedra and V-hedra, allow for direct access to their spatial shape through the use of control polygons, which can be utilized within interactive design tools.

T-hedra can be seen as generalizations of discrete surfaces of revolution in such a way that (a) only the orientation of the rotation axis remains fixed but not its position and (b) the actions on the profile polyline p can be stretch-rotations instead of pure ones. This discrete kinematic generation results in a quad surface with trapezoidal (T) faces. By closing p under consideration of some geometric constraints, we obtain rigid-foldable tubes, which can even be composed to metamaterials. Especially, we focus on the so-called zipper coupling.

V-hedra are discrete analogs of Voss (V) surfaces and can be characterized by (1) the planarity of the quads and (2) the equality (supplementarity) of opposite angles made by edges around a vertex. By dropping the first condition, we get V-hedra with skew quads, which are discussed in more detail.