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Construction of Common Unfolding Using the Fixed Point Propagation Method

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For a polyhedron Q, an unfolding is a polygon obtained by cutting and unfolding the surface of Q onto a plane. For polyhedra Q and Q', a common unfolding is a polygon that serves as an unfolding for both Q and Q'. It is a famous open problem whether a common unfolding exists between distinct Platonic solids. This problem, proposed by Demaine et al. in 2008, remains unsolved for all 10 combinations of the 5 Platonic solids, and it continues to be a topic of active research from various perspectives.

One of the studies on common unfoldings of Platonic solids is the approach demonstrated by Shirakawa et al., which involves constructing a common unfolding for a polyhedron that closely approximates another Platonic solid. Through this study, a common unfolding between a cube and a tetramonohedron that closely approximates a regular tetrahedron was discovered. A tetramonohedron is a tetrahedron in which all faces are congruent.

In this research, we name the discrete point-generation process used in the previous study as the fixed point propagation method and extend its application to the combination of a regular octahedron and a regular tetrahedron. The procedure consists of two main steps: (1) creating a common unfolding for an octahedron and a tetramonohedron, and (2) gradually transforming the tetramonohedron into a regular tetrahedron, during which the fixed point propagation method is used to generate the required points sequentially along the boundary of the common unfolding.

As a result, it is confirmed that when a small margin of error is allowed, the procedure terminates, and a common unfolding is generated between the octahedron and a tetramonohedron close to a regular tetrahedron. Conversely, when no error is allowed and the edge lengths of the octahedron and regular tetrahedron are strictly specified, the procedure does not terminate. Ultimately, this study discovered a common unfolding for the regular octahedron and a tetramonohedron with an edge length error of 1.8866×10^{-8} from the regular tetrahedron. Furthermore, it was observed that the set of points generated by the fixed-point propagation method forms diverse geometric patterns depending on the parameters, which reveals certain underlying rules.