Hinged Threading: A Novel Method to Deploy Convex Polyhedral Nets

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Some objects can transform between multiple geometric configurations when you interact with them. These systems, known as deployable structures, have significant applications in space technologies, quick-to-deploy relief shelters, and pop-up architecture. There are many methods to execute their transitions. Previous work to model them has been done using tubes, tiles, nets, and hinges. This paper explores a novel and more efficient technique for creating deployable structures by combining hinges and threads, and coining the term "hinged threading" for it. Hinges are utilized to maintain order and provide a pathway for transformations, while threads enable smoother and more controlled operations of these hinges. The structure to be threaded is modeled as a graph and analyzed using the mathematical framework of graph threading. This approach focuses on minimizing the number of thread turns to decrease friction and in the process also reduces thread length to lower manufacturing costs. An algorithm is developed to identify the most optimal threading points for convex polyhedral nets. To validate the algorithm, nets for both regular and irregular polyhedrons are laser-cut and tested. Further, friction analysis is carried out for these nets based on the number of threaded holes. According to it, they are classified as good (low-friction) and bad (high-friction) nets. Hinged threading gives a user-friendly mechanism to enable smooth deployment of 2D nets into 3D shapes. Future work could focus on development of hinges that automatically stop at the desired angle and multi-threaded nets to broaden its applications.

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