Geometry and control of scissor mechanism

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Abstract

Scissor mechanisms are versatile in their utility and have been used in various engineering applications for scalable and extendable planar motion. A scissor mechanism comprises several connected scissor-units, each of which is made up of a pair of rigid linkages fastened by a pin joint. When the mechanism is actuated at one of its ends, this results in displacement across the entire mechanism, making it amenable to non-local control. The geometry of such a mechanism is closely related to discrete curves in 2D and we find that each configuration of the mechanism is completely described by the aspect ratio of the individual units and the angle of actuation. Leveraging the underlying geometry of the scissor-units, we estimate the aspect ratio and the actuation angle required to morph the mechanism to desired shapes. To exhibit the precise controllability of this mechanism, we identify the aspect ratio of each scissor-unit needed to make the distal end traverse a particular trajectory upon actuation, effectively demonstrating its ability to 'write'. Through experiments using precision 3D-printed models, we compare our results with theoretical predictions and demonstrate the viability of our approach for robotic applications. Our approach provides a general framework for designing mechanical structures by embedding functions into their form while accounting for intrinsic geometric non-linearities.

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