

C-space analysis of 1-dof mechanisms using tropical geometry

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Abstract: The configuration space (C-space) of a mechanism is a mathematical representation defining all feasible configurations it can achieve. Singularities are critical for understanding a mechanism's behavior, and they often arise from self-intersections of the C-space that lead to distinct motion branches. While methods exist to identify these intersections when they are transversal, challenges persist when they are tangential, cuspidal, or inter-dimensional, or combinations thereof. The methodology presented here addresses this challenge for 1-degree-of-freedom (1-dof) mechanisms, whose C-spaces are 1-dimensional algebraic varieties. Leveraging tropical geometry principles, the approach relies on determining Puiseux series at specific points along C-curves, facilitating the identification of both real and complex branchings. The proposed approach is shown to detect transversal branchings in two foldable four-bar mechanisms. Additionally, a cusp in the C-space of a double Watt mechanism is detected, alongside two other branches exhibiting smooth motions.