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DISCRETE ELEMENT METHOD SIMULATION OF CONTACT EVOLUTION IN GRANULAR JAMMING GRIPPERS

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Abstract

Granular jamming grippers are a versatile and adaptable alternative for object manipulation in soft robotics (Amend et al., 2012; Brown et al., 2010; Shintake et al., 2018). *Their operating principle is based on taking advantage of the variable stiffness of granular material when a vacuum is applied. This technology allows for adapting to complex geometries without the need for sensors or active control, making it especially useful for fragile or irregularly shaped objects* (Delaney & Cleary, 2010). *While progress has been made in topics such as the influence of grains on gripper performance, the influence of membranes, applications with fluids other than water, and collaborative robotics applications, the precise nature of contacts between the granular material and the target body during the grasping process remains unclear due to low visibility.*

Using discrete element method (DEM) simulations, an ovoid gripper containing the granular material is assembled, the interaction with the target body is simulated, and a vacuum is applied to achieve granular jamming (Dierks et al., 2025). *This work aims to present an analysis of surface affectation on the target body, as well as its relationship with the granular material used in the gripper, modeling the target bodies with computer aided design (CAD) tools and simulating the interactions of the particles with discrete element method (DEM) it is evidenced that the contacts are concentrated in specific areas of the target body, depending on its geometry, and evolve as the gripper performs vertical displacement on the object, manifesting behaviors such as local interlocks and non-contact zones that change the total contact area and vary the grip force. These findings mark an improvement path for future designs of granular jamming grippers, as well as the integration of DEM simulations in early stages of adaptive manipulation device development.*

Keywords:

Soft Robotics, Granular Jamming, DEM Simulations, Soft Gripper

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