# SPARK Hand: Scooping-Pinching Adaptive Robotic Hand with Kempe Mechanism for Vertical Passive Grasp in Environmental Constraints

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IROS Contributed paper

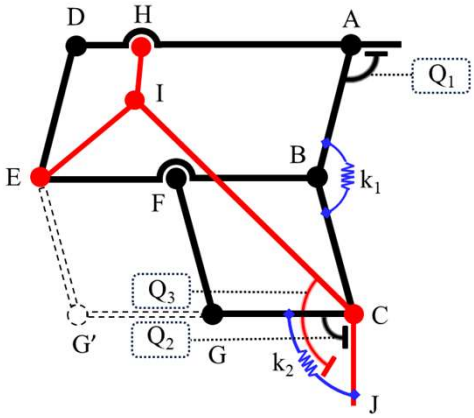
## Motivations

- **Challenge:** Thin or flat objects on a surface are **difficult to grasp** with conventional grippers.
- **Design Goal:** Enable a robot hand to **pinch** small objects or **scoop** objects from a flat surface, **adapting passively** to the environment.
- **Key Mechanism:** The SPARK finger uses a modified **Kempe straight-line linkage** plus a parallelogram linkage to ensure the fingertip moves vertically and maintains a fixed orientation.
- **Passive Adaptation:** Integrated springs and mechanical stoppers allow **automatic switching** between a parallel pinching mode and scooping modes when the finger presses against a surface.
- **Simplicity:** This passive design avoids additional actuators, achieving adaptability with lower complexity and cost.

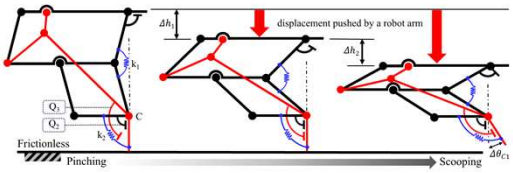
Fig. 1. The SPARK Hand, a robotic end-effector consisting of two SPARK fingers on a single base, capable of performing both parallel pinching and scooping grasps.

## Methodology

**Mechanism overview:**

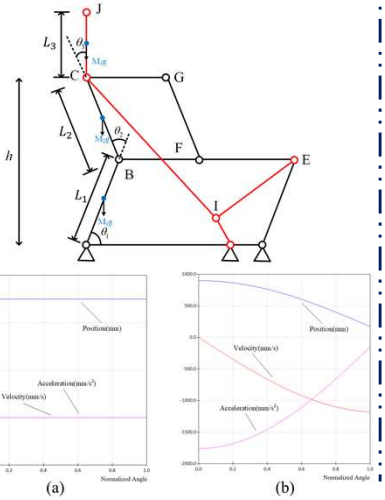



**Passive mode switching:**



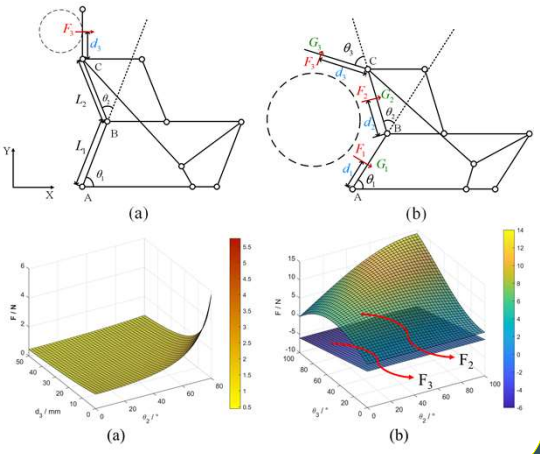

### Kinematic Analysis

Kempe straight-line + parallelogram → fingertip follows an almost vertical line with fixed orientation; lateral drift ≈ 0. Simulation shows smooth position/velocity/acceleration, enabling scratch-free slide-in under thin items.




### Grasping Force Analysis

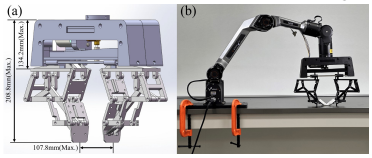
Pinch: load concentrates at the distal link—ideal for sheets and small parts (a).
Scoop: stops + springs tuck the distal link; load passively shifts to proximal/middle links (b).
Result: "slide-in then lift" in constrained spaces, reducing table friction/marks and improving stability/safety.

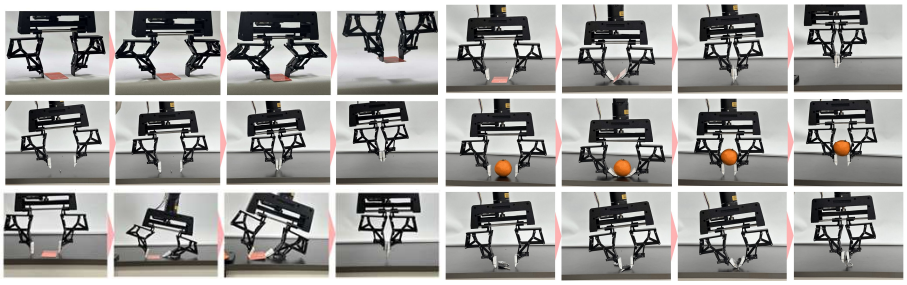



## Experiment Results

**Tasks:**
**Pinch:** thin plastic card, small screw.
**Symmetric scoop:** card, orange, keychain.
**Asymmetric scoop (wrist tilt):** wide/flat objects.

Watch the video



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