Tactile-Reactive Gripper with an Active Palm for Dexterous Manipulation

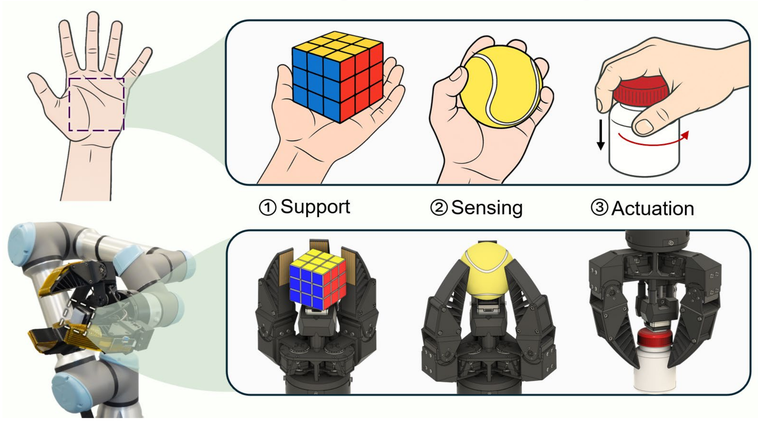
Yuhao Zhou[1], Won Suk Lee[2], Yan Gu[3] & Yu She[1]✉

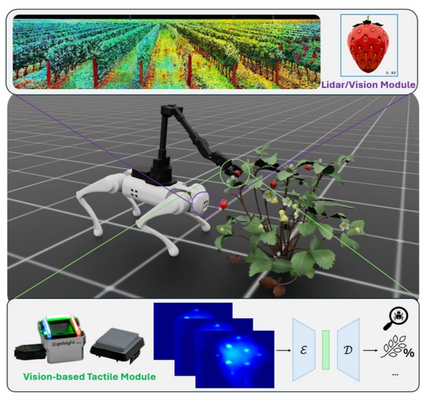
[1]Edwardson School of Industrial Engineering, Purdue University, West Lafayette, IN
[2]Department of Agricultural and Biological Engineering, University of Florida, Gainesville, FL
[3]School of Mechanical Engineering, Purdue University, West Lafayette, IN

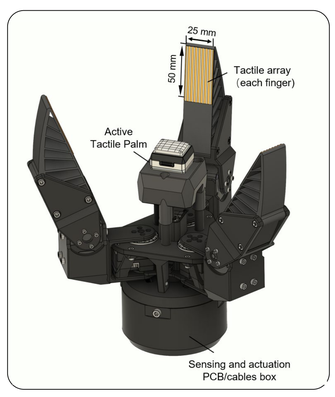
Overview

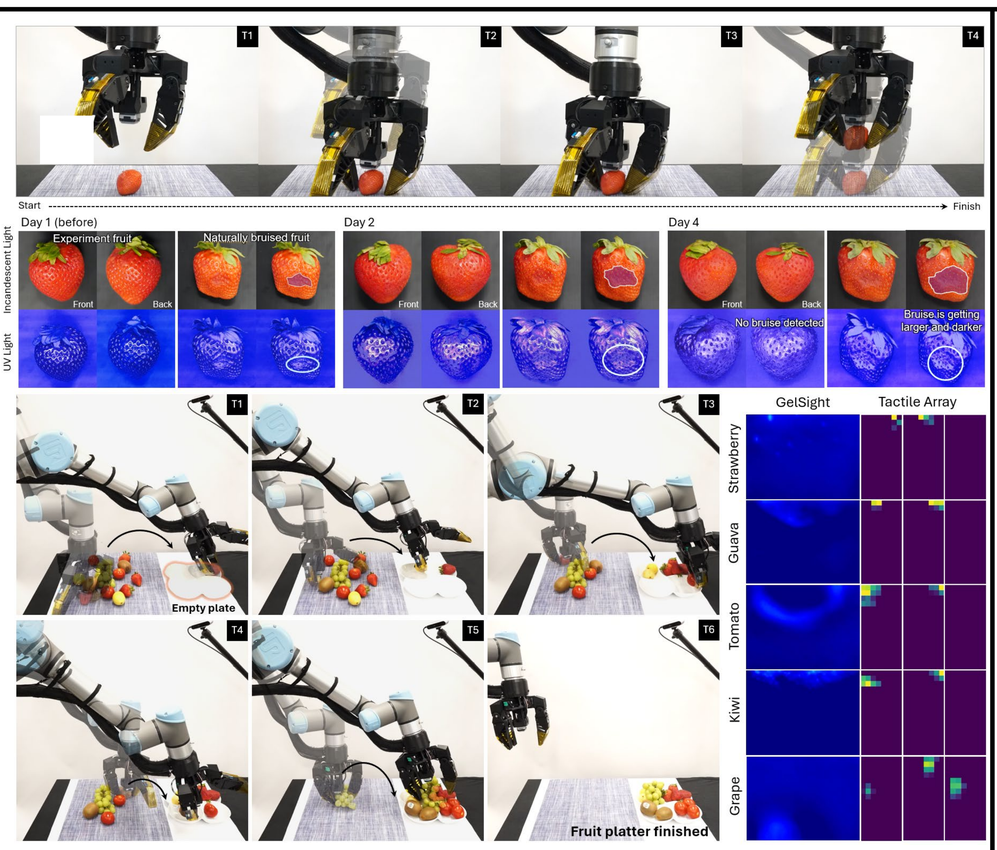
Introduction

Robotic grippers are critical for agricultural automation, where robots must handle crops and produce with diverse shapes, sizes, stiffness, and fragility. Conventional single degree-of-freedom (DOF) grippers are simple but lack adaptability, while high-DOF robotic hands offer dexterity at the cost of increased mechanical and control complexity. Recent tactile grippers improve contact perception, but most focus on fingertip sensing and finger actuation, overlooking the palm's roles in ***support***, ***sensing***, and ***actuation***. Inspired by the human palm, this work introduces a gripper with three compliant tactile fingers and an active vision-based tactile palm, enabling adaptive, tactile-reactive manipulation for ***delicate agricultural handling***.

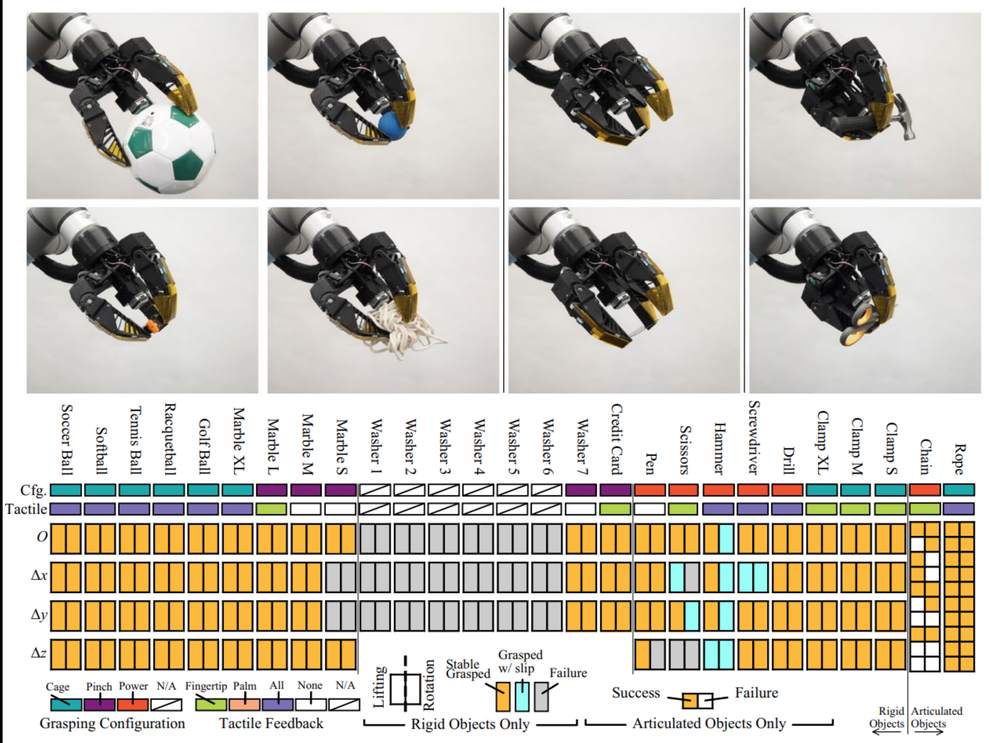




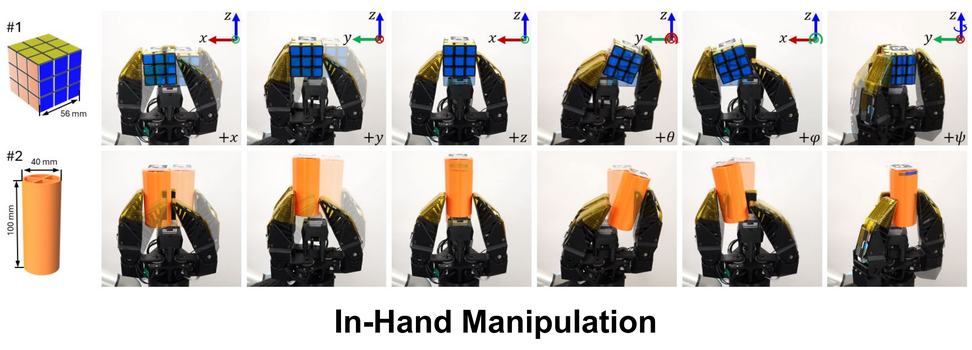




Delicate Fruit Picking

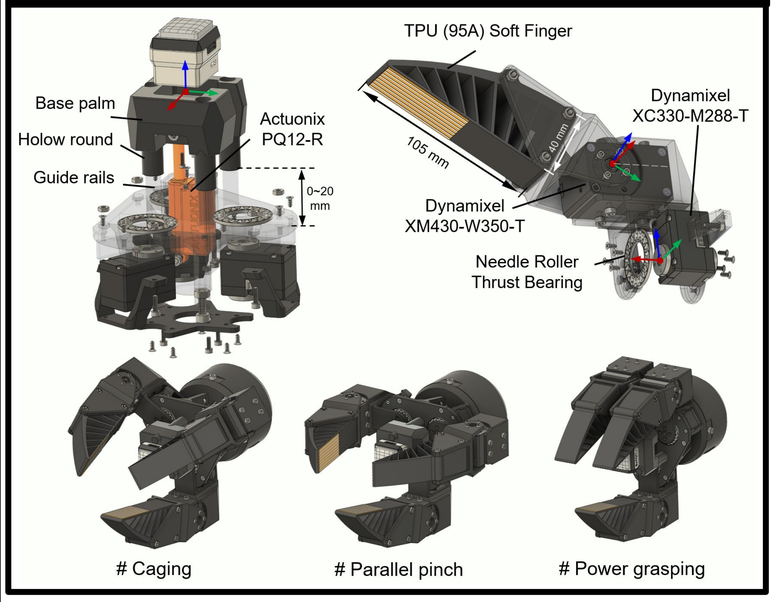


Tactile-Reactive Grasping

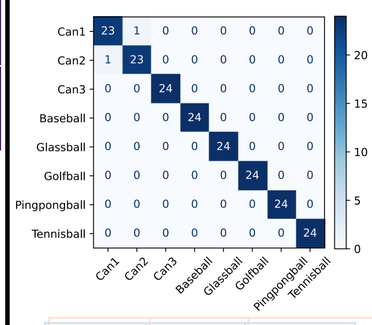


In-Hand Manipulation

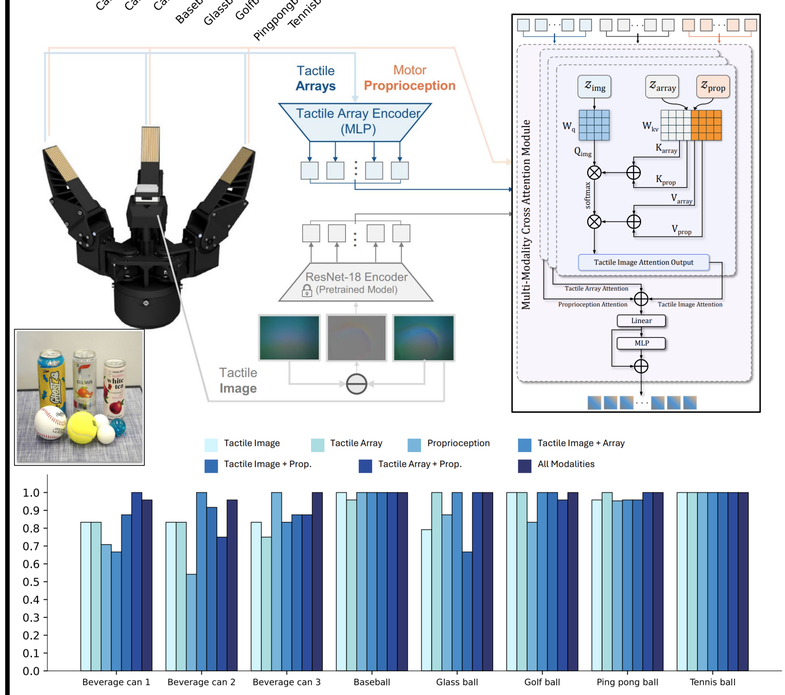
Design



Multi-Sensing Fusion

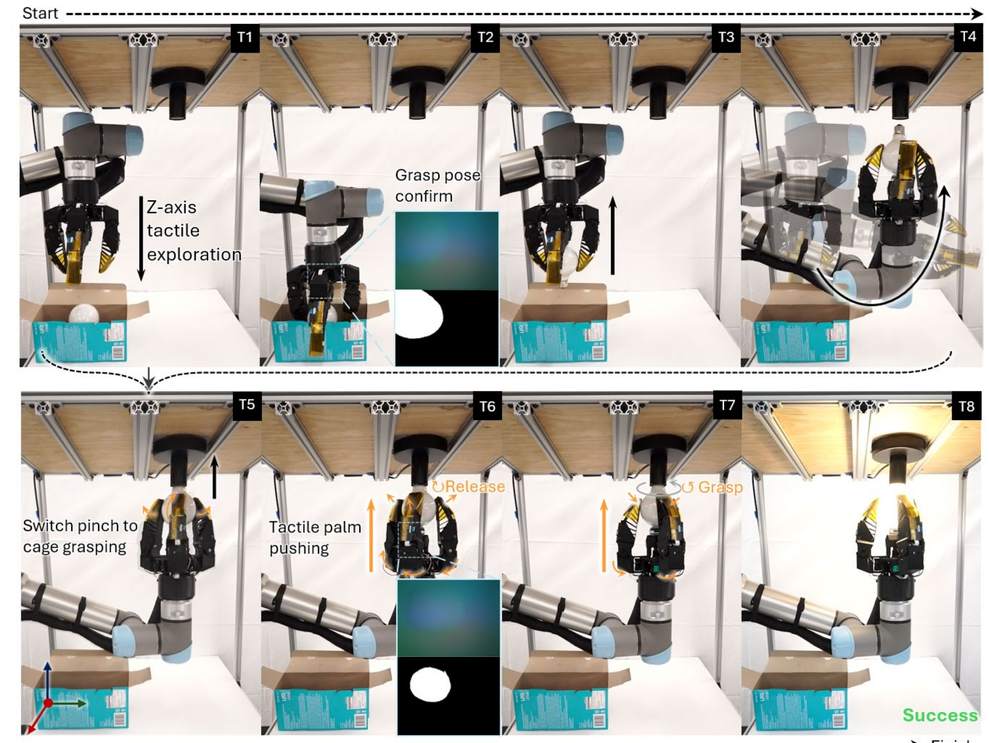


The proposed gripper fuses fingertip *tactile arrays*, vision-based palm *tactile images*, and motor *proprioception* through a cross-attention network. By combining local contact force, surface geometry, and finger configuration, the system improves object perception and achieves a **98.96% classification success rate**, outperforming single- and dual-modality sensing.

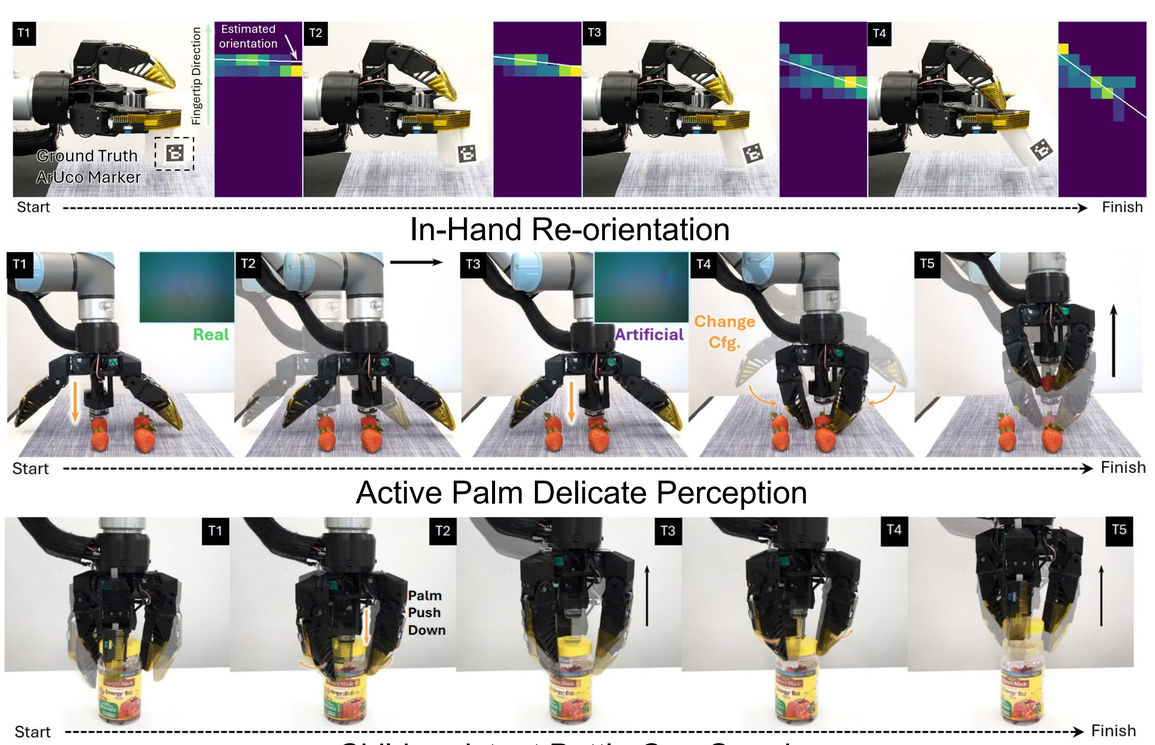


Conclusion

This work presents a tactile-reactive gripper that integrates compliant fingers with an active vision-based tactile palm. By combining palm actuation, fingertip tactile sensing, and multi-sensing fusion, the gripper achieves adaptive grasping, delicate fruit handling, and dexterous in-hand manipulation with only seven DOFs, demonstrating a practical design for contact-rich robotic manipulation.



Light Bulb Installation



In-Hand Re-orientation

Active Palm Delicate Perception

Child-resistant Bottle Cap Opening

Applications

The gripper demonstrates dexterity in diverse contact-rich tasks. For light bulb installation, the active palm provides upward support while fingers rotate the bulb. Fingertip tactile arrays enable in-hand re-orientation through pose estimation. The active palm identifies and picks an artificial strawberry via tactile perception. For child-resistant cap opening, coordinated palm pressing and finger rotation complete the task, highlighting dexterous palm-finger synergy.

This work was partially supported by USDA under award No. 2023-67021- 39072, No. 2024-67021-42878; NSF under award No. 2322056, No. 2423068, and No. 2520136. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funding agencies.