Synergia consortium meeting - Pitch presentation

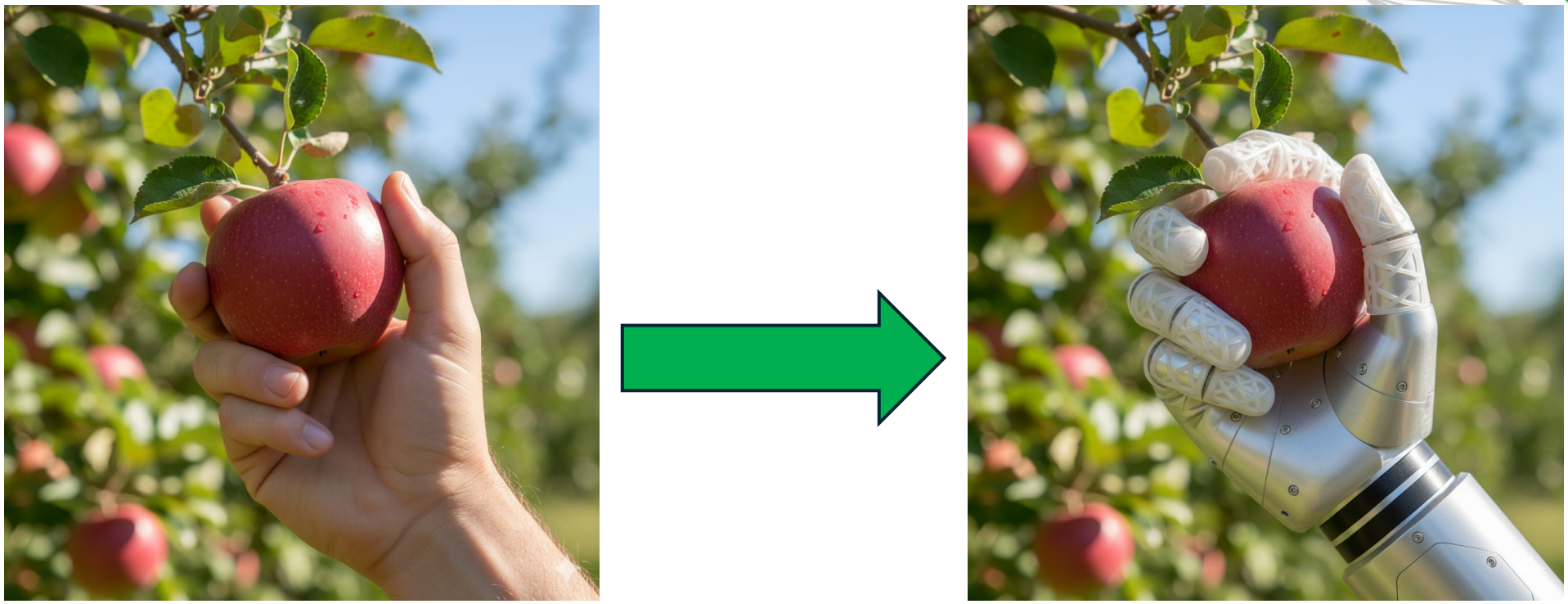
Force Distribution in Soft Grippers: An Analysis of Force and Pressure in the Fin Ray Effect Gripper for Delicate Object Handling

FILIP ŠUNJIĆ

DATE AND TIME: 23.09.2025

DURATION : 10 MINUTES

The Future of Agricultural Automation

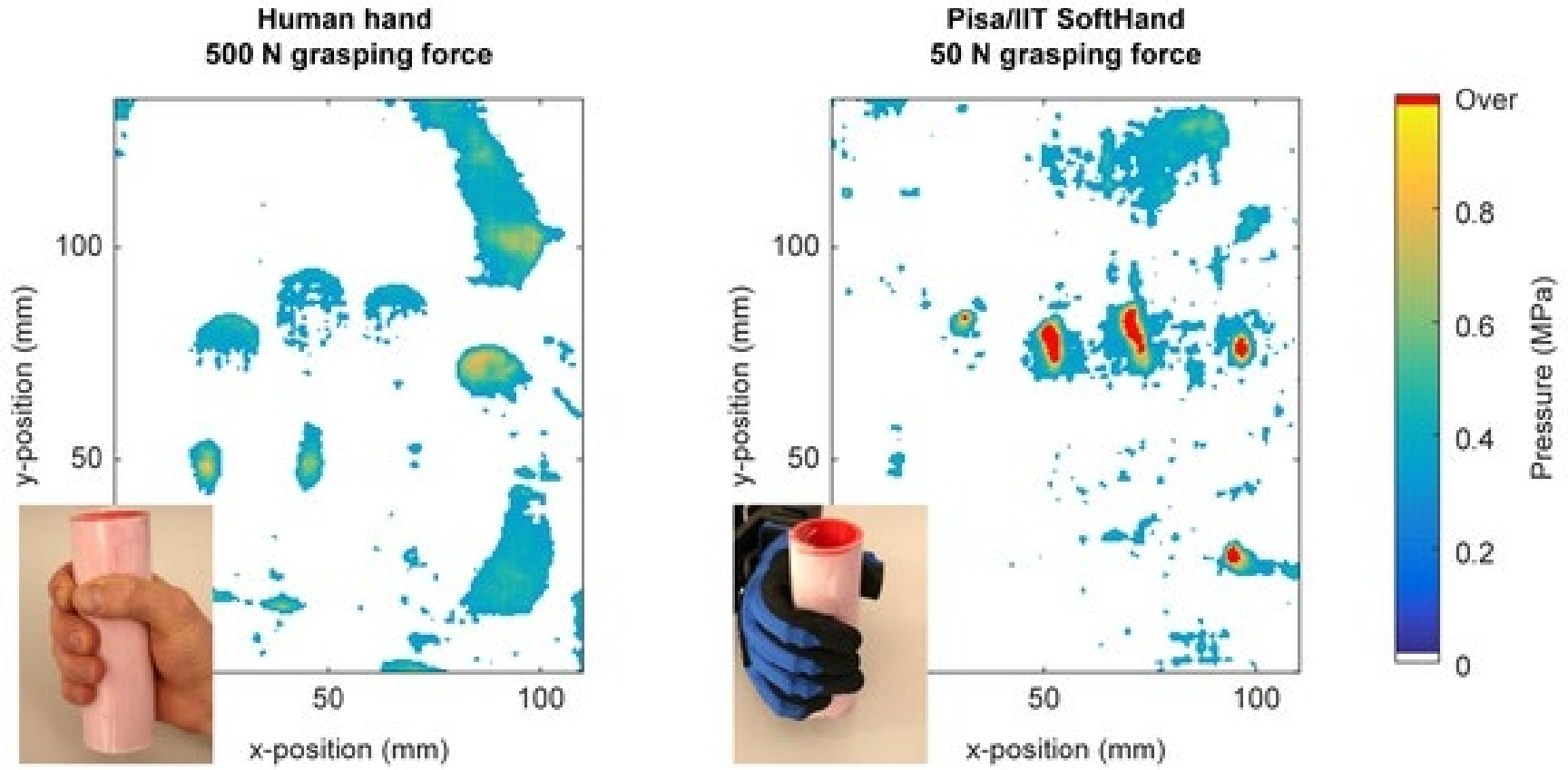


- Increasing shortage of agricultural workers (projected 29% shortfall over the next decade) [1]
- Damage rates during picking are typically 5–20% under standard commercial harvesting conditions [2]
- While we've made progress in computer vision, navigation, and manipulation, one critical challenge remains largely unexplored: contact mechanics.

1. Elfferich, J.F., Dodou, D., & Della Santina, C. (2022). Soft Robotic Grippers for Crop Handling or Harvesting: A Review. IEEE Access, 10, 75428-75443.
2. Jedermann, R., Nicometo, M., Uysal, I., & Lang, W. (2014). Reducing food losses by intelligent food logistics. Philosophical Transactions of the Royal Society A, 372(2017).

Human vs. Robot: The Pressure Distribution Reality

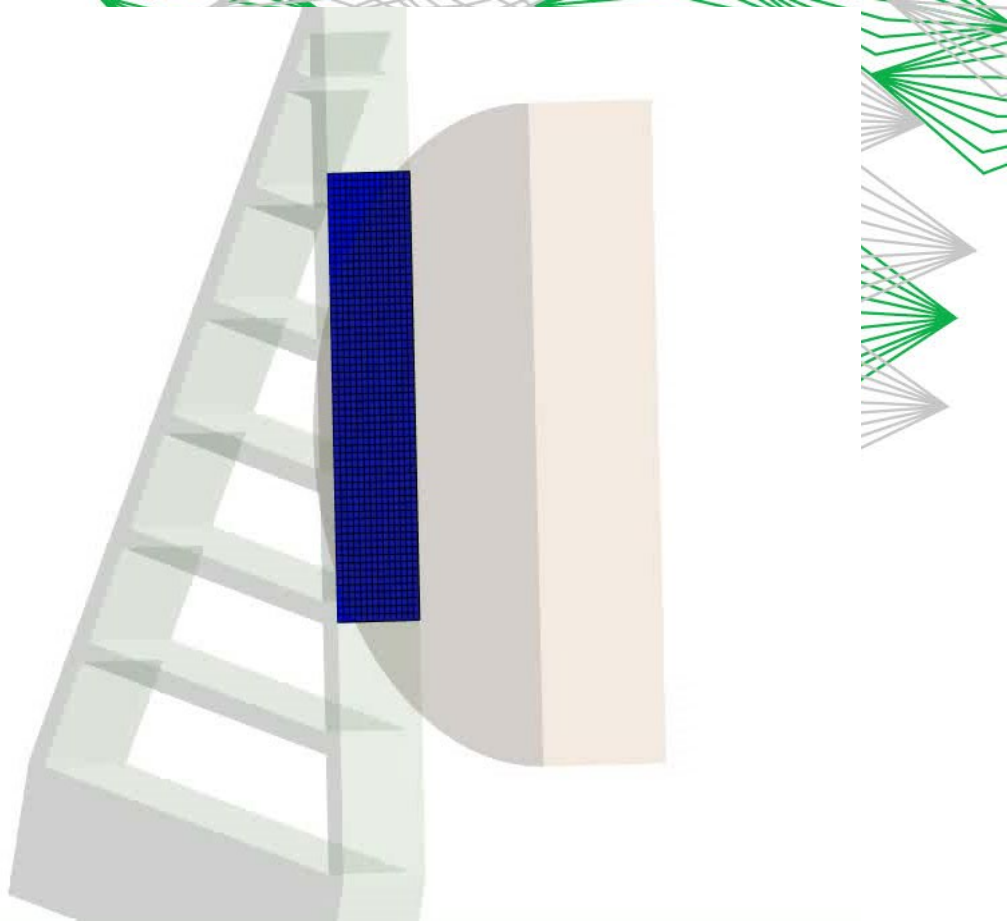
We assumed robots could replicate human gentleness - but the physics tells a different story

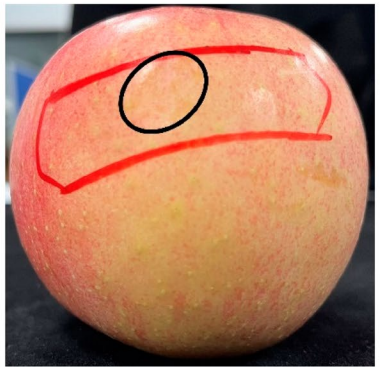


3. Knoop, E., Baecher, M., & Beardsley, P. (2017, March 7). *Contact Pressure Distribution as an Evaluation Metric for Human-Robot Hand Interactions*. HRI 2017 workshop – Towards reproducible HRI experiments: scientific endeavors, benchmarking and standardization 2017. Disney Research.

Contact mechanics of the fin ray effect gripper

- **Assumption:** Fin Ray grippers provide uniform, gentle contact through geometric conformity
- **Do these "soft" grippers actually distribute pressure evenly across the contact surface?**
- **Methodology:** Combined finite element analysis (ANSYS), multibody dynamics simulation (SPACAR), and experimental validation
- **Key Focus:** Understanding force transmission pathways and pressure patterns during interaction





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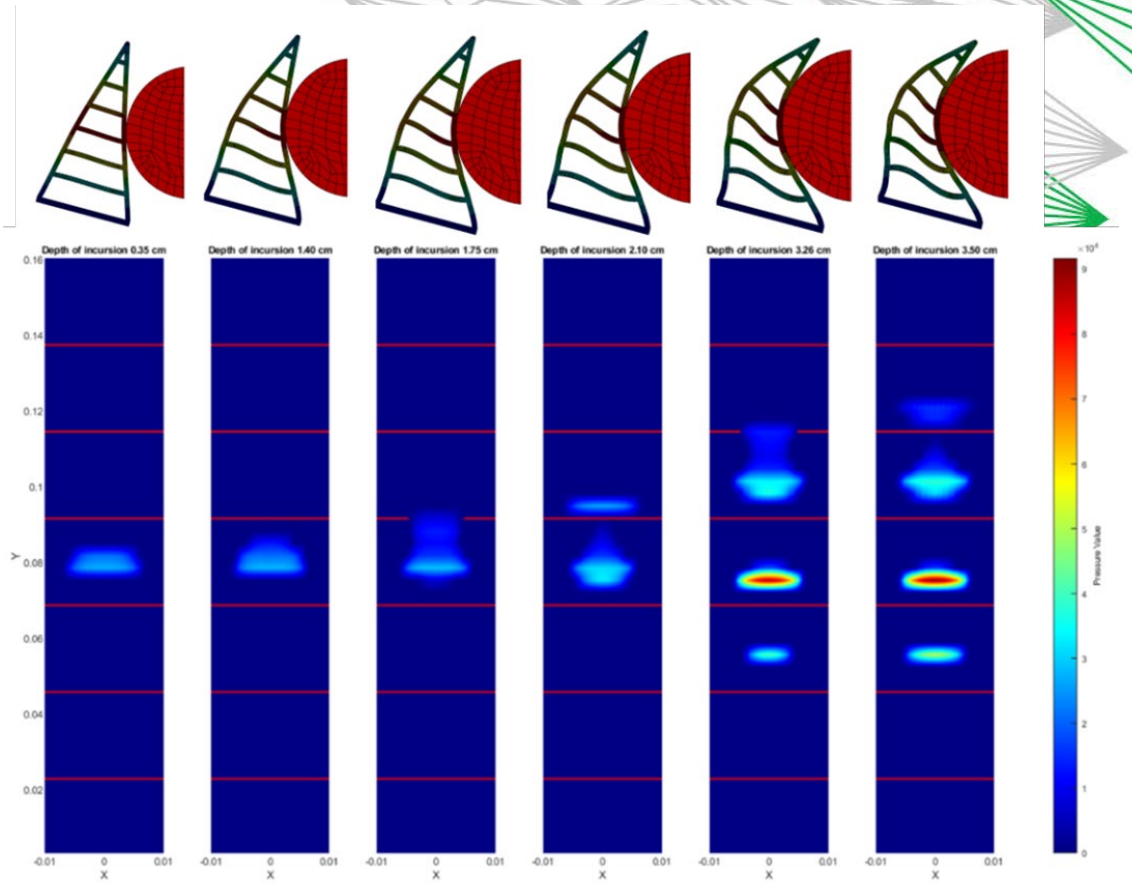
4. Chen K, Li T, Yan T, Xie F, Feng Q, Zhu Q, Zhao C. A Soft Gripper Design for Apple Harvesting with Force Feedback and Fruit Slip Detection. Agriculture. 2022; 12(11):1802.

Research Impact: Bridging the Contact Mechanics Gap

- **Understanding the Shape:** fin ray geometry determines pressure distribution patterns - **not just total force, but where that force concentrates**

- **Bridging the Knowledge Gap:** mechanistic explanation of contact mechanics in soft grippers, **moving beyond empirical trial-and-error design**

- **Practical Utilization Guidelines:**
  - Cross-beam placement strategies for optimization
  - Predictive design frameworks for agricultural applications
  - Material and geometry selection



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Impacts of the research

- **From Discovery to Application:** Transform gripper design from guesswork to predictive engineering
- **Immediate Opportunities:**
  - Design optimization consulting for equipment manufacturers
  - Application-specific gripper development for different crops
  - Integration frameworks for existing automation systems
- **Evaluation Revolution:** Shift industry standards from force-based to pressure-distribution metrics for truly gentle handling

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Guo, T., et al. "Research on the Bionic Flexible End-Effector Based on Tomato Harvesting." *Journal of Sensors*, 2022.