# Robust Grasping by Integrating Machine Learning with Physical Models

Award ID#: 1924984 | Poster #: [TODO]

Zixi Liu[1], Alexandre Bayle[1], Robert D. Howe[1,2], Lucas Janson[1]

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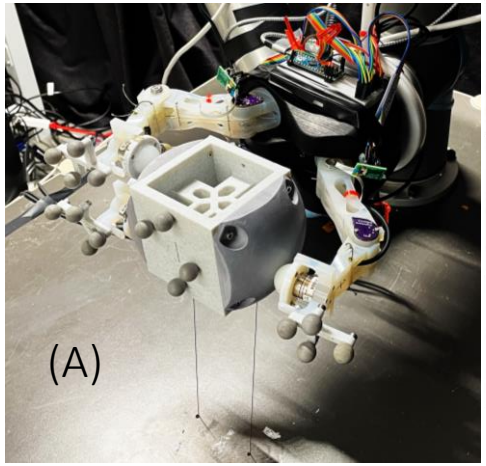
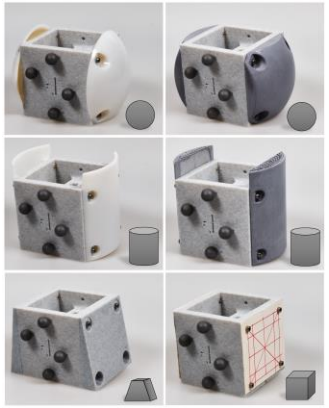
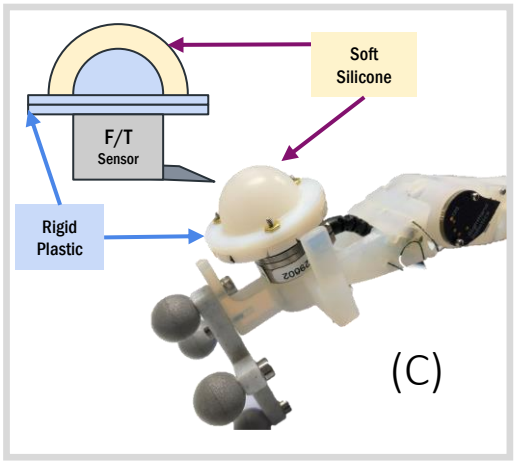
## Highly Instrumented Robot Hand



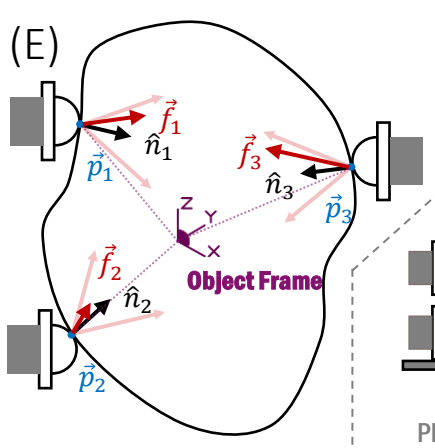



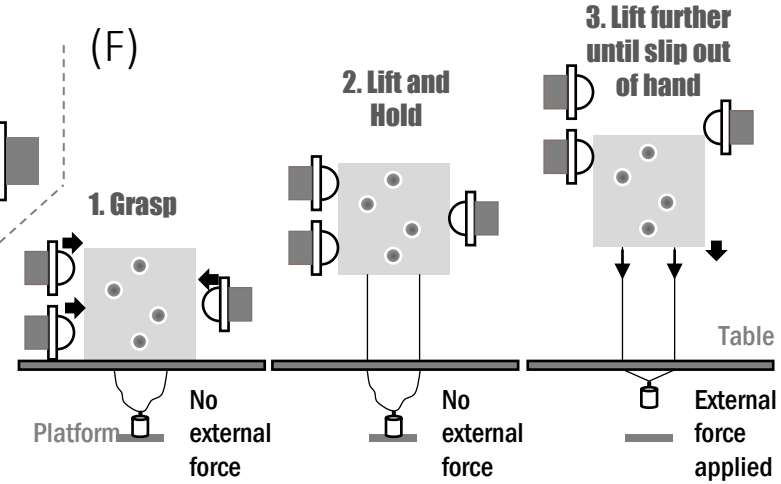

(A) The robot hand holding an object during an experiment.
(B) Six objects including 2 spheres, 2 cylinders, one cube, and one pyramid, with precise fiducial mounting for accurate gold-standard calculation.
(C) The robot finger has a high precision force/torque sensor (ATI Nano17) and hemispherical fingertip with a 3mm soft silicone padding.

(D)

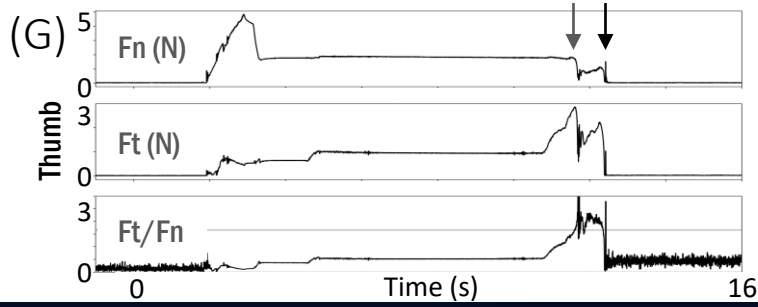
| Grasp Parameters | In-Hand | Lab Gold-Standard |
|---|---|---|
| Contact Location | Optical tracker (Atracsys Fusion Track 500, resolution: 90 µm RMS) + geometry of fingertip & object | Joint angles (0.0219°/LSB) + kinematic models (±5 mm) |
| Surface Normal | Optical Tracker + geometry of fingertip & object | Contact location (fingertip frame) + fingertip geometry + kinematics |
| Contact Force/Torque | Force Torque sensor (ATI Nano17, resolution: 1/160N, 1/32Nmm) | (same as in-hand) |

## Grasp—Lift and Hold—Slip: Experiment Setup




(E) Illustration of grasp parameters where $\vec{p}_1, \vec{p}_2, \vec{p}_3$ are contact locations, $\hat{n}_1, \hat{n}_2, \hat{n}_3$ are surface normal, and $\vec{f}_1, \vec{f}_2, \vec{f}_3$ are contact forces.
(F) The experiment process: 1. Grasping the object, 2. lifts and holds the object in air, 3. continues to lift the object until external force is activated and pulls the object, causing it to slip out of the robot hand.




(G) Typical sensor data: normal, tangential forces and the ratio of the two on the thumb in one experiment.

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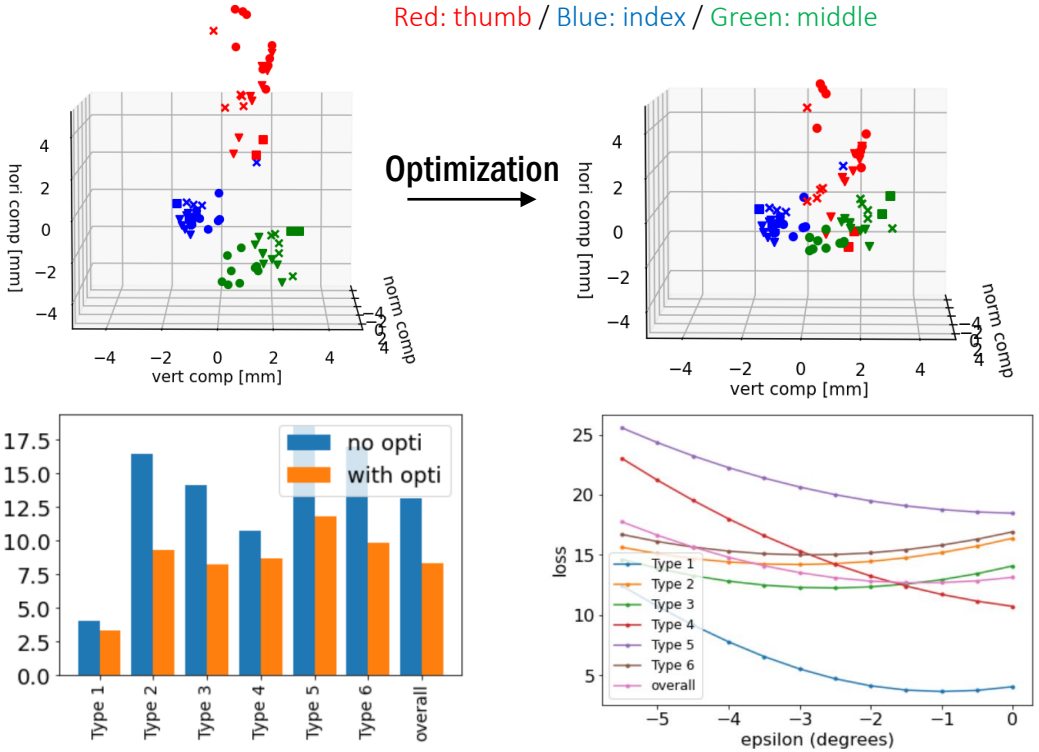
## Improved Hybrid Grasp Parameter Estimation

Square: cube / Circle: sphere / Triangle down: cylinder / Cross: slanted

Red: thumb / Blue: index / Green: middle



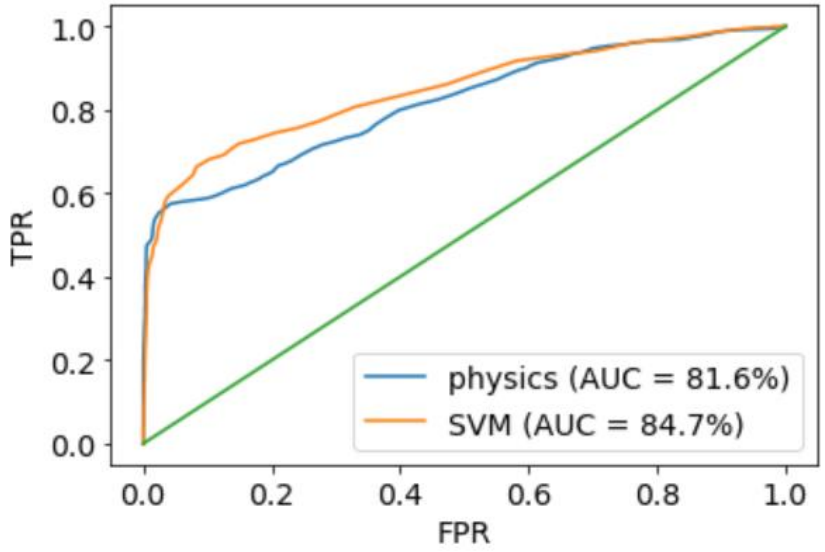

Ground-truth grasp parameters, necessary for this ML-based improvement, are obtained with the Atracsys Optical tracker

## Improving Physics and ML Grasping

Goal: grasp stability prediction

Want to compare hybrid approach with:

- physics-based approach
- ML approach (SVM)




Hybrid is a work-in-progress with more parameters to add and tune