Robust Grasping
by Integrating Machine Learning with Physical Models

Award ID#: 1924984 | Poster #: 51

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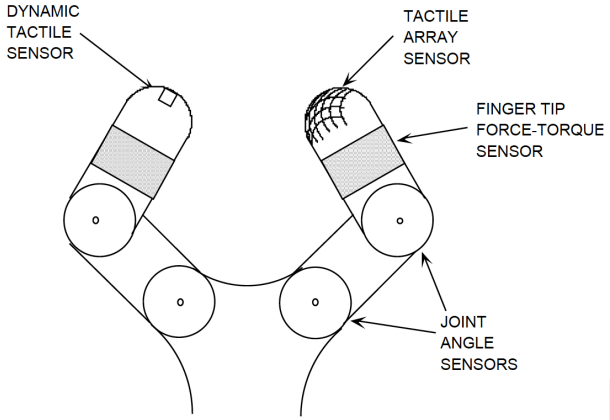
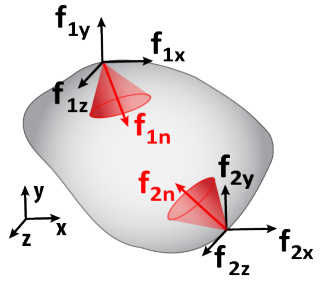


Hand Sensor Signals
- Tactile Array
- Force-Torque
- Joint Angles

Inverse Sensor Physical Model

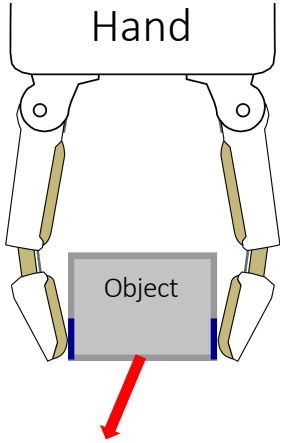
Residual Machine Learning Model



Grasp Parameters
- Contact Locations
- Surface Normal
- Contact Forces

Grasp Stability Physical Model

Residual Machine Learning Model



Grasp Stability Prediction
- Grasp Quality
- Maximum Task Wrench

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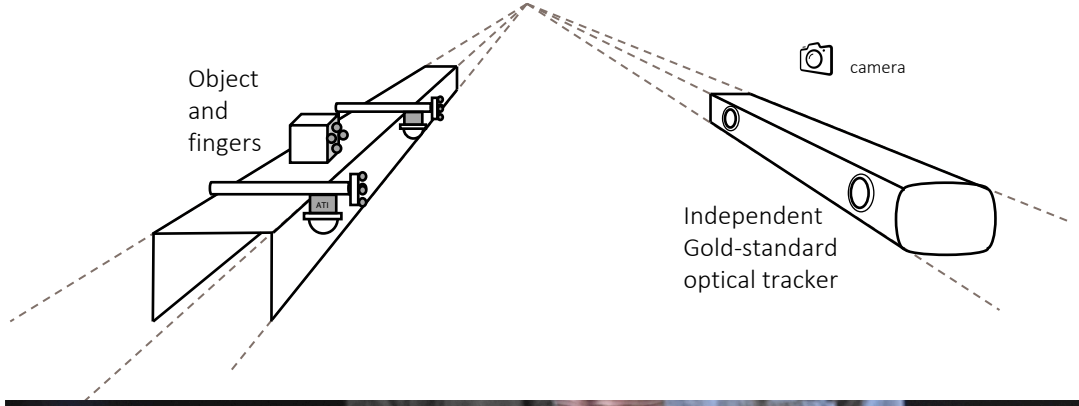
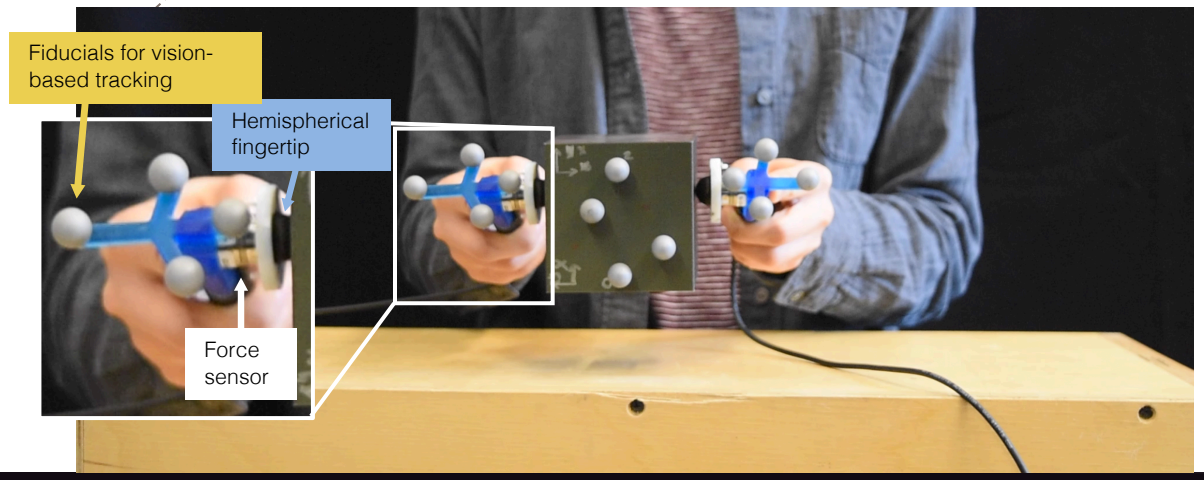
Independent Gold-Standard Validation

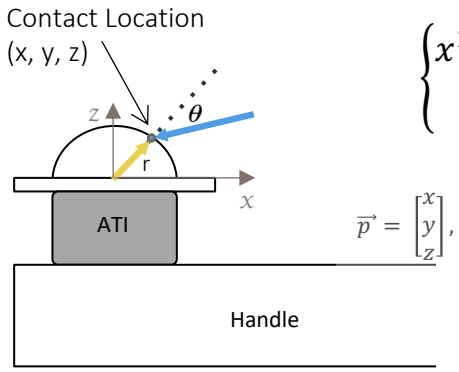
Experimental setup recording from both sensors in robot hand as well as an independent gold-standard sensor.





Intrinsic Sensing Accurately Estimates Grasp Parameters

Estimating grasp parameters contact location and contact surface normal via intrinsic sensing (Salisbury 1992). Validation results show high estimation accuracy.



$$\begin{cases} x^2 + y^2 + z^2 = r^2 \\ \vec{\tau} = \vec{p} \times \vec{f} \end{cases}$$

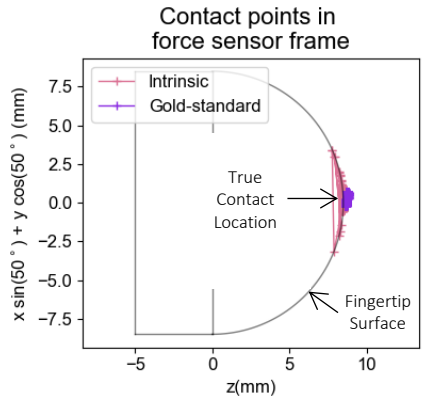
$$\vec{p} = \begin{bmatrix} x \\ y \\ z \end{bmatrix}, \quad \vec{f} = \begin{bmatrix} F_x \\ F_y \\ F_z \end{bmatrix}, \quad \vec{\tau} = \begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix}$$

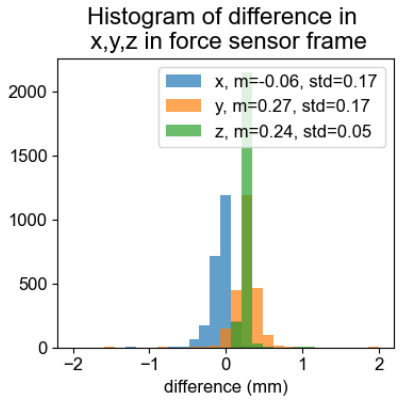
For Contact Location:
Solve for

$$\vec{p} = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

For Surface Normal:
Solve for

$$\vec{n} = \frac{\vec{p}}{|\vec{p}|_2}$$





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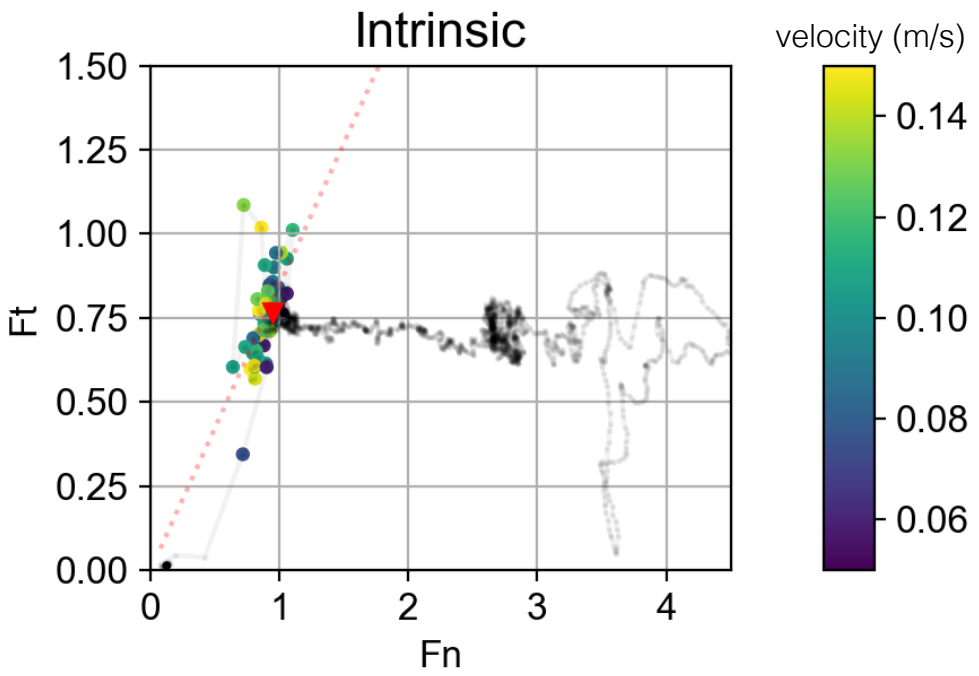
Friction behavior Shows High Variability

By evaluating tangential vs. normal force during a slip, analysis show that the coefficient of friction is highly variable, indicating sources of error when assuming Coulomb's Law of Friction.



$$\mu = \frac{Ft}{Fn}$$