Carnegie Mellon University

Design and Fabrication of Robot Hands for Dexterous Tasks

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with Dominik Bauer, Kai-Hung Chang, Chris Hazard, Jonathan King, Yuzi Nakamura, and Cornelia Schlagenhauf







From Task Description to Custom Robot Hand





Simple Manipulations



Simple Manipulations



Simple Manipulations



Alternative Objective: Drawing



"Multi-objective" Chaining Example





"Multi-objective" Chaining Example Sphere Rotation + xy translation Nancy Pollard and Stelian Coros -- Design and Fabrication of Robot Hands for Dexterous Tasks

Hand Optimized for Sphere Rotation



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Soft Foam Hands



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Morphology and Rest Shape Design



Simulation Model

Minimizing total deformation energy

$$E = E_{foam} + E_{contractile} + E_{pins}$$

 E_{foam} $E_{contractile}$ E_{pins}

Mesh deformation Tendons Pins

- Tendon contraction level $a_c \in [0, 1]$
- Contracted length $l_c = l_0 \cdot (1 a_c)$





Interactive and Iterative Design

Main Menu Interactive simulation **, FPS 🖬 🔍 Nayback Controls 0. F H Load and save tendors / mesh Place/remove & & A save mesh tecord and play back motion tendons 2 2 + 0 * **Isualization** option Explore Place tendons workspace endon properties Nodes pertendo Add draggable point Create motion + 0 keyframes

Optimize for Tendon Placement



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| Example Result – Precision Tripod | | | | |
|-----------------------------------|-----------------|---|---|---|
| | | | Finger Thumb Index Middle Ring Pinky | $\begin{array}{c} {\rm Pos \; Error[cm]} \\ 0.75 \\ 0.69 \\ 0.48 \\ 0.26 \\ 0.41 \end{array}$ |
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Control – Keyframed Motions



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Control – Teleoperation using a CyberGlove

- CyberGlove
 - 22 resistive bend sensors
- Data collection
 - Imitating robot hand pose
 - 24 poses, each pose recorded 5 times





Control – Teleoperation using a CyberGlove

- Linear Regression Model
 - Input: 22 joint angles
 - Output: 10 motor actuations
 - Ridge regression with a linear kernel





This year

- Optimization for multiple independent tasks
- Refine tendon optimizationNew materials and processes







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