

Hybrid Active-Passive Actuation For Human-Robot Collaboration and Rehabilitation



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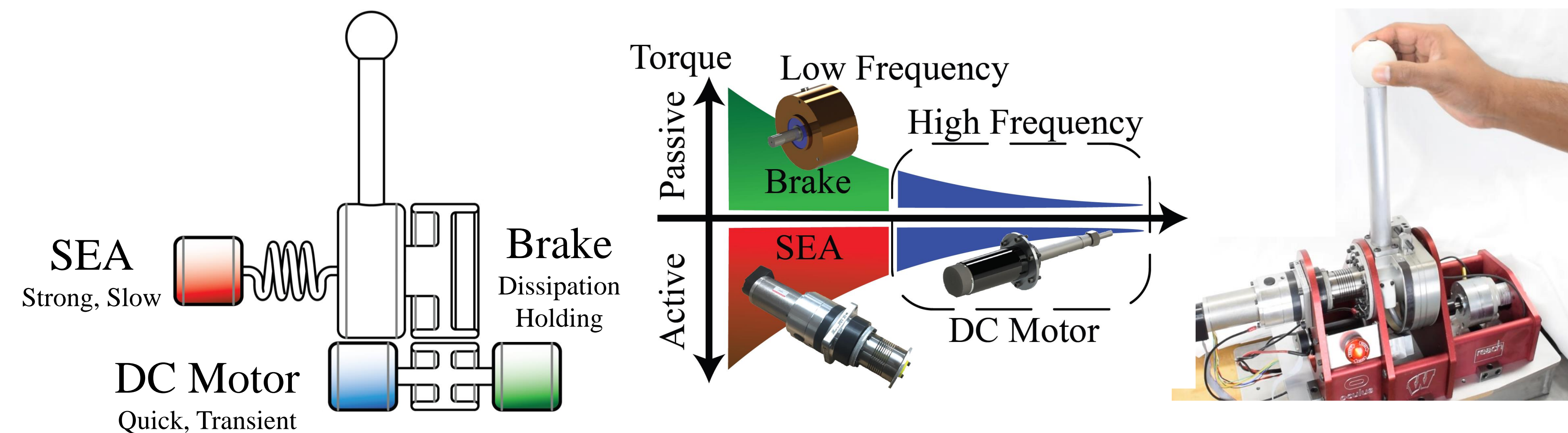
Challenge: Interactive Robots

Strong • Fast • Safe

Needs New Actuation!

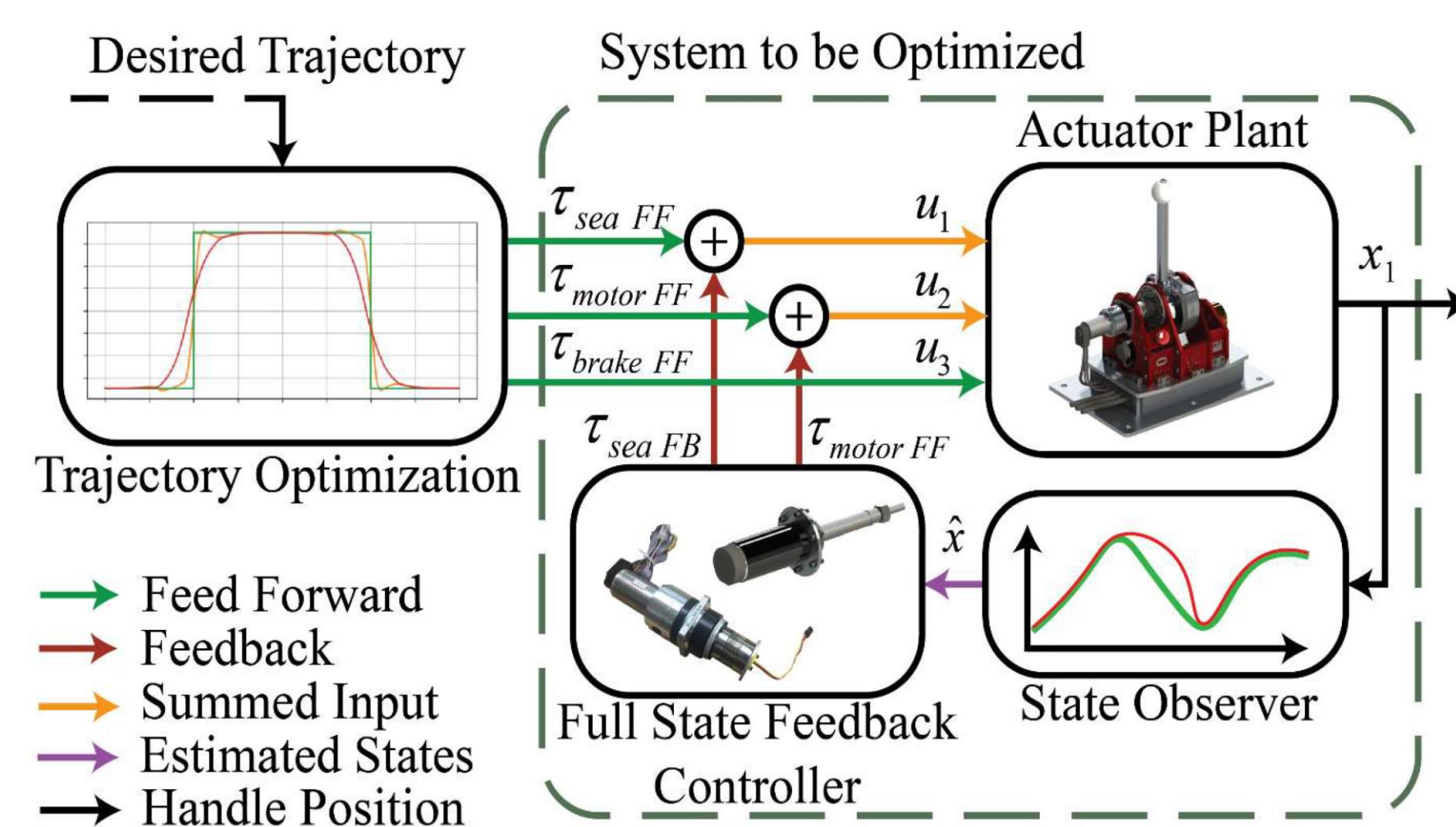
	Large Forces or Torques	Large Bandwidth Of Forces	Transparent	Variable Impedance Rendering	High Stiffness Rendering
Controllable Brakes or Shape Rendering	✓	✗	✓	✗	✗
Admittance Control Based Devices	✓	✗	✗	✓	✓
Series Elastic Actuator Devices	✓	✗	✓	✓	✗
G geared DC Motors	✓	✓	✗	✓	✓
Pneumatic and Soft Actuation	✓	✗	✗	✓	✗
Hybrid Actuation	✓	✓	✓	✓	✓

Hybrid Active-Passive Actuation



Optimal Feedforward Control

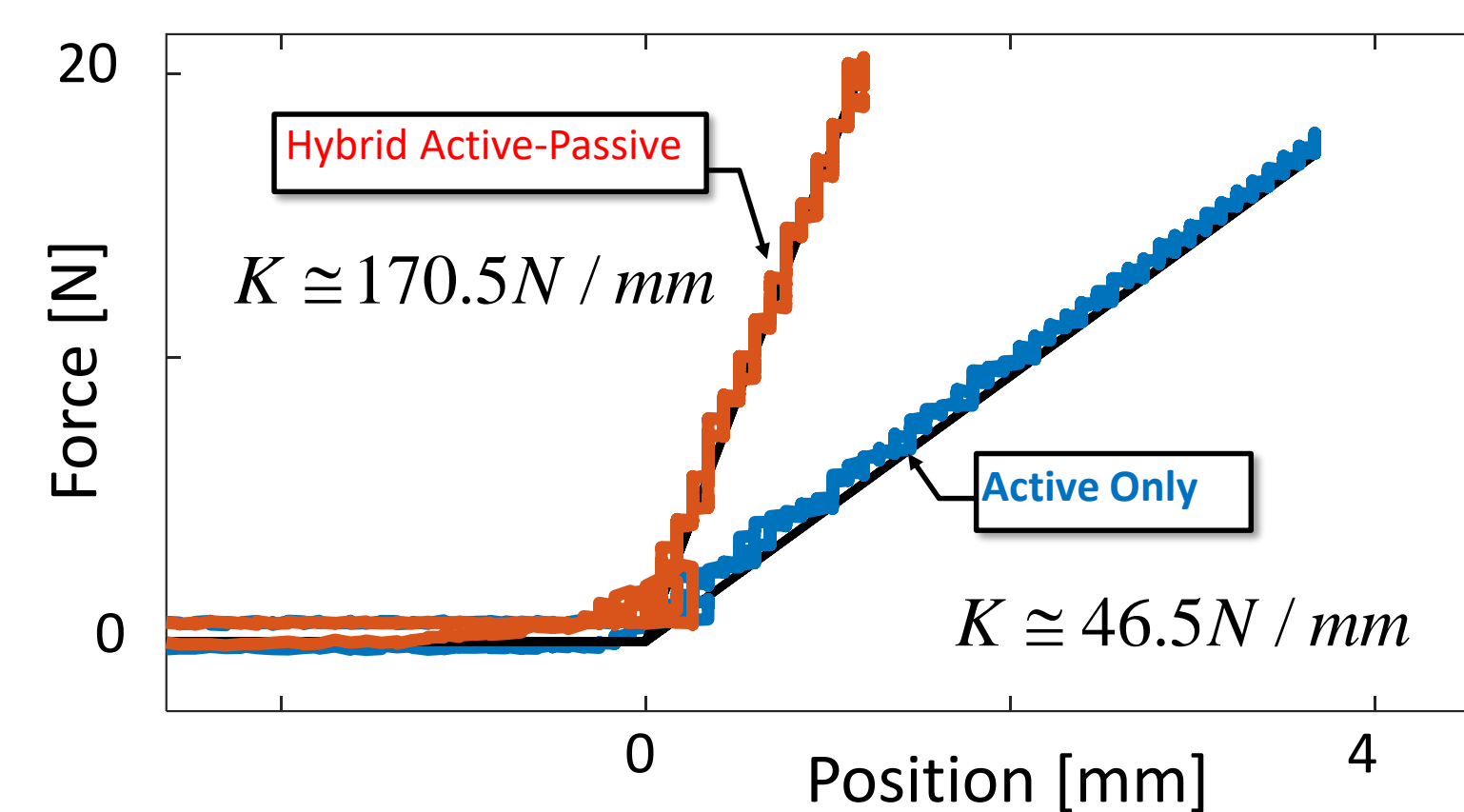
Brake Model • Time vs. Energy vs. Effort Optima



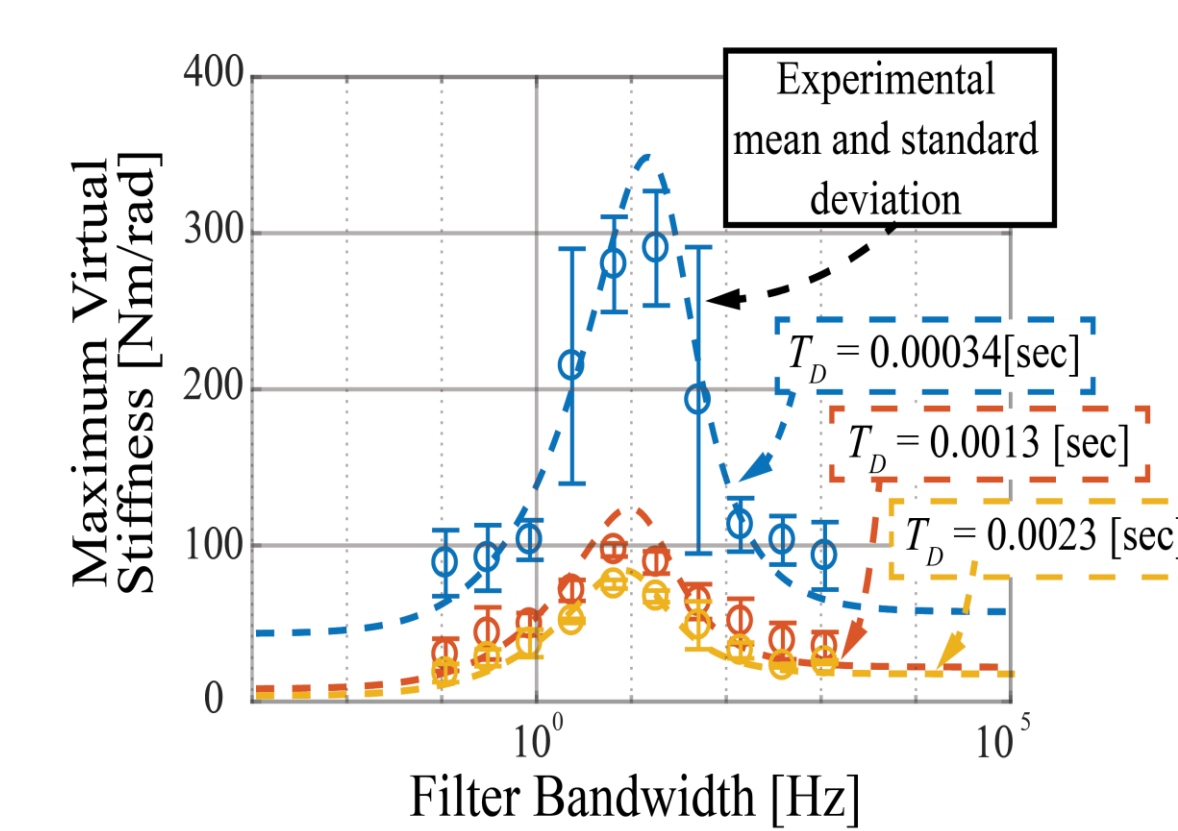
Novel Results

Stiffer Virtual Walls

Physical Stiffness of Brake Control and Filter Design

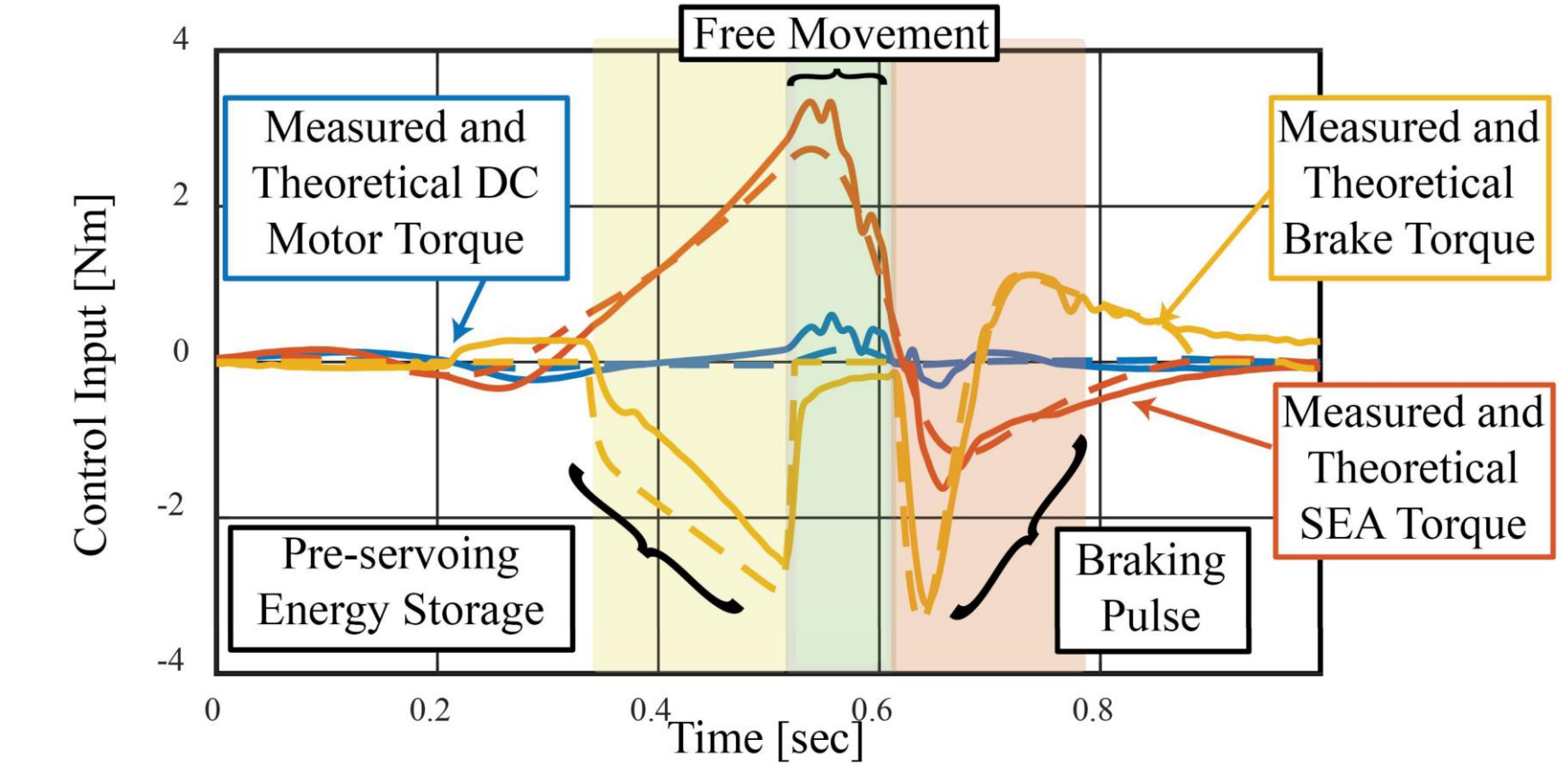


Control and Filter Design



Quicker Servoing

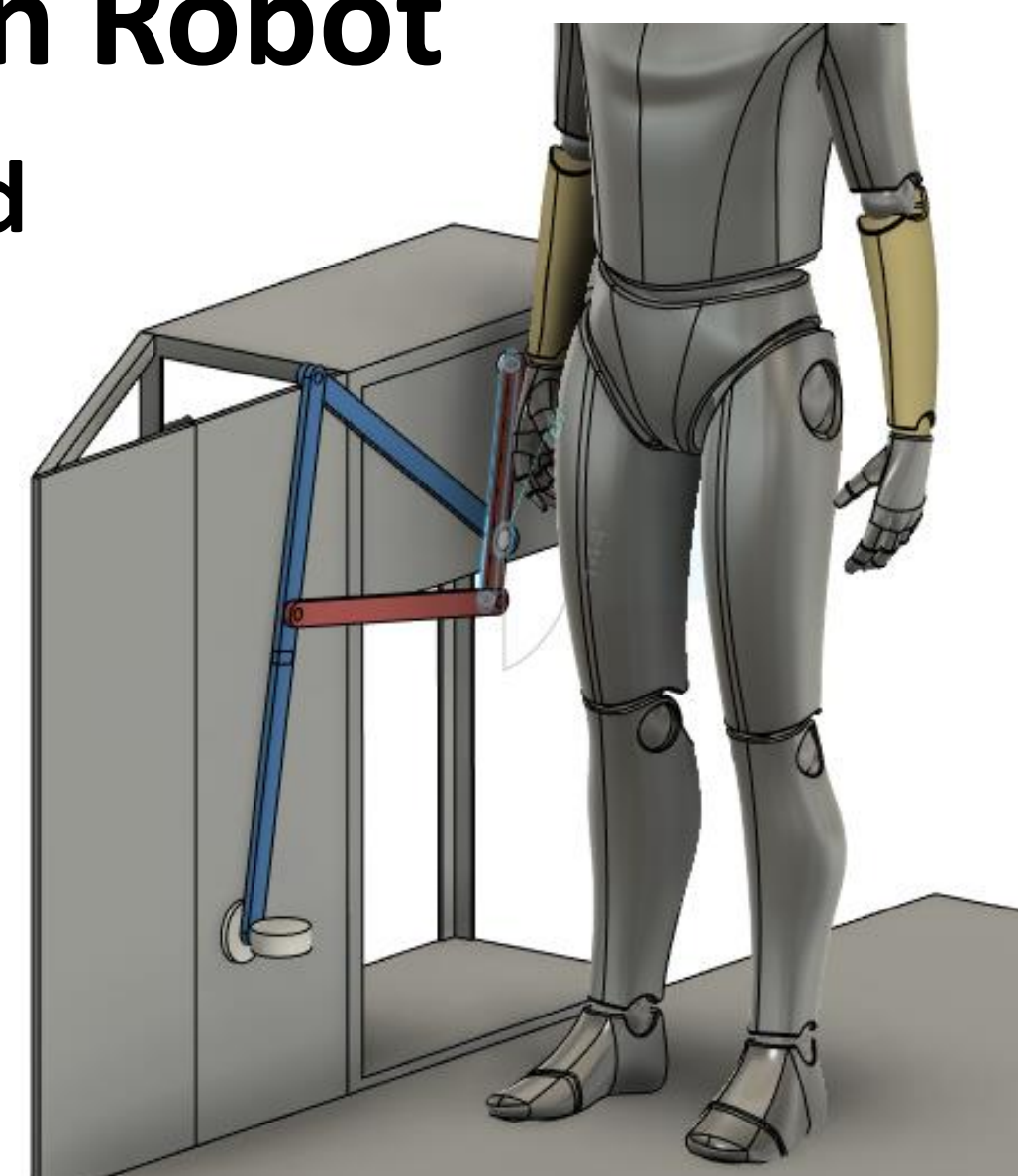
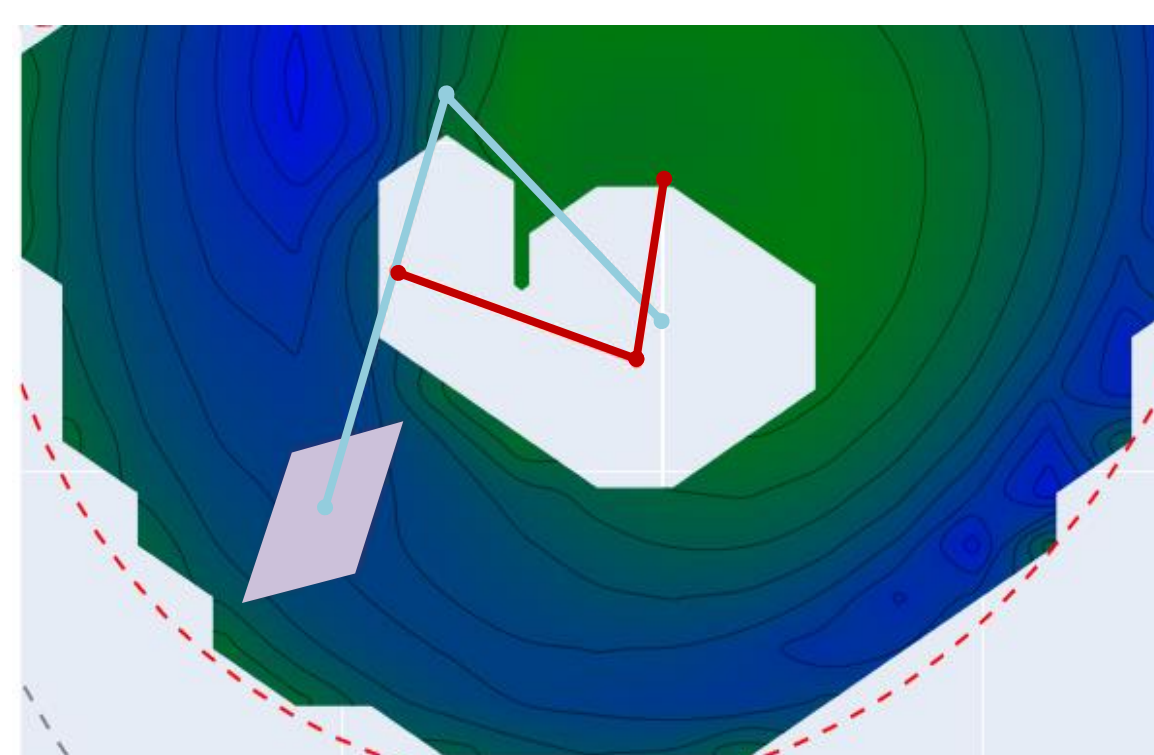
Quick Stops • Spring Preloading



Impact Application: Rehabilitation Robot



Human-Optimal Force and Workspace Matching



Impact: Education

Handheld Demo

- Feel Hybrid vs. Active Control
- Goal: Demo at Engineering Expo (3000+ students)



Impact: Science and Technology

Hybrid Active-Passive Actuators

- Design Rules
- Control Laws

Human-Interactive Robotics

- Rehabilitation
- Materials Co-handling
- Fixturing