NRI: FDN: Dexterous Manipulation Using Multi-Serial Manipulator Systems with Real-Time Compliance Modulation

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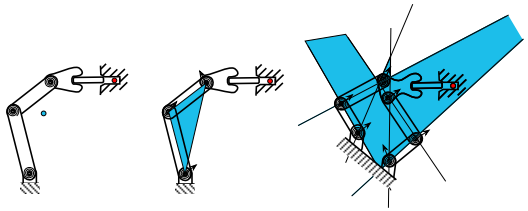
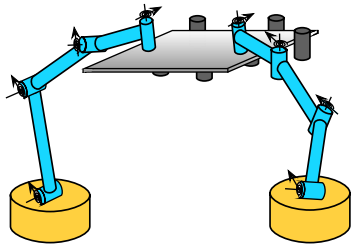
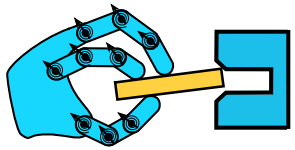
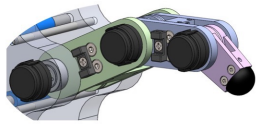
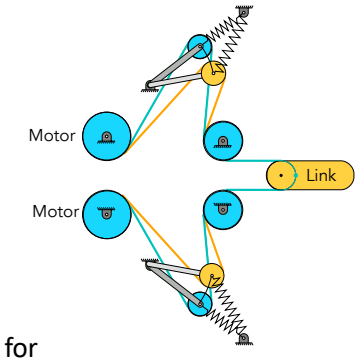
https://www.eng.mu.edu/schimmelsj/research.html











Challenge

- Achieve robot dexterity in ***any*** constrained manipulation task
- Identify and realize the task-appropriate passive compliance that can be readily adjusted in real-time for fast constrained manipulation with regulated contact forces
- Single manipulator systems are not able to project compliance center outside its workspace so task-beneficial compliance behavior not attainable

Solution

- Realize much larger set of passive compliant behaviors using multi-serial manipulator systems
- Variable stiffness actuation used in each manipulator allows both position control and stiffness modulation of each joint

Scientific Impact

- Identify the necessary and sufficient conditions needed for different mechanism topologies to achieve any specified compliance
- Develop procedures to synthesize any desired compliant behavior by specifying joint locations and joint stiffnesses when each manipulator is:
  - rigidly coupled to part (multi-serial compliant manipulator systems (above))
  - making point contact with part (fingers of compliant hand (above))
- Develop procedures to track a position/compliance trajectory for kinematic and actuator redundant systems
- Design and test a planar variable stiffness actuated robot hand (above) that is
  - tendon driven
  - antagonistically actuated with quadratic springs

  to demonstrate manipulation 30x faster w/ lower contact forces

Societal Broader Impact

- Provides manipulation assistant for:
  - senior assistance (food preparation, cleaning)
  - manufacturing (assembly, material handling)
  - agriculture (picking/handling fruit/vegetables)
  - nuclear remediation
  - ordnance disposal

Educational Broader Impact

- Funding supports:
  - 1 Ph.D. student, 2 M.S. students
  - Compliance Selection/Realization Workshop
- Work complements:
  - FASN Advanced Manufacturing Center

Technical Broader Impact

- Allows dexterous robot manipulation in any constrained task involving:
  - large or heavy objects (multi-arm system)
  - small or fragile objects (multi-finger system)

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