Compliant and Robotics Systems (CARS) Laboratory

Laboratory Coordinator: Dr. Anupam Saxena

Associated Faculty Members (if any): No

List of Major Equipment:

- Computer Systems

Brief description of the laboratory:

We find realizable solutions to design problems in areas of Compliant and Robotic Systems (CARS) with applications in product design, precision instrumentation, sensing and actuation, MEMS/NEMS, bio-medical devices, humanoid robotics, exploration, surveillance, search and rescue, transportation, prosthetic and orthotic/exoskeletal devices. We derive inspiration from designs in nature, which amongst having many interesting attributes, are sustainable (time tested and robust) and exemplify integration of subsystems of a variety of properties and scales.

Laboratory research keywords:

Design of compliant mechanisms and MEMS, Structural Topology Design/Optimization, Computer Aided Engineering Design and Graphics, Geometrically/Materially Large displacement Finite Element Analysis, Robotics, Kinematics.

Major Research and Development Contribution of the Laboratory

Year	Major research and development activity
2020-2021	▪ Developed a Normalized Field Product method for Topology Optimization ▪ Topology Optimization in 3-dimensions with Tetra-kai-decahedra and Spheroidal Masks ▪ Compliant Constant Output/Input Force Mechanisms — Topology Optimization with Contact ▪ A Material Mask Overlay Strategy for Close to Binary Design-dependent Pressure-loaded Optimized Topologies ▪ Comprehending finger flexor tendon pulley system using systematic computational analysis ▪ Topology synthesis of a 3-kink Contact-aided compliant switch. ASME Journal of Mechanical Design
2019-2020	▪ On topology optimization of large deformation contact-aided shape morphing compliant mechanisms ▪ On Topology Optimization with Elliptical Masks and Honeycomb Tessellation with Explicit Length Scale Constraints

2018-2019	▪ On Upper Bounds with $ABC = 2^m p^n$ and $ABC = 2^m p^n q^r$ with p and q as Mersenne or Fermat Primes ▪ Computational optimization of large deformation compliant mechanisms undergoing self and mutual contact
2017-2018	▪ Adaptive Discretization for Computerized Tomography. ▪ On Redundancy Resolution of the Human Thumb, Index and Middle Fingers in Cooperative Object Translation.
2016-2017	▪ On Synthesis of C^0 Path Generating Compliant Mechanisms with Mutual Contact using the Material Mask Overlay Method
2015-2016	▪ Optimal Spatial filtering schemes and compact tomography setups ▪ On topology optimization with embedded boundary resolution and smoothing ▪ Reliable reconstruction strategy with higher grid resolution for limited data tomography ▪ Non-uniform Arrangement of Emitter-Receiver Pairs Arrangement and Compact Ultrasonic Tomography Setup

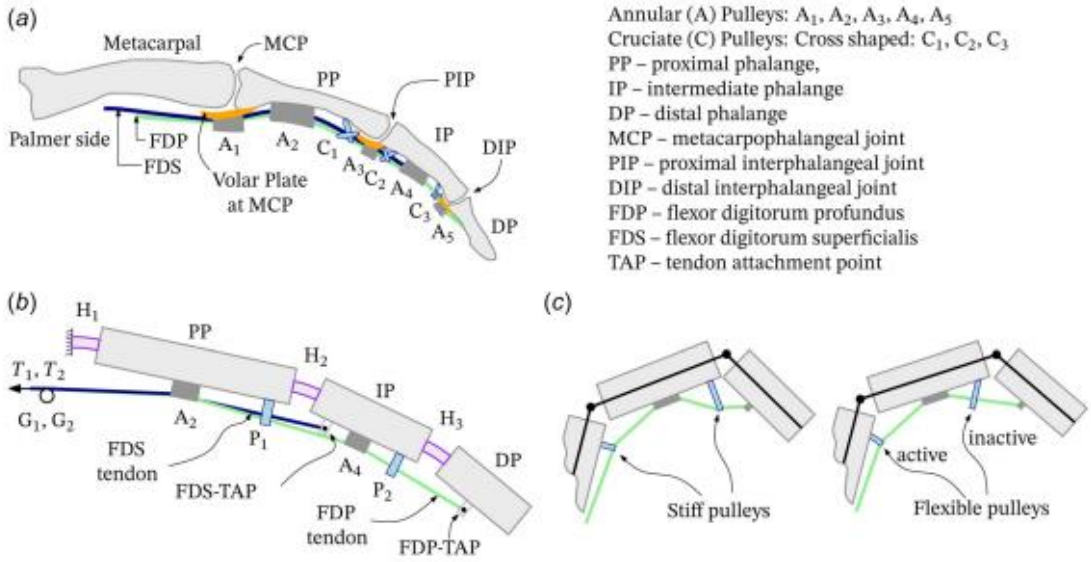

Figure #1: Computational modeling the human finger tendon pulley system using FEM and 3R PRBM to study the role of individual pulleys and tendons. [Khatik V. M., et. Al. 2021]

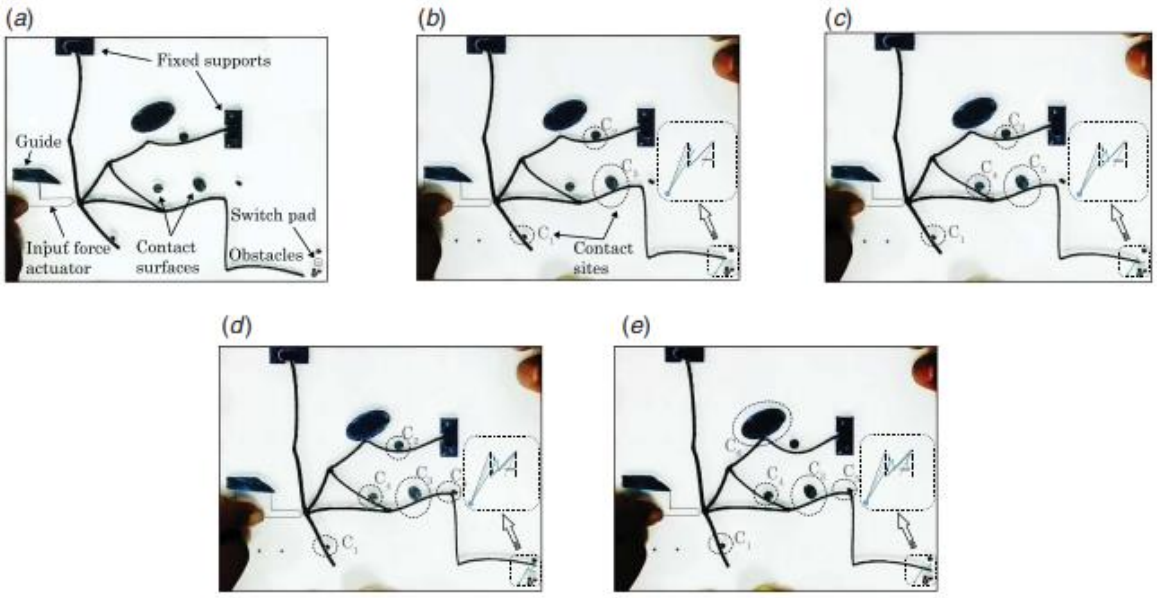

Figure #2: Prototype of CCM generating three-kinks. (a) Undeformed configuration with fixed supports and contact surfaces. (b)–(d) Intermediate configurations at the instance of a kink generation. (e) Final deformed configuration after tracing the complete three kink path. Path traced upto each intermediate stage is shown as green continuous line. Black dashed line represents the user specified path and blue dotted line represents the simulation result. [BVS Nagendra Reddy, et al. 2021]

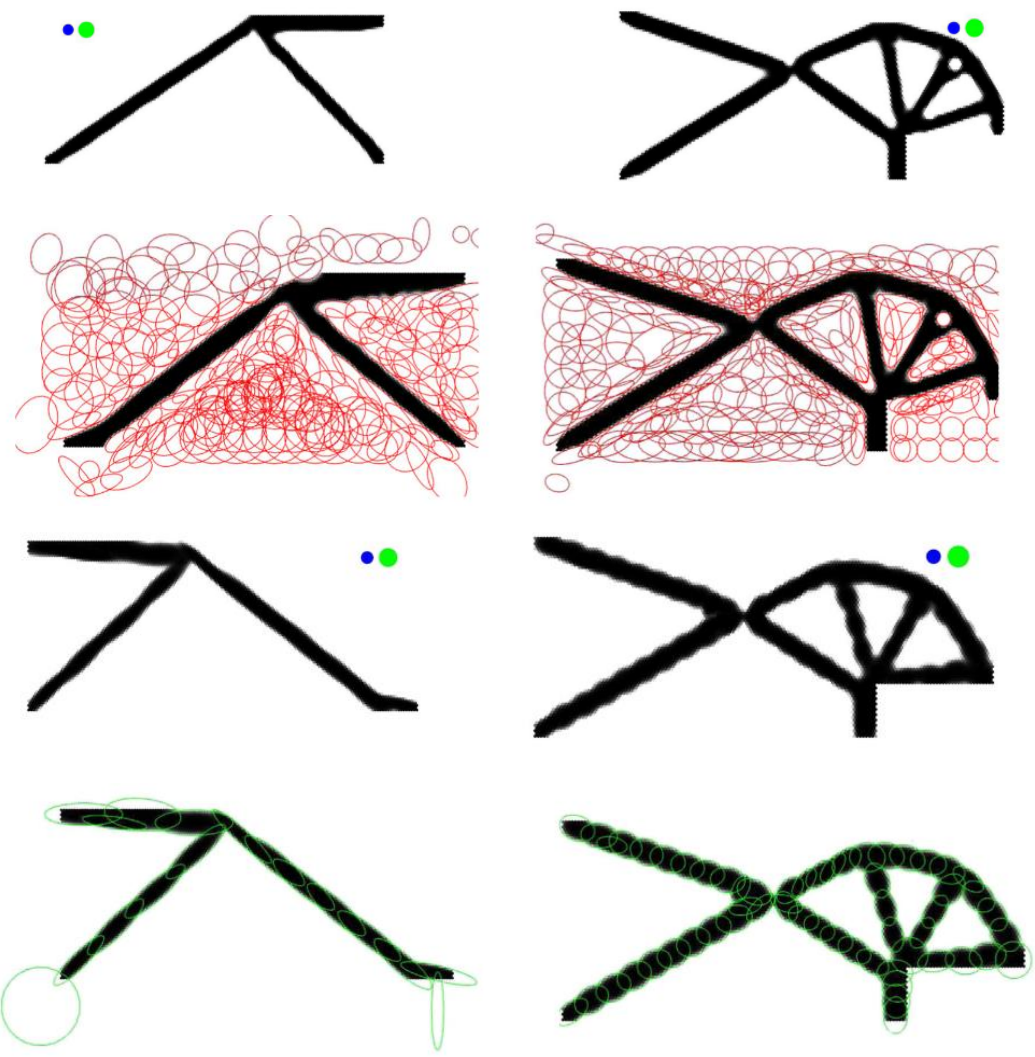

Figure #3: Topology Optimization with Elliptical Masks and Honeycomb Tessellation with Explicit Length Scale Constraints. Topological solutions obtained using 20 × 10 negative elliptical masks as design variables. Domain of size 100 × 46 unit2 is discretized via 150 by 80 regular honeycomb mesh. [Singh N., et al. 2020]

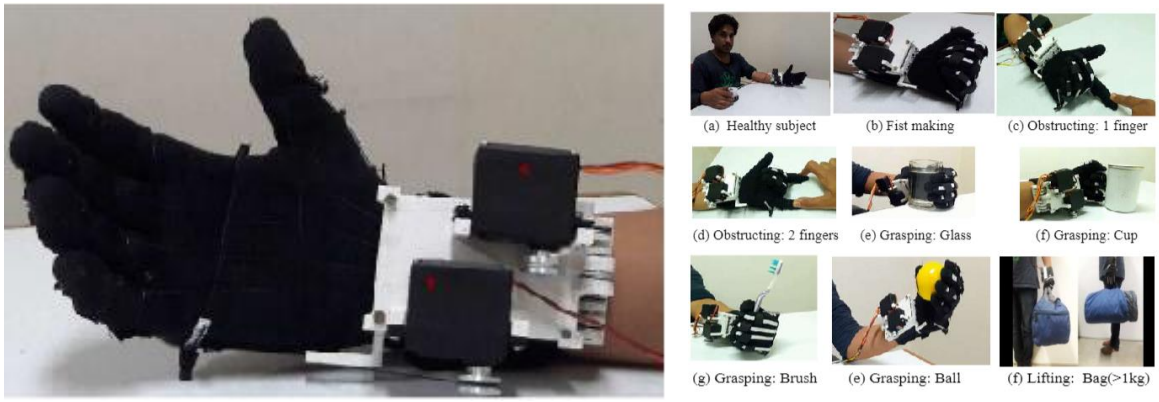

Figure #4: Soft Hand Exoskeleton for Adaptive Grasping using a Novel Differential Mechanism. [Bajaj et al. 2018]

Figure #5: Synthesis of C^0 Path-Generating Contact-Aided Compliant Mechanisms Using the Material Mask Overlay Method. [Prabhat Kumar, et Al. 2016]

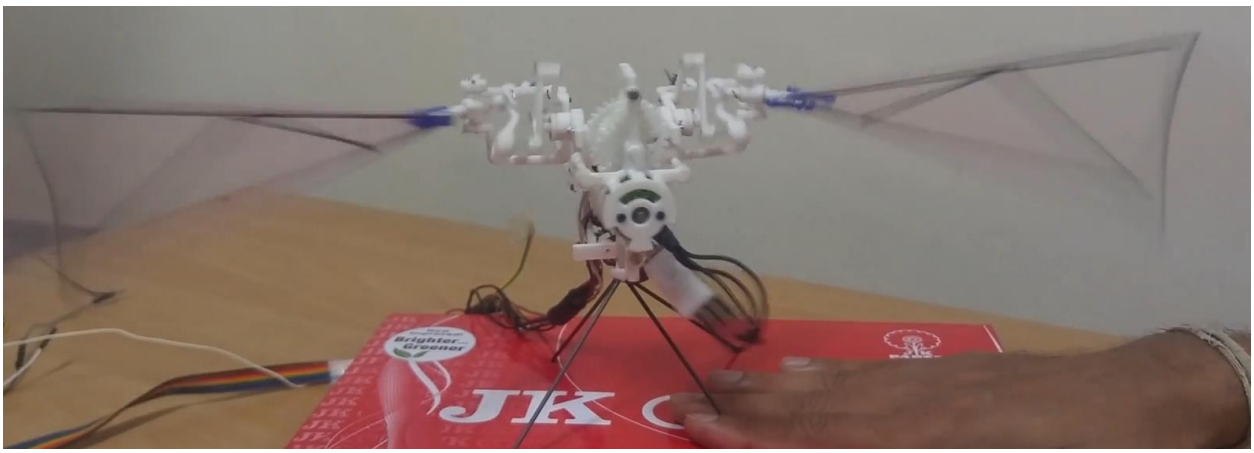

Figure #6: Flapping wing arial vehicle-1. [Anuj, et al. 2016]

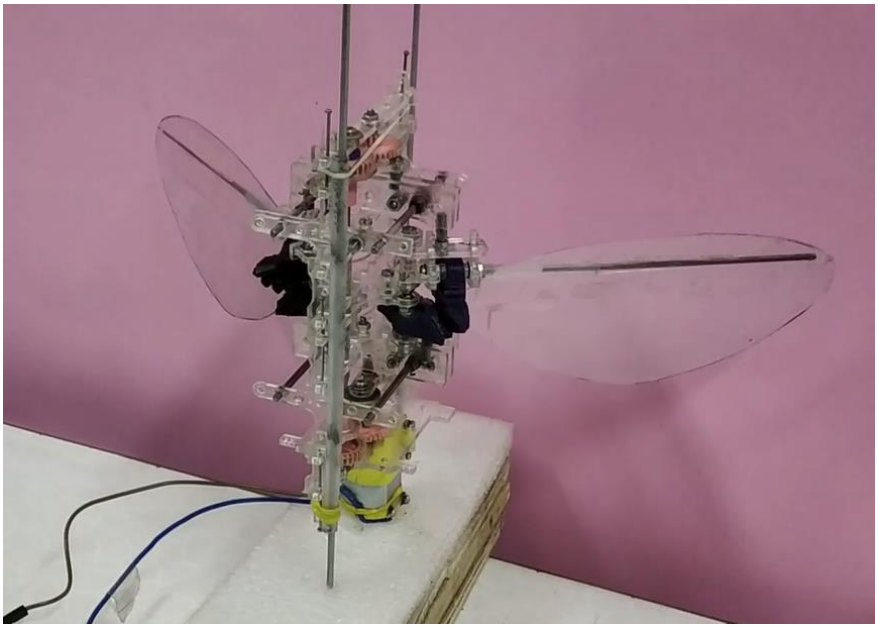

Figure #7: Flapping wing arial vehicle-2. [Vishal Jain, et al. 2016]

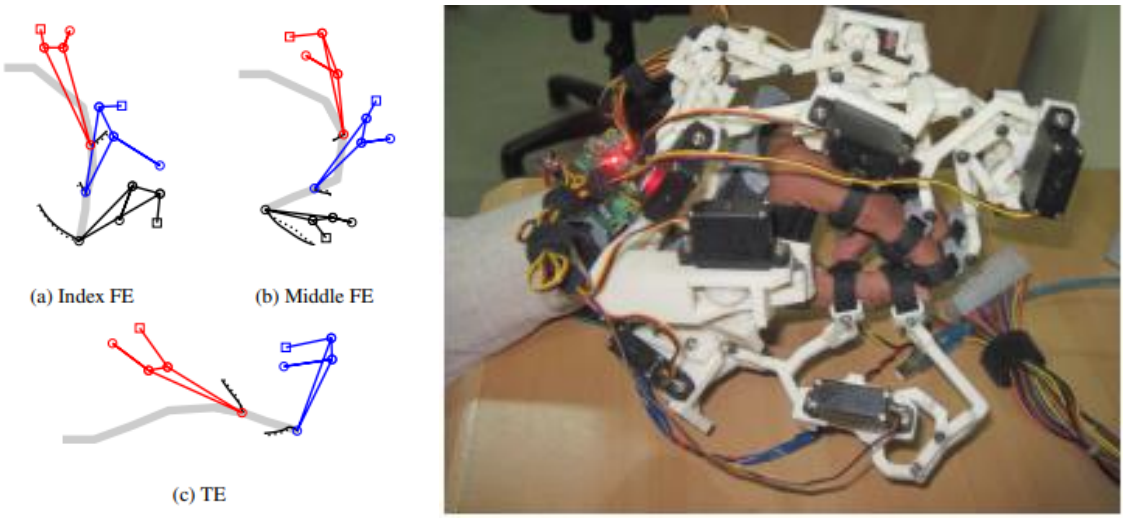

Figure #8: Three Finger Hand Exoskeleton for Translation of a slender object. [Shyam, et al. 2014]