Khoi Ly - Ph.D

Electromechanical Systems, Soft Robotics, Dynamic Modeling & Control Theory

khoidangly@gmail.com

Career Interests

My career interests center around the design and control of tightly integrated, highly nonlinear electromechanical systems. I envision cyber-physical systems with high-speed embedded sensors, actuators, and computational hardware that allows the robots to handle increasingly complex tasks. Over the past 4 years, I have worked on 8 research projects (4 of which I created and lead), published 6 research articles, and filed 2 provisional applications related to sensor designs for a new class of actuators. I would like to apply my knowledge of system designs, specifically in soft robotics, to address the challenges of aging population around the world by supporting and improving the elderly people's mobility, making the digital world more tangible and interactive, and improving our opinions of robotics.

Employment

Cornell University - Sibley School of Mechanical Engineering — Ithaca, NY, USA
Postdoctoral Research Associate - Organic Robotic Laboratory — *January 2022 – Present*

Education

- **University of Colorado Boulder** — Boulder, CO, USA
  Paul M. Rady Mechanical Engineering - Doctor of Philosophy - GPA: 3.95 — *August 2017 – December 2021*
  Thesis Title: Embedded Sensing and Control for High Speed Electro-hydraulic Soft Robots

- **Texas Tech University** — Lubbock, TX, USA
  Magna Cum Laude with Highest Honor, Mechanical Engineering - Bachelor's Degree - GPA: 3.89 — *August 2014 – May 2017*
  Thesis Title: Evaluation of 3D Printed Soft Fingertip Grasping Ability for Variable Fingertips Design Parameters

Past Research Projects

- **2.5D Shape-changing Colon Simulator**, *Team Member* — **On-going**
  - Contribution: Designing and testing the layout for an array of 10x10 of HASEL actuators.
  - Contribution: Interfacing the sensor grid with an array 10 of Teensy 3.6 microcontrollers
  - Contribution: Testing sensor data streaming via UDP from 10 ESP32 microcontrollers to a Python-based program

- **Electro-hydraulic Rolling Soft Robot**, *Project Lead* — **Published in IEEE TRO, 2022**
  - Designing and characterizing a novel rolling soft robot propelled by electro-hydraulic actuators.
  - Demonstrating the robot that carries integrated hardware (total weight of 0.979 kg) at a maximum rolling speed at 0.7 m/s (1.56 mph)
  - Modeling the robot's locomotion based on hybrid dynamic state-space modeling method.
  - Developing a state-dependent model predictive controller using particle swarm optimization algorithm for speed regulation.
  - Implementing the real-time controller using concurrent programming on C++.

- **Sensing and Control for Soft 6-DOF Tilting Platform**, *Project Co-lead* — **Under Review, IEEE TRO**
  - Developing a magnetic-based high speed, high resolution displacement sensing for high-voltage electro-hydraulic actuators.
  - Designing and controlling a soft 6-DOF tilting robot using the embedded magnetic sensing and kinematic linearization.

- **Control for Soft Actuators with Recursive Network Models**, *Team Member* — **Published in ISER, 2021**
  - Contribution: Testing and integrating a physical network of 11 infrared optical wave guides to a flexible actuator
  - Contribution: Experimental designing to evaluate the neural controller's performance

- **Self-Sensing for Electrostatic Transducers**, *Project Lead* — **Published in Soft Robotics, 2020**
  - Inventing a low-voltage coupling self-sensing method for high-voltage capacitive electrostatic transducers.
  - Achieving simultaneous sensing and actuation for a range of electrostatic transducers and demonstrate accurate estimated displacements with errors under 4%
  - Validating the miniaturized self-sensing circuit with a closed loop PID control for a HASEL soft robotic arm

- **Dual-mode PID Controller for a Folded-HASEL Actuator**, *Team Member* — **Published in IEEE RA-L, 2020**
  - Contribution: Implementing the real-time dual-mode PID controller on Teensy 3.6 microcontroller for reference tracking

- **Joystick Interface for a Soft-robotic Tentacle**, *Team Member* — **Published in Advanced Science, 2019**
  - Contribution: Developing a high-voltage (10 kV) polarity reversing circuit that drives a soft electro-hydraulic tentacle.
  - Contribution: Designing a joystick interface for the tentacle's tilting angle.

Technical Skills

- **Theoretical Knowledge**: Classical and State Space Modeling, Statistical Estimation, System Identification, Controller Design and Implementation, Solid Mechanics, Power Electronics, Signal Processing, Deep Neural Network.

- **Programming Languages**: C, C++, RTOS, Python, Keras, LATEX.

- **Software Proficiency**: SolidWork, Altium Designer, MATLAB, LabView, Adobe Premiere Pro, Adobe Illustrator.

- **Hardware Proficiency**: PCB Design, 3D Modeling and Printing, motion capture system, Laser Cutting, Machining, Wet Lab Skills.

Patents: Provisional Applications

- "**Capacitive Self-sensing for Electrostatic Transducers with High Voltage Isolation**," Application No 63/032,209.

- "**Embedded Magnetic Sensing Method for Soft Actuators**," Application No 63/189,571.

Relevant Publications

1. "Electrohydraulic Rolling Soft Wheel: Design, Hybrid Dynamic Modeling, and Model Predictive Control"
   __K. Ly__, J. Mayekar, S. A. Manzano, M. Rentschler, and N. Correll
   IEEE Transaction on Robotics 2022

2. "High-bandwidth nonlinear control for soft actuators with recursive network models"
   S. A. Manzano, A. Xu, __K. Ly__, R. Shepherd, and N. Correll
   ISER 2021

3. "Miniaturized Circuitry for Capacitive Self-sensing and Closed-Loop Control of Soft Electrostatic Transducers"
   __K. Ly__, N. Kellaris, D. McMorris, B. Johnson, E. Acome, V. Sundaram, M. Naris, S.Humbert, M. Rentschler, C. Keplinger, and N. Correll
   Soft Robotics 2020

4. "Identification and Control of a Nonlinear Soft Actuator and Sensor System"
   B. Johnson, V. Sundaram, M. Naris, E. Acome, __K. Ly__, N. Correll, C. Keplinger, J. Humbert, and M. Rentschler
   IEEE Robotics and Automation Letters 2020

5. "An Easy-to-Implement Toolkit to Create Versatile and High-Performance HASEL Actuators for Untethered Soft Robots"
   S. Mitchell, X. Wang, E. Acome, T. Martin, __K. Ly__, N. Kellaris, VG. Venkata, and C. Keplinger
   Advanced Science 2019

6. "Quantitative Motor Assessment, Detection, and Suppression of Parkinson's Disease Hand Tremor: A Literature Review"
   __K. Ly__, A. Cloutier, and J. Yang
   ASME-IDETC 2016

Peer Reviewing

- **Journals**: Science, Science Robotics, Soft Robotics, International Journal of Robotics Research, IEEE Transactions on Robotics, IEEE RA-L

- **Conferences**: Robotics Science and Systems, IEEE Robosoft, IEEE ICRA, IEEE IROS, ISER

Teaching & Mentoring

- **Department of Mechanical Engineering, CU Boulder**, *Teaching Assistant*   **Fall 2019, Fall 2020**
  - **System Dynamics (4043)**: Teaching and delivering hand-on workshops on Control Implementation Labs
  - **Solid Mechanics (2063)**: Teaching Assistant Team Lead
- **Department of Computer Science, CU Boulder**, *Mentor*   **Spring 2018 - present**
  - **Kyle Martinaitis, Undergraduate Research**: Force Characterization for Electro-hydraulic Rolling Soft Robot
  - **Jatin Mayerkar, Master Thesis**: Electro-hydraulic Rolling Soft Robot
  - **Dade McMorris, Undergraduate Research**: Self-sensing of High Voltage Electrostatic Transducers.

Honors and awards

- Texas Tech Ph.D. Presidential Fellowship Award (offered), 2017.

- Undergraduate Research Scholar Award 2017.

- Texas Tech President Honor Roll 2015, 2016, and 2017.

- Texas Tech Honors College Scholarship Award 2015.

References

- **Dr. Robert Shepherd**, Postdoctoral Advisor
  Cornell University, Department of Mechanical Engineering
  553 Upson Hall, 124 Hoy Rd, Ithaca, NY, USA
  +1-607-279-2845, rfs247@cornell.edu
  https://orl.mae.cornell.edu/

- **Dr. Nikolaus Correll**, Ph.D. Advisor
  University of Colorado Boulder, Department of Computer Science
  1111 Engineering Drive, Boulder, Colorado 80305, USA
  +1-303-492-2233, nikolaus.correll@colorado.edu
  http://correll.cs.colorado.edu/

- **Dr. Mark E. Rentschler**, Ph.D. Co-advisor
  University of Colorado Boulder, Department of Mechanical Engineering
  1111 Engineering Drive, Boulder, Colorado 80305, USA
  +1-303-735-6149, Mark.Rentschler@colorado.edu
  https://www.colorado.edu/lab/amtl/

- **Dr. Christoph M. Keplinger**, Principle Collaborator
  University of Colorado Boulder, Department of Mechanical Engineering
  1111 Engineering Drive, Boulder, Colorado 80305, USA
  +1-303-735-8064, christoph.keplinger@colorado.edu
  http://www.keplingerresearchgroup.com/