Khoi Ly

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Robotic Materials, Cyber-physical Systems, Dynamic Modeling & Control Theory

Research Interests

My research interests center around **the development of multi-functional robotic materials and cyber-physical systems that can accommodate increasingly more complex intelligent and autonomous tasks**. I envision hybrid of rigid-soft integrated robotic structures inspired by natural systems with practical functionalities that traditional robots fail to achieve. As the field of soft robotics thus far has emphasized on isolated development of soft actuators, sensors, or stretchable and flexible electronics with limited comprehensive studies regarding the system-level integration, communication, and control, my work aims to address the issues of embedded and integrated designs to not only improve the accuracy and precision of novel soft actuators but also better integrate subsystems consisting of actuators, sensors, and computation modules for high-performance robotic applications. My research direction will allow for tighter integration and improved system-level soft robotic performance while capitalizing on decades of rigid-bodied robotics.

Education

- **University of Colorado Boulder** — Boulder, USA
  Paul M. Rady Mechanical Engineering - Ph.D. Candidate — *August 2017 – December 2021*
- **Texas Tech University** — Texas, USA
  Magna Cum Laude with Highest Honor, Mechanical Engineering - Bachelor's Degree — *August 2014 – May 2017*

Research Experience

- **Electro-hydraulic Rolling Soft Robot**, *Project Lead* — **Submitted to IEEE Transactions on Robotics**
  - Designing and characterizing a novel rolling soft robot propelled by electro-hydraulic actuators.
  - Modeling the robot's locomotion based on hybrid dynamic state-space modeling.
  - Developing a model predictive controller using particle swarm optimization algorithm for speed regulation.
  - Implementing the real-time controller using multi-threaded programming on C++.
- **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.
  - Validating the miniaturized self-sensing circuit with a closed loop PID control for a HASEL soft robotic arm
- **Joystick Controller for a Soft-robotic Tentacle**, *Team Member* — **Published in Advanced Science, 2019**
  - Developing a high-voltage polarity reversing technique for a miniature circuit that drives a HASEL-based tentacle.
  - Designing a human-in-the-loop controller with a joystick interface for the tentacle's tilting angle.
- **Dual-mode PID Controller for a folded-HASEL Actuator**, *Team Member* — **Published in IEEE RA-L, 2020**
  - Implementing the dual-mode PID controller on a microcontroller for real-time, high-speed displacement regulation.
- **2.5D Shape-changing Deformable Surface**, *Team Member* — **On-going**
  - Designing and testing the layout for an array of 10x10 of HASEL actuators.
  - Developing a large scale soft, stretchable, magnetic silicone skin with high speed, high resolution sensing.
- **Magnetic Sensing for Soft Electro-hydraulic Actuators**, *Project Co-lead* — **On-going**
  - Inventing a magnetic-based high speed, high resolution displacement sensing for high-voltage electro-hydraulic actuators.
  - Designing and controlling a soft 3D pan-tilt platform using the embedded magnetic sensing technique.

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.

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.

Peer-Reviewed Publications

1. "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, N. Correll*
   Soft Robotics 2020

2. "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

3. "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 2020

Peer Reviewing

- **Journals**: Science, Science Robotics, Soft Robotics, International Journal of Robotics Research, 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.

Technical Skills

- **Theoretical Knowledge**: Classical and State Space Modeling, Statistical Estimation, System Identification, Controller Design and Implementation, Solid Mechanics, Power Electronics, Signal Processing, Neural Network.
- **Programming Languages**: C, C++, RTOS, Python, LATEX.
- **Software Proficiency**: SolidWork, Altium Designer, MATLAB, LabView, Adobe Premiere Pro, Adobe Illustrator.
- **Hardware Proficiency**: PCB Design, 3D Modeling and Printing, Laser Cutting, Machining, Wet Lab Skills.

References

- **Dr. Nikolaus Correll**, Ph.D. Advisor
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