

Chase Frazelle

Chase G. Frazelle

204 Village Way, Pendleton, SC 29670

Phone: (336) 250-9770

Email: cfrazel@g.clemson.edu

EDUCATION

Doctor of Philosophy in Electrical Engineering

May 2021

Dissertation: Continuum Robots: Interfacing, Modeling, and Automation

Dissertation Chair: Ian Walker

Clemson University

Clemson, SC

Master of Science in Electrical Engineering

May 2017

Thesis: Developing Intuitive, Closed-loop, Teleoperative Control of Continuum Robotic Systems

Clemson University

Clemson, SC

Bachelor of Science in Electrical Engineering

May 2015

Minor: Mathematical Science

GPA: 3.85/4.00

Magna cum Laude, Departmental Honors, General Honors

Honors Thesis: Teleoperation Mappings from Rigid-Link Robots to Their Extensible Continuum Counterparts

Clemson University

Clemson, SC

RESEARCH INTERESTS

Interests include robot design, assembly, and testing, along with implementing control and motion planning methods for the general execution of desirable tasks. Related research interests include biomimicry and development of sensing and actuation methods that draw inspiration from similar systems in biology, including mimicry of various sensing functions such as vision and audition.

SKILLS/EXPERIENCE

- **Robotics (general):** Solid kinematics/geometry foundation and experience with dynamic model derivation and simulation. Experience with both industry level systems (Kuka and Kinova) and custom-built robotic systems (continuum robots, see publications below). Past projects have involved teleoperation, haptics, machine learning, nonlinear control, motion planning, mechanism design, and system software development and troubleshooting.
- **Programming:** Extensive experience using C/C++ and MATLAB, functional knowledge of Python. Applications include machine/reinforcement learning (all languages), embedded programming (C++), computer vision (all languages), control (C++, MATLAB), and motion planning (Python, MATLAB). Experience with ROS, MoveIt, Gazebo, and RoboDK software.
- **Mechanical:** Design experience using Solidworks to create individual parts and functional assemblies. Prototype fabrication experience using 3D printers and standard machine shop tools. Practice with mechanical diagnostics, troubleshooting, and repair.
- **Electrical:** Circuit design, assembly, and diagnostic experience, including PCB design, assembly of wire harnesses, and use of oscilloscope and digital multimeter to diagnose electrical malfunctions. Experienced with sensor integration and arrangement of system components with a whole-system approach.

Chase Frazelle

- **Communication:** Experience writing technical papers and presenting technical work to broader robotics community (see publications/presentations below). Accustomed to weekly recap meetings, quarterly detailed reporting, and annual progress summaries. Also experienced with collaboration between local and remote groups, including international collaboration.
- **Software/OS:** Comfortable with both Windows and Linux operating systems. Experienced with Microsoft tools, Adobe suite tools, and LaTeX, among others.

RESEARCH EXPERIENCE

Post-Doctoral Fellow

July 2021-Present

Clemson University

Clemson, SC

Project manager and primary researcher for a South Carolina Department of Agriculture funded project aimed at solving challenges facing the agriculture industry in South Carolina. Primary responsibility was to implement and evaluate applicability of robotic solutions in agriculture, specifically in an industry designated by the state agriculture department. Other responsibilities included correspondence with industry partners and documentation of solution feasibility and progress.

NASA Space Technology Research Fellow

August 2017-May 2021

Johnson Space Center/Clemson University

Houston, TX, and Clemson, SC

Research dedicated to exploring and expanding applicability of continuum robots to support ongoing and future Space exploration and discovery. Focus of time at NASA research centers was to enable the ability to integrate continuum robots with current NASA platforms such as Robonaut, largely through the development of custom ROS packages to be used for integration and task planning, and simulation for exploring possible deployment scenarios. Reporting responsibilities included annual publication and attendance of major conferences in the robotics field along with quarterly progress reports and annual research proposals and summaries.

Graduate Research Assistant

May 2015-2021

Clemson University

Clemson, SC

Research included investigation into intuitive teleoperation of extensible continuum robotic systems as well as the closed-loop control of multi-section continuum robots. The primary focus was exploring methods that promoted the automation of continuum manipulators, including the development of dynamic models and implementation closed-loop controllers, as well as motion planning through methods including configuration space navigation and machine learning algorithms. Other responsibilities included managing the research lab space as well as mentoring and advising junior members of the lab, along with serving as an unofficial teaching assistant for the graduate level course Architectural Robotics (4 years).

Undergraduate Research Assistant

August 2014-May 2015

Clemson University

Clemson, SC

Developed a series of kinematic mappings between a six degree-of-freedom rigid-link robotic arm and the six degrees-of-freedom of a three-section, planar, extensible continuum robot. Tested the developed mappings for intuitiveness by inviting participants to test each mapping via a series of tasks to be completed with the continuum device. Further developed mappings from the previous rigid-link robot to the continuum robot in free space, which involved mapping six degrees-of-freedom to nine degrees-of-freedom in the continuum system.

Chase Frazelle

TEACHING EXPERIENCE

Online Lecture Material for Associates Degree in Robotics August 2019-2020
Clemson Center for Workforce Development Clemson, SC

This work was designed to develop a series of online lectures that would provide supplemental material to students pursuing associate level degrees in fields related to robotics, including robot technician and operator positions in a manufacturing environment. Responsibilities included content creation and editing of source material for virtual, recorded lectures. I was also responsible for presenting the relevant material for the recordings that would be the core of the supplemental curriculum. Final responsibilities included creation and revision of assessment tools based on the knowledge conveyed in the recorded lectures.

Online Lecture Material for Aviation Technician Training June 2017-2018
Clemson Center for Workforce Development Clemson, SC

The goal of this work was to develop a series of online lectures that would teach aviation technicians the basics of electrical engineering and electrician knowledge in preparation for the FAA certification exam. I was responsible for developing an outline for the Basic Electricity training course, including high level modules and individual lessons based on the training manual provided by the FAA. Along with the outline I created individual lecture presentations and example problems which I then presented in a recording studio using a light board. Final responsibilities were to help develop assessment tools and questions meant to reinforce learning.

Teaching Assistant for Senior Design August 2016-2017
Clemson University Clemson, SC

Provided support to students by helping to develop ideas and solutions to assigned project milestones throughout the semester. Presented lectures and information regarding project expectations and provided feedback on each assignment through graded work and comments. Assisted professor in developing reachable goals for students and establish background material for the various milestones and projects.

PUBLICATIONS – JOURNAL

C. Wang, **C. Frazelle**, J. Wagner and I. Walker, "Dynamic Control of Multi-Section Three-Dimensional Continuum Manipulators Based on Virtual Discrete-Jointed Robot Models," in *IEEE/ASME Transactions on Mechatronics*, doi: 10.1109/TMECH.2020.2999847.

C. Frazelle, A. Kapadia, and I. Walker, "A Haptic Continuum Interface for the Teleoperation of Extensible Continuum Manipulators," in *IEEE Robot. and Autom. Letters*, Vol. 5, No. 2, Apr. 2020.

C. Frazelle, A. Kapadia, and I. Walker, "Developing a Kinematically Similar Master Device for Extensible Continuum Robot Manipulators," *Journal of Mech. And Robot.* Vol 10, No. 2, Feb 2018.

PUBLICATIONS – CONFERENCE PAPER

C. Frazelle, I. Walker, A. AlAttar, and P. Kormushev, "Kinematic-Model-Free Control for Space Operations with Continuum Manipulators," in *Proc. IEEE Aerospace Conf.*, Big Sky, MO, Mar. 2021, pp. 1-11.

Chase Frazelle

C. Frazelle, J. Rogers, I. Karamouzas, and I. Walker, "Optimizing a Continuum Manipulator's Search Policy Through Model-Free Reinforcement Learning," in Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, Las Vegas, NV, Oct. 2020, pp. 5564-5571.

C. Wang, **C. Frazelle**, J. Wagner, and I. Walker, "A Discrete-Jointed Robot Model Based Control Strategy for Spatial Continuum Manipulators," in Proc. IEEE Industrial Electronics Conf. Singapore, Oct 2020, pp: 543-549.

Z. Hawks, **C. Frazelle**, K. Green, and I. Walker, "Motion Planning for a Continuum Robotic Mobile Lamp: Defining and Navigating the Configuration Space," in Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, Macau, China, Nov. 2019, pp. 2559-2566.

Y. Wang, **C. Frazelle**, R. Sirohi., L. Li, I. Walker, and K. Green, "Design and Characterization of a Novel Robotic Surface for Application to Compressed Physical Environments," in Proc. IEEE Int. Conf. on Robot. and Autom., Montreal, Canada, May 2019, pp. 102-108.

C. Wang, **C. Frazelle**, J. Wagner, and I. Walker, "Continuum Robot Control Base on Virtual Discrete-Jointed Robot Models," in Proc. IEEE Industrial Electronics Conf. Washington D.C., Oct 2018, pp: 2508-2515.

C. Frazelle, A. Kapadia, I. Walker, "A Nonlinear Control Strategy for Extensible Continuum Robots," in Proc. IEEE Int. Conf. Robot. Autom. Brisbane, Australia, May 2018, pp: 7727-7734.

M. Wooten, **C. Frazelle**, A. Kapadia, and I. Walker, "Exploration and Inspection with Vine-Inspired Continuum Robots," in Proc. IEEE Int. Conf. Robot. Autom., Brisbane, Australia, May 2018, pp: 1-5.

A. Chawla, **C. Frazelle**, and I. Walker, "A Comparison of Constant Curvature Forward Kinematics for Multisection Continuum Manipulators," in Proc. IEEE Int. Conf. Robot. Comp., Laguna Hills, California, Jan 2018, pp: 217-223.

C. Frazelle, A. Kapadia, and I. Walker, "Developing a Kinematically Similar Master Device for Extensible Continuum Robot Manipulators," in Proc. ASME Int. Design Eng. Tech. Conf., Cleveland, OH, August 2017, pp: V05BT08A005.

C. Aguiar, R. Fateminasab, **C. Frazelle**, R. Scott, Y. Wang, M. Wooten, K. Green, I. Walker, "The Networked, Robotic home+ Furniture Suite: a Distributed, Assistive Technology Facilitating Aging in Place," in Proc. IEEE Int. Conf. Autom. Sci. Eng., Fort Worth, TX, 2016, pp: 1067-1072.

C. Frazelle, A. Kapadia, K. Fry, and I. Walker, "Teleoperation mappings from rigid-link robots to their extensible continuum counterparts," in Proc. IEEE Int. Conf. Robot. Autom., Stockholm, Sweden, 2016, pp: 4093-4100.

PRESENTATIONS

C. Frazelle, I. Walker, A. AlAttar, and P. Kormushev, "Kinematic-Model-Free Control for Space Operations with Continuum Manipulators," in Proc. IEEE Aerospace Conf., Big Sky, MO, Mar.

Chase Frazelle

2021.

C. Frazelle, A. Kapadia, and I. Walker, "A Haptic Continuum Interface for the Teleoperation of Extensible Continuum Manipulators," IEEE Int. Conf. on Robot. and Autom., Paris, France, May 2020.

Z. Hawks, **C. Frazelle**, K. Green, and I. Walker, "Motion Planning for a Continuum Robotic Mobile Lamp: Defining and Navigating the Configuration Space," in Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, Macau, China, Nov. 2019.

Y. Wang, **C. Frazelle**, R. Sirohi., L. Li, I. Walker, and K. Green, "Design and Characterization of a Novel Robotic Surface for Application to Compressed Physical Environments," IEEE Int. Conf. on Robot. and Autom., Montreal, Canada, May 2019.

I. Walker, A. Kapadia, **C. Frazelle**, M. Wooten, "Thin Continuum Robots for Inspection Operations," World Conference for Inspection and Maintenance Robotics, Galveston TX, Nov. 2018.

C. Frazelle, A. Kapadia, I. Walker, "A Nonlinear Control Strategy for Extensible Continuum Robots," IEEE Int. Conf. Robot. Autom. Brisbane, Australia, May 2018.

A. Chawla, **C. Frazelle**, and I. Walker, "A Comparison of Constant Curvature Forward Kinematics for Multisection Continuum Manipulators," IEEE Int. Conf. Robot. Comp., Laguna Hills, California, Jan 2018.

C. Frazelle, A. Kapadia, I. Walker, "Teleoperation mappings from rigid-link robots to their extensible continuum counterparts," IEEE Int. Conf. Robot. Autom., Stockholm, Sweden, 2016.

C. Frazelle, "Teleoperation mappings from rigid link robots to their extensible continuum counterparts," Naval Academy Sci. Eng. Conf., Annapolis, Maryland, 2014. (Poster).

REVIEWER FOR

- International Conference on Robotics and Automation (ICRA)
- Journal of Mechanisms and Robotics (JMR)
- Science Robotics
- IEEE Transactions on Robotics (TRO)
- International Journal of Robotics Research (IJRR)
- American Control Conference (ACC)

OTHER EXPERIENCE

Electrical Engineering Intern

Nucor Steel Berkeley

Summer 2014
Berkeley, SC

- Designed and assembled PLC I/O Cabinets.
- Designed and implemented equipment safety systems.
- Performed daily electrical maintenance.

Electrical Engineering Intern

Sturgill Engineering PA

Summer 2013
Lexington, NC

- Developed quality control and process improvement tools.

Chase Frazelle

- Created and revised electrical layouts and elevations.
- Arranged client proposals.

Field Manager/Volunteer

AUVSI

Summer 2013, 2014
Washington D.C., Orlando, FL

- Assisted company representatives in setup and break down of product demonstrations.
- Attended and aided in industry discussions and presentations.

GRANTS/FELLOWSHIPS

NASA Space Technology Research Fellowship

National Aeronautics and Space Agency

August 2017-May 2021

Clemson Departmental Scholarship

Holcombe Department of Electrical and Computer Engineering

August 2016-2019

Graduate Assistantship in Areas of National Need (GAANN)

U.S. Department of Education/Holcombe Department of Electrical and Computer Engineering

May 2015-August 2016

Clemson Departmental Honors Research Grant

Calhoun Honors College

August 2014

PROFESSIONAL ASSOCIATIONS

Eta Kappa Nu

IEEE

Tau Beta Pi

August 2017-Present

August 2014-Present

August 2014-Present