Tairan Liu, PhD

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Postdoctoral Research Scholar at North Carolina State University
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Raleigh, North Carolina, USA

Education

Louisiana State University — Baton Rouge, LA, USA
Doctor of Philosophy — *May 2020*
Mechanical Engineering, Department of Mechanical & Industrial Engineering

University of Science and Technology of China — Hefei, Anhui, P.R.China
Bachelor of Natural Science — *Jul. 2012*
Theoretical and Applied Mechanics, Department of Modern Mechanics

Professional Appointments

North Carolina State University — Raleigh, NC, USA
Postdoctoral Research Scholar — *Nov. 2021 – Present*
Department of Mechanical & Aerospace Engineering

University of Georgia — Athens, GA, USA
Postdoctoral Fellow — *Sep. 2020 – Oct. 2021*
School of Electrical & Computer Engineering

Research Interests

- System and Control Theory
- Multi-Agent/Robot System
- Cyber-Physical System
- Complex Network
- Large-Scale Networked System
- Cooperative Control
- Distributed System/Algorithm
- Human-Robot/Swarm Interaction
- Robotics

∗ Applications or intersections of the above areas: communication networks, social networks, precision agriculture, farm management, livestock management, smart farming, traffic control, smart city, connected vehicles, multi-robot smart manufacturing/construction, multi-robot task allocation, etc.

Grants

Co-authored Proposal

Transportation Consortium of South-Central States, *Real-Time Work Zone Traffic Management via Unmanned Air Vehicles*, $79,991, 18 months, Co-PIs: Charles Malveaux, Marcio de Queiroz, Xin Li, and Hany Hassan.

Awards and Honors

Outstanding Graduate Research Assistant, 2019

Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA, USA

Economic Development Assistantship Award, 2016-2019

Louisiana State University, Baton Rouge, LA, USA

LSU-ME Enrichment Award, 2014

Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA, USA

Publications

Refereed Journal Articles

9. **Tairan Liu** and Marcio de Queiroz. Distance + angle-based control of 2-d rigid formations. *IEEE Transactions on Cybernetics*, 51(12):5969–5978, 2021

8. **Tairan Liu** and Marcio de Queiroz. An orthogonal basis approach to formation shape control. *Automatica*, 129:109619, 2021

7. **Tairan Liu**, Marcio de Queiroz, Pengpeng Zhang, and Milad Khaledyan. Further results on the distance and area control of planar formations. *International Journal of Control*, 94(3):767–783, 2021

6. **Tairan Liu**, Victor Fernandez-Kim, and Marcio de Queiroz. Switching formation shape control with distance + area/angle feedback. *Systems & Control Letters*, Jan. 2020. Article 104598

5. Milad Khaledyan, **Tairan Liu**, Victor Fernandez-Kim, and Marcio de Queiroz. Flocking and target interception control for formations of nonholonomic kinematic agents. *IEEE Transactions on Control Systems Technology*, 28(4):1603–1610, 2020

4. Pengpeng Zhang, Marcio de Queiroz, Milad Khaledyan, and **Tairan Liu**. Control of directed formations using interconnected systems stability. *Journal of Dynamic Systems, Measurement, and Control*, 141(4):041003, 2019

3. Limeng Pu, Misagh Naderi, **Tairan Liu**, Hsiao-Chun Wu, Supratik Mukhopadhyay, and Michal Brylinski. eToxPred: a machine learning-based approach to estimate the toxicity of drug candidates. *BMC Pharmacology and Toxicology*, 20(1):2, 2019

2. **Tairan Liu**, Misagh Naderi, Chris Alvin, Supratik Mukhopadhyay, and Michal Brylinski. Break down in order to build up: Decomposing small molecules for fragment-based drug design with eMolFrag. *Journal of Chemical Information and Modeling*, 57(4):627–631, 2017

1. Tong Jin, **Tairan Liu**, Fenghua Qin, and Jiming Yang. Measurement and optimization of flexible double–tail fin for UUV. *Journal of Experimental Mechanics*, 28(1):27–35, 2013

Conference Proceedings

3. **Tairan Liu** and Javad Mohammadpour Velni. Multi-agent systems coverage control in mixed-dimensional and hybrid environments. In *First IFAC Modeling, Estimation and Control Conference (MECC 2021)*, pages 765–770, Austin, TX, Oct. 2021

2. **Tairan Liu**, Marcio de Queiroz, and Farid Sahebsara. Distance-based planar formation control using orthogonal variables. In *2020 IEEE Conference on Control Technology and Applications (CCTA)*, pages 64–69, Montréal, Canada, Aug. 2020

1. **Tairan Liu**, Marcio de Queiroz, Pengpeng Zhang, and Milad Khaledyan. Directed formation control of n planar agents with distance and area constraints. In *2019 Annual American Control Conference (ACC)*, pages 1824–1829, Philadelphia, PA, Jul. 2019

Manuscripts in Submission

3. Sainan Zhang, Tzu-Hao Huang, Chunhai Jiao, Mhairi MacLean, Junxi Zhu, Shuangyue Yu, **Tairan Liu**, Thomas C. Bulea, and Hao Su. Pediatric exoskeleton actuator design: An optimization framework and systematic considerations. *IEEE/ASME Transactions on Mechatronics*. In submission

2. **Tairan Liu** and Javad Mohammadpour Velni. Heterogeneous multi-agent system coverage control in mixed-dimensional and hybrid environments with varying number of agents. *Journal of Intelligent & Robotic Systems*. In submission

1. **Tairan Liu**, Davoodi Mohammadreza, and Javad Mohammadpour Velni. Deployment of heterogeneous multi-agent systems with varying mass over a graph. *International Journal of Intelligent Systems*. Under review

Ph.D. Dissertation

Tairan Liu. *Distance-Based Formation Control: Theory, Applications, and Issues*. PhD dissertation, Louisiana State University, May 2020

Research Experience

North Carolina State University // Postdoc — Raleigh, NC, USA

Magnetic Series Elastic Actuator — *Nov. 2021 – Present*

Project goal: The goal of this work is to design, model, control, and optimize a magnetic series elastic actuator (SEA) for robot actuation.
My role: Researcher, Supervisor
My contribution:

- Modelling, control, and optimization of the magnetic series elastic actuator

Exoskeletons with Quasi-Direct Drive Actuators — *Nov. 2021 – Present*

Project goal: The goal of this work is to design exoskeletons with quasi-direct drive (QDD) actuators. This novel design can augment humans' performance and provide assistance to people with disabilities and injuries, including gait impairments, age-related gait decreases in physical capabilities, and musculoskeletal disorders.
My role: Researcher, Supervisor
My contribution:

- Conduct system analysis, control design, optimization, and experiment

Optimization of Pediatric Exoskeletons *Nov. 2021 – Present*

Project goal: The goal of this work is to design and optimize exoskeletons for children with crouch gaits caused by cerebral palsy.

My role: Researcher, Supervisor

My contribution:

- Provide support in experiment design, data analysis, and manuscript preparation

University of Georgia // Postdoc — Athens, GA, USA

Human-Swarm Interactions and Multi-Robot System Autonomy *Jan. 2021 – Oct. 2021*

Project goal: This work aimed to achieve multi-agent system autonomy by learning from human-swarm interactions such that monitoring and managing a swarm of robots is possible with a few or even no operators behind the control panel.

My role: Researcher, Supervisor

My contribution:

- Proposed the structure of the human-swarm interaction model
- Instructed a student to create graphical user interfaces (GUI) to collect users' data, train models from the collected data, analyze results, and prepare manuscript
- Proposed various extensions of this approach to multiple subjects

Coverage Control and Path Planning with Heterogeneous Robots *Sep. 2020 – Aug. 2021*

Funded by the US NSF under award #1934481.

Project goal: The goal of this project was to propose new approaches and algorithms that can be used to deploy robots in the fields. The robots may not have uniform configurations, such as dynamics, parameters, and capabilities. The environments may also have irregular shapes to capture the features of real fields.

My role: Researcher

My contribution:

- Proposed new concepts and algorithms of coverage control and path planning for heterogeneous robots
- Provided mathematical proofs and conducted numerical simulations to validate algorithms

Aerial Robotics in Agricultural Measurements *Sep. 2020 – Aug. 2021*

Funded by the US NSF under award #1934481.

Project goal: The goal of this project was to create a robotic system that can capture information within or under the plant canopy such that the changes of the plants can be detected as early as possible.

My role: Researcher

My contribution:

- Built an open-source drone platform for field monitoring
- Designed a telescopic structure for measurements under/within the plant canopy
- Developed an open-source graphical user interface (GUI) to define tasks, generate desired flight trajectory, and monitor drone's status and real-time trajectory

Louisiana State University // PhD — Baton Rouge, LA, USA

Multi-Agent System Formation Control *Jul. 2016 – May 2020*

Funded by the LSU Economic Development Assistantship (EDA) program.

Project goal: The goal of this project was to propose new approaches and algorithms that can be used to deploy aerial or ground robots in space to form a specific geometric pattern.

My role: Research Assistant
My contribution:
- Proposed new formation control approaches
- Provided mathematical proofs
- Conducted numerical and experimental validations

Aerial Robotic Network in Precision Agriculture *Jul. 2016 – Oct. 2019*

Funded by the LSU Economic Development Assistantship (EDA) program.
Project goal: The goal of this project was to create a multi-drone platform that can control a fleet of drones to fly simultaneously over the field to collect data of crops.
My role: Research Assistant
My contribution:
- Designed and built a drone (quadrotor) fleet from scratch
- Developed autonomous flight control firmware on MCU and flight control/monitor applications on computer
- Developed distributed communication and control network for drones using XBee modules

Computational Molecule Synthesis *Oct. 2015 – May 2016*

Project goal: The goal of this project was to develop open-source software which can decompose large molecules to small bio-active fragments, then use fragments to generate target molecules or new molecules for drug design.
My role: Research Assistant
My contribution:
- Developed algorithms and open-source software (eMolFrag) to decompose large molecules to small bio-active fragments
- Tested the software on high performance computing (HPC) clusters and conducted benchmark test
- Wrote user's manual
- Generated libraries of fragments from the Directory of Useful Decoys, Enhanced (DUD-E) database, NuBBE database, Universal Natural Products database (UNPD), and ZINC database, respectively
- Optimized virtual screening search space
- Tested building targeted screening library with novel active compounds
- Maintained the software repository on GitHub and provided technical support

Multi-rotor Copters in Precision Agriculture Applications *Feb. 2015 – Jun. 2015*

Project goal: The goal of this project was to create customized software that can process aerial images and data generated from on-board cameras and sensors.
My role: Research Assistant
My contribution:
- Developed scripts and graphical user interface (GUI) to process aerial images and data collected from various sensors
- Optimized the software for better processing speed

University of Science and Technology of China // Undergrad HEFEI, ANHUI, P.R.CHINA

Bionic Four-Tail Fin UUV (Mimic Dragonfly) *Aug. 2011 – Jan. 2013*

Project goal: The goal of this project was to design a bionic unmanned underwater vehicle (UUV) with four oscillatory tail fins to mimic the motion pattern of dragonflies.

My role: Undergraduate Researcher
My contribution:

- Developed code on Micro-Controller Unit (MCU) for motor control
- Developed remote control and wireless data transmission scripts/software on computer and MCU for the bionic UUV

Bionic Long Undulatory Fin UUV (Mimic Black Ghost Knifefish) *Nov. 2011 – Jun. 2012*

Undergraduate graduation project and bachelor's degree thesis.
Project goal: The goal of this project was to (1) design and build a bionic UUV that mimics the approach of propulsion of black ghost knifefish, and (2) study the factors which have effects on the performance of the UUV.
My role: Undergraduate Researcher
My contribution:

- Designed and built a UUV to mimic the propulsion pattern of black ghost knifefish
- Developed code on Arduino to control motors and manage wireless communication between the UUV and computer
- Studied the effects of the frequency and amplitude of the swaying fin ray, wave number in the fin surface, and the speed of the incoming flow on thrust

Bionic Double-Tail Fin UUV *Sep. 2011 – May 2012*

Project goal: The goal of this project was to optimize the performance of the double-tail fin UUV.
My role: Undergraduate Researcher
My contribution:

- Conducted experiments to collect data of the double tail fin UUV in water tunnel
- Developed a whole system to automatically conduct experiments, collect and process data, and generate figures of the results

Composite Bionic Actuators *Apr. 2011 – Aug. 2011*

Project goal: The goal of this project was to explore new approaches of propulsion for underwater vehicles.
My role: Undergraduate Researcher
My contribution:

- Designed motion pattern for the bionic actuators which mimic the movement of pectoral fins
- Developed code on Arduino for the actuators to follow the designed motion trajectory
- Designed parts with AutoCAD, fabricated with engraving machine, and assembled the mechanical structure
- Conducted experimental validations

Teaching Experience

Louisiana State University // PhD — Baton Rouge, LA, USA

Fundamentals of Instrumentation and Measurement (ME 3603) *Jan. 2020 – May 2020*

Mechanical Engineering junior-level class and lab.
Course Instructor: Dr. Eamonn Walker

My role: Independent Lab Instructor (lab sessions) and Teaching Assistant (lecture sessions)

- Full control of all the lab activities
- Gave mini-lectures (20 minutes each) on lab instructions, instruments, lab report guidelines, and data analysis software (MATLAB and MS Excel)
- Instructed students with all the lab experiments, resolved problems in software or hardware during experiments

Autonomous Vehicles (ENGR 4200) *Jan. 2016 – May 2016*

Engineering senior-level technical elective course.
Course Instructor: Dr. Supratik Mukhopadhyay
My role: Teaching Assistant and Lab Instructor

- Configured new arriving robots and wrote instructions for experiments
- Attended all classes, prepared and provided experiment demos, gave three mini-lectures (30 minutes each) on electronics, wireless communication, Robot Operating System, and unmanned aerial systems
- Instructed course projects and provided technical support
- Supervised lab activities and managed lab inventory

Mechanical Engineering Design Lab (ME 4201) *Aug. 2015 – Dec. 2015*

Mechanical Engineering senior-level lab as a preparation for the final capstone design.
Course Instructor: Dr. Muhammad Wahab
My role: Independent Lab Instructor

- Full control of all the lab activities
- Gave mini-lectures (20 minutes each) on lab instructions, instruments, and lab report guidelines
- Instructed students with all the lab experiments
- Prepared material for the Accreditation Board for Engineering and Technology (ABET)

Professional Activities

Reviewer

Journal

- Actuators
- Applied Sciences
- Automatica
- ChemEngineering
- Drones
- Electronics
- Energies
- IEEE Robotics and Automation Letters
- IEEE Transactions on Automatic Control
- IEEE Transactions on Cybernetics
- IEEE Transactions on Human-Machine Systems
- IEEE Transactions on Industrial Electronics
- Mathematics
- Micromachines
- Robotics
- Sensors

Conference

- IEEE Conference on Control Technology and Applications
- IEEE Conference on Decision and Control
- IEEE International Conference on Robotics and Automation

Membership

Institute of Electrical and Electronics Engineers (IEEE)

Institute of Electrical and Electronics Engineers - Control Systems Society (IEEE-CSS)