Tairan Liu, PhD

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Postdoctoral Fellow at the University of Georgia
liutairan2012@gmail.com • +1 (225)931-6955 • https://liutairan.github.io/
Athens, GA, 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

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 (Aerial/Ground/Underwater/Manipulator)

∗ 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.

Research Experience

University of Georgia // Postdoc — Athens, GA, USA
Modeling of Trust in Human-Swarm Interactions — *Jan. 2021 – Present*
Project goal: A human operator can give feedback and corrections to a robot if it is not working as desired. Monitoring and controlling a swarm of robots is not something easy to do for one operator. The goal of this work is to achieve multi-agent system autonomy such that monitoring and managing a swarm of robots is possible with a few operators or even no one 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

Flow Trajectory Around Two Circular Cylinders *Oct. 2011 – Nov. 2011*

Project goal: The goal of this project was to observe the water flow trajectory around two circular cylinders.
My role: Undergraduate Researcher
My contribution:

- Designed and built an adjustable two-circular-cylinder model for the experiment
- Conducted experiments with hydrogen bubbles, laser beam, and high resolution high speed camera to study the water flow trajectory around two circular cylinders

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: Teaching Assistant / Independent Lab Instructor

- 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 issues 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 / 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 Manager: 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)

Publications

Refereed Journal Articles

8. **Tairan Liu** and Marcio de Queiroz. Distance + angle-based control of 2-d rigid formations. *IEEE Transactions on Cybernetics*. In press

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

6. **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

5. **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

4. 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

3. 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

2. 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

1. **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

Conference Proceedings

3. **Tairan Liu** and Javad Mohammadpour Velni. Multi-agent systems coverage control in mixed-dimensional and hybrid environments. In *Modeling, Estimation and Control Conference (MECC 2021)*. To appear

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

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

Conference Abstracts, Posters, Presentations, and Talks

3. **Tairan Liu**. Start from distance-based formation control. University of Georgia, Athens, GA, May 2020

2. **Tairan Liu**. Directed formation control of planar agents with distance and area constraints. In *2019 MIE Graduate Student Conference*, LSU, Baton Rouge, LA, Apr. 2019

1. **Tairan Liu**, Misagh Naderi, Supratik Mukhopadhyay, and Michal Brylinski. Decomposing small molecules for fragment-based drug design with eMolFrag. In *SCALA 2018 - Scientific Computing Around Louisiana*, LSU, Baton Rouge, LA, Feb. 2018

Ph.D. Dissertation

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

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

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.

Professional Activities

Reviewer

Journal

- Actuators
- Applied Sciences
- Automatica
- ChemEngineering
- IEEE Robotics and Automation Letters
- IEEE Transactions on Cybernetics
- Mathematics
- 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)

Graduate Level Courses

- Advanced Mechanical Systems Control
- Introduction to Modern Control Theory
- Advanced Linear Systems
- Advanced Topics in Control
- Industrial Robotics
- Topics in Modern System Science
- Advanced Engineering System Dynamics
- Sensors and Actuators
- Numerical Methods in Applied Mechanics
- Advanced Vibrations
- Mathematical Methods in Engineering
- Intelligent Control and Applications in Power Systems
- Stress Analysis in Mechanical Engineering

Teaching Interests

Undergraduate Level Courses

Engineering Basics

- Numerical Methods
- Mathematical Methods in Engineering
- Engineering System Dynamics
- Instrumentation and Measurement

Mechanical Engineering Basics

- Mechanics (Statics and Dynamics)
- Mechanical Vibrations

Control and System

- Classical Control Theory

- Modern Control Theory
- Intelligent Control and Applications

Robotics

- Introduction to Robotics
- Sensors and Actuators
- Industrial Robotics
- Autonomous Vehicles

Graduate Level Courses

Mechanical Engineering

- Advanced Vibrations
- Advanced Dynamics

Control and System

- Advanced Linear Systems
- Nonlinear Control Theory

Robotics

- Multi-copter Design and Control Practice

Advanced Topics

- Introduction to Multi-Agent System Autonomy and Control
- Advanced Topics in Multi-Agent Systems: Consensus, Formation, Coverage, Distributed Algorithms, etc