



Zijian WANG

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- Education**
- Stanford University**, Stanford, CA *Mar 2016 – Apr 2019 (expected)*
Ph.D. Candidate, Aeronautics and Astronautics, GPA: 3.96
- Boston University**, Boston, MA *Sept 2013 – Jan 2016*
Master of Science, Mechanical Engineering, GPA: 3.79
- Beihang University**, Beijing, China *Sept 2009 – Jul 2013*
B.Eng, Automation and Mechatronic Engineering, GPA: 3.81
- Research Interest** Multi-robot Systems, Cooperative Manipulation, Quadrotors, Deep Reinforcement Learning
- Work Experience**
- Research Intern**, Ford Research and Innovation Center, Palo Alto, CA *Jun 2018 – Sept 2018*
- Proposed a hierarchical deep reinforcement learning algorithm for drone landing on a moving ground vehicle. Created a custom simulation environment in Gazebo and with ROS for training and testing.
 - Built a custom drone from scratch based on Ardupilot open-source autopilot.
 - Used RTK GPS that enabled centimeter-level positioning on the drone. Conducted outdoor flight tests, where the drone autonomously took off, navigated via waypoints, and precisely landed on a F-150 truck.
- Research Experience**
- Game Theoretic Multi-Robot Motion Planning** [[Demo Video](#)]
Research Assistant, Advisor: *Prof. Mac Schwager* *Nov 2017 – Present*
- Proposed an online, real-time collision-free motion planning algorithm that accounts for the intentions of multiple competing neighboring robots in a multi-robot racing scenario.
 - Computed approximate Nash equilibrium using an iterative best response algorithm (IBR) and sequential quadratic programming (SQP).
 - Verified the algorithm on a full-size electric steer-by-wire car and four quadrotor aerial robots.
- Collaborative Aerial Manipulation with Multiple Drones** [[Demo Video](#)]
Research Assistant, Advisor: *Prof. Mac Schwager* *Jul 2016 – Present*
- Devised a decentralized nonlinear SE(3) controller that allows a group of rigidly-connected quadrotors to lift an object without peer communication.
 - Automatically generated trajectory that minimizes snap and satisfies input thrust and torque constraints based on differential flatness theory, and by using quadratic programming (QP) and bi-level optimization.
 - Designed, built 6 quadrotors based on the PX4 open-source flight controller, and conducted experiments for hardware verification.
- Model-Augmented Deep Reinforcement Learning** [[Demo Video](#)] [[Report](#)]
Research Assistant, Advisor: *Prof. Hao Su (UCSD)* *Jun 2017 – Dec 2017*
- Implemented DQN and DDPG algorithm in tensorflow and tested with OpenAI gym.
 - Proposed a novel deep RL method for continuous control that is robust, adaptive and generalizable, by augmenting deep RL with classical model-based controllers.
- Multi-Robot Collision Avoidance and Autonomous Driving** [[Video1](#)] [[Video2](#)]
Research Assistant, Advisor: *Prof. Mac Schwager* *May 2016 – Present*
- Proposed a novel Buffered Voronoi Cell (BVC) algorithm that guarantees collision-free navigation for multiple robots without communication.
 - Used Model Predictive Control (MPC) to plan path inside BVC. Simulated up 100 robots in both 2D and 3D, and conducted experimental validation with 5 quadrotors.
 - Generalize BVC algorithm to higher-order dynamics as Buffered Input Cell, and used it for multi-vehicular collision avoidance in a simulated highway driving scenario.
- Multi-robot Manipulation**, Multi-robot Systems Lab (MSL) [[Video 1](#)] [[Video 2](#)]
Research Assistant, Advisor: *Prof. Mac Schwager* *Oct 2013 – Jul 2016*

- Proposed a decentralized consensus-based controller for multi-robot cooperative object transport without communication among robots. Verified by simulation up to one thousand robots.
- Mathematically characterized the performance of the proposed controller via rigid-body dynamics analysis, and complex time-varying Lyapunov-style stability proof.
- Designed and built two robot platforms (differential/omnidirectional drive) equipped with force/torque/laser/velocity/IMU sensing for experimental validation.

Biomimetic Robot Boxfish, Intelligent Control Laboratory (ICL), Peking University

Research Assistant, Advisor: *Prof. Guangming Xie*

May 2012 – Jun 2013

- Led the mechanical design and manufacturing of the robot fish. Controlled the attitude and motion of the robot fish using Central Pattern Generator (CPG). [\[Demo Video\]](#)
- Designed a compact Inertial Measurement Unit (IMU), including the PCB design and the 9-DOF data fusion algorithm using Mahony complementary filters.
- Created a real-time Particle Swarm Optimization (PSO) platform which enabled the robot to automatically swim and optimize its velocity using overhead camera feedback.

Modular Self-Reconfigurable Robot, National Student Research Training Program (SRTP), Fengru Cup (largest scientific competition in Beihang University) [\[Demo Video\]](#)

Team Leader, Advisor: *Prof. Shaoping Wang*

May 2011 – Apr 2012

- Built and manufactured 12 robot modules. Designed and soldered PCB. Wrote software for a GUI control console, cross-module I2C communication, motor control and sensor measurement.
- Invented a novel automatic connector, which enabled the robot to automatically connect new modules both mechanically and electrically. Performed robot self-reconfiguration experiments.
- Generated gaits for snake shape (8-DOF) and quadrupedal shape (11-DOF) using keyframe-based strategy.

Teaching Experiences

Teaching Assistant, Boston University

Sept 2013 – May 2014

ME404 – Dynamics and Control of Mechanical Systems (Fall 2013)

ME359 – Introduction to CAD and Machine Components (Spring 2014)

Honors and Awards

- **PhD Forum Travel Award**, International Conference on Robotics and Automation 2018
- **May 4th Youth Medal**, one of the 12 honorees selected from all the undergrad/master/Ph.D. students in Beihang University 2012
- **Meritorious Winner** (first 9% global), Interdisciplinary Contest In Modeling (ICM) 2012
- **National Scholarship** (first 2% in Beihang Univ.), awarded by Ministry of Education of People's Republic of China 2012
- **Best Work Award** (1/1500+ projects), The 22th Fengru Cup (largest annual undergraduate scientific competition in Beihang University) 2012

Publications

[J1] **Z. Wang** and M. Schwager, “Force-Amplifying N-Robot Transport System (Force-ANTS) for Cooperative Planar Manipulation without Communication,” *International Journal of Robotics Research (IJRR)*, vol. 35(13), pp. 1564–1586, 2016.

[J2] A. Pierson, **Z. Wang** and M. Schwager, “Intercepting Rogue Robots: An Algorithm for Capturing Multiple Pursuers with Multiple Evaders,” In *IEEE Robotics and Automation Letters (RA-L)*, vol. 2(2), pp. 530–537, 2017. [\[Video\]](#)

[J3] D. Zhou, **Z. Wang**, S. Bandyopadhyay and M. Schwager, “Fast, On-line Collision Avoidance for Dynamic Vehicles using Buffered Voronoi Cells,” In *IEEE Robotics and Automation Letters (RA-L)*, vol. 2(2), pp. 1047–1054, 2017. [\[Video\]](#)

[J4] W. Wan, B. Shi, **Z. Wang**, R. Fukui, “Multirobot Object Transport via Robust Caging,” In *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 2017.

[J5] D. Zhou, **Z. Wang**, M. Schwager, “Agile Coordination and Assistive Collision Avoidance for Quadrotor Swarms Using Virtual Structures,” In *IEEE Transactions on Robotics*, vol. 34, no. 4, pp. 916–923, 2018. [\[Video\]](#)

- [C1] **Z. Wang**, R. Spica, and M. Schwager, “Game Theoretic Motion Planning for Multi-Robot Racing,” In *International Symposium on Distributed Autonomous Robotic Systems (DARS)*, 2018. **Accepted.** [\[Video\]](#)
- [C2] **Z. Wang**, S. Singh, M. Pavone, and M. Schwager, “Cooperative object transport in 3D with multiple quadrotors using no peer communication,” In *Proc. IEEE Conf. on Robotics and Automation (ICRA)*, pp. 1064–1071, 2018. [\[Video\]](#)
- [C3] M. Wang, **Z. Wang**, S. Paudel, and M. Schwager, “Safe Distributed Lane Change Maneuvers for Multiple Autonomous Vehicles Using Buffered Input Cells,” In *Proc. IEEE Conf. on Robotics and Automation (ICRA)*, pp. 4678–4684, 2018.
- [C4] **Z. Wang**, G. Yang, X. Su and M. Schwager, “OuijaBots: Omnidirectional Robots for Cooperative Object Transport with Rotation Control using No Communication,” In *Proc. of the International Symposium on Distributed Autonomous Robotics Systems (DARS)*, London, UK, November, 2016. [\[Video\]](#)
- [C5] **Z. Wang** and M. Schwager, “Kinematic multi-robot manipulation with no communication using force feedback,” *IEEE International Conference on Robotics and Automation (ICRA)*, pp. 427–432, 2016. [\[Video\]](#)
- [C6] **Z. Wang** and M. Schwager, “Multi-robot manipulation with no communication using only local measurements,” *IEEE International Conference on Decision and Control (CDC)*, pp. 380–385, 2015
- [C7] G. Habibi, Z. Kingston, **Z. Wang**, J. McLurkin, M. Schwager, “Pipelined consensus for global state estimation in multi-agent systems,” *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, pp. 1315–1323, 2015
- [C8] **Z. Wang** and M. Schwager, “Multi-robot manipulation without communication,” *International Symposium on Distributed Autonomous Robotic Systems (DARS)*, 2014 [\[Video\]](#)
- [C9] W. Wang, J. Guo, **Z. Wang**, G. Xie, “Neural controller for swimming modes and gait transition on an ostraciiform fish robot,” In *Advanced Intelligent Mechatronics (AIM), 2013 IEEE/ASME International Conference on*, pp. 1564–1569, 2013

Workshop Presentations

Z. Wang and M. Schwager. “Multi-robot manipulation without communication.” The IROS workshop on The Future of Multiple-robot Research and Its Multiple Identities, September 18th, Chicago, IL, USA

Patents

- [P1] G. Xie, W. Wang, **Z. Wang**, Z. Wang, C. Wang and R. Fan, “A novel autonomous bioinspired robotic fish”, China Patent CN201610139531, 2016.
- [P2] **Z. Wang**, J. Yang, S. Wang, J. Gao, X. Ye, W. Hong, “A Novel Automatic Connector For Modular Self-reconfigurable Robots”, China Patent, CN102632510A, 2012.

Skills

- Coding: C/C++, Python, Matlab, Git, Linux, Tensorflow/PyTorch
- Robotics: Robot Operating System (ROS), Gazebo, Motion Planning, Trajectory Optimization, Kalman Filter, Model Predictive Control
- Mechanical: Proficient in CAD (Solidworks), 3D Printing, Machine Shop Experience
- PCB: Two-layer board design in Altium Designer, PCB Prototyping
- MCUs: STM32, Arduino, TI MSP430, AVR ATmega Series
Experienced in debugging SPI, I2C, CAN, RS232, Interrupts, etc.
- Soldering: Professional in hand soldering SMT/SMD including QFN, LQFP, SSOP, 0603
- Music: Guitar (electric and acoustic), Saxophone, Composition, Arranging, Lyrics, Recording, Mixing

Academic Reviewing

Journal Reviewer for:
 International Journal of Robotics Research, 2016/17 • IEEE Transactions on Robotics, 2016 • IEEE Robotics and Automation Letters, 2017 • Autonomous Robots, 2017 • Swarm Intelligence, 2017 • IEEE Transactions on Control of Network Systems, 2016 • System & Control Letters, 2016

• ASME Journal of Dynamic Systems, Measurement and Control, 2017/18 • International Journal of Adaptive Control and Signal Processing, 2017 • Transaction on Mechatronics, 2018

Conference Reviewer for:

IEEE International Conference on Robotics and Automation (ICRA), 2015/16/17/18 • IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2015/16/17/18 • International Symposium on Distributed Autonomous Robotic Systems (DARS), 2016 • Workshop on the Algorithmic Foundations of Robotics (WAFR), 2016 • American Control Conference (ACC), 2018

Mentorship

Highschool students

Evelyn Huang (BU Academy), *Summer 2014*

Undergraduate students

Monica Anuforo, Stanford CS, *Jun 2017 – Sept 2017*

Xuanshuo Su, BU ME, *May 2015 – Jan 2016* (currently at Vanderlande Industries Inc.)

Guang Yang, BU ME, *May 2015 – Jan 2016* (currently PhD student at BU)