

Shupeng Lai

PH.D · MOTION PLANNING · CONTROL · ROBOTICS

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Education

National University of Singapore

PH.D · GRADUATE SCHOOL FOR INTEGRATIVE SCIENCES & ENGINEERING

GPA: 4.79/5.0

Singapore

Aug. 2012 - Dec. 2016

Nanyang Technological University

B.ENG · SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

GPA: 4.89/5.0 (First class honors)

Singapore

Aug. 2008 - Aug. 2012

Experience

National University of Singapore Unmanned Aerial Vehicle Research Group

RESEARCH FELLOW

- Take lead in research directions related to motion planning and model predictive control.
- Help the main PI on the research group's daily operation.

Singapore

Jan. 2017 - present

GPS-less Navigation System for Unmanned Aerial Vehicles (\$1.6M grant)

PROJECT LEAD & SYSTEM ARCHITECT

- Lead a team of researchers in developing an onboard 3-dimensional navigation system for unmanned aerial vehicles in unknown and realistic indoor environments.
- The system allows an unmanned rotor-craft system to *fly freely in GPS-denied and obstacle-dense environment*.

Singapore

Jan. 2018 - present

Autonomous Power Grid Inspection Vehicle

TECH LEAD · GUIDANCE UNIT & HUMAN MACHINE INTERFACE

- Design and develop the guidance unit and human machine interface for a type of power grid inspection drone.
- The system supports path following, point to point flight and arbitrarily shaped flight barriers and forbidden zones.
- The guidance algorithm is computationally efficient (requires only a 168MHz CPU and 512KB of memory).
- The vehicles have been *deployed by the State Grid Corporation of China* for daily operation.

Singapore/China

Oct. 2014 - Aug. 2017

Sensor-based Motion Planning Module

LEAD DESIGNER & DEVELOPER

- Design and develop a motion planning system for the safe operation of multicopters. The system takes input from lidar or depth/stereo camera and outputs desired trajectory to avoid static/dynamic obstacles and flying towards the goal.
- Compared to other trajectory based methods, this module requires much less computational power, and is capable of achieving a re-planning rate of 100 Hz on an Intel I5 processor.
- The vehicles equipped with this module have been deployed by the *Singapore Public Utilities Board for tunnel inspection* and a multinational supply chain company for *warehouse inspection*.

Singapore

Jan. 2014 - Dec. 2016

Trajectory Generation & Editing Software for Multiple Aerial Vehicles

LEAD DESIGNER & DEVELOPER

- Design and develop a software to generate and edit trajectories for a formation of aerial vehicles.
- The algorithm supports dynamically changing formation and the collision free trajectories will be generated automatically to lead each vehicle to the desired new position.
- The system has seen successful indoor/outdoor applications in events like the *Singapore airshow* and the *Rotorcraft Asia*.

Singapore

Jan. 2014 - Jan. 2015

Research

Model Predictive Planning with Learned Motion Primitives

- It allows the controller to use a wider range of motion primitives by using neural networks to describe the underlying model.
- It gives a fast steering function that increases the speed of sampling based planner such as the batch informed tree star.

Jan. 2018 - Jan. 2019

Safe Flight Corridor Navigation with Time Optimal Control

- Adopt control based method to navigate a micro-sized unmanned aerial vehicle inside a safe corridor.
- The method is 1000 times faster than previous methods.
- The algorithm has been deployed in several types of commercial product.

Dec. 2017 - Aug. 2018

Concurrent motion planning for aerial vehicle formation

Jan. 2017 - Aug. 2017

- Design an algorithm to generate collision free trajectories for quadrotor formation reconfiguration.
- The algorithm generates the initial guess using velocity obstacles, followed by a smoothing procedure using B-spline.
- With an efficient quadratic programming problem formulation, the trajectory and its arbitrarily ordered derivatives can be constrained inside one or multiple convex polytope sets.

Online motion planning for micro rotorcrafts

Jan. 2014 - Aug. 2015

- Design a multiple layered motion planning system to allow a quadrotor to fly safely in obstacle dense environment.
- The system combines task and motion planning, and is capable of handling mission design failure by human.
- The method has been deployed in several types of commercial vehicles.

Realtime jerk limited boundary value problem solver

Jan. 2016 - Jun. 2016

- Design and implement a fast algorithm to solve the time-optimal two-point boundary value problem for a triple integrator with constraints on its velocity, acceleration, and jerk.
- The proposed algorithm takes less than 10 microseconds to find the solution.
- The method has been applied to multiple types of vehicles ranging from helicopters to unconventional tail sitters.

Teaching & Academic Services

2019	Lecturer , Advances in Intelligent Systems and Robotics, National University of Singapore	Singapore
2018	Lecturer , Special Topics in Automation and Control, National University of Singapore	Singapore
2019	Associate Editor , International Conference on Control and Automation	Edinburgh
2018	Associate Editor , International Conference on Control and Automation	Alaska, USA
2018	Associate Editor , International Conference on Control, Automation, Robotics and Vision	Singapore

Honors & Awards

2018	Best Paper Award , 37th Chinese Control Conference	Wuhan, China
2017	1st Place, Team Captain , 10th International Micro Aerial Vehicle Competition, Indoor	Toulouse, France
2017	1st Place , 10th International Micro Aerial Vehicle Competition, Outdoor	Toulouse, France
2017	1st Place, Team Captain , Singapore Amazing Flying Machine Competition	Singapore
2014	1st Place , 6th International Micro Aerial Vehicle Competition	Delft, Netherlands
2012	ABB Gold Medal , Nanyang Technological University Gold Medal for Graduating Students	Singapore
2012	IEEE Control Systems Chapter Prize , Nanyang Technological University Book Prizes	Singapore

Skills

Programming	C++, Qt, Matlab, LaTeX, Python
Robotics	Robotic Operating System (ROS), MAVLink, QGroundControl
Languages	Chinese, English

Selected Publications

- [1] S. Lai, M. Lan, and B. M. Chen, "Model predictive local motion planning with boundary state constrained primitives," *IEEE Robotics and Automation Letters*, 2019.
- [2] S. Lai, M. Lan, and B. M. Chen, "Safe navigation of quadrotors with jerk limited trajectories," *Frontiers of Information Technology and Electronic Engineering*, 2019.
- [3] S. Lai, M. Lan, and B. M. Chen, "Optimal constrained trajectory generation for quadrotors through smoothing splines," in *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2018.
- [4] S. Lai, K. Wang, H. Qin, J. Q. Cui, and B. M. Chen, "A robust online path planning approach in cluttered environments for micro rotorcraft drones," *Control Theory and Technology*, 2016.
- [5] X. Yang, S. Lai, J. Li, D. Luo, and Y. You, "Concurrent optimal trajectory planning for indoor quadrotor formation switching," *Journal of Intelligent and Robotic Systems*, 2018.
- [6] Y. H. Tan, S. Lai, K. Wang, and B. M. Chen, "Cooperative control of multiple unmanned aerial systems for heavy duty carrying," *Annual Reviews in Control*, 2018.
- [7] J. Q. Cui, S. Lai, X. Dong, and B. M. Chen, "Autonomous navigation of uav in foliage environment," *Journal of Intelligent and Robotic Systems*, 2016.
- [8] M. Lan, S. Lai, Y. Bi, H. Qin, J. Li, F. Lin, and B. M. Chen, "Bit*-based path planning for micro aerial vehicles," in *IECON 42nd Annual Conference of the IEEE*, 2016.

*The full publication list can be found at: <https://scholar.google.com/citations?hl=en&user=QtA90DcAAAAJ>