

FEI LIU

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Research Focus

Robotics in system modeling, control, dynamics, physical-based simulation, autonomy, haptic teleoperation and mechatronics, in particular for surgical and biomedical applications.

Bio

Fei is a postdoctoral researcher at the Contextual Robotics Institute at University of California San Diego (UCSD). He is currently working on robotic autonomy for surgical applications, with semantic modeling, real-to-sim simulation, and advanced control techniques. Before that, he served as a research associate/postdoctoral scholar both at the Biorobotics Institute at Scuola Superiore Sant'Anna (SSSA), and the Center for Micro-BioRobotics at Italian Institute of Technology (IIT) in Italy. He finished his Ph.D. at Laboratory Ampère at INSA de Lyon, a top French grande école and engineering university. Right after his PhD dissertation, he also worked for a start-up company (ROBO Medical Co., Ltd.) as a senior control engineer and project manager for the creation of a robot for endoscopic submucosal dissection (ESD) surgery. During the last few years, he has experiences in several robotic areas, including modeling, control, dynamics, planning, simulation, and optimization. I also have knowledge of sensor perception, signal processing, and computer vision. He has authored a number of journal and conference papers that have advanced and impacted on both the academic and industrial worlds.

Education

Institut National des Sciences Appliquées de Lyon (<u>INSA de Lyon</u>) <i>Ph.D. in Robotics</i> <ul style="list-style-type: none">Thesis title : Dual-user Haptic Training SystemSupervisors : Prof. Arnaud Lelevé, Prof. Tanneguy Redarce, Dr. Damien Eberard	Sep. 2013 – Sep. 2016 <i>Lyon, France</i>
Institut National des Sciences Appliquées de Lyon (<u>INSA de Lyon</u>) <i>Master of Science in Robotics</i> <ul style="list-style-type: none">Thesis title : Teleoperation System Using Port-Hamiltonian ApproachSupervisor : Prof. Arnaud Lelevé	Sep. 2012 – Aug. 2013 <i>Lyon, France</i>
Northwestern Polytechnical University (<u>NWPU</u>, <u>985</u> & <u>211</u> Rank) <i>Bachelor of Science in Automation</i> Speciality: Automation and Inertial Navigation	Sep. 2008 – Jul. 2012 <i>Xi'an, China</i>

Working Appointments

Postdoctoral Scholar <i>Advanced Robotics and Controls Lab, University of California San Diego</i> Advisor: Prof. Michael Yip	Dec. 2019 – present <i>San Diego, CA, USA</i>
Research Associate Scholar <i>Biorobotics Institute, Scuola Superiore Sant'Anna</i> Advisor: Prof. Filippo Cavallo	Apr. 2019 – Nov. 2019 <i>Pisa, Italy</i>
Postdoctoral Scholar <i>Center for Micro-BioRobotics, IIT@SSSA, Italian Institute of Technology</i>	Mar. 2018 – Mar. 2019 <i>Pisa, Italy</i>
Senior Control Engineer & Project Director <i>ROBO Medical Technology Co., Ltd</i> Main works : Control system design for single-port/cable-driven surgical robot and autonomous mobile robot with SLAM	Sep. 2017 – Feb. 2018 <i>Shenzhen, China</i>

Publications

Dissertation and Thesis:

- [PhD] Fei Liu, Dual-user Haptic Training System, archives-ouvertes.fr/tel-01514992, Ph.D. Dissertation, INSA de Lyon, 2017.
- [Master] Fei Liu, Cooperative Haptic Hands-on Minimally Invasive Surgery (MIS) Trainer, M.Sc. Thesis, INSA de Lyon, 2013.

To-submit/Pre-prints:

- [TS-J1] **Fei Liu**, Florian Richter, Fei Yin, Chong He, Cédrec Girerd, Michael C. Yip. Continuum Robot Shape Reconstruction and Tracking from Monocular Endoscopic Image Sequences. *IEEE Robotics and Automation Letters (RAL)*, To submit.
- [TS-J2] Xiao Liang, Shan Lin, **Fei Liu**, Dimitri Schreiber, Michael C. Yip. ODERegNet: an ODE-based Recursive Image Registration Network for 4D Lung CT. *IEEE Transactions on Biomedical Engineering (T-BME)*, To submit.
- [TS-J3] Zhaowei Yu, Dimitri A. Schreiber, **Fei Liu**, Alexander M. Grant, Michael C. Yip. An Underwater Remote Teleoperation Robot Arm with Rolling Diaphragm Actuation and End Effector Force Reconstruction. *IEEE/ASME Transactions on Mechatronics (T-MECH)*, To submit.

Journal Articles (★ shares the first author.):

- [J1] **Fei Liu**[★], Mingen Li[★], Jingpei Lu, Entong Su, Michael C. Yip. Parameter Identification and Motion Control for Articulated Rigid Body Robots Using Differential Position-based Dynamics. *IEEE Transactions on Robotics (T-RO)*. In revision. [arXiv: 2201.05753](https://arxiv.org/abs/2201.05753).
- [J2] **Fei Liu**[★], Entong Su[★], Jingpei Lu, Mingen Li, Michael C. Yip. Differentiable Robotic Manipulation of Deformable Rope-like Objects Using Compliant Position-based Dynamics. to submit. *IEEE Robotics and Automation Letters (RAL)*. Submitted. [arXiv: 2202.09714](https://arxiv.org/abs/2202.09714)
- [J3] Florian Richter, Shihao Shen, **Fei Liu**, Jingbin Huang, Emily K. Funk, Ryan K. Orosco, Michael C. Yip. Autonomous Robotic Suction to Clear the Surgical Field for Hemostasis Using Image-Based Blood Flow Detection. *IEEE Robotics and Automation Letters (RAL)*, 2021. DOI: [10.1109/LRA.2021.3056057](https://doi.org/10.1109/LRA.2021.3056057)
- [J4] Sarmad Mehrdad[★], **Fei Liu**[★], Minh Tu Pham, Arnaud Lelevé, S. Farokh Atashzar. Review of Advanced Medical Telerobots. *Applied Sciences*, 2020. DOI: [10.3390/app11010209](https://doi.org/10.3390/app11010209)
- [J5] Angel R. Licona, **Fei Liu**, David Pinzon, Ali Torabi, Pierre Boulanger, Arnaud Lelevé, Richard Moreau, Minh Tu Pham, Mahdi Tavakoli, Troy McDaniel. Applications of Haptics in Medicine. *Haptic Interfaces for Accessibility, Health, and Enhanced Quality of Life*, Nov. 2019. DOI: [10.1007/978-3-030-34230-2_7](https://doi.org/10.1007/978-3-030-34230-2_7)
- [J6] **Fei Liu**, Angel Ricardo Licona, Arnaud Lelevé, Damien Eberard, Minh Tu Pham, Tanneguy Redarce. An Energy-Based Approach for n-dof Passive Dual-user Haptic Training Systems. *Robotica*, 2019. DOI: [10.1017/S0263574719001309](https://doi.org/10.1017/S0263574719001309)

Conference Proceedings (★ shares the first author.):

- [C1] Jingpei Lu[★], **Fei Liu**[★], Michael C. Yip. Image-based Pose Estimation and Shape Reconstruction for Robot Manipulators and Soft, Continuum Robots via Differentiable Rendering. *IEEE International Conference on Robotics and Automation (ICRA) 2023*. Submitted. [todo](#)
- [C2] Neelay Joglekar, **Fei Liu**, Ryan Orosco, Michael C. Yip. Suture Thread Spline Reconstruction from Endoscopic Images for Robotic Surgery with Reliability-driven Keypoint Detection. *IEEE International Conference on Robotics and Automation (ICRA) 2023*. Submitted. [arXiv: 2209.13657](https://arxiv.org/abs/2209.13657)

- [C3] **Fei Liu***, Zihan Li*, Yuhai Han, Jingpei Lu, Florian Richter, Michael C. Yip. Real-to-Sim Registration of Deformable Soft-Tissue with Position-Based Dynamics for Surgical Robot Autonomy. *IEEE International Conference on Robotics and Automation (ICRA) 2021*. DOI: [10.1109/ICRA48506.2021.9561177](https://doi.org/10.1109/ICRA48506.2021.9561177)
- [C4] Jingbin Huang*, **Fei Liu***, Florian Richter, Michael C. Yip. Model-Predictive Control of Blood Suction for Surgical Hemostasis using Differentiable Fluid Simulations. *IEEE International Conference on Robotics and Automation (ICRA)*, 2021. DOI: [10.1109/ICRA48506.2021.9561624](https://doi.org/10.1109/ICRA48506.2021.9561624)
- [C5] Yunhai Han, **Fei Liu**, Michael C. Yip. A 2D Surgical Simulation Framework for Tool-Tissue Interaction. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) Workshop on Cognitive Robotic Surgery*, 2020. [arXiv: 2010.13936](https://arxiv.org/abs/2010.13936)
- [C6] Jacob J. Johnson, Linjun Li, **Fei Liu**, Ahmed H. Qureshi, Michael C. Yip. Dynamically constrained motion planning networks for non-holonomic robots. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020. DOI: [10.1109/IROS45743.2020.9341283](https://doi.org/10.1109/IROS45743.2020.9341283)
- [C7] Angel Ricardo Licona Rodriguez, **Fei Liu**, Arnaud Lelevé, Damien Eberard, Minh Tu Pham. Collaborative Hands-on Training on Haptic Simulators. *7th International Conference on Mechatronics and Control Engineering*, Nov. 2018. DOI: [10.1145/3332305.3332318](https://doi.org/10.1145/3332305.3332318)
- [C8] **Fei Liu**, Arnaud Lelevé, Damien Eberard, Tanneguy Redarce. An Energy Based Approach for Passive Dual-user Haptic Training Systems. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Oct. 2016. DOI: [10.1109/IROS.2016.7759771](https://doi.org/10.1109/IROS.2016.7759771)
- [C9] **Fei Liu**, Arnaud Lelevé, Damien Eberard, Tanneguy Redarce. A Dual-user Teleoperation System with Online Authority Adjustment for Haptic Training. *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Aug. 2015. DOI: [10.1109/EMBC.2015.7318574](https://doi.org/10.1109/EMBC.2015.7318574)
- [C10] **Fei Liu**, Arnaud Lelevé, Damien Eberard, Tanneguy Redarce. A Dual-user Teleoperation System with Adaptive Authority Adjustment for Haptic Training. *4th International Workshop on Medical and Service Robots*, Jul. 2015. DOI: https://doi.org/10.1007/978-3-319-30674-2_13
- [C11] **Fei Liu**, Yanan Sang, Jie He, Jie Fan, Ruichao Li, Xiongyi Cui, Haoyu Li, Jie Chen. Northwestern Polytechnical University Team Entry for the 2012 AUVSI International Aerial Robotics Competition, International Aerial Robotics Competition (IARC) Symposium, Aug. 2012. [Link](#)
- [C12] **Fei Liu**, Haoyu Li, Li Li. Modeling of the Snowboard Course, International Mathematical Contest in Modeling (MCM) Symposium, Apri. 2011

Research Experience

Advanced Robotics and Controls Lab, UCSD

Dec. 2019 – present

PostDoc, [ARCLab](#) 

San Diego, CA, USA

- Modeling of deformable, rigid, articulated, fluid object using position-based dynamics (PBD), in particular for surgical scenes, i.e., soft tissue, membrane, blood and tools etc.
- Differentiability for the PBD simulation using adjoint method based on chain-rule.
- Simulation framework using NVIDIA-Flex, PBD, and self-written constrained based solver.
- Real-to-sim transfer techniques using non-rigid perception, registration, and tracking.
- Closed-loop controller design and validation using field robots, such as da Vinci Research Kit (DVRK), 7-dof Baxter Robotic Arm.
- **Continuum robot project**: Shape reconstruction using projection of geometrical primitives (cylinders, circles etc.) and perform visual servoing control.

Biorobotics Institute, Scuola Superiore Sant'Anna

Apr. 2019 – Nov. 2019

Researcher, [Assistive Robotics Lab](#) 

Pisa, Italy

- Simultaneous localization and mapping (SLAM) of mobile robotic platform under ROS.
- Autonomous initialization through computer vision approaches using aruco markers (QR codes).


- Autonomous navigation of the mobile robot including path planning, obstacle avoidance.
- Shared control theory development and implementation of the mobile platform.
- Design of PHP/HTML-based web user interface.
- Experimental tests in Verona, Italy.

Center for Micro-BioRobotics IIT@SSSA

Mar. 2018 – Apr. 2019


PostDoc, *Istituto Italiano di Tecnologia* 

Pisa, Italy

- Modeling and control KUKA LWR4+ robotic arm using ROS and Gazebo : motion control, trajectory planning, master-slave
- Modeling and control of flexible continuum surgical tool : static tension-deflection model, Euler-Lagrange dynamics, port-Hamiltonian based control.
- Analysis of several continuum structure prototypes : variation of design (notches, single-backbone, articulated).
- Develop teleoperation framework using haptic devices (Sigma.7).
- Preliminary study of simulation platform for flexible surgical tools using SOFA (Simulation Open Framework Architecture )

Control Engineer & Project Director

Aug. 2017 – Feb. 2018

 *ROBO Medical Technology Co., Ltd*

Shenzhen, China

- Develop teleoperation of a single-port abdominal robotics surgical system using haptic devices (i.e., PHANTOM Omni, Novint Falcon, Omega.3) and joysticks (i.e., Logitech G Extreme 3D, Microsoft Xbox).
- Modeling and control of a tendon-driven articulated end-effector : kinematics, motion control, master-slave.
- Model-based uncertainties identification and compensation : hysteresis, friction.
- Modeling and control of a 4 dofs positioning arm (parallel mechanisms) : kinematics, motion control, master-slave.
- Calculation of the RCM point of positioning arm.
- Modeling and control (based on gait analysis) of a powered lower limb orthosis for rehabilitation.
- SLAM algorithm (build on ROS) of autonomous mobile robots for medical transportation in hospitals.

PHD Thesis : Dual-user Haptic Training System

Sep. 2012 – Sep. 2016

Advisors: Prof. Tanneguy Redarce, Prof. Arnaud Lelevé, Dr. Damien Eberard

INSA de Lyon, France

- Focused on modeling and control aspects with/without time delays.
- Developed real-time experiments both with Matlab/Simulink, ROS and Chai3D.
- Published three international conference papers, and one journal paper.

Group Leader : DJI RoboMasters Mobile Manipulation Challenge

Aug. 2014

Design of Autonomous Mobile Robot Using SLAM and Computer Vision Approach.

Shenzhen, China

 *Dajiang Innovations Technology Co., Ltd (DJI)*

- Developed SLAM framework for mobile robots (chariots) u on ROS.
- Implemented fast on-board object tracking and recognition algorithms.
- Developed multi-robot coordination and searching algorithms.

Master Thesis : Cooperative Haptic Hands-on MIS Trainer

Sep. 2012 – Aug. 2013

Master Internship at Ampère Laboratory

INSA de Lyon, France

- Designed teleoperation system using port-Hamiltonian approach.
- Implemented control algorithms with haptic devices (PHANTOM Omni).
- Developed real-time experiments using Matlab/Simulink.

Team Leader : International Aerial Robotics Competition (IARC)

Aug. 2012

A Low Cost Autonomous Quadrotor UAV-Icarus

Peking, China

- Mathematical modeling of a self-made low cost laser rangefinder based on geometric calculation for environment mapping.
- Autonomous control of the quadrotor using environment mapping and detection algorithm (wall and window detection using point cloud analysis).

- Awarded **Innovative Design**.

Undergraduate Internship

Image Meta-data Feature Extraction for Content-Context Based Image Retrieval

- Implemented image processing and classification algorithms.

Sep. 2011 – Jun. 2012

NPU, Xi'an, China

Team Leader : International Mathematical Contest in Modeling (MCM)

Optimal Design of U-shaped Snowboard Course

- Awarded **Meritorious Winner** (First Prize Mention).

Feb. 2012

NPU, Xi'an, China

Team Leader : Robocup 3D Simulation Group

Robocup Soccer Center of NPU, Simulation Robots of Robocup Soccer

- Designed gait algorithm of NAO (Humanoid) robot.
- Developed control strategies for simulated soccer competition under linux platform.
- Awarded **Third Prize** in China Open 2011.

Sep. 2010 – Jun. 2012

NPU, Xi'an, China

Project Leader : Student Project of Chinese Ministry of Education

Mining Methods for Gene Expression Profile Classification

- Implemented statistical and computing algorithms related to data mining.

Nov. 2011 – Jun. 2012

NPU, Xi'an, China

Project Leader : Student Project of Chinese Ministry of Education

Path Planning of Mobile Robot

- Implemented path planning algorithms of mobile robot (A^* , genetic algorithm, fuzzy control etc.

Nov. 2010 – Jun. 2011

NPU, Xi'an, China

“Freescale Cup” National Smart Car Design Competition

Design and Control of an Intelligent Car for Path Following

- Awarded **Third Prize** in NPU Open 2011.

Dec. 2010 – May. 2011

NPU, Xi'an, China

Research Assistant : Laboratory Project

Navigation of Unmanned Aerial Vehicle (UAV) Based on Digital Map

- Supervisor: Prof. Suilao Li, College of Automation, NPU

Sep. 2010 – Jun. 2011

NPU, Xi'an, China

Research Assistant : Laboratory Project

Design of Intelligent Vehicle and Autonomous Navigation

- Supervisor: Prof. Suilao Li, College of Automation, NPU

Sep. 2009 – Jun. 2010

NPU, Xi'an, China

Professional Activities

Journal/Conference Reviewer

2016 – present

- *IEEE Transactions on Robotics (T-RO)*
- *IEEE Transactions on Mechatronics (T-MECH)*
- *IEEE Robotics and Automation Letters (RAL)*
- *IEEE Transactions on Medical Robotics and Bionics*
- *Control Engineering Practice*
- *Robotica*
- *International Conference on Robotics and Automation (ICRA)*
- *American Control Conference (ACC)*
- *International Conference on Learning Representations (ICLR)*
- *IFAC Workshop on Lagrangian and Hamiltonian Methods for Nonlinear Control (LHMNC)*

Poster Presentation

2015 – 2021

- *Emerging Frontiers in Research and Innovation (EFRI) All-Teams Workshop, Virtual, USA.*
- *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Milano, Italy.*

Oral Presentation

2015 – 2021

- 2021 International Conference on Robotics and Automation, Virtual, Xi'an, China.
- 7th Summer School on Surgical Robotics (SSSR 2015), Montpellier, France.
- 37th EMBS Ignite Sessions, Milano, Italy.
- 4th International Workshop on Medical and Service Robots (MESROB), Nantes, France.

Volunteer

May. 2014

- 20th World Olympic Collectors Fair, Lausanne, Switzerland.

Membership

2015 – 2021

- IEEE Membership 2017 – present
- IEEE Student Membership. 2015 – 2016
- EMBS Membership. 2015 – 2016

Supervision Activities

PhD Students

🎓 **Yu Huan** : currently senior engineer at United-Imaging Healthcare Co., Ltd., Shanghai

Mar. 2018 – Mar. 2019, Scuola Superiore Sant'Anna

- Topic : Design and control of flexible miniature surgical tools (continuum robot).

Master Students

🎓 **Junming Wu** : currently second-year master student at UCSD

Sep. 2021 – present, Department of Electrical and Computer Engineering (ECE), UCSD

- Topic : Bi-manual close-loop control of dual-arm suturing using physical-based simulation.

Xiao Liang : currently second-year master student at UCSD

Sep. 2021 – present, Department of ECE, UCSD

- Topic : Reconstruction of 4D lung motion using neural-ODE integration.

Chong He : currently second-year master student at UCSD

Sep. 2021 – Aug. 2022, Department of Mechanical and Aerospace Engineering (MAE), UCSD

- Topic : Shape reconstruction of catheter robot using monocular images.

Mingen Li : currently first-year PhD student at University of Minnesota, Twin Cities

Jan. 2021 – Jan. 2022, Department of ECE, UCSD

- Topic : Simulation and control of articulated rigid body robots using position-based dynamics.

🎓 **Yunhai Han** : currently first-year PhD student at Georgia Institute of Technology

Jan. 2021 – Jan. 2022, Department of MAE, UCSD

- Topic : Simulation framework using position-based dynamics using self-written constraints based solver.

🎓 **Entong Su** : currently second-year master student at UCSD

Jan. 2021 – Jan. 2022, Department of ECE, UCSD

- Topic : Simulation of rope-like object using position-based dynamics for shape control.

🏢 **Zihan Li** : currently software algorithm engineer at OmniVision Technologies, Inc.

Jan. 2020 – Nov. 2020, Department of ECE, UCSD

- Topic : Registration method for real-to-sim transfer applications of deformable tissue manipulation.

🏢 **Jingbin Huang**

Mar. 2020 – Nov. 2020, Department of ECE, UCSD


- Topic : Modeling and control of surgical tool for suction based simulation of blood fluid.

 *Sean Liu* : currently lead engineer at *Hyperspec.ai*

Jun. 2020 – Sep. 2020, Department of ECE, UCSD

- Topic : Reconstruction of a catheter robot shape using projection of geometrical primitives.

Undergraduate Student

 *Neelay Joglekar* : currently third-year undergraduate student at *UCSD*

Jan. 2021 – present, Department of ECE, UCSD

- Topic : Dynamic model of rope-like objects using cosserat rod theory and surgical thread reconstruction.

 *Yutong Zhang* : currently first-year master student at *UCSD*


Jan. 2021 – present, Department of Computer Science, UCSD

- Topic : Simulation platform using libIGL/openGL rendering and visualization for various objects, i.e., rigid, articulated robots, deformable, fluid etc.

Bryan Yuan: currently software engineer at *Qualcomm Inc.*

Jan. 2021 – May 2022, Department of ECE, UCSD

- Topic : Coding of the gradients computed for position-based dynamics constraints.

 *Nemanja Babic* : currently senior engineer at *Hypertherm Associates Inc.*

May. 2015 – Aug. 2015, Research Internship, University of Ottawa & INSA de Lyon

- Topic : Simulation of haptic systems using CHAI3D.

Research Techniques and Relevant Skills

Computer Languages: Python, C++, C, MATLAB/Simulink, PHP

Software Skill: PyTorch, Linux, LaTeX, ROS, Gazebo, MoveIt, Chai3D, SOFA, OpenCV, Open3D, OSQP etc..

Hardware Experiences: da Vinci Research Kit (DVRK), 7-DOF Baxter Robotic Arm, KUKA LWR 4+, NDI Electromagnetic Sensor, Phantom Omni, Omega.3 & Sigma.7 (Force Dimension), Novint Falcon, MAXON Motors, EPOS Drivers, Aurora, SICK Laser Range-finder, IMU sensors, etc..

Languages

Chinese: Native

English: Advanced

French: Intermediate B1

Italian: Beginner

Media Publicity