# Lei Shi

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## RESEARCH INTEREST

To create unprecedentedly and robust robot algorithm that can fully exploit robot dynamical and sensing abilities to operate in natural environments. Specific areas: robotics, motion planning, control, machine learning.

## EDUCATION

**JOHNS HOPKINS UNIVERSITY,** Baltimore, MD — Dec 2022
MSE, Robotics Engineering, (GPA 3.72) — Concentration: Motion Planning and Control

**SHANDONG UNIVERSITY,** Shandong, China — Jun 2020
BE, Energy and Power Engineering, (GPA 84.94) — Concentration: Vehicle Engine

## RESEARCH EXPERIENCE

**JOHNS HOPKINS UNIVERSITY** — Baltimore, MD
Lab for Computational Sensing and Robotics (Advisor: Marin Kobilarov) — May 2022 - present

**Rough Terrain Ground Vehicle Control:**

- Setting up simulation environment from scratch with **CARLA** and **RoadRunner** to build a time-aligned, randomized and balanced dataset, including data collection, dataset transforming and real-time plotting.
- Implemented a ***CNN & LSTM*** based model from scratch to make motion prediction of an autonomous ground vehicle in urban area and arbitrary rough terrain area. The customized rough terrain map is from RoadRunner.
- (IN PROGRESS) Implementing a **MPPI-Control** based algorithm from scratch to guide the motion planning and control of the vehicle.

**TENCENT CO.LTD** — Shenzhen, China
Robotics-X Lab (Advisor: Yu Zheng) — May - Aug, 2021

**Robot Dexterous Manipulation:**

- Designed a general dynamic hybrid manipulation strategy for ***dynamic grasping***.
- Designed specific unprecedented ***non-prehensile*** manipulation based on UR16e, including fast dynamical grasping mechanism.
- Customized ***double inverted pendulum*** *model-based* algorithm (MATLAB) to guide the motion planning of UR16e.
- Controlled a real UR16e with C++.

## PUBLICATION

Cheng Z, Yanbo L, Lei S, Longfei Z & Yu Z: Differential Dynamic Programming based Dynamic Hybrid Manipulation Strategy for Dynamic Grasping. ICRA 2023 accepted for presentation.

## GRADUATE PROJECTS

**Robot Motion Planning Algorithm** — Oct, 2021 - May, 2022

- Implemented a ***RRT*** and ***PRM*** (Rapidly-Exploring Random Tree & Probabilistic Roadmaps) based package (MATLAB) from scratch of a 4-link planar serial manipulator to achieve complex obstacles avoidance tasks.
- Implemented an ***APF*** (Artificial Potential Field) based package (MATLAB) from scratch of a holonomic planar rigid robot to achieve complex obstacles avoidance tasks.
- Implemented a ***RRT*** (Rapidly-Exploring Random Tree) based package (MATLAB) from scratch of a flexible needle to avoid complex obstacles, where the needle tip is modeled as a nonholonomic mobile robot.
- Customized an ***EST*** (Expansive-Space Trees) based algorithm (C++) of UR5 to achieve complex obstacles avoidance. To enhance the computational efficiency, bi-directional trees was adapted. Implemented it onto real UR5.

**Machine Learning Algorithm: Image Completion** — Mar - May, 2022

- Implemented a package (Python) from scratch based on VDSR (Very deep super resolution, i.e. ***CNN***: 18 layers convolution neural networks, a deep learning method) to bring low resolution images(480p) to high resolution(1440p).
- Adopted ***residual learning*** to make the model converge much faster.
- Evaluated generated image with PSNR (Peak signal-to-noise ratio) method.

**Optimal Control Algorithm** Oct - Dec, 2021

- Customized three algorithms (MATLAB) based on ***DDP*** *(Differential Dynamic Programming)/indirect shooting/direct shooting* respectively of planar rigid object with anti-collision.
- Implemented an ACADO based package (MATLAB) from scratch for ***optimal motion planning*** of interplanetary traveling rocket with ***moving obstacles avoidance*** and ***moving target tracking***. Optimized the path of ***minimizing the fuel cost by making use of the gravity of moving plants.***

**SLAM Algorithm** Jan - May, 2022

- Customized an ***EKF*** (extended Kalman filter) based algorithm (C++ & MATLAB) to estimate the location of a mobile robot (Clear path Robotics Jackal) in mountainous area with ***Gazebo***.
- Customized a ***SLAM*** algorithm (C++) based on likelihood field model of a laser range finder and the odometry motion model in the simulation of a Husky robot being teleoperated in an outdoor environment with ***Gazebo****.*

**Calibration Algorithm** Feb – Mar, 2022

- Implemented a ***hand-eye calibration*** package (MATLAB) from scratch by ***RViz*** simulation.
- Implemented it robustly on a ***real UR5****.*

**Nonlinear Control and Planning Algorithm: Parallel parking** Feb – May, 2021

- Customized a ***A**** based algorithm (Python) of four-wheeled vehicle with anti-collision.
- Customized a ***MPC*** (Model predictive control) method-based algorithm (Python) to track the path.

**Kinematics and Dynamics Algorithm: UR5** Jan – May, 2021

- Implemented a MATLAB based package from scratch to ***control UR5*** robot in ***RViz*** based on three methods: inverse kinematics or resolved-rate control using differential kinematics or transpose-Jacobian control.
- Implemented it into ***real UR5*** to finish move-and-place tasks with complex anti-collision.

## SKILLS

- Theory: Optimal Control, Linear System, Nonlinear Control and Planning, Robot Motion Planning, ROS, Machine Learning, Deep Learning, SLAM, Robot Kinematics and Dynamics.
- Coding Language: Python, C++, MATLAB.
- Simulation: CARLA, Gazebo, RViz, Marc, ANSYS.
- Languages: English, Chinese.

## TEACHING EXPERIENCE

- Graduate Course TA: “Introduction to Linear System and Theory”
    - Graded weekly homework
    - Held TA Office Hours
    - Developed computational lab assignment