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 – Dec 2022

Rough Terrain Ground Vehicle Control:

- Set up a simulation environment with CARLA and customized rough terrain maps in RoadRunner.
- Built a time-aligned, randomized and balanced dataset from scratch.
- Implemented a CNN & LSTM based learning model to make motion prediction of an autonomous vehicle.
- Implemented a MPP-Control based algorithm for the vehicle.

TENCENT CO.LTD — Shenzhen, China
Robotics-X Lab (Advisor: Cheng Zhou) — May - Aug, 2021

Dexterous Manipulation Dynamic Grasping:

- Customized a dynamic hybrid manipulation strategy for dynamic grasping.
- Designed a double inverted pendulum model-based algorithm to guide the motion planning of UR16e.

Human-Like Motion Planning:

- Analyzed human motion and concluded the coordinate movement.
- Derived the closed-form solution of coordinate movement with parametric optimal control on 2D translation and rotation model.

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.

Cheng Z, Lei S & Yu Z. Uncovering the Secrets of Human-Like Movement: A Fresh Perspective on Motion Planning. In progress.

GRADUATE PROJECTS

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

- Implemented a RRT and PRM (Rapidly-Exploring Random Tree & Probabilistic Roadmaps) based package from scratch of a 4-link planar serial manipulator to achieve complex obstacles avoidance tasks.
- Implemented an APF (Artificial Potential Field) based package from scratch of a holonomic planar rigid robot to achieve complex obstacles avoidance tasks.
- Implemented a RRT (Rapidly-Exploring Random Tree) based package 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 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 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 based on DDP (Differential Dynamic Programming)/indirect shooting/direct shooting respectively of planar rigid object with anti-collision.
- Implemented an ACADO based package 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 to estimate the location of a mobile robot (Clear path Robotics Jackal) in mountainous area with Gazebo.
- Customized a SLAM algorithm 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 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 of four-wheeled vehicle with anti-collision.
- Customized a MPC (Model predictive control) method-based algorithm to track the path.

Kinematics and Dynamics Algorithm: UR5 Jan – May, 2021

- Implemented a 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, Robot Motion Planning, ROS, Machine Learning, Deep Learning, SLAM, Robot Kinematics and Dynamics.
- Coding Language: Python, C++.

TEACHING EXPERIENCE

- Graduate Course TA: “Introduction to Linear System and Theory” in JHU
- Undergraduate Course TA: “Dynamics” in UW-Madison