Zhizhuo Zhang

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GitHub Profile
Portfolio Website

Research Interest: Robotic manipulation of AI, Computer Vision in Robotics
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Education

•Columbia University in the City of New York *2022-2023*
Master of Science in Mechanical Engineering - Robotics and Control concentration GPA: 3.79/4.00

•Beijing Forestry University *2018-2022*
Bachelor of Engineering in Machine Design & Manufacturing and Automation Percentage: 5/124 GPA: 3.70/4.00

Research Experience

•Knolling bot *Sep. 2022 - May. 2023*
Supervisor: Hod Lipson Columbia University in the City of New York

- In this study, we proposed the Knolling bot, an activity related to organizing scattered items into neat arrangements during household tidying tasks.
- Customized and fine-tuned the YOLO v8 model visual perception model to detect the key points of objects in both the simulated environment and the real world, providing the object position, pose, and size information to subsequent tasks.
- Implemented the Knolling model with a transformer-based architecture, using the encoder-decoder mechanism and the mask mechanism to handle varying input sizes. After N iterations, the model can predict N neat positions based on the length and width of N objects in one scenario.
- Finished the socket programming in Python to realize the client-server interaction of the information about the joint motor of the robot arm, adding the cubic spline interpolation and PID feedback control to correct the error during the motion.

•Knolling bot 2 *Jun. 2023 - Now*
Supervisor: Hod Lipson Columbia University in the City of New York

- In this study, we improved the Knolling bot in terms of manipulation, trajectory planning policies, and the strategy of grasping to make the whole system more robust.
- Implemented the Grasp-predict Model with an LSTM-based architecture to predict the grasp probability for each object in one scenario based on the relative position and relative pose relationship between each object. The robotic arm can judge which objects can be grasped without interference according to the different target placement positions output by the Knolling model.
- Implemented the Unstack Model to handle the pile of hard-to-grasp objects. Based on the self-supervised learning paradigm, the robot arm can find the best push trajectory to unstack this pile from several candidate trajectories.
- Simplified the inverse kinematic and forward kinematic calculation of the robot arm to make the calculation more efficient, compared with using official APIs in the PyBullet.

•Robot Arm Grasping Device based on Proximal Optimization Strategy Algorithm *Dec. 2020 - Aug. 2021*
Supervisor: Chang'e Zheng Beijing Forestry University

- This project aimed to design a motion planning algorithm that can learn from real-time images, and optimize the inverse kinematic solution of the robot arm.
- Improved the criterion of the reward function by dividing the distance between the robot arm and the target point into four segments, so as to give the robot arm a better guiding effect and enable it to complete the training as soon as possible.
- Built a simulation environment containing the KUKA robot arm by using PyBullet and built the deep reinforcement learning environment by using Stable Baselines3 and PyTorch.

•Apple Picking Robotic Arm Control System based on ROS *May. 2020 - Aug. 2021*
Supervisor: Chang'e Zheng Beijing Forestry University

- This project aimed to develop a motion planning software package for a six-axis manipulator with Rapidly-Exploring Random Tree (RRT) algorithm as the core, which can theoretically be applicable to almost all six-axis robotic arms.
- Proposed an improved algorithm based on the parent point priority determination strategy and real-time optimization strategy to optimize the RRT algorithm
- Designed the display interface of the control system based on the Wxpython module, and configured the software interface and the operation interface of ROS to make the control system more visually.

Project Experience

•Robotic Pick and Place Task Based on Visual Affordance Model *Feb. 2023 - May. 2023*

Supervisor: Shuran Song Columbia University in the City of New York

- In this project, I implemented object recognition, obstacle avoidance, and pick and place tasks in an environment with multiple objects.
- Built the Mini-U-net architecture to learn the grasping position and the rotation angle of the gripper from the picture. After training, the model can find the plane coordinates of the object on the picture and select the gripper rotation angle with the highest success rate for grasping according to the probability distribution provided by the Gaussian heat map.
- Added Gaussian blur processing to the grasping point and data augmentation processing on the image to make the model more robust.

•Evolving Soft Robots *Sep. 2022 - Dec. 2022*

Supervisor: Hod Lipson Columbia University in the City of New York

- In this project, I compiled the program to evolve a robot with a variable morphology in the customized physical simulator by using the evolutionary algorithm.
- Built a physics simulator by using VPython and created a robot body with several connected cubes, parameterizing every spring in each cube to make the robot to move smoothly in the simulator. The dynamic data of each spring can be regarded as the population parameter in the evolutionary algorithm.
- Changed the morphology of the robot by adding and removing springs during the implementation of the evolutionary algorithm, so as to growing a robot with the fastest moving speed.

•Learning Robot Motion Control with MPC Demonstration *Feb. 2023 - May. 2023*

Supervisor: Matei Ciocarlie Columbia University in the City of New York

- In this project, I used different control methods to complete the control task of a 2-link robot arm, whose teacher policy MPC control, specifically to control the end effector of it to reach any point on the 2D plane.
- Compiled the MLP network whose input is the velocity and the position of each joint and the output is the torque of each joint at the next moment, and made the agent learn from the motion generated by the teacher policy.
- Implemented the DQN algorithm whose reward function is the negative square of L2 distance between the current position of the end-effector and the goal position.

Work Experience

•Mechanical R&D Department Internship *Jul. 2021 - Aug. 2021*

Supervisor: Zhenguo Li Rokae (Beijing) Technology Co., Ltd.

- Completed the mechanical structure design of the Motor Test Cabinet Box by using Siemens NX (Unigraphics).
- Compiled the program for the NB4L robot arm to complete its tests under extreme conditions.
- Analyzed the data collected by the sensor of the robot arm by using Python and Matlab, and compared them with the standard parameters of the motor to evaluate the working state of the joint.

Technical Skills

Programming Languages: Python, C++, Linux (Ubuntu)
Libraries: ROS, Python Libraries such as PyTorch, PyBullet, Stable Baselines3, OpenCV, Socket, Gym
Dev Tools: PyCharm, Git, Flask, VScode, Colaboratory
Cad Design: SolidWorks, Siemens NX, OpensCAD
Relevent Coursework: Robot Learning, Evolutionary Computation, Reinforcement Learning - Topics in Signal Processing, Computational Aspects of Robotics

Publications

Yuhang Hu, **Zhizhuo Zhang**, Ruibo Liu, Philippe Martin Wyder, Hod Lipson. (2023) "Knolling bot: A Transformer-based Approach to Organizing a Messy Table" *The International Conference on Robotics and Automation* (Under review)

Lijing Tian, **Zhizhuo Zhang**, Change Zheng, Baogang Zhao, Ye Tian, Yuchen Zhao, Zhongyu Wang, Yihan Qin. (2021) "An improved RRT algorithm combining parent point priority determination strategy and real-time optimization strategy for path planning". *Sensors*, Volume 21, Issue 20, 6907. https://doi.org/10.3390/s21206907