Zhizhuo Zhang

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Portfolio Website
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Research Interest: Robotic manipulation, Human-robot Interaction, Computer Vision
Current Address: 500 West 120th Street New York, NY, 10025, United States

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 Ranking: 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.
- Tried to train and deploy several visual perception models, including ResNet, YoloV7, and YoloV8 to detect the key points of objects in both the simulated environment and the real world, solving the sim-to-real problem
- Implemented the Knolling model with a transformer-based architecture, using the encoder-decoder and mask mechanisms to handle varying input sizes. After N iterations, the model can predict N neat positions based on the embedded features of N objects in one scenario.
- Added the Gaussian Mixture Models and the temperature parameter to the output of the model, sampling from the distribution to adapt to the situation of single label and multiple outputs, avoiding the problem of using MSE as the loss function that can only output the expected value.
- 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 grasping strategy to make the whole system more robust.
- Implemented the Grasp Estimation Model with an LSTM-based architecture to predict the grasp probability for each object in one scenario. 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 SAC algorithm, the robot arm can leverage the information of current objects and several positions of the end effector in recent motion trajectory to unstack overlapped objects.
- Replace the Raspberry Pi with the Jetson platform as the lower computer to realize the computation with high efficiency.

•Robot Arm Grasping Device based on Reinforcement Learning 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 reward function of the PPO algorithm 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 using PyBullet and built the deep reinforcement learning environment 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 a Rapidly-Exploring Random Tree (RRT) algorithm as the core, which can theoretically apply 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 gripper's grasping position and rotation angle 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.
- Implemented the ICP algorithms to improve the accuracy of object pose prediction through the point cloud.
- 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 using the evolutionary algorithm.
- Built a physics simulator using VPython and created a robot body with several connected cubes, parameterizing every spring in each cube to make the robot move smoothly in the simulator.
- Changed the robot's morphology by adding and removing springs during the implementation of the evolutionary algorithm to grow 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 motor's standard parameters to evaluate the joint's working state.

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: Introduction to Robotics, 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" *International Conference on Intelligent Robots and Systems 2024* (Submitted) **Click to view the Article**

Yuhang Hu, **Zhizhuo Zhang**, Hod Lipson. (2023) "Knolling bot 2.0: Enhancing Object Organization with Self-supervised Graspability Estimation" *Conference on Neural Information Processing Systems: 6th Robot Learning Workshop* (Accepted) **Click to view the Article**

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. **Click to view the Article**

Zhizhuo Zhang, Change Zheng. "Simulation of robotic arm grasping control based on proximal policy optimization algorithm". *2022 J. Phys.: Conf. Ser. 2203 012065* **Click to view the Article**

Patents

Invention Patent: Xiangyue Yuan, **Zhizhuo Zhang**, Yihan Qin, Zhongyu Wang, Gaoxiang Chen, Zeyuan Yu. An adaptive stair-cleaning robot. CN202110187190.2.

Computer Software Copyright Registration Certificate: **Zhizhuo Zhang**, Yuchen Zhao, Zhongyu Wang, Yihan Qin. The user interface of apple picking robotic arm control system based on Wxpython.