Kai Gao

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EDUCATION

Rutgers, the State University of New Jersey   Aug. 2019 – Present
PhD, Robotics/Computer Science| Advisor: by Dr. Jingjin Yu   Piscataway, USA
- IROS 2023 Finalist of Best RoboCup Paper Award. (Top 6% among accepted papers)

University of Science and Technology of China (USTC)   Aug. 2015 – Jun. 2019
Bachelor, Mathematics   Hefei, China

WORK EXPERIENCE

Advanced Robotics Intern   May. 2022 – Sep. 2022
Siemens Corporation   Berkeley, USA

1. Designed and implemented a model-free online algorithm for the bin packing problem with irregularly shaped objects. The method consists of a depth-image preprocessing process and a gradient-based optimizer.
2. Built a prototype pick-and-pack system utilizing a UR5 robot and RealSense cameras, seamlessly integrating the proposed packing strategy with Siemens' FlexGrasp.
3. Created demonstration videos of the pick-n-pack system, which helped the team find potential customers.

RESEARCH EXPERIENCE

Robot Arm Manipulation Planning   Mar. 2020 – Present
Research Assistant Advised by Dr. Jingjin Yu   Algorithmic Robotics and Control Lab (ARCL), Rutgers University, USA

1. Designed and implemented perception-planning-control pipelines for multiple real-world robotic systems, utilizing UR5 robots in tabletop rearrangement settings and a Baxter Robot for shelf-based object retrieval scenarios.
2. Applied deep learning models for precise object segmentation, grasp pose generation, and prediction of object pose stability.
3. Designed and constructed simulation scenarios for shelf, tabletop, room environments using physics engines such as PyBullet, Issac Gym, Drake, ROS+Gazebo, and Moveit.
4. Explored dual-arm motion planning through C-space decomposition on MIT Drake and GPU-accelerated parallel RRT-connect on Nvidia Isaac Gym.

Language-Guided Semantic Object Rearrangement   Mar. 2023 – Sep. 2023
Research Assistant Advised by Dr. Jingjin Yu   Algorithmic Robotics and Control Lab (ARCL), Rutgers University, USA

1. Explored language-guided manipulation planning strategies in collaboration with Dr. Abdeslam Boularias' team.
2. Developed a Monte-Carlo Tree Search based task planner that uses goal state conditions, interpreted by large language models from human language instructions, as input.

Image Registration   Sep. 2017 – Jun. 2019
Research Assistant Advised by Dr. Juyong Zhang   Graphics & Geometric Computing Laboratory (GCL), USTC, China

1. Developed a non-rigid image registration algorithm based on Iterative Closest Points and Quasi-Newton method adept at handling noise and outliers.
2. Implemented the algorithm in C++ and utilized OpenGL for enhanced visualization and thorough code testing.

Lab Toolkits Development, and Miscs   Jul. 2018 – Present
Research Assistant Advised by Dr. Jingjin Yu   Algorithmic Robotics and Control Lab (ARCL), Rutgers University, USA

1. Developed camera calibration software to precisely evaluate the perception accuracy of RealSense cameras.
2. Created a pose estimation dataset featuring synthesized desktop scenes from diverse camera angles, using Blender.

SELECTED CERTIFICATES & AWARDS

IROS 2023 Finalist of Best RoboCup Paper Award.	IROS, Oct 2023
Gold Award of China Undergrad. Math. Contest in Modeling in Anhui Province (1/65 in USTC)	2017
Reinforcement Learning Specialization.	Coursera, July 2023
Outstanding Graduates (2019)	USTC, Jun. 2019
Outstanding Student Scholarship (2015-2016) (2017-2018)	USTC, 2016, 2018

SKILLS

Programming Languages : Python, C++, Matlab
Tools : Git, ROS, Docker, PyBullet, Gazebo, OpenCV, PyTorch, Gurobi, Drake, Isaac Gym, Unreal Engine, Blender

INVITED TALKS

Fast High-Quality Tabletop Rearrangement in Bounded Workspace. March 2022
TRIPODS/DATA-INSPIRE Graduate Student Workshop Virtual

On Minimizing the Number of Running Buffers for Tabletop Rearrangement May 2021
TRIPODS (Transdisciplinary Research in Principles of Data Science) Seminar Virtual

PUBLICATIONS

Published First-Author

- **K. Gao**, J. Yu, T. S. Punjabi, and J. Yu. "Effectively Rearranging Heterogeneous Objects on Cluttered Tabletops." 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2023) **(Finalist of Best RoboCup Paper Award.)**.

- Andy Xu*, **K. Gao***, S. W. Feng*, and J. Yu. "Optimal and Stable Multi-Layer Object Rearrangement on a Tabletop." 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2023).

- **K. Gao**, S. W. Feng, B. Huang, and J Yu. "Minimizing Running Buffers for Tabletop Object Rearrangement: Complexity, Fast Algorithms, and Applications." The International Journal of Robotics Research (IJRR).

- **K. Gao**, and J. Yu. "On the Utility of Buffers in Pick-n-Swap Based Lattice Rearrangement." 2023 IEEE International Conference on Robotics and Automation (ICRA 2023).

- **K. Gao** and J. Yu. "Toward Efficient Task Planning for Dual-Arm Tabletop Object Rearrangement." 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2022).

- **K. Gao**, D. Lau, B. Huang, K. E. Bekris and J. Yu. "Fast High-Quality Tabletop Rearrangement in Bounded Workspace." 2022 IEEE International Conference on Robotics and Automation (ICRA 2022).

- **K. Gao** and J. Yu. "Capacitated Vehicle Routing with Target Geometric Constraints." 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2021).

- **K. Gao**, S. W. Feng, and J Yu. "On Minimizing the Number of Running Buffers for Tabletop Rearrangement." 2021 Robotics: Science and Systems (RSS 2021).

- R. Wang*, **K. Gao***, D. Nakhimovich*, J. Yu, and K. E. Bekris. "Uniform Object Rearrangement: From Complete Monotone Primitives to Efficient Non-Monotone Informed Search." 2021 IEEE International Conference on Robotics and Automation (ICRA 2021).

Published Co-Author

- E. R. Vieira, **K. Gao**, D. Nakhimovich, J. Yu and K. E. Bekris. "Effective and Robust Non-Prehensile Manipulation via Persistent Homology Guided Monte-Carlo Tree Search" the 18th International Symposium on Experimental Robotics (ISER 2023).

- E. R. Vieira, D. Nakhimovich, **K. Gao**, R. Wang, J. Yu and K. E. Bekris. "Persistent Homology for Effective Non-Prehensile Manipulation" 2022 IEEE International Conference on Robotics and Automation (ICRA 2022).

- R. Wang, **K. Gao**, J. Yu and K. E. Bekris. "Lazy Rearrangement Planning in Confined Spaces." the 32nd International Conference on Automated Planning and Scheduling (ICAPS 2022).

- S. W. Feng, **K. Gao**, J. Gong, and J. Yu. "Sensor Placement for Globally Optimal Coverage of 3D-Embedded Surfaces." 2021 IEEE International Conference on Robotics and Automation (ICRA 2021).

- S. W. Feng, S. D. Han, **K. Gao**, and J. Yu. "Efficient Algorithms for Optimal Perimeter Guarding." 2019 Robotics: Science and Systems (RSS 2019).

UNDER REVIEW

- **K. Gao**, Y. Ding, S. Zhang, and J. Yu "ORLA*: Mobile Manipulator-Based Object Rearrangement with Lazy A*" Submitted to ICRA 2024.

- H. Chang, **K. Gao**, K. Boyalakuntla, A. Lee, B. Huang, H. U. Kumar, J. Yu, and A. Boularias "LGMCTS: Language-Guided Monte-Carlo Tree Search for Executable Semantic Object Rearrangement." Submitted to ICRA 2024.