Kaiyu Zheng

Roboticist / Research Scientist @ RAI Institute
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Education

Ph.D. in Computer Science 2018/09 - 2022/12
Brown University, Providence, RI
Dissertation title: *"Generalized Object Search"*
Advisor: Stefanie Tellex

M.S. in Computer Science 2017/09 - 2018/06
B.S. in Computer Science, Minor in Mathematics 2013/09 - 2017/06
University of Washington, Seattle, WA
"Learning Graph-Structured Sum-Product Networks for Probabilistic Semantic Maps"
Advisors: Andrzej Pronobis, Rajesh P. N. Rao

Selected Honors

Robotics: Science and Systems (RSS) Pioneers 2022
IROS RoboCup Best Paper Award (winner) 2021
for "Multi-Resolution POMDP Planning for Multi-Object Search in 3D"
Publication of the Week, Weekly Robotics Newsletter 2019
for "ROS Navigation Tuning Guide"

Employment

Roboticist / Research Scientist, 2023/02 - current
Robotics and AI Institute (RAI) (formerly Boston Dynamics AI Institute), Cambridge, MA

Member of Ultra Mobility Vehicle (UMV) team 2024/06 - current:

- I focus on developing the high-level autonomy for the UMV by coordinating lower-level behaviors.
- Contributed key components in developing a motion generation and tracking pipeline and conduct sim-to-real transfer iterations toward dynamic terrain course traversal (e.g., multi-table jumps).
- Experimented with Hierarchical Reinforcement Learning for learning a high-level policy that outputs affordances – commands to multiple low-level policies (e.g. drive, jump) based on perception.
- Designed and implemented a navigation stack in ROS2 (C++), along with algorithms such as A*, Reeds-Shepp, Stanley controller, occupancy grid, to enable precise, obstacle-aware navigation.
- Using the above stack, developed an autonomous parking behavior of the UMV robot (15x success).
- Been through various stages of the UMV Project since its early days (on a 2D planarizer).

Member of Dexterous Mobile Manipulation (DMM) team 2023/04 - 2024/06:

- Integrated a 3D multi-object search system, GenMOS (my PhD project), into Spot robots at the company and demonstrated the result to a group of people. Assisted in building Spot infrastructure such as `spot_ros2`.
- Initiated a novel research direction "physical question answering" targeting a complex, open problem.
- Improved a sampling-based MPC pipeline with macro actions based on inverse kinematics.
- Joined the team since its inception; supported project goal setting and intern projects

Research Experience

Research Assistant, Humans To Robots Lab, Brown University 2018/09 - 2022/12
Advisor: Stefanie Tellex

- *GenMOS* [2]: the first general-purpose system for multi-object search (MOS) in a 3D region that is robot-independent and environment-agnostic (ICRA 2023).
- *Optimal Correlational Object Search* [4]: Enabled robots to find hard-to-detect objects (e.g. knife) by exploiting the correlational information with easier-to-detect objects (e.g. fridge) (ICRA 2022).
- *Dialogue Object Search* [11]: Explored how one might enable robots to engage in natural language dialogue with a human while finding objects (RSS Workshop 2021).
- *Spatial Language Understanding for Object Search* [6]: Enabled robots to interpret possibly ambiguous spatial language (e.g. "The red car is *behind* Chase Bank") for urban object search (ROMAN 2021).
- *Multi-Object Search in 3D* [7]: Proposed a POMDP formulation of multi-object search in 3D with volumetric observation space and solved it with a novel multi-resolution planning algorithm (IROS 2021).

• `pomdp_py` [13]: Open-source Python/Cython framework with clean, intuitive interfaces for building and solving POMDPs (280+ GitHub stars).

Research Intern (virtual), Learning & Intelligent Systems Lab, MIT 2020/06 - 2021/03
Mentors: Yoonchang Sung, Rohan Chitnis; Advisors: Leslie P. Kaelbling, Tomás Lozano-Pérez
• *Optimal Correlational Object Search* [4]: Enabled robots to find hard-to-detect objects (e.g. knife) by exploiting the correlational information with easier-to-detect objects (e.g. fridge) (ICRA 2022).

Research Assistant, Neural Systems Lab, University of Washington 2016/03 - 2018/06
Advisors: Andrzej Pronobis, Rajesh P. N. Rao
• *End-to-End Large-scale Semantic Mapping* [8]: Proposed TopoNets, end-to-end deep networks for modeling semantic maps with structure adapting to dynamic environment topology (IROS 2019).
• *Structured Prediction Using Sum-Product Networks* [9]: Proposed GraphSPNs, a probabilistic deep model for graph-structured data that learns a template distribution allowing for making inferences about graphs of different global structure (AAAI 2018).
• *Cognitive rObot Localization Database (COLD)*: Created a large dataset of fully-annotated robot sensory information, localization and topological maps.
• *Maintenance of the SCITOS G5 Mobile Robot* [5]: Improved the ROS-based navigation system significantly, and developed a sub-system to handle recovery behavior.

Research Assistant, Movement Control Lab, University of Washington 2015/04 - 2015/06
Advisors: Vikash Kumar, Emanuel Todorov
• Programmed the Myo armband to control a 3D-printed wearable robotic arm.

Teaching Experience

Learning & Sequential Decision Making (CSCI 2951F), Brown University, Providence, RI
Head Teaching Assistant. Instructor: Michael L. Littman. Fall 2021

- Graduate-level course on automated decision making from a computer-science perspective. Topics include Markov decision processes, stochastic and repeated games, partially observable Markov decision processes, and reinforcement learning.
- As a head teaching assistant, I contributed to the course by developing project requirements, presenting project ideas, mentoring project groups, creating homework problems and solutions, holding office hours, and managing teaching assistants.

Machine Learning (CSE 446), University of Washington, Seattle, WA
Teaching Assistant. Instructor: Sham M. Kakade. Winter 2018
Teaching Assistant. Instructor: Emily B. Fox. Winter 2017

- Undergraduate-level machine learning course. Topics include supervised learning and predictive modeling: decision trees, rule induction, nearest neighbors, Bayesian methods, neural networks, support vector machines, and model ensembles. Unsupervised learning and clustering.
- TA responsibilities: Lead section discussions ($\sim$ 30 students), grading, office hours

Foundation of Computing I (CSE 311), University of Washington, Seattle, WA
Teaching Assistant. Instructors: Paul Beame, Kevin Zatloukal. Spring 2018
Teaching Assistant. Instructors: Paul Beame, Shayan Oveis Gharan. Fall 2016

- First CS major course. Examines fundamentals of logic, set theory, induction, and algebraic structures with applications to computing; finite state machines; and limits of computability.
- TA responsibilities: Lead section discussions ($\sim$ 30 students), grading, office hours

Data Structures and Algorithms (CSE 373), University of Washington, Seattle, WA
Teaching Assistant. Instructor: Evan McCarty. Fall 2017

- For non-CS majors. Fundamental algorithms and data structures for implementation. Linked lists, stacks, queues, directed graphs. Trees: representations, traversals. Searching, hashing, sorting.
- TA responsibilities: Lead section discussions ($\sim$ 30 students), grading, office hours

Other Experience

Software Engineering Intern 2015/06 - 2015/09
Chicago Mercantile Exchange (CME), Chicago, IL

• Developed a planning & allocation utility (web app) that replaces an excel workflow (Java & Groovy).

Web Developer 2014/10 - 2015/06
UW Information Technology, Seattle, WA
• Developed and maintained university websites including IT Connect, eScience, Labgeeks, etc. Workflow followed the Agile software development cycle using JIRA.

Preprints

1. Benjamin Bokser, Daniel Gonzalez, Aaron Preston, Alex Bahner, Annika Wollschläger, Arianna Ilvonen, Asa Eckert-Erdheim, Ashwin Khadke, Bilal Hammoud, Dean Molinaro, Fabian Jenelten, Henry Mayne, Howie Choset, Igor Bogoslavskyi, Itic Tinman, James Tigue, Jan Preisig, **Kaiyu Zheng**, Kenny Sharma, Kim Ang, Laura Lee, Liana Margolese, Nicole Lin, Oscar Frias, Paul Drews, Ravi Boggavarapu, Rick Burnham, Samuel Zapolsky, Sangbae Kim, Scott Biddlestone, Sean Mayorga, Shamel Fahmi, Surya Singh, Tyler McCollum, Velin Dimitrov, William Moyne, Yu-Ming Chen, Farbod Farshidian, Marco Hutter, David Perry, Al Rizzi, Gabe Nelson, "System Design of the Ultra Mobility Vehicle: A Driving, Balancing, and Jumping Bicycle Robot," arXiv preprint arXiv:2602.22118.

Publications

2. **Kaiyu Zheng**, Anirudha Paul, Stefanie Tellex, "A System for Generalized 3D Multi-Object Search," in *IEEE International Conference on Robotics and Automation (ICRA)*, 2023.

3. **Kaiyu Zheng**, "Generalized Object Search," *PhD Thesis*, Brown University, February, 2023.

4. **Kaiyu Zheng**, Rohan Chitnis, Yoonchang Sung, George Konidaris, Stefanie Tellex, "Towards Optimal Correlational Object Search," in *IEEE International Conference on Robotics and Automation (ICRA)*, 2022.

5. **Kaiyu Zheng,** "ROS Navigation Tuning Guide," in *Robot Operating System (ROS) - The Complete Reference (Volume 6)*, edited by Anis Koubaa, Springer, Cham, pp 197-226, July 2021. (Publication of the Week, Weekly Robotics)

6. **Kaiyu Zheng**, Deniz Bayazit, Rebecca Mathew, Ellie Pavlick, Stefanie Tellex, "Spatial Language Understanding for Object Search in Partially Observed Cityscale Environments," in *IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, 2021.

7. **Kaiyu Zheng**, Yoonchang Sung, George Konidaris, Stefanie Tellex, "Multi-Resolution POMDP Planning for Multi-Object Search in 3D," in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2021. **IROS RoboCup Best Paper Award**

8. **Kaiyu Zheng**, Andrzej Pronobis, "From Pixels to Buildings: End-to-end Probabilistic Deep Networks for Large-scale Semantic Mapping," in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019.

9. **Kaiyu Zheng**, Andrzej Pronobis, Rajesh P. N. Rao, "Learning Graph-Structured Sum-product Networks for Probabilistic Semantic Maps," in *AAAI Conference on Artificial Intelligence (AAAI)*, 2018. (oral presentation)

Workshops

10. Shangqun Yu, Sreehari Rammohan, **Kaiyu Zheng**, George Konidaris, "Hierarchical Reinforcement Learning of Locomotion Policies in Response to Approaching Objects: A Preliminary Study," in *Multidisciplinary Conference on Reinforcement Learning and Decision Making (RLDM)*, 2022

11. Monica Roy*, **Kaiyu Zheng***, Jason Liu, Stefanie Tellex, "Dialogue Object Search," in *Robotics: Science and Systems (RSS) Workshop on Robotics for People: Perspectives on Interaction, Learning, and Safety*, 2021. * indicates equal contribution.

12. Semanti Basu, Sreshtaa Rajesh, **Kaiyu Zheng**, Stefanie Tellex, R. Iris Bahar, "Parallelizing POMCP to Solve Complex POMDPs," in *Robotics: Science and Systems (RSS) Workshop on Software Tools for Real-Time Optimal Control*, 2021.

13. **Kaiyu Zheng**, Stefanie Tellex, "`pomdp_py`: A Framework to Build and Solve POMDPs," in *International Conference on Automated Planning and Scheduling (ICAPS) Workshop on Planning and Robotics (PlanRob)*, 2020.

Patents

Kaiyu Zheng, Stefanie Tellex, "Generalized Three Dimensional Multi-Object Search," *U.S. Patent App. 18500768.*

Software

`pomdp-py`: A framework to build and solve POMDP problems.
`https://github.com/h2r/pomdp-py/`

Datasets

Spatial Language on Open Street Maps
`https://h2r.github.io/sloop/html/`

Cognitive rObot Localization Database (COLD).
`https://www.coldb.org/site/`

Talks

POMDP Lecture
The Boston Dynamics AI Institute, Cambridge, MA. 2023/06/26

Generalized Object Search
Northeastern GRAIL Laboratory, Boston, MA. 2022/12/15
MIT Interactive Robotics Group, Cambridge, MA. 2022/12/02
WPI ECE Graduate Seminar Lecture, virtual. 2022/11/30
Viam, New York, NY. 2022/11/04
CMU HRI Reading Group, virtual. 2022/10/11

Representations in Robotics
Brown Robotics Group Seminar, Providence, RI. 2022/07/01

Planning Under Uncertainty for Object Search
Georgia Tech RoboGrads Seminar, Atlanta, GA. 2022/04/22

Look we have a Spot
Brown Robotics Group Seminar, virtual. 2022/02/25

Towards Optimal Correlational Object Search
Brown Robotics Group Seminar, virtual. 2021/10/01

A Peek into Robotics Research Here at Brown
Brown University Staff Development Days, virtual. 2021/06/09

Multi-Resolution POMDP Planning for Multi-Object Search in 3D
MIT CSAIL Learning and Intelligent Systems Group, virtual. 2020/07/10
Brown Robotics Group Seminar, Providence, RI. 2020/02/07

End-to-end Probabilistic Deep Networks for Large-scale Semantic Mapping. Brown Visual Computing Seminar, Providence, RI. 2019/09/23

An Introduction to Semantic Mapping in Robotics
Brown Robotics Group Seminar, Providence, RI. 2019/03/22

Probabilistic Semantic Mapping Using Graph-Structured Sum-Product Networks Allen School Industry Affiliates Research Day, Seattle, WA. 2017/11/15

Teaching

Sheridan Teaching Certificate I 2021/12

Certificates

Brown University, Providence, RI.

- Develop and refine fundamental teaching and assessment strategies and communication skills based on how students learn.

Mentoring

Brown University

Anirudha Paul, MSc. student in CS	2021/10 - 2022/10
Semanti Basu, PhD student in CS (advised by R. Iris Bahar)	2020/09 - 2022/09
Vedant Gupta, BSc. student in CS	2022/03 - 2022/05
Eliza Sun, BSc. student in Math & CS	2022/03 - 2022/05
Haowei Gao, MSc. student in CS	2022/02 - 2022/05
Shangqun Yu, MSc. student in CS	2022/01 - 2022/05
Monica Roy, BSc. student in CS	2021/02 - 2022/05
Thomas Ottaway, BSc. student in CS	2020/09 - 2020/12
Deniz Bayazit, BSc. & MSc. student in CS (Now pursuing PhD in CS at EPFL in Switzerland)	2020/04 - 2021/03
Rebecca Mathew, BSc. student in CS & Linguistics	2020/04 - 2021/03

Service

Organizer

Brown Robotics Group Seminar Series. 2021

Organized a total of 40 talks, including 27 with external speakers.

Co-Organizer

Workshop on Language and Robot Learning, Conference on Robot Learning 2022

Program Committee

AAAI Student Abstract and Poster Program, AAAI 2023, 2024

Reviewer

IEEE Transactions on Robotics (T-RO)
Years served: 2021, 2022

IEEE Robotics and Automation Letters (RA-L)
Years served: 2020, 2021, 2023, 2024, 2025

IEEE International Conference on Robotics and Automation (ICRA)
Years served: 2019, 2020, 2021, 2023, 2024, 2026

IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
Years served: 2019, 2021, 2023, 2024, 2025

Robotics: Science and Systems (RSS)
Years served: 2024, 2025, 2026

Conference on Robot Learning (CoRL)
Years served: 2024, 2025, 2026

IEEE-RAS International Conference on Humanoid Robots (Humanoids)
Years served: 2022

IEEE International Conference on Robot and Human Interactive Communication (RO-MAN).
Years served: 2023

ACM SIGGRAPH Posters Program
Years served: 2022, 2023

Ocean Engineering, ScienceDirect from Elsevier
Years served: 2024