Luyang Zhao

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Research Interest

My current research spans a range of different topics in **Soft robots**, **Modular robots**, **Multi-robot Systems**, **Motion Planning**, **SLAM** and **Machine Learning**.

Education

Dartmouth College   **Hanover, NH**
Ph.D. Candidate in Computer Science   *Sep. 2018–Expected June 2024*
  – Advisor: Prof. Devin Balkcom
  – Honors: Neukom Outstanding Graduate Research Prize

University of Minnesota   **Minneapolis, MN**
B.S. in Computer Science   *Graduated **with distinction** in 2018*
  – Research advisor: Prof. Maria Gini
  – Honors: Dean's list

B.A. in Mathematics
  – Senior project advisor: Prof. Karel Prikry
  – Honors: Dean's list

Research Experience

Design of Soft Modular Robots   Oct. 2020 - Now
Dartmouth College (Advisor: Prof. Devin Balkcom)   *Hanover, NH*
- Led the development of **FlexBlocks** and **StarBlocks**, along with various soft modular robotic systems. Focused on designs for autonomous and collaborative tasks, aiming to **integrate modular and soft robotics**. For selected project demonstrations, please refer to the video links provided: Link1, and Link2.

Motion Planning Research   Sep. 2018 - Nov. 2020
Dartmouth College (Advisor: Prof. Devin Balkcom)   *Hanover, NH*
- Conducted research in optimal robot motion strategies, including Bounds Planning and Piecewise Linear Regression Complex. Focused on developing **memory-efficient algorithms** and heuristic approaches for single and multi-robot motion planning.

Undergraduate Research   Sep. 2016 - May 2018
University of Minnesota (Advisor: Prof. Maria Gini)   *Minneapolis, MN*
- Developed an **assistive AI device** for individuals with memory loss, integrating voice-activated technologies for cognitive support; Designed an **object-finding robot** utilizing SLAM and advanced object detection algorithms for efficient navigation in unknown environments.

Work Experience

Applied Scientist Intern @ Amazon Robotics   June 2021 – Sep. 2021
Amazon   *Westborough, Massachusetts*
- Conducted in-depth research and development in the fields of **localization**, **path planning**, and **navigation** for **Amazon's autonomous mobility robots**. This involved identifying and addressing key challenges in robotic movement and efficiency.
- Designed and implemented innovative algorithms tailored to enhance robot performance. These solutions were effectively integrated into the robots' systems using **ROS** and **C++**, demonstrating a significant improvement in their operational capabilities.

Summer Research Intern @ TuSimple Planning   June 2022 – Sep. 2022
TuSimple   *San Diego, California*
- Developed an advanced **local turn lateral trajectory optimization** for **autonomous trucks**, utilizing a **kinematic tractor-trailer model**. This model enhanced the precision in describing the kinematic behavior during local turns, significantly improving upon the traditional point-mass model.
- Focused on achieving **obstacle avoidance** through the generation of optimized lateral trajectories. Employed **sequential quadratic programming** techniques to effectively minimize a cost function that included state cost, input cost, and jerkiness, while adhering to necessary constraints.
- Successfully implemented and integrated the optimized trajectory solution in a **real-time environment** using **ROS** and **C++**. Demonstrated improved efficiency and safety in autonomous truck maneuvers.

Workshops Organized

Tensegrity Robotics Workshop — October 5, 2023
IROS 2023 — *Room 250C, Huntington Place, Detroit*

- Co-organized the tensegrity robot workshop with Xiaonan (Sean) Huang, Rebecca Kramer-Bottiglio, Kostas Bekris, Devin Balkcom, Joran Booth, Will Johnson, Kun Wang, and Shiyang Lu.
- Presented our work "Untethered Self-Reconfiguring Morphable Modular Robots for Field Deployment", which highlighted new designs in robotic mobility and adaptability in natural, unstructured environments.
- Workshop link: https://www.eng.yale.edu/faboratory/tensegrityworkshop/

Mentorship Experience

Lab Mentor — Sep. 2018 – Now
Dartmouth Reality and Robotics Lab — *Hanover, NH*

- Master students: Yijia Wu (2021-2022, now PhD student at WPI), Weishu Zhan (2022), Yitao Jiang (2022-now)
- Undergraduate students: Josiah Putman (now in Google), Maxine Perroni-Scharf (now PhD student at MIT)

Teaching Assistant — Sep. 2018 – Now
Dartmouth College — *Hanover, NH*

- **CS81/281** : Principles of Robot Design and Programming – 2018 Fall
- **CS76/276** : Artificial Intelligence – 2018 Winter, 2019 Fall and 2023 Fall
- **CS1** : Introduction to Programming and Computation – 2019 Spring and 2020 Spring
- **CS50** : Software Design and Implementation – 2019 Summer

Teaching Assistant, Summer Computing Academy — June 2017
University of Minnesota — *Minneaplis, MN*

- Assisted senior high school students in developing programs for Scribbler robots, image processing, video, 3D printing, and other applications.

Honors and Awards

Admissions Ambassador for Dartmouth College(2023-2024)
2nd place in the **Neukom Outstanding Graduate Research Prize**, $750 (2023)
Undergraduate **Research** Opportunities Program (UROP) **Scholarship**, $1500 (2016)
First prize in Provincial High School **Mathematics** Competition (2011)

Manuscripts in Preparation

[1] "Versatile Variable-Stiffness Modular Robots: Enhanced Design and Adaptive Control for Multifunctional Performance in Varied Aquatic Environments" (In preparation to submit to RA-L in July)

[2] "Designing Dolphin Dynamics: Integrating Cable-Driven Mechanisms and Tensegrity Structures for Replicating Marine Locomotion" (In preparation to submit to WAFR in May)

[3] "Unsupervised Reinforcement Learning for Task-Specific Design of Soft Modular Robots" (In preparation to submit to CoRL in May)

[4] "SeeSea: Multi-modal 3D Perception Dataset of In-water Obstacles for Navigation of Autonomous Surface Vehicles" (In preparation to submit to IJRR in May)

[5] "Design and Implementation of an Untethered Underwater Glider Using Syringe-Based Actuation Mechanisms" (In preparation to submit to ICRA in Sep.)

Manuscripts Under Review

[6] **Luyang Zhao**, Y. Jiang, K. Bekris, and D. Balkcom. FlexBlocks: Shape-Changing Modular Blocks Enable Self-assembling Robotic Structures (Under review in Science Robotics)

PUBLICATIONS

[7] **Luyang Zhao**, Y. Jiang, D. Balkcom. FlexBlocks: Untethered Self-Reconfiguring Morphable Modular Robots for Field Deployment (Video accepted by ICRA 2024)

[8] **Luyang Zhao**, Y. Wu, W. Yan, W. Zhan, X. Huang, J. Booth, A. Mehta, K. Bekris, R. Kramer-Bottiglio, and D. Balkcom. Starblocks: Soft actuated self-connecting blocks for building deformable lattice structures. *IEEE Robotics and Automation Letters*, 8(8):4521–4528, 2023

[9] **Luyang Zhao**, Y. Wu, J. Blanchet, M. Perroni-Scharf, X. Huang, J. Booth, R. Kramer-Bottiglio, and D. Balkcom. Soft lattice modules that behave independently and collectively. *IEEE Robotics and Automation Letters*, 7(3):5942–5949, 2022

[10] **Luyang Zhao**, J. Putman, W. Wang, and D. J. Balkcom. PLRC*: a piecewise linear regression complex for approximating optimal robot motion. In *International Conference on Intelligent Robots and Systems, IROS 2020*

[11] J. Putman, L. Oh, **Luyang Zhao**, E. Honnold, G. Brown, W. Wang, and D. J. Balkcom. Piecewise linear regressions for approximating distance metrics. *CoRR*, abs/2002.12466, 2020

[12] J. Putman, L. Oh, **Luyang Zhao**, E. Honnold, G. Brown, W. Wang, and D. J. Balkcom. LLDM: locally linear distance maps for robot motion planning: Extended abstract. In *2019 International Symposium on Multi-Robot and Multi-Agent Systems, MRS 2019*

[13] L. Ferland, Z. Li, S. Sukhani, J. Zheng, **Luyang Zhao**, and M. L. Gini. Assistive AI for coping with memory loss. In *The Workshops of the The Thirty-Second AAAI Conference on Artificial Intelligence, 2018*, AAAI Workshops

CONFERENCE AND SEMINAR PRESENTATIONS

[1] "StarBlocks: Soft Actuated Self-Connecting Blocks for Building Deformable Lattice Structures." Presented at RoboSoft 2024.

[2] "FlexBlocks: Untethered Self-Reconfiguring Morphable Modular Robots for Field Deployment" Presented at ICRA 2023 Tensegrity workshop

[3] "StarBlocks: Soft Actuated Self-Connecting Blocks for Building Deformable Lattice Structures." Initially presented part of the idea at the ICRA 2022 MSRR Workshop, and at NERC 2022.

[4] "Soft Modular Robotics: Design and Applications" invited talk at Rutgers university robotics seminar (10/17/2022 10:30am-12:00am)

[5] "Soft Lattice Modules That Behave Independently and Collectively," Presented at Robosoft 2022

[6] "PLRC*: a piecewise linear regression complex for approximationg optimal robot motion", Presented at IROS 2020

[7] "LLDM: locally linear distance maps for robot motion planning", Presented at MRS 2019

REVIEW ACTIVITIES

IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
IEEE-RAS International Conference on Soft Robotics (RoboSoft)
IEEE RAS EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)

REFERENCES

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Prof. Kostas Bekris
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Prof. Xiaonan (Sean) Huang
Assistant Professor, Robotics
University of Michigan   Email: xiaonanh@umich.edu

Prof. Rebecca Kramer-Bottiglio
Associate Professor, Mechanical Engineering & Materials Science
Yale University   Email: rebecca.kramer@yale.edu