Zhongqiang (Richard) Ren

Email: zhongqiang.ren@sjtu.edu.cn

Homepage: https://rap-lab.github.io/

Assistant Professor (Since 2024)

Global College, Shanghai Jiao Tong University

Research Interests

- Robotics, motion planning, multi-robot systems, path planning, and optimal control.

Education

- 09/2019 - 08/2022, Ph.D., Carnegie Mellon University, Mechanical Engineering, Advisors: Howie Choset and Maxim Likhachev.
- 09/2015 - 05/2017, M.S., Carnegie Mellon University, Mechanical Engineering, Advisor: Howie Choset.
- 08/2011 - 07/2015, B.Eng. (Dual Degree), Tongji University, P.R. China and FH Aachen, Germany, Mechatronics.

Industrial Experience

- 05/2017 - 08/2019, CTO and Co-founder, BITO Robotics, the U.S. and P.R. China. Tech department management, multi-robot planning and autonomous navigation software development.
- 01/2015 - 06/2015, Intern, APS GmbH-European Center for Mechatronics, Germany. Packet detection and stacking using an ABB manipulator with embedded Linux.

Teaching Experience

- 2025 Fall, 2024 Fall, ME4670J - Introduction to Robotics
- 2025 Summer, 2025 Spring, 2024 Spring, ECE2800J - Programming and Introductory Data Structures

Awards

- 05/2025, Best Paper Finalist, IEEE international conference on robotics and automation (ICRA).
- 12/2023, Best Paper Finalist, IEEE International Symposium on Multi-Robot & Multi-Agent Systems (MRS).
- 05/2017, Best paper award in computational group, symposium of mechanical engineering department at CMU.

Academic Activities

- Co-chair, Doctoral Symposium, the 16th International Symposium on Combinatorial Search (SoCS)
- Associate Editor, ICRA(24,25,26), IROS(24,25)
- Organizing Committee Member, AAAI 2023 Workshop on Multi-Agent Path Finding (WoMAPF)

Publications (# Corresponding Author)

Journal Papers

[J15] Philip, A. G., **Ren, Z.,** Rathinam, S., and Choset, H., "C*: A New Bounding Approach for the Moving-Target Traveling Salesman Problem," in IEEE Transactions on Robotics **(T-RO'25)**, vol. 41, pp. 4663-4678, 2025.

[J14] Zhao, S., Nandy, A., Choset, H., Rathinam, S. and **Ren, Z.(#)**, 2025. Heuristic Search for Path Finding with Refuelling. IEEE Robotics and Automation Letters **(RA-L'25)**, vol. 10, no. 4, pp. 3230-3237, April 2025.

[J13] Wang, C., Ji, K., Geng, J., **Ren, Z.**, Fu, T., Yang, F., Guo, Y., He, H., Chen, X., Zhan, Z. and Du, Q., 2025. Imperative learning: A self-supervised neuro-symbolic learning framework for robot autonomy. The International Journal of Robotics Research **(IJRR'25)**.

[J12] **Ren, Z.**, Hernández, C., Likhachev, M., Felner, A., Koenig, S., Salzman, O., Rathinam, S. and Choset, H., 2025. EMOA*: A framework for search-based multi-objective path planning. Artificial Intelligence **(AIJ'25)**, 339, p.104260.

[J11] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2024. A Bounded Sub-Optimal Approach for Multi-Agent Combinatorial Path Finding. IEEE Transactions on Automation Science and Engineering **(T-ASE'24)**.

[J10] **Ren, Z.(#)**, Nandy, A., Rathinam, S. and Choset, H., 2024. DMS*: Towards minimizing makespan for multi-agent combinatorial path finding. IEEE Robotics and Automation Letters **(RA-L'24)**.

[J9] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2023. CBSS: A new approach for multiagent combinatorial path finding. IEEE Transactions on Robotics **(T-RO'23)**, 39(4), pp.2669-2683.

[J8] **Ren, Z.(#)**, Srinivasan, A.K., Vundurthy, B., Abraham, I. and Choset, H., 2023. A pareto-optimal local optimization framework for multiobjective ergodic search. IEEE Transactions on Robotics **(T-RO'23)**, 39(5), pp.3452-3463.

[J7] **Ren, Z.(#)**, Rubinstein, Z.B., Smith, S.F., Rathinam, S. and Choset, H., 2023. ERCA*: A New Approach for the Resource Constrained Shortest Path Problem. IEEE Transactions on Intelligent Transportation Systems **(T-ITS'23)**, 24(12), pp.14994-15005.

[J6] Cao, C., Zhu, H., **Ren, Z.**, Choset, H. and Zhang, J., 2023. Representation granularity enables time-efficient autonomous exploration in large, complex worlds. Science Robotics **(SR'23)**, 8(80), p.eadf0970.

[J5] Yan, J., Lin, X., **Ren, Z.**, Zhao, S., Yu, J., Cao, C., Yin, P., Zhang, J. and Scherer, S., 2023. Mui-tare: Cooperative multi-agent exploration with unknown initial position. IEEE Robotics and Automation Letters **(RA-L'23)**, 8(7), pp.4299-4306.

[J4] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2022. A conflict-based search framework for multiobjective multiagent path finding. IEEE Transactions on Automation Science and Engineering **(T-ASE'22)**, 20(2), pp.1262-1274.

[J3] **Ren, Z.(#)**, Rathinam, S., Likhachev, M. and Choset, H., 2022. Multi-objective path-based D* lite. IEEE Robotics and Automation Letters **(RA-L'22)**, 7(2), pp.3318-3325.

[J2] **Ren, Z.(#)**, Rathinam, S., Likhachev, M. and Choset, H., 2022. Multi-objective safe-interval path planning with dynamic obstacles. IEEE Robotics and Automation Letters **(RA-L'22)**, 7(3), pp.8154-8161.

[J1] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2021. Subdimensional expansion for multi-objective multi-agent path finding. IEEE Robotics and Automation Letters **(RA-L'21)**, 6(4), pp.7153-7160.

Conference Papers

[C27] Liu, Y. and **Ren, Z.(#)**, 2025. A Probabilistic Measure of Multi-Robot Connectivity and Ergodic Optimal Control. Proceedings of Robotics: Science and Systems **(RSS'25)**, Los Angeles, CA, USA.

[C26] Zhao, S., Wu, Y. and **Ren, Z.(#)**, 2025, July. Bi-Objective Search for the Traveling Salesman Problem with Time Windows and Vacant Penalties. In Proceedings of the International Symposium on Combinatorial Search **(SoCS'25)** (Vol. 18, pp. 171-179).

[C25] Chen, Y., Xu, J., Cai, Y., Wong, T.W., **Ren, Z.**, Choset, H. and Shi, G., 2025, May. Propagative Distance Optimization for Motion Planning. In 2025 IEEE International Conference on Robotics and Automation **(ICRA'25)** (pp. 1794-1800). IEEE.

[C24] **Ren, Z.(#)**, Suvonov, B., Chen, G., He, B., Liao, Y., Fermuller, C. and Zhang, J., 2025, May. Search-Based Path Planning in Interactive Environments among Movable Obstacles. In 2025 IEEE International Conference on Robotics and Automation **(ICRA'25)** (pp. 533-539). IEEE.

[C23] Bhat, A., Gutow, G., Vundurthy, B., **Ren, Z.**, Rathinam, S. and Choset, H., 2025. A Complete and Bounded-Suboptimal Algorithm for a Moving Target Traveling Salesman Problem with Obstacles in 3D. In 2025 IEEE International Conference on Robotics and Automation **(ICRA'25)** (pp. 6132-6138). IEEE.

[C22] Zhao, S., Philip, A.G., Rathinam, S., Choset, H. and **Ren, Z.(#)**, 2025, August. CB-GCS: Conflict-Based Search on the Graph of Convex Sets for Multi-Agent Motion Planning. In 2025 IEEE 21st International Conference on Automation Science and Engineering **(CASE'25)** (pp. 2208-2214). IEEE.

[C21] Philip, A.G., **Ren, Z.**, Rathinam, S. and Choset, H., 2025. A mixed-integer conic program for the multi-agent moving-target traveling salesman problem. In 2025 IEEE 21st International Conference on Automation Science and Engineering **(CASE'25)** (pp. 492-498). IEEE.

[C20] Zhou, S., Zhao, S. and **Ren, Z.(#)**, 2025, April. Loosely Synchronized Rule-Based Planning for Multi-Agent Path

Finding with Asynchronous Actions. In Proceedings of the AAAI Conference on Artificial Intelligence (**AAAI'25**) (Vol. 39, No. 14, pp. 14763-14770).

[C19] Bhat, A., Gutow, G., Vundurthy, B., **Ren, Z.**, Rathinam, S. and Choset, H., 2024. Propagative distance optimization for constrained inverse kinematics. In International Workshop on the Algorithmic Foundations of Robotics (**WAFR'24**).

[C18] Chen, Y., Cai, Y., Xu, J., **Ren, Z.**, Shi, G. and Choset, H., 2024. Propagative distance optimization for constrained inverse kinematics. In International Workshop on the Algorithmic Foundations of Robotics (**WAFR'24**).

[C17] Cao, C., Xu, J., Zhang, J., Choset, H. and **Ren, Z.(#)**, 2024, June. Heuristic Search for the Orienteering Problem with Time-Varying Reward. In Proceedings of the International Symposium on Combinatorial Search (**SoCS'24**) (Vol. 17, pp. 11-19).

[C16] **Ren, Z.(#)**, Cai, Y., and Wang, H., 2024, October. Multi-Agent Teamwise Cooperative Path Finding and Traffic Intersection Coordination. In 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'24**), Abu Dhabi, United Arab Emirates, 2024, pp. 7990-7995.

[C15] Guo, Y., **Ren, Z.**, and Wang, C., 2024, October. iMTSP: Solving Min-Max Multiple Traveling Salesman Problem with Imperative Learning. In 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'24**), Abu Dhabi, United Arab Emirates, 2024, pp. 10245-10252. IEEE.

[C14] Philip, A. G., **Ren, Z.**, Rathinam, S., and Choset, H., 2024, October. A Mixed-Integer Conic Program for the Moving-Target Traveling Salesman Problem based on a Graph of Convex Sets. In 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'24**), Abu Dhabi, United Arab Emirates, 2024, pp. 8847-8853. IEEE.

[C13] **Ren, Z.(#)**, Li, J., Zhang, H., Koenig, S., Rathinam, S. and Choset, H., 2023, July. Binary branching multi-objective conflict-based search for multi-agent path finding. In Proceedings of the International Conference on Automated Planning and Scheduling (**ICAPS'23**) (Vol. 33, No. 1, pp. 361-369).

[C12] **Ren, Z.(#)**, Zhang, C., Rathinam, S. and Choset, H., 2023, May. Search Algorithms for Multi-Agent Teamwise Cooperative Path Finding. In 2023 IEEE International Conference on Robotics and Automation (**ICRA'23**) (pp. 1407-1413). IEEE.

[C11] Tang, Y., **Ren, Z.**, Li, J. and Sycara, K., 2023, December. Solving multi-agent target assignment and path finding with a single constraint tree. In 2023 International Symposium on Multi-Robot and Multi-Agent Systems (**MRS'23**) (pp. 8-14). IEEE.

[C10] Srinivasan, A.K., Gutow, G., **Ren, Z.**, Abraham, I., Vundurthy, B. and Choset, H., 2023, October. Multi-Agent Multi-Objective Ergodic Search Using Branch and Bound. In 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'23**) (pp. 844-849). IEEE.

[C9] **Ren, Z.(#)**, Zhan, R., Rathinam, S., Likhachev, M. and Choset, H., 2022, July. Enhanced multi-objective A* using balanced binary search trees. In Proceedings of the international symposium on combinatorial search (**SoCS'22**) (Vol. 15, No. 1, pp. 162-170).

[C8] **Ren, Z.(#)**, Srinivasan, A.K., Coffin, H., Abraham, I. and Choset, H., A Local Optimization Framework for Multi-Objective Ergodic Search. In Proceedings of Robotics: Science and Systems (**RSS'22**).

[C7] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2022, January. Conflict-Based Steiner Search for Multi-Agent Combinatorial Path Finding. In Proceedings of Robotics: Science and Systems (**RSS'22**).

[C6] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2022, June. A Lower Bounding Framework for Motion Planning amid Dynamic Obstacles in 2D. In International Workshop on the Algorithmic Foundations of Robotics (**WAFR'22**) (pp. 540-556). Cham: Springer International Publishing.

[C5] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2021, May. Ms*: A new exact algorithm for multi-agent simultaneous multi-goal sequencing and path finding. In 2021 IEEE international conference on robotics and automation (**ICRA'21**) (pp. 11560-11565). IEEE.

[C4] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2021, September. Loosely synchronized search for multi-agent path finding with asynchronous actions. In 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'21**) (pp. 9714-9719). IEEE.

[C3] **Ren, Z.(#)**, Rathinam, S. and Choset, H., 2021, May. Multi-objective conflict-based search for multi-agent path finding. In 2021 IEEE International Conference on Robotics and Automation (**ICRA'21**) (pp. 8786-8791). IEEE.

[C2] Gong, C., **Ren, Z.**, Whitman, J., Grover, J., Chong, B. and Choset, H., 2018, September. Geometric motion planning for systems with toroidal and cylindrical shape spaces. In Dynamic Systems and Control Conference (**DSCC'18**) (Vol. 51913, p. V003T32A013). American Society of Mechanical Engineers.

[C1] **Ren, Z.(#)**, Gong, C. and Choset, H., 2017, September. Deformed state lattice planning. In 2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS'17**) (pp. 6307-6312). IEEE.