Sipu Ruan

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*Associate Professor from Robotics Institute, School of Mechanical
Engineering and Automation, Beihang University, Beijing, China*

Research interests: robot motion planning, theoretical and computational kinematics, probability theory, robot imitation learning, etc.

Education

Johns Hopkins University   **Baltimore, Maryland, USA**
PhD degree   *August 2016 - December 2020*

- PhD degree in Mechanical Engineering, Advisor: Prof. Gregory S. Chirikjian
- Dissertation: "Quantization, Calibration and Planning for Euclidean Motions in Robotic Systems"

Johns Hopkins University   **Baltimore, Maryland, USA**
Master's degree in Robotics   *August 2015 - May 2017*

- GPA: 4.0/4.0

Harbin Institute of Technology   **Harbin, Heilongjiang Province, China**
Bachelor's degree   *August 2011 - July 2015*

- Bachelor of Engineering degree in Mechatronic Engineering (June 2011), GPA: 90.11 / 100
- Honor School, Elite Student Program (top 2% students selected from leading majors of the university)

University of California, Riverside   **Riverside, California, USA**
Visiting Undergraduate Student   *August 2013 - December 2013*

- Sponsored by China Scholarship Council

Working Experience

- **Associate Professor**: Robotics Institute, School of Mechanical Engineering and Automation, Beihang University, Beijing, China (Feb. 2024 - Now)
- **Research Fellow**: Department of Mechanical Engineering, National University of Singapore, Singapore (Jan. 2021 - Jan. 2024)
- **Internship**: Aptiv Autonomous Mobility, planning team, Pittsburgh, PA (July - Sept. 2019)
    - Implemented proximity computations for autonomous vehicles.
    - Designed and compared prototypes for graph-based planning algorithms.

Research Experience

- **Robot imitation learning and motion planning with guidance from affordance reasoning**
    - Developed efficient learning from demonstration method using probability theory in Lie groups.
    - Developed optimized motion planning algorithm that is guided affordance and imitation learning.
    - Demonstrated manipulation skills for daily tasks like pouring, scooping and door opening, etc.
- **Robot motion planning based on parameterizations of free space**
    - Developed efficient motion planning frameworks for narrow passage problems based on closed-form parameterization of collision-free configuration space.
    - Developed effective hybrid algorithms with sampling-based planners for high dimensional problems.
- **Collision detection using closed-form contact space parameterization**
    - Applied gradient-parameterized closed-form contact space between two convex bodies.
    - Developed a unified collision detection framework to query distance, penetration depth, contact status and points using optimization techniques.
    - Developed a continuous collision detection method for two moving objects with linear deformations.
- **Closed-form Minkowski sums for two bodies with positively-curved boundary**
    - Developed normal- and gradient-parameterized boundaries for Minkowski sums between two bodies in closed-form.
    - Derived closed-form expressions for Minkowski sums under linear deformations.

Academic Experience

Community Service

- **Conference Associate Editor**: *IEEE ICRA* (2024)
- **Conference Session Chair**: *IEEE IROS* (2022)
- **Assistant to the Editor-in-Chief**: *Robotica* journal (2018-2020)

Teaching Experience

- **Instructor**: Mechanized Assemby: Hardware and Algorithms (Summer 2018)
- **Teaching Assistant**: Advanced System Modeling (Fall 2017)
- **Teaching Assistant**: Dynamics of Robot and Spacecraft (Fall 2016)

Technical skills

- **Programming Languages:** C++, Matlab, Python, TeX

- **Industrial Software Skills:** ROS, Gazebo, Pro/Engineer

Publications

Journal Articles

- **Ruan, S.**, Liu, W., Wang, X., Meng, X. and Chirikjian, G. S. (2024). PRIMP: PRobabilistically-Informed Motion Primitives for Efficient Affordance Learning from Demonstration. IEEE Transactions on Robotics. doi: 10.1109/TRO.2024.3390052.
- Meng, X., Wu, H., **Ruan, S.** and Chirikjian, G.S., 2023. Prepare the Chair for the Bear! Robot Imagination of Sitting Affordance to Reorient Previously Unseen Chairs. IEEE Robotics and Automation Letters, vol. 8, no. 10, pp. 6515-6522, Oct. 2023, doi: 10.1109/LRA.2023.3306671.
- **Ruan, S.**, Poblete, K.L., Wu, H., Ma, Q. and Chirikjian, G.S., 2023. Efficient Path Planning in Narrow Passages for Robots with Ellipsoidal Components. IEEE Transactions on Robotics, 39(1). pp.110-127. doi: 10.1109/TRO.2022.3187818.
- **Ruan, S.**, Wang, X. and Chirikjian, G.S., 2022. Collision Detection for Unions of Convex Bodies With Smooth Boundaries Using Closed-Form Contact Space Parameterization. IEEE Robotics and Automation Letters, 7(4), pp.9485-9492. doi: 10.1109/LRA.2022.3190629.
- **Ruan, S.** and Chirikjian, G.S., 2022. Closed-form Minkowski sums of convex bodies with smooth positively curved boundaries. Computer-Aided Design, 143, p.103133. doi: 10.1016/j.cad.2021.103133.
- Wuelker, C., **Ruan, S.** and Chirikjian, G. S., 2019. Quantizing Euclidean Motions via Double-coset Decomposition. Research, 2019, 1608396. doi: 10.34133/2019/1608396.
- **Ruan, S.**, Ding, J., Ma, Q. and Chirikjian, G.S., 2019. The Kinematics of Containment for N-Dimensional Ellipsoids. Journal of Mechanisms and Robotics, 11(4), p.041005. doi: 10.1115/1.4043458.
- Ma Q., Goh Z., **Ruan S.** and Chirikjian G.S., 2018. Probabilistic Approaches to the AXB=YCZ Calibration Problem in Multi-robot Systems. Autonomous Robots, 42(7), 1497-1520. doi: 10.1007/s10514-018-9744-3.
- Chirikjian G.S., Mahony R., **Ruan S.** and Trumpf J., 2018. Pose Changes From a Different Point of View. Journal of Mechanisms and Robotics, 10(2), p.021008. doi: 10.1115/1.4039121.

Refereed Conference Papers

- Liu, W., Wu, Y., **Ruan, S.** and Chirikjian, G.S., 2023. Marching-Primitives: Shape Abstraction from Signed Distance Function. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (pp. 8771-8780). (**Highlight, top 2% among submitted papers**)
- Wu, Y., Liu, W., **Ruan, S.** and Chirikjian, G.S., 2022, October. Primitive-Based Shape Abstraction via Nonparametric Bayesian Inference. In Computer Vision–ECCV 2022: 17th European Conference, Tel Aviv, Israel, October 23–27, 2022, Proceedings, Part XXVII (pp. 479-495). Cham: Springer Nature Switzerland.
- Wu, H., Meng, X., **Ruan, S.** and Chirikjian, G.S., 2022, May. Put the Bear on the Chair! Intelligent Robot Interaction with Previously Unseen Chairs via Robot Imagination. In 2022 International Conference on Robotics and Automation (ICRA) (pp. 6276-6282). IEEE.
- Liu, W., Wu, Y., **Ruan, S.** and Chirikjian, G.S., 2022. Robust and Accurate Superquadric Recovery: a Probabilistic Approach. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (pp. 2676-2685).
- **Ruan, S.**, Poblete, K.L., Li, Y., Lin, Q., Ma, Q. and Chirikjian, G.S., 2019, May. Efficient exact collision detection between ellipsoids and superquadrics via closed-form Minkowski sums. In 2019 International Conference on Robotics and Automation (ICRA) (pp. 1765-1771). IEEE.
- **Ruan, S.**, Ma, Q., Poblete, K.L., Yan, Y. and Chirikjian, G.S., 2018, December. Path planning for ellipsoidal robots and general obstacles via closed-form characterization of Minkowski operations. In International Workshop on the Algorithmic Foundations of Robotics (pp. 3-18). Springer, Cham.
- Mitchel, T.W.*, **Ruan S.*** and Chirikjian, G.S., 2018, November. Signal alignment for humanoid skeletons via the globally optimal reparameterization algorithm. In 2018 IEEE-RAS 18th International Conference on Humanoid Robots (Humanoids) (pp. 217-223). IEEE. *(* Equal contributions)*

- Mitchel, T.W.*, **Ruan S.***, Gao, Y. and Chirikjian, G.S., 2018, November. The globally optimal reparameterization algorithm: an alternative to fast dynamic time warping for action recognition in video sequences. In 2018 15th International Conference on Control, Automation, Robotics and Vision (ICARCV) (pp. 1290-1297). IEEE. *(* Equal contributions)*
- **Ruan S.**, Chirikjian, G.S. and Ding, J., 2018, August. Lower bounds of the allowable motions of one n-dimensional ellipsoid contained in another. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (Vol. 51814, p. V05BT07A081). American Society of Mechanical Engineers.
- **Ruan S.**, Kim, J.S. and Chirikjian, G.S., 2016, December. Symmetrical rigid body parameterizations for humanoid robots. In 2016 IEEE International Conference on Robotics and Biomimetics (ROBIO) (pp. 1655-1661). IEEE.