

From State Estimation on Lie Groups to Affordance Learning and Robot Imagination

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Abstract: Today's robots are very brittle in their intelligence. This follows from a legacy of industrial robotics where robots pick and place known parts repetitively. For humanoid robots to function as servants in the home and in hospitals they will need to demonstrate higher intelligence, and must be able to function in ways that go beyond the stiff prescribed programming of their industrial counterparts. A new approach to service robotics is discussed here. The affordances of broad classes of common objects such as chairs, cups, etc., are defined. When a new object is encountered, it is scanned and a virtual version is put into a simulation wherein the robot "imagines" how the object can be used. In this way, robots can reason about objects that they have not encountered before. After affordances are assessed, the robot then takes action in the real world, resulting in real2sim2real transfer. As part of this broad framework, probabilistic methods on Lie-groups are used. These mathematical methods were developed originally by the presenter for mobile robot state estimation, and have been adapted recently to one-shot learning of affordances from demonstration. Videos of physical demonstrations will illustrate the effectiveness of this paradigm. Future plans will be discussed, including the integration of large language models.

Bio: Gregory S. Chirikjian received undergraduate degrees from Johns Hopkins University in 1988, and a Ph.D. degree from the California Institute of Technology, Pasadena, in 1992. From 1992 until 2021, he served on the faculty of the Department of Mechanical Engineering at Johns Hopkins University, attaining the rank of full professor in 2001. Additionally, from 2004-2007, he served as department chair. Starting in January 2019, he moved to the National University of Singapore, where he served as Head of the Mechanical Engineering Department, where he has hired 14 new professors. As of January 2024 he moved to the University of Delaware, where he is chair of the Mechanical Engineering department. Chirikjian's research interests include robotics, applications of group theory in state estimation, information-theoretic inequalities, and applied mathematics more broadly. He is a 1993 National Science Foundation Young Investigator and a 1994 Presidential Faculty Fellow. In 2010 he became a fellow of the IEEE. From 2014-15, he served as a program director for the US National Robotics Initiative, which included responsibilities in the Robust Intelligence cluster in the Information and Intelligent Systems Division of CISE at NSF. Chirikjian is the author of more than 250 journal and conference papers and the primary author of three books, including *Engineering Applications of Noncommutative Harmonic Analysis* (2001) and *Stochastic Models, Information Theory, and Lie Groups, Vols. 1+2.* (2009, 2011). In 2016, an expanded edition of his 2001 book was published as a Dover book under a new title, *Harmonic Analysis for Engineers and Applied Scientists*.