ME Seminar

Leveraging kinematic intelligence for safer learning and skill transfer in robots

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ABSTRACT

In this talk, I will argue that many of the failure modes of modern robot learning systems can be traced back to a poor understanding of the underlying kinematics. I will first revisit cuspidal manipulators, robots that can change inverse-kinematic solutions without crossing singularities, and show how their subtle topology challenges conventional path planning, which has contributed to their limited industrial adoption, including in cobots. Building on my work in global kinematic analysis, I will present a framework that systematically characterizes feasible and repeatable paths in both cuspidal and non-cuspidal robots, using homotopy-based classification of singularities and reduced aspects in joint space.

I will then show how these analytic kinematic insights can be embedded into Learning-from-Demonstration (LfD) via dynamical-system-based policies that explicitly respect joint limits, singularity boundaries, and connectivity of feasible regions. This notion of kinematic intelligence enables safer, more predictable motion planning and execution. Finally, I will discuss kinematic-informed skill transfer across different robot morphologies, including redundant arms, illustrating how demonstrations given on one platform can be certified, adapted, and re-executed on other industrial robots and cobots despite structural differences. The talk will highlight how this integration of kinematics and learning leads to more reliable, scalable motion transfer in real-world settings.

ABOUT THE SPEAKER

I am a Postdoctoral Researcher at the LASA laboratory at EPFL, where my work focuses on integrating precise kinematic analysis with robot learning to achieve safer generalization and robust motion transfer. My research builds on a long-standing interest in cuspidal and non-cuspidal manipulators, global workspace analysis, and singularity-aware path planning, which I developed during my PhD at LS2N in Nantes under the supervision of Philippe Wenger and Damien Chablat.

More recently, I have been working on embedding these kinematic structures, joint limits, singularity surfaces, and connectivity of feasible regions, directly into Learning-from-Demonstration frameworks and dynamical-systems-based policies, toward what I call kinematic intelligence for robots. This line of work aims to make modern industrial robots and cobots capable of learning from a few demonstrations while still offering certified safety and repeatability in execution. Further details and ongoing projects are available at: www.salunkhedurgesh.com.

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