

RAISE 2026 FIELD DAY

Responsive & Resilient AI for

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Autonomous Systems Engineering

**The Dynamics of Fluid Physical Interaction:
Towards Safe, Adaptive, and Compliant
Robot Intelligence**

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University of Pennsylvania

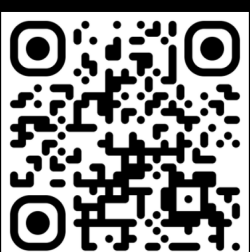
Friday, March 27, 2026, at 12:30 pm
Centennial Engineering Center
Stamm Commons (Room 1044)

Abstract

For decades, we have envisioned robots that can move, adapt, and collaborate with humans as fluidly as we do with each other. Yet, even the most advanced systems struggle to achieve what I call fluid physical interaction: a regime where motion, force, and intent predictions are continuously co-regulated through constraint-aware estimation, learning, and control, enabling safe, adaptive, and seamless exchanges of energy and information. Achieving this requires robots that are stable yet flexible, adaptive yet predictable, and compliant yet purposeful. In this talk, I will show how a dynamical-systems perspective provides a unifying foundation for realizing fluid physical interaction. By shaping robot behavior through stable vector fields, constraint and viability manifolds, and adaptive estimation models, we can generate control policies that remain reactive, safe, and consistent even under uncertainty. I will present recent results that demonstrate how this framework enables robots to generalize complex behaviors from minimal demonstrations, adapt online to changes in their dynamics and environment, avoid obstacles in real-time, and maintain safety during physical collaboration. I will also discuss new efforts that combine dynamical-systems principles with visuomotor learning to achieve stable, compliant, and force-aware behavior in dynamic contact-rich tasks. Together, these developments move us closer to embodied, adaptive, and compliant robot intelligence that can truly flow with humans and the environments they inhabit.

Speaker Bio

Nadia Figueroa is the Shalini and Rajeev Misra Presidential Assistant Professor of Mechanical Engineering and Applied Mechanics at the University of Pennsylvania, with secondary appointments in Computer and Information Science and Electrical and Systems Engineering. She is also a core faculty member of the GRASP Lab. Before joining Penn, she was a Postdoctoral Associate in the Interactive Robotics Group at the Massachusetts Institute of Technology (MIT). She earned her Ph.D. in Robotics, Control, and Intelligent Systems from the Swiss Federal Institute of Technology in Lausanne (EPFL) and previously conducted research at the Robotics and Mechatronics Institute of the German Aerospace Center (DLR) and at NYU Abu Dhabi. She holds a B.Sc. in Mechatronics Engineering from Tecnológico de Monterrey and an M.Sc. in Automation and Robotics from TU Dortmund. Her research focuses on developing integrated learning, control, and estimation algorithms that enable fluid human-robot collaboration with formal guarantees of safety, efficiency, and robustness. Her work bridges control theory, machine learning, AI, perception, and biomechanics through the lens of physical human-robot interaction. She is a recipient of a 2025 NSF CAREER Award, a finalist for the 2020 Georges Giralt Ph.D. and 2017 KUKA Innovation Awards, and has received multiple best paper honors at leading robotics venues.



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