



— ADAPTIVE ROBOTICS AND CONTROL —

Dept. of Electrical & Computer Engineering · Louisiana State University

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## THE FRONTIER & OUR ANSWER

The next frontier of autonomy is **embodied AI operating safely in the real world**. Humanoids are leaving the lab, multi-agent teams coordinate at scale, and vehicles act under intermittent feedback. Today's learning systems excel at perception but lack stability guarantees. Classical control offers stability but struggles in data-driven, high-dimensional settings. *The ARC Lab works on the gap between these two worlds.*

We develop **mathematically certified** methods that fuse control theory, physics-based modeling, and deep learning. Our core framework, **Lyapunov-based deep learning for autonomy**, embeds stability directly into the learning dynamics of deep neural networks, with every adaptation law backed by a Lyapunov function and an analytically verifiable convergence certificate. The framework was validated on robotic platforms at the UF Autonomy Park and has produced 30+ publications and a forthcoming Springer book.

**The unifying question:** *How can an autonomous system learn an unknown dynamics model online, in real time, while a Lyapunov function simultaneously certifies that the closed-loop trajectories remain stable and converge, with a proof rather than a simulation?*

## OPEN RESEARCH THRUSTS

**Physics-Aware Adaptive System ID.** Online frameworks in which neural networks learn energy-based formulations (Lagrangian, Hamiltonian, Rayleighian) in real time under intermittent feedback. Physics structure improves robustness and tracking; dynamic shifts trigger automatic fault flagging via interpretable parameters.

**AI-Lyapunov Synthesis.** An AI system that *discovers* control laws, Lyapunov functions, and safety certificates from data, acting as a co-theorist that can prove the laws of control rather than just approximate them.

## APPLICATION FRONTIERS

Each application area below is driven by a specific theoretical thrust above and tied to a concrete research direction the lab is actively pursuing.

**Humanoid robotics** (*emerging direction*). Whole-body locomotion and dexterous manipulation involve uncertain contact dynamics, hybrid switching, and failure modes where a fall is physically catastrophic. Lyapunov-based adaptation is one of the few frameworks that can certify online learning under these conditions, and is a natural extension of prior work on adaptive control of robotic manipulators.

**Multi-agent and swarm autonomy.** Distributed adaptive tracking, formation control, and cooperative estimation over heterogeneous agent networks, with graph-based estimators and node-level certificates that compose to network-level guarantees. A near-term funding target is ONR's CAST program for cooperative autonomous mine countermeasures.

**Autonomy on General Metric Spaces.** A metric-first framework where stability, safety, and adaptation are expressed using distances and measures. One unified language for  $SE(3)$  robotics, networked systems, and distributional control, so proofs and algorithms transfer across representations.

**Computational Physics-Data Fusion.** Structure-aware neural operators, learned closures constrained by physical priors, and differentiable solvers, with run-time certification that monitors residuals and triggers fallback models when risk increases.

**Autonomy under intermittent feedback.** Composite adaptive control for systems that must remain stable when sensing is degraded, occluded, or temporarily lost. A direct extension of prior research on Lyapunov-based deep learning for unmanned vehicles operating with unreliable measurements.

**Energy, power, and physical infrastructure.** Adaptive observers and physics-informed identification for nonlinear, decentralized power networks and thermodynamic systems, where online learning must respect conservation laws and decentralized constraints.

*My passion is to bring the best out of people. A dissertation is just an artifact. The real outcome of a Ph.D. is the researcher you become. I will hold you to the standard of work you are capable of, and I will meet your effort with my own. Few decisions in your professional life matter more than where, and with whom, you choose to do this work.*

## WHAT YOU WILL GAIN

**Technical depth that transfers anywhere.** The hardest unsolved problems in industry robotics today (humanoid locomotion, adaptive manipulation, safe multi-robot coordination) live at the intersection of learning and control. Understanding why a learning system works, not just that it does, is what separates engineers who can build reliably from those who can only tune hyperparameters.

**A portfolio of validated results.** At most three co-authors per paper, and every project goes to hardware. You leave with published work and demonstrated systems, the combination that gets you taken seriously whether you are interviewing at a robotics startup, an autonomy research team, or a top academic program.

**Direct, high-bandwidth mentorship.** As an incoming professor building a first cohort, I work alongside you. You develop independent technical judgment from the person who built the framework, not through a chain of lab tradition.

**The rare ability to go from proof to platform.** You will design, analyze, and physically validate control systems on real robots. Companies building on the frontier of autonomy, including humanoid platforms, autonomous vehicles, and aerial and underwater systems, need engineers who can do all three. Most candidates can only do one.

**A credential that opens every door.** This training prepares you equally for a research role at a robotics company, a position at a national laboratory, or a faculty career. Where you take it is your choice.

## TRAINING MODEL

**Year 1.** *Nonlinear, Adaptive, and Learning-Based Control of Robotic Systems* (special topics, Fall 2026) builds the foundation. By year end you are working on an open problem, not reading background papers.

**Years 2–3.** Conference submissions, external peer review, experimental validation, journal development targeting IEEE TAC, Automatica, or IEEE CSL.

**Years 3–4.** Journal acceptance. Because every chapter is already peer-reviewed, the dissertation is a focused assembly of vetted, published work.

**Graduation standard:** 3 first-authored journal papers (at least 1 accepted, 2 submitted) and 1 published conference paper.

## WHAT WE BUILD TOWARD

- ▶ Embodied AI with *provable* safety, not statistical hope
- ▶ “Machine-discovered control theory” with AI as co-theorist
- ▶ Guarantees that survive the move from simulator to hardware
- ▶ A unified language for control across robotics, networks, and learning

## Funded Ph.D. Positions Open · Fall 2026

### Contact

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Subject: [ARC Lab PhD]

### Application Materials

CV, transcripts, and one paragraph on a problem you find interesting and why.

### Department

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