2025-11-01

E013: Monitoring Infrastructure

DIP-SMC-PSO Educational Series

January 25, 2026

Overview

This episode covers monitoring infrastructure from the DIP-SMC-PSO project.

Part: Part3 Advanced
Duration: 15-20 minutes
Source: Comprehensive Presentation Materials

section0 Phase 5 Research Roadmap: Overview

72-Hour Roadmap (Oct 29 - Nov 7, 2025):

Quick Wins (Week 1, 8 hours):

- QW-1: SMC theory documentation (800-1,200 lines) - QW-2: Baseline benchmarks (7 controllers × 4 metrics) - QW-3: PSO visualization tools - QW-4: Chattering metrics (FFT analysis) - QW-5: Status tracking updates

Medium-Term (Weeks 2-4, 18 hours):

- MT-5: Comprehensive 7-controller benchmark (100 Monte Carlo) - MT-6: Boundary layer optimization (3.7 - MT-7: Robust PSO validation (bonus task) - MT-8: Disturbance rejection analysis

Long-Term (Months 2-3, 46 hours):

- LT-4: Lyapunov proofs for all 7 controllers (1,000 lines) - LT-6: Model uncertainty analysis (±10 - LT-7: Research paper SUBMISSION-READY (v2.1)

section0 LT-7 Research Paper: Submission-Ready v2.1

Target Journals: IEEE Transactions on Control Systems Technology, IFAC

Paper Structure:

- **Introduction** – Motivation, related work, contributions - **Controller Overview** – 7 SMC variants, theoretical foundations - **PSO Methodology** – Gain tuning, multi-objective cost function - **Lyapunov Analysis** – Stability proofs for all controllers - **Experimental Setup** – DIP model, simulation parameters - **Performance Comparison** – MT-5 benchmark results - **Robustness Analysis** – Disturbances (MT-8), model uncertainty (LT-6) - **Discussion** – Insights, tradeoffs, practical considerations - **Conclusions** – Summary, future work

Deliverables:

- 14 publication-ready figures (PDF/EPS) - Comprehensive bibliography (39 academic references) - LaTeX source (95 - Cover letter + user manual

section0 Research Contributions Summary

Novel Contributions:

- **Comprehensive Controller Comparison**

- First systematic comparison of 7 SMC variants on DIP - 100 Monte Carlo runs per controller (statistical rigor)

- **PSO-Based Automatic Gain Tuning**

- Multi-objective cost function (settling time, energy, chattering) - Validated across 100 random seeds (MT-7)

- **Lyapunov Stability Proofs**

- Formal proofs for all 7 controllers (LT-4) - 1,000 lines of rigorous mathematical derivations

- **Robustness Validation**

- Disturbance rejection (MT-8): Impulse, step, sinusoidal - Model uncertainty (LT-6): ±10

- **Open-Source Framework**

- Production-grade Python codebase - 985 documentation files, complete learning paths

section0 Experimental Data Organization

Controller-Based Structure:

‘academic/paper/experiments/‘

- ‘classical_smc/‘ – Classical SMC experiments - ‘sta_smc/‘ – Super-Twisting experiments - ‘adaptive_smc/‘ – Adaptive SMC experiments - ‘hybrid_adaptive_sta/‘ – Hybrid controller experiments - ‘comparative/‘ – Cross-controller studies (MT-5, MT-7, MT-8, LT-6)

- ‘MT5_comprehensive_benchmark/‘ - ‘MT7_robust_pso/‘ - ‘MT8_disturbance_rejection/‘ - ‘LT6_model_uncertainty/‘

- ‘figures/‘ – 14 LT-7 paper figures - ‘reports/‘ – Task completion summaries

CSV: Time-series data (states, control, metrics)
*JSON:** Metadata, configuration, statistical summaries
*PDF/EPS:** Publication-ready figures

Resources

- **Repository:** `https://github.com/theSadeQ/dip-smc-pso.git`
- **Documentation:** See `docs/` directory
- **Getting Started:** `docs/guides/getting-started.md`

Educational podcast episode generated from comprehensive presentation materials