

2025-11-01

E008: Research Outputs and Publications

DIP-SMC-PSO Educational Series

January 25, 2026

Overview

This episode covers research outputs and publications from the DIP-SMC-PSO project.

Part: Part2 Infrastructure

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 \times 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