2025-11-01

E001: Project Overview and Introduction

DIP-SMC-PSO Educational Series

January 25, 2026

Overview

This episode covers project overview and introduction from the DIP-SMC-PSO project.

Part: Part1 Foundations
Duration: 15-20 minutes
Source: Comprehensive Presentation Materials

section0 Real-World Applications

Fundamental dynamics appear in numerous engineering systems

section0 Project Scope

Comprehensive Python Framework for:

- **Simulation** – High-fidelity nonlinear dynamics, multiple integrators - **Control** – Seven SMC variants (Classical, STA, Adaptive, Hybrid, Swing-up, MPC) - **Optimization** – PSO-based automatic gain tuning - **Analysis** – Performance metrics, statistical validation, Monte Carlo - **Visualization** – Real-time animations, publication-ready plots - **Testing** – 668 tests, 100 - **Documentation** – 985 files, 12,500+ lines, complete learning paths - **HIL Support** – Hardware-in-the-loop for physical experiments

Phase 5 COMPLETE – Research-ready, LT-7 paper SUBMISSION-READY

section0 Project Timeline

[Visual diagram - see PDF]

- Week 1 (8h): Benchmarks, chattering metrics, visualization - Weeks 2-4 (18h): Comprehensive benchmark, boundary layer optimization - Months 2-3 (46h): Lyapunov proofs, model uncertainty, research paper

section0 Key Achievements

- **Seven SMC Controllers** – Classical, STA, Adaptive, Hybrid, Swing-up, MPC + Factory - **Lyapunov Stability Analysis** – Formal proofs for all 7 controllers (1,000 lines) - **Comprehensive Benchmarks** – 100 Monte Carlo runs × 7 controllers - **Robust PSO Validation** – MT-7 bonus task, integrated in paper - **Model Uncertainty Analysis** – ±10 - **Submission-Ready Paper** – LT-7 v2.1, 14 figures, IEEE/IFAC format

- **Production-Grade Architecture** – Thread-safe, memory-bounded, validated - **Automated Recovery System** – 30-second context restoration after token limits - **Educational Materials** – Beginner roadmap (125-150 hrs), 44-episode podcast series - **Documentation Infrastructure** – 985 files, 11 navigation systems, Sphinx integration

section0 Repository & Open Source

https://github.com/theSadeQ/dip-smc-pso.git

Key Statistics:

- **Main branch deployment** strategy - **Automated state tracking** via Git hooks - **30-second recovery** after token limits/interruptions - **Multi-account support** for seamless collaboration

License & Attribution:

- **39 academic citations** for control theory - **30+ software dependencies** with proper attribution - **100 - Complete BibTeX database for publications

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