2025-11-01

E022: Key Statistics and Metrics

DIP-SMC-PSO Educational Series

January 25, 2026

Overview

This episode covers key statistics and metrics from the DIP-SMC-PSO project.

Part: Part4 Professional

Duration: 15-20 minutes

Source: Comprehensive Presentation Materials

section0 CA-02 Quality Audit Results

Comprehensive Codebase Quality Analysis:

Audit Scope:

- 50+ Python modules analyzed - Code quality, architecture, test coverage - Performance bottlenecks, memory leaks

Key Findings:

Category	**Score**	**Status**
Code quality	8.5/10	[OK]
Architecture	9/10	[OK]
Test coverage	N/A	(broken)
Documentation	9/10	[OK]
Performance	7.5/10	

- Weakref patterns for circular reference prevention - Explicit ‘cleanup()‘ methods for all controllers - Memory leak detection in long-running simulations

section0 Performance Benchmarks

Simulation Speed Benchmarks:

Configuration	**Time (s)**	**Speedup**	**Throughput**
Single sim (Python)	2.5	1×	1 sim/2.5s
Single sim (Numba)	0.8	3.1×	1 sim/0.8s
Batch 100 (vectorized)	12	20.8×	100 sim/12s
Monte Carlo 1000	95	26.3×	1000 sim/95s

PSO Optimization Speed:

- **30 particles × 50 generations:** 80 seconds (classical SMC) - **Parallelization:** 4 cores → 2.8× speedup - **Bottleneck:** Simulation time (85

Further speedup via GPU acceleration (CuPy) – planned for future work

section0 Thread Safety Validation

Multi-Threading Support:

Thread Safety Tests:

- 11/11 tests passing (100 - Concurrent controller instantiation - Parallel simulation execution - Shared configuration access

Thread-Safe Components:

- **Configuration Loader:**

- Immutable after loading - Thread-local copies for modification

- **Controller Factory:**

- Stateless instantiation - Independent controller instances

- **Dynamics Models:**

- Pure functions (no shared state) - Thread-safe NumPy operations

- **Logging:**

- Thread-safe logging handlers - Mutex-protected file writes

section0 Memory Leak Prevention

Long-Duration Simulation Test:

Test Scenario:

- 10,000 simulations sequentially - Monitor memory growth - Target: ¡10

Results:

- **Initial memory:** 85 MB - **Final memory:** 92 MB (+8.2 - **Peak memory:** 105 MB (during PSO) - **Verdict:** [OK] No significant leaks

Prevention Mechanisms:

- Explicit ‘cleanup()‘ calls after simulations - Bounded history buffers (FIFO) - Periodic ‘gc.collect()‘ in batch simulations - Weakref for callback references

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