



BoolMinGeo

Decay Analysis: 4D Minimization Beyond 10 Variables

9-16 Variable Boolean Functions

Total Tests: 54

Date: 2026-01-07

© *Stan's Technologies* 2025

EXPERIMENTAL SETUP & CONFIGURATION

STUDY INFORMATION

Study Type:	Decay Analysis (4D minimization beyond 10 vars)
Scope:	9-16 variable Boolean functions
Total Tests:	54
Date:	2026-01-07

SYSTEM CONFIGURATION

Platform:	Windows-11-10.0.26200-SP0
Processor:	Intel64 Family 6 Model 142 Stepping 12, GenuineIntel
Python:	3.12.10

SOFTWARE VERSIONS

NumPy:	2.3.4
SciPy:	1.16.3
Matplotlib:	3.10.7

EXPERIMENTAL PARAMETERS

Random Seed:	42
Variable Range:	11-13
Tests per Distribution:	3

TEST DISTRIBUTIONS

- Sparse: 20% ones, 5% don't-cares
- Dense: 70% ones, 5% don't-cares
- Balanced: 50% ones, 10% don't-cares
- Minimal DC: 45% ones, 2% don't-cares
- Heavy DC: 30% ones, 30% don't-cares
- Edge cases: all-zeros, all-ones, all-dc

METRICS COLLECTED

- Execution time (seconds)
- Memory consumption (MB)
- Peak memory usage (MB)
- Solution complexity (literal count, term count)
- Time per truth table entry (ms)
- Memory per truth table entry (KB)

METHODOLOGY

1. Random Boolean functions generated per distribution
2. BoolMinGeo minimization executed (SOP form)
3. Execution time measured using perf_counter
4. Memory tracked using tracemalloc + psutil
5. Results aggregated by variable count and distribution
6. Decay patterns analyzed across variable range

STUDY OBJECTIVE

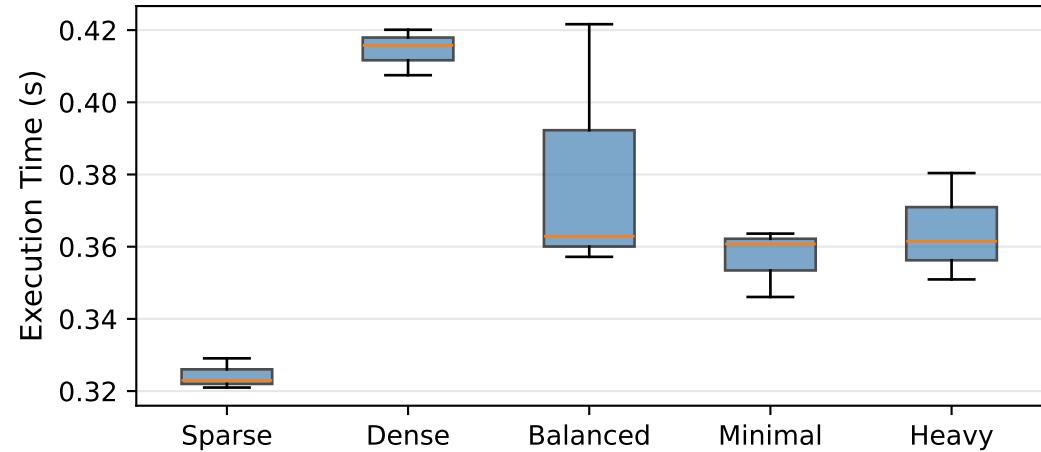
This study demonstrates performance decay in 4-dimensional minimization beyond 10 variables, where the geometric advantages of four-dimensional K-map visualization are eliminated. Results show degradation in time and memory efficiency.

REPRODUCIBILITY

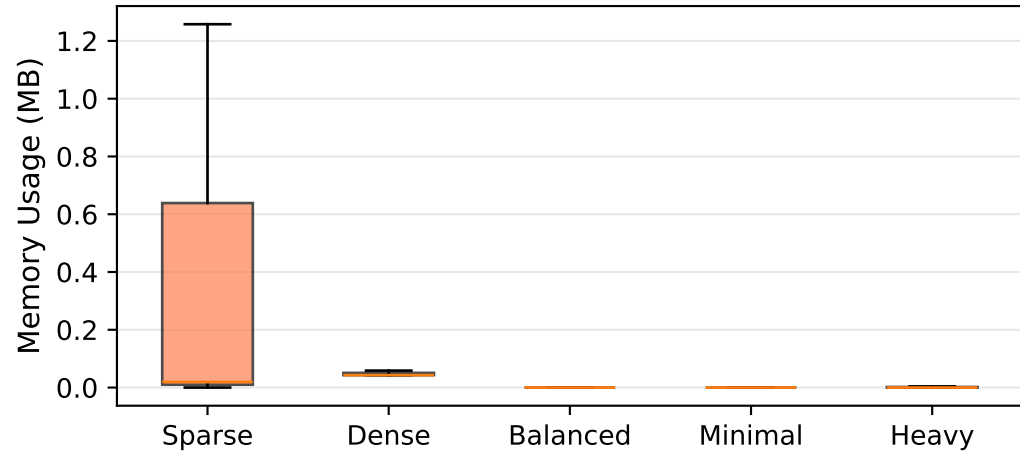
- To reproduce this experiment:
1. Set random seed: random.seed(42)
 2. Run with identical system configuration
 3. Use same library versions as documented above
 4. Execute: python benchmark_test4D_decay.py

11-Variable Analysis: Distribution Performance
Truth Table Size: $2^{11} = 2,048$ entries | Decay Study

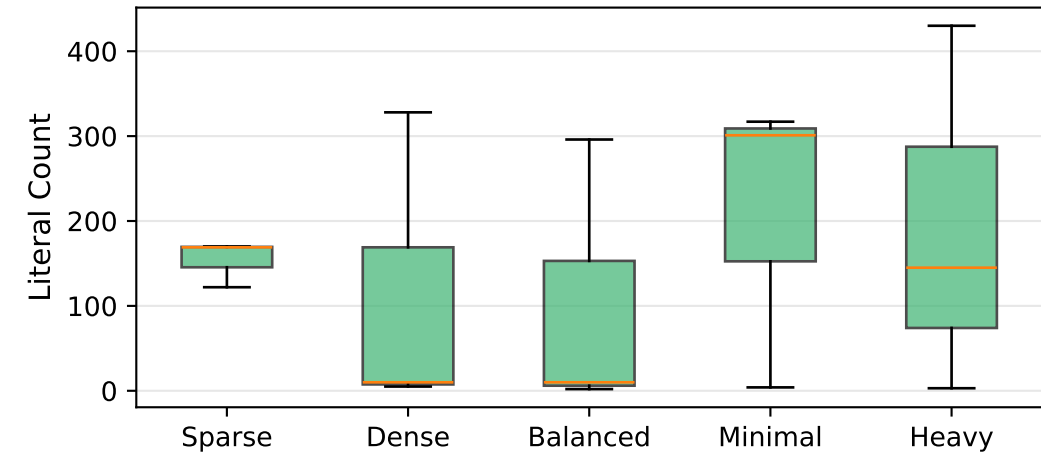
A) Time Distribution Comparison



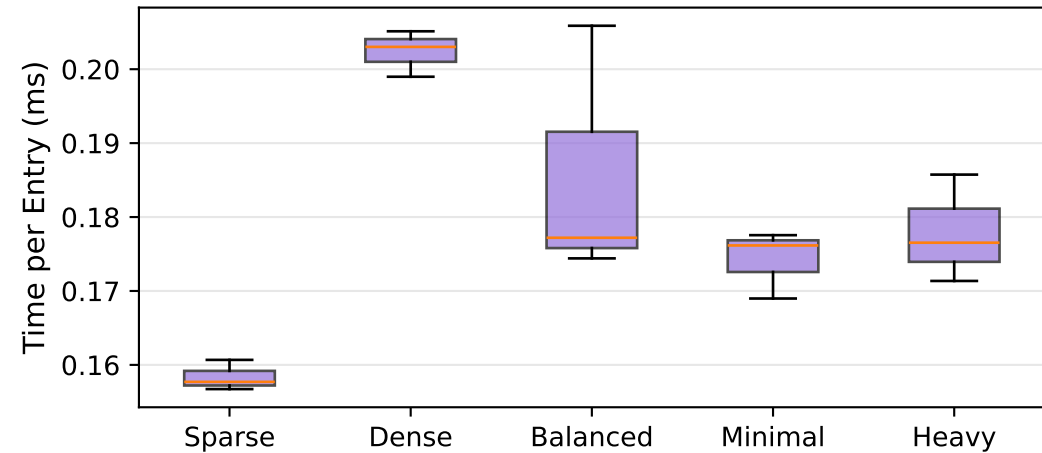
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

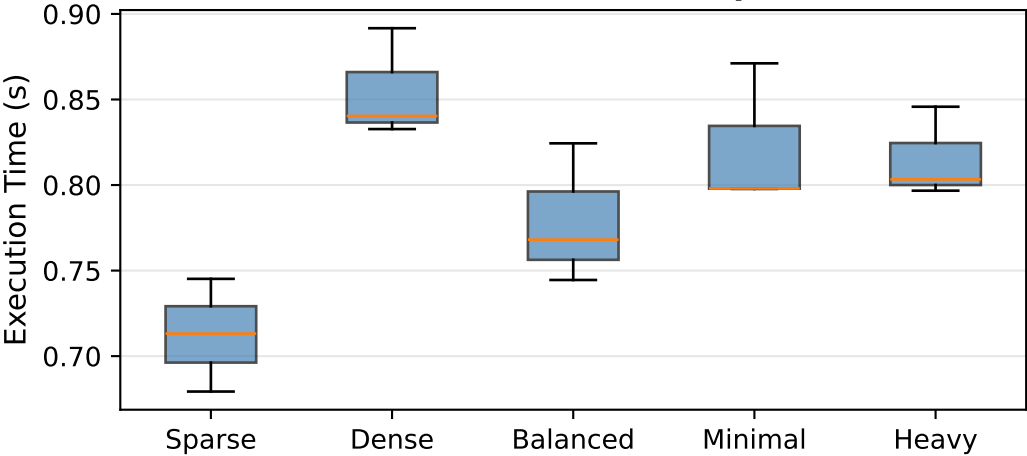


E) Statistical Summary

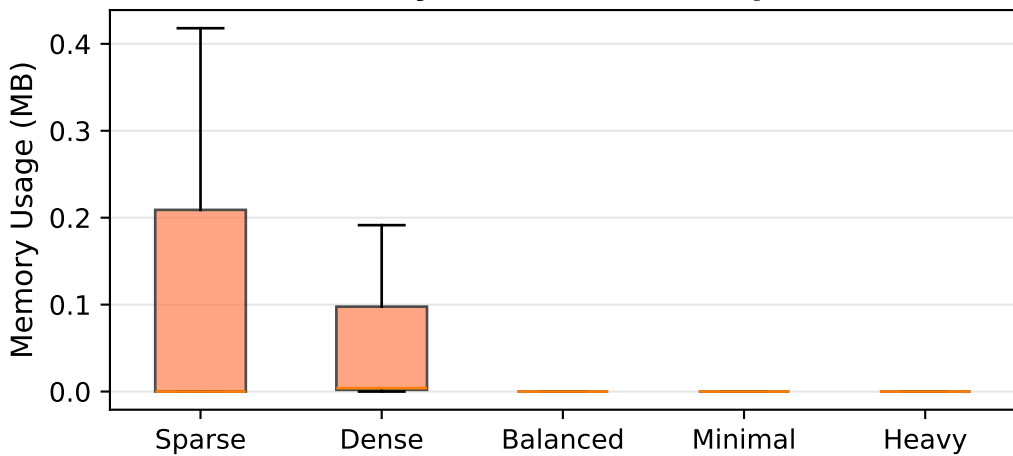
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.3243	0.0034	0.43	153.7	30.0
Dense (70% 1s)	3	0.4145	0.0052	0.05	114.3	27.7
Balanced (50% 1s)	3	0.3806	0.0291	0.00	102.7	22.0
Minimal DC (2%)	3	0.3568	0.0077	0.00	207.3	41.3
Heavy DC (30%)	3	0.3643	0.0122	0.00	192.7	34.7

12-Variable Analysis: Distribution Performance
Truth Table Size: $2^{12} = 4,096$ entries | Decay Study

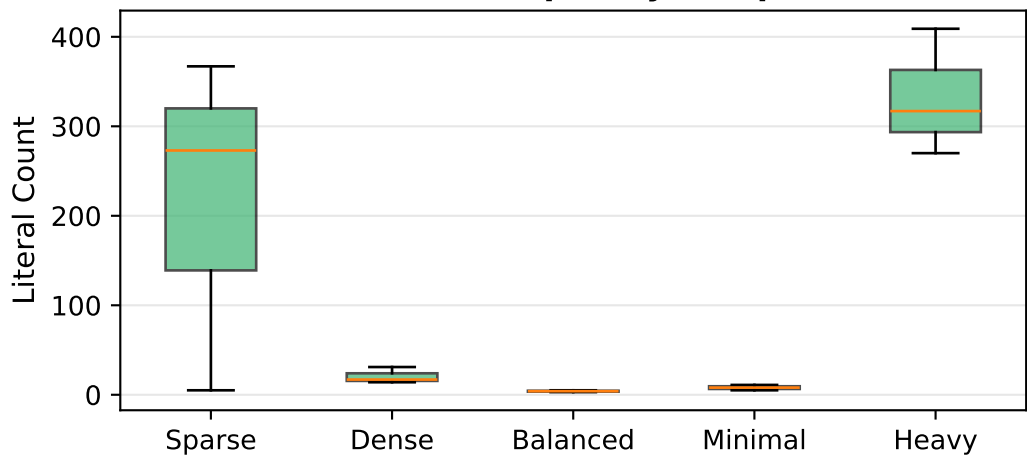
A) Time Distribution Comparison



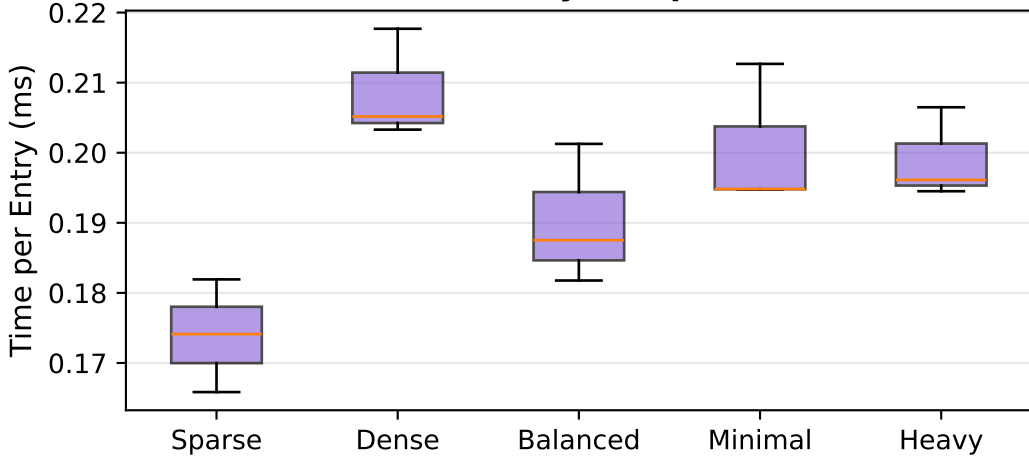
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

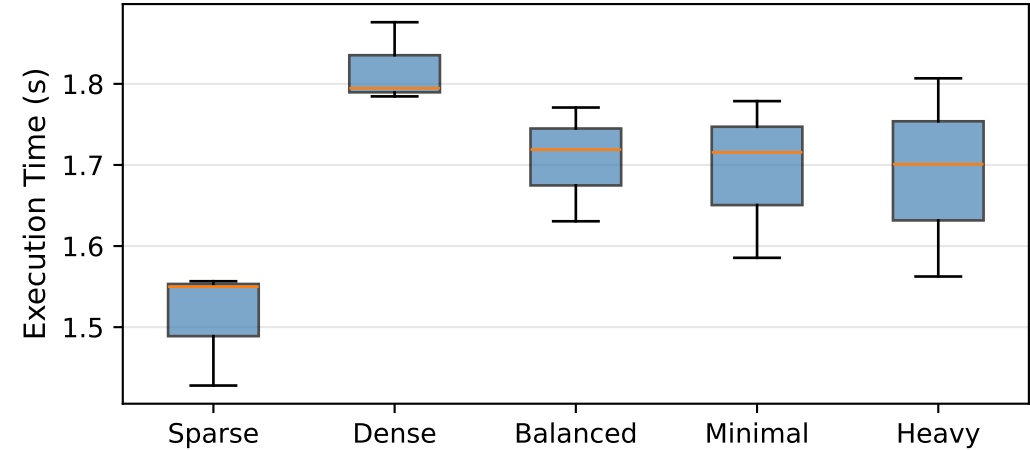


E) Statistical Summary

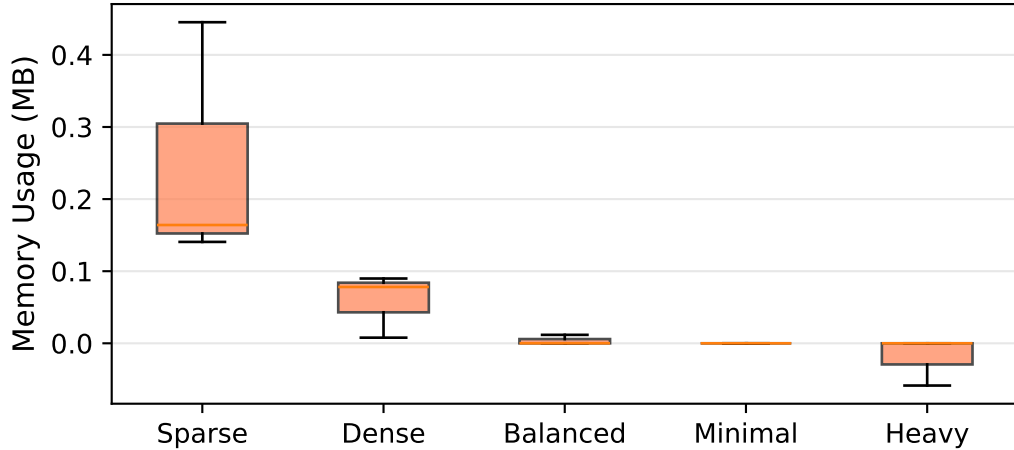
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.7125	0.0269	0.14	215.0	37.7
Dense (70% 1s)	3	0.8549	0.0262	0.07	20.7	4.7
Balanced (50% 1s)	3	0.7790	0.0335	0.00	4.0	1.0
Minimal DC (2%)	3	0.8223	0.0345	0.00	8.0	1.7
Heavy DC (30%)	3	0.8153	0.0217	0.00	332.0	62.3

13-Variable Analysis: Distribution Performance
Truth Table Size: $2^{13} = 8,192$ entries | Decay Study

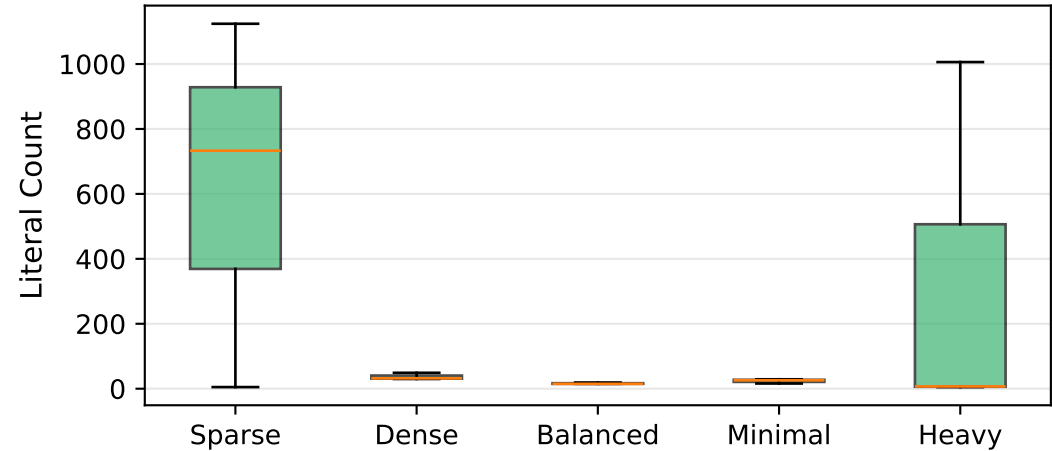
A) Time Distribution Comparison



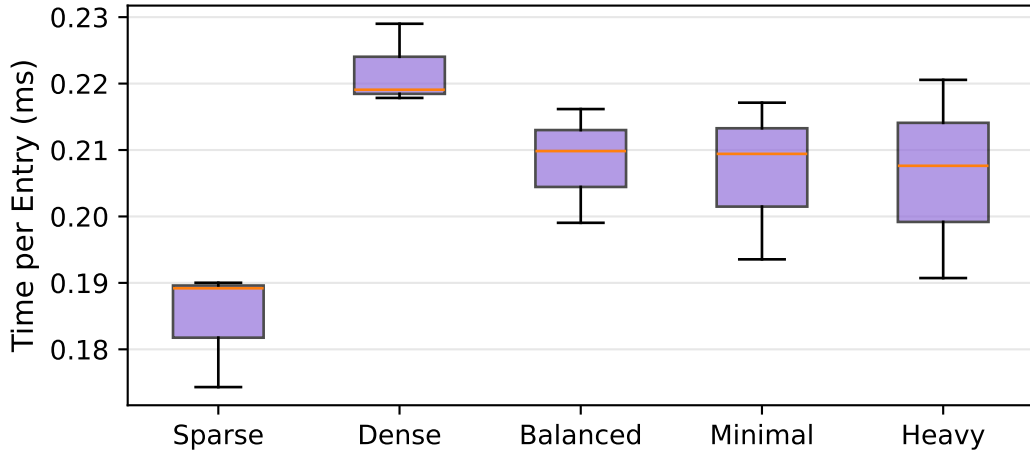
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison



E) Statistical Summary

Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	1.5115	0.0591	0.25	620.7	97.3
Dense (70% 1s)	3	1.8184	0.0409	0.06	37.0	7.3
Balanced (50% 1s)	3	1.7068	0.0579	0.00	16.3	3.3
Minimal DC (2%)	3	1.6933	0.0804	0.00	23.7	4.0
Heavy DC (30%)	3	1.6900	0.1001	-0.02	339.3	55.7