



BoolMinGeo

Decay Analysis: 3D Minimization Beyond 8 Variables

9-16 Variable Boolean Functions

Total Tests: 72

Date: 2026-01-07

EXPERIMENTAL SETUP & CONFIGURATION

STUDY INFORMATION

Study Type: Decay Analysis (3D minimization beyond 8 vars)
Scope: 9-16 variable Boolean functions
Total Tests: 72
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: 9-12
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 3-dimensional minimization beyond 8 variables, where the geometric advantages of three-dimensional K-map visualization are eliminated. Results show degradation in time and memory efficiency.

REPRODUCIBILITY

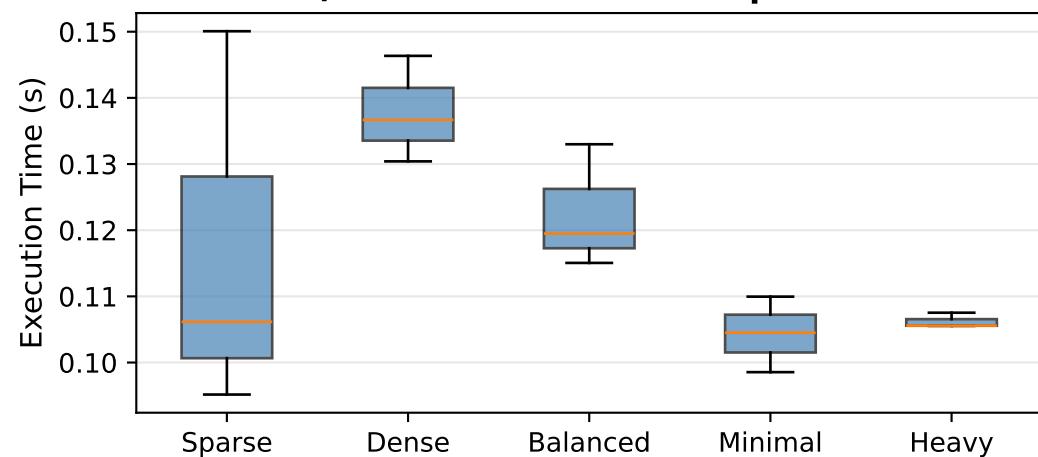
To reproduce this experiment:

1. Set random seed: `random.seed(42)`
2. Run with identical system configuration
3. Use same library versions as documented above
4. Execute: `python test_kmapsolver3d_9to16var_performance.py`

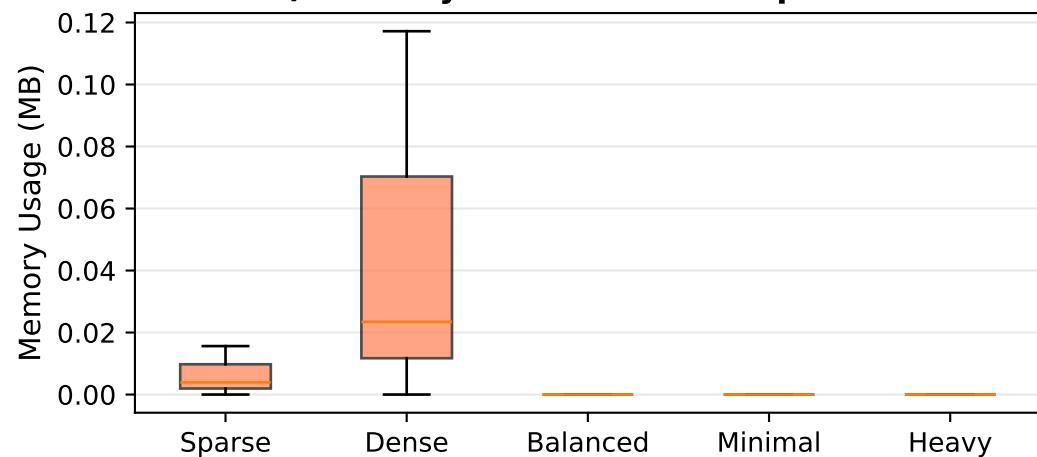
9-Variable Analysis: Distribution Performance

Truth Table Size: $2^9 = 512$ entries | Decay Study

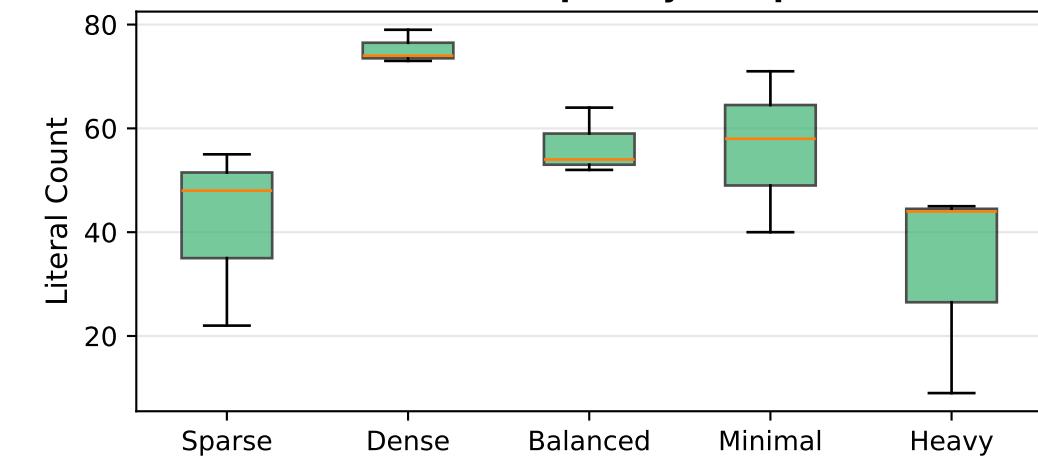
A) Time Distribution Comparison



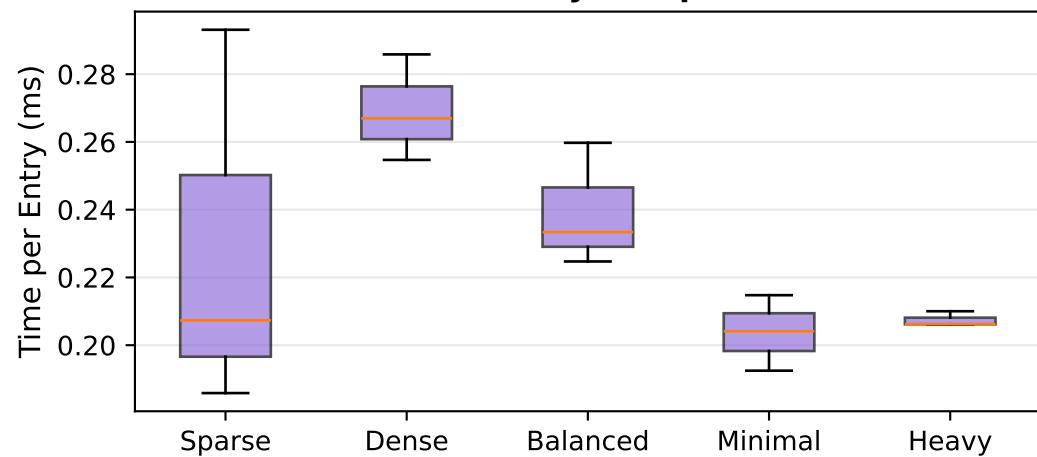
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison



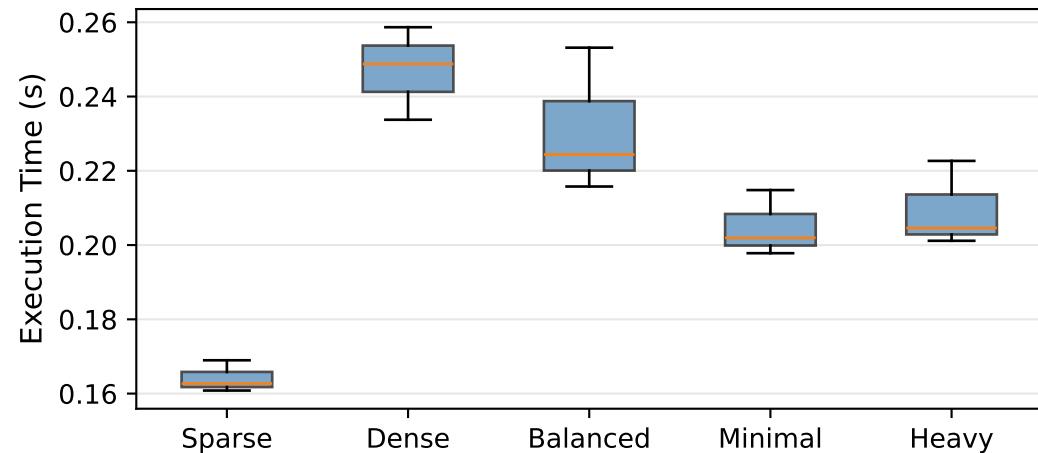
E) Statistical Summary

Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.1171	0.0237	0.01	41.7	9.3
Dense (70% 1s)	3	0.1378	0.0066	0.05	75.3	22.7
Balanced (50% 1s)	3	0.1225	0.0076	0.00	56.7	14.0
Minimal DC (2%)	3	0.1043	0.0047	0.00	56.3	15.7
Heavy DC (30%)	3	0.1062	0.0009	0.00	32.7	8.3

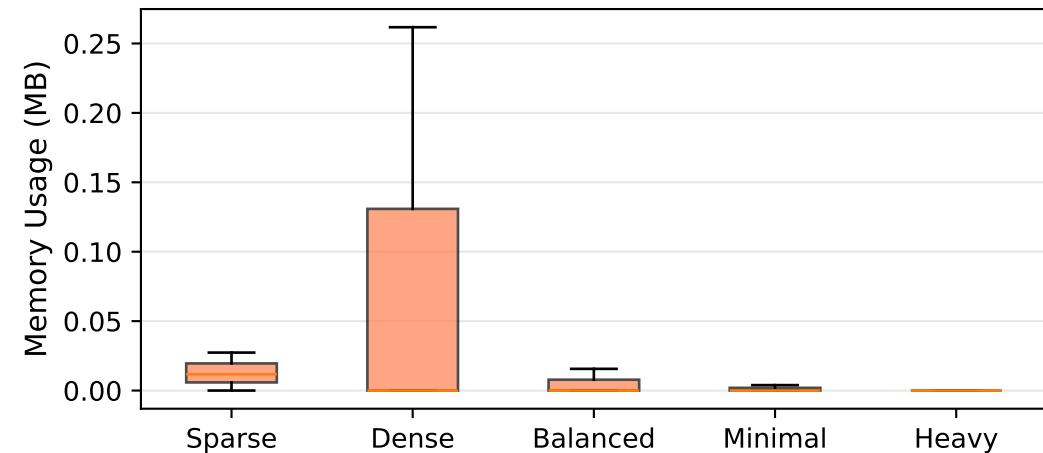
10-Variable Analysis: Distribution Performance

Truth Table Size: $2^{10} = 1,024$ entries | Decay Study

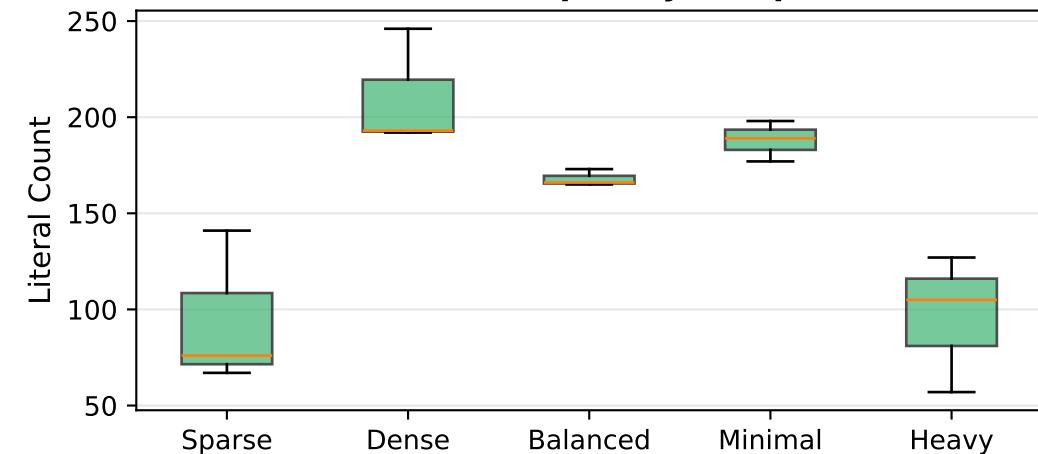
A) Time Distribution Comparison



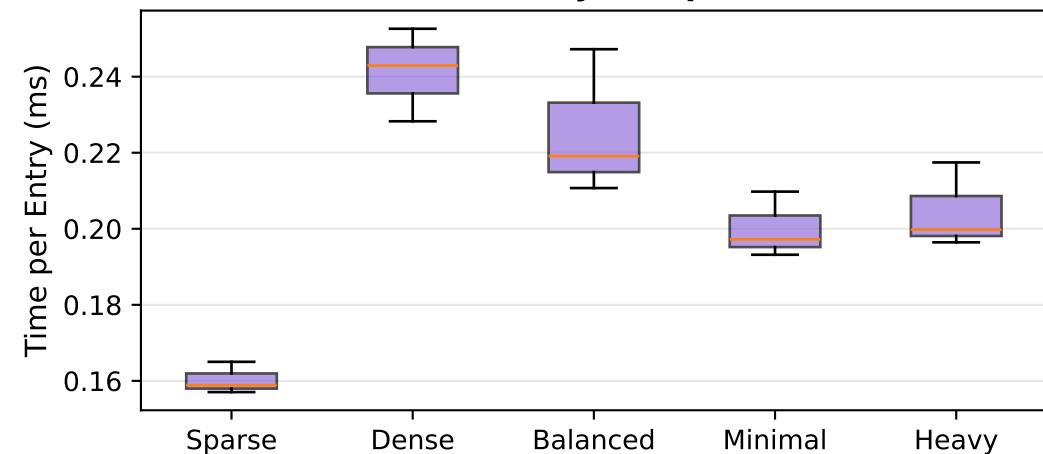
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

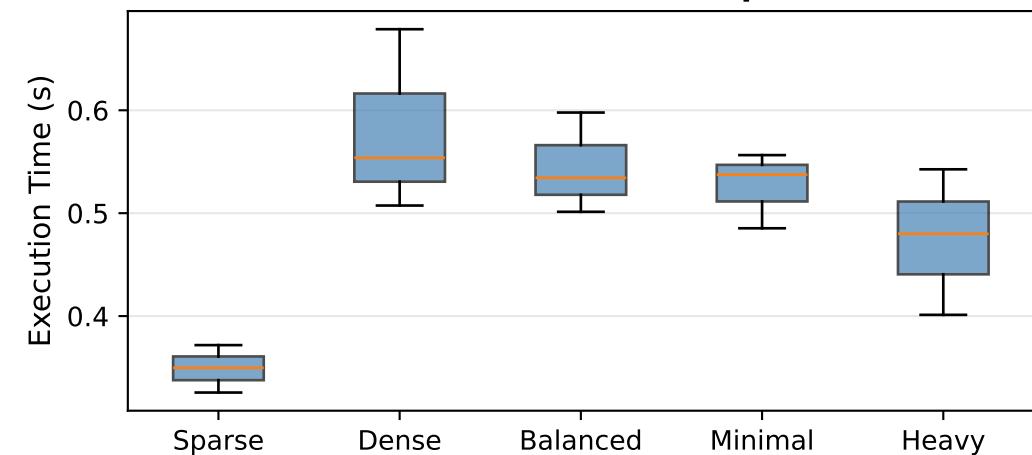


E) Statistical Summary

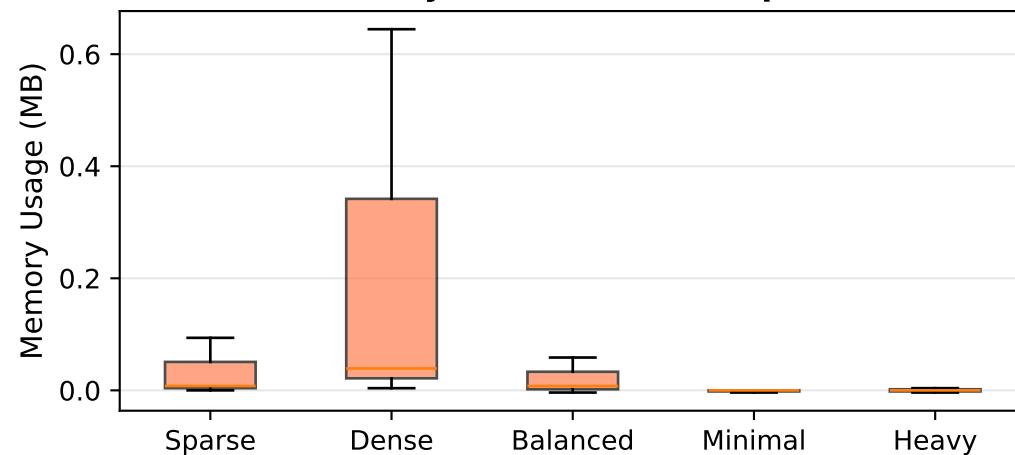
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.1642	0.0035	0.01	94.7	20.3
Dense (70% 1s)	3	0.2471	0.0102	0.09	210.3	53.7
Balanced (50% 1s)	3	0.2311	0.0160	0.01	168.0	38.7
Minimal DC (2%)	3	0.2049	0.0072	0.00	188.0	41.7
Heavy DC (30%)	3	0.2095	0.0094	0.00	96.3	23.3

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

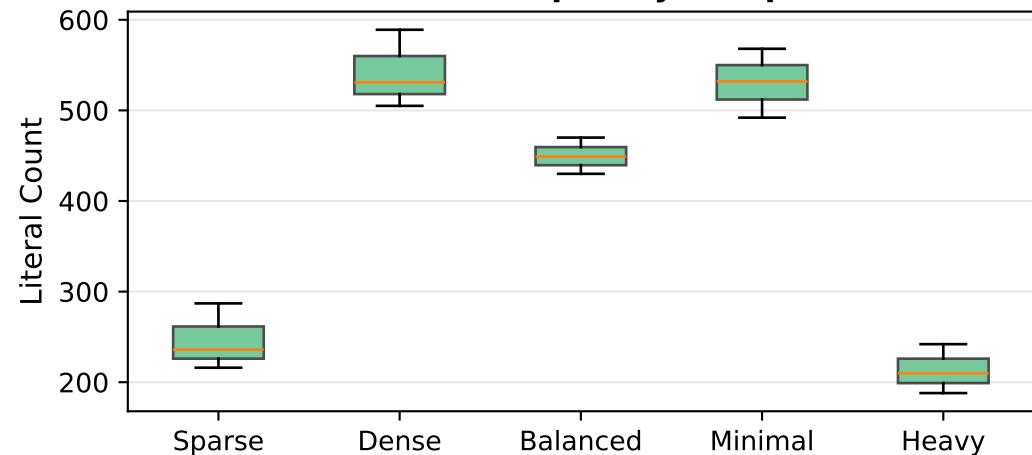
A) Time Distribution Comparison



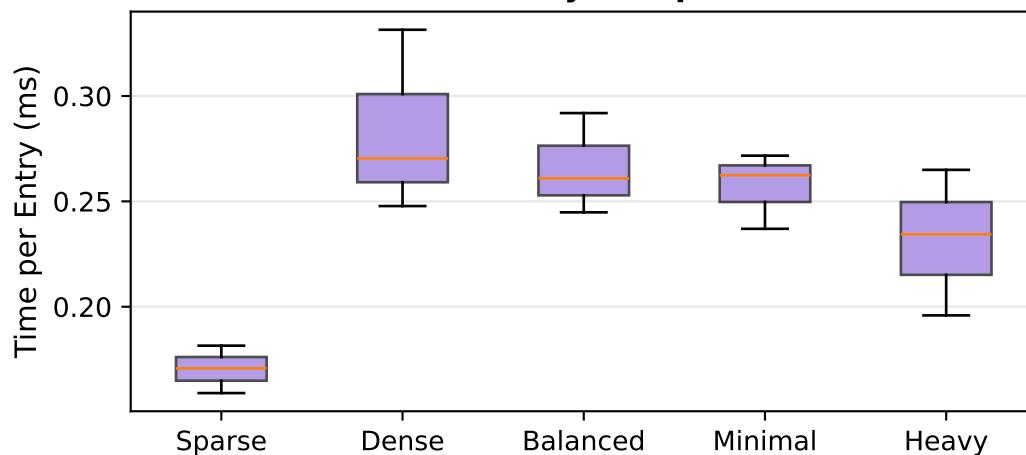
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison



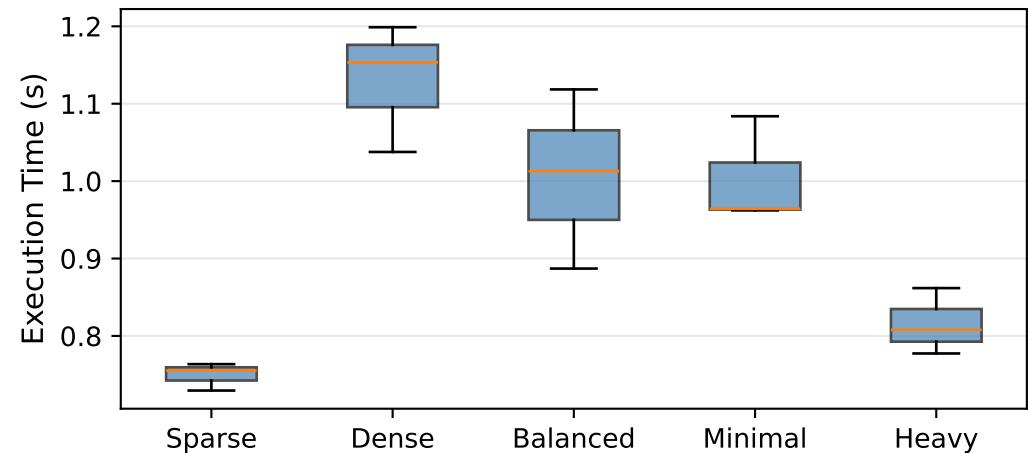
E) Statistical Summary

Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.3491	0.0188	0.03	246.3	44.7
Dense (70% 1s)	3	0.5800	0.0724	0.23	541.7	118.0
Balanced (50% 1s)	3	0.5445	0.0400	0.02	449.7	100.3
Minimal DC (2%)	3	0.5264	0.0301	-0.00	530.7	105.3
Heavy DC (30%)	3	0.4746	0.0579	0.00	213.3	45.7

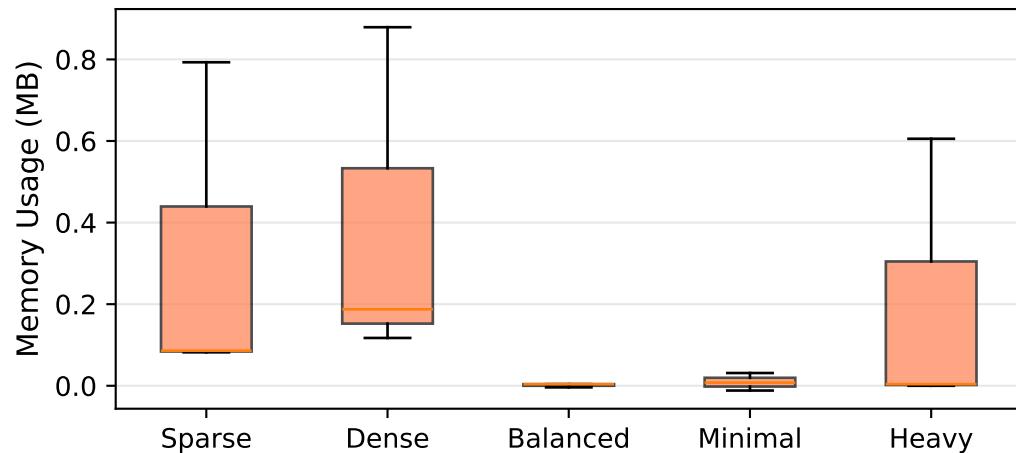
12-Variable Analysis: Distribution Performance

Truth Table Size: $2^{12} = 4,096$ entries | Decay Study

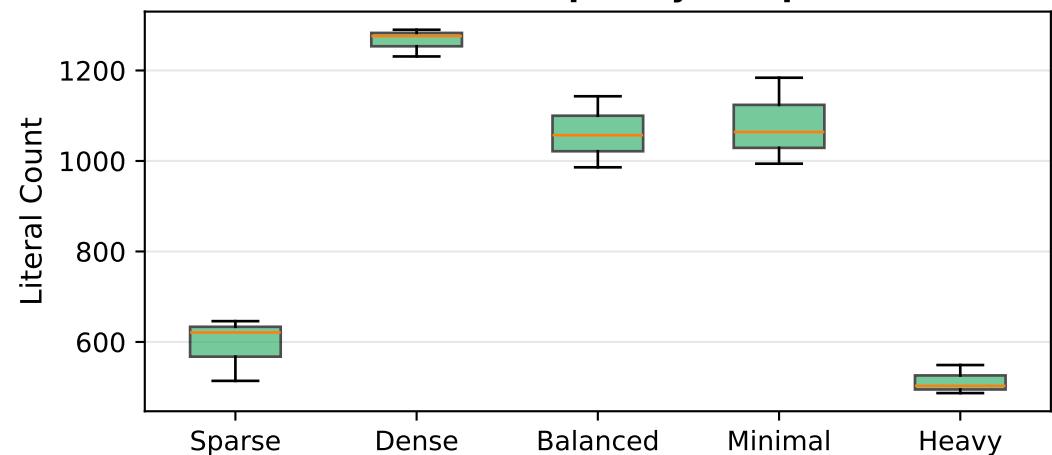
A) Time Distribution Comparison



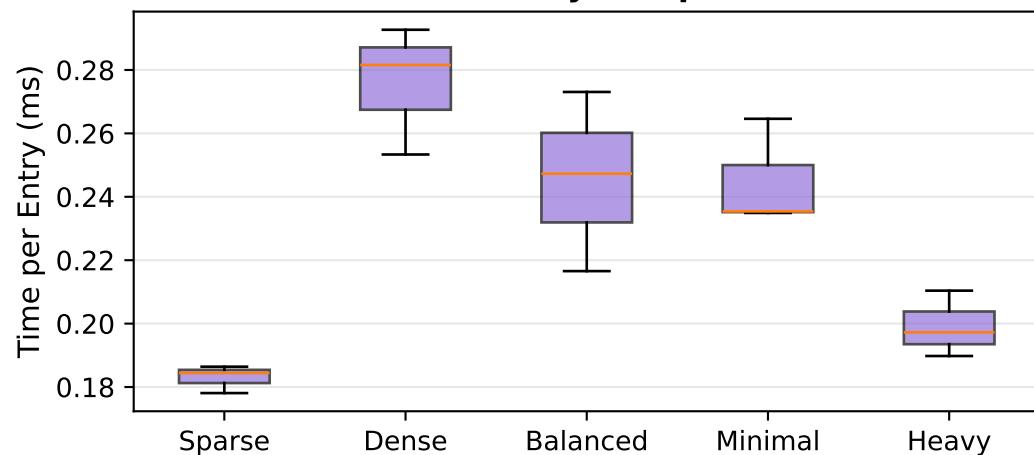
B) Memory Distribution Comparison



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	0.7495	0.0145	0.32	593.7	102.7
Dense (70% 1s)	3	1.1299	0.0678	0.39	1265.7	252.3
Balanced (50% 1s)	3	1.0061	0.0946	0.00	1062.0	204.0
Minimal DC (2%)	3	1.0034	0.0569	0.01	1080.7	199.0
Heavy DC (30%)	3	0.8157	0.0349	0.20	513.0	98.7