BoolMinGeo

Decay Analysis: 3D Minimization Beyond 8 Variables

9-16 Variable Boolean Functions

Total Tests: 72

Date: 2026-01-07

EXPERIMENTAL SETUP & CONFIGURATION
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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
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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

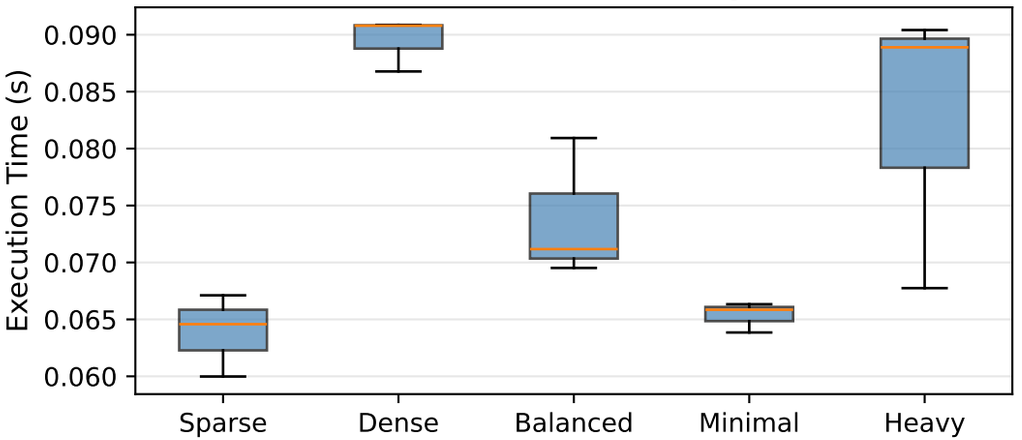
This study demonstrates performance decay in 3-dimensional
minimization beyond 8 variables, where the geometric advantages
of three-dimensional K-map visualization are eliminated.
Results show degradation in time and memory efficiency.

REPRODUCIBILITY

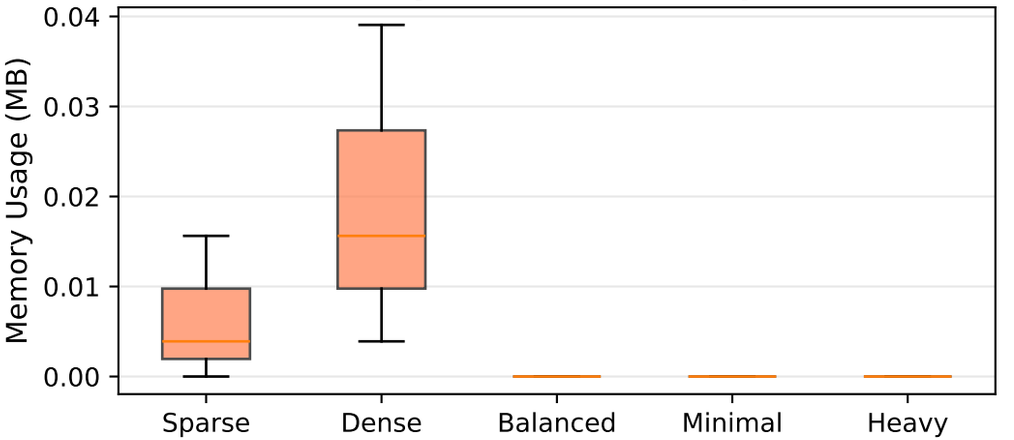
To reproduce this experiment:
  1. Set random seed: random.seed(42)
  2. Run with identical system configuration
  3. Use same library versions as documented above
  4. Execute: python test_kmapsolver3d_9to16var_performance.py

9-Variable Analysis: Distribution Performance
Truth Table Size: 2^9 = 512 entries | Decay Study

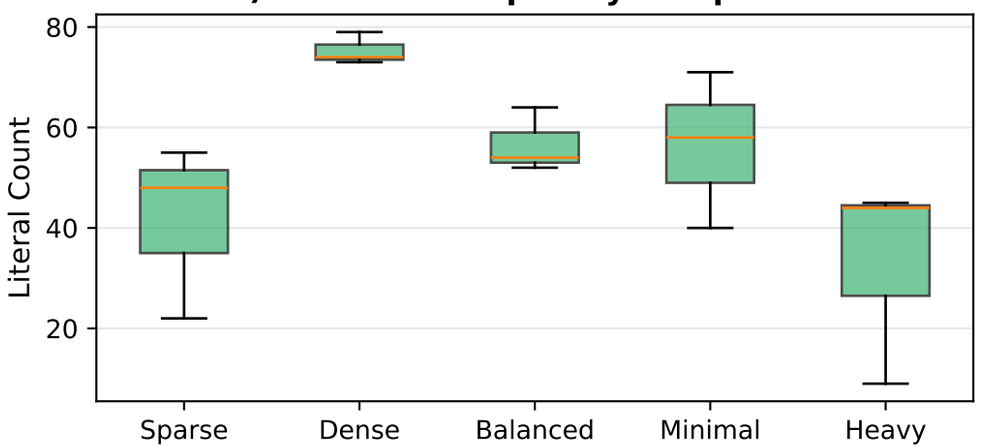
A) Time Distribution Comparison



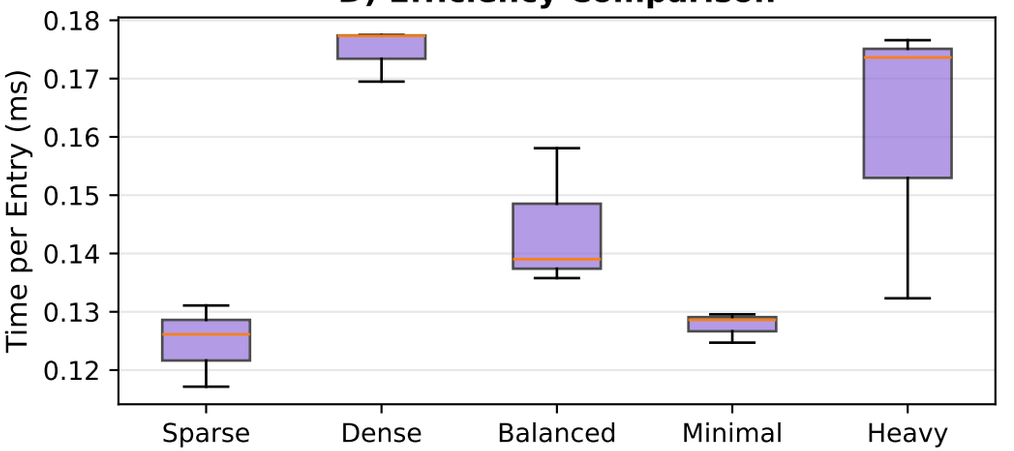
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

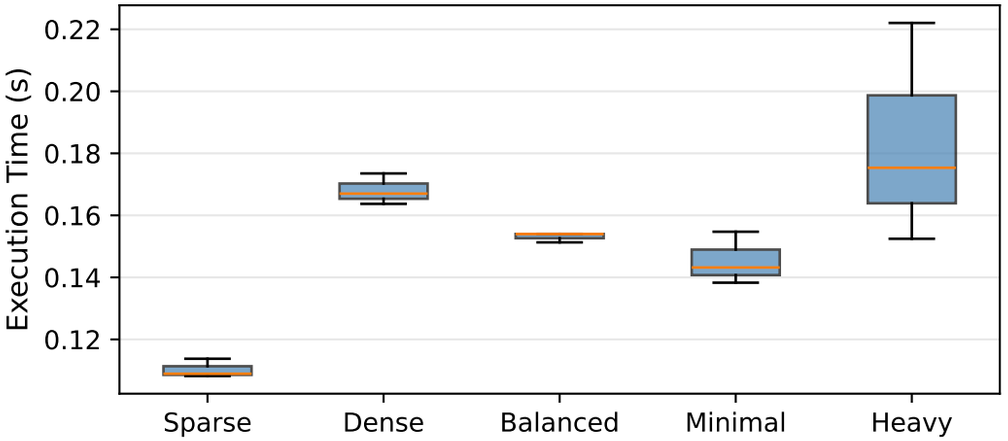


E) Statistical Summary

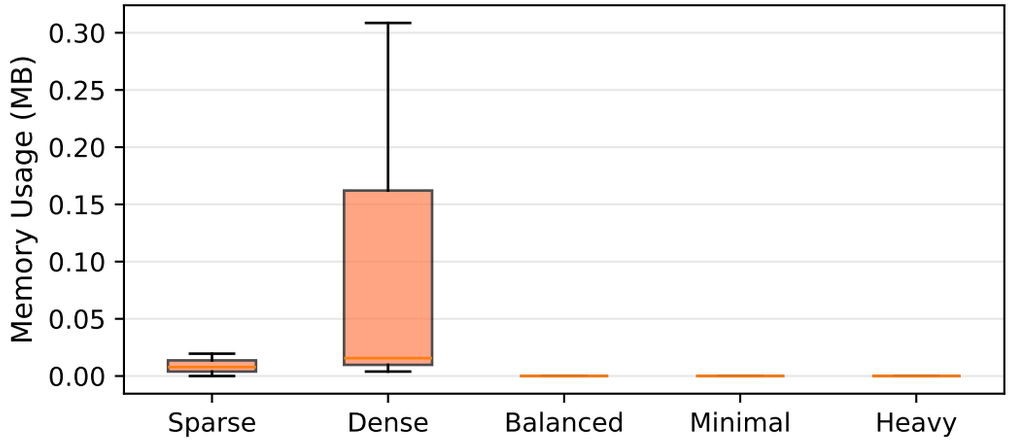
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.0639	0.0030	0.01	41.7	9.3
Dense (70% 1s)	3	0.0895	0.0019	0.02	75.3	22.7
Balanced (50% 1s)	3	0.0739	0.0050	0.00	56.7	14.0
Minimal DC (2%)	3	0.0653	0.0011	0.00	56.3	15.7
Heavy DC (30%)	3	0.0824	0.0103	0.00	32.7	8.3

10-Variable Analysis: Distribution Performance
Truth Table Size: 2^10 = 1,024 entries | Decay Study

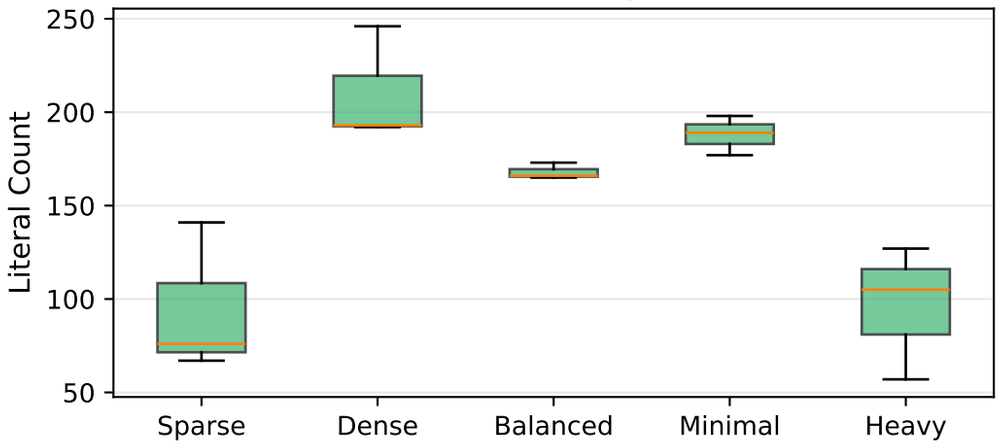
A) Time Distribution Comparison



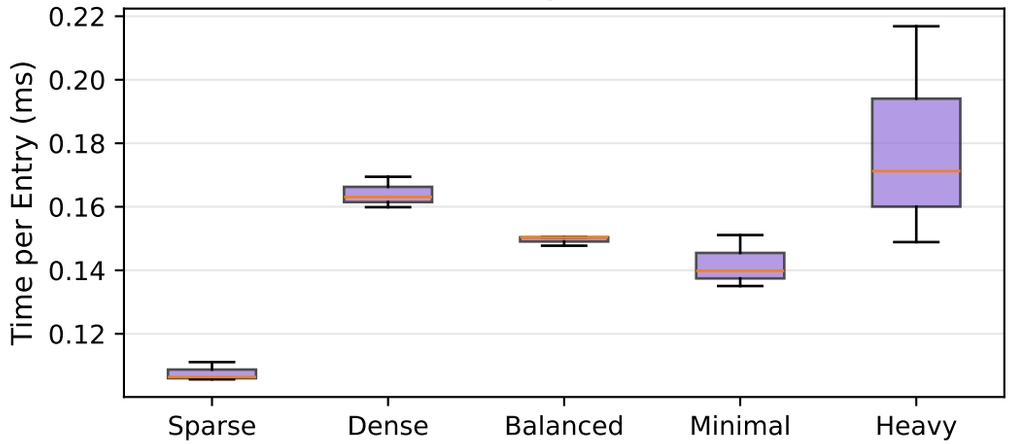
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

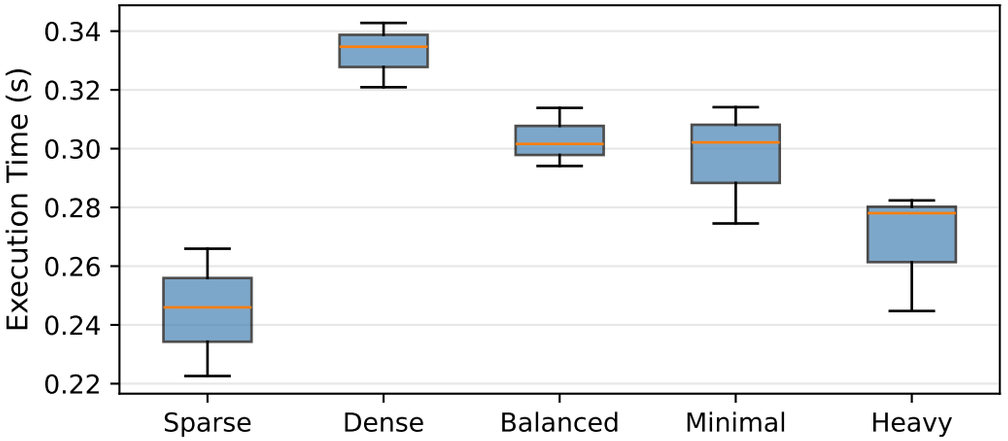


E) Statistical Summary

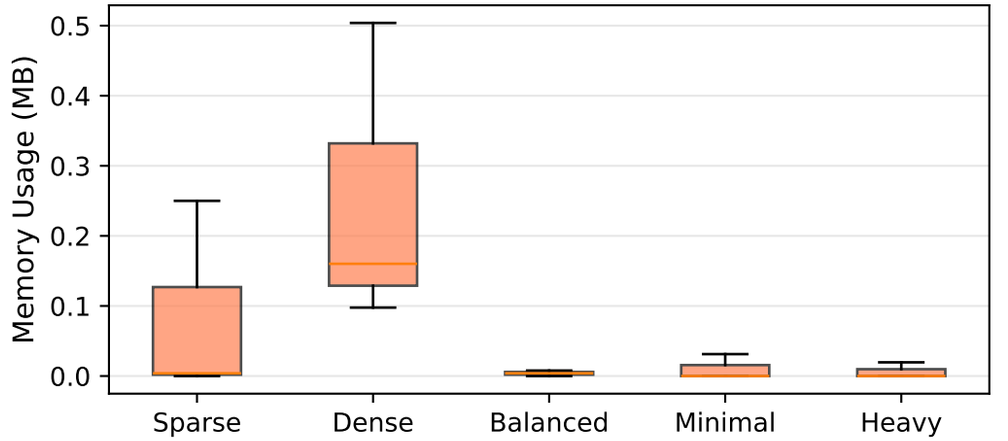
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.1103	0.0025	0.01	94.7	20.3
Dense (70% 1s)	3	0.1681	0.0041	0.11	210.3	53.7
Balanced (50% 1s)	3	0.1531	0.0013	0.00	168.0	38.7
Minimal DC (2%)	3	0.1454	0.0069	0.00	188.0	41.7
Heavy DC (30%)	3	0.1833	0.0290	0.00	96.3	23.3

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

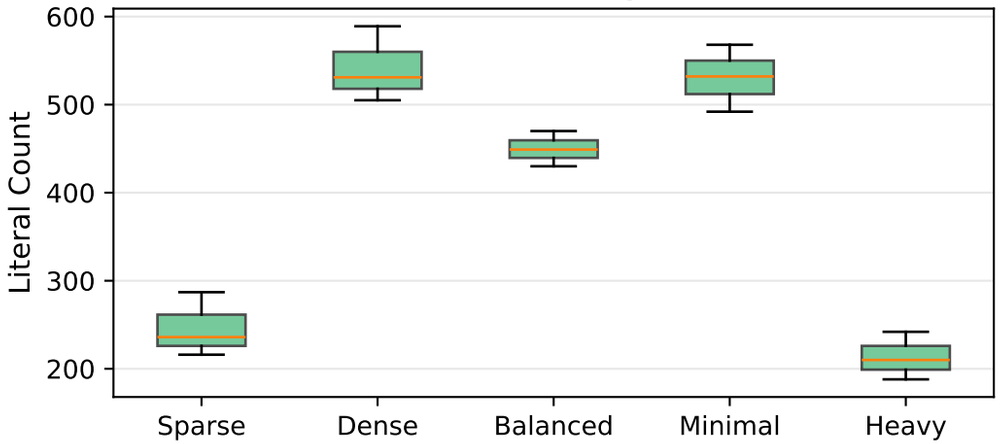
A) Time Distribution Comparison



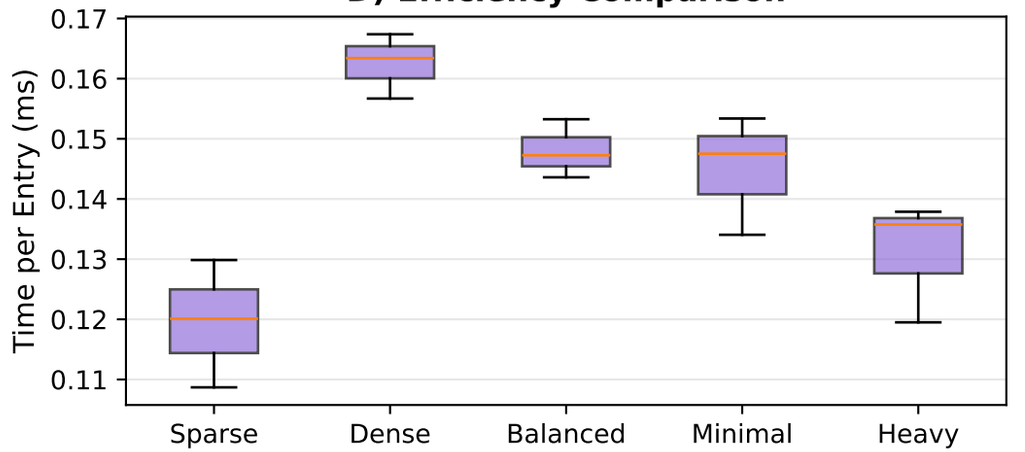
B) Memory Distribution Comparison



C) Solution Complexity Comparison



D) Efficiency Comparison

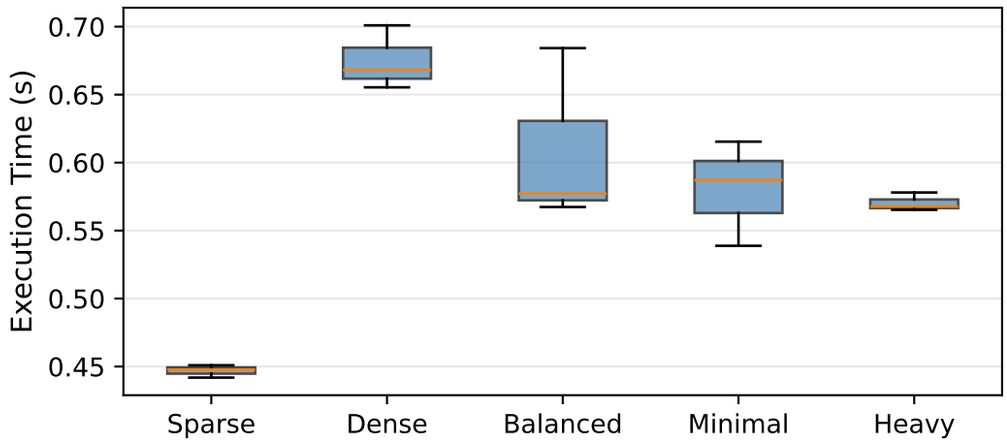


E) Statistical Summary

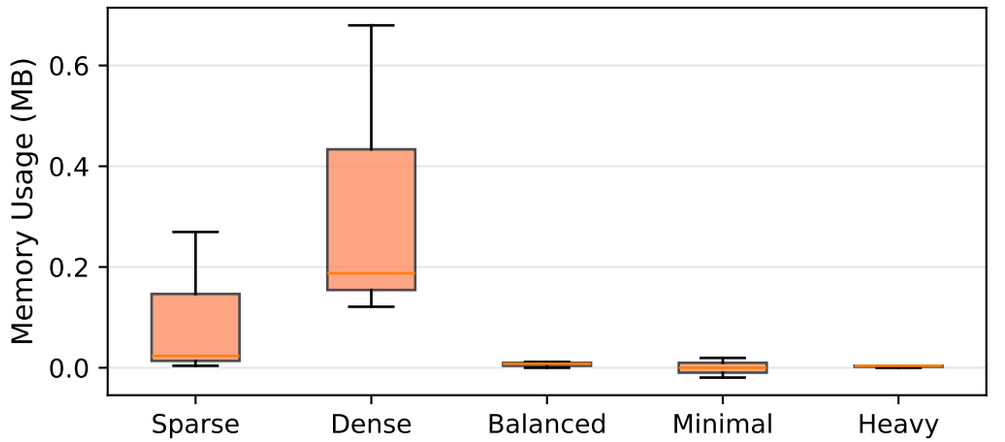
Distribution	N	Mean Time (s)	Std Time	Mean Mem (MB)	Mean Lits	Mean Terms
Sparse (20% 1s)	3	0.2448	0.0177	0.08	246.3	44.7
Dense (70% 1s)	3	0.3328	0.0090	0.25	541.7	118.0
Balanced (50% 1s)	3	0.3032	0.0081	0.00	449.7	100.3
Minimal DC (2%)	3	0.2969	0.0166	0.01	530.7	105.3
Heavy DC (30%)	3	0.2684	0.0168	0.01	213.3	45.7

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

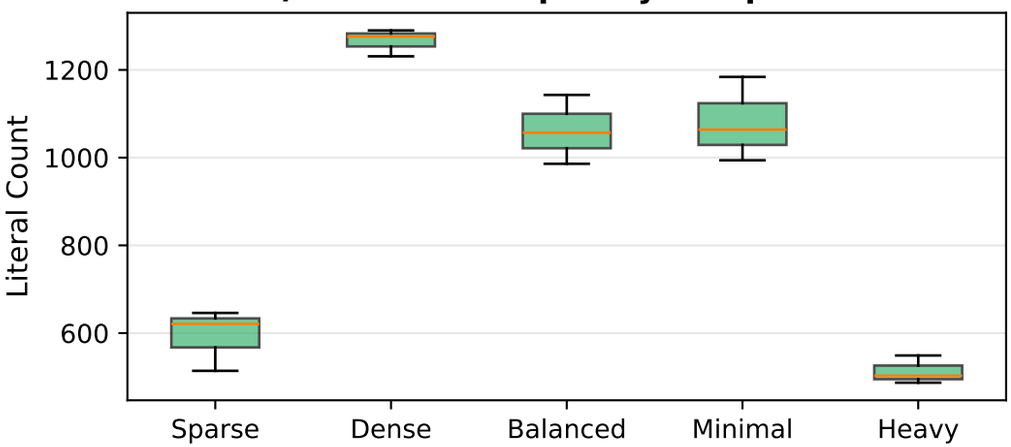
A) Time Distribution Comparison



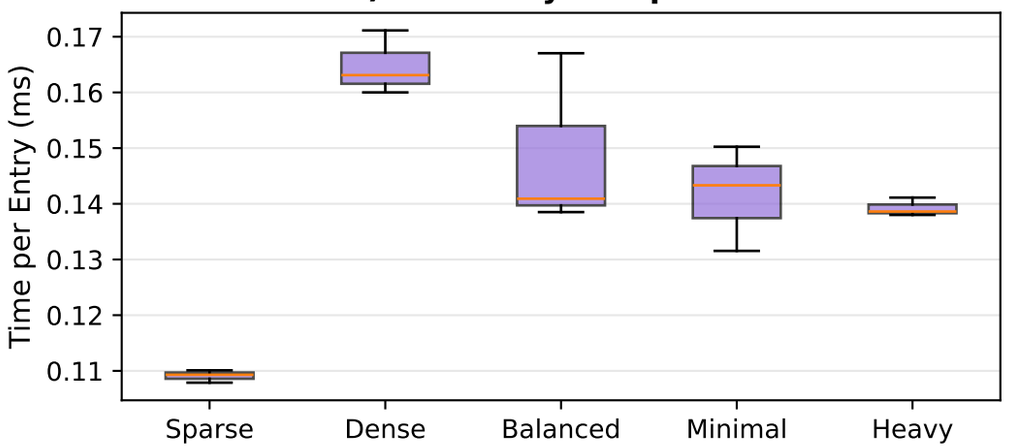
B) Memory Distribution Comparison



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	0.4468	0.0038	0.10	593.7	102.7
Dense (70% 1s)	3	0.6748	0.0192	0.33	1265.7	252.3
Balanced (50% 1s)	3	0.6096	0.0529	0.01	1062.0	204.0
Minimal DC (2%)	3	0.5804	0.0316	0.00	1080.7	199.0
Heavy DC (30%)	3	0.5703	0.0055	0.00	513.0	98.7