Experiment Report

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Table 1: Without Deadend Detection

Puzzle	size of the grid	number of free cells at the start	solution time	number of generated states	memory used (MB)
regular_5x5_01.txt	25	15	0.000	18	0.00
regular_6x6_01.txt	36	24	0.000	283	0.08
regular_7x7_01.txt	49	37	0.001	3317	0.89
regular_8x8_01.txt	64	52	0.143	409726	109.41
regular_9x9_01.txt	81	63	0.209	587332	156.83
jumbo_10x10_01.txt	100	76	0.116	34898	93.19

Table 2 : With Deadend Detection

Puzzle	size of the grid	number of free cells at the start	solution time	number of generated states	memory used (MB)
regular_5x5_01.txt	25	15	0.000	16	0.00
regular_6x6_01.txt	36	24	0.000	85	0.02
regular_7x7_01.txt	49	37	0.000	192	0.05
regular_8x8_01.txt	64	52	0.001	916	0.24
regular_9x9_01.txt	81	63	0.002	2575	0.69
jumbo_10x10_01.txt	100	76	0.006	6432	1.72
jumbo_11x11_01.txt	121	97	0.535	449663	120.07
jumbo_12x12_30.txt	144	116	4.598	3834792	1024.00

Table 3 : Direct comparison

Puzzle	size of the grid	number of free cells at the start	NoDeadend			Deadend		
			solution time	number of generated states	memory used (MB)	solution time	number of generated states	memory used (MB)
regular_5x5_01.txt	25	15	0.000	18	0.00	0.000	16	0.00
regular_6x6_01.txt	36	24	0.000	283	0.08	0.000	85	0.02
regular_7x7_01.txt	49	37	0.001	3,317	0.89	0.000	192	0.05
regular_8x8_01.txt	64	52	0.143	409,726	109.41	0.001	916	0.24
regular_9x9_01.txt	81	63	0.209	587,332	156.83	0.002	2,575	0.69
jumbo_10x10_01.txt	100	76	0.116	348,980	93.19	0.006	6,432	1.72
jumbo_11x11_01.txt	121	97	Killed	Killed	Killed	0.535	449,663	120.07
jumbo_12x12_30.txt	144	116	Killed	Killed	Killed	4.598	3,834,792	1024.00

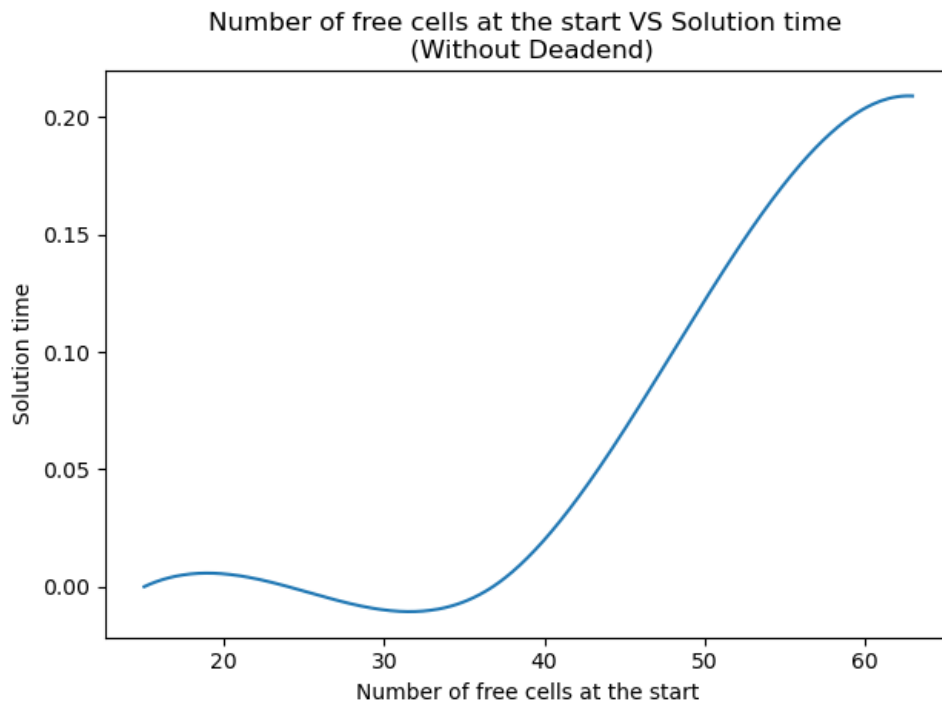Figure 1. **Plot Figure: Time Complexity - Without Deadend Detection**

Figure 2. **Plot Figure: Time Complexity - With Deadend Detection**

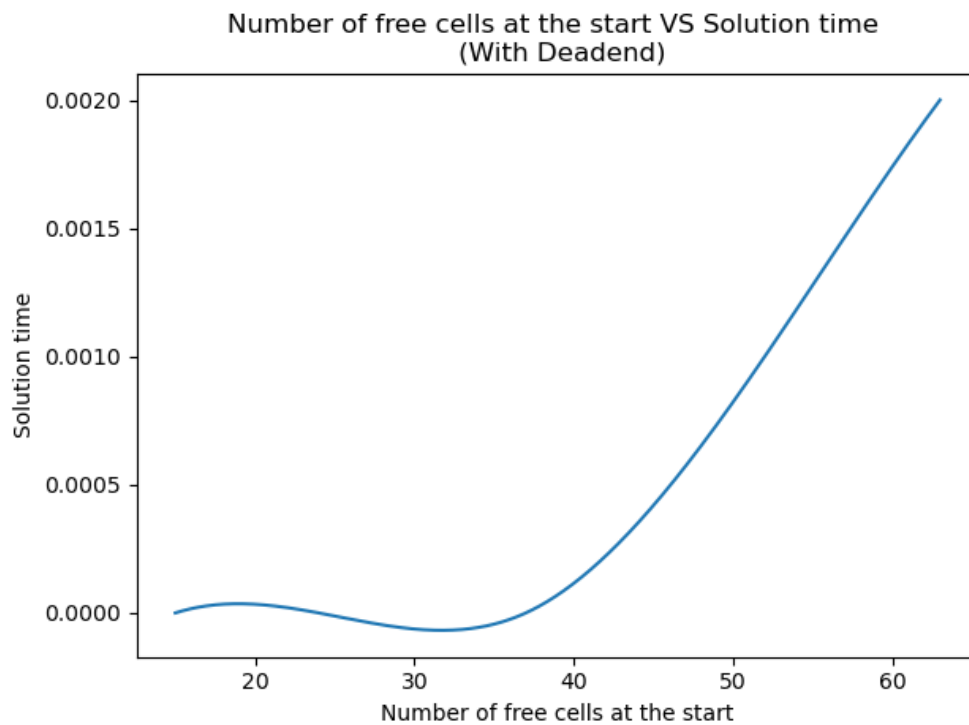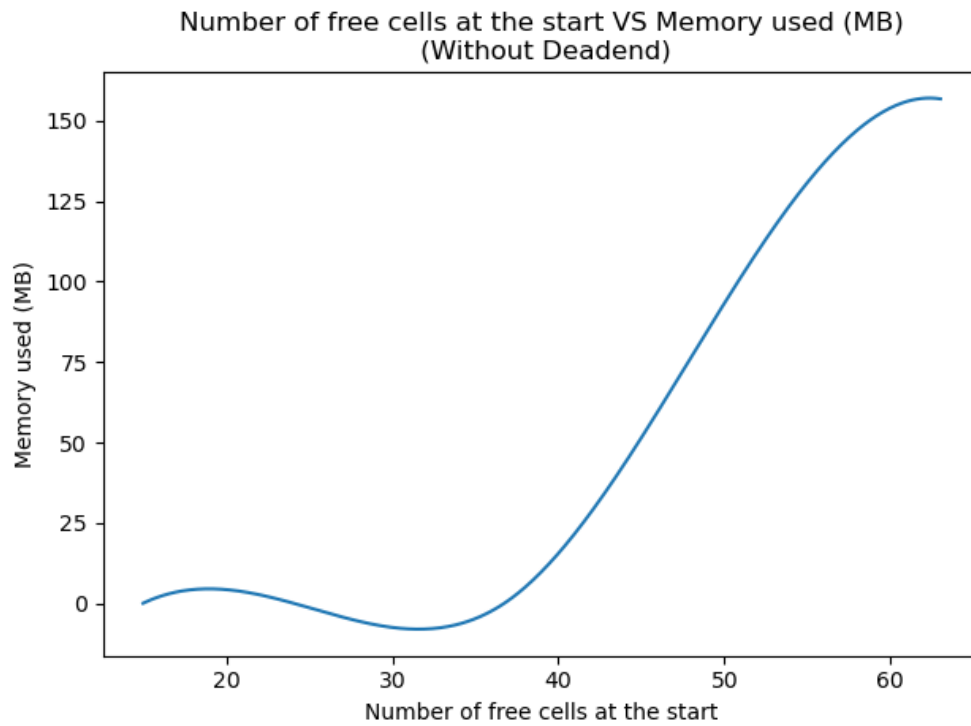Figure 3. **Plot Figure: Space Complexity - Without Deadend Detection**

Number of free cells at the start VS Memory used (MB)
(Without Deadend)

Figure 4. **Plot Figure: Space Complexity - With Deadend Detection**

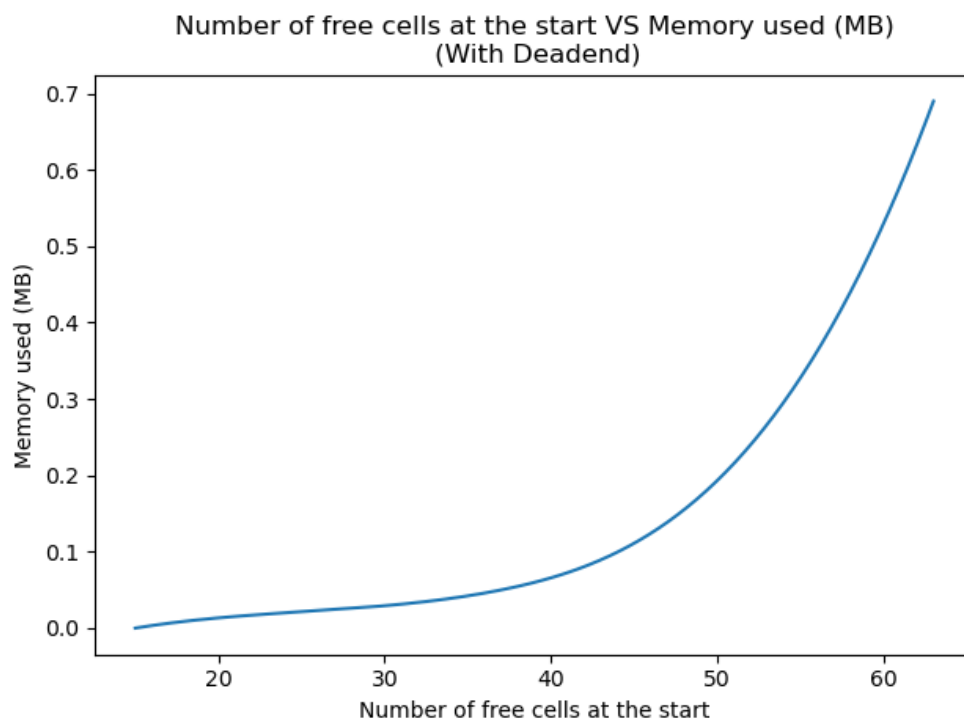Number of free cells at the start VS Memory used (MB)
(With Deadend)

Figure 5. **Plot Figure: Time Complexity - Comparison**
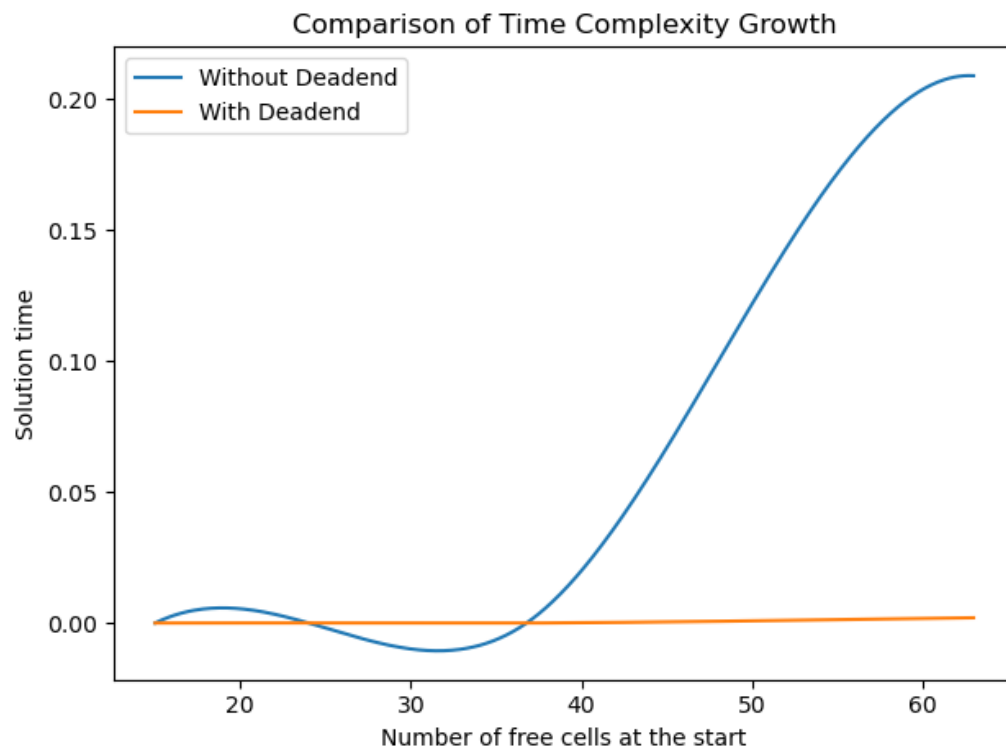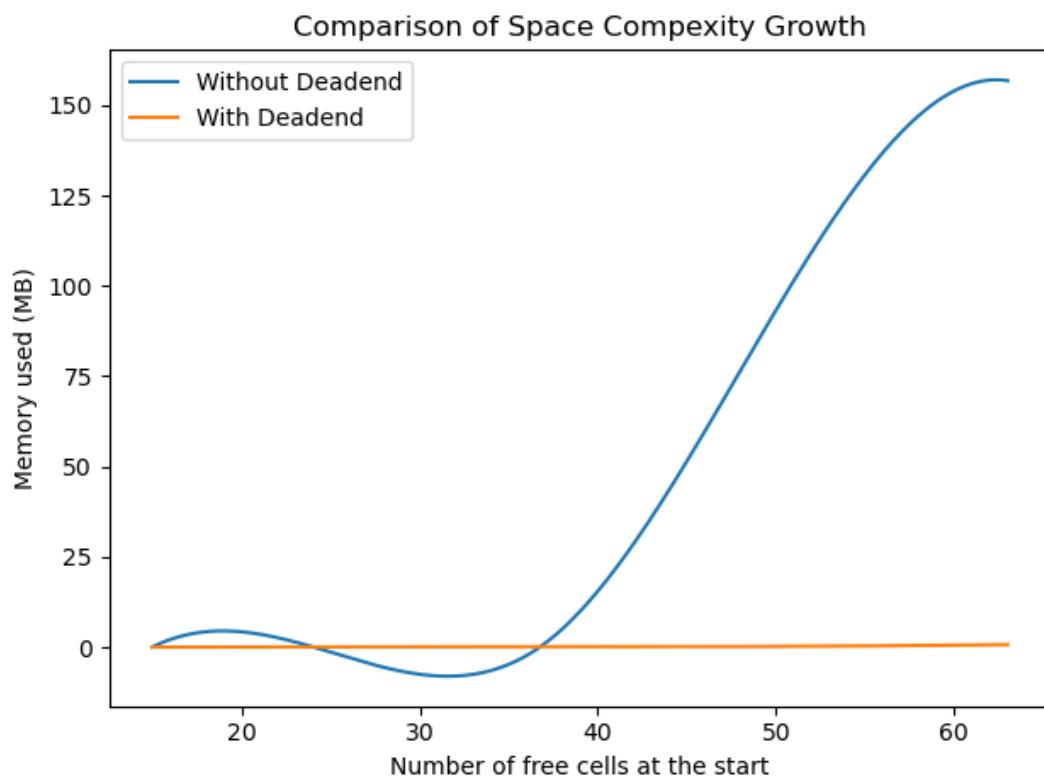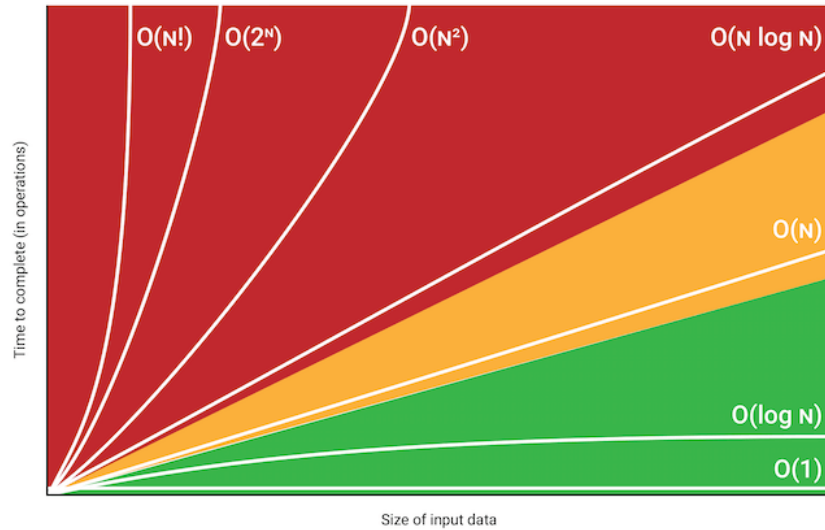

Figure 6. **Plot Figure: Space Complexity - Comparison**

Analysis

Complexity Analysis

According to Figure 1, considering the number of generated states is much smaller with the smaller puzzle, the smoothed curve graph might not be very accurate.

However, according to Figure 1, considering the range starting from 30 to 60 and scale problem, it is shown that the growth rate of search without dead-end is between $O(n^3)$ to $O(2^n)$.

If calculated briefly, the approximate complexity of growth rate is around $O(n^{3.3})$

Dead-end Comparison

The benefit of dead-end detection is reducing possible states to explore , therefore reducing the number of nodes generated and the time to find a solution. Hence, both time and space complexity are improved, which is also observed in Figure 5 and Figure 6.

However, dead-end detection does introduce extra operations in checking dead-ends cells. Yet, according to Table 3, the additional operations by dead-end detection do not offset the significant reduction in memory used.

From Table 3, it can also be seen that as the number of nodes generated and time to find a solution is reduced, the solver is able to solve more puzzles with the same number of nodes as compared to the solver without dead-end detection.