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CIS*3700
2025/02/08

CIS*3700 Assignment #2 Report

Report Overview:

The motive of this report is to analyze the performance of different search algorithms, particularly, Brute Force, Breadth-First Search, and Best-First Search using two different heuristics. The focus will be on evaluating the admissibility of the heuristics, comparing their effectiveness, in guiding the search towards an optimal solution, and further assessing the efficiency of each approach based on the number of states explored and the solution depth. The results aim to highlight how each heuristic choice impacts search space exploration and solution equality, providing insights into the trade-offs between exhaustive and informed search strategies.

Convincing Argument #1 - Each heuristic is admissible

(a) **Block Heuristic (Best-First with Blocking Heuristic)**

- **Observation from output:**
  Moves: 16
  States visited: 999

The Actual Argument:

- The heuristic estimates the cost by counting the number of blocking pieces in the path of the target piece. As each blocking piece represents at least one move that must be made, this heuristic reflects the minimum required moves to unblock the path. Now, onto the real question, why is it admissible? It may suggest that the total number of moves (as moving a block may require multiple steps or create new obstacles), but it will never be overestimated due to the fact that every blocking piece must sometimes be dealt with. All in all, this suggests that it is definitely admissible.

Contd. Heuristic #2

(b) Distance Heuristic (Best-First with Distance Heuristic)

- **Observation from output:**
  Moves: 16
  States visited: 893

The Actual Argument:

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- This second heuristic measures the straight-line distance from the target piece to its destination. It further assumes that there are no obstacles, giving us a lower-bound estimate of the moves required. Now moving onto to why it is actually admissible, then that is because since the heuristic ignores obstacles, the actual moves will always be equal to or greater than the heuristic's estimate. Which is why, it never overestimates the true cost and remains admissible.

A convincing argument that one of the heuristics gives consistently higher (or occasionally equally high) admissible estimates than the other.

Explanation:

Observation from the Output:

- Blocking Heuristic: Visited 999 states.
- Distance Heuristic: Visited 893 states.
- Both found solutions in 16 moves.

The Actual Argument:

- The Blocking Heuristic gives consistently higher estimates because it considers actual obstacles that need to be cleared, leading the algorithm to explore more nodes to find an optimal path. The Distance Heuristic, however, gives lower estimates since it focuses primarily on proximity to the target, ignoring obstacles. This mostly makes it more efficient (as fewer states are visited) but may risk overlooking potential blockages.

Proof based on my output:

- Both heuristics reached the solution in 16 moves, but the Distance Heuristic explored fewer states (893) compared to the Blocking Heuristic (999). This implies that the Blocking Heuristic's estimates are higher, leading the algorithm to explore more alternatives.

Search Space Comparison:

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Search Space Comparison: States Explored

	Algorithm	States Explored
0	Brute Force	776
1	BFS	1076
2	Best-First (Blocking Heuristic)	999
3	Best-First (Distance Heuristic)	893

Analysis:

(a) Brute Force: Explores 776 states but takes a significantly longer path, 202 moves, as it does not have any heuristic guidance. Interestingly enough, it explores fewer states than the heuristic methods but finds highly inefficient paths.

(b) Best-First with Blocking Heuristic: Explores 999 states and solves in 16 moves. This approach focuses on clearing blocks and can at times lead to more states being explored, as it might prioritize unnecessary block-clearing paths.

(c) **Best-First with Distance Heuristic:** Explores 893 states and solves in 16 moves. This approach focuses on the shortest path and it allows it to explore fewer nodes while still achieving an optimal solution.

Final Words:

Both heuristics are admissible because neither overestimates the cost to reach the target. The Blocking Heuristic provides consistently higher estimates due to accounting for obstacles, leading to more nodes being explored. The Distance Heuristic is more efficient in terms of state exploration but still finds the optimal solution. The Brute Force approach, while exploring fewer states, results in an inefficient solution with far more moves, highlighting the advantage of heuristic-guided search.

Below are some graphs to visualize the comparison efficiently:

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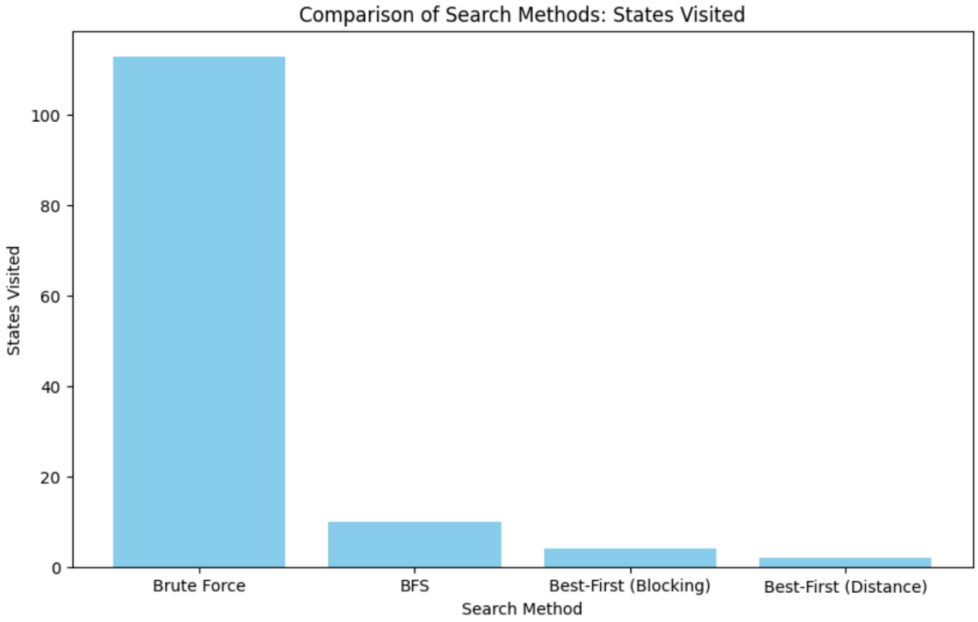
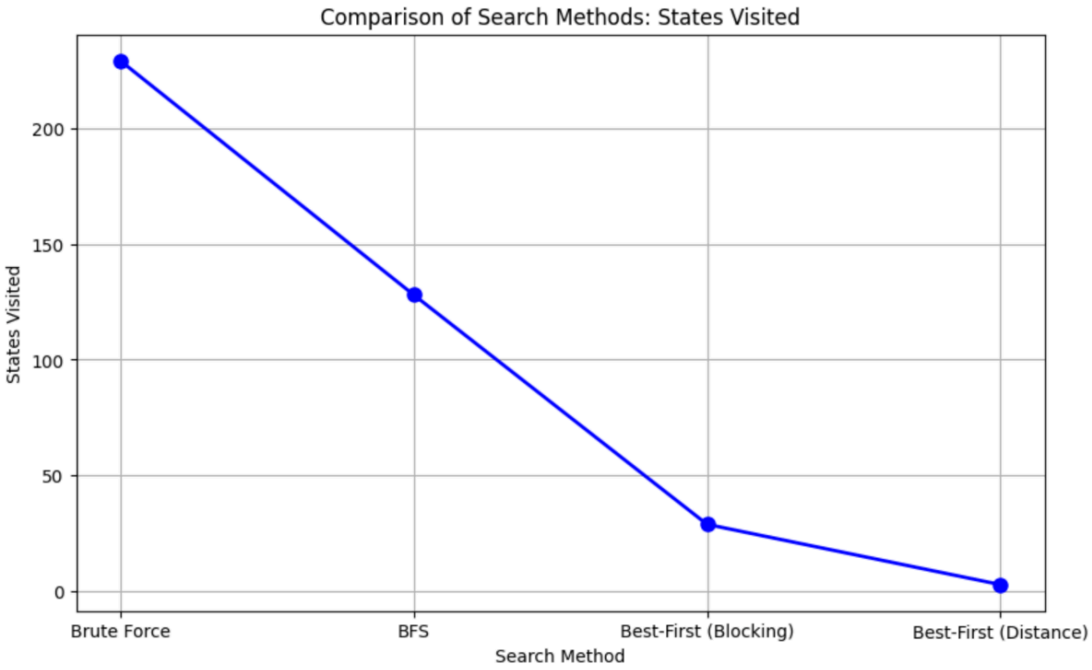


Bar Graph, illustrating the comparison of the Search Methods based on the states visited



Line Graph, illustrating the comparison of the Search Methods based on the states visited

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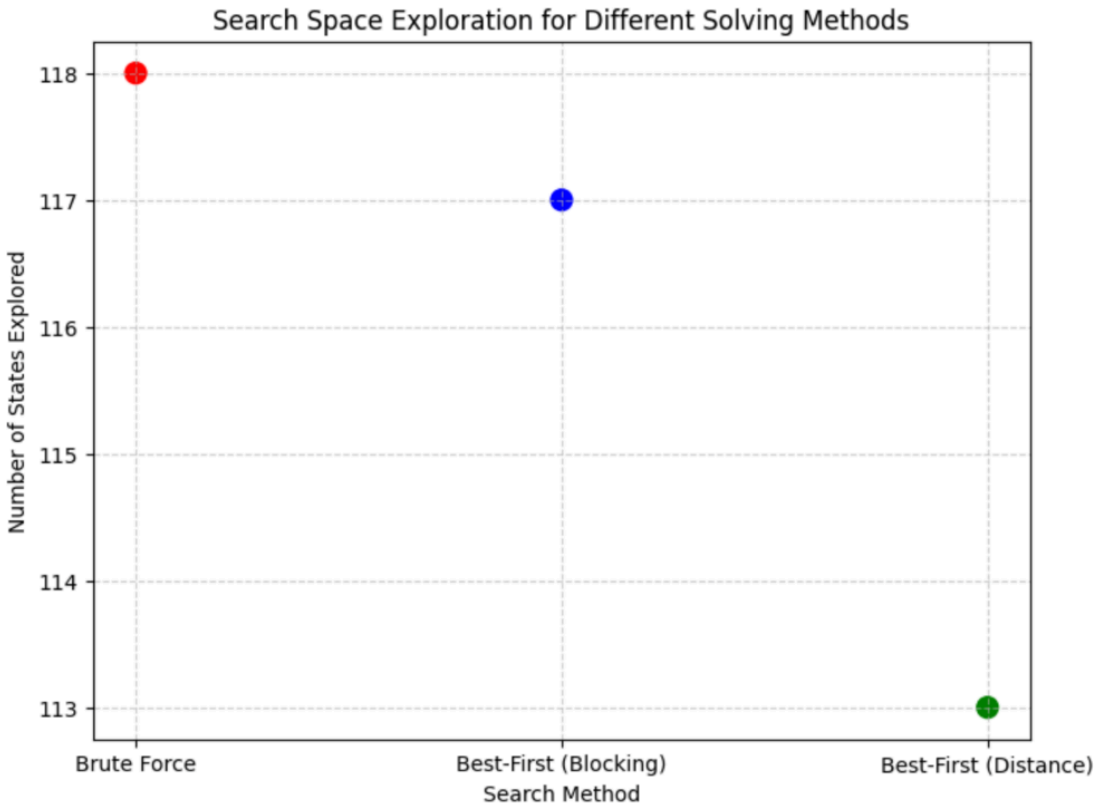

Scatterplot, illustrating the comparison of the Search Methods based on the states visited

Further Documentation:

Screenshot (Beginner Puzzle 1 output)

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```
bhangua@linux-07:~/CIS3700_A$ python3 p.py < puzzle1.txt
Initial Board:
A A . . . O
P . . Q . O
P X X Q . O
P . . Q . .
B . . . C C
B . R R R .

Brute Force:
OD
CL
OD
OD
CL
CL
OU
OU
OU
CR
RR
OD
OD
QU
CR
OU
OU
CR
AR
OD
RL
CL
OD
OD
CL
CL
OU
OU
OU
CR
RR
OD
PU
OD
CR
QD
OU
OU
CR
RL
OD
RL
CL
OD
OD
CL
CL
OU
OU
OU
CR
RR
OD
OD
BU
OD
```

```
OD
CR
QU
OU
OU
OU
CR
RR
OD
QD
QD
OU
RL
RL
OD
RL
QD
OU
XR
XR
OD
AR
XL
AR
OU
XL
QU
OD
RR
RR
OU
RR
QU
OD
CL
OD
CL
CL
OU
OU
CR
RL
OD
RL
OD
OD
CR
RR
BD
OU
OU
OU
CR
RL
OD
PD
CL
OD
OD
CL
CL
OU
OU
OU
CR
RR
OD
```

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```
BFS:
AR
PU
BU
RL
RL
CL
CL
CL
QD
QD
XR
XR
OD
OD
OD
XR
Depth: 16
States visited: 1076

Final Board State:
P A A . . .
P . . . . .
P . . . X X
B . . Q . O
B C C Q . O
R R R Q . O


Best-First (Blocking Heuristic):
AR
CL
CL
CL
PU
BU
QD
RL
RL
QD
OD
OD
OD
XR
XR
XR
Depth: 16
States visited: 999

Final Board State:
P A A . . .
P . . . . .
P . . . X X
B . . Q . O
B C C Q . O
R R R Q . O


Best-First (Distance Heuristic):
AR
CL
CL
CL
PU
BU
QD
RL
```

```
Best-First (Blocking Heuristic):
AR
CL
CL
CL
PU
BU
QD
RL
RL
QD
OD
OD
OD
XR
XR
XR
Depth: 16
States visited: 999

Final Board State:
P A A . . .
P . . . . .
P . . . X X
B . . Q . O
B C C Q . O
R R R Q . O


Best-First (Distance Heuristic):
AR
CL
CL
CL
PU
BU
QD
RL
RL
QD
XR
XR
OD
OD
OD
XR
Depth: 16
States visited: 893

Final Board State:
P A A . . .
P . . . . .
P . . . X X
B . . Q . O
B C C Q . O
R R R Q . O


Search Space Comparison:
Algorithm                       States Explored
--------------------------------------------------
Brute Force                     776
BFS                             1076
Best-First (Blocking Heuristic)999
Best-First (Distance Heuristic)893
bhangua@linux-07:~/CIS3700_A$
```