Sorting as Searching

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Part A

- Start State: **[4, 4, 6.3, 9, -3]**
- Goal State: **[-3, 4, 4, 6.3, 9]**

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  10
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (-3, 9)
[4, 4, 6.3, -3, 9]
action: swap (9, 6.3)
[4, 4, 9, -3, 6.3]
action: swap (6.3, 4)
[4, 6.3, 9, -3, 4]
action: swap (4, -3)
[4, 6.3, 9, 4, -3]
action: swap (-3, 9)
[4, 6.3, -3, 4, 9]
action: swap (9, 6.3)
[4, 9, -3, 4, 6.3]
action: swap (6.3, 4)
[4, 9, -3, 6.3, 4]
action: swap (4, -3)
[4, 9, 4, 6.3, -3]
action: swap (-3, 9)
[4, -3, 4, 6.3, 9]
action: swap (-3, 4)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  22
```

The path followed by DFS

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (6.3, 4)
[6.3, 4, 4, 9, -3]
action: swap (9, 6.3)
[9, 4, 4, 6.3, -3]
action: swap (-3, 9)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  36
```

The path followed by BFS

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (-3, 9)
[4, 4, 6.3, -3, 9]
action: swap (-3, 6.3)
[4, 4, -3, 6.3, 9]
action: swap (-3, 4)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  15
```

The path followed by Iterative deepening

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (6.3, 4)
[6.3, 4, 4, 9, -3]
action: swap (-3, 9)
[6.3, 4, 4, -3, 9]
action: swap (-3, 6.3)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  59
```

The path followed by UCS

```
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (-3, 4)
[-3, 4, 6.3, 9, 4]
action: swap (4, 9)
[-3, 4, 6.3, 4, 9]
action: swap (4, 6.3)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  4
```

The path followed by Hill climbing search

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (6.3, 4)
[6.3, 4, 4, 9, -3]
action: swap (-3, 9)
[6.3, 4, 4, -3, 9]
action: swap (-3, 6.3)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  58
```

The path followed by A-star search

```
Solution found
state:  [-3, 4, 4, 6.3, 9]
path cost:  3
path:
action: swap None
[4, 4, 6.3, 9, -3]
action: swap (-3, 4)
[-3, 4, 6.3, 9, 4]
action: swap (4, 9)
[-3, 4, 6.3, 4, 9]
action: swap (4, 6.3)
[-3, 4, 4, 6.3, 9]
number of explored nodes:  34
```

The path followed by Greedy Search

Heuristics used:

- **Greedy search:** Total number of misplaced numbers.
- A^***star search:** 0 as heuristics value since we want to imitate UCS
- **Hill climbing:** Norm of difference between goal state and current state.

Observations and Results

- The path followed by the DFS is the longest and, hence the highest path cost.
- BFS explored more nodes than the DFS but gave a shorter path.
- UCS has explored the largest number of nodes.
- Iterative deepening is the best search, excluding local search algorithms, as it gives a path with the least cost and the least number of nodes explored.
- Hill climbing has reached the goal state in 4 nodes.

Part B

```
Results for n=3:
Average Explored Nodes: 1.95
----------------------------------------
Results for n=4:
Average Explored Nodes: 11.95
----------------------------------------
Results for n=5:
Average Explored Nodes: 48.95
----------------------------------------
Results for n=6:
Average Explored Nodes: 327.1
----------------------------------------
```

Average nodes explored by BFS

```
Results for n=3:
Average Explored Nodes: 2.6
----------------------------------------
Results for n=4:
Average Explored Nodes: 11.45
----------------------------------------
Results for n=5:
Average Explored Nodes: 47.45
----------------------------------------
Results for n=6:
Average Explored Nodes: 430.65
----------------------------------------
```

Average nodes explored by UCS

```
Results for n=3:
Average Explored Nodes: 2.5
----------------------------------------
Results for n=4:
Average Explored Nodes: 12.75
----------------------------------------
Results for n=5:
Average Explored Nodes: 51.75
----------------------------------------
Results for n=6:
Average Explored Nodes: 361.75
----------------------------------------
```

Average nodes explored by Greedy search

```
Results for n=3:
Average Explored Nodes: 2.7
----------------------------------------
Results for n=4:
Average Explored Nodes: 11.85
----------------------------------------
Results for n=5:
Average Explored Nodes: 61.45
----------------------------------------
Results for n=6:
Average Explored Nodes: 314.1
----------------------------------------
```

Average nodes explored by DFS

```
Results for n=3:
Average Explored Nodes: 1.7
----------------------------------------
Results for n=4:
Average Explored Nodes: 6.1
----------------------------------------
Results for n=5:
Average Explored Nodes: 32.35
----------------------------------------
Results for n=6:
Average Explored Nodes: 169.35
----------------------------------------
```

Average nodes explored by Iterative Deepening

```
Results for n=3:
Average Explored Nodes: 2.35
---------------------------------------
Results for n=4:
Average Explored Nodes: 2.85
---------------------------------------
Results for n=5:
Average Explored Nodes: 3.65
---------------------------------------
Results for n=6:
Average Explored Nodes: 4.6
---------------------------------------
```

Average nodes explored by Hill Climbing Search

```
Results for n=3:
Average Explored Nodes: 2.85
---------------------------------------
Results for n=4:
Average Explored Nodes: 10.85
---------------------------------------
Results for n=5:
Average Explored Nodes: 62.95
---------------------------------------
Results for n=6:
Average Explored Nodes: 329.7
---------------------------------------
```

Average nodes explored by A-star search

Observation

- order of nodes explored: Hill climbing → Iterative deepening → DFS → Astar → BFS → Greedy → UCS
- Nodes explored in UCS increase exponentially
- Nodes explored in Hill climbing at a constant rate.