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Class: 18CTT1

Lab01: The Knight's Tour – Report

#	Criteria	% credits	Completed
1	Manipulate the input and output	10	Completed
2	Implement the backtracking	10	Completed
3	Implement the Warnsdorff's Heuristic	10	Completed
4	Provide valid results for the backtracking strategy	20	Completed
5	Provide valid results for the Warnsdorff's Heuristic	20	Completed
6	Provide all evidential files in the OUTPUT folder	10	Completed
7	Report sufficient information in the document	20	Completed

Environment

- MacOS Big Sur Version 11.0.1
- 1,4 GHz Quad-Core Intel Core i5
- 8 GB 2133 MHz LPDDR3 RAM
- Python 3.9.0

How to run

To run again all of my test case:

- From "18125013/" folder, move the directory to "SOURCE/" folder.

```
cd SOURCE/
```

- Run both two of this command:

```
python3 run.py and python3 run_backtrack_8x8.py
```

- All result file will place in 18125013/OUTPUT/ folder

To manually run your test case:

- From "18125013" folder, move the directory to "SOURCE/" folder.

```
cd SOURCE/
```

- Run 18125013_backtracking.py for backtracking strategy.

```
python3 18125013_backtracking.py -px <x> -py <y> -m <m>
```

```
THE KNIGHT STARTS AT SQUARE ((X), (Y)) ON THE BOARD OF SIZE (M).
```

- Run 18125013_warnsdorffs.py for Warnsdorff's Heuristic strategy.

```
python3 18125013_warnsdorffs.py -px <x> -py <y> -m <m>
```

```
THE KNIGHT STARTS AT SQUARE ((X), (Y)) ON THE BOARD OF SIZE (M).
```

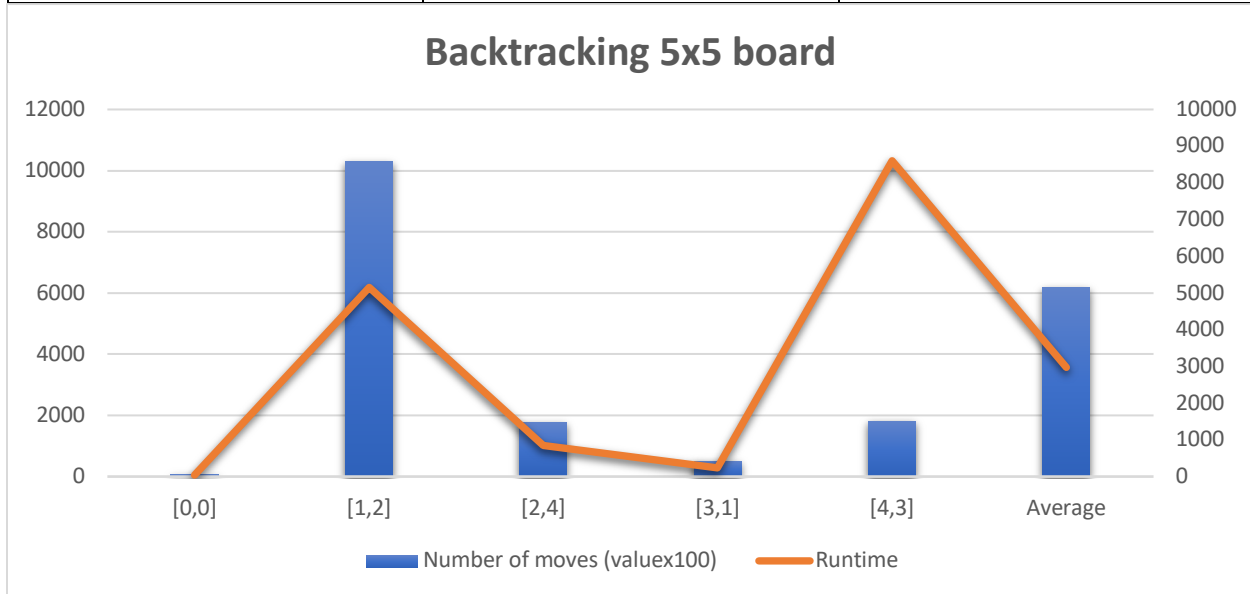
- All result will place in 18125013/OUTPUT/ folder

Backtracking Strategy

Board size 5x5

In my test cases, there are two initial point that cannot get to the answer (1,2) and (4,3), runtime of two cases are larger than 1000ms

Initial	Number of moves	Runtime (millisecond)
(0,0)	8839	40,53
(1,2)	1028892	5145,64
(2,4)	178319	844,86
(3,1)	51116	236,03
(4,3)	1829420	8602,33
Average	619317	2978,878



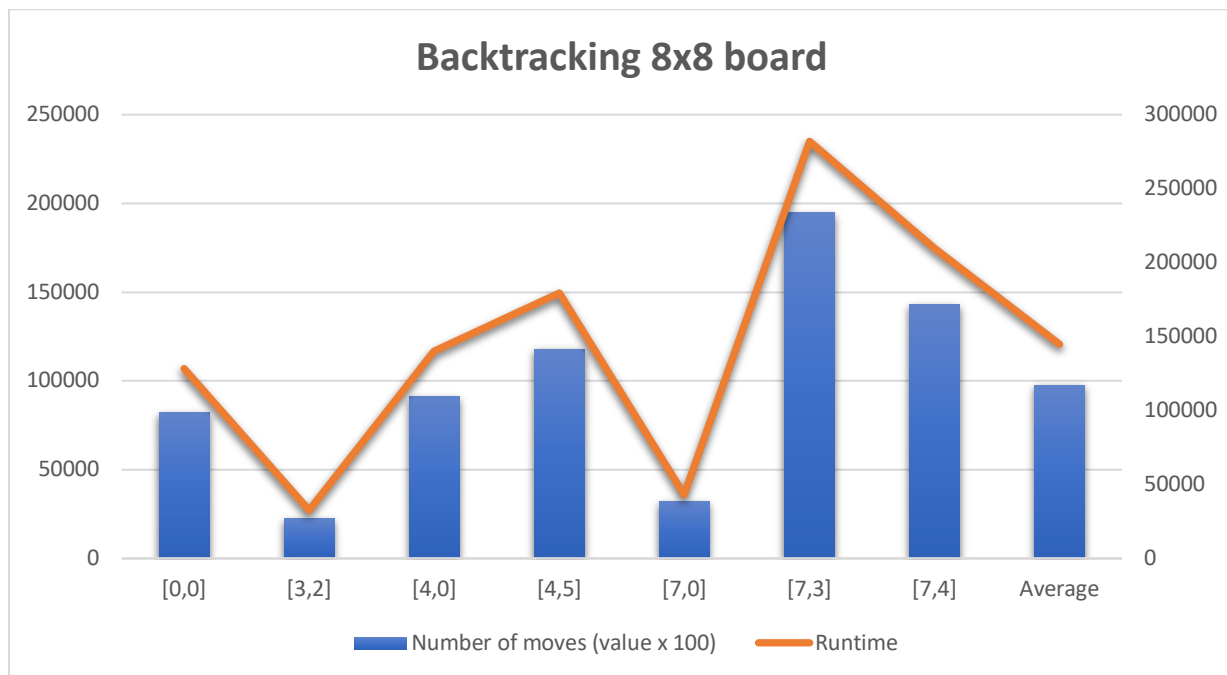
Board size 8x8

With board size 8x8 or larger, I decided to put a time-limited (5 minute) for the runtime. Because of the popularity of the 8x8 board, so I test all the initial point of this case. Only 7 initial points can finish its search with a 5 minute time-limited. (0,0) – (3,2) – (4,0) – (4,5) – (7,0) – (7,3) – (7,4)

In the test that cannot finish in 5 minutes, the knight moves about 20000000 steps before it stops. (All are export in OUTPUT/Backtracking 8x8 /)

In this report, I only discuss cases that finished in 5 minutes.

Initial	Number of moves	Runtime (millisecond)
(0,0)	8250732	128425,42
(3,2)	2252172	32568,88
(4,0)	9152985	140177,14
(4,5)	11807341	179301,13
(7,0)	3242064	42918,22
(7,3)	19489816	281957,05
(7,4)	14318941	209644,83
Average	9787722	144999



Board size 15x15, 25x25, 40x40

All initial points in all 3 cases 15x15, 25x25, 40x40 exceed the search time limit.

In the test that cannot finish in 5 minutes, the knight moves about 20000000 steps before it stops. (All are export in OUTPUT/Backtracking_*/)

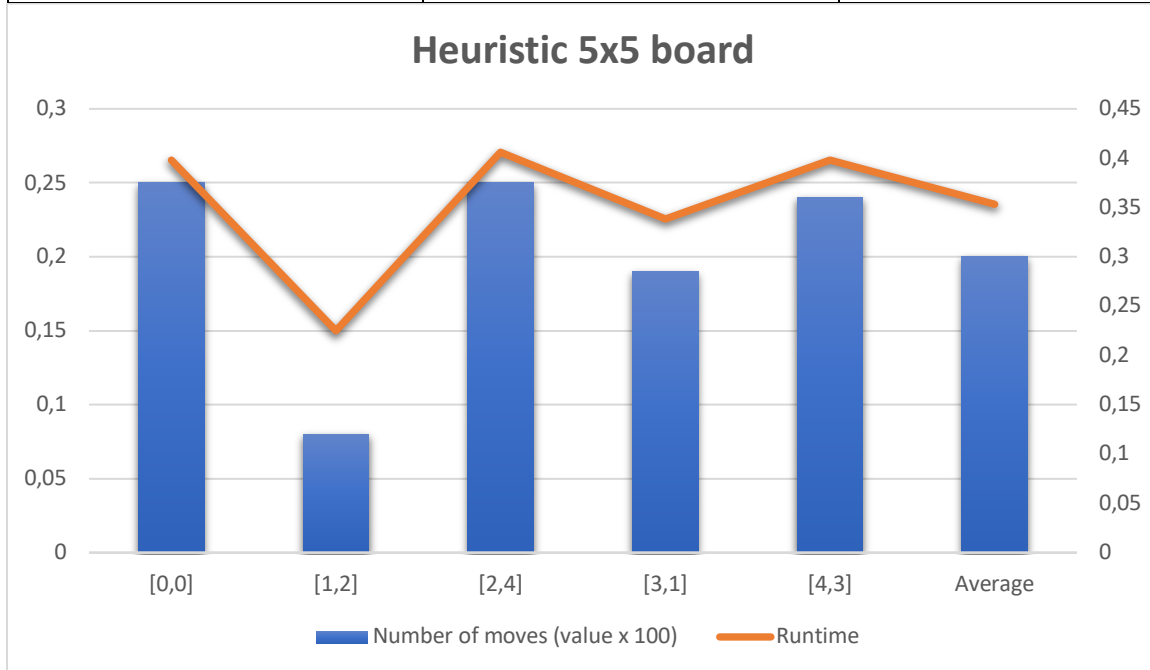
Warnsdorff's Heuristic Strategy

Board size 5x5

All test cases finished the search in 0,3 milliseconds.

Comparing to the backtracking strategy, the case (3,1) cannot get a valid solution.

Initial	Number of moves	Runtime (millisecond)
(0,0)	25	0,398
(1,2)	8	0,225
(2,4)	25	0,406
(3,1)	19	0,338
(4,3)	24	0,398
Average	20	0,353

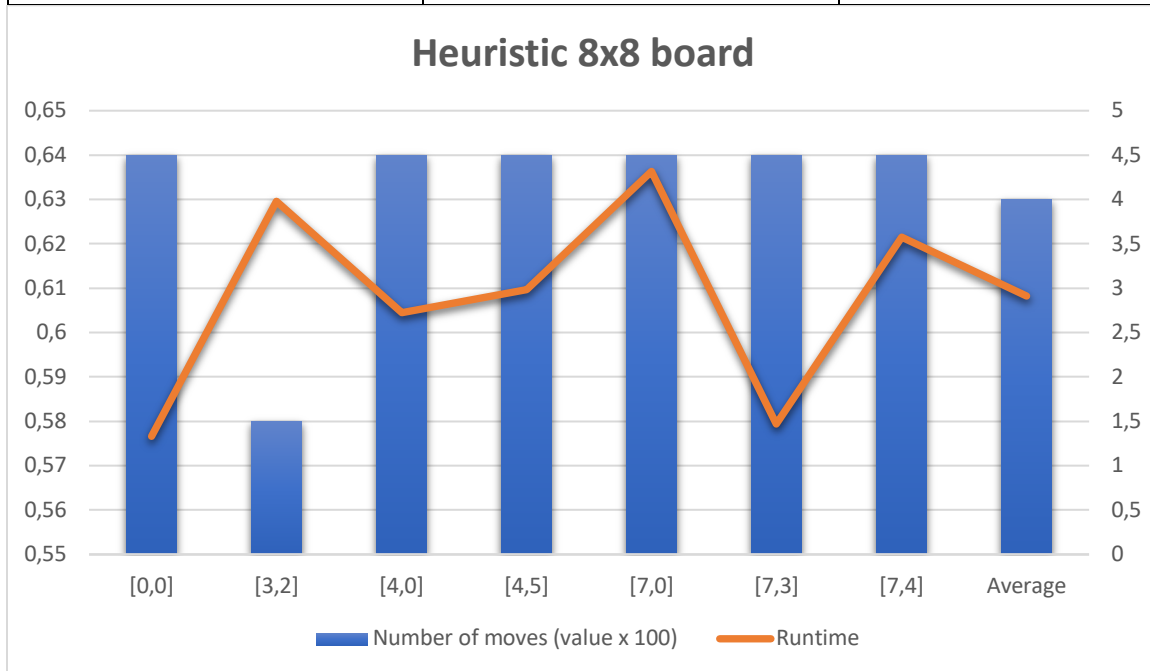


Board size 8x8

All test cases finished the search in under 5 milliseconds. Compare to other board sizes, runtime is not stable, maybe because of the unstable performance of the computer.

Comparing to the backtracking strategy, the case (3,2) cannot get a valid solution (58 steps).

Initial	Number of moves	Runtime (millisecond)
(0,0)	64	1,331
(3,2)	58	3,981
(4,0)	64	2,725
(4,5)	64	2,983
(7,0)	64	4,316
(7,3)	64	1,472
(7,4)	64	3,572
Average	63	2,911



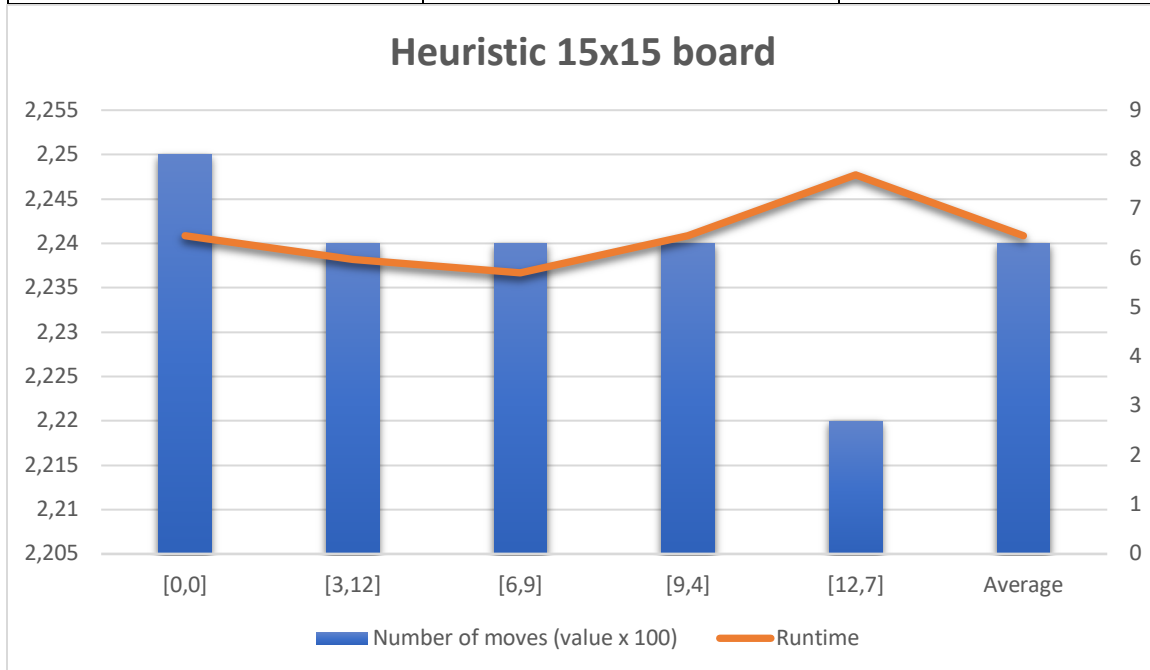
Board size 15x15

All test cases finished the search in 6 milliseconds.

Only one case can get a valid solution (0,0).

Other cases just only get close to the solution. (224 steps, 222steps)

Initial	Number of moves	Runtime (millisecond)
(0,0)	225	6,453
(3,12)	224	5,979
(6,9)	224	5,701
(9,4)	224	6,448
(12,7)	222	7,688
Average	224	6,454

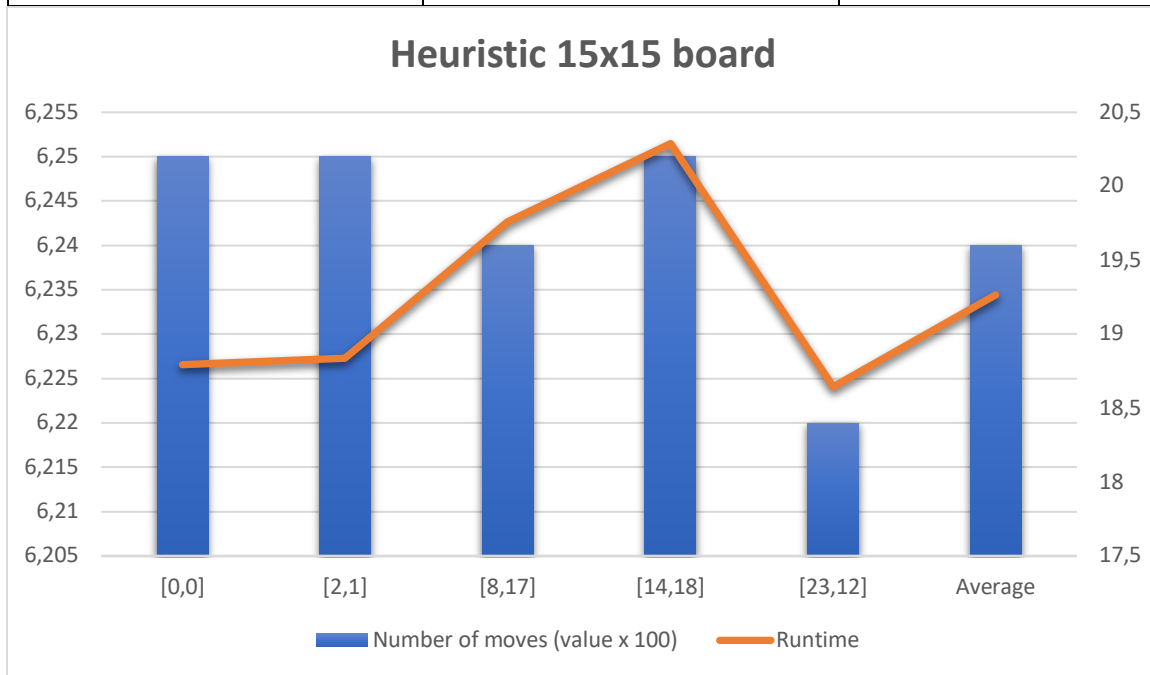


Board size 25x25

All test cases finished the search in 19 milliseconds.

Two cases (8,17) and (23,12) cannot get a valid solution.

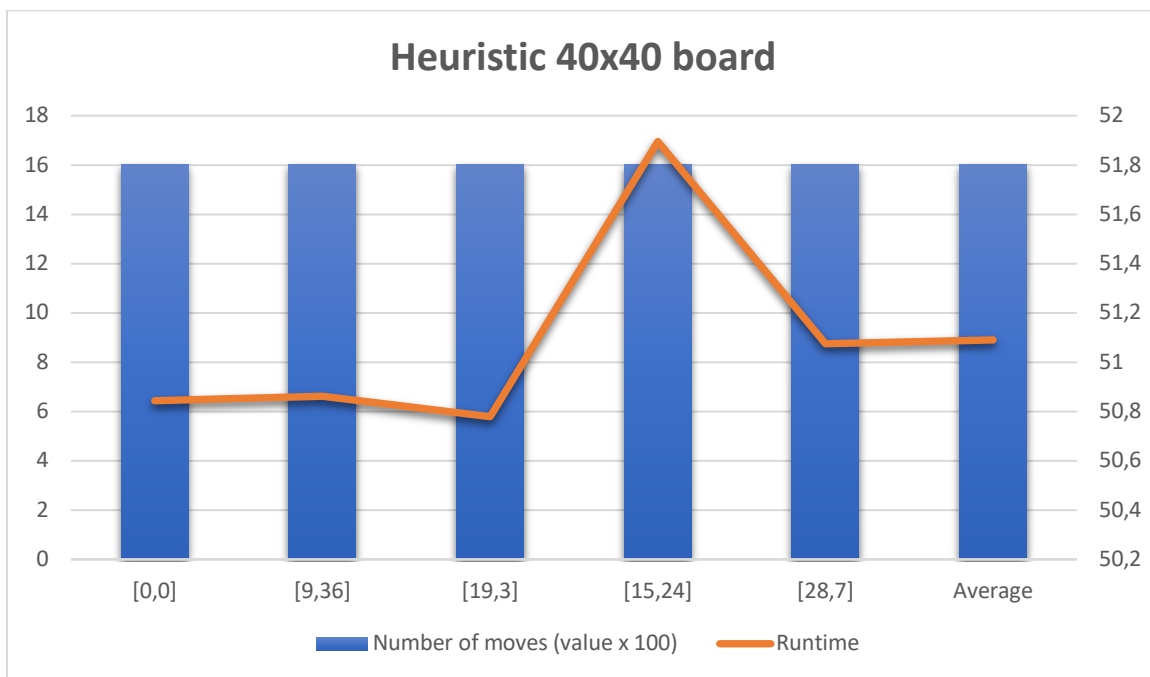
Initial	Number of moves	Runtime (millisecond)
(0,0)	625	18,795
(2,10)	625	18,835
(8,17)	624	19,758
(14,18)	625	20,288
(23,12)	622	18,644
Average	624	19,264



Board size 40x40

All test cases finished the search in 50 milliseconds.

Initial	Number of moves	Runtime (millisecond)
(0,0)	1600	50,844
(9,36)	1600	50,863
(10,30)	1600	50,779
(15,24)	1600	51,895
(28,7)	1600	51,076
Average	1600	51,091



Conclusion

Runtime of the Heuristic strategy is much better compare to the Backtracking strategy. But in some cases Heuristic cannot get a valid solution.

In my opinion, on a board with a size smaller than 8x8, we should use a Backtracking strategy to find as many solutions as possible. With a board size larger than 8x8 we should use the Heuristic strategy with some modification to the algorithm to get a higher possibility to get a valid solution.

References:

<https://github.com/alexkiro/knight-tour>

<https://www.geeksforgeeks.org/warnsdorffs-algorithm-knights-tour-problem/>

<https://www.geeksforgeeks.org/the-knights-tour-problem-backtracking-1/>

https://en.wikipedia.org/wiki/Knight%27s_tour