University of Liège

Bachelor in engineering
Orientation: Civil Engineering
Introduction to artificial intelligence

Project 1: Pacman is hungry

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October 2018

1 Formalisation of the game

We can formalise the search problem as follow:

- **Initial state:**
  - initial position of pacman available in the *state*
  - initial position of the food dots within the maze from the *.lay* files
- **Actions(s):** depending on the presence of walls or not,

$$action(s) = \{West, East, North, South\}$$

- **Transition model**:

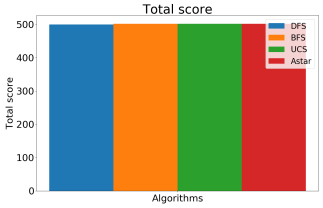
```
result(pacmanPosition, direction, foodMap)
                        =
updated(pacmanPosition), updated(foodMap)
```

- **Goal test:** no more food
- **Path cost:**
  - if movement leads to a food dot: path cost is 1
  - else: path cost is 10

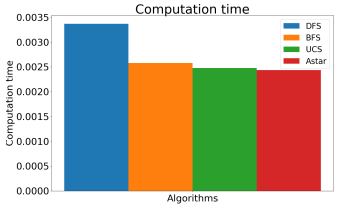
2 Comparison between agents

2.1 Small

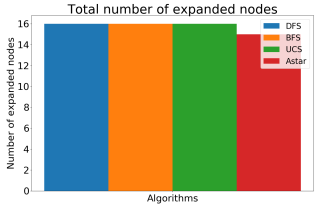
	Final score	Total computation time	Total number of expanded nodes
DFS	500.0	0.0033721923828125	16
BFS	502.0	0.0025811195373535156	16
UCS	502.0	0.0024771690368652344	16
A-Star	502.0	0.0024368762969970703	15



(a) Final score



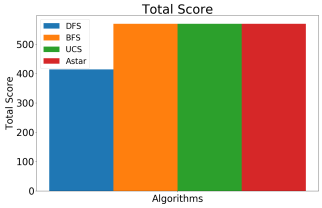
(b) Computation Time



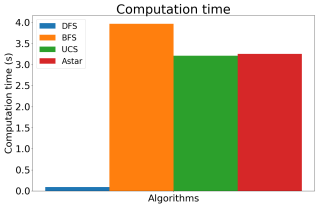
(c) Number of expanded nodes

2.2 Medium

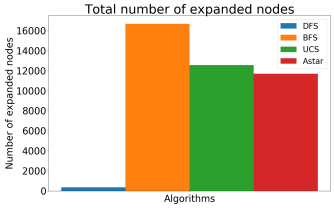
	Final score	Total computation time	Total number of expanded nodes
DFS	414.0	0.09369635581970215	361
BFS	570.0	3.970214605331421	16689
UCS	570.0	3.2096621990203857	12561
A-Star	570.0	3.2512166500091553	11692



(a) Final score



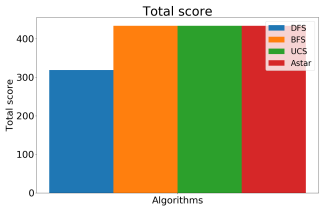
(b) Computation Time



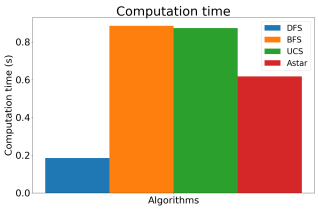
(c) Number of expanded nodes

2.3 Large

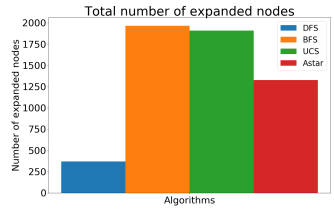
	Final score	Total computation time	Total number of expanded nodes
DFS	319.0	0.18555068969726562	371
BFS	434.0	0.8868625164031982	1967
UCS	434.0	0.8738136291503906	1909
A-Star	434.0	0.6179904937744141	1329



(a) Final score



(b) Computation Time



(c) Number of expanded nodes

3 Performance and limitations of the agents

3.1 Depth-first search:

Final scores are inversely proportional in regard to the size of the maze. Furthermore, the *total computation time* and the *total number of expanded nodes* are increase with the size of the maze. Indeed this algorithm expands nodes digging always in the same branches of the tree until it finds a solution or check a state already visited. Therefore there is no optimisation in the way of getting the food dots. This also explains the few number of expanded nodes.

3.2 Breadth-first search:

We find the maximum *final score* for the medium maze but the *total number of expanded nodes* is the biggest one, and thus the *computation time* is also the highest. We already reached the optimal score with this algorithm.

3.3 Uniform-cost search:

Like BFS, medium maze returns the maximum *final score*. *computation time* and *total number of expanded nodes* are more important in this maze. The score is also optimal because the algorithm visits the least-cost paths first, advantaging the states where the dots food are eaten over the ones where the dots remain in the grid.

3.4 A-Star:

The maximum is found in the medium maze, but *total number of expanded nodes* and *computation time* are bigger than the other mazes. To have an admissible *heuristic*, we always choose the longest *manhattanDistance* between pacman's position and all food positions to ensure the heuristic to be at most equals or inferior to the real path cost.

4 Conclusion

The three algorithms, *BFS*, *UCS* and *Astar*, returns the same final score for all the maze, and a maximum for the medium maze. However, computation time and the number of expanded nodes vary with the different search. *Astar* is generally the best method with a good score and small number of expanded nodes (thus, computation time). In contrary of *Astar*, *DFS* is mostly the worst method. Despite of its very fast computation time, the total score is very bad.

To sum up, the choice of an algorithm over another one will depend of our expectation. In one hand, if we aim for fast result but a lack of precision, *DFS* is advised. In the other hand, if we prefer optimal score over computation time, A-star should be selected.