

# Assignment 4

TDT4136 - Introduction to Artificial Intelligence  
Fall 2023

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## 1 Introduction

In this assignment we implemented the Minimax algorithm following the pseudocode in the AIMA book [2] in the Pac-Man Projects, developed at UC Berkeley [1].

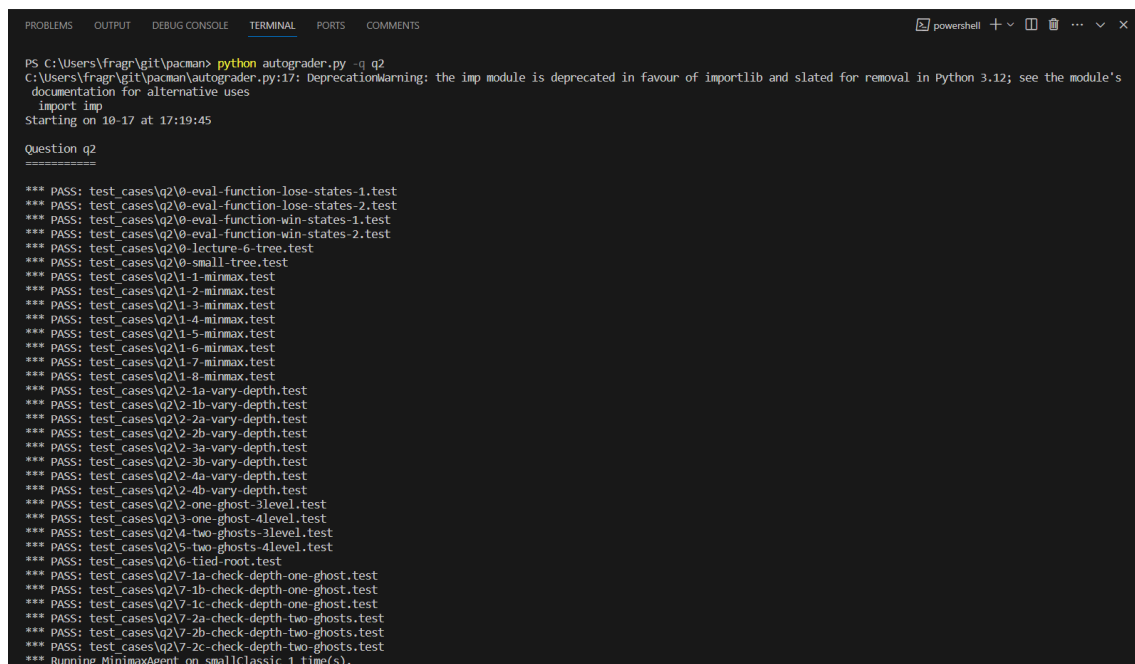
More specifically, we completed the classes `MinimaxAgent` and `AlphaBetaAgent` with `maxValue` and `minValue` functions. These are invoked recursively by `minimaxSearch` and `alphabetaSearch` respectively, based on the index of the current agent (which is 0 if the player is Pacman and a number  $\geq 1$  if it is the turn of one of the ghosts). The search stops when one of the terminal conditions is met: the tree was expanded to the maximum depth, or Pacman won or lost the game.

The algorithm in the `AlphaBetaAgent` differs from that of `MinimaxAgent` for the two bounds introduced:  $\alpha$  and  $\beta$ .  $\alpha$  represents the value of the best choice we have found so far at any choice point along the path for MAX, while  $\beta$  is the value of the best choice found so far for MIN [2].

The code downloaded from [1] includes the program `autograder.py`, used to run various tests in order to evaluate our solutions.

The program's outputs are presented in sections 2 and 3.

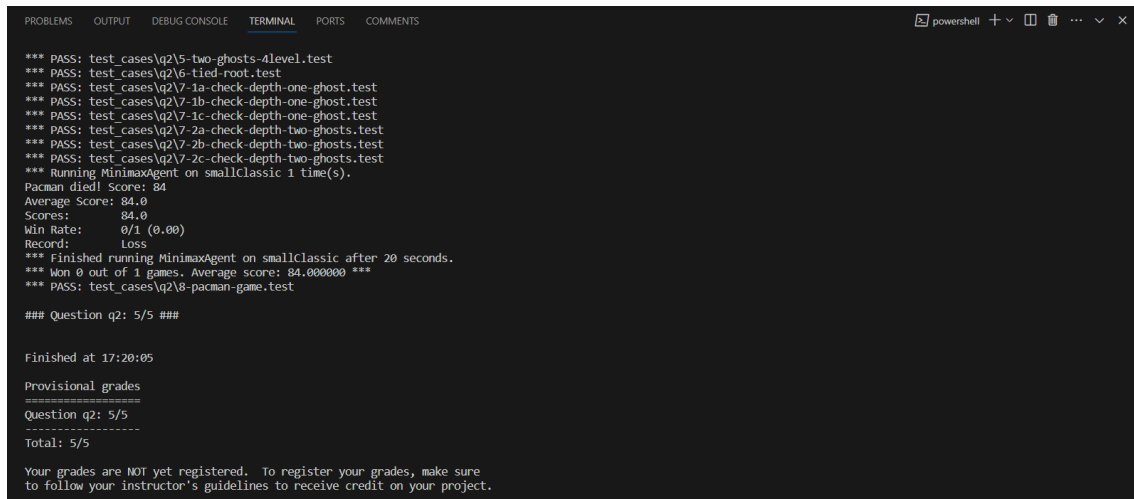
## 2 Minimax



```
PS C:\Users\fragr\git\pacman> python autograder.py -q q2
C:\Users\fragr\git\pacman\autograder.py:17: DeprecationWarning: the imp module is deprecated in favour of importlib and slated for removal in Python 3.12; see the module's documentation for alternative uses
  import imp
Starting on 10-17 at 17:19:45

Question q2
=====
*** PASS: test_cases\q2\0-eval-function-lose-states-1.test
*** PASS: test_cases\q2\0-eval-function-lose-states-2.test
*** PASS: test_cases\q2\0-eval-function-win-states-1.test
*** PASS: test_cases\q2\0-eval-function-win-states-2.test
*** PASS: test_cases\q2\0-lecture-6-tree.test
*** PASS: test_cases\q2\0-small-tree.test
*** PASS: test_cases\q2\1-1-minimax.test
*** PASS: test_cases\q2\1-2-minimax.test
*** PASS: test_cases\q2\1-3-minimax.test
*** PASS: test_cases\q2\1-4-minimax.test
*** PASS: test_cases\q2\1-5-minimax.test
*** PASS: test_cases\q2\1-6-minimax.test
*** PASS: test_cases\q2\1-7-minimax.test
*** PASS: test_cases\q2\1-8-minimax.test
*** PASS: test_cases\q2\2-1a-vary-depth.test
*** PASS: test_cases\q2\2-1b-vary-depth.test
*** PASS: test_cases\q2\2-2a-vary-depth.test
*** PASS: test_cases\q2\2-2b-vary-depth.test
*** PASS: test_cases\q2\2-3a-vary-depth.test
*** PASS: test_cases\q2\2-3b-vary-depth.test
*** PASS: test_cases\q2\2-4a-vary-depth.test
*** PASS: test_cases\q2\2-4b-vary-depth.test
*** PASS: test_cases\q2\2-one-ghost-3level.test
*** PASS: test_cases\q2\3-one-ghost-4level.test
*** PASS: test_cases\q2\4-two-ghosts-3level.test
*** PASS: test_cases\q2\5-two-ghosts-4level.test
*** PASS: test_cases\q2\6-tied-root.test
*** PASS: test_cases\q2\7-1a-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-1b-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-1c-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-2a-check-depth-two-ghosts.test
*** PASS: test_cases\q2\7-2b-check-depth-two-ghosts.test
*** PASS: test_cases\q2\7-2c-check-depth-two-ghosts.test
*** Running MinimaxAgent on smallClassic 1 time(s).
```

Figure 1: Question 2 output (a)



```

PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS  COMMENTS
*** PASS: test_cases\q2\5-two-ghosts-4level.test
*** PASS: test_cases\q2\6-tied-root.test
*** PASS: test_cases\q2\7-1a-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-1b-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-1c-check-depth-one-ghost.test
*** PASS: test_cases\q2\7-2a-check-depth-two-ghosts.test
*** PASS: test_cases\q2\7-2b-check-depth-two-ghosts.test
*** PASS: test_cases\q2\7-2c-check-depth-two-ghosts.test
*** Running MinimaxAgent on smallClassic 1 time(s).
Pacman died! Score: 84
Average Score: 84.0
Scores: 84.0
Win Rate: 0/1 (0.00)
Record: Loss
*** Finished running MinimaxAgent on smallClassic after 20 seconds.
*** Non 0 out of 1 games. Average score: 84.000000 ***
*** PASS: test_cases\q2\8-pacman-game.test

### Question q2: 5/5 ###

Finished at 17:20:05

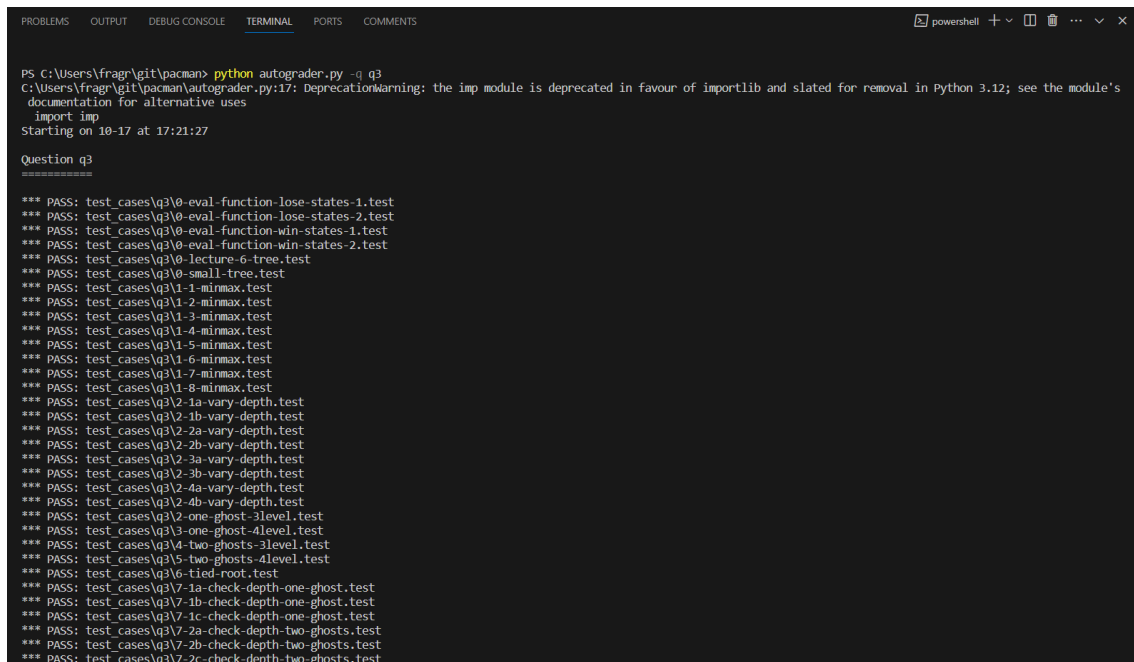
Provisional grades
=====
Question q2: 5/5
-----
Total: 5/5

Your grades are NOT yet registered. To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.

```

Figure 2: Question 2 output (b)

### 3 Alpha-Beta Pruning



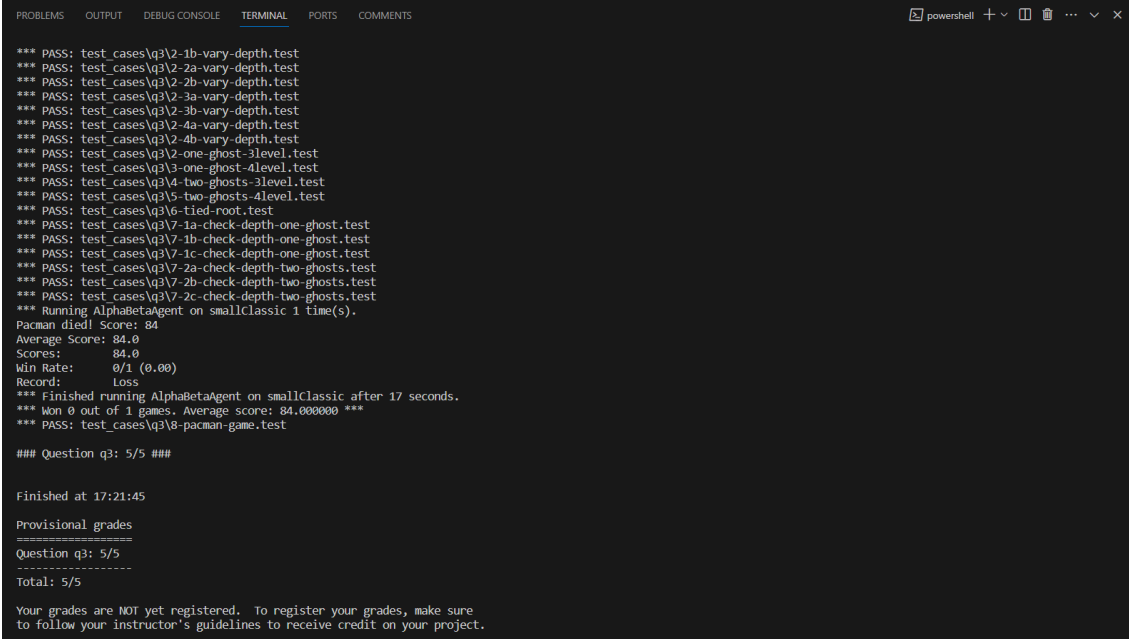
```

PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS  COMMENTS
PS C:\Users\fragn\git\pacman> python autograder.py -q q3
C:\Users\fragn\git\pacman\autograder.py:17: DeprecationWarning: the imp module is deprecated in favour of importlib and slated for removal in Python 3.12; see the module's
documentation for alternative uses
  import imp
Starting on 10-17 at 17:21:27

Question q3
=====
*** PASS: test_cases\q3\0-eval-function-lose-states-1.test
*** PASS: test_cases\q3\0-eval-function-lose-states-2.test
*** PASS: test_cases\q3\0-eval-function-win-states-1.test
*** PASS: test_cases\q3\0-eval-function-win-states-2.test
*** PASS: test_cases\q3\0-lecture-6-tree.test
*** PASS: test_cases\q3\0-small-tree.test
*** PASS: test_cases\q3\1-1-minimax.test
*** PASS: test_cases\q3\1-2-minimax.test
*** PASS: test_cases\q3\1-3-minimax.test
*** PASS: test_cases\q3\1-4-minimax.test
*** PASS: test_cases\q3\1-5-minimax.test
*** PASS: test_cases\q3\1-6-minimax.test
*** PASS: test_cases\q3\1-7-minimax.test
*** PASS: test_cases\q3\1-8-minimax.test
*** PASS: test_cases\q3\2-1a-vary-depth.test
*** PASS: test_cases\q3\2-1b-vary-depth.test
*** PASS: test_cases\q3\2-2a-vary-depth.test
*** PASS: test_cases\q3\2-2b-vary-depth.test
*** PASS: test_cases\q3\2-3a-vary-depth.test
*** PASS: test_cases\q3\2-3b-vary-depth.test
*** PASS: test_cases\q3\2-4a-vary-depth.test
*** PASS: test_cases\q3\2-4b-vary-depth.test
*** PASS: test_cases\q3\2-one-ghost-3level.test
*** PASS: test_cases\q3\3-one-ghost-4level.test
*** PASS: test_cases\q3\4-two-ghosts-3level.test
*** PASS: test_cases\q3\5-two-ghosts-4level.test
*** PASS: test_cases\q3\6-tied-root.test
*** PASS: test_cases\q3\7-1a-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-1b-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-1c-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-2a-check-depth-two-ghosts.test
*** PASS: test_cases\q3\7-2b-check-depth-two-ghosts.test
*** PASS: test_cases\q3\7-2c-check-depth-two-ghosts.test

```

Figure 3: Question 3 output (a)



```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS COMMENTS
*** PASS: test_cases\q3\2-1b-vary-depth.test
*** PASS: test_cases\q3\2-2a-vary-depth.test
*** PASS: test_cases\q3\2-2b-vary-depth.test
*** PASS: test_cases\q3\2-3a-vary-depth.test
*** PASS: test_cases\q3\2-3b-vary-depth.test
*** PASS: test_cases\q3\2-4a-vary-depth.test
*** PASS: test_cases\q3\2-4b-vary-depth.test
*** PASS: test_cases\q3\2-one-ghost-3level.test
*** PASS: test_cases\q3\3-one-ghost-4level.test
*** PASS: test_cases\q3\4-two-ghosts-3level.test
*** PASS: test_cases\q3\5-two-ghosts-4level.test
*** PASS: test_cases\q3\6-tied-root.test
*** PASS: test_cases\q3\7-1a-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-1b-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-1c-check-depth-one-ghost.test
*** PASS: test_cases\q3\7-2a-check-depth-two-ghosts.test
*** PASS: test_cases\q3\7-2b-check-depth-two-ghosts.test
*** PASS: test_cases\q3\7-2c-check-depth-two-ghosts.test
*** Running AlphaBetaAgent on smallClassic 1 time(s).
Pacman died! Score: 84
Average Score: 84.0
Scores: 84.0
Win Rate: 0/1 (0.00)
Record: Loss
*** Finished running AlphaBetaAgent on smallClassic after 17 seconds.
*** Won 0 out of 1 games. Average score: 84.000000 ***
*** PASS: test_cases\q3\8-pacman-game.test

### Question q3: 5/5 ###

Finished at 17:21:45

Provisional grades
=====
Question q3: 5/5
-----
Total: 5/5

Your grades are NOT yet registered. To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.

```

Figure 4: Question 3 output (b)

## References

- [1] The Pac-Man Projects, UC Berkeley. Available at <https://inst.eecs.berkeley.edu/cs188/su21/projects/> (Last accessed 17 October 2023).
- [2] Stuart Russell and Peter Norvig. *Artificial Intelligence, A Modern Approach*. Pearson, 2022.