

■ Show your autograder results and describe each algorithm:

● Q1. Reflex Agent

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Question q1
=====

Pacman emerges victorious! Score: 1231
Pacman emerges victorious! Score: 1231
Pacman emerges victorious! Score: 1229
Pacman emerges victorious! Score: 1229
Pacman emerges victorious! Score: 1233
Pacman emerges victorious! Score: 1233
Pacman emerges victorious! Score: 1231
Pacman emerges victorious! Score: 1227
Pacman emerges victorious! Score: 1226
Pacman emerges victorious! Score: 1231
Average Score: 1230.1
Scores: 1231.0, 1231.0, 1229.0, 1229.0, 1233.0, 1233.0, 1231.0, 1227.0, 1226.0, 1231.0
Win Rate: 10/10 (1.00)
Record: Win, Win, Win, Win, Win, Win, Win, Win, Win, Win
*** PASS: test_cases/q1/grade-agent.test (30.0 of 30.0 points)
*** 1230.1 average score (2 of 2 points)
*** Grading scheme:
*** < 500: 0 points
*** >= 500: 1 points
*** >= 1000: 2 points
*** 10 games not timed out (0 of 0 points)
*** Grading scheme:
*** < 10: fail
*** >= 10: 0 points
*** 10 wins (2 of 2 points)
*** Grading scheme:
*** < 1: fail
*** >= 1: 0 points
*** >= 5: 1 points
*** >= 10: 2 points

### Question q1: 30/30 ###

Finished at 19:17:25

Provisional grades
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Question q1: 30/30
=====
Total: 30/30

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首先在最基本的 Reflex Agent，演算法僅僅考慮了與食物之間的距離、考慮鬼魂的位置與驚嚇狀態，並且根據食物的遠近給予分數上的權重、根據和鬼魂的距離來給予分數上的懲罰，最後結合計算的評分和遊戲的基本分數來進行決策。

● Q2. Minimax

首先 Pacman 的策略是要極大化自己的分數效益；而相反地 Ghost 的策略是要極小化 Pacman 的效益。根據投影片上提供的 pseudo-code 來進行修改，透過遞迴關係來看 Pacman 的下一步應該要如何行動。修改完 max-value, min-value 後，加上一個啟動步驟，首先將最佳行動設為 None，最佳分數設為負無限大，然後開始進行演算法，從 Pacman 開始，透過生出 successor，也就是生成執行該行動後的新遊戲狀態，並假設所有 Ghost 都會選擇對他們最有利的行動時，Pacman 能達到的最低評分，若此評分大於先前的最佳評分則更新分數與行動。

Question q2

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```
*** 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-minmax.test
*** PASS: test_cases/q2/1-2-minmax.test
*** PASS: test_cases/q2/1-3-minmax.test
*** PASS: test_cases/q2/1-4-minmax.test
*** PASS: test_cases/q2/1-5-minmax.test
*** PASS: test_cases/q2/1-6-minmax.test
*** PASS: test_cases/q2/1-7-minmax.test
*** PASS: test_cases/q2/1-8-minmax.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).
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 0 seconds.
*** Won 0 out of 1 games. Average score: 84.000000 ***
*** PASS: test_cases/q2/8-pacman-game.test
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Question q2: 30/30

Finished at 19:24:11

Provisional grades

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Question q2: 30/30

Total: 30/30

- Q3. Alpha-Beta Pruning

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Question q3
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*** 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-minmax.test
*** PASS: test_cases/q3/1-2-minmax.test
*** PASS: test_cases/q3/1-3-minmax.test
*** PASS: test_cases/q3/1-4-minmax.test
*** PASS: test_cases/q3/1-5-minmax.test
*** PASS: test_cases/q3/1-6-minmax.test
*** PASS: test_cases/q3/1-7-minmax.test
*** PASS: test_cases/q3/1-8-minmax.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
*** 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 0 seconds.
*** Won 0 out of 1 games. Average score: 84.000000 ***
*** PASS: test_cases/q3/8-pacman-game.test

### Question q3: 30/30 ###

Finished at 20:13:25

Provisional grades
=====
Question q3: 30/30
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Total: 30/30
```

和 minimax 類似，只是利用 Alpha-Beta 剪枝，來跳過那些不會影響決策的分支，得以節省大幅運算時間。Alpha 剪枝：如果當前節點的值 v 超過 β ，則剪枝並返回 v 。同時更新 α ；Beta 剪枝：如果當前節點的值 v 低於 α ，則剪枝並返回 v 。同時更新 β 。其餘和 minimax 大致一樣。

- Describe the idea of your design about evaluation function in Q1.

初始想法就是：首先給距離越近的食物越大的權重、距離越遠的食物越小的權重。接著就是設定一個安全距離並考慮鬼魂的位置與驚嚇狀態：離鬼魂接近到一個安全距離內，首先判斷此時鬼魂是否在驚嚇狀態內，若是且離驚嚇狀態結束還有至少兩秒，則我們要接近他必且吃掉；若已經要結束驚嚇狀態或甚至根本不在驚嚇狀態內，則要設定 penalty 來懲罰近距離接觸，最後將此分數加上原有的評分，即為我們的 evaluation function 所回傳的分數。

- Demonstrate the speed up after the implementation of pruning.

左邊為 Q2(minimax)，右邊為 Q3(alpha-beta pruning)，可以看出透過觀察擴展出的 states 數量，pruning 後的 states 數量每一個確實都小於等於 minimax 擴展的 state。

```
Question q2
=====
Total states expanded in Minimax: 2
*** PASS: test_cases/q2/0-eval-function-lose-states-1.test
Total states expanded in Minimax: 2
*** PASS: test_cases/q2/0-eval-function-lose-states-2.test
Total states expanded in Minimax: 2
*** PASS: test_cases/q2/0-eval-function-win-states-1.test
Total states expanded in Minimax: 2
*** PASS: test_cases/q2/0-eval-function-win-states-2.test
Total states expanded in Minimax: 12
*** PASS: test_cases/q2/0-lecture-6-tree.test
Total states expanded in Minimax: 7
*** PASS: test_cases/q2/0-small-tree.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/1-1-minimax.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/1-2-minimax.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/1-3-minimax.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/1-4-minimax.test
Total states expanded in Minimax: 19
*** PASS: test_cases/q2/1-5-minimax.test
Total states expanded in Minimax: 19
*** PASS: test_cases/q2/1-6-minimax.test
Total states expanded in Minimax: 19
*** PASS: test_cases/q2/1-7-minimax.test
Total states expanded in Minimax: 19
*** PASS: test_cases/q2/1-8-minimax.test
Total states expanded in Minimax: 5
*** PASS: test_cases/q2/2-1a-vary-depth.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/2-1b-vary-depth.test
Total states expanded in Minimax: 5
*** PASS: test_cases/q2/2-2a-vary-depth.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/2-2b-vary-depth.test
Total states expanded in Minimax: 5
*** PASS: test_cases/q2/2-3a-vary-depth.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/2-3b-vary-depth.test
Total states expanded in Minimax: 5
*** PASS: test_cases/q2/2-4a-vary-depth.test
Total states expanded in Minimax: 10
*** PASS: test_cases/q2/2-4b-vary-depth.test
Total states expanded in Minimax: 14
*** PASS: test_cases/q2/2-one-ghost-3level.test
Total states expanded in Minimax: 30
*** PASS: test_cases/q2/3-one-ghost-4level.test
Total states expanded in Minimax: 14
*** PASS: test_cases/q2/4-two-ghosts-3level.test
Total states expanded in Minimax: 30
*** PASS: test_cases/q2/5-two-ghosts-4level.test
Total states expanded in Minimax: 5
*** PASS: test_cases/q2/6-tied-root.test
Total states expanded in Minimax: 6
*** PASS: test_cases/q2/7-1a-check-depth-one-ghost.test
Total states expanded in Minimax: 12
*** PASS: test_cases/q2/7-1b-check-depth-one-ghost.test
Total states expanded in Minimax: 18
*** PASS: test_cases/q2/7-1c-check-depth-one-ghost.test
Total states expanded in Minimax: 9
*** PASS: test_cases/q2/7-2a-check-depth-two-ghosts.test
Total states expanded in Minimax: 18
*** PASS: test_cases/q2/7-2b-check-depth-two-ghosts.test
Total states expanded in Minimax: 27
```

```
Question q3
=====
Total states expanded in Alpha-Beta: 2
*** PASS: test_cases/q3/0-eval-function-lose-states-1.test
Total states expanded in Alpha-Beta: 2
*** PASS: test_cases/q3/0-eval-function-lose-states-2.test
Total states expanded in Alpha-Beta: 2
*** PASS: test_cases/q3/0-eval-function-win-states-1.test
Total states expanded in Alpha-Beta: 2
*** PASS: test_cases/q3/0-eval-function-win-states-2.test
Total states expanded in Alpha-Beta: 11
*** PASS: test_cases/q3/0-lecture-6-tree.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/0-small-tree.test
Total states expanded in Alpha-Beta: 9
*** PASS: test_cases/q3/1-1-minimax.test
Total states expanded in Alpha-Beta: 9
*** PASS: test_cases/q3/1-2-minimax.test
Total states expanded in Alpha-Beta: 7
*** PASS: test_cases/q3/1-3-minimax.test
Total states expanded in Alpha-Beta: 10
*** PASS: test_cases/q3/1-4-minimax.test
Total states expanded in Alpha-Beta: 18
*** PASS: test_cases/q3/1-5-minimax.test
Total states expanded in Alpha-Beta: 18
*** PASS: test_cases/q3/1-6-minimax.test
Total states expanded in Alpha-Beta: 17
*** PASS: test_cases/q3/1-7-minimax.test
Total states expanded in Alpha-Beta: 17
*** PASS: test_cases/q3/1-8-minimax.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/2-1a-vary-depth.test
Total states expanded in Alpha-Beta: 9
*** PASS: test_cases/q3/2-1b-vary-depth.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/2-2a-vary-depth.test
Total states expanded in Alpha-Beta: 9
*** PASS: test_cases/q3/2-2b-vary-depth.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/2-3a-vary-depth.test
Total states expanded in Alpha-Beta: 7
*** PASS: test_cases/q3/2-3b-vary-depth.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/2-4a-vary-depth.test
Total states expanded in Alpha-Beta: 7
*** PASS: test_cases/q3/2-4b-vary-depth.test
Total states expanded in Alpha-Beta: 10
*** PASS: test_cases/q3/2-one-ghost-3level.test
Total states expanded in Alpha-Beta: 18
*** PASS: test_cases/q3/3-one-ghost-4level.test
Total states expanded in Alpha-Beta: 13
*** PASS: test_cases/q3/4-two-ghosts-3level.test
Total states expanded in Alpha-Beta: 19
*** PASS: test_cases/q3/5-two-ghosts-4level.test
Total states expanded in Alpha-Beta: 5
*** PASS: test_cases/q3/6-tied-root.test
Total states expanded in Alpha-Beta: 6
*** PASS: test_cases/q3/7-1a-check-depth-one-ghost.test
Total states expanded in Alpha-Beta: 12
*** PASS: test_cases/q3/7-1b-check-depth-one-ghost.test
Total states expanded in Alpha-Beta: 18
*** PASS: test_cases/q3/7-1c-check-depth-one-ghost.test
Total states expanded in Alpha-Beta: 9
*** PASS: test_cases/q3/7-2a-check-depth-two-ghosts.test
Total states expanded in Alpha-Beta: 18
*** PASS: test_cases/q3/7-2b-check-depth-two-ghosts.test
Total states expanded in Alpha-Beta: 27
```