School of Data and Computer Science, Sun Yat-sen University

P01 Pacman Game

17341015 Hongzheng Chen

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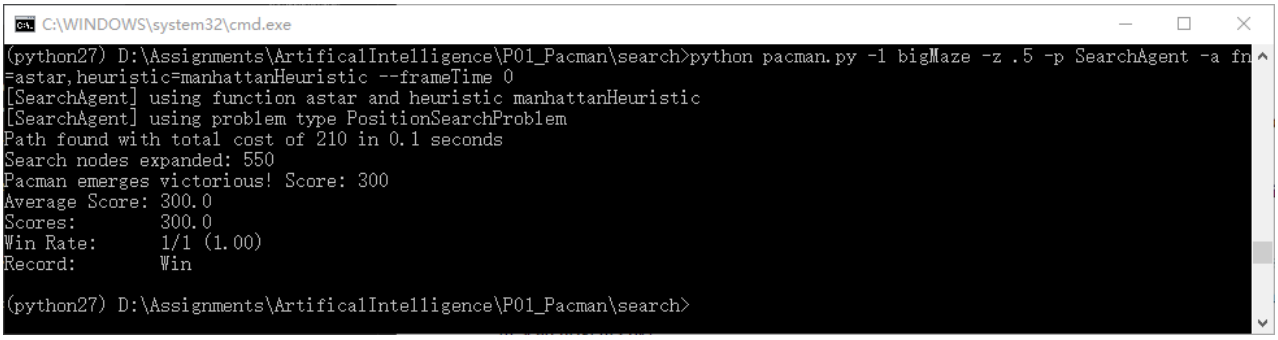
Contents

For the codes, please refer to the attached files.

1 Question 1: A* search (3 points)

```
python pacman.py -l bigMaze -z .5 -p SearchAgent -a fn=astar,heuristic=manhattanHeuristic
```

```
def aStarSearch(problem, heuristic=nullHeuristic):
  """Search the node that has the lowest combined cost and heuristic first."""
  start = problem.getStartState()
  queue = util.PriorityQueue()
  queue.push((0,start,[]),0)
  visited = []
  while not queue.isEmpty():
      cost, curr, actions = queue.pop()
      if problem.isGoalState(curr):
          break
      for succ in problem.getSuccessors(curr):
          if succ[0] in visited:
              continue
          priority = cost + succ[2] + heuristic(succ[0],problem)
          queue.push((cost+succ[2],succ[0],actions+[succ[1]]),priority)
          visited.append(succ[0])
  return actions
```



2 Question 2: Corners Problem: Heuristic (3 points)

```
python pacman.py -l mediumCorners -p SearchAgent -a fn=aStarSearch,prob=CornersProblem,heurist
```

We represent the state as below

pacmanx, pacmany, 0, 0, 0, 0

where the last four numbers indicating whether there is food in the corner. And the goal state is

*, *, 1, 1, 1, 1

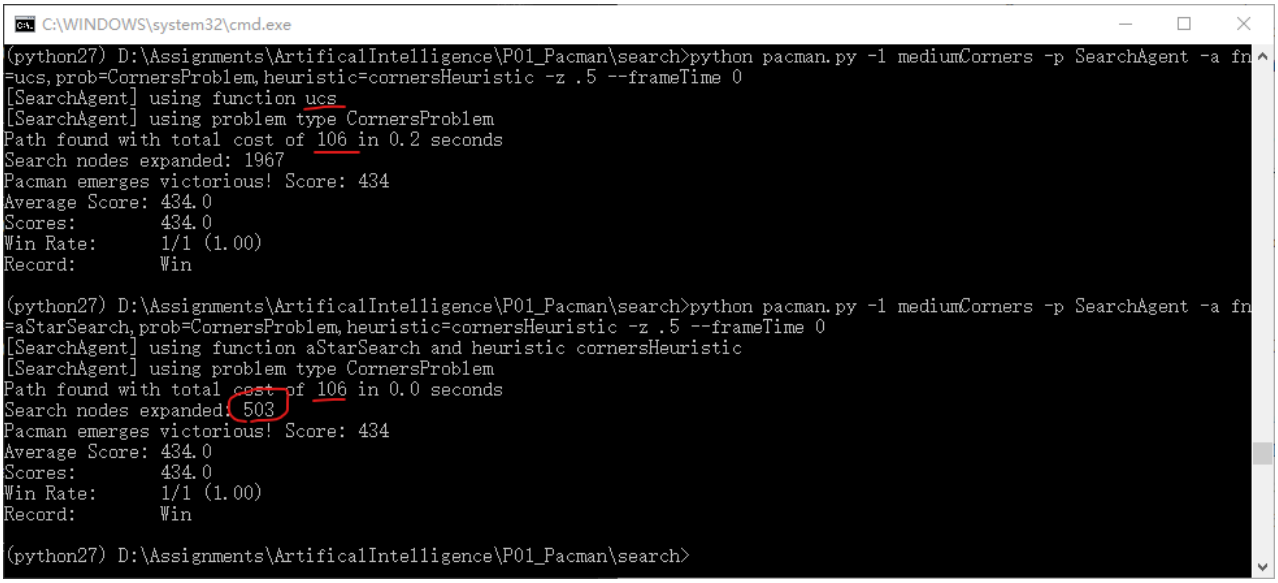
We design a heuristic that calculates the total Manhattan distance from the current position of the pacman to each unvisited corner. This is obviously admissible and consistent, since every time the pacman reach to a corner, the total distance can be reduced, and the heuristic value of the goal state is 0.

```
class CornersProblem(search.SearchProblem):

  def __init__(self, startingGameState):
      """
      Stores the walls, pacman's starting position and corners.
      """
      self.walls = startingGameState.getWalls()
      self.startingPosition = startingGameState.getPacmanPosition()
      top, right = self.walls.height-2, self.walls.width-2
      self.corners = ((1,1), (1,top), (right, 1), (right, top))
      for corner in self.corners:
          if not startingGameState.hasFood(*corner):
              print 'Warning: no food in corner ' + str(corner)
      self._expanded = 0 # DO NOT CHANGE; Number of search nodes expanded
      # Please add any code here which you would like to use
      # in initializing the problem
      visited = [0,0,0,0]
      for (i,corner) in enumerate(self.corners):
          if self.startingPosition == corner:
              visited[i] = 1
      self.startState = (self.startingPosition,visited)

  def getStartState(self):
      """
      Returns the start state (in your state space, not the full Pacman state
      space)
      """
      return self.startState

  def isGoalState(self, state):
```

```
        """
        Returns whether this search state is a goal state of the problem.
        """
        if state[1] == [1,1,1,1]:
            return True
        return False

    def getSuccessors(self, state):
        """
        Returns successor states, the actions they require, and a cost of 1.

         As noted in search.py:
            For a given state, this should return a list of triples, (successor,
            action, stepCost), where 'successor' is a successor to the current
            state, 'action' is the action required to get there, and 'stepCost'
            is the incremental cost of expanding to that successor
        """

        successors = []
        for action in [Directions.NORTH, Directions.SOUTH, Directions.EAST, Directions.WEST
            ↪ ]:
            # Add a successor state to the successor list if the action is legal
            # Here's a code snippet for figuring out whether a new position hits a wall:
            #   x,y = currentPosition
            #   dx, dy = Actions.directionToVector(action)
            #   nextx, nexty = int(x + dx), int(y + dy)
            #   hitsWall = self.walls[nextx][nexty]
            x, y = state[0]
            dx, dy = Actions.directionToVector(action)
            nextx, nexty = int(x + dx), int(y + dy)
            if not self.walls[nextx][nexty]:
                nextCorner = [item for item in state[1]]
                if (nextx,nexty) in self.corners:
                    i = self.corners.index((nextx,nexty))
                    nextCorner[i] = 1
                nextState = ((nextx,nexty),nextCorner)
                successors.append((nextState,action,1))
```

```
        self._expanded += 1 # DO NOT CHANGE
        return successors

    def getCostOfActions(self, actions):
        """
        Returns the cost of a particular sequence of actions. If those actions
        include an illegal move, return 999999. This is implemented for you.
        """
        if actions == None: return 999999
        x,y= self.startingPosition
        for action in actions:
            dx, dy = Actions.directionToVector(action)
            x, y = int(x + dx), int(y + dy)
            if self.walls[x][y]: return 999999
        return len(actions)


def cornersHeuristic(state, problem):

    corners = problem.corners # These are the corner coordinates
    walls = problem.walls # These are the walls of the maze, as a Grid (game.py)

    pos = state[0]
    cornerFlag = state[1]
    res = 0
    for i,corner in enumerate(corners):
        if not cornerFlag[i]:
            res += abs(pos[0] - corner[0]) + abs(pos[1] - corner[1])
    return res
```

We can see that the heuristic is admissible and consistent that it can find the optimal solution the same as what UCS found.



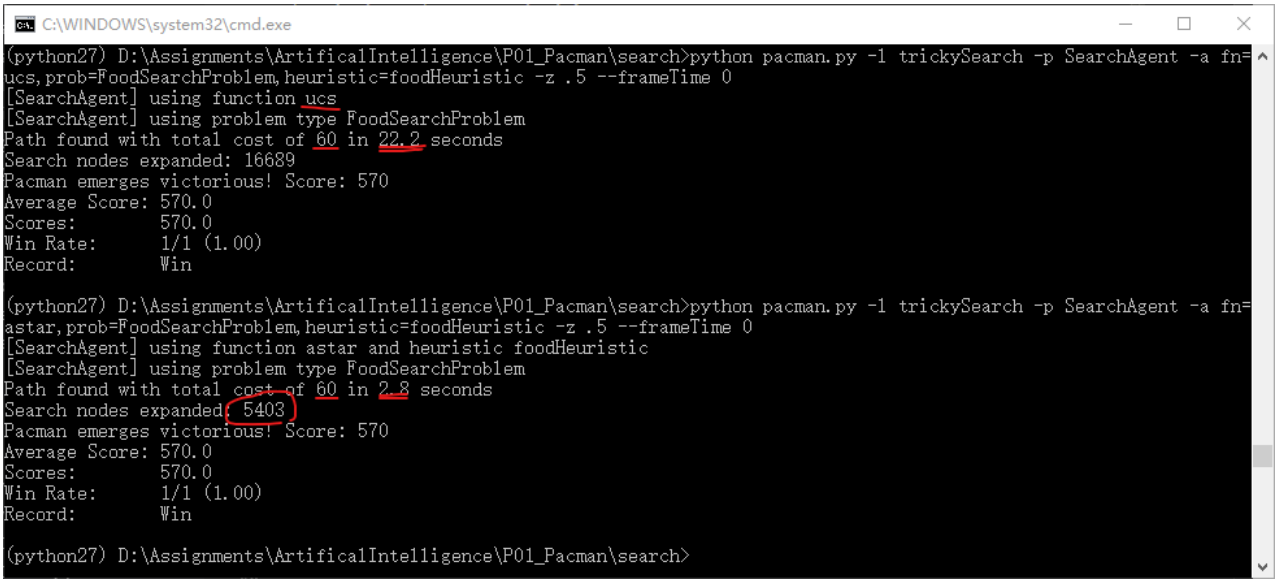
3 Question 3: Eating All The Dots (4 points)

`python pacman.py -l testSearch -p SearchAgent -a fn=astar,prob=FoodSearchProblem,heuristic=foo`

We design a heuristic that calculates the total Manhattan distance from the current position of the pacman to each food (similar to Question 2, which is indeed a very efficient heuristic). This is also obviously admissible and consistent, since every time the pacman get to one food, the total distance can be reduced, and the heuristic value of the goal state is 0.

```
def foodHeuristic(state, problem):


    position, foodGrid = state
    foodLst = foodGrid.asList()
    # print(position) # (10, 3)
    # print(foodLst) # [(1, 1), (1, 4), (1, 5), (2, 1), (3, 1), (4, 1), (4, 4), (5, 1), (7,
        ↪  4), (10, 4), (13, 4), (13, 5), (14, 5)]
    sumup = 0
    for food in foodLst:
        sumup += abs(position[0] - food[0]) + abs(position[1] - food[1])
    return sumup
```

We can see that the heuristic is admissible and consistent that it can find the optimal solution the same as what UCS found.



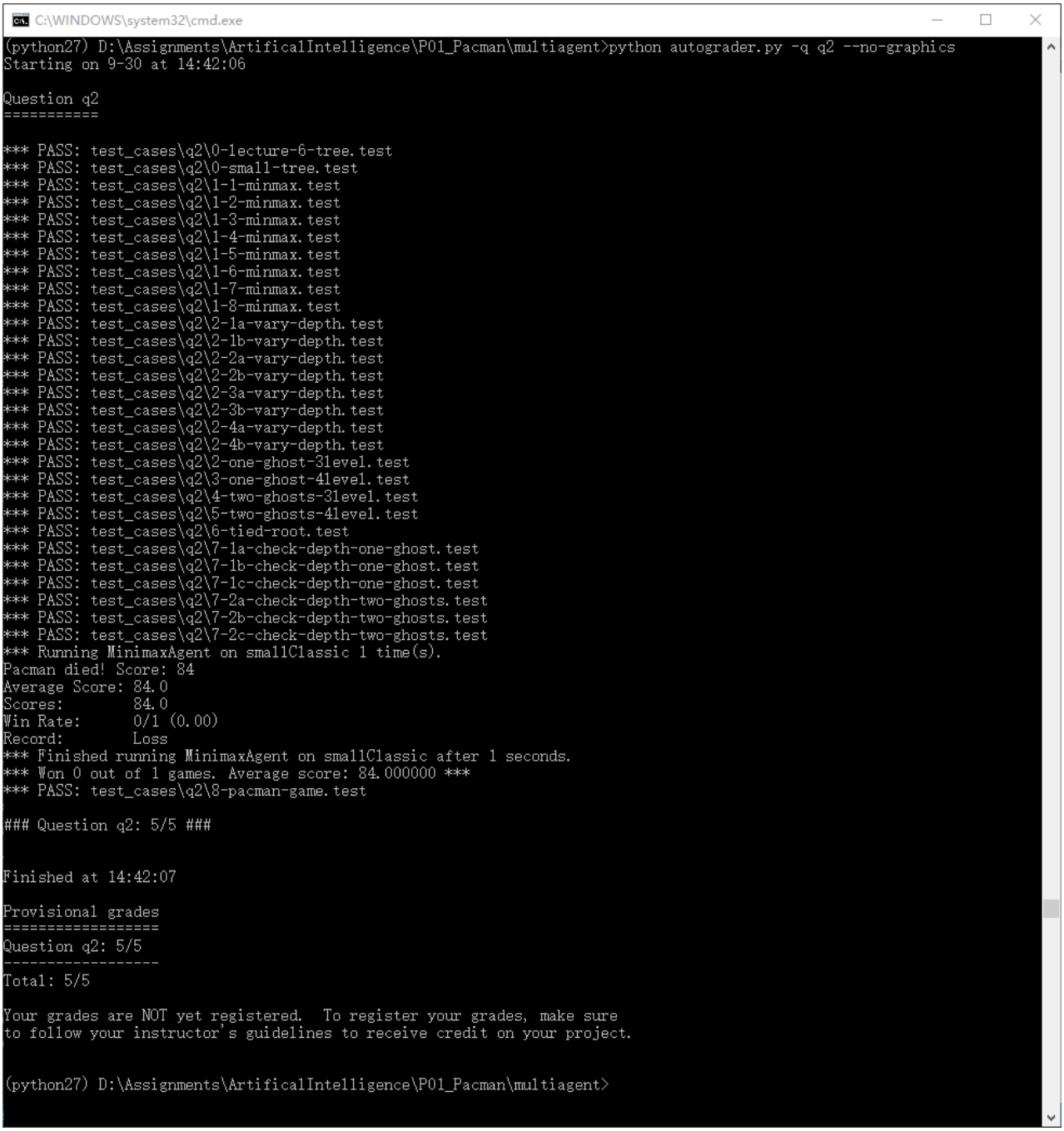
4 Question 4: Minimax (5 points)

python autograder.py -q q2 --no-graphics

```
class MinimaxAgent(MultiAgentSearchAgent):


  def DFMinimax(self, depth, gameState, currAgent):
      actions = gameState.getLegalActions(currAgent)
      if depth > self.depth or len(actions) == 0:
          return (self.evaluationFunction(gameState),Directions.STOP)
      if currAgent == 0: # MAX node
          maxVal = []
          for action in actions:
              state = gameState.generateSuccessor(currAgent,action)
              maxVal.append((self.DFMinimax(depth,state,1)[0],action))
          return max(maxVal)
      else: # MIN node
          minVal = []
          for action in actions:
              state = gameState.generateSuccessor(currAgent,action)
              if currAgent == gameState.getNumAgents() - 1:
                  minVal.append((self.DFMinimax(depth+1,state,0)[0],action))
              else: # one by one action
                  minVal.append((self.DFMinimax(depth,state,currAgent+1)[0],action))
          return min(minVal)
```

```
    def getAction(self, gameState):
        _, action = self.DFMinimax(1,gameState,0)
        return action
```

The figure below shows my agent passes all the tests.

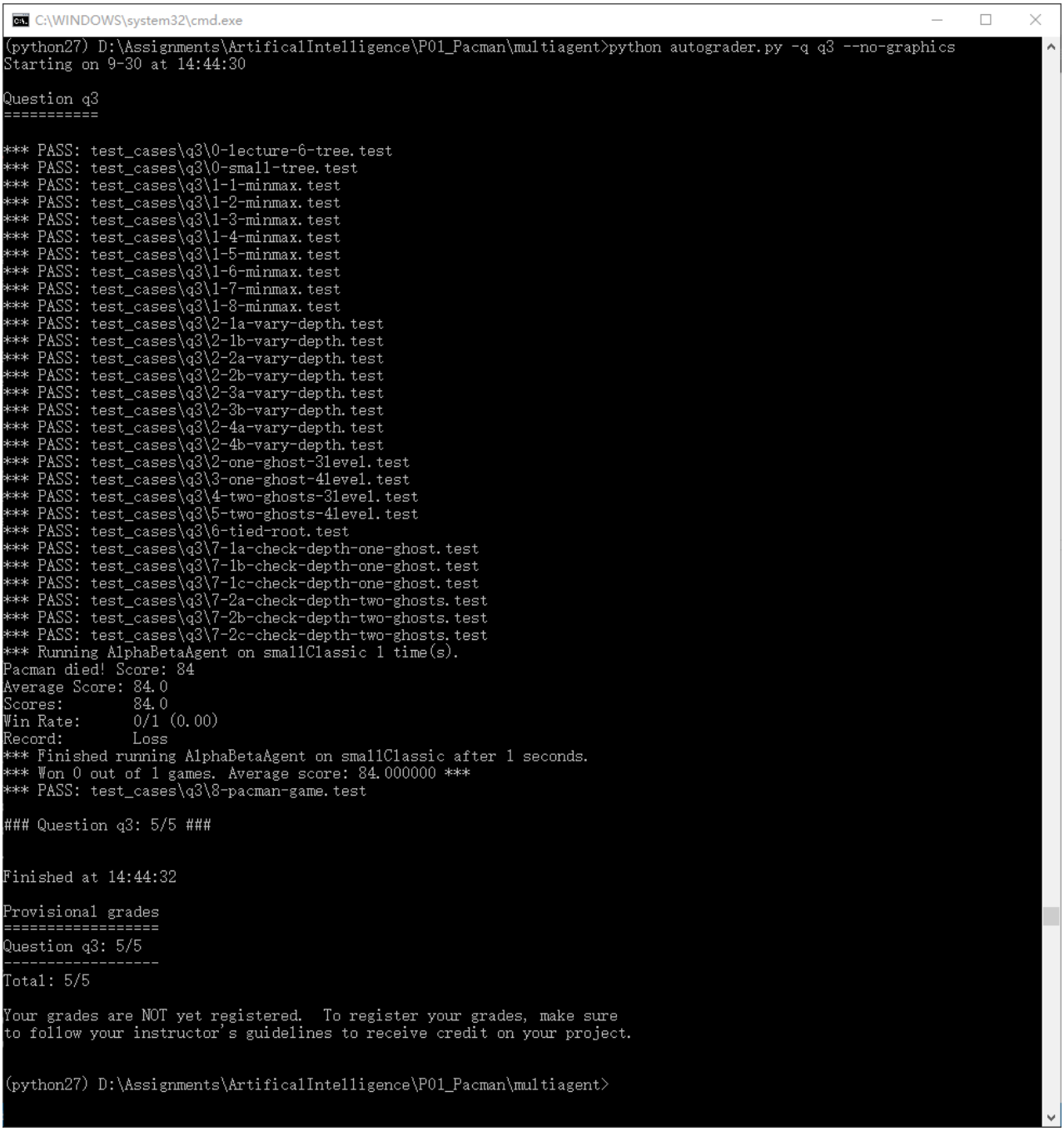


5 Question 5: $\alpha - \beta$ Pruning (5 points)

```
python autograder.py -q q3 --no-graphics
```

```
class AlphaBetaAgent(MultiAgentSearchAgent):


  def DFMinimax(self, depth, gameState, currAgent, alpha, beta):
      actions = gameState.getLegalActions(currAgent)
      if depth > self.depth or len(actions) == 0:
          return (self.evaluationFunction(gameState),Directions.STOP)
      if currAgent == 0: # MAX node
          val = (-0x3f3f3f3f,Directions.STOP)
          for action in actions:
              state = gameState.generateSuccessor(currAgent,action)
              val = max(val,(self.DFMinimax(depth,state,1,alpha,beta)[0],action))
              if val[0] > beta:
                  return val
              alpha = max(alpha,val[0])
          return val
      else: # MIN node
          val = (0x3f3f3f3f,Directions.STOP)
          for action in actions:
              state = gameState.generateSuccessor(currAgent,action)
              if currAgent == gameState.getNumAgents() - 1:
                  val = min(val,(self.DFMinimax(depth+1,state,0,alpha,beta)[0],action))
              else: # one by one action
                  val = min(val,(self.DFMinimax(depth,state,currAgent+1,alpha,beta)[0],
                      ↪ action))
              if val[0] < alpha:
                  return val
              beta = min(beta,val[0])
          return val


  def getAction(self, gameState):
      _, action = self.DFMinimax(1,gameState,0,-0x3f3f3f3f,0x3f3f3f3f)
      return action
```

The figure below shows my agent passes all the tests.


C:\WINDOWS\system32\cmd.exe
(python27) D:\Assignments\ArtificalIntelligence\P01_Pacman\multiagent>python autograder.py -q q3 --no-graphics
Starting on 9-30 at 14:44:30
Question q3
==========
*** 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 1 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 14:44:32
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.
(python27) D:\Assignments\ArtificalIntelligence\P01_Pacman\multiagent>